THE PROCEEDINGS OF THE LINNEAN SOCIETY OF NEW SOUTH WALES

FOR THE YEAR

1918

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WITH NINETY-THREE PLATES,
and 112 Text-figures.

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PART III. *(Continued).*

PART IV. (No. 172).

(Issued 26th March, 1919).

PART IV. *(Continued).*

CORRIGENDA.

Page 191, line 31—*for* length, *read* lengthen.
Page 231, line 25—*for* Museum, *read* Herbarium.
Page 235, line 19—for *corniculatus*, read *corniculata*.
Page 315, line 17—*for* forewing, *read* frenulum.
Page 377, line 36—for *S. partita*, read *S. partitum*.
Page 415, line 32—for *laurina*, read *laurifolia*.
Page 669, line 7—for *novæ-angliæ*, read *nova-anglica*.
Page 702, line 21—for *A. riparius*, read *S. riparius*.
Page 827, line 4—for *Anophiles*, read *Anopheles*.
Page 829, line 23—*after* length, *add* 3 mm.
Page 829, line 33—*for* 1914 and (1915) *read* 1913 and (1914).
Page 832, line 33—*after* Skuse, *add* Taylor.
Page 843, last line—*for* sp.n., *read* Taylor.

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PROCEEDINGS
OF THE
LINNEAN SOCIETY
OF
NEW SOUTH WALES.

WEDNESDAY, MARCH 27TH, 1918.

The Forty-third Annual General Meeting, and the Ordinary Monthly Meeting, were held in the Linnean Hall, Ithaca Road, Elizabeth Bay, on Wednesday evening, March 27th, 1918.

ANNUAL GENERAL MEETING.

Professor H. G. Chapman, M.D., B.S., President, in the Chair.

The Minutes of the preceding Annual General Meeting (March 28th, 1917) were read and confirmed.

The President delivered the Annual Address.

PRESIDENTIAL ADDRESS.

LADIES AND GENTLEMEN,

This is the forty-third occasion on which the President has delivered an annual address to the Members of the Society. The progress of this Linnean Society, aiming at advancing the study of Natural Science in this newly-populated continent, is also shown by your election of a graduate of an Australian University to the presidential chair. Such a selection bears witness to the increasing influence and preponderating numbers of the scientists trained in Australia in the personnel of the membership. This is the first occasion on which such an honour has been conferred on a student of our Universities by the naturalists of our Society. I appreciate the honour that you have done me. I think, however, that I should be ungrateful if I did not render some tribute to those who have given me of the best of their intellect and of their assistance. I feel that I owe my educational development to two men. One has ceased to be a Member of this Society and to continue his work in Australia, but, in a larger sphere, he still directs the labours and lends his kindly hand to encourage the early efforts to learn of Nature of those of another land. I refer to Charles James Martin. The other lives among us and sets us the example of an earnest student of the animals, plants, and rocks around us. I pay my homage to Charles Hedley.

You will pardon me if I spend a few minutes in pointing out what I owe to my chief teachers. The Australians are said to lack reverence and gratitude. Perhaps their critics are, sometimes, astray. It is rather more than twenty-one years since I saw for the first time C. J. Martin. I was a student of medicine at the Medical School in Melbourne, and had reached my third year. We students had heard, towards the end of our second year, that the venerable Professor of Physiology, Dr. Halford, had been granted leave of absence, and that a lecturer had been appointed in his place. Early in the next year, I went, in the company of a fellow student, to find out if we could not start our year's reading before lectures commenced. The Long Vacation seemed too lengthy an holiday. We were young in many ways. We thought that in books lay the knowledge of natural phenomena. We had not learnt that our work in the laboratory was anything more than an attempt to assist our memories by visualising what we committed to our minds. I recollect that we went to the Old Medical School through the Grecian porch. We passed through the bare hall with its tablet in commemoration of Professor Kirkland, and into the asphalted court. On the right was the Department of Physiology. It consisted of a theatre into which opened the Professor's library and a small ante-room. Beyond stretched a commodious laboratory with benches equipped for chemical work, with gas, with water, and with shelves for bottles. A preparation-room in which the Professor's assistant made ready the microscopical sections and chemical solutions with which we worked, and two empty rooms completed the suite of rooms. As we walked to the door, I little thought that I was to spend the greater part of five out of the next six years within those walls. In answer to our knock, there appeared a tall, fair man in singlet and pants, a file in one hand and a piece of brass in the other. We asked for Professor Martin, and were curtly told to say what we wanted. Slowly it dawned on our minds that we were addressing a new type of teacher. Those we had formerly known were dignified and distant. We had never thought of them, even in the heat of summer, unbending so far as to remove their coats. Many of them never spoke to us unless covered by their academic robes, and we were taught to prepare for any interview with them by donning our academic attire. A new era in the Melbourne School of Medicine had already commenced. I would not have you think that we students did not benefit from the instruction of those with whom we had only a formal association. They contributed to our education, but neither in the same way nor to the same extent as Dr. Martin. When we two had stated our errand and sought advice as to what books we should read, we were made not to value ourselves too highly for our desire to start work early by the kindly yet satirical praise that we received. We were also informed that we could not do better than give some weeks to a renewed study of the microscopical specimens that we had mounted in the preceding year. As to the books, we might take our choice. We were to study Physiology and the functions of the living organism, not any description of them in a book. We went away with little understanding, and somewhat perplexed.

One fact remained in my mind. I had to examine once more and to draw again the pieces of animal tissue prepared for microscopical study. I devoted the rest of the vacation to that labour, and I have kept to this day my sketches and those slides. It was several years before I realised the value of those few minutes' counsel. Scientific study not only includes the reading of books and pamphlets about natural objects and happenings, but demands the investigation of the things and of their behaviours. The books, papers, and monographs are the records of what other students have noted on these matters. I wonder often if we make this position plain in advocating more attention to scientific subjects. We suggest that children should be taught science in schools. We mean that the children should be given the objects to handle and regard so as to become aware of what is known of them. Do we make the parent and the schoolteacher understand that education in science is the examination of things and not of words or descriptions? I fear that many of us who have some control over education in this State by means of examinations and the institution of courses of instruction, sometimes forget at what we aim. We demand too large a store of knowledge. We force the child to learn of Nature by books. We do not remember how slowly we acquired our own acquaintance with the world of matter about us. We yield to the critic who tells us that we set too low a standard, and that we do not ask the child to know enough. We set out examinations without sufficient regard for the hours needed to experiment and to observe the facts necessary for an answer. I have tried often to persuade examiners and boards of examiners to give more weight to practical examinations. I like to ask students to record their observations on simple objects. My fellow-examiners have said to me that the questions are so easy. They are easy to the student who has learnt to study things, and they mislead the student who does not know of things but only about words. Such students do not recognise what they see. Life, however, is concerned with the persons and objects around us, not with the descriptions of them that literary men may pen.

I have told you that I used my microscope. To those hours of observation I owe the interest that Dr. Martin took in my future education. Some weeks after lectures had begun, I went, at the close of the instruction, to ask a question about the act of breathing on high mountains. The conversation passed to personal topics. I mentioned that I had seen certain appearances in some sections of the lungs. I was invited to come into the laboratory to arrange the microscopical objects that Dr. Martin had brought with him from Sydney. Each day I spent an hour or so in looking at the specimens and putting them in the different drawers of the cabinets. Now and then, my teacher came to hear what I was doing or to invite me to look at some experiment that he was performing in the laboratory. I saw for the first time a working laboratory engaged in the observation of physiological phenomena. I noted that experiments were arranged to ascertain how these phenomena were brought about. I noticed how these experiments gave answers, at times precise, at other times inconclusive, as to the characters of the events examined. I was led to think of these experiments, to ask questions myself, to form my own answers from the sequence of the events of any experiment, and, indeed, to inquire of natural occurrences how they happened.

I trust that I do not weary you with these reminiscences, but I think that it would be advantageous to the people of this Commonwealth if they knew more of the work of that laboratory. I believe that the citizens of this continent would have derived more benefit if Dr. Martin had possessed better opportunities of making others aware of the meaning of scientific education. Charles James Martin had that personal magnetism which gave him command over others. He did not preach to us on his doctrines, but he set us an example in his own attitude to the science that he taught. During the first year, I was the only undergraduate that worked daily in the laboratory at hours beyond those prescribed by the curriculum. Other older men came to do research at his inspiration. Dr. (later Professor) T. Cherry, J. F. Wilkinson, A. B. Colquhoun, A. C. Halford, A. Finch Noyes, and J. W. Barrett (now Sir James) were amongst the earliest workers. A little later, E. H. Embley commenced his investigation upon anæsthetics, destined to become one of the principal studies of the laboratory during Dr. Martin's directorship. Other undergraduates, among whom were R. A. O'Brien, now head of the Wellcome Research Laboratories in London, S. W. Patterson, M. Lidwill, and, lastly, G. C. Mathieson, endowed with genius of highest order, who might have influenced the world for generations, was regarded as one of the brightest stars of the rising generation of British scientists, but gave his life at Gallipoli while acting as a regimental medical officer, came into the laboratory in the next few years. All too soon, Dr. Martin's work among us came to an end. He held no Professorship. An offer from Belfast had been declined, but he accepted with reluctance the post of Director of the Lister Institute of Preventive Medicine in London. This post is one of much importance, for the Institute is the largest medical research laboratory in the British Empire. Dr. Martin did not wish to leave Australia. His heart was with his students. His work lay in training them to continue what he had begun. His influence was growing in Melbourne. The years of sowing, at times disheartening, were almost over, and the days of fruition and reaping were at hand. An attempt to obtain for him a chair in the University failed, and one of the most inspiring scientific teachers that we have had in Australia left our shores.

The influence that Dr. Martin wielded, was due to his personal relations with those around him. He worked with his students at the same tasks. He asked all to take an interest in his researches. When graduates or students started their own researches, he came each day to see what was going on. He made the necessary instruments with his own hands. He manipulated the apparatus or took the notes. He drew the conclusions or criticised the inferences. He expected discussion at every step. It is well, perhaps, that I remind you that he fitted up the workshop, setting up the benches with his own hands. He repaired the gas engine that supplied the power. He made the apparatus before H. J. Grayson became the mechanic. He was carpenter, fitter and turner, glass worker and electrician for the laboratory, and for the rest of us. He was the chief under whom we all delighted to serve. I am afraid that we shall never be able to let you know how much we stand in his debt.

I would like to add just a few words about his methods of teaching science. He did not use diagrams or models to any extent. If he referred to the structure of a muscle-fibre, he threw on the screen the image cast by a specimen of muscle through a projecting microscope. The students thus formed their own mental pictures of natural objects instead of accepting the interpretation that some other person had embodied in a diagram or model. Each lesson was a demonstration rather than an exposition. Experiment followed experiment throughout each lecture. These experiments were selected to answer the queries which rose in the mind as the result of the previous experiment.

Great skill was manifested in choosing the experiments and in arranging their order. The sequence of the experiments was sufficient instruction to most students. The results were so obvious and the interpretation so easy that most of those who saw the demonstration needed no prompting as to the inferences and conclusions. Dr. Martin possessed little oratorical skill. He was not a successful lecturer. His expositions were by no means good accounts of all that is known on a subject. It was necessary to work with him to obtain his instruction. The student who attended classes with a note-book in which he intended to write all he meant to learn on a subject found the lectures most unsatisfactory. The lesson was not prepared for assimilation. The student found that he had to work out much for himself. If the student did what was asked of him, he had, at the end of the course, a training in the science of the functions of the living organisms.

From Charles James Martin I learnt of the inductive and deductive methods of analysis. I observed how experiments were employed. I saw how to select an experiment so that some precise inference could be drawn from it. I learnt of physics and chemistry and of their use in explaining the behaviour of living cells, tissues, organs, and animals. To Charles Hedley I am indebted for a different awakening. I was a teacher of some years' standing in the University of Sydney before I became acquainted with Mr. Hedley. He was a neighbour, and our common interest in this Society led me to cultivate his friendship. I had attended classes in zoology and botany at the University. During my holidays I had wandered through the bush or meandered over the rocky shore or beach. Many plants and animals attracted my notice, but I found my instruction had left me ignorant of what they were and how to learn of them. As I became acquainted with Mr. Hedley, I formed the habit of taking walks with him, and I was soon the pupil of an accomplished naturalist. The trees, shrubs and herbs, rocks, birds, and insects had a message. I was led to look at them and see what they revealed. Until this time, science had appeared to me to need incessant analysis. I now saw the science of simple observation. The plants seemed to give me special interest, and I started to collect those around my home, to notice their construction, and to learn their names from their descriptions. I was told for the first time that much could be learnt from noting what plants occurred together, or how different plants favoured different localities and surroundings. I need not tell you much as to how Mr. Hedley made stone, animal, and green plant of such interest that I had to look at them. Few of you knew Charles James Martin, but all of you know Charles Hedley. There will be no one in this room who has not had some words from him on natural history, who has not had his attention turned to some object of interest, and who has not been led by his inspiration to look again at some natural object. No naturalist has done more for those of us of the younger generation. I think some of the older naturalists do not realise how difficult it is for the Australian to obtain information about the things around him. There is an almost complete absence of simple books about our plants or animals. Even the elementary text-books used in schools are those of European authors, and deal with European forms. It seems to me that there is here an opportunity which should not be missed by those among us capable of supplying this information. We need cheap books dealing with the different forms of life of our bush, beaches, and waters. Such books as have been prepared cover a wide range. They deal with the birds, fishes, animals, or insects of Australia. I believe there would be a ready sale for cheap books dealing with the fauna and flora of small districts. When I started to examine the flowering plants about my home, I read once again Hooker's Botany, and then used Moore's Flora of New South Wales. I will not say how many hours I spent in discovering the name of a plant. No beginner will find it easy if he has to use Moore's Flora. The classification of plants depends on characters which are not readily ascertained. After several weeks, I named *Bauera rubioides*, and was materially aided by the presence of eight petals. Observation seems easy to those who have not observed. I cannot remember how often it became necessary to revise my description of the characters of a plant. I used to write them out as I recognised them in the plant. When my account was completed, I started to find the family, the genus, and the species. If I found the correct genus, the rest was comparatively simple. How I wished for a book with some figures or diagrams of the floral characters of the principal families of plants found in our bush! From these labours, I learned to appreciate the value of precise observation. I have mentioned plants, but our rocky foreshores are alive with animal life, and no one but a specialist can learn of them. Butterflies and moths attract many. We have a useful book about butterflies, and we would all welcome others treating of other kinds of insects. May I hope that the day is not very distant when ten or twenty of these useful books will have been written.

On this occasion our thoughts may fittingly turn to our absent soldier-members. In addition to those mentioned at the last two Annual Meetings, Mr. E. Griffiths, B.Sc., of the Department of Agriculture, Mr. Tilley, of the Geological Department of the University of Sydney, and Mr. R. B. Oliver, of Auckland, New Zealand, have departed for the front during the year, or are preparing to do so. Not only have we not had the pleasure of welcoming any of them back during the year, but we have heard, with sorrow, of the death of Dene B. Fry, one of our promising junior Members.

Four Ordinary Members have been elected during the Session, two resignations have been received, and three Members have been lost by death.

Dene Barrett Fry, killed in action in France, on April 9th, 1917, aged 23, was the first of our Soldier-members to fall. He was a rising young biologist of great promise, elected a Member in 1913; and his loss is greatly to be deplored. His training began at the Australian Museum, as a cadet, in 1908, where he remained until 1914. When the war broke out, he was a student at the University, and a demonstrator in zoology; but he gave up his University work in order to enlist, joining the Army Medical Corps in May, 1915. After two voyages in a hospital-ship, he transferred to the Infantry, qualifying for the post of lieutenant. But as there was no vacancy available, he left for the front with reinforcements, as sergeant. After some time spent at Salisbury Plains, his regiment was sent to France, where he took part in several engagements. His last contribution to science, "Description of *Aphantophryne*, a new Batrachian Genus from New Guinea," and his only one to our Proceedings, appeared in the volume for 1916. Ten other papers dealing with reptiles or amphibia were published in the Records of the Australian Museum (1912-13), in the Memoirs of the Queensland Museum (1913), in the Records of the Australian Museum (1913-14), and in the Proceedings of the Royal Society of Queensland (1915).

Dr. Thomas P. Lucas, one of our Senior Members, elected in 1861, died in Brisbane on November 15th, 1917, in his 75th year. He came out to Australia in 1876; and after practising his profession in Melbourne for ten years, he removed to the warmer climate of Brisbane, where he continued to practise up to the time of his last illness. He was especially interested in Lepidoptera, an enthusiastic collector, and the possessor of a very fine collection.

Alfred John North, another Senior Member, elected in 1886, died on May 6th, 1917, aged 61. He came to Sydney from Melbourne in 1886, and became associated with the Australian Museum, as Assistant in the Zoological Department, to undertake the preparation of a "Descriptive Catalogue of the Nests and Eggs of Birds found breeding in Australia and Tasmania" (Catalogue No.12) which was published in 1889. In 1891 he was appointed Assistant in Ornithology. He was the author of numerous papers published in the Records of the Australian Museum, and other Journals, including the Society's Proceedings. But his most important contribution to ornithology was Special Catalogue No.1 of the Australian Museum, being a second and much enlarged, well-illustrated edition of Catalogue No, 12, entitled "Nests and Eggs of Birds found breeding in Australia and Tasmania," in four quarto volumes (1901-14). Mr. North was a keen observer of bird-life as well as a voluminous writer; and he frequently exhibited specimens of interest at our Meetings over a long period.

The year's work of the Society's research-staff may be summarised as follows:—Dr. R. Greig-Smith, Macleay Bacteriologist to the Society, contributed two papers during the Session, which have already appeared in Parts i.-ii. of the Proceedings for 1917. One, the fifteenth of his series of contributions to a knowledge of soil-fertility, dealt especially with the action of certain micro-organisms upon the number of bacteria in the soil; and the other was descriptive of an improvement in the technique of the single cell cultivation of yeast. He also completed the sixteenth of the series already alluded to, which is concerned with the search for toxin-producers. Certain soil-bacteria, moulds, and amœbæ, all reasonably supposed to be capable of furnishing substances of a toxic nature, have been grown in various media and under varying conditions, and, in all cases, the signs of toxicity, which become manifest, can be attributed to an alteration in in the reaction of the media. The effect of reaction is quite of a different order from the evidence of toxic action obtained in former researches.

Dr. Petrie, Linnean Macleay Fellow of the Society in Biochemistry, contributed three papers, which are contained in Part i. of last year's Proceedings. One of them was a continuation of his investigations on the occurrence of hydrocyanic acid in plants (Part iii.), and furnished a record of some new cyanogenetic plants. The other two treated, in an exhaustive manner, of the chemistry of the Duboisias, and the alkaloids of *Duboisia Leichhardtii.* Additional subjects which occupied his attention were certain quantitative problems of cyanogenetic plants, the determination of the amount of hydrocyanic acid capable of being obtained from these plants by fermentation, and the isolation of the glucoside of *Heterodendron*, one of our most fatal stock-poisons.

Mr. E. F. Hallmann, Linnean Macleay Fellow in Zoology, contributed a paper descriptive of the genera *Echinaxia* and *Rhabdosigma*, which was published in Part ii. of last year's Proceedings. He also had under consideration a paper embodying a reform in the classification of the *Desmacidonidæ*, a rather troublesome family to the systematist. At the end of the month, Mr. Hallmann gives up his Fellowship to engage in other work. We wish him all success in his new sphere.

Mr. R. J. Tillyard, Linnean Macleay Fellow in Zoology, contributed eleven papers during the Session, of which seven have already appeared in Parts i.-iii. of the Proceedings for 1917; two others will be found in the forthcoming Part iv. of the same volume; and the remaining two will be read at an early Meeting. Three of these papers dealt with the Odonata, four with fossil insects, one each with the Orders Lepidoptera, Planipennia, and Mecoptera respectively, and one with the neuropteroid fauna of Lord Howe and Norfolk Islands. The researches upon the breathing-apparatus of the larvæ of Odonata were completed ; the work begun upon Australian fossil insects made considerable progress ; and a start was made with the study of other neglected Orders. A considerable amount of work was carried on in the investigation of the Orders comprising the "Panorpid Complex," namely, the Mecoptera, Planipennia, Megaloptera, Trichoptera, Lepidoptera, and Diptera, with a view to the elucidation of their phylogeny, and inter-relationships. In making a careful study of the Jugate Lepidoptera, in this connection, Mr. Tillyard recently made the important discovery, that five genera of the Family *Micropterygidæ* have a wing-coupling apparatus not of the jugate type found in *Hepialidæ*, as has hitherto been supposed, but of a more primitive, jugo-frenate type, closely resembling that found in the Planipennia and Mecoptera. On the hindwing, near the base of the costa, there is a strongly developed frenulum of from two to six bristles, which becomes engaged, during flight, in the sinus formed between the base of the dorsum of the forewing and the so-called jugum; this latter is bent under the forewing, with its apex pointing outwards and forwards, and acts as a retinaculum for the frenulum, and not in any way as a jugum or "yoke" for the costa of the hindwing, as it does in *Hepialidæ*.

Dr. H. S. Halcro Wardlaw, Linnean Macleay Fellow in Physiology, completed the first part of an elaborate study of the variability of cows' milk, which will appear in the forthcoming Part of last year's Proceedings. This dealt with the variations and properties of samples of afternoon-milk from 109 normal cows, kept in connection with a Government Institution solely for the supply of the inmates, and not for profit. It is of interest to note that about 40 per cent. of the samples contained a percentage of solids not fat below 8·5—the standard for the perceentage of solids not fat in all the States of the Commonwealth, and in England. Dr. Wardlaw has in contemplation the continuation of this important investigation, the extension and continuation of some work of a similar character upon human milk carried out by him in 1914, and to subject to a more detailed examination certain questions suggested by his work on the chemistry of respiration.

In response to the Council's invitation for applications for Fellowships, 1918-19, only three applications were received; and I have now the pleasure of making the first public announcement of the Council's re-appointment of Dr. J. M. Petrie, Mr. R. J. Tillyard, and Dr. H. S. H. Wardlaw to Linnean Macleay Fellowships for a period of one year from 1st proximo; and, on behalf of the Society, of wishing for them a fruitful research-period.

The concluding Part of the forty-second volume of the Proceedings is nearly ready for issue. The complete volume (926 pp., 50 Plates, and 196 text-figures) will contain thirty-three papers, two of which have been divided for convenience on account of their length. Six papers exceed 40 pp. (43-82 pp. in length); and sixteen of them were contributed by members of the Society's research-staff.

The war's interference with our exchange-relations with Societies outside the Commonwealth, continues in an aggravated form. We have heard from fewer Societies, and there has been a marked falling off in our receipts during the year. Even Societies in the United Kingdom are finding it advisable to suspend their despatches for the present, in order to avoid the risk of losses. The total number of exchanges received during the Session 1916-17 amounts to 846 additions to the library, received from 136 Societies or Institutions, &c., and five private donors, as compared with 1285 (1913-14), 1028, 1243, for the three preceding Sessions. The Society is much indebted to the Public

Library of New South Wales, for a special donation of some partial sets of Anthropological publications, comprising 34 complete vols., 37 incomplete vols., 39 Bulletins, and 11 Reports, issued by twelve Societies, not previously contained in the Society's Library.

If I have spent some time on personal topics, I hope that you will pardon me. They will serve to turn your attention to two different kinds of scientific knowledge. The educationists of this State have laid stress on the analytical sciences, mathematics, physics, and chemistry, and have, perhaps unwittingly, undervalued the biological sciences. The student in our Universities is forced to learn the analytical sciences, and is handicapped if he wishes to study zoology, botany, and geology. Some have advocated extending this handicap to the teaching of these sciences in schools. I am still a young man, and I remember well the frequent expression of the wish that the student entering the University should have had no previous instruction in science. A liberal education at school with no science was to be the prelude to specialism consequent on learning a little chemistry or physics. The people of this State owe to Mr. Peter Board, C.M.G., Director of Education, the adoption of that great principle of toleration, of suiting the subjects to the inclination of the child. Instead of trying to teach all children the same subjects, the child may select a certain proportion of the subjects to be studied. Lately an attempt has been made to influence the child's selection by giving different marks to different subjects at the examinations for leaving certificates. As free education at the University is granted on the results of this examination, it is obvious that those desiring better education will only learn subjects carrying the highest numbers of marks. What we seek in this State at the present time is the opportunity to study the natural objects that interest us, without hindrance. When we plead for freedom in the choice of subjects in education, we desire that those in schools may be taught those subjects which attract their attention and hold their minds. We protest against the suggestion that any study of natural objects bespeaks a worship of materialism destined to wreck the progress of our evolution. A brighter day for science has already dawned within our University. The unfair influence exercised upon the boy or girl leaving school and entering the University, by the scanty recognition granted to any study of scientific objects, has been done away with. It is seen that it is possible in Australia to train students well in science without forcing them to go to Europe and become bound by European traditions. The force of these traditions is seen in our University with its mediæval architecture. The scientific departments of British Universities are housed in badly lighted rooms because they have had to accept the buildings handed to them from the Dark Ages. In this country, it is ridiculous to build a laboratory for microscopical study, in which many students have to work, and fit it with narrow, arched Gothic windows because our forefathers revered such building. In Great Britain the modern laboratory is built to facilitate the investigation that is to take place within it. Here we are told that artificial lighting is most suitable for microscopical study, but are left to get what light we can from long, narrow windows twenty to forty feet away from the mirrors of the microscopes.

May I remind you what a small company we are here in New South Wales. We number among us practically all those dwelling in this State who are engaged in increasing our knowledge of the living objects of New South Wales. Surely we should aid each other in learning of our flora and fauna. Some seem to consider that our work consists in writing and publishing the results of their own inquiries. The papers embodying these observations and investigations appear in our Proceedings. They may be read in the printed parts. There is another and quicker method of imparting information. When a Member describes to us his work, his personality adds interest to his description, and we easily become acquainted with his results. A few well chosen remarks on an exhibit will cause every one to examine what is shown to them. We would all be pleased if every Member attending our meetings would bring some object of interest to himself and explain that object and its interest to his fellow Members. In this way we can all acquire a better acquaintance with natural history. Discussion leads to clarity in our ideas, and assists in formulating our scientific conceptions. During last year, we had some discussion on the characters of hybrids. The discussion was brief, but it helped us to understand better how we were to recognise hybrids in the plants around us We should not be always waiting for those in Europe to lay down the principles on which we are to work. These are problems which can be studied more readily in Australia than elsewhere. The separation of Australia from the other great land-masses and its isolation for long epochs have affected the characters of our animals and plants. I hope that our Council will promote discussions of the general questions to the study of which contributions are made in the monographs of our Members. Two such discussions might well be arranged each year.

If I have spent some time in making more precise my conception of the essential features of scientific work, I have been desirous of ensuring that there is no misunderstanding upon this point. We are now in the fourth year of the insensate war which is devastating more and more of Europe. We recognise that we must utilise our resources of men and material in the most economical and advantageous manner if we are to emerge victorious from the struggle. We have learnt that it is our duty to give the best of our manhood in the prime of life for the service of our country, not counting what the sacrifice may involve personally. We give our savings to provide for the cost, which shows still a tendency to increase to a greater daily expenditure. We endeavour to do what we can in personal service to assist in defeating our enemies. We have heard much of our duty to our country, but we have heard very little of the duty of the Government of this Commonwealth to use men, money, and training to its full extent. I suppose that no one asserts that this war has revealed the ability of the Government to place each man and woman whose services have been put at its disposal in the position in which the training and experience of the individual can be fully employed. I have looked along this table from month to month and thought how few of our Members are utilised in ways in which their special training can be of service to the community. Surely it cannot be true that the years of observation and experiment have made our members useless to the Department of Defence. I am aware that the habit of casting ridicule upon Dr. Dry-as-dust existed in the past. I know that it is still common to hear jokes at the expense of the naturalist, but I thought that those raised to authority were acquainted with the fact that science can play a part in every phase of work in Australia in connection with the War. Some have affirmed that the recognition of the importance of Science will be one of the permanent benefits conferred on our nation by the war. It is perhaps difficult to imagine any benefit given us by the war, which has caused such unspeakable misery and sorrow, yet we can understand the statement. Whether there is any greater use of Science made in Europe, I cannot say from personal knowledge, but I can remind you that there are few evidences in this country of a much greater employment of those possessed of scientific training. It is true that the Federal Government is using the services gratis of a small number of scientists who devote the time that is not taken up with other duties to some investigation. The Council of Science and Industry supplies some money towards the cost of this research work. This is a step in the right direction, but that is all. When we say that greater use should be made of Science, we do not mean that some particular method should be employed, but that every problem should be studied by the means adequate to give the solution. In connection with the war, we find much evidence of the failure to use scientific methods. The whole number of those who have spent time and trouble in acquiring knowledge of Nature is a very small fraction of the population. Even this small number has little to do. It has been said that it looks as if our authorities regarded scientific training as a disqualification rather than as a qualification. I do not suppose that there is any desire not to use the experience and learning of scientists, but I do think that the majority of our community are quite unaware of the scope and character of scientific knowledge. The scientist cannot replace the practical man who is managing a business or dealing with some particular problem, but he can supply information, and he can make observations to provide facts on which the practical man can work. A scientist does not make, as a rule, what is known as a good business man. I think it unlikely that he ever will, but I think a study of the uses made of Science in the last century will teach any one who will examine the question that information obtained by scientific study has been of incalculable value to the community. Our Government does not especially need advice and direction from scientific persons, and there are so many ready to offer this. It needs scientific workers who will obtain accurate information by making studies on the problems of the hour. Each scientific worker can only do a little. It takes a long time to make precise observations and to conduct experiments. Let me take an illustration. There are millions of bags of wheat stored in Australia. Insects, fungi, and other forms of animal and plant life are destroying that wheat. If every zoologist now in Australia worked for a century upon that wheat, there could be no thorough examination of the whole of it. To examine the contents of even a million bags would require a very great time. To determine where an insect or fungus came from, how its growth was favoured by various circumstances, what is the life-history, and at what stage in its development can the destructive agent be destroyed so that it does not reach the wheat, would take many months. I do not want you to think that I exaggerate. May I remind you that it took many men and many years to obtain some information about the mosquito in its relation to malaria; that to-day we are not in a position to prevent those of our soldiers who go to New Guinea and elsewhere from acquiring the disease by the bite of the mosquito, and that it has taken several years to obtain even a little knowledge of the different mosquitoes scattered over a small portion of Australia? There is an opportunity for every zoologist in Australia with some acquaintance with entomology, and for every botanist with some knowledge of fungi, to be of service in saving some of that wheat. Is there no way in which the Defence Department can be informed of this simple fact? Is it better that many of these trained zoologists or botanists should be doing none of that work for which they are specially fitted in relation with the war. It surely cannot be true that we have such a vast surplus of food that it is unnecessary to take these steps to preserve this wheat against loss. Further, it cannot be true that we know so much of the insects and fungi in this wheat that further knowledge is unnecessary. I believe that the Defence Department has already at its disposal the services of those who can advise it what to do when the knowledge of what insects and fungi are present has been obtained. May I invite all the Members of this Society to assist in making these facts known?

I have often thought that the scientific experts in the State and Federal services do not make the authorities, under whom they work, aware of what a small amount of scientific investigation can be done by one person. We have a State Entomologist who sets us an example of industry and devotion in the way in which his whole life is dedicated to the study of insect life. I am, however, amazed at the range over which his advice is sought. He is expected to report and advise on matters in a few weeks when months of research would probably only serve to reveal the nature of the problem to be attacked. Even if we had twenty entomologists as learned as Mr. Froggatt in the ways of insects, we would be aware that all the twenty naturalists could go on working for many years without exhausting the possibilities of research in insect life. Does not the work done by all the entomologists of the world in the century that has passed only serve to show us what remains to be done? Are we not all like Newton, when he remarked that he was as an infant playing with a few grains of sand with the whole ocean before him yet to be explored?

The community has little appreciation for the labours of those seeking the advancement of knowledge of Natural Phenomena. The man who could supply a pound of tea to every person on this globe of ours would gain an immense fortune. Lister, who did something to diminish the suffering of every living person, and who was, perhaps, better rewarded than most other scientific men for his discoveries, had much less reward than any really successful man of business. Have not scientists some right to ask more encouragement from their fellows? Most of us have made our scientific observations in our leisure time. Even those of us employed in our Universities soon learn from those under whom we work that teaching and not scientific investigation is what the University demands. We learn that it gives greater satisfaction if no scientific research is done, since the absence of scientific investigation shows that there cannot have been any leisure time in which it could be done. It is only a few years ago that the Senate of the University of Sydney was informed by the President of the Professorial Board that only those with leisure from teaching duties did any research work. The attitude of official discouragement should be removed. It seems to me desirable that young graduates should be promoted more often when they do research work. Some have seen those who have never made a single original observation placed above others who have spent three or four years in research after graduation. We often find the attitude that it were better that a problem be not studied at all than that we should study it. I once suggested to the late President of the Board of Health that it would be a fortunate day when every town in New South Wales was the home of one biochemist making investigations in respect to the people's food. To my surprise, his answer expressed the hope that not a single biochemist would meddle with the affairs of the Department of Public Health. The opinion is held by many holding positions in the educational and professional services that it is better that scientific research should not be done at all than it should be done by Australian graduates or by those trained in this country. Many of the Members of this Society will have had experience of the contempt for their capacity, training, and public utility exhibited by some holding high official stations in our University, our Department of Public Instruction, our Civil Service, and our learned professions. Scientific research is little regarded. Few attempts are made by the official bodies connected with scientific work to assist the progress of investigation. The research student finds that it often takes longer to fight for the material with which he wishes to work, in order that he may have the opportunity to conduct his research, than to carry out the actual work of investigation. The research student learns that his investigation is regarded as a personal matter, and that the time taken in its performance is considered misspent, since some of the experiments may have been done in the hours for which he is presumably paid by the University or State. Australian graduates are considered by some of the official heads in our Universities as required only for the "teaching of the drill-work." The graduate who does research work rather than this drudgery need expect no promotion in some of the Departments of our University. Surely this is a poor policy in our educational development. Ability to do research work is not commonly found. The desire to carry it on continuously is even less frequently present. The power of directing investigation in others to a successful conclusion is one of the rarest accomplishments. These facts are well known to the members of the Senate of our Universities, to the heads of our Departments of Health, Mines, Agriculture, and Education, to the members of the State Committees and the Executive Committee of the Federal Advisory Council of Science and Industry. Why is it so difficult to pass from opinion to practice in these matters? Why is there not a better attempt to ensure that every scientist in New South Wales who shows that he can train students to become more efficient investigators, has as many students as possible brought under his influence? Not infrequently after years of labour in building up a laboratory and a team of workers, the investigator is driven to cast aside what has been done, to provide himself with an income sufficient for his needs.

The naturalist is not only interested with the structure of dead animals and dried plants, but he spends his time in learning of the behaviour of living animals and plants. Living animals and plants seem endowed with attributes not found among inanimate objects. Life is associated with a definite form of construction. If we cut a thin slice of a rock and recognise that the rock is built up of inorganic material arranged to show a body-wall and nucleus, such as are found in vegetable or animal cells, we know that we are looking at the petrified remains of what was once alive. Not only so, but if we find any substance composed of certain chemical compounds, as proteins, carbohydrates, or fats, we are aware that this material has been part of the animal or vegetable body. Life is thus associated with a particular architecture built with characteristic chemical substances. While the qualities and properties of living things appear so different from those of lifeless matter, the biochemist soon discovers that all living things are constructed from lifeless substance. As an animal or plant grows, it adds to its bulk material from the inanimate world. All the carbonaceous material in the protoplasm of the cells of all living objects contains carbon once diffused through the atmosphere as carbon dioxide. For a brief period this carbon is found in some animal or plant. Perhaps it in the green leaf of a growing wheat-plant. A few weeks later, it lies in the golden grain. The farmer harvests that grain and sends it to the miller. The same carbon is part of a particular sack of flour, delivered to a baker. It is portion of some loaf of bread eaten by John Smith. It is the carbonaceous constituent of glucose in the blood of John Smith. It is combusted in some part of John Smith's body, and it is dissolved as carbon dioxide in his blood. It diffuses through the epithelium of his lungs. It goes out again into the atmosphere in the expired breath of the individual. Some day it will be taken up by another plant, and so on in an endless cycle. It is difficult to suppose that this carbon becomes endowed with new qualities while it lies in the living tissues of the animal or plant. It is necessary to seek some other explanation of the characteristic properties of living things.

It has long been obvious that animals and plants make the chemical constituents of their bodies from raw materials by different processes from those used in the chemical laboratory or in the factory for the manufacture of similar substances. Heat and pressure, so freely used in the synthesis of bodies akin to those found in living things, play no part in the manufacture of starch, fat, or protein in a plant. We have a dim idea that those intangible materials, known as ferments, are chiefly concerned with vital synthesis. In fact, the presence of ferments and the capacity to produce ferments appears to be one of the most distinctive chemical characters of living matter. Ferments bring about decompositions and incite combinations under the conditions favourable to the continued life of animals and plants. We sow a wheat-seed, presumed to contain minute amounts of a number of these ferments, and from the fully grown wheat-plant we can obtain a greater degree of ferment-activity. The powers of these ferments do not differ from those possessed by lifeless chemical substances under certain conditions. Most chemical substances appear capable of bringing about decompositions or combinations in other bodies in the same way and under analogous circumstances as do the ferments from living tissues. When acting in this manner, these substances are called catalysts. Chemists do not, however, suppose that platinum black inciting the union of hydrogen with oxygen contains some unknown ferment. The sulphuric acid which brings about the decomposition of cane sugar into glucose and lævulose is presumed to be chemically pure sulphuric acid. Chemists are beginning to recognise that catalysts are not a group of substances possessed of these special qualities, but that many, if not all, chemical substances can act as catalysts under particular conditions. Evidence is accumulating to show that it is on the arrangement of the particles, molecules, or whatever we may call the minute masses of the substance, that the capacity to act as a catalyst depends. The physical state of a substance rather than the kind of matter of which it is formed, confers catalytic activity. There appears to be no reason to infer that the catalytic action of the extracellular and endocellular ferments found in animal and vegetable tissues has a different basis. I have always been impressed by the fact that the power of an extract of an animal or vegetable extract to act as a ferment was abolished by those agencies which profoundly alter the colloidal state of proteins and lipoids. The attempts to identify the unorganised ferments as a special class of chemical substances have invariably ended in failure. May we not look for better progress along other lines of investigation? The study of the position of the particles composing inorganic crystals has given us an insight into the arrangement of the atoms or ultimate particles in the molecule. The crystals of proteins and fats have not yet been examined in the same way. May we not hope that these studies may be extended in connection with fermentative activity?

The functions of living matter have been the object of that branch of science in which I have been a student. The aim of the physiologist is to explain the behaviour of living things in terms of the mechanical, physical, chemical, and psychical sciences. It is believed that progress is at present possible if an endeavour is made to reduce biological phenomena to physical and chemical problems. Living things are built from inanimate matter, and the attributes of living things are the expressions of the properties of matter. I am aware that such a belief is condemned as materialistic. I must confess, however, that I see no difficulty in supposing that, as heat, light, magnetism, and electricity are qualities of the arrangement of matter, the psychical qualities of the higher forms of living things are likewise material. Heat apart from matter does not exist. Why should we suppose that memory and thought exist apart from some matter in the living organism? Whoever will become acquainted with the history of physiological knowledge will find that progress is represented by the explanation of a greater number of the functions of animals and plants in terms derived from the study of physics and chemistry. On such a conception, there is no such thing as inanimate matter, though there may be lifeless objects.

With these ideas in your mind, I invite your attention to the problem of variation as exemplified in the different functions of each kind of animal and plant. For many centuries, naturalists had believed that each kind of animal or plant was endowed with unchanging characters. The fixity of species was considered axiomatic by zoologists and botanists. Darwin and his followers have demonstrated to us the progressive evolution from one form to another in animal and plant. Every animal and plant showed a certain degree of variation in its characters. Some of these characters favoured the living organism in its struggle for existence, others rendered it less able to cope with the conditions of environment. Some organisms survived longer and had a better chance of reproducing their kind, others died early and had less opportunity for transmitting their peculiar qualities to their descendants. It is well known that the offspring of any organism possess, in general, similar external characters and biochemical properties to their parents. The mechanism by which the resemblances and variations were brought about received little study in the last century. Indeed it was held by most biologists that environment had little influence on the qualities of the different generations of any race, however much it might affect the individual in a particular generation. It was denied emphatically by the Darwinian evolutionists that the conditions of the environment could produce new characters in the descendants of any individual. While naturalists, in general, held these views, there were notable dissentients from these doctrines. Physicians, who have many occasions for observation in this field, have in general believed that some acquired characters can be transmitted to the offspring.

The progress of knowledge is showing us that the question of the inheritance of acquired characters no longer interests this generation in the form in which it attracted the previous generation A wider acquaintance with the qualities of a living thing has led us to have a more comprehensive idea of inheritance. Differences that seemed insurmountable to older generations are no longer differences to us. We can produce an artificial immunity to some particular chemical substance, and we find that this immunity can be transmitted permanently to the race. We can cause an animal or plant to acquire new characters, which seem to become fixed characters in succeeding generations. We find that the characters of animals and plants are much more labile than had been supposed, and that it is a comparatively easy matter to engraft some new qualities upon them. There are limits to what can be done, but we have not yet fathomed what can be accomplished. It may be of interest to you to consider how some of these changes can be produced.

We may take as an example the control of some of the qualities of micro-organisms which are known to have such intimate relations with the existence of more differentiated animals and plants. The behaviour of yeasts in connection with the conversion of glucose into alcohol and carbonic acid gas, the so-called alcoholic fermentation, will serve for this purpose. The fermentation of sweet liquids has attracted some attention from every generation of natural philosophers. The slow accumulation of real knowledge is illustrated by the fact that we have no record of any observation, current in our descriptions of the process, before the end of the seventeenth century. Until that date, it was thought that the spirit of the liquid made its escape in the heaving struggle of the bubbling liquid. Van Helmont identified the gas vinorum escaping from the fermenting liquid with the gas sylvestre found in woods and caves or freed from marble by acids. Becher observed that only sweet liquids underwent this change. Leeuwenhoek, indeed, saw the countless myriads of particles with his microscope, but did not connect their presence with fermentation. Another century rolled by before Lavoisier made use of the balance, and discovered that sugar is split into approximately equal parts of alcohol and carbon dioxide. Cagniard Latour, using a better microscope, noted in 1831 that the yeast particles multiplied by budding, and that they were living plants. He suggested that the growth of these plants occasioned fermentation. Theodore Schwann came to the conclusion that fermentation was brought about by the entrance of living micro-organisms into the fermenting liquid. Liebig denied the relation of the yeast-plants to the process of fermentation. He drew a humorous picture of the yeast cell equipped with its still and condenser, furnishing alcohol and blowing off gas. He asked whether such scenes were really visible through the microscope. Later he accepted the yeast-cell as a living plant, but affirmed that its presence had nothing to do with the occasioning of fermentation. Pasteur showed that the sugar was split in the body of the yeast-plant, and attributed this decomposition to the vital powers of the living cell. Buchner demonstrated that an unorganised ferment could be separated from crushed yeast-cells, and that this lifeless body decomposed glucose into alcohol and carbon dioxide. It has taken more than two hundred and fifty years to gain this information. To those of you who know little of fermentation, our knowledge seems very complete. The agent for decomposition is made in the body of the yeast-plant, in which it remains. The sugar enters the yeast-plant and is split into roughly equal weights of alcohol and carbonic acid gas. To those who have a more extended acquaintance with these objects, it is obvious that much more has to be learnt. We are not aware how the sugar is split into alcohol and carbon dioxide. The arrangement of the carbon, hydrogen, and oxygen in glucose does not make it easy to imagine a decomposition into alcohol and carbon dioxide. Further, we have some knowledge that, without other agencies, such as the presence of salts of phosphoric acid, no decomposition of sugar can be accomplished by the ferment. Time will undoubtedly reveal other aspects of this phenomenon at present entirely unsuspected.

The process of fermentation has not only a scientific aspect. It forms the basis of some manufacturing industries of great antiquity. The preparation of wines, beers, and spirits is an application of this fermentation. Yeast is also used commercially in the manufacture of wheaten bread. In making bread, bakers mix flour, water, and a little salt with a small quantity of a specially prepared yeast at 28·3°C. The dough thus formed is kept warm, when it swells to three times its original volume. At the present time, doughs stand about nine hours in the troughs to ripen. With a greater amount of yeast, doughs ripen more quickly, and the time of waiting for the distended dough can be diminished. It is also found that a quantity of one yeast may be much more efficient in liberating gas in the dough than the same weight of another yeast. The yeast obtained by the brewers of beer in such large quantities, will not ripen a dough in the time required by a baker, even when used in large quantities. A yeast has to possess special characters if it is to bring about alcoholic fermentation rapidly in a baker's dough. At one time it was supposed that some strains or races of yeast were capable of multiplying freely in a baker's dough, while others could not breed quickly under these conditions. It was supposed that it was necessary to search for these yeasts in nature and cultivate them. The capacity of fermenting doughs at some suitable speed was considered a fixed character of each race of yeast-cells. It was thought that the cultivation of the progeny of an individual possessed of this quality would produce a race with the desired properties. In practice, bakers found that it was impossible to continue the cultivation of a particular strain of yeast, as the fermenting power appeared to undergo deterioration. Every few weeks, a baker started a new stock of yeast. Failure in maintaining suitable yeast by continued cultivation was ascribed to contamination of the stock by unsuitable yeasts. When I started my study on yeasts for the Advisory Council, I thought that my task was to isolate suitable races of yeast-cells and then to cultivate them under conditions which would prevent contamination with unsuitable yeasts. I hoped, indeed, to isolate the strains that I needed by physiological means rather than by bacteriological separation and the routine examination of the progeny of hundreds of individuals, but I did not imagine that I was going to find that any race of yeast could be taught in a few days to ferment glucose quickly in a baker's dough. Without going into details, I may say that I found that any yeast of the species *Saccharomyces cerevisiæ*, growing under certain conditions in a baker's wort, caused rapid evolution of carbon dioxide in a dough. These conditions, as far as I could define them, were a temperature less than that of dough, aëration with a plentiful supply of air, the presence of certain extractives from flour, the presence of certain substances from hops detrimental to the growth of acid-forming bacteria and a particular concentration of the sugar and other products of malted starch. These conditions were so favourable to the growth of yeast that in the bakehouse of the Technical College, Sydney, Mr. F. Elliott was able to keep one strain of yeast for making bread for almost six months. This yeast was so active that two and a half ounces of the moist yeast ripened four hundred and ten pounds of dough in six hours. If any of the conditions in the wort were altered, the yeast rapidly became quite unsuited for making bread.

The manner in which the yeast is selected may be conceived in two different ways. Each yeast-cell buds off daughter-cells

Some of these may possess a greater capacity for fermenting glucose in a dough than others. The conditions may favour a more speedy multiplication of these desirable cells. In this way the resulting yeast would be made up of a larger number of cells capable of inducing fermentation in the dough. On the other hand, we can suppose that the yeast-cells all become so altered by their environment that they can ferment the glucose in the dough more rapidly. It is not possible to explain with certainty just what happens in this process. By cultivation from a single cell, yeast suitable for a baker can be obtained. It is therefore clear that the desirable yeast may be selected from the progeny of a yeast not endowed with the required qualities. A similar selection is made in the dough. This explains the rapid ripening of doughs made with "sponges." The elucidation of what happens is made clearer by study upon other organisms.

When the *Bacillus coli communis* is grown in a nutrient liquid containing glucose, both acid and gas are produced by the fermentation of the glucose. The gas consists of carbon dioxide and hydrogen, and the acids which are liberated, comprise lactic, acetic, succinic, and formic acids. It has been found by W. J. Penfold that strains af *Bacillus coli communis* which do not produce gas from glucose, can be isolated by cultivation in the presence of sodium mono-chloracetate. These races differ from the typical parent-stock in their fermentative character on glucose, and no individual member of the selected race appears to retain the action of the typical parent micro-organism. The presence or absence of the quality of liberating gas enables us to recognise that, in the production of this character, every individual of the selected race exhibits the altered function. If a number of selected races are examined, it is, however, noted that some show a complete absence of the gas-forming quality, while others still retain more or less activity in this direction. The careful studies of Egerton Gray have enabled us to learn something of the enzymatic changes which accompany this selection. The estimation of the amount of the different products of the decomposition of glucose supplies evidence to demonstrate that lactic acid is formed in greater amount, and acetic acid, formic acid, and alcohol in less amount, by the selected strains than by the typical micro-organism. Evidence has also been obtained to show that the failure to ferment glucose is associated with the absence (or diminution) of the reducing ferments in the cell. In this way, the intermediate substance from which formic acid, acetic acid, and alcohol is formed, is not decomposed. The selection by the sodium mono-chloracetate can thus be explained on a rational chemical basis, since those microbes endowed with reducing qualities would liberate hydrochloric acid, and thus occasion their extinction. Only microbes in which the reductase is absent or diminished, would survive.

The study of these micro-organisms has made it evident that the characters of these plants are determined by the conditions of the environment. The question remains as to whether such a conception can be applied to higher forms. Have soil and climate any influence on the structure and functions of higher plants? There is much to suggest that the forms of plants are dependent on the interaction with the environment. Before this problem can be considered, it is necessary to obtain a better knowledge of the plants which occur together in any district. Owing to the small aboriginal population and their low state of civilization, there has been little interference with the flora of this Continent. Studies can be made upon areas in which plants have grown together with little, if any, human selection. These areas are, however, being settled by the white population. Before these areas have been destroyed, it behoves our naturalists to make their survey. In this vast continent, we can travel from Cape Otway, in the south, to Cape York, in the north, without losing sight of one or other species of Eucalyptus. It is possible to go from Sydney, in the east, to the western shores of Australia without missing anywhere the familiar Eucalyptus. Is it not possible to determine what characters have enabled these trees to extend over such a vast area? May I suggest to you that the members of our Linnean Society consider the systematic study of the distribution of our plants and the factors which determine their association. Such a labour would be a worthy memorial of the work of this generation, and would remain a testimony of our appreciation of the benefaction of our revered founder, Sir William Macleay.

Mr. J. H. Campbell, Hon. Treasurer, presented the balance sheets for the year 1917, duly signed by the Auditor, Mr. F. H. Rayment, F.C.P.A., Incorporated Accountant, and he moved that they be received and adopted, which was carried unanimously. The income accounts are summarised in the following table:—

Heads of Expenditure.	General.	Bacteriology.	Fellowships.	Total.
	£	£	£	£
Administration ...	586	5	—	591
Maintenance	39	63	—	102
Publication	303	—	221	524
Research (Salaries) ...	—	400	1,525	1,925
Capital Accounts ...	654	100	—	754
Totals	1,582	568	1,746	3,896
Income (all sources) ...	1,245	567	2,328	4,140

No nominations of other Candidates having been received, the President declared the following elections for the Current Session to be duly made:—PRESIDENT: Professor H. G. Chapman, M.D., B.S.—MEMBERS OF COUNCIL (to fill six vacancies): Messrs. R. T. Baker, F.L.S., W. W. Froggatt, F.L.S., Alex. G. Hamilton, C. Hedley, F.L.S., Thomas Steel, F.L.S., and G. A. Waterhouse, B.Sc., B.E.—AUDITOR: Mr. F. H. Rayment, F.C.P.A.

On the motion of Dr. J. B. Cleland, a very cordial vote of thanks to the President, was carried by acclamation.

The Linnean Society of New South Wales.

GENERAL ACCOUNT.

Balance Sheet at 31st December, 1917.

Liabilities.	£	s	d
Capital: Amount received from Sir William Macleay during his lifetime	14,000	0	0
Further Sum bequeathed by his Will, ...	6,000	0	0
	£20,000	0	0
Bookbinding A/c	92	8	0
Income A/c at 31st December, 1917 ...	792	7	9
	£20,884	15	9

Assets.	£	s	d	£	s	d
Society's Freehold				585	0	0
Investments:						
War Loan...	3,815	0	0			
N.S.W. Treasury Bills ...	4,000	0	0			
Loans on Mortgage ...	11,600	0	0			
				20,000	0	0
Cash:						
Current A/c	362	3	9			
Savings Bank A/c... ...	512	12	0			
In hand	10	0	0			
				884	15	9
				£20,884	15	9

Audited and found correct. Securities produced.
F. H. Rayment, F.C.P.A., Auditor.
Sydney, 12th March, 1918.

J. H. Campbell, Hon. Treasurer
Sydney, 31st January, 1918.

INCOME ACCOUNT, year ended 31st December, 1917.

Dr.

	£	s	d	£	s	d
To Salaries and Wages				540	0	0
,, Printing (Publications)	242	0	11			
,, Illustrations	60	14	8			
				302	15	7
,, Rates	29	9	6			
,, Insurance	7	17	9			
,, Repairs	2	2	6			
				39	9	9
,, Postage, Advertising and Petty Cash	24	6	0			
,, Printing (sundries), Stationery, etc.	8	11	6			
,, Maintenance Fee, Sir William Macleay's grave	1	10	0			
,, Audit Fee	5	5	0			
,, Telephone	5	9	7			
,, Bank Charges	1	3	10			
				46	5	11
,, Bookbinding A/c				4	4	0
,, Appropriations to Society's Freehold A/c—						
Income A/c	67	18	10			
Fellowships A/c	582	1	2			
				650	0	0
,, Balance to 1918				792	7	9
				£2,375	3	0

Cr.

	£	s	d	£	s	d
By Balance from 1916				548	5	11
,, Subscriptions—						
1917	106	1	0			
Arrears	19	19	0			
In advance	2	9	6			
				128	9	6
,, Entrance Fees				4	4	0
,, Interest on Investments				982	0	6
,, Sales (including 100 copies of Proceedings purchased by the Govt. of N.S.W.)				114	1	11
,, Rent (Bacteriology A/c				16	0	0
, Fellowships A/c: surplus income transferred				582	1	2
				£2,375	3	0

BACTERIOLOGY ACCOUNT

Balance Sheet at 31st December, 1917.

LIABILITIES.	£	s	d
Capital: Amount bequeathed by Sir William Macleay	12,000	0	0
Accumulated Income capitalised	2,000	0	0
	£14,000	0	0

ASSETS.	£	s	d	£	s	d
Investments:						
New South Wales Inscribed Stock ...				13,900	0	0
War Loan				50	0	0
Cash: Current A/c	42	3	1			
In hand...	6	0	0			
				48	3	1
Income A/c at 31st December, 1917 ...				1	16	11
				£14,000	0	0

INCOME ACCOUNT, year ended 31st December, 1917.

Dr.	£	s	d
To Salary	400	0	0
,, Rent	16	0	0
,, Rates	9	16	6
,, Insurance	1	6	0
,, Gas	6	11	5
,, Apparatus and Chemicals	30	0	0
,. Petty Cash and Expenses	4	17	1
,, Capital A/c	100	0	0
	£568	11	0

Cr	£	s	d	£	s	d
By Balance from 1916				45	9	11
,, Interest on Investments				521	4	2
,, Balance to 1918				1	16	11
				£568	11	0

Audited and found correct. Securities produced.
F. H. Rayment, F.C.P.A., Auditor.
Sydney, 12th March, 1918.

J. H. Campbell, Hon. Treasurer
Sydney, 31st January, 1918.

LINNEAN MACLEAY FELLOWSHIPS' ACCOUNT.

Balance Sheet at 31st December, 1917.

LIABILITIES.	£	s	d	ASSETS.	£	s	d
Capital: Amount bequeathed by Sir William Macleay, £35,000, less Probate Duty, £1,750	33,250	0	0	Investments:			
Surplus Income capitalised	9,750	0	0	War Loan	10,635	0	0
				N.S.W. Inscribed Stock	7,715	0	0
				Loans on Mortgage	24,650	0	0
	£43,000	0	0		£43,000	0	0

INCOME ACCOUNT, year ended 31st December, 1917.

DR.	£	s	d	CR.	£	s	d
To Salaries of Linnean Macleay Fellows ...	1,525	0	0	By Interest on Investments	2,328	2	4
,, Cost of publishing Fellows' Papers ...	221	1	2				
,, Transfer to General A/c	582	1	2				
	£2,328	2	4		£2,328	2	4

Audited and found correct. Securities produced.
F. H. RAYMENT, F.C.P.A., Auditor.
Sydney, 12th March, 1918.

J H. CAMPBELL, Hon. Treasurer.
Sydney, 31st January, 1918.

ORDINARY MONTHLY MEETING.

March 27th, 1918.

Professor H. G. Chapman, M.D., B.S., President, in the Chair.

The Donations and Exchanges received since the previous Monthly Meeting (28th November, 1917), amounting to 16 Vols., 155 Parts or Nos., 27 Bulletins, 8 Reports, and 7 Pamphlets, received from 75 Societies, Institutions, etc., and two private donors, were laid upon the table

THE GEOLOGY OF THE LOWER MESOZOIC ROCKS OF QUEENSLAND,

With special reference to their Distribution and Fossil Flora, and their Correlation with the Lower Mesozoic Rocks of other parts of Australia.

By A. B. Walkom, D.Sc., Assistant Lecturer in Geology, the University of Queensland.

(Plates i.-ii., and six Text-figures).

Contents.

Introduction, and Scope of the Paper.

In Eastern Australia and Tasmania there is no large development of rocks of marine origin, representing deposition during the period between the close of the Palæozoic era and the beginning of the Cretaceous period. During this interval, with a single exception, the sediments deposited in this region were of origin other than marine; the organic remains included in these rocks consist for the most part of plants, but, in addition, fish* and insects† are abundant on some horizons, phyllopods are represented by *Estheria*, and pelecypods by *Unio* and *Unionella*. The exception mentioned above is the upper portion of the Wianamatta Stage in New South Wales; the top of this stage is formed by a thickness of 100 feet of a calcareous rock, which contains a fauna of Ostracoda and Foraminifera. This fauna has been described by Chapman, whose conclusion regarding the species is as follows: "These undoubtedly represent a brackish or estuarine fauna, having a curious intermingling of Rhætic and Lower Jurassic types, with others more properly referable to the Upper Palæozoic of Europe."‡

The term "Lower Mesozoic" will be used throughout this work for these rocks; the name "Trias-Jura" has been generally used, but it is not a suitable one, and we have not been, up to the present, in a position to assign either a Triassic or Jurassic age definitely to all of them. The name Lower Mesozoic may be used generally to include the whole of these rocks, and to refer to all the strata in Eastern Australia which were deposited between the close of the Palæozoic era and the beginning of the Cretaceous period.

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* Woodward, Mem. Geol. Surv. N. S. Wales, Palæontology, Nos.4, 9, 10.

† Etheridge and Olliff, *ibid.*, Palæontology, No.7; Tillyard, Queensland Geol. Surv., Publication No.253.

‡ Records Geol. Surv. N. S. Wales, viii., p.335, 1909.

The correlation of these beds is necessarily based on the fossil plants, since they are the only remains which are of widespread distribution. In the past, fossil plants have formed a very uncertain means for the accurate correlation of strata. This has been due, particularly in the case of Australia, to imperfect study of the material available. This statement is not made to detract from the value of the work done by the earlier Australian geologists; we owe much to their efforts, for they did an immense amount of work under conditions much less favourable than those under which we work at the present time. The vastly improved conditions existing at the present day must always be borne in mind, when the work of the older geologists is under consideration; this point cannot be too strongly emphasised, for there is very often a tendency to forget or overlook it.

The author has just completed an examination of the fossil flora of the Queensland Lower Mesozoic strata,* and the present paper is concerned chiefly with a discussion of the results of that examination.

Briefly stated, the object of this contribution to Australian Geology is to attempt to place the correlation of the Lower Mesozoic rocks of Australia on a sound basis. The paper aims at :

(*a*) Dealing in a fairly comprehensive manner with the general characters and distribution of the Lower Mesozoic rocks of Queensland.

(*b*) A critical discussion of the relations of the flora of these rocks.

(*c*) A comparison and correlation of the Lower Mesozoic rocks of Queensland with other Lower Mesozoic rocks of Australia, paying particular attention to the relations of the fossil floras of the various occurrences to one another.

(*d*) The determination of the position of the Australian Lower Mesozoic rocks in the Geological Record. And

(*e*) A discussion of the palæogeography of the Australasian region during Lower Mesozoic time.

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* Queensland Geol. Surv., Publications Nos. 252, 257, 259.

It may be of advantage here to summarise the present position of our knowledge of the floras of Australian Lower Mesozoic rocks.

Rocks of this age are developed in all the Australian States, but only in Western Australia are they of marine origin. The state of our knowledge of the fossil floras cannot be considered satisfactory. In Western Australia, the number of plants in these rocks is very small, but the fact, that they are associated with strata containing marine fossils, is of great importance as giving some indication regarding their exact position in the Geological Record. In South Australia, a few fossil plants have been described from the Lower Mesozoic rocks at Leigh's Creek, and *Phyllopteris Feistmanteli* has also been recorded from Ooroowilanie Swamp, 100 miles north of Leigh's Creek; this latter record may be from the Cretaceous rocks overlying the Rolling Downs Series. In Tasmania, fossil plants are abundant, and a large number have been described and figured from Lower Mesozoic rocks. Unfortunately, some of the determinations are open to doubt, and many of the figures and description are too imperfect to be of value in a comparison of the Tasmanian Mesozoic flora with other Australian Mesozoic floras In Victoria, Lower Mesozoic rocks occur in three areas (South Gippsland, Cape Otway, and Wannon areas). A collection of fossil plants from these strata has been described by Professor Seward, and more recent additions have been determined by Mr. F. Chapman. This flora has been determined as of Jurassic age, and it is sufficiently well-known to enable reliable comparison to be made with other floras. In New South Wales, fossil plants are abundant in Lower Mesozoic rocks, but no comprehensive examination of the whole flora has been undertaken. Lists of the floras of the different Series, prepared by Mr. W. S. Dun, were published in Carne's memoir on the Western Coalfield of New South Wales, in 1908. These have been supplemented, from time to time, by descriptions of additional specimens, by Mr. Dun. From these lists, it is possible to obtain a fairly good idea of the flora of the Lower Mesozoic rocks in New South Wales. In Queensland, the author has just completed an examination and revision of the floras of the Ipswich and Walloon Series, the results of which have been published by the Queensland Geological Survey.

The correlation of the Lower Mesozoic rocks of Australia (based mainly on their fossil floras) and their exact position in the Geological Record have been the subject of much discussion, and different views regarding their correlation have been put forward from time to time. In a summary of the literature dealing with the Queensland Lower Mesozoic rocks,* I have already briefly summarised the majority of these views, and there is no need to discuss them in further detail here. It is sufficient to state that no finality has been reached on this point, and, in many cases, conclusions have been based on insufficient evidence.

As a result of my examination of the Queensland fossil flora, together with a consideration of the evidence of the fossil faunas, and, in addition, general considerations of the strata containing the fossils, certain conclusions regarding the correlation of the various series have been arrived at (see p.95) which differ from any previously put forward.

ACKNOWLEDGMENTS.

It is almost impossible to express the extent of my indebtedness to Mr. B. Dunstan, Chief Government Geologist of Queensland, in connection with the whole of my geological and palæontological work in Queensland. He has placed at my disposal every facility for examining the large collection of Mesozoic plants in the possession of the Geological Survey; in addition, he has made available to me a very considerable amount of unpublished information, and permitted me to use such for the purpose of making this paper as complete as possible. In the section of this paper dealing with the extent and distribution of the Lower Mesozoic rocks, much field-information is published for the first time, and this is based almost entirely on information supplied by Mr. Dunstan. I would like, therefore, to make special acknowledgment of my indebtedness to Mr. Dunstan,

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* Queensland Geol. Surv., Publication No.252, p.6.

and to place on record my appreciation of the generous way in which he has lent me all possible assistance.

To other officers of the Geological Survey, I am indebted for their willingness to assist me with their knowledge of these strata in the field, especially Mr. W. E. Cameron, who has made such a detailed study of the Ipswich Series in the Ipswich Coal-field, and who has given me access to the information which he has obtained for the preparation of his third report on this field.

For assistance in connection with the geology of the Lower Mesozoic rocks in Western Australia, South Australia, and Tasmania, I have to thank Messrs. A. Gibb Maitland, L. K. Ward, and W. H. Twelvetrees, respectively.

To Professor David, I owe my introduction to the broader problems of Australian Geology, and the resulting desire to assist in the solution of some of the problems of Australian stratigraphy. I have been inspired to carry out the palæo-botanical portion of my work as thoroughly as possible, by the kindly encouragement of Professor Seward.

I am indebted to the authorities of the University of Sydney for permission to publish this paper.

Previous Literature.

Most of the papers dealing directly with the subject of the Lower Mesozoic rocks of Queensland, or their flora, have already been briefly summarised in an earlier paper, but there are a few additional papers to which reference may be made here.

Mr. C Hedley, in his Presidential Address to Section D of the Australasian Association for the Advancement of Science in 1909, published two maps of the Queensland region in Mesozoic time, one reproduced after Neumayr, showing the distribution of land and water in Triassic time; and the other original, showing the same at the close of the Mesozoic Era.

Dr. H. I. Jensen, in a paper entitled "The Building of Eastern Australia,"* has many references to the Lower Mesozoic rocks. The paper partakes rather of the nature of a summary of views

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* Proc. Roy. Soc. Queensland, xxiii., Pt. 2, 1912, p. 149.

the author stating in his introduction that the object of the paper "is not to offer the reader any really new material, but rather to present the knowledge we already possess in a concise form . . . ." Nevertheless, many interesting points are raised, one or two of which bear more particularly on the problem of the Lower Mesozoic, and these will be referred to later. A series of maps accompanies the paper, showing suggested distribution of land and sea in the Australian region during the various geological periods.

Mr. E. C. Saint-Smith has carried out extensive observations on the Lower Mesozoic rocks in the Roma District, and presented a summary of his results* to the Second Interstate Conference on Artesian Water. These observations cover a very large area of Lower Mesozoic rocks, and fossil plants were found at various localities. The present author had the pleasure of accompanying Mr. Saint-Smith on a reconnaisance-trip over part of the area between Yeulba, Goongarry (Hornet Bank Station), and Roma, and can confirm Mr. Saint-Smith's remarks regarding the strata of that area. The greater part of the country traversed consists of outcrops of sandstones, with, here and there, shales and coal-seams, belonging to the equivalents of the Walloon Series.

Professor David, in the Federal Handbook for the Meeting of the British Association for the Advancement of Science in Australia in 1914, refers briefly to the Lower Mesozoic rocks of Queensland, which he classes as Jurassic.

Mr. R. J. Tillyard has described a number of fossil insects, from Lower Mesozoic rocks in Queensland and New South Wales.† The majority of the insects were obtained from Denmark Hill, Ipswich, in strata belonging to the Ipswich Series, and others from St. Peter's, near Sydney, N.S.W., from the Wianamatta Stage of the Hawkesbury Series. Twenty-two species were described from the Ipswich Series, and six species from the Wianamatta Beds.

The insects appear to be of considerable interest from the

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* Rept. Second Interstate Conference on Artesian Water, Brisbane, 1914, p.19.

† Queensland Geol. Surv., Publication No.253.

point of view of the phylogeny of the Insecta, but the results, up to the present, do not indicate that they will be of material value in the determination of horizons, or in fixing the position of the strata in the Geological Record.

In Appendix B to the "School Geography of Queensland," by G. Harrap, published in 1916, Mr. Dunstan gives a new classification of the geological formations of Queensland In this classification, the Lower Mesozoic rocks are divided into (?)Triassic and Jurassic, the Ipswich Series and Bundamba Series being classed as (?)Triassic, and the Walloon Series as Jurassic. No definite evidence is given for the separation. Included also in the Jurassic are the trachytes of the Glasshouse Mts., which all recent work goes to show are of Cainozoic age.

Professor Schuchert, in a paper recently issued, entitled "The Problem of Continental Fracturing and Diastrophism in Oceanica,"* gives a series of palæogeographic maps of Oceania; these include one showing the distribution of land and water in the Triassic period.

Mr. E. C. Andrews, in a recent paper entitled "Notes on the Structural Relations of Australasia, New Guinea, and New Zealand,"† makes many statements which invite criticism, some of them coming within the scope of this paper. He considers the growth of Australia, New Guinea, New Caledonia, and New Zealand as independent units. The question suggests itself—Are not these portions of the one continental mass, which have become separated as a result of folding-movements? In discussing the Trias-Jura, he infers two basins of deposition in New South Wales and Queensland, viz.: the Hawkesbury basin, and a northern basin, separated by high land-barriers, and with sedimentation taking place simultaneously in the two basins.

There are many papers dealing with the volcanic rocks of south-eastern Queensland, in which passing reference is made to the Lower Mesozoic rocks occurring in the same area as the volcanic rocks. It is unnecessary to mention these in detail

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* Amer. Journ. Sci., xlii., 1916, p.91.

† Journ. Geol., xxiv., 1916, p.751.

here; such papers include the works of Jensen, Wearne and Woolnough, and Richards, in addition to the publications of the Queensland Geological Survey.

THE LOWER MESOZOIC ROCKS OF QUEENSLAND.

(*a*) *General.*—Until quite recently, the Lower Mesozoic rocks of Queensland have been officially designated "Trias-Jura." This name was first used in 1892, it being suggested that the Burrum and Ipswich Formations represented a period of time extending from the base of the Trias to the top of the Oolite.* Prior to that date, in 1888, regarding the Ipswich and Burrum Formations, Jack says† "The Burrum Coalfield is plainly on a higher horizon than the Bowen River field [Permo-Carboniferous]. It contains a fossil flora in which many plants are common to the Mesozoic Ipswich Formation, and also, it is said, *Glossopteris* with a very meagre fauna, most of it peculiar to the coalfield." . . . . . "Probably to call it Triassic would not be very far from the mark, in at least a homotaxial sense." In the same paper, speaking of the Ipswich coalfield, he says "The coalfield contains an abundant fossil flora of a strongly Jurassic facies, and is probably the equivalent of the Clarence River beds of New South Wales."

It appears, then, that the recording of *Glossopteris* in the Burrum Formation was originally responsible for its being regarded as older than the Ipswich Formation. There is, however, no authentic record of the presence of *Glossopteris* in the Burrum Series.

When the two formations were united, in 1892, as the Trias-Jura, the Burrum Formation was regarded as Lower, and the Ipswich Formation as Upper Trias-Jura.‡ Ten species of plants were described by Etheridge from the Burrum Formation, and thirty-one from the Ipswich. The two formations were not known in contact in the field, so there was no stratigraphic evidence as to their relation to one another, and this had to

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* Geology and Palæontology of Queensland, 1892, p.312.

† Report Aust. Assoc. Adv. Sci., i., 1889, p.196.

‡ Geology and Palæontology of Queensland, 1892, p.312.

be determined from the contained fossil plants. The fossils, which were available from the Burrum Formation at the time, were, unfortunately, fragmentary, and were not a representative collection. Further collections have been obtained from time to time since, and a cursory examination of the material now available in the Geological Survey collections shows distinct differences from the floras of the Ipswich and Walloon Series. It is intended that an examination of the Burrum flora will be undertaken after the completion of the present paper.

In 1907, Mr. Cameron, in discussing the age of the Ipswich Formation, says* "The evidence for considering the Burrum Beds as belonging to an earlier period of the Trias-Jura is not conclusive. The two formations have long been considered as identical in age by the Geological Survey, and the recent observations of Mr. Jensen lend confirmation to that conclusion."

Our present knowledge shows that a large part of what was, at that time (1907), regarded as part of the Burrum Formation, is actually a continuation of the upper series of what was considered then as the Ipswich Formation. Dr. Jensen had recorded the fact that these were continuous in the field in the neighbourhood of Point Arkwright.†

The question of the age and extent of the Burrum Formation has, however, been established beyond doubt by the observations in the field of Mr. Dunstan. As a result of these observations, it is now certain that the Burrum Series, in the Maryborough-Howard district, overlies, with apparent stratigraphic conformity,‡ rocks of marine origin, whose contained fossils indicate a Cretaceous age, probably equivalent to the Rolling Downs Formation of Western Queensland. Mr. Dunstan has also shown that the strata to the south and south-west of Maryborough, originally mapped as part of the Burrum Formation, dip towards the north-east beneath the marine Cretaceous rocks, and are equivalent to the Walloon Series. For these equivalents of the

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* Queensland Geol. Surv., Publication No.204, pp.12, 13.

† Proc. Linn. Soc. N. S. Wales, 1906, xxxi., pp.74-75.

‡ Ann. Rept. Dept. Mines, Queensland, 1911 (1912), p.195; Queensland Govt. Mining Journ., xiii.(1912), p.641.

Walloon Series in this area, Mr. Dunstan has proposed the name "Tiaro Series."[*]

Of the two formations which were united to form the so-called Trias-Jura System, then, one has been removed into the Cretaceous System, and the remaining one (the Ipswich Formation) is that which was originally regarded as the probable equivalent of the Jurassic System.

The Ipswich Formation was divided into three Series by Mr. Cameron, viz.: Ipswich Series, Bundamba Series, and Walloon Series. The use of the terms Ipswich Formation and Ipswich Series (part of the Ipswich Formation) has probably led to a certain amount of confusion, but the removal of the Burrum Formation to the Cretaceous System renders the use of the name Ipswich Formation superfluous, and it would be an advantage to abandon it.

(*b*) *Geological Succession.*—The Lower Mesozoic rocks of Queensland consist of three Series, viz.:—

3. Walloon Series (Upper).
2. Bundamba Series (Middle).
1. Ipswich Series (Lower).

The complete succession is found only in South-eastern Queensland, where a considerable amount of detailed geological work has been carried out, chiefly because both Ipswich and Walloon Series contain workable coal-seams.

The Ipswich district has been examined in detail by Mr. Cameron, who has published two reports on the area,[†] and is preparing a third, incorporating the results of recent developments in the district.

South-east Moreton has been the subject of investigation by Mr. E. O. Marks, late of the Queensland Geological Survey, whose results are embodied in a publication entitled "The Coal-Measures of South-east Moreton."[‡] The examination of the continuation of the Coal-Measures, from the area examined by

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[*] See Rept. Second Interstate Conference on Artesian Water, Brisbane, 1914, p.7.

[†] Queensland Geol. Surv., Publications 147, 204.

[‡] Queensland Geol. Surv., Publication 225.

Mr. Marks towards the New South Wales border, has been commenced by Mr. J. H. Reid, of the Geological Survey.

Other areas of Lower Mesozoic rocks in Queensland have been studied in detail by other officers of the Geological Survey, the more important ones being: the Stanwell Coal-Measures, examined by Mr. Dunstan;* the Laura Coalfield, west of Cooktown, by Mr. Ball;† the Lower Mesozoic rocks in the Roma district, by Mr. Saint-Smith. Unfortunately, the full results of Mr. Saint-Smith's work have not been published, but a summary was communicated to the Second Interstate Conference on Artesian Water.‡ For local details regarding these areas, reference must be made to these publications.

(*c*) *Lithological Characters.*—The lithological characters of the Lower Mesozoic rocks in Queensland do not call for very special remark. For the greater part, they consist of sandstones and shales in varying proportions, with which are associated occasional conglomerates, grits, and also coal-seams.

The Ipswich Series consists, for the most part, of light-coloured shales and sandstones, with associated conglomerates, and fourteen or fifteen workable coal-seams. There are coarse conglomerates developed near the base of the series, indicating vigorous erosion in the early portion of the period.

The Brisbane Tuff, which is near the base of the Ipswich Series in the Brisbane area, is a rock probably of volcanic origin (though there is no indication of its source), resulting from the deposition of volcanic ash of acid nature over a long, narrow area in the vicinity of Brisbane. The general direction of the outcrop of this belt of tuff is N.30°W. As far as known, there are no volcanic rocks of undoubted Lower Mesozoic age in South-eastern Queensland, with the exception of a series of andesites south of Maryborough, which are apparently interbedded in the Tiaro Series. Marks, Andrews, and Wearne and Woolnough have, at times, advocated a Lower Mesozoic (Trias-Jura) age for

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* Queensland Geol. Surv., Publication 131.

† Queensland Geol. Surv., Publication 222, p.5.

‡ Report Second Interstate Conference on Artesian Water, Brisbane, 1914, p.19.

some of the South-east Queensland volcanic rocks, but Dr. Richards has recently examined all their evidence[*] and shown that, in each case, there is no doubt that the volcanic rocks are of Cainozoic age. Since then, Mr. Dunstan has placed the volcanic rocks of the Glasshouse Mountains in the (?)Walloon Series;[†] the only field-evidence regarding the age of these rocks is that they are intrusive through a series of sandstones, which Mr. Dunstan believed, at the time, to belong to the Ipswich Series. On the evidence of the relationship between these volcanic rocks and other volcanic rocks of South-eastern Queensland, their age certainly seems to be Cainozoic. Some of the beds of the Ipswich Series at Denmark Hill, Ipswich, are regarded by Mr. Dunstan as tuffaceous in character.[‡]

The Bundamba Series, which succeeds the Ipswich Series, consists, for the most part, of massive sandstones. With the exception of one coal-seam about 1 foot, 6 inches thick, known as the West Moreton seam, they have proved unproductive of coal; they are also practically barren of fossils, the only record being of silicified wood. The basal portion of the Bundamba Series lies about seventy feet above the top seam (Aberdare seam) in the Ipswich Series, and consists of coarse grits and conglomerates.

The Walloon Series, lithologically, is of somewhat similar nature to the Ipswich Series. In consists mainly of comparatively soft sandstones, with which are interbedded fine-grained shales and coal-seams. Conglomerates are developed, but are of limited occurrence. The soft sandstones and shales weather away rapidly, and, consequently, in many places, outcrops are few and inconspicuous.

In the Stewart's Creek (Stanwell) district, the Series includes a hard, white, siliceous tuff in which abundant fossils are preserved.

A remarkable feature in the Walloon Series is the very wide-

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[*] For summary of evidence, *see* Proc. Roy. Soc. Queensland, xxvii. (2), 1916, p.126.

[†] Harrap's School Geography of Queensland, Appendix B, p 167,

[‡] Queensland Geol. Surv., Publication No.253, p.5

spread distribution of a fine-grained, ferruginous sandstone. This rock is very characteristic, and is developed on one or perhaps more horizons. It has been observed from the following localities: Beaudesert, Kalbar (late Engelsburg), near Warwick, near Toowoomba, three miles north of Texas, a number of localities in the Wallumbilla-Roma district, and Stewart's Creek, Rockhampton. All these occurrences are in the Walloon Series or its equivalents. This rock, in nearly every case, contains fossil plants, the genus *Otozamites* being particularly characteristic. It is also to be noted that, in the Jurassic rocks of Western Australia, *Otozamites* occurs in a fine-grained, ferruginous sandstone.

The widespread distribution of this rock, apparently on a few horizons, leads us to believe that it gives indication of some special conditions of deposition. It would, however, be useless to attempt to account adequately for it in the present state of our knowledge of the conditions under which these beds were laid down; most of the areas from which it has been obtained have not yet been studied in detail geologically.

(*d*) *Coals.*—The development of a number of coal-seams of workable quality and thickness is an important feature of the Lower Mesozoic rocks of Queensland. Coal is obtained from both the Ipswich and Walloon Series, and the character of the coal from the two Series is generally distinct. This distinction has been expressed both by Mr. Cameron and Mr. Marks. The former, speaking of the Walloon coals, says* "the coals hitherto found show characteristic conchoidal fracture in the hand-specimen, burn readily with a long, luminous flame, and give off a much larger proportion of volatile hydrocarbons when heated in a closed vessel than do the brittle, bituminous coals of the Ipswich Beds."

On the same subject, Marks says† "The Walloon Beds are characterised by coals which, like those of the Darling Downs, are of the nature of a cannel coal—highly gaseous, hard, and

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* Queensland Geol. Surv., Publication No.204, p.16.

† Queensland Geol. Surv., Publication No.225, p.9.

breaking with a conchoidal fracture, in contrast to the more brittle bituminous coal of the Ipswich Beds."

The Ipswich coals are steam-coals, and are suitable for heating and coke-making; the Walloon coals are essentially gas-coals. A table of typical analyses of the coals from various areas has been published by Mr. Dunstan,* from which we may quote the typical Ipswich and Walloon coals for comparison.

	Ipswich Coal.		Walloon Coal.	
	Mean %.	Range.	Mean %.	Range.
Moisture	1·5	2·0–0·7	6·0	8–4
Volatile hydrocarbons ...	27·0	33–21	39·0	40–23
Fixed carbon	58·5	72–50	44·0	48–29
Ash	14·0	21–4	11·0	25–6

The most notable point of contrast between the two is in the relation of volatile hydrocarbons to fixed carbon; in the Ipswich coals, the latter is very much in excess of the former, while, in the Walloon coals, the two are of about the same value. In some cases, Walloon coals show a much higher percentage of fixed carbon than of volatile hydrocarbons, and the analysis is then indistinguishable from that of Ipswich coals; in these cases, however, the field-relations of the strata usually supply the explanation for this irregularity, by the presence of intrusive rocks not far away, and resultant alteration of the coal.

In normal cases, then, there is a more or less marked distinction between the coals of the Ipswich and Walloon Series in Queensland, and this distinction is of some practical value in helping to distinguish between the two Series. The Walloon coals are distinctive, and can frequently be recognised with a reasonable amount of certainty as belonging to that Series. The Ipswich coals, however, though they are distinct from the Walloon coals, are very similar to the coals of the Burrum Series, of Cretaceous age, and their age cannot be identified by the nature of the coal.

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* Queensland Geol. Surv., Publication No.239, p.23.

(*e*) *Extent and Distribution.*—(i.) *The Ipswich Series.*—The Ipswich Series is of comparatively limited extent, and has a thickness, in the type-district, of about 2,000 to 2,500 feet, as estimated by Mr. W. E. Cameron. Its best development is in the Ipswich district, where the strata have been studied in detail by Mr. Cameron.*

North-west of the town of Ipswich, the north-western end of the Ipswich Series is hidden by Cainozoic rocks. Mapping in this portion of the area has not been carried out in detail, but apparently the Ipswich Series cuts out between the Bundamba Series and Brisbane Schists (as shown in Plate ii.), and it is not known to outcrop further in this direction. It is, of course, possible that this series extends some distance north under the Walloon Series, but one might expect, in this case, to find some indication of its presence by outcrops between the outcrops of the Walloon Series and the older rocks to the east.

From Ipswich, the Ipswich Series extends in a general easterly direction to Oxley, where it disappears beneath overlying Cainozoic rocks, as shown on the most recent maps prepared by Mr. Cameron. It reappears along a line running approximately N.30°W.-S.30°E through Brisbane, and is succeeded to the east by a line of schists of Palæozoic age. This belt of Palæozoic rock is not very wide here, and, on the eastern side of it, the Ipswich Series reappears. Between Mt. Cotton and Mt. Petrie, the two belts of Ipswich Series are in direct connection, as also are they between Mt. Petrie and White's Hill

Still going to the east, the Ipswich Series again disappears under the overlying Bundamba sandstone along a line running in a N.30°W. direction through Hemmant, and reappears on the other side of a syncline at various points on the coast south of the Brisbane River. The axis of this syncline is in a direction N.30°W.-S.30°E.

The whole of the Ipswich Series so far described skirts the southern extremity of an extensive occurrence of the schists known as the Brisbane Schists, whose age is uncertain, and can only be stated definitely as Pre-Mesozoic.

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* Queensland Geol. Surv., Publications Nos. 147, 204.

From the Brisbane River, extending north as far as Maryborough, there is a narrow, coastal belt of Lower Mesozoic rocks. These are, here and there, intruded or overlain by volcanic rocks of Cainozoic age, with which we are not concerned here. The Mesozoic rocks of this coastal belt are gently folded into anticlines and synclines, the general direction of dip being north-easterly or south-westerly.

This coastal belt averages about 15 to 20 miles in width. At its southern end, it consists of rocks of the Ipswich Series, representing a continuation of the syncline just mentioned south of the Brisbane River. The Bundamba sandstone in this synclinal area does not extend much north of the Brisbane River, and appears to be entirely surrounded on its northern end by the Ipswich Series. The north-eastern side of this syncline, produced northwards, forms the south-western arm of an anticline whose axis passes approximately through the region of the Glasshouse Mountains, in a direction N.30°W., and whose north-eastern arm dips away towards the north-east under the sandstones of the Toorbul Point-Landsborough district, which probably represent the Bundamba Series.

This is the last that is seen of the outcrop of the Ipswich Series, and their extent under the Bundamba Series to the east and north east cannot be determined.

The distribution of this Series is indicated generally in Plate ii.

(ii.) *The Bundamba Series.*—The Bundamba Series comprises a development of massive sandstones in which there are practically no fossils, the only ones so far recorded being examples of fossil wood. Mr. Cameron estimates the thickness of the Series at between 3,000 and 5,000 feet.

This Series overlies the Ipswich Series conformably. It extends, roughly, from the Ipswich District eastwards to a little beyond the railway-line between South Brisbane and Kingston, and in a general south-easterly direction past Canungra to the New South Wales border. It is impossible, in this area, to define accurately the limits of the formation, but its existence is beyond doubt. Mr. Dunstan has recently observed it in New South Wales, not far from Mt. Warning.

The Series also occupies a syncline, with an axis in a direction approximately N.30°W.-S.30°E., between Hemmant and Wynnum, extending southwards to about the latitude of Redland Bay, and northwards only just beyond the Brisbane River. Further north, there is a parallel belt of the Bundamba Sandstone extending from Toorbul Point in a direction approximately N.30°W. through the Landsborough district. The presence of the Bundamba sandstones has been indicated at Toorbul Point by Mr. Cameron.* At this point, a bore (the Bribie View Bore) in Portion 28, Parish of Toorbul, passed through 508 feet of massive sandstones, with one or two seams of hard, black, sandy shales and, near the bottom, pebbly conglomerates; no coal-seams were observed in these sandstones. Mr. Cameron correlated these sandstones with the Bundamba grits and conglomerates occurring at Logan Village. The sandstones of the Landsborough district have been correlated with the Bundamba Series by Mr. Dunstan.†

It can thus be recognised, that there is a belt of the Bundamba Series running through this area, and its position can be defined in a general way, but the exact determination of its boundaries would involve a careful geological survey of the whole area, and it is not certain even then that the boundaries could be accurately defined.

This belt disappears towards the north-east under the southern extension of the Tiaro Series, which is equivalent to the Walloon Series. The distribution of the Series is indicated in Plate ii.

The Helidon sandstones may be the equivalents of the Bundamba sandstones, as suggested by Mr. Dunstan,† but we do not know sufficient detail of the geology of the Helidon district, at present, to be sure of their position.

(iii.) *The Walloon Series.*—The rocks belonging to this Series cover a vastly wider area than either the Ipswich or Bundamba Series. Their distribution is indicated in Plates i. and ii. In South-eastern Queensland, they outcrop over most of the country between a line drawn from just west of Esk to Toowoomba, thence along the eastern foot of the Main Range to the New

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* Ann. Rept. Dept. Mines, Queensland, 1908, p.172.

† Queensland Geol. Surv., Publication No 252, p.4.

South Wales border, and a line drawn roughly from Ipswich to Canungra, and thence to the New South Wales border. In a good deal of this area, they are overlain by volcanic rocks of Cainozoic age, but there is no doubt that they are practically continuous through the whole area. In addition, there is a belt, five to fifteen miles wide, from Esk up the valley of the Brisbane River nearly to Cooyar Creek, but this belt is not a continuous outcrop; there is also an extension from Esk in a north-easterly direction past Mt. Brisbane.

Rocks belonging to the Walloon Series also outcrop very extensively to the west of the Main Divide. There is probably a continuous belt from the New South Wales border near Killarney, running through Warwick to Dalby and Chinchilla, then swinging round to an east and west direction parallel to the railway-line past Roma. The exact extent of the belt past this point is not absolutely proven, but there seems little doubt that it swings round in a general north-north-westerly direction, and extends right to the Gulf of Carpentaria towards Cape York. Mr. Dunstan* has placed, in the Walloon Series, sandstones and shales in this belt at the following localities: the Upper Maranoa River, the Upper Dawson River, Jericho, the Upper Flinders River, Croydon, and probably the heads of the rivers flowing westerly across the Cape York peninsula to the Gulf of Carpentaria.

This belt dips to the west and south-west, and underlies, with apparent conformity, the marine Cretaceous rocks of the Rolling Downs Series. In the east, the Walloon Series is represented by a number of occurrences scattered over a very wide area. To the south and south-west of Maryborough is the Tiaro Series (equivalent to the Walloon Series); other occurrences include those at Callide Creek, Westwood-Wycarbah-Stanwell district, Waterpark, Brovinia, a small area about 10-15 miles west of Mundubbera, a small area west of the Burnett River in latitude 25° 45′S., a small area west of Barambah Creek in latitude 26°S., at Mondure on Barambah Creek, and the Laura Coalfield, Cooktown district. The exact positions of these areas are shown on

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* Harrap's Geography of Queensland, 1916, p.166.

Plates 3, 5, and 9 of the Queensland Mineral Index. On Plate 11 of the same work, a small patch is shown as belonging to the Walloon Series, just west of Anakie. Mr. Dunstan, who investigated the Anakie district some years ago, kindly informed me that there is no representative of the Walloon Series in that district, and that the colouring of this area as Walloon was due to an error in lithographing. Another area, to which attention should be called, is that of the Styx River, marked on Plate 3 of the Mineral Index as belonging to the Ipswich Series. Mr. Dunstan now believes this to be of Cretaceous age, and has recently obtained, from the Styx River Coal-Measures, a fragment which appears to be a dicotyledonous leaf. This is an interesting find, and the greatest age, which can reasonably be assigned to these Measures in view of it, is Cretaceous.

In the case of most of the isolated occurrences of the Walloon Series just mentioned, there is sufficient evidence to render it almost certain that the determination of the age is correct. The evidence is here summarised :—

In the Westwood-Wycarbah-Stanwell district, the fossil flora is distinctly of the Walloon type (*infra*, Table vii.). At Waterpark, the coal is of Walloon type, but there appears to be no record of fossils. The areas in the vicinities of Brovinia, Mundubbera, Burnett River, Barambah Creek, and Mondure are all residuals, occupying rather higher ground, and Mr. Dunstan is of opinion that they undoubtedly represent outliers of the extensive outcrop a little to the south-west. In the Laura coalfield, the strata consist of arenaceous beds, with occasional thin beds of shale and coal-seams. Mr. Ball records the finding of the following fossils: *Phyllotheca*(?), *Tæniopteris*, *Alethopteris*, *Brachyphyllum*, and *Taxites*(?). The presence of *Brachyphyllum* and *Taxites*(?) is sufficient to indicate a Walloon age. In the remaining area, Callide Creek, there is no definite indication of age; the fossils, *Thinnfeldia odontopteroides* [= *T. Feistmanteli*], and *Tæniopteris* sp., have been recorded, but they are not sufficient to determine the age. In view, however, of the wide distribution of strata of Walloon age, the Callide Creek beds are regarded as probably of similar age.

It is thus seen that the Walloon Series extends uninterruptedly over a great part of Eastern Queensland. Though occurring in comparatively small, isolated areas at the present time, I believe that these occurrences represent the remnants of a deposition which probably covered the greater part of Queensland. This will be discussed later.

Further, that the western belt, extending past Toowoomba and Warwick, probably extends a great deal further west than is shown on the map, is indicated by the known occurrences of Lower Mesozoic rocks to the south-west of Dalby, and west of Warwick.

Towards the south, this belt divides into two; the eastern portion extends past Killarney into New South Wales, and is continuous with the western extent of the Clarence Series; and the western portion continues along the western margin of New England, and dips away to the west under the marine Cretaceous. In New South Wales, this latter belt is known as the Artesian Series.

It must be noted that the Walloon Series, in the Toowoomba-Warwick District and in South-eastern Queensland, have probably been separated by heavy faulting along the Main Range, but were formerly continuous; and it is quite natural, therefore, that this Series should, in these two areas, be continuous with parts of the Clarence Series of New South Wales.

That the Walloon Series continues for great distances westward under the Cretaceous rocks, is proved by the Artesian bores of Queensland and New South Wales. It is fairly well established now that the rocks from which the Artesian water (or rather that part of it which is of meteoric origin) is obtained, are part of the so-called Trias-Jura System, and not of the Cretaceous System. This fact is of great value in determining the extent to which the Lower Mesozoic rocks continue under the Cretaceous.

Small flows of water have undoubtedly been obtained from the Cretaceous rocks, but the rocks from which the large flows of water have been obtained are of Lower Mesozoic age. Examination of the bore-records, then, will show the extent of the

Lower Mesozoic rocks, both in Western Queensland and in New South Wales. At some places, there is a very great thickness of Cretaceous and possibly Cainozoic strata overlying the Lower Mesozoic rocks; *e.g.*, in South Australia, the bore at Goyder's Lagoon struck water-bearing strata at 4,700 feet, and the Patchawarra bore was abandoned at a depth of 5,458 feet, being still in the Cretaceous rocks.

Palæontological proof of the age of the water-bearing strata in the bores is not often forthcoming, but, in a number of cases in New South Wales, records have been made, *e.g.*, (*a*) in the Bulyeroi bore, 60 miles W. by S. of Moree, Lower Cretaceous rocks with marine fossils were passed through down to 520 feet, and then shales, sandstones, and coal-seams with fossil plants; (*b*) in the Wallon bore, 20 miles N. by W. of Moree, Lower Cretaceous rocks with marine fossils were encountered down to 1,500 feet; at 1,630 feet, fragments of *Tæniopteris spatulata* [*T. Daintreei*] were obtained, and water was struck at 2,330 feet; (*c*) in the Coonamble bore, both *Tæniopteris spatulata* [*T. Daintreei*], and *Thinnfeldia odontopteroides* were obtained. These are not all of the recorded occurrences.

The Walloon Series (or its equivalents) is considerably thicker than the Ipswich or Bundamba Series. In Western Queensland (Roma District), the map and sections prepared by Messrs. Saint-Smith and Thom show a width of outcrop of about 60 miles, and dips of the order of 3 or 4 degrees; the dips are small, but, if the average dip be only 2 degrees, the thickness represented is about 11,000 feet. In the Maryborough District, the thickness of the Tiaro Series has been estimated at 12,000 feet by Messrs. Blake and Bryan.

(*f*) *Artesian Water.*—A general consideration of the Lower Mesozoic rocks of Queensland would not be complete without some reference to the question of artesian water. This question has been the subject of considerable controversy between the exponents of the two theories as to the origin of the water, known respectively as the "Meteoric" Theory, and the "Plutonic" Theory. Suffice it to state, that there seems now to be no reasonable doubt that a large portion of the water is of meteoric origin, and that the belt of Lower Mesozoic rocks extending, probably without interruption, from near Dubbo in New South Wales, to the Cape York Peninsula, forms the intake-beds of the Great Australian Artesian Basin. Probably also a small percentage of the water is of plutonic origin. It is also now generally agreed among Australian geologists that, in the Great Australian Artesian Basin, the rocks, from which all the large flows of water are obtained, are of Lower Mesozoic age, underlying the Marine Cretaceous (Rolling Downs) Series.

An examination of the bore-records shows conclusively that the sandstones of the Walloon Series in Queensland, and the Artesian Series in New South Wales, extend continuously in a westerly and south-westerly direction into the north-eastern portion of South Australia. The depths at which the sandstone is found vary, but, in general, the deepest occurrences are in the north-eastern corner of South Australia, not far from the Queensland border.

It must be noted here, that, near the border between Queensland and New South Wales, in the vicinity of Hungerford, there are patches of granite at the surface, and also that some of the bores in that vicinity have struck granite at comparatively shallow depths. There is here, then, indication of an island in Lower Mesozoic time.

In the north-east of South Australia, where the Lower Mesozoic sandstones are at great depths, it seems probable that the strata above them include Cainozoic, Cretaceous freshwater-beds (equivalent to the Winton Series of Western Queensland), and Cretaceous marine beds (Rolling Downs Series). This is inferred from a comparison with conditions in parts of Queensland; in the great majority of bores, unfortunately, the records kept are of little value for detailed geological purposes. In the case of the Patchawarra bore in South Australia, which was abandoned at 5,458 feet without reaching the water-bearing strata, it appears that the bore, when abandoned, was still in the Cretaceous rocks, and there is nothing to indicate that the Artesian Series of sandstones does not exist further down. I am indebted to Mr. L. Keith Ward, Government Geologist of South

Australia, for supplying me with all available information regarding this bore. Mr. Ward also remarks that the bores sunk by the South Australian Government, with the exceptions of Hergott and Marree at the margin of the basin, have failed to reach bedrock. In other bores in the north-east of South Australia, water is obtained from sandstones at great depths, indicating surely the presence of equivalents of the Walloon Series, *e.g.*, Goyder's Lagoon Bore, 4,700 feet; Mount Gason Bore, 4,420 feet; and others.

Examples of palæontological proof of the age of the sandstones, carrying the large supplies of artesian water, are quoted above (*see* p.58), and these show that the presence of artesian water is an indication of the existence of the Lower Mesozoic Sandstones, and can be used in the determination of the extent of these beds.

(*g*) *Folding-movements* In studying the folding-movements to which the Lower Mesozoic rocks of Queensland have been subject, two areas may be considered separately, viz., (*a*) the western belt, extending from the Cape York Peninsula to the New South Wales border, and (*b*) the occurrence in South-eastern Queensland. (*a*) The western belt has not been subject to any considerable movement, and the rocks usually dip gently to the west and south-west beneath the marine Cretaceous strata; occasional high angles of dip have been observed. (*b*) In South-eastern Queensland, a study of the distribution and directions of dip shows that the Lower Mesozoic rocks have been considerably folded, and that the folding in some cases gives place to faulting. The folding takes the form of a series of anticlines and synclines, whose axes are in a direction approximately N.30° W.-S.30°E. The distribution of the Lower Mesozoic strata in South-eastern Queensland has never been thoroughly understood, but the recognition of this series of folds seems to explain the distribution in a simple and reasonable manner. In places, the folding gives place to faulting, *e.g.*, north of Ipswich, and probably also near Hemmant. Mr. Ball has also described a fault near Woodford,* which he believes to represent a continuation

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* Queensland Government Mining Journal, xvii., 1916, p.169.

of the supposed fault at Hemmant. The general directions of the dip and of the axes of folding are shown in Plate ii.

The extent of this folding, which has affected both the Lower Mesozoic rocks and the overlying Cretaceous strata, has not been generally recognised, as may be seen from the following quotations. Dr. Jensen* says, "Our Mesozoic sediments show no folding of consequence. Generally speaking, they show only slight dips, and have never been under the influence of tangential pressure like the Mesozoic sediments of the Alps, Himalayas, Java, etc." Dr. Richards,† writing of South-eastern Queensland, says, "Folding-movements of only a very gentle nature have taken place since the Palæozoic era."

Such statements are not consistent with the folding which has been observed to the west of Ipswich, in the neighbourhood of Hemmant; and in the Maryborough District, particularly on Woody Island, where the strata are often nearly vertical.

The nature of the folding is illustrated in two Sections (Text-fig. 1), of which Section A has been prepared from a section drawn by Mr. Dunstan, and Section B from a combination of sections by Messrs. Cameron and Marks. Neither Mr. Dunstan's nor Mr. Cameron's original section has been published, and I am indebted to them for permission to modify these sections for use here.

This folding may be quite adequately and reasonably explained as the result of the adaptation of the earth's crust to a shrinking nucleus. Such folding would, naturally, be expected along zones of weakness, and the east coastal area of Australia is undoubtedly such a zone. Folding of this nature often passes into faulting, and this may have occurred near Hemmant, where there seems to be a line of faulting associated with folding, and also in the Ipswich District, where, Mr. Cameron informs me, the severe folding just south of Ipswich gives place to a fault further north.

From the originals of the sections, it was possible to estimate, approximately, the amount of shortening of the earth's crust

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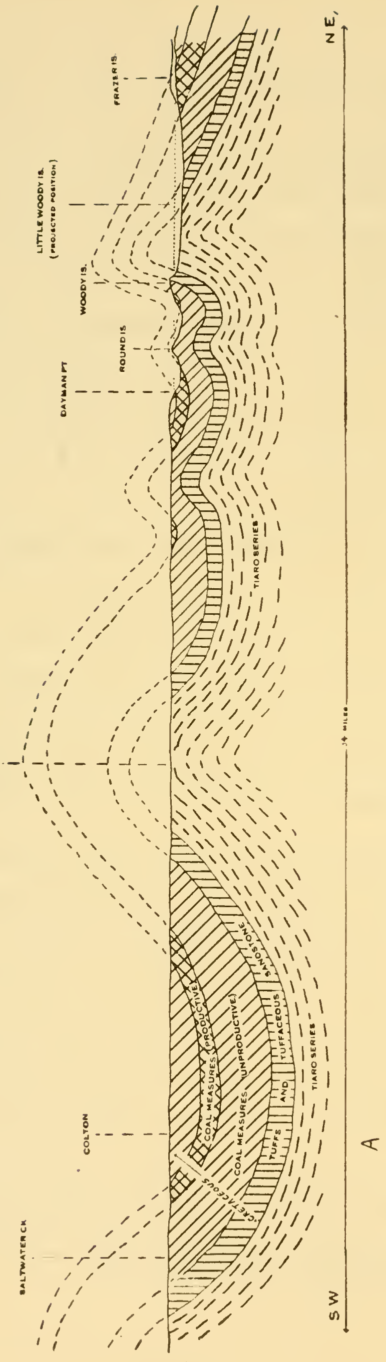
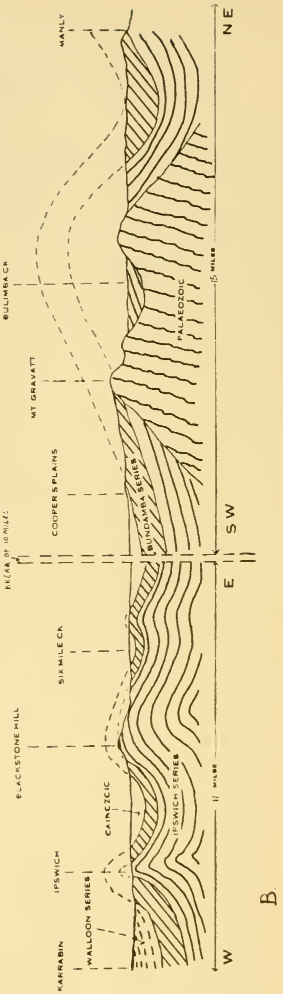
* Proc. Roy. Soc. Queensland, xxiii., Pt.2, p.163.

† Proc. Roy. Soc. Queensland, xxvii., Pt.2, p.114.



Text-fig. 1A.



Text-fig. 1B.

Text-fig. 1A.—Sketch-Section from near Colton to Frazer Island, showing the folding of the Jurassic and Cretaceous rocks. Vertical scale exaggerated about 2½ times. (Modified from Section drawn by Mr. B. Dunstan).

Text-fig. 1 B.—Diagrammatic Section from Ipswich to Manly, showing the folding of the Lower Mesozoic Strata. Vertical scale exaggerated. (Modified from Sections by Messrs. W. E. Cameron, B.A., and E. O. Marks, B.A.).

represented by the folding. Both sections are approximately at right angles to the axes of folding. In the section between Ipswich and the mouth of the Brisbane River, a shortening of the order of $1\frac{1}{8}$ miles in 34 miles has been effected; and, in the Maryborough district, a shortening of about 0·8 mile in 34 miles. This shortening is circumferential, and if it be regarded as the shortening represented at this particular time for the east-west extent of Australia (a not unreasonable supposition, since we know of no other folding of the same age across Australia), the radial shrinkage represented would be of the order of 0·05%.

Regarding the age of the folding, it certainly took place after the Burrum Coal-Measures (probably Lower Cretaceous) were deposited, for both Marine Cretaceous strata, which are apparently conformable with the Tiaro Series, and the overlying Burrum Coal-Measures have been subject to this folding force, and have been folded to an extent closely comparable with the Lower Mesozoic strata. This is shown by a comparison of Sections A and B.

This same folding took place before the Cainozoic, since it has not affected any of the Cainozoic rocks of South eastern Queensland. Also the disposition of the Cainozoic volcanic rocks in South-eastern Queensland indicates that the Pre-Cainozoic drainage-system was approximately meridional, and this may be closely connected with the N.30°W. strike of the folds of the Lower Mesozoic rocks.

In the Ipswich District, there appears to have been a subsequent period of folding. This is comparatively restricted, and the folds produced by it have an approximately meridional direction. The Cainozoic deposits have been affected by this movement, which must, therefore, have been later than the period of folding already mentioned. I am indebted to Mr. Cameron for information regarding this latter folding.

FLORA OF THE LOWER MESOZOIC ROCKS OF QUEENSLAND.

The lists, presented below, of the floras of the Ipswich and Walloon Series have been prepared after a careful examination of the specimens available in the collections of the Queensland Geological Survey, the University of Queensland, the Queensland Museum, and the "Simmonds" Collection. In addition, previous records have been examined and verified as far as possible, and, only when it is believed that they are reliable, have they been included. In cases where the original specimens have been lost, the records have been used only when the determination is not subject to the least doubt. These lists, then, are regarded by the author as being as complete and reliable as it is possible to make them, in the light of our present knowledge.

(*a*) *Ipswich Series.*—The flora of the Ipswich Series comprises the following species:—

EQUISETALES.
- *Equisetites rotiferum* Tenison-Woods.
- *Equisetites* sp. (tubers).
- *Phyllotheca australis* Brongniart.
- *Neocalamites hœrensis* (Schimper).
- *Neocalamites* cf. *Carrerei* Zeiller.
- *Schizoneura* cf. *africana* Feistmantel.

FILICALES.
- Osmundaceæ.
  - *Cladophlebis australis* (Morris).
  - *C. Roylei* Arber.
- Cyatheaceæ.
  - *Coniopteris delicatula* (Shirley).
- Dipteridinæ.
  - *Dictyophyllum rugosum* Lindley and Hutton.
- Thinnfeldieæ.
  - *Thinnfeldia Feistmanteli* Johnston.
  - *Th. lancifolia* (Morris).
  - *Th. odontopteroides* (Morris).
  - *Th. acuta* Walkom.
- Marattiaceæ.
  - *Danæopsis Hughesi* Feistmantel.
- Hydropterideæ(?).
  - *Sagenopteris rhoifolia* (Presl).

GENERA OF FERNS AND PLANTÆ INCERTÆ SEDIS.

Sphenopteris lacunosa Shirley.
Sph. superba Shirley.
Tæniopteris Tenison-Woodsi Etheridge Jr.
T. Carruthersi Tenison-Woods
T. lentriculiforme (Etheridge Jr.).
T. Dunstani Walkom.
T. wianamattæ (Feistmantel).
T. crassinervis (Feistmantel).
Stenopteris elongata (Carruthers).

GINKGOALES.

Ginkgo antarctica Saporta.
G. digitata (Brongniart).
G. cf. *magnifolia* Fontaine.
Baiera Simmondsi Shirley.
B. bidens (Tenison-Woods).
B. ipsviciensis Shirley.
B. ginkgoides Shirley.

(?)GINKGOALES.

Stachyopitys annularioides Shirley.
S. Simmondsi Shirley.

CYCADOPHYTA.

Bennettitales.

Bennettites (*Williamsonia*) sp.

CYCADOPHYTA INCERTÆ SEDIS.

Pterophyllum multilineatum Shirley.

Gymnospermous seeds.

Examination of this list at once shows certain distinctive features, the most notable being the comparatively large number of Ginkgoales, the relatively few Cycadophyta, and apparent entire absence of coniferous remains.* The small proportion of

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* This statement may need subsequent modification. Silicified woods from the Ipswich Series have, in the past, been described as *Araucarioxylon* spp. These woods are at present being re-examined by Professor A. C. Seward, and it is quite possible that they may not be of undoubted coniferous affinities. At any rate, we know of no remains from the Ipswich Series, other than these woods, which may, at the present time, be referred to the Conifers.

Cycads may ultimately be very greatly increased, if it should be shown that the genus *Tæniopteris* belongs to this group. In a recent publication, Thomas includes species of *Tæniopteris* with the Cycadophyta, as a result of his examination of the epidermis of a number of recent and fossil Cycads.* None of the Queensland Lower Mesozoic examples of *Tæniopteris* obtained have been preserved as carbonaceous films, and it is at present impossible to state the nature of the structure of the epidermis in them.

The list of species in this Series may be summarised, and the figures expressed in percentages, as in the following Table:—

TABLE i.

	1 No. of Species.	2 %	3 %	4 %
Equisetales	5	15	15	15
Filicales	10	30	57	39
Filicales incertæ sedis ...	3	9		
Tæniopteris	6	18		24
Cycadophyta	2	6	6	
Ginkgoales	7	21	21	21
Total	33			

Such tables as these must be used with a good deal of caution, as their indiscriminate use may lead to quite incorrect and even absurd results; but careful use, with a full realisation of their value and their drawbacks, may yield interesting and, to some extent, reliable results. The use of such numerical methods has not come into very general use, but their preparation and use have been illustrated recently by Wieland.†

In the above Table (Table i.) of the Ipswich flora, the species of *Stachyopitys*, and gymnospermous seeds have not been used, since they, in all probability, represent seeds or reproductive organs of plants already represented in the list by sterile fronds. The species of *Tæniopteris* are placed separately in the Table,

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* Thomas, Q.J.G.S., lxix.; p.223.

† Amer. Journ. Sci., xxxvi. (1913), pp.268-273.

since their position is uncertain. In column 3, the percentages are given, including *Tæniopteris* with the ferns; in column 4, this genus is included with the cycads. This latter result gives the flora a not abnormal character in the proportion of ferns and cycads, and indicates a general similarity to some Rhætic floras; there are, however, certain points which may indicate a somewhat greater age, *e.g.*, the high percentage of Equisetales, and the rather smaller percentage of Cycads, than is usual in Rhætic and Jurassic floras.

For convenience of reference and comparison, the following Table is quoted from Wieland :—*

TABLE ii. (after Wieland).
Elements of typical Rhætic-Oolitic Floræ.

	Graham Land, Mid-Jura.	Oroville, Oolite.	Yorkshire, Inferior Oolite.	Bornholm, Lias.	Rajmahal Hills, Lias.	Oaxaca, Lias to Rhætic.	Tonkin, Rhætic.
Ferns	42	46	37	35	32	18	48
Cycadeans	28	38	43	33 +	34 +	70	33
Conifers	27	12	16	17	8	(2)	9
Ginkgos	—	4		9	?	—	2
Cordaites	—	—	?	?	?	8	2
Equisetums	2	?	4	5	2	2	5·5

The flora of the Ipswich Series may now be examined in greater detail.

Equisetales.—The percentage of Equisetales in the Ipswich flora is unusually high for a Mesozoic flora. As I have already pointed out,† they show affinities with the Equisetales of Rhætic floras. *Neocalamites hœrensis* occurs in the Rhætic of Sweden, and *Neocalamites Carrerei* in the Rhætic of Tonkin, and in the Stormberg flora (Molteno Beds) of South Africa. *Phyllotheca australis* is one of the few species which continue from the Palæozoic into the Mesozoic in Australia, occurring in the Permian (Permo-Carboniferous) of Eastern Australia, and also in

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* Amer. Journ. Sci., xxxvi. (1913), p.272.

† Queensland Geol. Surv., Publication No.252, p.38.

the Wianamatta Stage of the Hawkesbury Series of New South Wales. *Schizoneura africana* occurs in the Beaufort Series in South Africa (Permian), and, according to Seward, is related to *S. gondwanensis* from the Talchir, Damuda, and Panchet Series (Permian and Lower Triassic) of India. The remaining species, *Equisetites rotiferum*, is a widespread type, and very similar forms are widely distributed in both Rhætic and Jurassic strata.

Filicales.—A majority of the true ferns of the Ipswich Series indicate a Rhætic or possibly greater age for the flora. Sterile *Cladophlebis*-fronds of the *C. australis* type are of very widespread occurrence in rocks varying in age from Rhætic to Middle Jurassic. *Cladophlebis Roylei* is a somewhat older type, occurring in the Raniganj Series (Upper Permian) of India. *Dictyophyllum rugosum* is a fairly widespread Jurassic (Lower Oolite) species, but there is so little difference between it and species of *Dictyophyllum* in Rhætic floras, that it cannot be regarded as a reliable indicator of age. The species of *Thinnfeldia* in the Australian Lower Mesozoic rocks do not appear to be represented in the Northern Hemisphere. The three species, *T. Feistmanteli*, *T. odontopteroides*, and *T. lancifolia*, are present in the Molteno Beds in South Africa; and *T. odontopteroides* and *T. lancifolia* in the Mesozoic flora in Argentina. *Danæopsis Hughesi* is a Rhætic or older form, occurring in the Rhætic Beds of Tonkin, the Burghersdorp Beds of South Africa (Triassic), and the Middle Gondwanas of India (Triassic). *Sagenopteris rhoifolia* is itself a Rhætic species, but it is at times difficult to distinguish between it and *S. Phillipsi*, a common Jurassic form.

Ginkgoales.—The Ginkgoales are represented by a comparatively large number of species, and, in addition, they are also relatively abundant as regards numbers of individuals. *Ginkgo antarctica* occurs in the Lower Mesozoic rocks in New South Wales, but there is no record of its exact locality or horizon. *G. digitata* is a very variable form met with in both Rhætic and Jurassic rocks. *G. magnifolia* occurs in the Jurassic strata of Oregon, and also bears some slight resemblance to *Baiera stormbergensis* from the Stormberg flora of South Africa. *Baiera bidens* is a very common type, and is similar to species which are abundant in both Rhætic and Jurassic rocks. *B. ipsviciensis* may be compared with *B. multifida*, occurring in the Rhætic of North America; and *B. Simmondsi* also occurs in the Wianamatta Stage of the Hawkesbury Series of New South Wales. *Stachyopitys annularioides* is a very similar type to specimens referred to as *Stachyopitys* sp., in the Stormberg flora of South Africa, and also to *Sphenolepis rhætica* from the Rhætic of San Juan (Argentine).

Cycadophyta.—The percentage of species of this group is unusually small in the Ipswich Series. Should the genus *Tæniopteris* ultimately prove to be a cycad, however, the percentage of cycads in the Ipswich flora would be a normal one for early Mesozoic floras. The specimen showing expanded bracts, referred to *Bennettites* (*Williamsonia*) sp., cannot be regarded as indicating any special age, as it agrees with similar specimens from the Mixteca-Alta flora of Mexico (Rhætic-Liassic), and also with *B. Carruthersi* from the Wealden of England. *Pterophyllum multilineatum* occurs in the Rhætic of Tonkin, and similar species are found in the Burghersdorp Beds of South Africa.

Genera incertæ sedis.—The species of *Sphenopteris* do not offer any evidence as to the age of the Series. Species of *Tæniopteris* are not usually to be regarded as reliable indicators of geological age. Of the species in the Ipswich Series, some appear to be confined to Australia, while others of them occur in South Africa and India. *T. Tenison-Woodsi* and *T. Carruthersi* are found in the Stormberg flora (Molteno Beds), and the latter also in the Burghersdorp Beds in South Africa; *T. crassinervis* occurs in the Rajmahal Series (Lias) of India. *Stenopteris elongata* occurs also in the Stormberg flora of South Africa.

The accompanying Table (Table iii.) shows the relationships of the species of the Ipswich flora to species in other floras. The Table is arranged in four columns, column 1 showing the species with affinity to species older than Rhætic, column 3 those with affinity to species in Rhætic floras, and column 4 those of Jurassic affinity. The Stormberg flora of South Africa is so similar in general appearance, that the species common to the two are grouped separately in column 2.

TABLE iii.

The flora of the Ipswich Series, arranged to show the relation of the species to those of other floras.

1	2	3	4
Species with affinity to species occurring in beds older than Rhætic.	Species identical with, or closely allied to, species occurring in the Stormberg flora (South Africa)	Species identical with, or closely allied to, species occurring in strata regarded as Rhætic.	Species with affinity to species in Jurassic floras.
Phyllotheca australis (Permo-Carb.)	*Neocalamites Carrerei*	*Equisetites rotiferum*	*Equisetites rotiferum* (*E. columnaris*, M. Jur.)
Schizoneura cf. *africana* (Permian)	*Thinnfeldia Feistmanteli*	*Neocalamites hœrensis* (Sweden)	*Cladophlebis australis*
Cladophlebis Roylei (Upper Permian, India)	*T. lancifolia*	*N. Carrerei* (Tonkin)	*Dictyophyllum rugosum*
Danæopsis Hughesi (Burghersdorp Beds, S. Africa; Middle Gondwana, India)	*T. odontopteroides*	*Cladophlebis australis*	*Tæniopteris crassinervis* (Rajmahal, Lias)
Tæniopteris Carruthersi (Burghersdorp Beds)	*Tæniopteris Carruthersi*	*Danæopsis Hughesi* (Tonkin)	*Ginkgo digitata*
Pterophyllum multilineatum (Burghersdorp Beds)	*T. Tenison-Woodsi*	*Sagenopteris rhoifolia*	*G. magnifolia*
	Stenopteris elongata	*Ginkgo digitata*	*Baiera bidens*
	Ginkgo magnifolia (=?*B. stormbergensis*)	*Baiera bidens*	
	Stachyopitys annularioides (*S.* sp.)	*B. ipsviciensis* (*B. multifida*, North America)	
		Pterophyllum multilineatum (Tonkin)	

This Table at once shows that the flora of the Ipswich Series is of a facies at least as old as Rhætic. In addition to the species occurring in Rhætic floras, there are also a number of species which occur in other parts of the world in rocks older than Rhætic. The number of species in the Ipswich flora, which represent Jurassic types, is not large, and nearly all of these are examples of species in which it is often difficult to find satisfactory distinctions between Rhætic and Jurassic species. The only two species of the Ipswich flora, which are characteristic of Jurassic rocks, are *Tæniopteris crassinervis* and *Ginkgo magnifolia*; and, regarding the latter of these, I have a slight doubt as to the determination in the Ipswich Series

Of twenty-two species in this Table, eighteen occur in Rhætic floras, six occur in floras older than Rhætic, and seven in Jurassic floras, only two of the latter, however, being characteristic of Jurassic floras.

The Table, together with the foregoing discussion, shows fairly conclusively that the flora of the Ipswich Series must be regarded as at least as old as Rhætic, and probably somewhat older.

(*b*) *Walloon Series.*—The flora of the Walloon Series comprises the following species :—

EQUISETALES.
    Equisetites rotiferum Tenison-Woods.
    Equisetites cf. *rajmahalensis* Oldham and Morris.
    Schizoneura sp.*a* Seward.
    Schizoneura sp.

FILICALES.
  (?)Osmundaceæ.
    Cladophlebis australis (Morris).
    C. Roylei Arber.
  (?)Matonineæ.
    Phlebopteris alethopteroides Etheridge Jr.
  Dipteridinæ.
    Dictyophyllum rugosum(?) Lindley and Hutton.
    D. Davidi Walkom.
    Hausmannia(?) *Buchii* (Andræ).

Thinnfeldieæ.
Thinnfeldia Feistmanteli Johnston.
Th. odontopteroides (Morris).
Th. lancifolia (Morris).
(?)Hydropterideæ.
Sagenopteris rhoifolia (Presl).
GENERA INCERTÆ SEDIS.
Sphenopteris superba Shirley.
Stenopteris elongata (Carruthers).
Phyllopteris Feistmanteli Etheridge Jr.
Tæniopteris spatulata McClelland.
T. spatulata var. *major* Seward.
T. Tenison-Woodsi Etheridge Jr.
T. Carruthersi Tenison-Woods.
T. lentriculiforme (Etheridge Jr.).
T. crassinervis (Feistmantel).
GINKGOALES.
Ginkgo magnifolia Fontaine.
Baiera Simmondsi Shirley.
CYCADOPHYTA.
Bennettitales.
Ptilophyllum (*Williamsonia*) *pecten* (Phillips).
CYCADOPHYTA INCERTÆ SEDIS.
Pterophyllum abnorme Etheridge Jr.
P. contiguum Schenk.
P. Nathorsti (Seward).
Pseudoctenis eathiensis (Richards).
Otozamites queenslandi Walkom.
O. obtusus (Lindley and Hutton).
O. Feistmanteli Zigno.
O. Mandelslohi Kurr.
CONIFERALES.
Araucarites polycarpa (Tenison-Woods)
Brachyphyllum crassum Tenison-Woods
Taxites planus Feistmantel.
GENUS INCERTÆ SEDIS.
Phœnicopsis elongatus(?) (Morris).

The outstanding feature of this flora is the large increase in the number of cycads. Other noticeable points are the decided decrease in the number of species of Ginkgoales, and the presence of a few Conifers.

Arranged in tabular form, and omitting from the Table *Schizoneura* sp., which may possibly be the external casts of which *S.* sp. *a* is the pith-cast, and also *Phœnicopsis elongatus*, whose position is quite unknown, the following result is obtained.

TABLE IV.

———	1 No. of species.	2 %	3 %	4 %
Equisetales	3	8	8	8
Filicales	10	28	53	36
Filicales incertæ sedis ...	3	8		
Tæniopteris	6	17		42
Cycadophyta	9	25	25	
Ginkgoales	2	6	6	6
Coniferales	3	8	8	8
Total	36			

This Table shows distinct differences from that of the Ipswich flora (Table i., p.66), and when, as in column 4, the species of *Tæniopteris* are combined with the Cycads, the percentages agree quite well with the percentages in Jurassic floras, particularly with the Lower Oolite flora of Yorkshire (*see* Table ii., p.67).

The flora of the Walloon Series may now be discussed in more detail.

Equisetales.—Members of this group are not of uncommon occurrence in the Walloon Series. *Equisetites rotiferum* is almost indistinguishable from the widely spread *E. columnaris* of Middle Jurassic floras, and *Equisetites* cf. *rajmahalensis* is closely comparable with the species in the Liassic flora of India. *Schizoneura* sp. *a* is identified with the species described from the Stormberg Beds of South Africa. Pith-casts of Equisetales, however, cannot be regarded as of any value in differentiating between Rhætic and Jurassic floras.

Filicales.—The ferns, although not particularly numerous, have the general appearance of a Jurassic flora. *Cladophlebis australis*, as already stated, is a type of frond of widespread occurrence, but is specially close to the *C. denticulata*-type, a widespread Jurassic form. *Phlebopteris alethopteroides* is, in all probability, very closely allied to *Laccopteris polypodioides* from the European Lower Oolite, though there appears to be a difference in the venation. *Dictyophyllum rugosum* is a Jurassic type, but its occurrence in the Walloon Series is doubtful. *Hausmannia Buchii*, with which some specimens from the Walloon Series have been compared, occurs in Jurassic floras of both Liassic and Kimeridgean age. *Sagenopteris rhoifolia*, though itself a Rhætic species, is, at times, indistinguishable from the Jurassic *S. Phillipsi.* The species of *Thinnfeldia*, and *Stenopteris elongata* in the Walloon Series are survivals from the Ipswich flora. The survival of a number of species from the Ipswich flora to the Walloon flora, and even to later floras, in Queensland is to be expected, since there were no violent earth-movements during these times, and no marked changes are known, which might have been expected to lead to any unusual dying out of the older flora. It is indeed fortunate, for stratigraphical study, that there are so many forms in the Ipswich Series, which apparently have not survived into the Walloon Series.

Ginkgoales.—There has been a remarkable change in the number of members of this group. In the Ipswich Series, we have at least seven species represented, while, in the Walloon Series, there are only so far two. *Ginkgo magnifolia* is probably identical with Fontaine's *G. Huttoni* var. *magnifolia* from the Jurassic of Oregon. The other species, *Baiera Simmondsi*, is another survival from the Ipswich Epoch.

Cycadophyta.—Cycads form the most prominent element of the Walloon flora, in which they are present to the extent of at least 25 per cent. of the species, and, perhaps, (if *Tæniopteris* is a Cycad) 42 per cent. On the whole, they indicate very distinctly the aspect of a Jurassic flora. *Ptilophyllum* (*Williamsonia*) *pecten* is a very widespread type in Jurassic (Oolite) floras. Up to the present, there is no indication of any Williamsonia-flowers associated with these sterile fronds of *Ptilophyllum pecten*. *Pterophyllum Nathorsti* occurs in the Jurassic of Sutherland, Scotland, and very similar forms occur in the Jurassic of Oregon; *Pterophyllum contiguum* occurs in the Jurassic of Oregon, and also in the Rhætic of Tonkin. *Pseudoctenis eathiensis* is practically identical with specimens from the Jurassic of Yorkshire and Sutherland. The three species of *Otozamites*, *O. obtusus*, *O Feistmanteli*, and *O. Mandelslohi* are species occurring widely in Jurassic rocks, and *O. Mandelslohi* occurs in the Mixteca-Alta flora of Mexico.

Coniferales.—Remains of Conifers are not abundant in the Walloon Series. Cones have been described, and referred to the genus *Araucarites*, indicating that they are similar in general to cones of the present-day *Araucaria*. A few fragments have been referred to the genus *Brachyphyllum*, and some specimens to *Taxites*. The specimens referred to *Taxites planus* show a very close resemblance to, and are probably identical with, that species, as described from the Upper Gondwana Beds (Liassic) on the Madras coast of India. Similar forms to *Brachyphyllum crassum* occur in the English Jurassic floras.

The accompanying Table (Table v.) shows the flora of the Walloon Series arranged in two columns, column 1 including those species comparable with species occurring in beds older than Jurassic, and column 2 those comparable with Jurassic species.

TABLE V.

Flora of Walloon Series, showing affinities of species with regard to age.

1 Species with affinity to Species older than Jurassic.	2 Species with affinity to Jurassic Species.
Equisetites rotiferum	*Equisetites rotiferum* (M. Jur.)
Schizoneura sp. *a*	*E.* cf. *rajmahalensis* (Liassic)
Cladophlebis australis	*Cladophlebis australis* (L. Oolite)
C. Roylei	*Phlebopteris alethopteroides* (L. Oolite)
Thinnfeldia Feistmanteli	*Dictyophyllum rugosum* (L. Oolite)
Th. odontopteroides	*Hausmannia* (?) *Buchii* (Liassic; Kimeridge)
Th. lancifolia	*Sagenopteris rhoifolia* (*S. Phillipsi*; Oolite)

Table v.—*(continued).*

1	2
Species with affinity to Species older than Jurassic.	Species with affinity to Jurassic Species.
Sagenopteris rhoifolia	*Phyllopteris Feistmanteli*
Stenopteris elongata	*Tæniopteris spatulata* (Lias)
Tæniopteris Tenison-Woodsi	*T. spatulata* var. *major*
T. Carruthersi	*T. crassinervis* (Lias)
Ginkgo magnifolia	*Ginkgo magnifolia* (Jurassic of Oregon)
Baiera Simmondsi	*Ptilophyllum* (*Williamsonia*) *pecten* (Oolite)
Pterophyllum contiguum	*Pterophyllum contiguum* (Jurassic of Oregon)
Otozamites Mandelslohi	*P. Nathorsti* (Kimeridge)
	Pseudoctenis eathiensis (Kimeridge)
	Otozamites obtusus (L. Oolite)
	O. Feistmanteli (L. Oolite)
	O. Mandelslohi (Lias)
	Brachyphyllum crassum
	Taxites planus (Lias)

The ages of the species, or of very closely related species, in column 2 are indicated in brackets after each one.

Examining this Table, we find that, excluding the six species common to the two lists, there are nine species with affinities to species older than Jurassic, and fifteen species with Jurassic affinities. Of the nine species regarded as older than Jurassic, eight occur also in the Ipswich Series, and are the species which survived from the Ipswich to the Walloon Epoch; there is only a single species (and that an equisetaceous pith-cast, *Schizoneura* sp.*a*) which could be considered as an argument in favour of an age older than Jurassic for the Walloon Series; whereas there are fifteen species characteristic of Jurassic floras, which appear in the Walloon Series, and were not present in the Ipswich Series. No other conclusion, then, seems possible, than that the flora of the Walloon Series indicates that the Series is homotaxial with strata of Jurassic age, and the greater number of species (*see* Table v.) indicate a lower Jurassic age, Liassic or Lower Oolite. It is possible that the Walloon Series represents deposition over a period covering both the Liassic and Lower Oolite of Europe.

(c) *Comparison of floras of the Ipswich and Walloon Series.*—We are now in a position to compare the floras of the Ipswich and Walloon Series. As a result of all previous examinations of these floras, it has been observed that there was no palæontological distinction between the floras of the two Series; *e.g.*, Mr. Cameron states :* "It does not, however, seem possible to draw any distinction between the formations from palæontological evidence, most of the fossils as yet found in the Walloon Beds occurring also in the Ipswich Beds."

The failure to note palæontological distinction between the two has been due, however, to imperfect collecting, and to the fact that the material available has not been thoroughly examined since the examination by Mr. Etheridge, prior to the publication of the "Geology and Palæontology of Queensland and New Guinea," in 1892. In 1898, Dr. Shirley examined and described a number of specimens, but all the Lower Mesozoic specimens among them were from the Ipswich Series. The same author, in 1902 recorded a few more specimens from the Ipswich Series, and some from the Stewart's Creek Beds (of Walloon age). At the time of these publications, however, there was no subdivision of the Ipswich Formation into Ipswich, Bundamba, and Walloon Series, so it is not remarkable that no distinction of horizons was noted in the upper and lower portions of the Formation.

A glance at the following Tables (Tables vi. and vii.) at once shows that there are points in which the two Series can be distinctly separated, and that there are a number of species characteristic of each. These species, characteristic of only one Series, are the more important ones from a stratigraphical point of view, and the finding of some of them may, in the future, be used for fixing the age of the strata in which they occur.

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* Queensland Geol. Surv., Publication No.204, p.16.

Table vi.

	Ipswich Series. No. of species.	Walloon Series. No. of species.
Equisetales	5	3
Filicales	10	10
Genera incertæ sedis—		
a, probably Filicales ...	3	3
b, Tæniopteris	6	6
Cycadophyta...	2	9
Ginkgoales	7	2
Coniferales	0	3
	33	36

Table vii.

Table showing distribution in Queensland of the Species of Fossil Plants in the Lower Mesozoic rocks.

	Ipswich Series.	Walloon Series.							
		S.E. Queensland.	Darling Downs.	Roma District.	Upper Brisbane R. (Esk, &c.).	Tiaro Series.	Stanwell-Wycarbah.	Callide Creek.	Laura Coalfield.
Equisetales.									
Equisetites rotiferum ...	×	×		×					(?)
E. cf. *rajmahalensis* ...							×		
Phyllotheca australis ...	×								
Neocalamites hærensis ...	×								
N. cf. *Carrerei*	×								
Schizoneura cf. *africana* ...	×								
Schizoneura sp. *a*		×			×				
Filicales.									
Cladophlebis australis ...	×	×	×	(?)	×	×	×		(?)
C. Roylei	×	×							
Coniopteris delicatula ...	×								
Phlebopteris alethopteroides ...		×	×						
Dictyophyllum rugosum ...	×			(?)	(?)				
D. Davidi					×				
Hausmannia Buchii(?) ...					×				
Thinnfeldia Feistmanteli ...	×				×			×	
Th. odontopteroides	×				×				
Th. lancifolia	×				×				
Th. acuta	×								
Danæopsis Hughesi	×								
Sagenopteris rhoifolia ...	×		×						
Genera of Ferns and Plants incertæ sedis.									
Sphenopteris lacunosa ..	×								

Table vii.—(*continued*).

		Walloon Series.							
	Ipswich Series	S.E. Queensland	Darling Downs.	Roma District.	Upper Brisbane R. (Esk, &c.).	Tiaro Series.	Stanwell-Wycarbah	Callide Creek.	Laura Coalfield.
Sphenopteris superba	×				(?)				
Stenopteris elongata	×				(?)				
Phyllopteris Feistmanteli ...				(?)			×		
Tæniopteris spatulata ...		×	×	×	×		×		
T. spatulata var. *major* ...		×			(?)		×		
T. Tenison-Woodsi	×				×		×		
T. Carruthersi	×				×		×		
T. lentriculiforme	×			(?)					
T. Dunstani	×								
T. wianamattæ	×								
T. crassinervis	×						×	×	
Ginkgoales.									
Ginkgo antarctica	×								
G. digitata	×								
G. cf. *magnifolia*	×				×				
Baiera Simmondsi	×				×				
B. bidens	×								
B. ipsviciensis	×								
B. ginkgoides	×								
(?)Ginkgoales.									
Stachyopitys annularioides ...	×								
S. Simmondsi	×								
Cycadophyta.									
Bennettites (*Williamsonia*) sp.	×								
Ptilophyllum (*Williamsonia*) *pecten*							×		
Pterophyllum abnorme ...					×				
Pt. contiguum					×				
Pt. multilineatum	×								
Pt. Nathorsti					×				
Pseudoctenis eathiensis ...					×				
Otozamites queenslandi ...					×				
O. obtusus		×							
O. Feistmanteli		×	×						
O. cf. *Mandelslohi*			×						
Coniferales.									
Araucarites polycarpa ...							×		
Brachyphyllum crassum ...		×	×	(?)					(?)
Taxites planus					×		×		(?)
Genus incertæ sedis.									
Phœnicopsis elongatus ...					×				
Gymnospermous seeds ...	×								

The marked difference between the two floras shows in the Gymnosperms. In the Equisetales and Filicales, there is little difference as regards number of species. Only two of the species of Equisetales, and seven of the Filicales, however, are common to the two Series; and, of the others, those in the Ipswich Series are of older type than those in the Walloon Series. When the Gymnosperms are examined, however, a marked distinction between the two Series is to be observed. Twenty-two species are described from the Lower Mesozoic rocks, and only two of these species are common to the Ipswich and Walloon Series. These two species are *Ginkgo* cf. *magnifolia* and *Baiera Simmondsi.* Ginkgoales are abundant, both as regards number of species and number of individuals, in the Ipswich Series, but are only poorly represented in both respects in the Walloon Series. Cycads are represented very sparsely, as regards number of species, in the Ipswich Series, whereas they constitute perhaps the most prominent feature of the Walloon flora, being very widespread in distribution and occurring in large numbers on some horizons. The species of *Otozamites* form one of the most characteristic and distinctive features of the Walloon Series. Up to the present, no Conifers are known from the Ipswich Series,* whilst there are three species representing three genera from the Walloon Series.

Table viii. shows the species occurring in Queensland, which are, so far as we know, found only in one Series of the Lower Mesozoic rocks.

Table viii.

Species known only in the Ipswich Series.	Species known only in the Walloon Series.
Phyllotheca australis	*Phlebopteris alethopteroides*
Neocalamites hœrensis	*Dictyophyllum Davidi*
N. cf. *Carrerei*	*Hausmannia*(?) *Buchii*
Schizoneura cf. *africana*	*Phyllopteris Feistmanteli*
Coniopteris delicatula	*Tæniopteris spatulata*
Thinnfeldia acuta	*T. spatulata* var. *major*
Danæopsis Hughesi	*Ptilophyllum* (*Williamsonia*) *pecten*
Sphenopteris lacunosa	*Pterophyllum abnorme*
Tæniopteris Dunstani	*P. contiguum*
T. wianamattæ	*P. Nathorsti*

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* See footnote on p. 65.

Table viii.—(*continued*)

Species known only in the Ipswich Series.	Species known only in the Walloon Series.
Ginkgo antarctica	*Pseudoctenis eathiensis*
G. digitata	*Otozamites queenslandi*
Baiera bidens	*O. obtusus*
B. ipsviciensis	*O. Feistmanteli*
B. ginkgoides	*O. Mandelslohi*
Stachyopitys annularioides	*Araucarites polycarpa*
S. Simmondsi	*Brachyphyllum crassum*
Bennettites (*Williamsonia*) sp.	*Taxites planus*
Pterophyllum multilineatum	*Phœnicopsis elongatus*
Gymnospermous seeds	

(*d*) *Age of the Queensland Lower Mesozoic Rocks.*—The evidence of the fossil floras of the Ipswich and Walloon Series is very strongly in favour of a Triassic Age for the former, and a Jurassic Age for the latter.

The flora of the Ipswich Series shows marked resemblance to floras which are regarded as Rhætic in age in other parts of the world, particularly those of Tonkin and South Africa. Regarding the actual position in the Geological Record of many of the occurrences classed as Rhætic from their fossil flora, I have received some interesting information from Dr. A. L. du Toit, of the South African Geological Survey.*

Dr. du Toit has come to the conclusion that some of the so-called Rhætic strata would be better placed in the Upper Trias (Keuper) than in the Rhætic. He includes among these the strata in South Africa, Tonkin, and Persia. In the case of South Africa, he finds this is borne out by an analysis of the vertebrate fauna of the Red beds and Cave sandstone overlying the Molteno Beds, which is of Triassic affinities. He concludes that *the flora of the Molteno Beds is of Keuper Age and not younger.*

The Ipswich flora is undoubtedly very similar to that of the Molteno Beds (see Table iii., column 2), but the finding of *Glossopteris* in the latter suggests that it is possibly slightly older than the Ipswich flora.

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* Letter dated 2nd December, 1916.

From the evidence available, we are justified in stating that the flora of the Ipswich Series indicates distinctly an Upper Triassic age, possibly Rhætic, but probably older.

The flora of the Walloon Series is decidedly of a Jurassic type, and the typical Jurassic forms in the Series seem to consist of about equal numbers of species characteristic of Liassic and Lower Oolitic strata. The Walloon Series is of very great thickness (probably of the order of 10,000 feet), and when it has been studied in greater detail, it seems quite probable that it may have to be subdivided into a number of stages. For the present, we may regard the Walloon Series as representing a portion of the Lower Jurassic System corresponding at least to the Lias and Lower Oolite.

It is very difficult to draw any reliable conclusion as to whether the Bundamba Series should be placed with the Ipswich Series in the Triassic, or with the Walloon Series in the Jurassic.

There is no fossil evidence which may be taken as a guide. Both Mr. Cameron and Mr. Dunstan have drawn my attention to the usual association of the Bundamba Series with the Ipswich Series, rather than with the Walloon Series; and, on this account, it is, for the present, tentatively placed in the Triassic System with the Ipswich Series.

CORRELATION OF THE LOWER MESOZOIC ROCKS OF QUEENSLAND WITH THOSE OF OTHER AREAS IN AUSTRALIA.

In considering the correlation of the Queensland Lower Mesozoic rocks with those of the other States, their relations with the States will be discussed separately in the first place, and then the results summarised by drawing up a table indicating the relative positions of the various occurrences.

(*a*) *New South Wales.*—In New South Wales, the strata of Lower Mesozoic age comprise (*a*) the Hawkesbury Series, including the Narrabeen Stage, Hawkesbury Sandstone Stage, and Wianamatta Stage, to which a Triassic age has generally been assigned; (*b*) the Talbragar Beds, the Clarence Series, and the Artesian Series, which have been regarded as of Trias-Jura age.

The Hawkesbury Series is divided into three Stages, viz.:—Narrabeen, Hawkesbury Sandstone, and Wianamatta. in ascending order. The Narrabeen Stage consists mainly of sandstones and shales, the Hawkesbury Stage of massive sandstones characterised by current-bedding, and the Wianamatta Stage mostly of shales.

This Series comprises a basin, and is apparently conformable, in the central portion of the basin, with the underlying Permian (Permo-Carboniferous) System; but, in the marginal areas, there is an overlap amounting to unconformity. The Hawkesbury Sandstone Stage rests conformably on the Narrabeen Stage, while the Wianamatta Stage occupies a slightly eroded basin in the Hawkesbury Sandstone.*

The Talbragar Beds cover only a small area, and occupy a basin eroded in the Hawkesbury Sandstone; and there is no doubt of an unconformity, stratigraphical as well as palæontological, between the Hawkesbury Sandstone and the Talbragar Beds.

The Clarence Series occurs in the north-east of New South Wales, between the New England Tableland and the coast; and, at its northern end, it is continuous with the Walloon Series of Queensland. Reference to the latest Geological Map of New South Wales shows that the Clarence Series is practically continuous with the Walloon Series in the neighbourhood of Mt. Lindsay, and also that, further west, it is continuous with the eastern branch of the belt of Walloon Series on the Darling Downs, extending through Warwick and Killarney to the border of New South Wales.

The Artesian Series of New South Wales exists on the western margin of the New England Tableland, and extends along the eastern margin of the Great Australian Artesian Basin. It is practically continuous into Queensland with the belt of Lower Mesozoic rocks extending past Warwick and Toowoomba. It is seen, then, that the Clarence Series and Artesian Series are each directly connected with the belt of Walloon Series in the Darling

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* See Carne, N.S.W. Handbook, B.A.A.S., 1914, pp.601-607.

Downs, and they must, therefore, be identified with one another as regards age, on the evidence of their field-occurrence alone.

Lithologically, the Clarence Series is divisible into three divisions, the middle one consisting of a series of massive sandstones. This lithological division led to a consideration of the possibility of the three stages being the equivalents of the Narrabeen, Hawkesbury Sandstone, and Wianamatta Stages of the Hawkesbury Series. Mr. Carne* has, however, shown, in a convincing manner, that this is not the case.

Another possibility that must be considered is, that the three stages of the Clarence Series might be the equivalents of the Ipswich, Bundamba, and Walloon Series of Queensland. Unfortunately, the Clarence Series has not been examined in great detail geologically, but the fact, that Carne indicates the presence of *Tæniopteris spatulata* [*T. Daintreei*] in the lower part of the Series,† is sufficient to render the correlation of any part of the Clarence Series with the Ipswich Series improbable. It is possible that the sandstones and conglomerates at the base of the Clarence Series may be the equivalents of the Bundamba, but, on the present evidence, I believe that the greater part of the Clarence Series (if not all of it) is to be correlated with the Walloon Series of Queensland.

Fossil plants are present in varying abundance in the various Lower Mesozoic Series of New South Wales. No thorough examination of the flora of the three Stages has been undertaken, and, therefore, the compilation of satisfactory lists of the floras of the different Series is not an easy matter. The following lists have been drawn up from descriptions and lists published from time to time, the majority of the determinations of New South Wales Mesozoic plants having been made by Messrs. R. Etheridge Junr., and W. S. Dun. Names included in square brackets in these lists are conclusions or comparisons suggested by myself to bring, where possible, the New South Wales determinations into line with my own work on the Queensland flora.

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* Carne, Mem. Geol. Surv. N.S. Wales, Geology, No.6, 1908, pp.31-40.

† Carne, *op. cit.*, p.34.

List of fossil plants recorded from the Lower Mesozoic rocks of New South Wales :—

i. HAWKESBURY SERIES.

(*a*) Narrabeen Stage.

Equisetum.
Phyllotheca.
Schizoneura australis.
Alethopteris sp.
Cladophlebis cf. *Roylei.*
Thinnfeldia narrabeenensis
T. lancifolia.
T. odontopteroides.
T. odontopteroides(Hawkesbury type) [= *T. Feistmanteli*].
Thinnfeldia, n.sp.
Sphenopteris sp.
Oleandridium[*Tæniopteris* sp.].
Macrotæniopteris [*Tæniopteris* sp.].
Tæniopteris cf. *McClellandi.*
Ginkgo dilatata var. *lata.*
Rhipidopsis ginkgoides var. *Sussmilchi.*
Araucarites (cones).
Brachyphyllum(?).

(*b*) Hawkesbury Sandstone Stage.

Ottelia præterita.
Phyllotheca concinna.
P. Hookeri.
Equisetum.
Alethopteris.
Thinnfeldia odontopteroides [*T. Feistmanteli*].
Macrotæniopteris.
M. wianamattæ.
Oleandridium lentriculiforme.

(*c*) Wianamatta Stage.

Phyllotheca Hookeri.
P. australis.
Thinnfeldia odontopteroides [*T. Feistmanteli* and *T. odontopteroides*].
Thinnfeldia, small var. *lancifolia*-type.
Cycadopteris scolopendrina.
Macrotæniopteris wianamattæ.
Sphenopteris
Pecopteris(?) *tenuifolia.*
Gleichenia dubia(?).
Alethopteris australis [*Cladophlebis australis*].
Baiera multifida[*B. Simmondsi*]
Pterophyllum(?).

ii. TALBRAGAR SERIES.

Thinnfeldia odontopteroides.
Thinnfeldia sp.
Neuropteridium australe.
Sphenopteris sp.
Tæniopteris Daintreei [*T. spatulata*].
Podozamites lanceolatus.
P. spathulatus.
P. longifolius.
Podozamites sp.
Taxites cf. *T. planus.*

iii. Clarence Series.

Alethopteris australis [*Cladophlebis australis*].
Thinnfeldia odontopteroides.
Sphenopteris.
Tæniopteris Daintreei [*T. spatulata*].
T. Tenison-Woodsi.

iv. Artesian Series.

Tæniopteris Daintreei [*T. spatulata*].
Thinnfeldia odontopteroides.
Baiera.

The plant to which special prominence has been given, in dealing with Australian Lower Mesozoic strata, is *Tæniopteris spatulata* [*T. Daintreei*]. This plant is of very widespread occurrence in Eastern Australia, and seems to be a reliable indicator of age. In Queensland, it is found abundantly in the Walloon Series, but not in the Ipswich Series. In New South Wales, it is found in the Clarence Series, Artesian Series, and Talbragar Series, but not in any stage of the Hawkesbury Series. There is no doubt of the identity of both the Clarence and Artesian Series with the Walloon Series, for they are continuous in the field. The Talbragar Series is unconformable on the Hawkesbury Sandstone, and the presence of *Tæniopteris spatulata* in the Talbragar Series indicates the relation of this Series to the Walloon Series; the occurrence of a *Taxites* comparable with *T. planus* is additional evidence for assigning the two Series to the same period.

The next point to be considered is the relation of the rocks of the Hawkesbury Series to the other Lower Mesozoic rocks. There is no doubt that the Hawkesbury Sandstone is older than the Talbragar Series, and, therefore, older than the Walloon Series. What then is the relation between the Ipswich Series and the Hawkesbury Series? In the following Table are included the species of plants in the stages of the Hawkesbury Series which are identical or closely comparable with species in the Ipswich Series, the allied species in the Ipswich Series being indicated in square brackets.

TABLE ix.

Table showing species in the Hawkesbury Series identical or closely comparable with species in the Ipswich Series.

Narrabeen Stage.	Hawkesbury Sandstone Stage.	Wianamatta Stage.
Thinnfeldia lancifolia *T. odontopteroides* *T. odontopteroides* (Hawkesbury type) [= *T. Feistmanteli*] *Cladophleiis* cf. *Roylei*	*Thinnfeldia odontopteroides* [= *T. Feistmanteli*] *Oleandridium* [*Tæniopteris*] *lentriculiforme* *Macrotæniopteris* [*Tæniopteris*] *wianamattæ*	*Phyllotheca australis* *Thinnfeldia odontopteroides* [− *T. odontopteroides* and *T. Feistmanteli*] *T. lancifolia* *Macrotæniopteris* [*Tæniopteris*] *wianamattæ* *Alethopteris* [*Cladophlebis*] *australis* *Baiera multifida* [*B. Simmondsi*] ?*Pterophyllum* (?) sp.

It must be admitted that the flora of the Hawkesbury Series has been but imperfectly determined, but what evidence there is, goes to show that the Ipswich flora is much more closely related to that of the Wianamatta Stage than to either the Hawkesbury Sandstone Stage or the Narrabeen Stage.

Having considered the evidence of the fossil plants, we may now briefly deal with the evidence provided by the other fossils in these Series.

The results so far published, of the examination of fossil insects* from the Ipswich Series and Wianamatta Stage, do not give promise of any special value from a stratigraphical point of view, though, no doubt, they are of interest to the entomologist. However, the fact that insects are found, more or less abundantly, in these two Series, and have not yet been discovered in the other Series of Lower Mesozoic rocks, with the exception of *Cicada* (?) *lowei* in the Talbragar Beds, is a point which must be taken into consideration when discussing the correlation of the Series. The insects in the Wianamatta Beds belong to the same Orders as some of those in the Ipswich Series, and, in one case, the same genus is present, but there is no specific identity.

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* Queensland Geol. Surv., Publication No.253.

One species of *Estheria* has been recorded from the Ipswich Series (*E. mangaliensis* Jones), and one from the Narrabeen Stage (*E. Coghlani* Cox). The two species are different, and the Ipswich species has been identified by Etheridge* with *E. mangaliensis* from the Damuda Beds (Permian) of India.

Two species of *Unio* (*U. ipsviciensis* and *U. eyrensis*) have been described from the Ipswich Series; and two species of *Unio* (*U. wianamattensis* and *U. Dunstani*) together with two species of *Unionella* (*U. bowralensis* and *U. Carnei*) from the Wianamatta Stage. They are the only pelecypods recorded from the Lower Mesozoic rocks of New South Wales and Queensland.

Fossil fish have been found somewhat abundantly on certain horizons of the Hawkesbury Series, and in the Talbragar Series; and have been described by Dr. A. Smith Woodward.†

From the Talbragar Series, seven species were described, all being new.‡ Regarding the age of this fish fauna, Woodward concludes (*op. cit.*, p.26) "The Talbragar fish-fauna is, therefore, probably not earlier than the Upper Lias, and may be referable to the Lower Oolites."

The results of his examination of the fossil fishes from Gosford and St. Peter's are remarkable. The Gosford horizon is about the junction of the Narrabeen and Hawkesbury Sandstone Stages, whereas the St. Peter's horizon is in the Wianamatta Stage, and is some 900 to 1,000 feet above the Gosford horizon. Regarding the fish-remains from Gosford, Woodward§ concludes: "So far as can be determined from the fishes, therefore, the Hawkesbury beds may be regarded as homotaxial with the Keuper of Europe, or, at latest, with the Rhætic; and, on the whole, the present writer is inclined to adopt the first of these interpretations."

In the case of the St. Peter's specimens, the fish were collected in two types of matrix, viz., an indurated shale or claystone, and a grey mudstone, the former occurring as several bands sepa-

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* Geology and Palæontology of Queensland, p.397.

† Mem. Geol. Surv. N. S. Wales, Palæontology, Nos 4, 9, 10.

‡ *Ibid.*, Palæontology, No.9.

§ *Ibid.*, p.55.

rated by the latter. Woodward refers to the fish from the indurated shale as indicating a distinct Permo-Carboniferous age, and those from the grey mudstone as Triassic or Rhætic.* Obviously, great caution must be exercised in using these results for the purpose of correlation.

(*b*) *Victoria.*—The Lower Mesozoic rocks of Victoria comprise series of shales, felspathic sandstones, and mudstones, with occasional conglomerates, which are developed in three areas, viz., South Gippsland, Cape Otway, and Wannon River. Associated with these rocks are coal-seams up to nine feet in thickness. Analyses of the coals are of the same general type as analyses of the Ipswich coals. The flora of some of these beds has been described by Seward,† whose conclusion regarding their age is, that they are approximately the same age as the Inferior Oolite of England, or the Rajmahal Series of India.‡ Occasional additions to the species described by Seward have been recorded by Chapman.

The following list comprises the species described by both Seward and Chapman :—

Marchantites sp.
β*Equisetites wonthaggiensis.*
Equisetites sp.
α*Lycopodites victoriæ.*
Adiantites lindsayoides.
α*Coniopteris hymenophylloides* var. *australica.*
Sphenopteris ampla.
Sphenopteris sp.
Tæniopteris Daintreei.
α*T. Daintreei* var. *major.*
β*T. spatulata* var. *crenata.*
α*Cladophlebis denticulata* var. *australis.*
β*Thinnfeldia odontopteroides.*
Thinnfeldia McCoyi.
Thinnfeldia sp.
Rhizomopteris Etheridgei.
β*Stenopteris elongata.*
β*Stenopteris* sp.
α*Ginkgo* sp.
α*Baiera australis.*
α*B. gracilis.*
Ginkgo (female flowers?).
α*Nilssonia* sp.
Podozamites Barklyi.
P. ellipticus.
β*P. Kidstoni.*
P. longifolius.
α*Araucarites* sp. A.

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* Mem. Geol. Surv. N. S. Wales, Palæontology, No. 10, pp. 27, 29.

† Rec. Geol. Surv. Victoria, Vol. i., Pt. 3, 1904.

‡ *Op. cit.*, p. 184.

Araucarites sp.B.
β*Conites* sp.
cf. *Brachyphyllum* sp
β*B. gippslandicum.*
α*Taxites* sp.
β*Palissya australis.*
β*Cheirolepis* (?) *setosus.*
β cf. *Albertia australis.*
Carpolithes sp.A.
Carpolithes sp.B.

The species marked β are recorded by Chapman, in addition to those described by Seward.

Of the species in this list, those marked with α (10 in number) are similar to types occurring in the Lower Oolite of England.

In the Victorian Lower Mesozoic rocks, a tooth and scales of *Ceratodus* have been found, and also a claw of a dinosaur. One species of *Unio* (*U. stirlingi*) occurs in these beds.

Although the number of species of plants common to the Victorian and Queensland Lower Mesozoic rocks is small, there is no doubt that the Victorian flora resembles the Walloon flora much more than it does the Ipswich flora. A few species, *e.g.*, *Tæniopteris Daintreei* (= *T. spatulata*), *T. Daintreei* var. *major*, and *Cladophlebis denticulata* var. *australis* (= *C. australis*) are identical with forms of the Walloon Series; while others, as *Sphenopteris ampla*, *Baiera gracilis*, cf. *Brachyphyllum* sp., and *Taxites* sp., are closely allied to forms found in the Walloon Series. The occurrence of *Tæniopteris spatulata* and the conifers, *Araucarites*, *Brachyphyllum*, and *Taxites* is sufficient to show clearly, that this flora is not to be compared with that of the Ipswich Series. There appears to be no doubt that the Victorian Mesozoic Coal-Measures are to be correlated with the Walloon Series in Queensland, and its equivalents in New South Wales.

(c) *South Australia.*—In South Australia, the strata of Lower Mesozoic Age comprise the south-western margin of the Great Australian Artesian Basin, and an outlier of this preserved as a faulted basin in the neighbourhood of Leigh's Creek. The Leigh's Creek basin is quite isolated, and surrounded by rocks of Upper Cambrian Age; the basin is 16 miles long, and has a maximum breadth of 6 miles; the total thickness of strata in it exceeds 2,000 feet of shales and carbonaceous shale, with bands of limestone and sandstone, and a belt of very hydrous coal, 48 feet thick.

Recent developments in Queensland show that large areas of sandstone on the margin of the Artesian Basin, which have previously been regarded as of Cretaceous Age, must now be considered as equivalents of the Walloon Series. Future work may show that the marginal portions of the Artesian Basin in South Australia represent the same sandstones, though these are all at present mapped as Cretaceous. Near the margins of the basin, the water-bearing sandstones obviously approach close to the surface, as shown from bore-records, and it seems more probable that they outcrop, than that they are overlapped by the Cretaceous.

The fossil plants recorded from the South Australian Lower Mesozoic rocks are:—

Thinnfeldia odontopteroides
  [? = *T. Feistmanteli*].
T. media [? *T. lancifolia*].
Macrotæniopteris wianamattæ.
Tæniopteris fluctuans.
Alethopteris sp.
Equisetum 2 spp.
Frenelopsis(?).
Anthrophyopsis(?) sp.ind.

Phyllopteris Feistmanteli occurs at Ooroowilanie Swamp, about 100 miles north of Leigh's Creek, but this may be in the Cretaceous rocks. This list has been drawn up by Howchin,* mainly from determinations by Etheridge. *Unio eyrensis* also occurs abundantly in the same rocks.

This list of plants does not provide any very conclusive evidence regarding correlation with other Australian strata. There seems no reason for not considering the Leigh's Creek basin as an outlier of the Artesian Series; and, further, the identity of the Artesian Series with that of New South Wales and the Walloon Series in Queensland is hardly open to question.

(*d*) *Western Australia.*—Western Australia provides the only Australian example of marine and freshwater fossils of Lower Mesozoic Age occurring in association with one another. The exact relation which the plant-bearing beds bear to those with marine fossils is not clearly stated, but it may be inferred from a study of Bulletins 36, 38, and 50 of the Geological Survey of Western Australia.

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* British Assoc. Adv. of Science: Handbook of South Australia, 1914, p.225.

The marine fossils fix the age of the Lower Mesozoic of Western Australia as Jurassic, and Etheridge refers those from the Greenough River to the Oolite.* The Jurassic rocks cover a large area in the Champion Bay district, near Geraldton, particularly between the Greenough and Irwin Rivers. According to Gibb Maitland, they consist of "oolitic limestones, clays, sandstones (which are often ferruginous), grits, conglomerates, and lignites."† They are horizontal or gently undulating, and their thickness has been proved to the extent of 2,000 feet, by bores in the Champion Bay district.

From these rocks, Arber‡ has described *Otozamites Feistmanteli*, and a coniferous fragment from near Minginew; and he has pointed out the resemblance of these to fossils from Talgai, Darling Downs, and Rosewood, west of Rockhampton in Queensland.

Examples of fossil plants in close association with marine fossils are noted by Campbell.§ Speaking of Mt. Hill,|| he says, "Fossil stems of a plant, apparently a species of Equisetaceæ, and Palm or *Otozamites* stem-scales and pieces of wood occur in the sandstones and grits of the north side."

"A limestone band occurs at about 100 feet below the summit of the hill, and can be well seen on the fence-line, 10 chains west of the summit. Here, numerous Jurassic fossils occur in an excellent state of preservation. On the ridge, also, extending north from the summit, there is a fossiliferous, fine-grained sandstone."

The results of Dr. Arber's examination of the plants from Minginew were apparently available to Mr. Campbell, since he quotes (p.58) Arber's conclusions, so it may be presumed that the plants from Mt. Hill are similar to those from Minginew. On Plate 5 of the same work, in the vertical section of the Don-

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* Geol. Surv. West Australia, Bulletin 36.

† Geol. Surv. West Australia, Bulletin 50, p.21.

‡ *Ibid.*, Bulletin 36, p.25.

§ *Ibid.*, Bulletin 38.

|| *Op. cit.*, p.60.

gara bore, "fossils" are indicated in shale at 535 feet, and "plant-remains" at about 1,300 feet.

Although the information is scanty, it may be concluded that comparatively flat-bedded rocks of Jurassic Age, and of considerable thickness, cover a large area in Western Australia; that these beds contain both marine and plant-fossils, and that the plant-fossils include equisetaceous stems, *Otozamites* and coniferous fragments, and also petrified, coniferous wood.

Where definite evidence for accurate correlation is scanty, as in the present case, all possible indications must be considered; and, at the same time, caution must be exercised in drawing conclusions. In comparing these Western Australian Jurassic rocks with the Lower Mesozoic strata of Queensland, the following points stand out.—(*a*) In the Western Australian Jurassic, the only definitely determined plant is *Otozamites Feistmanteli*, which occurs in a fine-grained, ferruginous sandstone, possibly of Oolite age; (*b*) in Queensland, fossil plants are abundant in the Lower Mesozoic strata, but the genus *Otozamites* occurs only in the Walloon Series, and usually in a fine-grained, ferruginous sandstone, which is of very wide occurrence;* (*c*) the species *Otozamites Feistmanteli* occurs both in the Western Australian Jurassic and in the Queensland Walloon Series.

The indications, then, point to the probability that the Walloon Series is homotaxial with the Jurassic strata of Western Australia. If, as the author believes, the development of the fine-grained, ferruginous sandstone containing *Otozamites Feistmanteli* indicates peculiar conditions under which deposition took place, then there is the further indication that the two Series are synchronous.

(*e*) *Tasmania.*—A rich, Lower Mesozoic flora is present in the strata of that age in Tasmania. This flora, however, has been untouched for many years, and the existing descriptions and figures by Johnston are too imperfect to be used for any purpose of definite correlation. In addition, Mr. Twelvetrees, Government Geologist of Tasmania, kindly informed me that the rela-

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* See above, p.50.

tions of the Lower Mesozoic strata in Tasmania to one another are not yet definitely settled. No attempt will be made here, therefore, to correlate any of the Tasmanian Lower Mesozoic rocks with the other Australian occurrences. One point may be noted. There appears to be an absence of *Tæniopteris spatulata* in the Tasmanian strata, and this may indicate that they are older than Jurassic.

Opinions have been expressed regarding the age of Tasmanian strata. Chapman* suggests that it may be possible to divide the "Upper Coal-Measures" of Twelvetrees into an older and a younger series. He concludes, "The Jurassic flora of the Tasmanian localities, Jerusalem, Fingal, Spring Hill, York Plain, Hamilton, Richmond, New Farm, Sandfly, Recherche, South Cape, Longford, etc., appears to contain an assemblage which, with some few exceptions, as *Sagenopteris* and *Phœnicopsis*, is practically identical with that of the plant-bearing strata of Jurassic age in South Gippsland, Cape Otway, and Western Victoria"

Professor David† classes them provisionally "as Upper Trias or Passage Beds into the Jurassic proper," whereas W. S. Dun‡ regards them as equivalents of the Victorian Jurassic.

Mr. Twelvetrees points out that the evidence of the fossil flora in Tasmania, as far as it goes, is slightly in favour of a Rhætic age. He also considers that some of the Tasmanian occurrences are the equivalents of the Clarence and Talbragar Series in New South Wales.§

Lower Mesozoic fossil plants are known from a number of localities in New Zealand, but, in view of the fact that an examination of them has recently been carried out by Dr. E. A. Newell Arber (the results not having been published yet||), it is deemed inadvisable to discuss them at this stage.

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* Records Geol. Surv. Victoria, iii., Pt.2, 1912, p.223.

† British Assocn. Adv. Science, Geology of the Commonwealth, p.277.

‡ *Ibid.*, p.297.

§ Geol. Surv. Tasmania, Bulletin 20, 1915, pp.14-16.

|| Issued in February, 1918, too late for consideration in the present paper.

(f) Summary. – The results of these comparisons of the Queensland, Lower Mesozoic rocks with those of the other Australian States, may be summarised in tabular form thus :—

TABLE X.

Table showing correlation of the Lower Mesozoic Strata of Australia.

	Queensland.	New South Wales.	Victoria.	S. Australia.	W. Australia.	Tasmania.
Jurassic (Lias-Lower Oolite)	Walloon Series	= Clarence Series Artesian Series Talbragar Beds	= Jurassic of S. Gippsland, Cape Otway, and Wannon River.	= Leigh's Ck. Basin.	= Marine strata in Geraldton, Champion Bay, and (?) C. Riche Districts.	Possibly there are representatives of both Jurassic and Triassic in the Lower Mesozoic of Tasmania.
Triassic (Rhætic or Upper Triassic)	Bundamba Series					
	Ipswich Series	Wianamatta Beds				
?Lower Triassic		Hawkesbury Sandstone				
		Narrabeen Beds				

GEOLOGICAL HISTORY.

In discussing the conditions which existed during Lower Mesozoic times in Queensland, reference must be made to the conditions, as far as we know them, towards the close of the preceding Permian (Permo-Carboniferous) Period. The latest sediments of this latter period are the Upper Coal-Measures in both New South Wales and Queensland. In New South Wales, the Newcastle or Upper Coal-Measures were formed in a large basin. In an earlier paper,* I have attempted to show, in a general way, the distribution of land and sea in New South Wales during the various stages of the Permian (Permo-Carboniferous)† Period, and have suggested that the successive stages within the period might have been produced by a tangential force acting towards the continental mass of Australia in a W. by S. direction.

The close of the Palæozoic era in Northern New South Wales and Southern Queensland was accompanied by extensive intrusions of granitic masses. In the New England and Stanthorpe-Warwick districts, these intrusions have resulted in extreme folding of the Permian (Permo-Carboniferous) strata, but have not affected the sediments of the Walloon epoch. The age of the intrusions is definitely between the upper marine sediments of the Permian System and the Walloon Series. The Permian (Permo-Carboniferous) sedimentary strata have been extremely folded and contorted, and converted into slates resembling, in general appearance, rocks of greater age than Permian; their age, however, has been fixed beyond doubt by the occurrence in them of marine fossils in the Drake district, and near Warwick.‡

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* Proc. Linn. Soc. N. S. Wales, 1913, xxxviii., pp.139-145.

† It has recently been suggested by Professor David and Mr. W. S. Dun (British Assocn. Adv. Sci., Australia, 1914: Report, p.379; and Federal Handbook on Australia, p.267) that perhaps the term Permo-Carboniferous in Australia should be replaced by the term Permian. Without going into reasons here, it may be stated that the author is entirely in accord with the suggestion, and, for the purposes of this paper, proposes to write the name thus: Permian (Permo-Carboniferous).

‡ Andrews, "Report on Drake Gold and Copper Field," Geol. Surv. N. S. Wales, Mineral Resources, No.12, 1908.

Further north, in the Gympie district, rocks of similar age are also folded and metamorphosed to much the same extent as in the districts just mentioned.

A word of caution must be expressed here regarding the so-called "Gympie" strata. The results of fieldwork carried out by the officers of the Queensland Geological Survey tend to show that many rocks have, in the past, been referred to the Gympie Series without sufficient evidence; these are gradually being sorted out by the Geological Survey, and put in their proper position; and they have been found to include representatives of the Carboniferous and Devonian Systems, in addition to true Permian (Permo-Carboniferous) strata. Care must be exercised, therefore, when dealing with rocks classed as Gympie.

In the Gympie district, where undoubtedly Permian (Permo-Carboniferous) sedimentaries are much altered, there are granitic, intrusive masses whose age is not directly determinable. It seems a reasonable suggestion that they are of similar age to the New England intrusions, and that they have been responsible (at least in part) for the folded and altered condition of the Gympie rocks.

Further north and north-west in Queensland, the Permian (Permo-Carboniferous) rocks [Bowen River coalfield, Dawson-Mackenzie coalfield, etc.] appear to be normal, and not to have suffered any considerable folding as the result of the intrusion of large plutonic masses.

In the distribution of the Permian (Permo-Carboniferous) rocks of New South Wales and Queensland, then, there are to be noted the following important points. Sediments of this age are known from Southern New South Wales to Northern Queensland; normally, these sediments are unaltered, and apparently have not been subject to extreme folding-forces; in the central part, however, (from New England to the Gympie district) the intrusion of extensive, granitic masses has resulted in extreme folding and metamorphism of sediments of this age, which, as a result, resemble strata of much greater age than the normal Permian (Permo-Carboniferous) strata of Eastern Australia.

These extensive intrusions probably resulted in the elevation of the areas affected, to a much greater altitude than the neighbouring areas.

The Lower Mesozoic rocks of Eastern Australia appear to have been deposited in a series of basins, which were not all developed at the one time. The sediments deposited in these basins are, with a single exception (*supra*, p.38), freshwater accumulations, and this fact tends to show that the basins must have had some outlet; otherwise, the bodies of water would comparatively soon have become salt. Regarding deposits formed in basins in this manner, we may note that Suess quotes Richthofen's distinction between central and peripheral types of drainage as illustrated by salt and coal. He says, "Salt with gypsum corresponds to a closed drainage system or central position; coal, when found in extensive freshwater basins, corresponds to the open outflow, without which no accumulation of water could maintain for long its original composition."* The latter part of this statement seems to admit of no contradiction, and it applies to the basins in which the sediments of Lower Mesozoic age in Eastern Australia were deposited. We shall consider later the positions of the outlets for the various basins.

The earliest basin developed was that in which the Hawkesbury Series of New South Wales was deposited. In the central portion of this basin there appears to be stratigraphic conformity between the Upper Coal-Measures, and the Narrabeen Stage of the Hawkesbury Series. Nearer the margins, however, there is unconformity. In addition, there is a very distinct palæontological break, only a few forms persisting from the lower to the upper. The unconformity between these two Series is one which involves a definite interval of time, but not any considerable movement. The time-interval must have been sufficiently long for the Mesozoic flora of the Narrabeen Stage to have almost completely replaced the typical Palæozoic flora of the Upper Coal-Measures

The basin in which the Narrabeen Stage was deposited was produced by a gradual subsidence, which apparently continued

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* Suess, "The Face of the Earth," iii., p.312.

throughout a long period during which the Narrabeen and Hawkesbury Sandstone Stages were deposited. The area of deposition increased gradually during this time, the Hawkesbury Sandstone Stage covering a much greater area than the Narrabeen Stage. During the early stages, volcanic activity appears to have been in evidence, as indicated by the development of tuffaceous rocks in the Narrabeen Stage. The thickness of the sediments deposited in this basin reaches a maximum of about 3,000 feet, made up of a maximum of 2,000 feet of the Narrabeen Stage, and 1,000 feet of the Hawkesbury Sandstone Stage.

The Hawkesbury Sandstone Stage is apparently conformable with the Narrabeen Stage. The existence of breaks, which do not show as very marked unconformities, must, however, always be borne in mind. Writing on this point, Schuchert remarks,* "The easily seen, marked unconformities . . . . . . are of course accepted at full face-value; but the many more apparently conformable and yet broken contacts, the disconformities, are generally overlooked, or when seen are generally undervalued. . . . In regard to the breaks, the statement can be made that there are at least ten disconformities for every known angular unconformity."

These statements may be applied to both the Permian (Permo-Carboniferous) and Mesozoic Systems of Australia, within which, apparent conformity appears to be general, but where there are quite a number of palæontological breaks.

During the time in which the Narrabeen and Hawkesbury Sandstone Stages were deposited, probably the rest of Australia, which at that time was of greater extent than to-day, was dry land.

Between the Hawkesbury Sandstone Stage and the Wianamatta Stage there is a distinct break. The Wianamatta beds have been deposited on the eroded surface of the Hawkesbury Sandstone, which must, therefore, have been elevated, exposed to denudation, and again submerged before the succeeding beds were laid down. In addition, the extent of the Wianamatta beds was much more limited than the Hawkesbury Sandstone.

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* Bulletin Geol. Soc. America, xxvii, 1916, p.497.

Our studies of the fossil floras indicate that the Ipswich Series in Queensland was laid down at the same time as the Wianamatta Stage in New South Wales. The strata of this Series were laid down over a comparatively restricted area in Southern Queensland, though it is not possible to obtain an accurate idea of its exact extent. Parts of the areas bordering the basin in which the Ipswich Series was deposited were probably very elevated, *e.g.*, the Stanthorpe-Warwick, and the Gympie Districts, the extent of the elevation having been due to the extensive intrusions of granite at the close of the Palæozoic era.

It is probable, also, that part of the Lower Mesozoic sediments of Tasmania was deposited contemporaneously with the Wianamatta Stage in New South Wales, and the Ipswich Series in Queensland.

The Bundamba Series, which follows the Ipswich Series in Queensland, has no equivalents, so far as we know, in New South Wales; apparently, sedimentation in the main Hawkesbury Basin came to a close with the end of the Wianamatta Stage. Later sediments in that State were laid down to the north and north west.

In Queensland, the dominant movement from the beginning of the Ipswich epoch was a subsidence. This movement was not continuous; there were, at least, breaks represented by the base of the Bundamba Series and of the Walloon Series, and there may have been further breaks within the Series. At the time of these breaks there was probably a cessation of sedimentation, accompanied by a slight uplift before the downward movement reasserted itself; the predominance of the downward movement is proved by the ever-increasing area covered by the Lower Mesozoic sediments until, towards the close of the Walloon epoch, the greater part of Queensland was probably covered by enormous stretches of fresh water. The portions of Queensland which were not submerged during the Walloon epoch (Jurassic) include the north-western corner of the State, an area in the neighbourhood of Hungerford on the New South Wales border, and probably areas to the east of the present Main Divide, which had been considerably elevated as a result of movements accompanying the intrusion of extensive granitic masses at the close of the Palæozoic era. It is impossible to define these latter areas at present, but they include the Stanthorpe and Gympie districts, and probably some of the present coastal portions of Queensland north of Rockhampton.

The area over which deposition of the Walloon Series took place extended into New South Wales and South Australia; and its boundary probably agreed fairly closely with the margin of the Great Australian Artesian Basin; it is from sandstones in the Walloon Series and its equivalents, that the great bulk of the artesian water is obtained, so that, although these are not known to outcrop along the southern margin of the Artesian Basin, their presence is known, and they are apparently overlapped by the Lower Cretaceous strata.

It may be remarked here, that it is only comparatively recent work that has shown the sandstones forming the intake in Queensland to be of Walloon age. In view of this, it is possible that outcrops on the southern and western margins of the Basin may, in the future, be shown to be of the same age, though at present mapped as Cretaceous.

The Clarence Series represents deposition in the south-eastern portion of the same basin. The Talbragar beds seem to represent deposition in a small, isolated lake.

In South Australia, the small, faulted basin at Leigh's Creek probably represents an outlier of the main occurrence further north.

Contemporaneously with the Walloon Series also, there were deposited the Jurassic sandstones, etc., of South Gippsland, Cape Otway, and the Wannon River areas in Victoria, and possibly also portion of the Lower Mesozoic strata of Tasmania. At the same time, marine sediments were laid down in Western Australia, and, associated with these, there are a few plant-remains.

The close of the Jurassic in Australia was not marked by any violent movement. In Queensland, New South Wales, and South Australia, the Jurassic rocks are followed by Cretaceous marine strata (Rolling Downs Series) without any observable unconformity. Palæontologically, however, there is a very marked break, and there is also generally a lithological distinction. The Cretaceous sea represents a transgression from the north, and covered the greater portion of the Jurassic strata over what is now the Great Artesian Basin, and, as shown in Text-fig.6, this transgression probably divided the Australian continent in two. The present Main Divide in Queensland was probably elevated, and became a land-area practically throughout its whole length in Cretaceous time, and has remained essentially so to the present day. On the west, the Cretaceous sea covered the area of the Artesian Basin as already mentioned, while, on the east, there are Cretaceous marine deposits between Maryborough and Bundaberg reaching a thickness of 1,000 feet. It is impossible to determine the exact extent of these to the east. The marine Cretaceous, both in western Queensland and in the Maryborough district, are followed by Cretaceous freshwater deposits known as the Winton Series and Burrum Series, respectively.

LOWER MESOZOIC PALÆOGEOGRAPHY OF THE AUSTRALASIAN REGION.

Published maps indicating the geography of the Australasian region during Mesozoic times are few in number.

Perhaps the oldest is that of Neumayr, which has been continually quoted and figured by later writers, including Jensen* and Hedley.† The latter‡ also prepared a map to show the Queensland coast at the close of the Mesozoic era. Jensen§ has published a series of maps showing the distribution of land and sea in the Australian region at various periods, including one in Triassic time. Recently, Schuchert|| has published a series of palæogeographic maps of Oceania, including one in Triassic time, and one in Cretaceous.

The important general feature of these maps is that they show

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* Proc. Linn. Soc. N. S. Wales, 1908, xxxiii., p.507.

† Report Aust. Assoc. Adv. Science, xii., 1909, p.332.

‡ *Op. cit.*, p.333.

§ Proc. Roy. Soc. Queensland, xxiii., Pt.2, 1912.

|| Amer. Journ. Science, xlii., 1916, p.99.

a coast-line not a great distance east of the present position of the eastern coast of Australia. This coast-line is the western shore of a long gulf running from the south in a general meridional direction between Australia and New Zealand. Neumayr called this the Gulf of Queensland. Schuchert's map shows the extension of this gulf further north to about the latitude of New Caledonia, when it turns to the east and again joins the ocean.

Evidence as to the existence, or otherwise, of this gulf is scanty. Hedley* says, "According to Neumayr, a meridional crease in the earth's crust produced, in Jurassic times, a gulf, which he called the Gulf of Queensland, whose western shore transgressed the present east Australian coast." The most important piece of evidence indicating the existence of this gulf is the presence of an impoverished fauna of Foraminifera and Ostracoda in the upper beds of the Wianamatta Stage in New South Wales (*supra*, p.38). This is positive evidence of marine or estuarine conditions in the Wianamatta Basin (probably during late Triassic time). There is no evidence at all to show that this gulf transgressed the present east coast of Australia during Jurassic time; it is certain that there are no evidences of Jurassic marine deposits in Eastern Australia.

The gulf was probably more or less coincident with the present position of the Thomson Trough; but whether the Thomson Trough is as old as Lower Mesozoic, is difficult to determine.

The palæogeography of the Australasian region involves a consideration of the structure of the south-western Pacific region. Structural studies of this region have been made by a number of geologists, including Dana, Suess, Gregory, Marshall, and Schuchert.

Marshall has pointed out that some of the earlier studies were based mainly on the geographic distribution of the island-chains, without much knowledge of structure. He has very rightly contended that conclusions drawn from such distribution may be quite erroneous.

Marshall has argued that "the real boundary of the south-west Pacific passes through New Zealand, Kermadec, Tonga,

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* Report Aust. Assoc. Adv. Science, xii., p.331.

Fiji, New Hebrides, Solomon, and on to the Admiralty Islands."* This line would then be the eastern boundary of the continental mass of which Australia, New Caledonia, New Zealand, etc., are remnants. Within this continental region there are a number of great deeps, *e.g.*, the two Solomon Island deeps (the northern one named the Planet Deep, the other unnamed) and an unnamed deep between the New Hebrides and New Caledonia. A discussion, which the author had recently with Rev. Father Pigot, of Riverview College, produced some facts which seem directly to concern the question of these deeps. The seismometers at the Riverview College observatory have, within the past few years, recorded a number of earthquake-shocks, and Father Pigot has calculated the positions of origin of these shocks. He kindly informed me that quite a large percentage of the shocks recorded had their origin along a line from Kermadec, through the deep between the New Hebrides and New Caledonia, the Planet Deep, and the Swire Deep (east of the Phillipines). The prevalence of earthquake-shocks emanating from this line of deeps is probably connected with faulting-movements, and it may reasonably be argued that these movements are probably a continuation of those which produced the deeps, and, therefore, that these deeps are of very recent origin. If this is so, we have, in these earthquake-records, evidence which supports Marshall's contention as to the true margin of the south-west Pacific. Marshall's conclusions in this respect seem reasonable; and Text-fig.2 (p.105) indicates the probable limits of the continental mass about the beginning of Mesozoic time; this map has been drawn-up mainly from the works of Marshall and Schuchert, already quoted.

This continental mass was connected with Asia about the beginning of Mesozoic time, and it may have been continuous with Gondwanaland. The breaking down of Gondwanaland commenced in early Mesozoic time, and the permanent enlargement of the Pacific basin probably commenced about the same time. There are marine Triassic rocks both in New Caledonia and New Zealand—evidences of epicontinental seas—but there is no marine deposit of Triassic age known on the present Aus-

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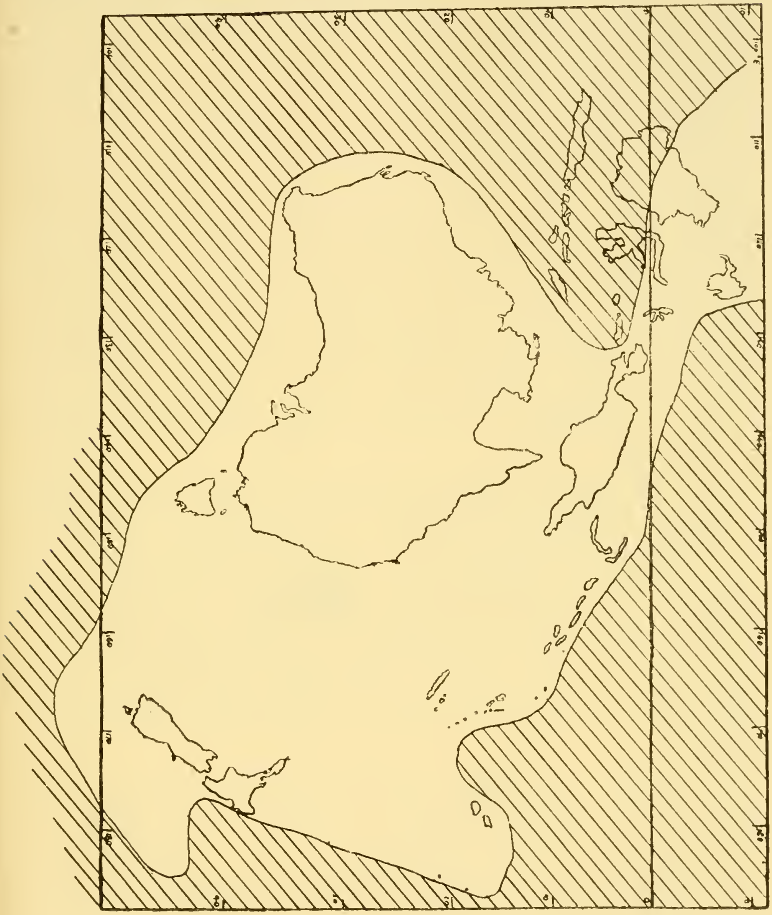
* Report Aust. Assoc. Adv. Science, xiii., 1911, p.99.

tralian Continent. The distribution of land and sea during Triassic time in this region appears to me to be as indicated in



Text-fig.2.

Map showing the approximate limits of the Continental Mass, of which Australia, New Zealand, New Caledonia. &c., are remnants.

Text-fig.3(p.107). Speaking of the Triassic marine deposits of New Caledonia and New Zealand, Marshall* expressed the opinion,

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* Geology of New Zealand, 1912, p.185.

that it cannot be definitely decided whether they represent coastal deposits on an eastern or western coast. If the boundary of the true Pacific basin on the south-west be the line stated, it seems more probable that they represent deposits along the eastern coast of a continent.

The evidence for the existence of the gulf, which Neumayr called the Gulf of Queensland, is not very definite.

The continued deposition of freshwater sediments in the Hawkesbury basin, indicates a continuance of freshwater conditions in this basin over a long period, and there must have been some outlet, as noted above (*see* p.98). As far as we know, there is no possibility of an outlet to the north, south, or west, and, in view of the presence of a foraminiferal and ostracodan fauna in the upper portion of the Wianamatta Stage, it seems probable that the outlet connected with an arm of the sea, such as the Gulf of Queensland. The exact extent of the gulf is purely conjectural.

During the time when the Wianamatta Stage in New South Wales, and the Ipswich Series in Queensland were being deposited, the Gulf of Queensland probably had its maximum extension in a northerly direction. At this time, there were two small basins in which the Wianamatta Beds and the Ipswich Series respectively were deposited. Both these basins may have had outlet to the Gulf of Queensland. Text-fig.4 (p. 109) indicates a probable distribution of land and water at this time.

In Jurassic time, there is no clear evidence to show the existence of the Gulf of Queensland. There are marine Jurassic rocks in New Caledonia. In New Zealand, in the south of the South Island, there are freshwater and marine strata of Jurassic age associated with one another, indicating probably oscillation of marine and fluviatile deposition in a coastal region. In the North Island, in the Kawhia-Waikato district, there are marine Jurassic rocks, and there are also records of fossil plants (Jurassic) from the same district. This, again, indicates a probable coastal region.

Text-fig. 3.

Map showing the distribution of land and water in the Australasian Region in early and middle Triassic time. (Solid black represents the present known extent of strata).

The Jurassic rocks of Victoria and Tasmania are freshwater deposits, and probably extended some distance east of the present coast. The Jurassic strata of New South Wales and Queensland extend right to the extreme north of the latter State, and there are marine Jurassic strata in New Guinea (Strickland River). This seems to indicate that these Jurassic rocks were laid down in a large basin, which had some outlet to the north. Another point which strengthens this, and is against the existence of the Gulf of Queensland during the Jurassic period, is the enormous amount of sediment represented by the continuous Jurassic strata of New South Wales and Queensland. These beds must average some thousands of feet in thickness over an area of some hundreds of thousand square miles, and must represent denudation of a large area. That the drainage to this basin was limited on the north, west, and south, is easily shown, for, in these directions, we know the regions of synchronous deposition, and the divides separating these from the Walloon basin do not allow of a very extensive area from which the sediments may have been derived. There is left, then, only extension to the south-east and east to any very large extent, and, if this was the case, there seems little possibility of the existence of the Gulf of Queensland.

These considerations have governed the drawing up of Text-fig.5 (p.111) showing the distribution of land and sea during Jurassic time.

The Thomson Trough, which lies to the east of Australia, may have been of comparatively recent origin. The east coast of Australia has been subject to folding since Lower Cretaceous, and to considerable faulting during Cainozoic; and it does not seem improbable that the Thomson Trough is a result of these movements. Schuchert* concludes his study of continental fracturing and diastrophism in Oceania thus: "To sum up, we may say that the bottom of the Pacific Ocean in the region of greater Australasia seemingly became more and more mobile with the Lower Carboniferous and especially during the Jurassic and Cretaceous. During this very long time, the eastern half of

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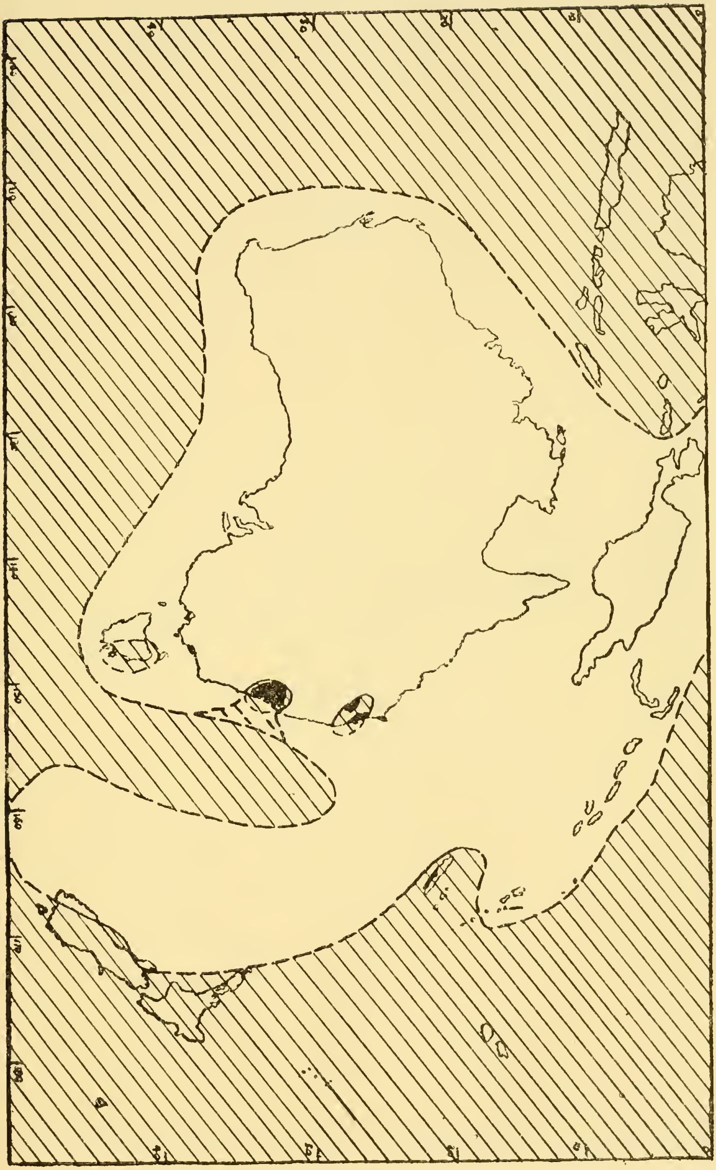
* Amer. Journ. of Science, xlii., 1916, p.104.



Text-fig.4.

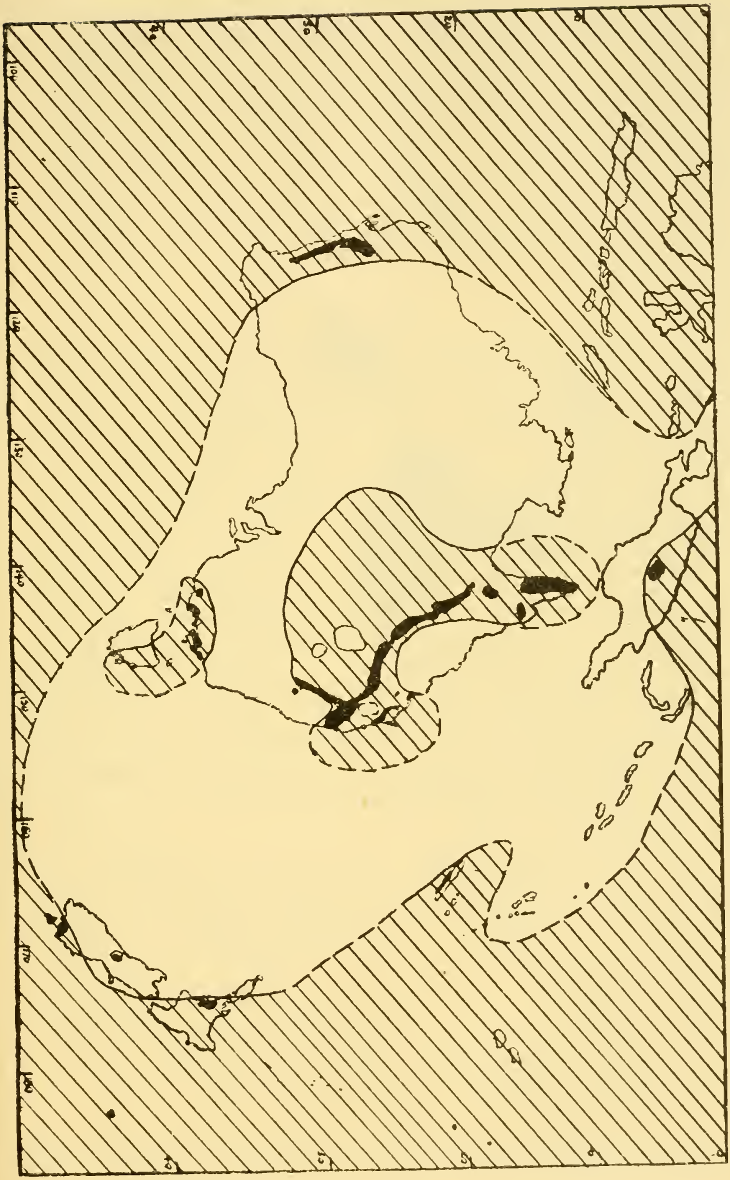
Map showing the distribution of land and water in the Australasian Region during Upper Triassic time (?Keuper or Rhætic). (Solid black represents the present known extent of strata).

the Australian Continent, a land about 1,800 miles east and west and 2,200 miles north and south, was folded into a series of parallel ridges trending north-west and south-east, nearly all of which went down more and more beneath the level of the sea to a maximum depth of about four miles and an average depth of between one and two and a half miles. Small parts of the ridges still protrude above the ocean (at least New Caledonia), but most of what we see are the volcanoes that have built themselves up above the folded rocks to the level of the sea."

This statement gives a general outline of the geological history of this region, but the stress laid on the Jurassic as a period of folding does not appear to be justified. As far as our present knowledge goes, the periods during which folding-forces have been effective since the Carboniferous are Permian (Permo-Carboniferous), late Cretaceous, and possibly late Cainozoic. The Permian strata of New South Wales indicate folding with axes approximately N. by W.; the Triassic, Jurassic, and Lower Cretaceous all show a general stratigraphical conformity, and have all been affected to the same extent by a folding which was later than Lower Cretaceous and earlier than Cainozoic, the direction of the axes of folding being about N.30° W.; the Cainozoic rocks in the Ipswich District have been subject to a minor folding-movement with approximately meridional axes.

It is also noted that, in New Caledonia, Triassic, Jurassic, and Cretaceous strata are apparently conformable, and have all been subject to subsequent overthrusting from the north-east. This strengthens the conclusion that the more important folding did not take place till after the deposition of the Cretaceous.

It appears, then, that there were transgressions in Triassic time (1) from the east, extending as far west as New Caledonia, and (2) from the south, forming the Gulf of Queensland. During Jurassic, the eastern coast remained in much the same position, the Gulf of Queensland disappeared or was very much reduced, and the sea transgressed in Western Australia parallel to the present western coast, and also in New Guinea to the Strickland River district; during this time, also, the extent of the basins,



Text-fig.5.

Map showing the distribution of land and water in the Australasian Region in Jurassic time. (Solid black represents the present known extent of strata).

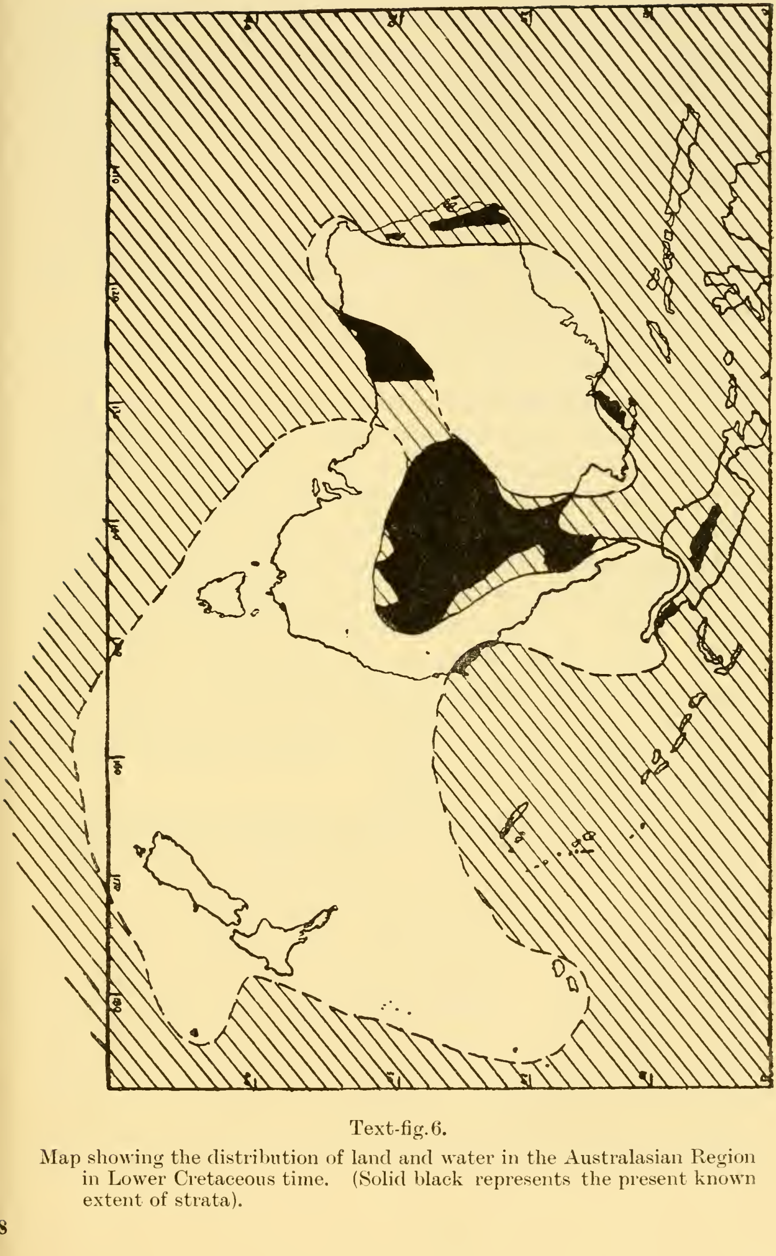
in which freshwater deposits were laid down, increased enormously. The early Cretaceous period saw very great changes in distribution of land and water. The sea transgressed from the north in the region of the Gulf of Carpentaria, at least as far as Lake Eyre; Australia appears to have been divided into two parts, either by the extension of this transgression to the south-west, or by meeting another from the south-west. These successive changes are shown on Text-figs.3-6.

SUMMARY.

The Lower Mesozoic rocks of Queensland comprise three divisions, namely, the Ipswich, Bundamba, and Walloon Series. The Ipswich and Bundamba Series are of comparatively limited distribution, and are confined to the south-eastern portion of the State. The Walloon Series has a much greater extent; in addition to occurring in South-eastern Queensland, in association with the Ipswich and Bundamba Series, it outcrops in a belt along the western slope of the Main Divide from the New South Wales border to Cape York, dipping westerly beneath the marine Cretaceous. It probably underlies the Cretaceous strata over the greater part of Western Queensland. In Eastern Queensland, there are a number of small, isolated occurrences of the Walloon Series, as indicated on Plate i. The thicknesses of the three series are approximately as follows: Ipswich Series, 2,000-2,500 feet; Bundamba Series, 3,000-5,000 feet; and Walloon Series, up to 10,000 feet.

From an economic point of view, the Lower Mesozoic rocks are of special importance in three respects, namely, (1) the greater part of the coal produced in Queensland is from the coal-measures of the Ipswich and Walloon Series, chiefly the former; (2), the large supplies of artesian water are obtained from sandstones which are the equivalents of the Walloon Series in Western Queensland; (3) practically all the Queensland sandstone used for building purposes is of Lower Mesozoic age.

In South-eastern Queensland, the Lower Mesozoic rocks (and also the Cretaceous strata) have been folded into a series of anti-



Text-fig. 6.

Map showing the distribution of land and water in the Australasian Region in Lower Cretaceous time. (Solid black represents the present known extent of strata).

clines and synclines, whose axes are in a general N.30°W.-S.30°E. direction. This folding is sometimes severe, the strata having been fractured, the folding giving place to distinct faulting. The age of this folding and faulting is Post-Lower Cretaceous and Pre-Cainozoic; none of the Cainozoic rocks in south-eastern Queensland have been affected by it.

In the Ipswich district, Mr. Cameron has observed a subsequent folding-movement with approximately meridional axes; this latter folding has affected the Cainozoic sedimentary and volcanic rocks, as well as the Lower Mesozoic rocks.

In Western Queensland, the Mesozoic rocks have not been subject to folding-movements.

The Bundamba Series is practically devoid of fossils, but both the Ipswich and Walloon Series contain abundant plant-remains; there are also numerous fossil insects in the Ipswich Series. Examination of the fossil floras indicates clearly that the Ipswich Series must be regarded as Triassic in age, and the Walloon Series as Jurassic. The exact position of the Ipswich Series in the Triassic cannot be definitely fixed at present, but it seems certain that it is Upper Triassic, possibly Rhætic, but probably older. The flora of the Walloon Series corresponds, to almost equal extents, with Liassic and Lower Oolitic floras. This Series probably corresponds to a period covering these two epochs, and when the Walloon Series is known in greater detail, it may be possible to subdivide it accurately.

The exact position of the Bundamba Series in the Geological Record cannot be fixed, but it is suggested that it is more closely associated with the Ipswich Series than with the Walloon Series, and, therefore, it is tentatively placed in the Triassic.

A comparison of the Queensland Lower Mesozoic strata with other occurrences in Australia of similar age seems to show, (1) that the Narrabeen and Hawkesbury Sandstone Stages in New South Wales are older than the Ipswich Series; (2) that the Wianamatta Stage of the Hawkesbury Series in New South Wales, and also possibly part of the Lower Mesozoic strata of Tasmania are of the same age as the Ipswich Series; and (3) that the following series in the other States are of the same age as the Walloon Series: the Artesian Series, Clarence Series, and Talbragar Beds in New South Wales; the Jurassic strata of the South Gippsland, Cape Otway, and Wannon areas of Victoria; the Leigh's Creek beds in South Australia; part of the Lower Mesozoic strata of Tasmania; and the marine Jurassic series in Western Australia.

An account has been given of the probable geological history of Eastern Australia between the close of the Palæozoic era and the beginning of the Cretaceous period, and it is evident that the Lower Mesozoic rocks are, with a single exception, of freshwater origin. Their exact mode of origin is not definitely settled; it has been shown that the basins in which they were deposited must have had some outlet; deposition may then have been in inland lake-basins with a river-outlet, or the deposits may represent accumulations under fluviatile conditions.

The geological history of the area is illustrated by a series of palæogeographic maps of Australia and the South-western Pacific region, representing the probable distribution of land and water at different stages in Lower Mesozoic time.

EXPLANATION OF PLATES I.-II.

Plate i.

Map of Queensland showing the distribution of Lower Mesozoic rocks.

Plate ii.

Geological Sketch-Map of South-eastern Queensland showing the areas occupied by the Lower Mesozoic rocks.

STUDIES IN AUSTRALIAN *NEUROPTERA*.

No. 5. The Structure of the Cubitus in the Wings of the *Myrmeleontidæ*.

By R. J. Tillyard, M.A., D.Sc., F.L.S., F.E.S., Linnean Macleay Fellow of the Society in Zoology.

(With three Text-figures).

In No.1 of this series of Studies,* I worked out the wing-venation of *Myrmeleon uniseriatus* Gerst., from the pupal wing-tracheation, and showed how, in the forewing, the apparently simple vein M was in reality a forked vein, the vein usually considered to be Cu_1 being in reality the *cubito-median*, $Cu_1 + M_2$, and the point of incidence of M_2 on to the line of Cu_1 being marked by the foot of the oblique vein O. The branch descending from the point of bifurcation, which I called the cubital fork (*cuf*), was, naturally enough, taken to be Cu_2. It was on the lack of specialisation of this branch, that I based my argument for the recognition of the tribe *Protoplectrini*, of which the correct name should be *Creagrini*, as previously given by Navás.

In No.4 of this same series of Studies,† when describing the wing-venation of the *Hemerobiidæ*, I showed how, in the forewings of *Drepanepteryx* and *Drepanacra*, an archaic Cu_2 was present close to the base, and that, in addition to this, Cu_1 was strongly branched at a sharp angle, much further distad, into two veins which I called Cu_{1a} and Cu_{1b}. In the allied genus *Drepanomina*, the archaic Cu_2 is lost, and replaced by a furrow. In the majority of the smaller *Hemerobiidæ*, even the furrow has disappeared. Thus, in the most highly specialised forms of the family *Hemerobiidæ*, all traces of the original Cu_2 are lost, and

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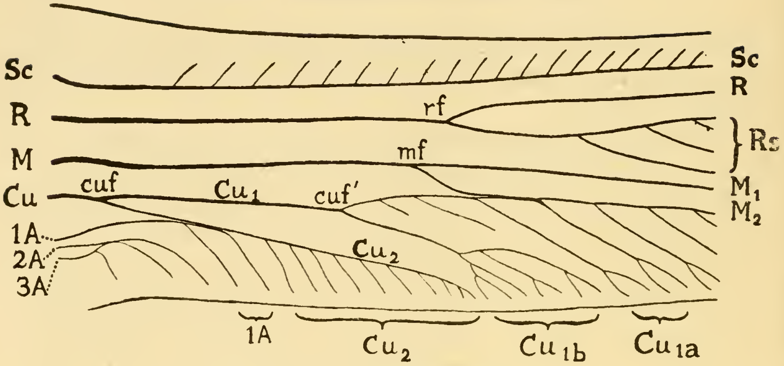
* These Proceedings, 1915, xl., Pt.4, pp.734-751, Pl. lviii.

† *Op. cit.*, 1916, xli., Pt.2, pp.269-332, Pls. xii.-xix.

there is left only the distal secondary forking of Cu_1 into Cu_{1a} and Cu_{1b}, the point of bifurcation being properly termed the *secondary cubital fork* (*cuf'*).

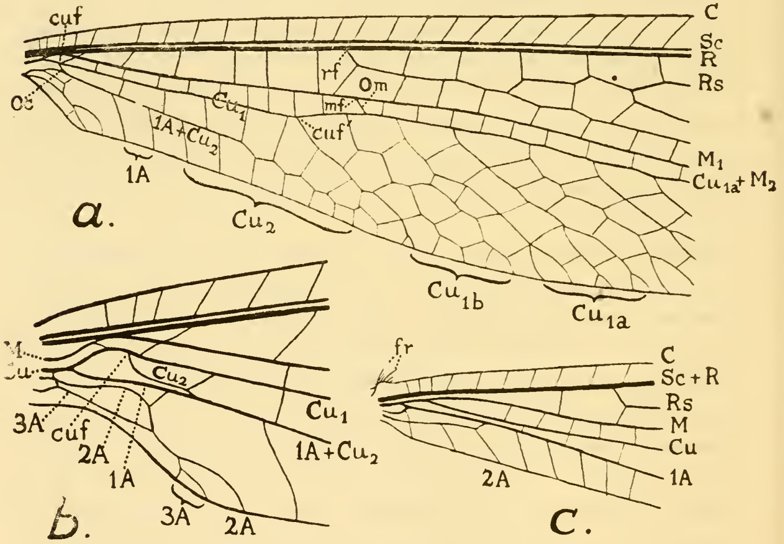
Now the resemblance between the condition of the cubitus in the forewings of these smaller specialised *Hemerobiidæ*, and in the forewings of the *Myrmeleontidæ*, is too striking to be ignored. It suggested to me at once that the veins which I had named Cu_1 and Cu_2 in the *Myrmeleontidæ* were in reality only Cu_{1a} and Cu_{1b} respectively, and that, if the true Cu^2 still existed, it must be sought for near the extreme base of the wing. I therefore examined a considerable number of *Myrmeleontidæ*, and found that, in many cases, there could be detected, close to the base of the wing, a semi-opaque connecting-vein, not unlike an oblique vein, (though not so well defined) running across from Cu_1 to 1A. This appeared to me to be the remains of Cu_2. With a view to proving this point, I decided to examine the pupal tracheation of some of the older *Myrmeleontidæ*, belonging to the subfamily *Dendroleontinæ*, in the imagines of which this supposed remnant of Cu_2 appeared to be much more evident than in the genus *Myrmeleon* itself.

Most of the larvæ of the *Dendroleontinæ* do not make pit-falls, but must be sought for either in loose sand, or in rubble or débris collected at the bases of large trees. During the winter of 1916, larvæ of several genera of this type were collected around Sydney. A number of these spun up in the following September. At the end of a fortnight, three likely-looking cocoons were opened, but were found still to contain larvæ. They were then placed under close observation until pupation took place. The first pupa examined proved to be very recently formed; so that, although a good dissection of the forewing was obtained, the structure was so exceedingly delicate that all the air passed out of the tracheæ before either a photomicrograph or a camera-lucida drawing could be obtained. With the second dissection, I decided to take no risks, but removed it at once to the microscope-stage, and made a camera-lucida drawing of it. Both the pupal tracheation and the imaginal venation showed up very clearly, and the result was



Text-fig. 1.

Tracheation of forewing in the pupa of *Xantholeon helmsi* Tillyard; (× 35).



Text-fig. 2.

Venation of *Xantholeon helmsi* Tillyard; *a*, basal half of forewing, (× 4½); *b*, basal portion of same, enlarged, (× 10); *c*, base of hindwing, (× 4½).

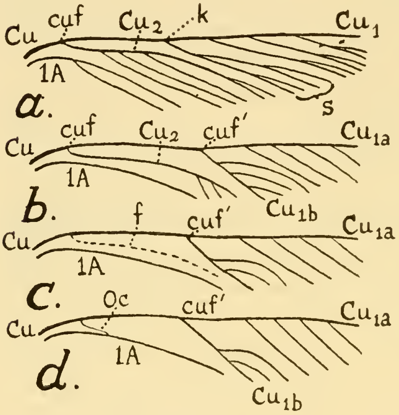
LETTERING OF TEXT-FIGURES.

1A, 2A, 3A, first, second, and third analis, respectively—$1A + Cu_2$, cubito-anal—C, costa—Cu, cubitus; Cu_1, Cu_2, its two principal branches; Cu_{1a}, Cu_{1b}, the two principal branches of Cu_1—$Cu_{1a} + M_2$, cubito-median—*cuf*, primary, and *cuf'*, secondary cubital fork—*fr*, vestigial frenulum—M, media; M_1, M_2, its two principal branches—*mf*, median fork—Oc, cubital oblique vein—Om, median oblique vein—R, radius—Rs, radial sector—*rf*, radial fork—Sc, subcosta.

a complete success, which is here reproduced in Text-fig.1. As the venation was complete, and even the delicate pigmentation of the imaginal wing could be noted, I was easily able to determine this wing as belonging to the rather rare insect *Xantholeon helmsi* Tillyard,—a result as fortunate as it was unexpected, since *Xantholeon* is certainly one of the most archaic of our Australian *Myrmeleontidæ.*

The result of this examination can be gathered by comparing Text-figs. 1 and 2. It will be seen that it not only bears out in full my suspicions concerning the real position of Cu_2, but shows also a further unexpected point of interest. For the *trachea* Cu_2 is not a weak remnant descending to 1A, as the examination of the imaginal venation had led me to suspect, but is a strong trachea *which has captured the line of 1A*, in the same manner that M_2 has captured the line of Cu_{1a}. In both cases, it is the *upper trachea* that prevails, the lower that goes under. In both cases, the crossing of the upper trachea on to the level of the lower is marked, in the imaginal venation, by an *oblique vein*, which represents, of course, the actual basal piece of the upper vein in question. We must therefore distinguish in future between the *median oblique vein* (*Om*) and the *cubital oblique vein* (*Oc*). This latter is very clearly marked in *Xantholeon* (Text-fig.2), also in *Glenoleon*, *Acanthaclisis*, and other genera; but it cannot be satisfactorily made out in our Australian species of the genus *Myrmeleon*, which are more highly specialised.

The process by which M_2 and Cu_2 have attained their present positions may be described as a process of "trachea-capture." The two tracheæ run at first more or less parallel. As the wing becomes narrower, they come to lie side by side. The oxygen-supply conveyed by both is now no longer fully needed; so that, in course of time, the weaker (in this case the lower) trachea becomes aborted, being reduced to a remnant impinging upon the strong upper trachea from below. In the resulting imaginal wing-venation, however, where the determining factor is not oxygen-supply, but the wing-stresses brought about during forward flight, the vein formed along the course of the lower trachea continues the line of the stronger upper trachea beyond the point where the partially aborted lower trachea ceases to exist, and must, therefore, be regarded as a composite vein, whose double origin is now only indicated by the oblique vein placed above it. Thus, in the case under consideration, we have two composite veins formed, viz., the *cubito-median*, $\mathrm{Cu}_{1a} + \mathrm{M}_2$, (whose structure I worked out in No.1 of this series of Studies), and the *cubito-anal*, $1\mathrm{A} + \mathrm{Cu}_2$, whose existence has not been before suspected. The oblique vein indicating the presence of the former is Om, that indicating the presence of the latter is Oc. The complete, correct, amended notation for the forewing of *Xantholeon helmsi* Tillyard, is given in Text-fig. 2. In Text-fig.3, I offer a phylogenetic series of stages to show the evolution of the Myrmeleontid type from the original archaic formation of these veins, as still preserved for us in the archaic *Hemerobiidæ*, *Drepanepteryx*, and *Drepanacra*.



Text-fig.3.*

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* Phylogenetic series illustrating the evolution of the cubitus in the wings of *Hemerobiidæ* and *Myrmeleontidæ*.—Series *a*, *b*, *c*, three stages leading to the reduced Hemerobiid type, also to the type found in *hindwings* of *Nymphidæ* and *Myrmeleontidæ*. With *a*, compare forewing of *Drepanepteryx*; with *b*, compare hindwing of *Drepanepteryx*; with *c*, compare wings of *Drepanomina*. The final stage, in which the furrow *f* is completely eliminated, is not shown in this figure.—Series *a*, *b*, *d*, three stages leading to the formation of the cubito-anal vein in the *forewing* of the *Myrmeleontidæ*, by fusion of the veins 1A and Cu_2. In *d*, the basal part of Cu_2 is indicated by the cubital oblique vein Oc.

Lettering as on p.118, and, in addition, *k*, the point destined to become *cuf′*, and *s*, the sector of Cu_1 destined to become Cu_{1b}.

In Text-fig.2, *c*, I have figured the base of the hindwing of *Xantholeon helmsi* Tillyard, in order to contrast the simplified condition of this wing with the complicated condition of the forewing discussed above. Since the *Myrmeleontidæ* are admittedly derived from Nymphid-like ancestors; and since, in the *Nymphidæ* themselves, both the media and the cubitus of the hindwing are already simple, unbranched veins, it must follow that this condition is to be found in their derivatives, the *Myrmeleontidæ*. It should, however, be noted that there are signs of specialisation even in the hindwing, in that the vein 1A approaches basally very close to Cu, very nearly fusing with it; while Sc and R are completely fused together throughout the basal portion of the wing.

We have now to consider whether our new discoveries on the structure of the cubitus require us to make any revision in the present classification of the *Myrmeleontidæ*. Esben-Petersen, in Part iii. of his "Australian Neuroptera,"* has named the area between $Cu_{1a}+M_2$, Cu_{1b}, and the hindmargin of the wing, the *intercubital area*, and has pointed out that a Banksian Line is sometimes developed in this space; such a line, he calls the *intercubital line*. With this I am in agreement. Now the development of an intercubital line is evidence of high specialisation in this area. Therefore, those genera in which it occurs, if they have hitherto been regarded as primitive, must have their position reconsidered. In the tribe *Creagrini*, this intercubital line is beautifully developed, and is correlated with a condition of parallelism between $Cu_{1a}+M_2$ and Cu_{1b}. It was natural, so long as this latter vein was taken to be Cu_2, that this condition of parallelism should be considered primitive. But the archaic condition existing for Cu_{1b} is not one of parallelism to $Cu_{1a}+M_2$, but rather, as may be seen in *Xantholeon*, one of strong divergence from it, Cu_{1b} running obliquely to the margin, and parallel to the numerous branches descending from $Cu_{1a}+M_2$. *Xantholeon*, *Gymnocnemia*, *Periclystus*, and other genera show this

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* These Proceedings, 1917, xlii., Pt.1, pp.203-219, Pl. x.-xv. (Pl. x., fig. 1, *Protoplectron striatellum* Esb.-Pet.).

primitive condition well. From this primitive state, two lines of development may follow:—

(1) Cu_{1b} may become fixed in its divergent position, and the intercubital line may be developed in the usual manner between the descending branches of $Cu_{1a} + M_2$. Various stages in this process may be studied within the genus *Glenoleon*, while the complete formation may be seen in *Acanthaclisis* and *Myrmeleon.*

(2) Cu_{1b} may become straightened out parallel to $Cu_{1a} + M_2$, the intercubital line becoming developed between them, and parallel to both. The beginning of this line of evolution is evident in the forewing of *Protoplectron striatellum* Esb.-Pet., which is, therefore, fairly primitive. In *P. venustum* Gerst., the formation is practically completed; while in *Creagris plumbeus* Ol., (Palæarctic) the development of the three parallel veins, with all connecting structures reduced to simple series of cross-veins, reaches the highest possible stage of evolution along this line.

It would appear, therefore, that my estimate of the tribe *Creagrini*, as the most primitive of the *Dendroleontinæ*, is not correct. They form, rather, a separate side-line of development away from the main stem, culminating in a very highly specialised genus, viz., *Creagris.* It should be noted, in this connection, that the larva of *Creagris* is the only one amongst the *Dendroleontinæ* that is known to make pit-falls. It will now be of special interest to find out whether the larvæ of *Protoplectron* do likewise.

ON THE AFFINITIES OF TWO INTERESTING FOSSIL INSECTS FROM THE UPPER CARBONIFEROUS OF COMMENTRY, FRANCE.

By R. J. Tillyard, M.A., D.Sc., F.L.S., F.E.S., Linnean Macleay Fellow of the Society in Zoology.

(With three Text-figures).

In May, 1917, Mr. Herbert Bolton, M.Sc., F.R.S.E., F.G.S., Director of the Bristol Museum, England, published an interesting paper upon the "Mark Stirrup" Collection of Fossil Insects from the Coal-Measures of Commentry (Allier), Central France.* As is well known, these insect-beds are of Upper Carboniferous Age, and have yielded a very large number of fossils, most of which have been described by Brongniart and Meunier. The chief characteristics of the assemblage may be shortly summed up in the statement that they appear to have been at a stage when the separate Orders known to us to-day were only beginning to be foreshadowed, nearly all the specimens found being of large size, with dense wing-venation, and primitive structure of head, thorax, and abdomen. The dominant group was the Blattoidea. No undoubted Holometabolous Insects are known to exist from these beds, nor were any such known from any Palæozoic rocks, until the discovery of *Permochorista*, a genus of undoubted Mecoptera, in the Permian Coal-Measures of Newcastle, N.S.W.†

Eight species are represented in the "Mark Stirrup" Collection. Five of these are Blattoids, and one is a Palæodictyopteron. The other two are of very great interest, and their affinities are certainly problematical enough to require very careful investigation before they can be settled with anything approaching finality.

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* Mem. Proc. Manchester Lit. Phil. Soc., 1916-17, Vol.61, Pt.1, No.2, pp.1-32, Pls. i.-v., [May, 1917].

† These Proceedings, 1917.

I refer to *Megagnatha odonatiformis* Bolton, and *Sycopteron symmetrica* Bolton. Bolton places the former in the family *Perlidæ* (by which the author evidently means the Order Perlaria, and not the family *Perlidæ* s.str.); though, in a note added to this determination, he states that Dr. A. D. Imms suggests that the specimen "may possibly come nearer to the *Sialidæ*," by which, I take it, he means the Order Megaloptera, rather than the actual family *Sialidæ* s.str. As for *Sycopteron*, this is assigned to the "family *Panorpidæ*," for which, again, we are evidently intended to read the "Order Mecoptera," since the author compares it with *Orthophlebia* of the Lias. If this placing be correct, then we have a Holometabolous insect present in the Upper Carboniferous—an occurrence which is, of course, not impossible, but is certainly improbable, in view of our present knowledge of the Phylogeny of the Insecta.

I have, of course, no opportunity of examining the specimens themselves; but Mr. Bolton has given us such excellent photographic reproductions and drawings of the fossils in his paper, that one would certainly scarcely desire anything better. As the determination of the affinities of these two fossils is a matter of prime importance to students of Insect Phylogeny, and as I have already informed Mr. Bolton by letter of the views that I shall here express, I propose now to state my reasons why these two insects cannot be accepted as belonging to the Orders to which Mr. Bolton would assign them, and to indicate also to what known Orders they may, with more probability, be considered to belong.

MEGAGNATHA ODONATIFORMIS Bolton. (Text-fig.1).

Bolton, *op. cit.*, pp.2-6, Pl. i., figs.1-4.

From the photograph given by Bolton in Pl. i, fig.1, and from the drawing in Fig.3, it is evident, as Bolton himself admits, that any reconstruction of the wing-venation of this fossil must be largely a matter of conjecture. We should, therefore, attempt to find other characters that may lead to a solution. The figures show that:—

(1) The wings were either absolutely, or approximately, equal

in size, and of similar shape; probably, therefore, the venations of fore- and hindwings were the same.

(2) The insect had a small, elongated head and prothorax.

(3) The head carried a pair of straight, slender, and fairly long antennæ, and also a pair of shorter, but very prominent, somewhat curved, slender appendages, which Bolton considers, with some doubt, to have been the mandibles.

(4) The three pairs of legs were well developed, and placed far apart from one another.

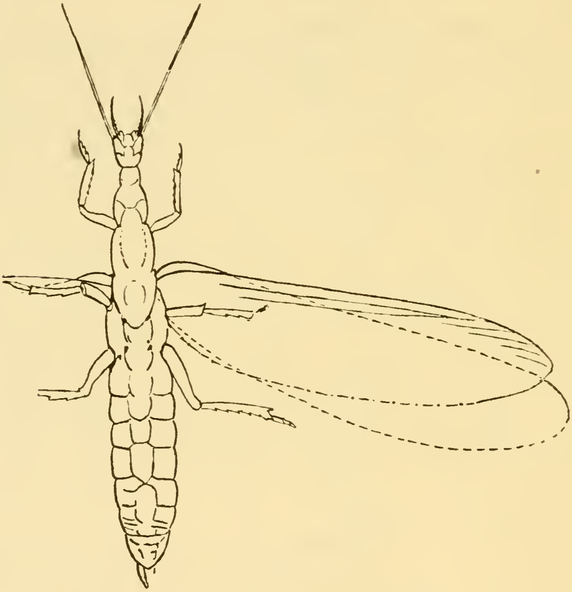
(5) The abdomen was also moderately short, and probably carried two very short cerci.

In the Perlaria, the head and prothorax are neither narrow nor elongated, but are always more or less flattened down dorsoventrally, more or less widened; and the prothorax is never far removed from the pterothorax. The antennæ are very long, and the cerci also, in all the most archaic forms; genera in which the cerci are shortened are demonstrably descended from forms which had longer cerci. Further, fore- and hindwing are never equal in size, or of similar shape; and forms in which there is an approximation to equality are demonstrably derived from forms in which there has been greater inequality. Nor are the venations of fore- and hindwing ever the same, but differ fundamentally, as a study of the nymphal tracheation of the two wings clearly proves. Finally, the Perlaria have mostly reduced, weak, nonprojecting mandibles; and it is demonstrable that these organs were never, within the limits of this Order, slender and projecting, as seen in *Megagnatha*.

Even if it were to be admitted that the restored venation in Bolton's Fig.4 were correct, I fail to see in it any true Perlarian characters. It much more resembles the venation of an archaic Termite forewing, such as *Mastotermes*.

I conclude, therefore, that no affinity between *Megagnatha* and the Order Perlaria can be shown to exist.

The only possible claim to affinity with the Order Megaloptera rests upon the projecting mandibles, since these structures also project strongly in the archaic *Corydalus* and allies. But the mandibles of these latter insects are much more strongly built, and are attached to a broad and massive head that is as unlike that of *Megagnatha* as it well could be. We may well ask, are these "mandibular-like structures" mandibles? Is it not much more likely that they are the maxillary palpi, whose joints, like those of the antennæ, have become obscured in the fossil? They are too slender to have been of any use for biting; and sucking mandibles, such as we find in the Ant-lion, do not occur, as far as we know, in any imaginal form whatever; nor are even such sucking mandibles ever so slender as in this fossil.

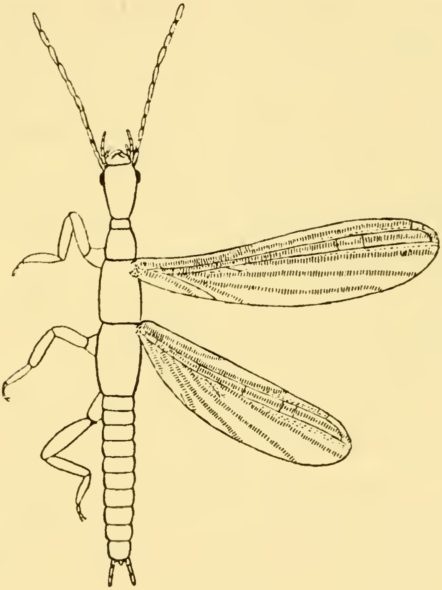


Text-fig. 1.

Megagnatha odonatiformis Bolton; (×42). Upper Carboniferous of Commentry. From Bolton's Pl. i., fig. 2. The short cercus on the left side of the figure is not shown in Bolton's figure, but is visible in his fig. 1 (photograph).

I am, therefore, forced again to conclude that no real affinity can be demonstrated between this fossil and the Megaloptera.

What, then, are the most likely affinities of this peculiar fossil? I should answer that it shows a very remarkable resemblance to the very ancient and mysterious Order Embioptera, about which, unfortunately, we know very little. In Text-fig.1, I reproduce Bolton's figure of *Megagnatha*, and place opposite to it, in Text-fig.2, a drawing of an Embid (*Oligotoma* sp., undetermined) which I happen to have in my collection. It must be at once admitted that the resemblance is a very striking one. The form of the head, prothorax, and legs, the great separation of the latter, and the equality of the wings, are characters that separate out the Embioptera very distinctly from all other groups. All these characters are possessed by *Megagnatha*. Further, the Embioptera possess elongated maxillary palpi, which, in the position of rest, lie projecting in front of the head, much in the



Text-fig.2.
Oligotoma sp.,(undetermined) in Coll. Tillyard; (×7½). Recent. Brisbane, Queensland.

manner that these supposed mandibles of *Megagnatha* do in the actual fossil. The only two discordant characters are the much more complex venation of the fossil, and the closeness of its wings at their bases. The latter may be easily explained as having been due to unequal crushing of the thorax; probably the wings were actually well separated at their bases, as the structure of the thorax, and the position of the legs, undoubtedly suggest. As for the venation, it is quite evident that recent Embioptera, like most recent Termites, possess a very reduced venation, containing only very little of the original elements. We see, in *Mastotermes*, how complex was the venation originally possessed by the Termites. In the Embioptera, the analogue of *Mastotermes* no longer exists; or, at any rate, it has not yet been discovered. But I have seen a species from Australia (of which, unfortunately, I have no notes or figures) with a venation considerably more complex than that of *Oligotoma*. All students of the Embioptera agree that they represent the last remnants of a peculiar group of great antiquity; but, so far, their fossil history has been almost completely missing.*

Megagnatha is larger than *Oligotoma*; but this is what we should expect, if the two are really related. For *Oligotoma* is clearly a reduced form, as its venation proves.

I would suggest, therefore, that *Megagnatha odonatiformis* is in reality an ancient representative of the Embioptera, and should be placed within that Order, as the sole known type of a new family, the *Megagnathidæ*, differing from all known members of the Order by its greater size and more complex venation, as well as, probably, by the shorter comparative distance between the bases of the fore- and hindwings.

As the identification of the "mandibular-like" structures as true mandibles is, at the best, very doubtful, and as not a single Odonate character is possessed by this fossil, it is much to be regretted that its author should have chosen a generic name

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* Two doubtful records from West African Copal can scarcely be regarded as more than subfossil, and add nothing to our knowledge of the group. A single species from Baltic Amber belongs to the genus *Oligotoma*.

based upon the former character, and an entirely misleading specific name, neither of which can be altered.

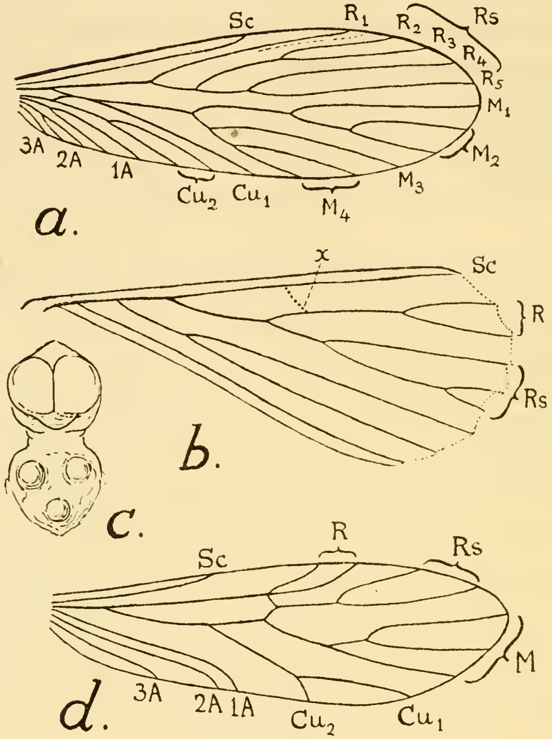
SYCOPTERON SYMMETRICUM Bolton. (Text-fig.3, *b*, *c*).

Sycopteron symmetrica Bolton, *op. cit.*, pp.6-8, Pl. ii., figs.1-2.

If this fossil could be proved to be Mecopterous, it would be one of the most striking discoveries in Palæoentomology. For that reason alone, we are all the more bound to examine the evidences of its supposed Mecopterous affinities as carefully as possible.

Text-fig.3, *b*, *c*, are portions of Bolton's Pl. ii., fig.2, which, as far as I can see by comparison with the photograph in his fig.1, is accurate in all except a possible minor detail or two. The first thing that strikes one, on examining this fossil, is the way that its wings are folded down the back of its abdomen. If this were the natural position of rest, it would be that of a Dipteron or a Hymenopteron; yet both these Orders are excluded from the question, for reasons that must be sufficiently obvious without stating them. We have, then, to conclude, either that *Sycopteron* belonged to some extinct Order, which folded its wings in this position (a highly improbable theory), or that it belonged to some Order in which the wings were held roof-like over the abdomen; in which case, the flattening down of the wings in the fossil may well have caused some underfolding of either the costal or the posterior border of the wings, or both.

Bolton claims for his insect a Panorpoid venation, stating that its nearest approach is to be found in *Orthophlebia* of the Lias. When, however, he goes into detail, it is quite clear that he is unable to homologise the separate veins of *Sycopteron* with those of *Orthophlebia*, without getting into very serious difficulties. In order to show this, I give in Text-fig.3, *a*, *b*, the venation of *Sycopteron*, (*b*), as interpreted by Bolton, and the venation of *Permochorista*, (*a*), which is the oldest fossil Mecopteron known, and the venation of which closely resembles that of *Orthophlebia*. It will be seen at once that the type of venation present in the Mecoptera (and there is no Order in which the venation is more constant in character, differing little right through from the Permian to recent times) is radically different from that of



Text-fig.3.

a, Forewing of *Permochorista mitchelli* Tillyard, (restoration, with all the cross-veins omitted); (× 4). Permian of Newcastle, N.S.W. *b*, Forewing of *Sycopteron symmetricum* Bolton, with his naming of the veins; (× 7¾). Upper Carboniferous of Commentry. From Bolton's Pl. ii., fig.2. *c*, Head and thorax of same, from the author's same figure; (× 7¾). *d*, Forewing of *Amphientomum paradoxum* Br.; (× 15). Oligocene, Baltic Amber. From Enderlein. In *b*, the dotted vein *x* indicates the probable position of the basal piece of Rs, not shown in Bolton's fig.2, but apparently slightly indicated in his fig.1 (photograph).

Sycopteron, this latter being of a much simpler type, which does not occur in the Order Mecoptera at all. The resemblance is due only to the method of branching dichotomously, and the absence of clearly-marked crossveins,—characters which are by no means confined to the Mecoptera.

I would suggest that the true costa of this insect has become folded under in the fossil, and is not clearly visible. Bolton says, "The costal margin seems to have been extremely delicate, and to have left very faint traces of its position." This might well be true of the subcosta, which is frequently a weak vein. In the Mecoptera, the costa is strongly formed, but there are other insects in which it is not so. This suggestion receives support from the fact that, if the front vein preserved in this fossil is really the costa, then Sc, R, and M all come off from a common stem, in a manner that cannot be paralleled except in the Homoptera, and certainly never occurs in the Mecoptera.

Whether we allow that the costa was underfolded or not, the following dilemma has to be faced:—

(1) If the fossil is Mecopterous, then the naming of the veins by Bolton is incorrect. The five-branched vein which he has distributed between R and Rs is certainly the media; and we are then driven to suppose that all the rest of the venation, costad of this, has been underfolded, except a portion of Rs, which would be Bolton's Sc.

(2) If Bolton's naming of the veins is correct [or even if the large extent of underfolding suggested in (1) cannot be admitted], the fossil is neither Mecopterous, nor in any way related to the Mecoptera, since the typical Sc, R, and Rs of that Order—the latter alone of which is never less than four-branched*—are all absent.

From this dilemma, there is only one escape, viz., to admit at once that the Mecopterous affinities, much as we must regret it, cannot be proved, and to seek for some more likely solution of the problem.

In Text-fig.3, *d*, I show the venation of the forewing of the very archaic insect *Amphientomum paradoxum* Br., from Baltic

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* Excepting in the highly reduced, recent *Nannochoristidæ*, where it is three-branched.

Amber. This insect belongs to the Order Psocoptera or Copeognatha, an Order which is not Holometabolous, but which possesses a reduced venation very closely resembling that of certain Holometabolous Orders, in particular the Hymenoptera. Nearly all recent Psocoptera have a much more specialised venation than *Amphientomum*; but close relatives of the latter still exist in the peculiar genera *Echmepteryx* and *Cymatopsocus*, as well as the genus *Amphientomum* itself, which has recently been rediscovered in Ceylon.

It will be seen that the correspondence between the wing-veins of *Sycopteron* and *Amphientomum* is exceedingly close; in fact, they can be completely homologised, provided only that *Sycopteron* possesses the short basal piece of Rs which is absent from Bolton's figure. A close examination of the photograph of *Sycopteron*, in Bolton's Pl. ii., fig. 1, suggests to me that this piece actually does exist; at any rate, it seems to be clearly indicated on the left wing. The fossil should certainly be further examined to determine this point.

In *Amphientomum*, the subcosta is a very weak vein, merging into the costa before halfway. The radius is a strong vein, forked distally, and giving off its sector far distally, at a point only just before its fork. Rs itself is forked, as in *Sycopteron* (the vein Bolton calls R). Further, M is three-branched in *Amphientomum*, in the same manner as in *Sycopteron* (the vein Bolton calls Rs). In *Amphientomum*, the cubitus is forked far distad, and is attached to the stem of M at a point quite one-third of the wing-length from the base; in *Sycopteron*, the attachment and forking lie both much further basad. So also the anal veins in *Amphientomum* are less primitive than in *Sycopteron*, being shorter and less straight.

Now *Amphientomum* is evidently specialised in the following points:—

(1) The shortening of Sc.

(2) The removal of the origin of Rs far distad, and consequent shortening of that vein.

(3) The close union basally between M and Cu.

(4) The removal of the cubital fork far distad.

(5) The shortening and curvature of the anal veins.

If, then, ancestors of this insect existed in Palæozoic strata, we should expect them to exhibit a generalised condition in these five characters. This is exactly what *Sycopteron* does exhibit. Without stating positively that *Sycopteron* lies in the ancestral line of *Amphientomum*, yet we can affirm that, as far as its venation is concerned, the two are certainly closely allied, and *Sycopteron is the older type.*

Let us now examine the rest of the fossil for clues as to its affinities. The first peculiarity to be noted is the huge boss-like areas upon the back of the head (Text-fig.3, *c*). If these be compound eyes, then *Sycopteron* is certainly neither a Mecopterous nor a Psocopterous insect; but, as Bolton mentions no facets on these areas, we may confidently take it that they are not. They must, therefore, be epicranial or occipital swellings. Now the head of *Sycopteron* is much too prominently developed to agree with the Mecopterous type. But almost all the Psocoptera have a comparatively large head, with prominent development of the posterior portion of the epicranium. If such a head were to be crushed somewhat in becoming fossilised, its appearance would certainly closely resemble that of *Sycopteron*. The small eyes would probably be completely covered by the flattened epicranium.

The structure of the thorax in *Sycopteron* is certainly primitive, and might indicate equally well affinities with several Orders, including both Psocoptera and Mecoptera (Text-fig.3, *c*).

Again, in the Psocoptera, the hindwing is always small and weakly chitinised. Hence, in insects of this Order which might become fossilised with their wings flattened down over the abdomen, no sign of the hindwing or of its venation would appear. The Mecoptera, on the other hand, have, of all the insects, except the Odonata and Planipennia, the most strongly chitinised hindwings, of a size almost equal to the forewings, and with a strongly marked and closely similar venation. Hence, if a Mecopteron became fossilised in the position we are supposing, it seems inevitable that traces of the hindwings and of their main veins must be present. But Bolton mentions nothing of this sort, and the photograph in his Pl. ii., fig. 1, certainly shows nothing that could be so interpreted. The probability, then, of this fossil having belonged to the Mecoptera, is very much diminished upon this count alone

Taking all the evidence into consideration, it seems legitimate to conclude that *Sycopteron* is most certainly not a member of the Order Mecoptera, but that it is very likely an archaic type of the Order Psocoptera, related to *Amphientomum* of the Oligocene, but considerably less specialised, in that it lacks all five of the venational specialisations possessed by this genus. It should certainly be placed in a new family *Sycopteridæ*, having the characters already mentioned. It should be noticed that the size of this insect (wings 9-10 mm.) agrees very well with its inclusion in the Order Psocoptera, all the known members of which are small, ranging from a wing-length of only 10 mm., at most, down to very minute and wingless recent forms.

ORDINARY MONTHLY MEETING.

April 24th, 1918.

Professor H. G. Chapman, M.D., B.S., President, in the Chair.

Mr. Clyde Douglas Gillies, M.Sc., University of Queensland, Brisbane, and Dr. Henry Priestley, B.Sc., University of Sydney, were elected Ordinary Members of the Society.

The President announced that the Council had elected Messrs. C. Hedley, F.L.S,, W. W. Froggatt, F.L.S., W. S. Dun, and A. G. Hamilton to be Vice-Presidents; and Mr. J. H. Campbell [Royal Mint, Macquarie Street] to be Honorary Treasurer—for the current Session, 1918-19.

On the motion of Dr. Cleland, it was resolved: that the congratulations of Members be tendered to Dr. S. J. Johnston, B.A., on his appointment to the Chair of Zoology in the University of Sydney.

The President offered the congratulations of Members to Dr. R. J. Tillyard and Dr. A. B. Walkom (*in absentiâ*) on their attaining the Doctorate of Science.

The Donations and Exchanges received since the previous Monthly Meeting (27th March, 1918), amounting to 51 Parts or Nos., 7 Bulletins, 2 Reports, and 5 Pamphlets, received from 30 Societies, etc., were laid upon the table.

THE ORIGIN OF YOLK IN THE OVA OF AN ENDOPARASITIC COPEPOD.

By H. Leighton Kesteven, D.Sc., M.B., Ch.M.

(Plate iii.).

In January, 1905, Professor J. P. Hill presented me with material for the study of the morphology and development of an endoparasitic copepod infesting *Ptychodera australiensis* Hill. The parasite was found to be new, and was subsequently described under the name of *Ubius hilli* Kestv., in 1913(**3**). The following observations were made on the developing, ultimate oögonium, and primary oöcyte at the time *U. hilli* was studied (1908), and were submitted to Prof. Hill for criticism. At his suggestion, this paper was withheld from publication because, at that time, the material on which the observations were made was all stained in one way. Since then, I have obtained fresh material, which was fixed in (*a*) 5% formaldehyde in seawater; and (*b*) Müller's bichromate-solution. Specimens, after cutting, were stained with (1) Delafield's hæmatoxylin, (2) in Heidenhain's hæmatoxylin, (3) Mayer's carm-alum, (4) Flemming's method for karyokinetic figures.

This staining was done over three years ago, but press of other work has, till now, prevenced me from examining the results. Recently, I have found time to go over these sections, and I find that I have nothing to add to the original paper. I am satisfied, that the observations recorded truly represent processes taking place in the developing cell, and are not artifacts, for I find the cells to present these appearances, not only in different specimens similarly stained, but also in the same and in different specimens dissimilarly stained. Were I situated in a city near a library, I doubt not I would find many reasons for altering that portion of the following paper which deals with the literature. This paper was written in 1908, and since then I have had no opportunity of keeping abreast of the cognate current literature, and, at present, I am beyond the reach of a library. I believe, however, that even though this contribution is thus nine years old at date of printing, it is deserving of publication.

The ovarian epithelium in the young female is composed of fairly regular, cubical oögonia.* The continued division of these gives rise to the mass of ultimate oögonia which fills not only the lumen of the ovary, but also the anterior portion of that of the oviduct. It is while lying free in the lumen, in this mass, that the ultimate oögonium advances so far towards maturity, that it may thereafter be regarded as the primary oöcyte.

When first shed into the lumen of the gland, the ultimate oögonium is a small, rounded, hyaline cell. Its comparatively large nucleus may contain only one karyosome, or it may contain two, three, or four of approximately equal size. The size of the nucleus is defined by the nuclear membrane alone; that is to say, the nucleoplasm is hyaline, and takes no stain, nor is it differentiated from the cytoplasm by the presence of a discernible chromatin-reticulum (Fig.1). In those cases where there is only one karyosome, I am unable to find that this *one* differs from the three or four in other cases, nor among these is there any difference *inter se.*

The cell now enlarges. The nucleus, increasing in size at a greater rate than the cell, comes ultimately to fill nearly the whole cell.

When this process has reached the stage depicted in Fig.2, a chromatin-reticulum is well established, and the karyosomes have increased in number. In short, the period is characterised by an increase of chromatin.

As soon as this increase has reached its maximum, the reticulum becomes broken down, till, as depicted in Fig.3, in place of a network, there is present a great number of fine granules of

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* The description is of material stained with hæmatoxylin without any counter stain.

chromatin, and the karyosomes lie free in the nucleoplasm. The period is characterised by the disintegration of the chromatin-reticulum formed during the last period.

The fine granules of chromatin next begin to increase in size, and lose in depth of staining, until, instead of being opaque black points, they become semi-translucent, purple spherules. The karyosomes meanwhile remain unchanged (Fig.4). This phenomenon, I regard as the formation of the first yolk-granules. During succeeding stages, they continue to increase in size.

The karyosomes very soon exhibit signs of activity. Each of them, from a solid sphere of chromatin, becomes converted into a small, spongiform mass (Fig.5), probably due to the formation of vacuoles within them. What this activity, which characterises the period, means, I am quite unable to say, but I do not think that it can affect the deductions made later.

Meanwhile, the nucleus has so increased in size, that it is now surrounded by a mere envelope of cytoplasm, the presence of the nuclear membrane being evidenced more by the definite outline of the nucleus, than by the actual visibility of the membrane.

The next period is characterised by the formation of a new and much smaller nucleus within the old. This takes place in three steps.

Around one, or it may be two or three, coalescent, spongiform karyosomes, there becomes recognisable an area of plasm devoid of the spherules, which are scattered plentifully throughout the rest of the nucleus, and this area of plasm takes a faint purple stain (Fig.6).

This purple-staining globule of plasm, with its contained karyosome or karyosomes, by this time quite coalesced, is next enclosed in a distinct membrane (Fig.7).

The karyosome once more assumes a solid spherical form, the surrounding plasm still staining purple.

This area henceforward constitutes the nucleus of the cell; it is shown in Fig.8, which is a section of a mature, primary oöcyte.

Meanwhile the remaining karyosomes, scattered throughout the old nuclear area, have also shrunken to their previous size and shape, and again become solid; during this time, none of them were surrounded by a clear area of plasm staining purple.

The old nuclear membrane is apparently still present, in some cases, until a much later period; but, in others, it seems to have broken down at the time when the new nucleus first develops its membrane.

Up to this time, the ultimate oögonium has lain free in the lumen of the gland or oviduct; it now becomes attached to the wall of the latter, either to one cell by a foot, as in Fig.9, or, in the absence of the foot, to several cells.

Growth in size appears now to take place very rapidly, and there is a great increase in the quantity of yolk-spherules. No changes are observable in the new nucleus.

Concurrently with the increase in size of the cell and quantity of yolk, the karyosomes left free in the old nuclear area appear to be dissolved without showing any further signs of activity. When the cell, now to be regarded as a primary oöcyte, has reached its full size, it is once more set free into the lumen of the oviduct.

There is present in the mature primary oöcyte only one set of spherules, variable in size, certainly, but differing in no other way from one another. All are yolk-spherules or none are yolk-spherules. The spherules which were formed by increase in size of the chromatin-granules are, therefore, similar to, and may be regarded as being the same as, those formed later.

After these observations had been made, and the conclusions given below had been deduced from them, I sought, in the publications of previous workers, for comparable observations and deductions. I cannot better give the results of my examination of literature than by the following quotation from a paper by Caroline McGill (**5**), who, on p.219 of the paper quoted, expresses the opinion that "it seems probable that chromatin may have something to do with yolk-formation."

Will (**7**) thinks that the larger nucleoli of the amphibian germinal vesicle pass out into the cytoplasm, and there become yolk-nuclei. MacCallum (**4**) concludes that, in the ova of Amphibia, the peripheral nucleoli generate a substance which diffuses first into the nucleus, and from there into the cytoplasm; finally, it combines with the cytoplasm to form yolk. Henneguy (**2**) believes that the corpuscles of Balbiani in vertebrates are either parts of the nucleolus, or the entire nucleolus, which pass through the nuclear wall into the cytoplasm. Montgomery (**6**), in *Pisicola*, describes the nucleus as contracting in volume, and, in so doing, discharging all except one of its nucleoli into the cytoplasm. Goldschmidt (**1**), in active gland-cells and in muscle-cells of *Ascaris*, has described a cytoplasmic chromatin, which, instead of being gathered into irregular masses as in the Nissl bodies of nerve-cells, is arranged in fibres or coarse reticula. In most instances, however, this chromatin, which he calls 'Chromidialapparat,' is not derived from nucleolar material, but represents nuclear chromatin which has made its way into the cytoplasm. In fact, in many cases, the chromatin-fibres of the cytoplasm extend directly through the nuclear membrane, and are continuous with the chromatic reticulum of the nucleus. Since the chromatic apparatus is more highly developed in active than in resting cells, Goldschmidt concludes that it must function in the metabolism of the cytoplasm.

My own deductions may now be put very briefly. They are:—

1. The yolk-granules are formed by the combination of a cytoplasmic constituent with chromatin.

2. The first yolk-granules are formed within the nucleus.

3. The formation of the new nucleus is a pseudo-contraction of the overladen, old nucleus.

4. This pseudo-contraction leads to the shedding of some of the karyosomes, which are henceforward to be regarded as yolk-nuclei.

5. These yolk-nuclei are stores of chromatin, which are to continue the functional activity of the nucleus of the growing primary oöcyte, that is to say, they are to supply chromatin for that combination which is yolk-formation.

6. The ultimate oögonium is nourished by endosmosis, the primary oöcyte by the epithelium of the oviduct. In both cases, the all-important substance received is the cytoplasmic constituent

which enters into yolk-formation. Chromatin-constituents, however, must be derived from without in the earliest stages.

LITERATURE.

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2. Henneguy—"Le corps vitellin de Balbiani dans l'œuf des Vertébrés." Journ. Anat. Physiol., xxix., 1893.
3. Kesteven—A new Endoparasitic Copepod: Morphology and Development. Proc. Linn. Soc. N. S. Wales, 1912, xxxvii.(1913).
4. MacCallum—"Contribution to the Morphology and Physiology of the Cell." Trans. Canadian Inst., i., 1891.
5. McGill—"The Behaviour of the Nucleoli during Oogenesis of the Dragonfly with special reference to Synapsis." Zool. Jahrb., xxii. 1906.
6. Montgomery—"Comparative cytological Studies, with special regard to the Morphology of the Nucleolus." Journ. Morphol., xv., 1899.
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EXPLANATION OF PLATE III.

Explanatory letters.—K., karyosomes—Nu'., the new nucleus in process of formation—Nu''., the new nucleus nearly formed—Nu. memb'., the nuclear membrane of the old nucleus—Nu. memb''., the nuclear membrane of the new nucleus.

Fig. 1.—The ultimate oögonium when first detached from the wall of the ovary.

Figs. 2, 3, 4, 5.—Stages in the growth of the ultimate oögonium.

Figs. 6, 7.—Stages in the formation of the new nucleus.

Figs. 8, 9.—Sections of mature primary oöcytes.

CONTRIBUTIONS TO OUR KNOWLEDGE OF SOIL-FERTILITY.

No. xvi. The Search for Toxin-Producers.

By R. Greig-Smith, D.Sc., Macleay Bacteriologist to the Society.

In the earlier papers of this series, it was shown that bacteriotoxic substances were sometimes present in the clear liquid obtained by shaking a soil with water and filtering it through porcelain. The toxins were potent, for, when the same portion of soil was extracted a second time with water, the extract was highly nutritive. The first extract undoubtedly contained substances which functioned as toxins, as well as substances which acted as nutrients, and, of these two, the toxins were the more powerful.

The local soils were found to be toxic during the cold winter months and not in the dry summer. The toxicity was variable, and even in the favourable season, one could not be certain that a soil, undoubtedly toxic at one time, would be toxic at another. It seemed to be a matter of chance, but this was undoubtedly due to the fact that the cause of this toxicity was unknown. With the elucidation of the origin of the toxins, it will be better understood when a soil is likely to be toxic or otherwise.

Soil-toxicity, as exhibited in the extracts of the soils, can be demonstrated directly and indirectly. Directly, by adding a certain number of a test-bacterium, and obtaining a diminution in that number after an incubation-period of, say, 20 hours at 22°. Indirectly, by obtaining an increased growth as a result of boiling the extract and also of diluting it. A toxic soil exhibits all three characters. There are other points connected with toxic soils, and these will be found in my former papers.

During my earlier work, I was led to believe that the cause of the toxicity would be found in the products of the bacteria, and, in the beginning of this research, into the etiology of toxicity, some of the more likely bacteria were tested with more or less completeness. The work was tentative, the bacteria were tried one way and another. A favourable result was occasionally obtained, which led to repeated trials with slight variations, but these ended in failure to obtain a truly toxic condition. Some moulds were also tested, but the experiments with these did not lead me to believe that the source of the toxins would be found in the flora of the soil. The fauna remained, and when the amœbæ were tested, the first results were so satisfactory that the source of the toxins seemed to have been traced. Unfortunately, these results were not confirmed, and, as the work proceeded, it became evident that the toxic effect was caused by the production of alkali in the solutions in which the protozoa were growing. The test-bacteria were very sensitive to changes of reaction, and, so far as the solutions were concerned, it was made clear that a perfectly neutral solution was exceedingly difficult to maintain, and that any departure from a strict neutrality retarded the growth of the bacteria and exhibited some of the effects of a toxic solution. The main steps of the work that led to this conclusion are recorded in the following pages. Many experiments have been omitted because the results did not appear to justify a lengthening of the paper. They were either indefinite or confirmed a negative result previously obtained.

It is well known that some soil-bacteria are inimical to others, and it was considered that some one group might be specially so to bacteria generally. Instances of an inhibiting or toxic effect exercised by some micro-organisms against others are familiar to most workers in soil-bacteriology. It is an ordinary experience to find certain colonies of bacteria, such as *Bac. mycoides* and certain moulds, passing over or through other bacterial colonies when spreading over the surface of an agar-plate. Occasionally, they are seen to avoid some particular colony, and we find these surrounded by a clear zone of agar, across which the wandering mould or bacterium will not pass. Apparently, the colony has sent into the medium some toxic substance, and there does not appear to be a thinning away of the toxin, for the wandering colony generally becomes heaped up at the margin of the toxic zone and then spreads round and eventually encircles the colony. It may be that the thickening of the edge is caused by the toxin becoming so weak as to be able to exercise a stimulating action like other weak poisons.[*] The Actinomyces-colonies are generally toxic to such wandering moulds and bacteria.

As soil contains so much sand and inert matter, it did not appear to be a suitable medium for experiments with these presumable toxin formers, and it was considered that a fluid medium would be better. With regard to the nutrient added to the water, Bottomley's work with auximones had suggested the idea that there might be a relation between them and decayed soil-toxins. Bottomley used moist peat-moss as a culture-material, but, as this could not be obtained, the first experiments were made with washed sphagnum-moss suspended in water.

The moss was picked, dried, cut up, washed, and again dried. Ten grams were put into a flask with 600 c.c. of tap-water and sterilised.

Two bacteria, T.P.2 and T.P.4, were selected as being possible toxin-producers. They were not identified at first, for, in experiments such as these, one determines the value of the bacterium first and identifies it afterwards, if its activity justifies the identification.[†] The bacteria were seeded into the flasks of sus-

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[*] Journ. Roy. Soc. N. S. Wales, 1916, p.77.

[†] Bac. T.P.2 is a short, motile rod measuring $0{\cdot}5:2\mu$. Gelatine is liquefied slowly, the colonies being round, white, and slightly raised with a ciliate edge. On agar, the growth is ivory-white, rough and cohesive. Long, needle-shaped crystals are quickly formed in agar containing sodium phosphate, and these are fairly characteristic of the organism. In some media, slime is formed from dextrose, although none is produced on Lipman-Brown agar. In bouillon, the growth produces turbidity, a film and a sediment; nitrates are not reduced. Milk is coagulated and slowly peptonised. On potato, the growth is yellow-brown. The indol test is positive, the Gram test negative, and the bacillus produces neither gas or acid from dextrose, saccharose, mannite, or glycerine. Nitrate is not produced from ammonia salts. It appears to have *Bac. inunctus* as its closest ally.

pended moss, which were incubated at 22° for varying periods.

The extract was prepared in the usual way by filtration first through paper, then through porcelain. One portion of the extract was boiled for an hour under an inverted condenser. The various portions, generally 50 c.c., of the raw, boiled, and diluted extracts, were each seeded with 1 c.c. of a suspension of *Bac. prodigiosus*, and incubated at 22° for 20 hours, when counts were made by the plate-method. The numbers of bacteria in the raw extracts were taken as 100, and those in the treated extracts were calculated in terms of this. Fractions were omitted, and numbers less than 1 were taken as 1. The actual number of the water-control can be found by dividing the extract by the extract/water ratio, for the latter was obtained by dividing the extract-count by the water-count.

EXPERIMENT i.

	Growth of *Bac. prodigiosus* in extract, 20 hours at 22°.							
Micro-organism.	T.P.4	T.P.2				Penicillium cladosporioides.		
Nature of moss.	new	new	old			new	old	
Duration of test; days—	29	8	12	11	10	13	10	11
Number of test.	1	2	3	4	5	6	7	8
Extract, boiled ...	766	223	72,000	600	5,500	34	184	1,167
Extract, raw	100	100	100	100	100	100	100	100
Extract, raw, 80% ...	33	54	122	92	100	479	90	48
Extract, raw, 60% ...	15	15	133	100	100	2,240	67	40
Extract, raw, 40% ...	6	4	300	107	100	600	56	14
Extract, raw, 20% ...	2	1	167	107	135	21	36	40
Water-control	1	1	111	77	88	1	25	8
Extract/water ratio ...	417	580	0·9	1·3	1·2	111	4	12

In looking over the results of Experiment i., it is seen that moss is not a good substance for determining toxin-production. When new, it is too nutritive, and when old, that is, when it had been used and washed once or twice, it is too poor. The dilution-curves of tests 3, 4, and 5 are almost horizontal lines, indicating that the extract is of a nature similar to water. The results obtained by boiling the extract in tests 3 and 5 cannot be explained; they certainly indicate a degree of toxicity which is not confirmed by the dilution-numbers.

The numbers with *Penicillium cladosporioides* are peculiar. A flask with new moss had been sterilised and allowed to stand for several weeks before being infected with Bac. T.P.2. At the end of the incubation-period, the mould was plainly seen growing as a floating mass upon the surface; it had ousted the bacteria, for few bacterial cells were obtained from the fluid. The rise in the numbers upon dilution is typical of a toxin, but the reduction upon boiling is not. Again, the dilution-effect was not obtained in tests 7 and 8.

On the whole the experiment was unsatisfactory, and consequently other media were tried.

Experiments were made with dilute solutions of nitrogenous salts such as ammonium sulphate, ammonium phosphate, and potassium nitrate, as well as with alkaline salts as potassium phosphate, but there was little sign of any probable formation of toxin with any of them.

THE USE OF COLLODION-CAPSULES.

In an endeavour to improve the experimental method, use was made of collodion-capsules, as it was considered that by growing the bacteria outside and the test-organism inside the capsule, the production of toxin might be rapidly determined. Accordingly, capsules were prepared by coating the insides of 3/4 in. test-tubes with 4% agar in water. After drying at 37°, they received one or two coats of thick collodion, and a narrow paper-scale was fixed inside near the middle, and a short length of thin tubing with a thread attachment near the top. The separation of the capsule from the tube was effected by filling the tube with water and slowly raising it to near the boiling-point, when the collodion separated easily from the glass. The capsules were washed in changes of water, steamed to get rid of all traces of alcohol, and finally inserted in wide test-tubes, which were plugged. The medium was added, 20 c.c. in the outer tube, and 5 c.c. in the capsule, and the whole was sterilised. The outer liquid was seeded with soil-organisms and incubated for some days, when a suspension of the test-organism, *Bac. prodigiosus*, was added to the capsule. After incubation at 22° for a day or two, the cells were distributed, either by blowing air through the culture or by repeatedly drawing up and blowing out the liquid in a pipette. Then 1 c.c. was abstracted, and a count of the bacteria made. Previous to the mixing, the height of the liquid on the paper-scale was read, and afterwards the volume was determined by water run from a burette to the same mark.

The soil-organisms were obtained from a garden-soil that had been kept some time in the laboratory. The numbers of bacteria, originally high, as the soil had been heated, had fallen to that normal for the soil, viz., to 6 to 8 millions per gram. Plates of Lipman-Brown agar were smeared with the soil-suspension in appropriate dilution, and, after several days, it was noted that the flora consisted roughly of 30% of bacteria, and 70% of Actinomyces-forms. Of the latter, 17% were *Actino. chromogena*, which darkened nutrient agar strongly; and 23% were *Actino. odorifera*, which darkened the agar slightly; the remaining 30% were indefinite. Many colonies were picked from the plates, the micro-organisms were classified or grouped, and representatives of the groups used for infecting the liquid outside the collodion-capsules in the tubes.

The experimental results were noted as the progeny of one test bacterial cell originally added to the collodion-capsule, but as nothing will be gained by giving the exact numbers, the general indications, as compared with control-tests obtained from the figures in the various experiments, are here noted.

Experiment ii. Soil-extract [soil 1, water 2 parts].

Soil-bacteria, 6 days at 18°; test-bacteria, 1 and 7 days at 22°.
Inhibiting strongly—Rhizobium from soil, Bac. A7.
Inhibiting slightly—Various (5) Actinomyces-forms, Bac. A5.
Accelerating slightly—*Aspergillus* sp., Bac. A2.
Accelerating strongly—Bac. A1.

As an indication of the value of the terms, it may be said that the control-test showed that one cell had, in 7 days, increased to 118,000; the Rhizobium had multiplied only to 100; the Actino.-forms averaged 53,000, Aspergillus 240,000, and Bac. A1 had a progeny of 7·28 millions.

Experiment iii. Gum-acacia, 0·2%.

Soil-bacteria, 12 days at 18°; test-bacteria, 5 days at 22°.
Inhibiting slightly—*Aspergillus* sp., *Penicillium* sp., *Actino. chrom.*
Indifferent—*Actino. odor.*, Bac. A1, Bac. A5.
Accelerating strongly—Bac. A17.

Experiment iv. Hay-infusion, 0·05%.

Soil-bacteria, 11 days at 16°; test-bacteria, 1 day at 16°.
Inhibiting—Bac. B4.
Inhibiting slightly—Bac. B5.
Indifferent—Bac. B2, grey and white Actinomycetes.
Accelerating—Bac. B8.

Experiment v. Hay-infusion, 0·05%.

Soil-bacteria, 11 days at 16°; test-bacteria, 2 days at 15°.
Inhibiting strongly—Rhizobium (from soil).
Inhibiting moderately—Bac. A1, Bac. A2.
Inhibiting slightly—Various Actinomycetes, Bac. A5, Bac. A7, Bac. A9.

Experiment vi. Albumen, 0·1% in tube, water in capsule (albumen coagulated upon steaming).

Soil-bacteria, 7 days at 15°; test-bacteria, 1 day at 22°.
Inhibiting strongly—Rhizobium (from soil), Bac. A7.
Inhibiting slightly—Bac. T.P.2, Bac. B4, Bac. C2, Bac. C3, Bac. C1.
Indifferent—Bac. A17.

Experiment vii. Soil-extract [soil 1, water 1 part].

Soil-bacteria, 11 days at 15°; test-bacteria, 1 and 3 days at 22°.
Inhibiting strongly—Rhizobium (from the Lupin), Bac. A7.
Inhibiting moderately—Bac. C3.
Inhibiting slightly—Bac. T.B.2, Bac. B8.
Indifferent—Bac. A1, Bac. A17, Bac. C2.

Experiment viii. Hay-infusion, 0·1%, with dextrose 0·1%.
Soil-bacteria, 12 days at 16°; test-bacteria, 2 days at 22°.
Inhibiting moderately—*Penic. cladosporioides.*
Inhibiting slightly—Actino. 11, Bac. A8, Bac. T.P.3, T.P.4, T.P.5, T.P.6, T.P.7, S.B.2, S.B.5.
Indifferent—Actino. 10, Bac. S.B.1, S.B.4.

The results of the experiments, as a whole, showed that the action of the soil-microbe is generally irregular. This is notably the case with Bac. A17, which is the same as Bac. A1. In some cases, it increased the growth of the test-organism, while, in others, it had an indifferent action. In the case of Rhizobium and of Bac. A7, we have bacteria which produce a luxuriant slime in media containing sugar, and even in those containing merely a trace of sugar or none at all, the inhibiting property is seen to remain. I cannot but think that they acted by extracting the nutrient from within the capsule in order to produce their slime, which remained in the outer tube. The inhibition is, therefore, in all probability, due to the absence of nutrients rather than to the presence of toxins in the collodion-capsule. As the experiments did not promise to aid the investigation, they were discontinued.

The Use of various Media.

The action of Rhizobium led to its being tested in flasks of various media, and the tests are grouped together in the following Table.

Experiment ix.

Soil-organism ...	Rhizobium.			
Derivation	Soil.	Soil.	Lupin-nodule.	Lupin-nodule.
Medium	Hay-infusion, 0·1%.	Gum-acacia, 0·2%.	Dried blood, 0·4%.	Ammonium sulphate, 0·1% with salts
Duration of test ...	3 days.	16 days.	6 days.	11 days.
Temp. of incubation	16°	15°	15°	16°
Number of test ...	1	2	3	4
Extract, boiled ...	1,684	343	325	41
Extract, raw... ...	100	100	100	100
Extract, raw, 80% ...	170	99	106	52
Extract, raw, 60% ...	106	69	96	15
Extract, raw, 40% ...	80	63	67	5
Extract, raw, 20% ...	175	44	49	18
Water-control ...	58	23	15	22
Extract/water ratio...	1·7	4·3	6·5	4·6

There are indications of the formation of toxin in some of these tests, although it must be said that they are not very pronounced. Test 1 shows a narrow extract/water ratio, pointing either to the possible absence of nutrients in the extract or to the presence of toxins. The increases obtained in the boiled and in the diluted extract lead one to believe that toxins were present. Test 2 had undoubtedly been incubated for too long, but there is a suspicion that the extract is of the same nature as test 1. Test No.4 is irregular, and, so far as we can judge, gives us no information.

In these tests, the growing organism had undoubtedly removed nutrients from solution, and, by utilising them, had prevented their appearance in the porcelain-filtered extract. This was shown by an extension of test 1, in which the raw, uninoculated, filtered hay-infusion gave 666,800 cells, and the same, when boiled, gave 379,600 cells as against 100 of the unboiled bacterial extract.

A mixed culture of bacteria, existing as an actively nitrifying suspension of soil-bacteria, was seeded into a solution of 0·1% dextrose in 0·1% hay-infusion. The suspension was incubated at 15° for 7 days. On preparing and testing the extract, it was found to give the boiling- and dilution-reactions. The original mixture of bacteria was plated out in levulose ammonium-sulphate agar, and the flora was seen to consist of five organisms named provisionally S.B.1-5. These were tested with the same hay- and dextrose solution, but as they showed no sign of toxin-formation, it is unnecessary to give the details. The original experiment was repeated, but the result was quite different from the first.

EXPERIMENT X.

Soil-organisms	Mixed bacteria.	
Medium	Hay-infusion, 0·1% with dextrose 0·1%.	
Duration of test	7 days.	12 days at 15°.
Extract, boiled	917	96
Extract, raw	100	100
Extract, raw, 80%	176	92
Extract, raw, 60%	230	59
Extract, raw, 40%	615	31
Extract, raw, 20%	465	7
Water-control	28	1
Extract/water ratio	3·5	472

The differences between these tests is marked, and, while there probably was a difference in the kinds of bacteria added in the two cases, there is the suggestion that the time of incubation may have an influence upon the result.* In the 12-days' test, the toxin may have been formed on or about the 7th day, and have

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* The experiment was repeated some months afterwards, with the following results:—

Soil-organisms.	Mixed bacteria.	
Duration of test.	2	7 days.
Extract, boiled	188	165
Extract, raw	100	100
Extract, raw, 80%	32	48
Extract, raw, 60%	8	40
Extract, raw, 40%	1	34
Extract, raw, 20%	1	26
Water-control	1	9
Extract/water ratio...	100	1·2

The previous experiment was not confirmed, and there is no evidence of toxicity shown by the dilution-curves.

become decayed by the 12th It appeared advisable, therefore, to test the solutions, from time to time, to see the influence of the time-factor. This was done in the following experiment, in which Bac. T.P.2 was used at 16° to 18°.

EXPERIMENT XI.

Soil-organism	Bac. T.P.2.						
Medium	Hay-infusion, 0·1%.				Hay-infusion and dextrose, 0·1%.		
Duration of test in days	3	5	7*	11	3	5	11*
Extract, boiled... ...	450	308	70	35	240	560	2,092
Ratio of boiled extracts	12·8	8·8	2	1	1	2·3	8·7
Extract, raw	100	100	100	100	100	100	100
Extract, raw, 80% ...	90	80	122	99	55	36	84
Extract, raw, 60% ...	48	107	118	76	32	24	107
Extract, raw, 40% ...	31	111	159	63	17	19	123
Extract, raw, 20% ...	16	82	111	58	8	7	73
Water-control	5	56	122	32	1	9	192
Extract/water ratio ...	18	1·8	0·8	3·1	113	11·5	0·5

* The numbers in these are irregular, largely owing to the counts being low.

During the filtration of the infusions through the porcelain, it was noted that, in the dextrose-media, a considerable amount of slime had been formed. Attention was not called to this in the three days' culture, but, in the five and eleven days' culture, the slime was pronounced. It is clear from the results that the organism had produced a certain amount of toxin about the sixth day in the simple hay-infusion, and that it had largely disappeared by the eleventh day. The ratio of growth, which is a rough index of the approximate amounts of nutrients in the extract, declined as time went on, and so did the effect of boiling the solution. In the hay- and dextrose-solutions, boiling showed a steady increase of nutrient produced as the age of the culture increased, while, without dextrose, the reverse was the case.

The organism T.P.2 was originally obtained upon an agar-plate which had been seeded with a suspension of soil-bacteria. It was conspicuous in producing a zone across which neither moulds nor spreading bacteria would go. The single colony upon purification was found to consist of two closely allied forms provisionally named T.P.1 and T.P.2, the former producing a white colony, the latter an ivory-white on nutrient agar. T.P.1 liquefies gelatine quickly and forms no slime on dextrose-media, while Bac. T.P.2 liquefies gelatine slowly, and forms a slime from dextrose. The belief was raised by other experiments that the formation of slime withdraws nutrients from the medium, and yields a poor extract; but whether the toxin-formation has anything to do with the production of slime, has yet to be determined. Bac. T.P.1, the slime-free ally of Bac. T.P.2, was tested under the conditions of the last experiment, viz., in hay-infusion, with and without dextrose, and at periods of 3, 6, and 10 days, but no evidence of toxin-formation was obtained.

An attempt was made to determine the effect of slime-formation upon the production of toxin by using a race of Rhizobium from the soil, which formed a luxuriant slime on solid dextrose-media.

EXPERIMENT xii.

Medium.	Hay-infusion, 0·1%.			Hay-infusion with dextrose, 0·1%.	
Soil-organism.	Rhizobium.			Rhizobium.	
Duration of test in days.	3	6	13	3	6
Extract, boiled	82	5	205	20,840	45,030
Extract, raw	100	100	100	100	100
Extract, raw, 80% ...	13	10	84	3	40
Extract, raw, 60% ...	1	5	77	2	36
Extract, raw, 40% ...	1	4	58	2	49
Extract, raw, 20% ...	1	3	50	2	47
Water-control	1	2	35	1	37
Extract/water ratio ...	1,900	49	2·8	72	3

A 13-days' test with hay-infusion and dextrose was found to be sterile, and has been omitted. Although these tests were intended to see the effect of slime-production upon toxin-formation, it happened that no slime was obtained on the porcelain filter from the dextrose-solution, and, but for the growths on agar-slopes, one would have thought that the cultures were dead. However, the slow reduction of the extract/water ratio as time went on, and the great increase obtained on boiling the dextrose-solutions were again noted.

I have found, in the past, that soils are more toxic in the winter than in the summer-months, and it is to be expected that temperature will have some influence in either the production or the decay of the toxin. The influence of temperature was tested in the following.

EXPERIMENT XIII.

Medium	Hay-infusion, 0·1%.				
Soil-organism	Bac. T.P.2.				
Temperature	15·5°.			22°.	
Duration of test in days ...	2	4	8	2	7
Extract, boiled	20	74	123	30	16
Extract, raw	100	100	100	100	100
Extract, raw, 80% ...	33	77	48	46	29
Extract, raw, 60% ...	12	64	19	26	12
Extract, raw, 40% ...	3	45	12	17	7
Extract, raw, 20% ...	1	45	10	13	5
Water-control	1	53	11	6	5
Extract/water ratio ...	248	2	9	15	18

The experiment was rather disappointing, as there was little evidence of toxin-formation at the lower or the higher temperature. In four days at 15·5° it is shown by the low extract/water ratio that much of the nutriment has been locked up in the bodies of the bacteria. As the ratio is higher on the eighth day, one would imagine that there had been some dissolution of the cells.

In an earlier experiment, there had been signs that some formation of toxin had occurred in a solution of gum-arabic infected with Bac. T.P.2. This led to the employment of an old culture of Rhizobium which had been grown in hay-infusion and dextrose, and which contained a quantity of slime. It was sterilised and infected with Bac. T.P.2. It showed no signs of toxicity on the third day.

An old culture of Bac. T.P.2 in hay-infusion was sterilised and infected with Bac. T.P.2, but there were no signs of toxicity on the second or fourth day.

A solution of Gum-Acacia, 0·2%, when infected with Bac. T.P.2, showed no toxicity on the second or fourth day.

A rod-shaped bacillus, Bac. A17, which had appeared to stimulate the growth of *Bac. prodigiosus* in collodion-capsules, was tested in hay-infusion, but there was no evidence of toxin formation in the boiled or diluted extracts.

In view of the indeterminate nature of the results hitherto obtained, it was deemed advisable to augment the intensity of the growth of the bacteria by increasing the amounts of the nutrients and by aërating the media during cultivation. To gain this end, beakers containing cotton-wool were sterilised, and media, such as 1% hay-infusion with and without 1% dextrose, which had been seeded with various organisms, were added in sufficient quantity to moisten the wool. After incubation at 22°, the cotton-wool was squeezed and washed, and the liquids made up to a definite volume before being filtered through porcelain.

A soil-Rhizobium, Bac. T.P.2, *Penicillium cladosporioides*, and an Actinomyces, A10, were tested at different times, such as 3, 6, and 11 days; but, in none of the tests, was any evidence of toxin-formation demonstrated. This also applied to old cultures of bacteria reinfected with moulds. The method was useless, therefore, for the object in view.

The experiments, however, raised the idea that small changes in the reaction might be responsible for much of the irregularity in the results. Bacterial cultures, in the absence of a fermentable sugar, are generally more or less alkaline, while soil-extracts are supposed to be more or less acid. The soils used in this set of researches were acid, that is to say, when a piece of litmus-paper was inserted or pressed into a paste or porridge made by mixing the soil with water, it became reddened in the course of a few minutes. The aqueous extract of such soils should, therefore, be acid, and it appeared that, if the extract could be prevented from becoming alkaline through the action of bacteria, there would be a better chance of demonstrating any development of toxicity. At any rate, the cultural fluids would be more in harmony with the conditions that pertain in the soil. To effect this faint, permanent acidity, it would be necessary to add some substance which would absorb any alkalinity produced, in the same manner that chalk maintains a faint acidity in fermenting solutions of sugar. The only substance that promised to achieve this purpose was humic acid, and its use appeared advisable, as it is ever present in soils.

A quantity of humic acid was accordingly prepared from rotted bamboo-mould by treatment with sodium hydrate, followed by acidification, washing with water by decantation, filtration, and finally by dialysis. The acids were dissolved in normal soda and sterilised.

Tests were made with strong hay-infusion with and without dextrose by the cotton-wool method, but, although several organisms were used, no results of any importance were obtained: the solutions were far too nutritive. A converse test with tap-water and no nutrient showed that the humic acid acted as a poison. Although an opalescent suspension of bacteria had been added, no living bacteria were to be found by the third day. In one case, a pink yeast had obtained access to the flask, and, on the thirteenth day, the extract showed a rise upon boiling; and, upon dilution with dilute hay-infusion, the same sterility, towards the introduced bacteria, was noted after a few days. The humic acid was undoubtedly the cause of the phenomenon. It had been dissolved in normal soda, and the solution was added to the flask of medium, and was followed by the quantity of normal hydrochloric acid necessary to neutralise the soda. The humic acid remained largely dissolved, and acted as a soluble acid. In one test, that of the pink yeast on the thirteenth day, the acidity of the extract to phenolphthalein was $= +0{\cdot}5^{\circ}$ by Fuller's scale, that is the extract contained 0·5 c.c. of normal acid per litre. The experiments suggest that, to be effective, the humic acid should be insoluble in water.

EXPERIMENTS WITH HUMUS.

As the toxin-formation in soil must be related to the changes in the organic matter, an attempt was made to see in how far humus would be useful in elucidating the problem. Rotted bamboo-grass was sifted, partly dried, mixed and sifted again to obtain a uniform mould. Portions weighing 10 grams were put into deep Petri-dishes, and sterilised by heating for two hours at

130°. When cold, 10 c.c. of a suspension of Bac. T.P.2 were added to each portion. After various periods of incubation at 18°, a portion was transferred to a shaking bottle, treated with 500 c.c. of distilled water, and shaken 50 times at 10-minute intervals for an hour. The suspension was then filtered through paper and porcelain, and the usual procedure followed.

EXPERIMENT xiv.a.

Soil-organism	Bac. T.P.2.	
Duration of test	3 days.	6 days.
Extract, boiled	3,870	210
Extract, raw	100	100
Extract, raw, 80%	50	79
Extract, raw, 60%	13	50
Extract, raw, 40%	9	21
Extract, raw, 20%	5	4
Water control	1	2
Extract/water ratio... ...	150	52

As the experiment did not seem to be going to give any useful information, the remaining portions were extracted with different quantities of water to test the influence of various strengths of extract.

EXPERIMENT xiv.b.

	Growth of *Bac. prodigiosus* in extracts of leaf-mould infected with Bac. T.P.2, and incubated for 11 days at 18°.		
	10-gram portion to water.		
	500 c.c.	300 c.c.	100 c.c.
Extract, raw ...	100	100	100
Extract, raw, 80% ...	35	240	487
Extract, raw, 60% ...	5	276	1,563
Water-control ...	23	3	46
Extract/water ratio ...	4	36	2

The results of Experiment xiv.a, are much the same as have been obtained in solutions, viz., a lessening of the nutritive and of the boiling effects, as the period of incubation proceeded. In Experiment xiv.b, we have the dilution-effect becoming more pronounced as the water used in making the extract became less, Portions of the air-dried mould containing 14 grams of dry matter were put into Petri-dishes and sterilised. They were infected with cultures of Bac. T.P.2, and of Actinomyces 10, and the moisture raised to 40%. The extracts were prepared by shaking each portion with 500 c.c. of distilled water.

EXPERIMENT XV.

Soil-organism ...	Bac. T.P.2.				Actino. 10.		Control.
Duration of test in days	4	6	18	24†	10*	18†	24†
Extract, boiled ...	44	164	119	47	71	90	138
Extract, raw ...	100	100	109	100	100	100	100
Extract, raw, 80% ...	849	532	270	66	292	171	119
Extract, raw, 60% ...	3,710	1,880	1,845	54	574	268	68
Extract, raw, 40% ...	9,500	3,090	6,637	37	1,038	160	57
Extract, raw, 20% ...	8,070	2,500	16,090	17	562	5	25
Water-control ...	47	20	153	1	2	1	1
Extract/water ratio ...	2	5	0·6	1,130	44	275	460
Reaction	+0·6	+0·6	+0·55	+0·3	—	+0·4	+0·2

* Growth of a green Penicillium at edge of dish.
† Permeated with Penicillium.

The growth of the accidentally introduced Penicillium resulted in a flattening of the dilution-curves, and in a diminution of the acidity. From this, it must be inferred that the acidity was chiefly responsible for the toxicity of the extracts. To test the matter, a further experiment was made with partially neutralised mould, and with neutralised extracts.

Four-ounce glass bottles were used instead of Petri-dishes, and, into each, 18·2 grams of mould, containing 14 grams of dry matter, were introduced. They were sterilised at 130° for two hours, moistened with 3 c.c. of sterile water, and steamed for an hour. The steaming proved to be unnecessary, as portions of the heated soil proved to be sterile. One of the portions was infected with a Fusarium, another with a Rhizobium, a third served as a control, a fourth was treated with enough lime-water to neutralise the apparent acidity, and the last was subjected to the vapour of ammonia for a couple of hours. The moisture in them all was brought to 40%. The extract of the raw mould was found to be very acid, 1000 c.c. containing the equivalent of one c.c. of normal acid, using phenolphthalein as an indicator. The extracts were neutralised with sodium bicarbonate. The Fusarium, the Rhizobium, and the control-tests were incubated for five days at 22°.

EXPERIMENT XVI.

Soil-organism... ...	Fusarium sp.		Rhizobium (soil).		None.			
Reaction of extract ...	acid.	neutral.	acid.	neutral.	acid.	neutral.	Lime.	Ammonia.
Extract, raw	100	1,074,000	100	8,151	100	114,000	609	29,070
Extract, raw, 80% ...	176	315,400	127	3,200	116	109,000	1,783	43,250
Extract, raw, 20% ...	27,940	218	153,800	38	21,860	791	81,390	46,740
Water-control ...	1,000	—	763	—	1,040	—	—	—
Extract/water ratio ...	0·10	—	0·13	—	0·09	—	—	—
Reaction	+1·0	—	+0·9	—	+1·0	—	+0·75	+0·7

The point to be noted from this set of tests is, that the neutralisation of the acidity of the extract has converted the toxic into a nutritive condition, not only in the raw extract, but also in the 80% dilution. The numbers obtained in the extracts of the control and of the infected leaf-moulds are of the same order, and indicate that the toxic property is inherent in the sterilised medium. The suspicion is strengthened, that the toxins are really acids developed during the sterilisation of the organic matter. It is evident that the treatment of the leaf-mould with lime-water or with ammonia was not sufficient to neutralise the excessive acidity of the humus, for the numbers show a position intermediate between the acid and the fully neutralised extracts.

In a new set of tests, the sifted mould was treated with water to eliminate the sand with which it was mixed. It was then dried, and again sifted through a finer sieve to remove the bulk of the fine, light fibres. It contained moisture 10·2%, and ash 43-8%, leaving 46% for the organic matter. Portions containing 10 grams of organic matter were put into 4-ounce bottles, and sterilised at 130° for two hours. During the sterilisation, an odour of burnt sugar was noticeable.

A portion of the sterilised leaf-mould was tested against a portion of the unsterilised for acidity. Each was shaken 300 times with 500 c.c. of water, and filtered. This was repeated a third time. The acidity of the filtrates was tested with N/100 soda, using phenolphthalein as an indicator. The figures represent the number of c.c. required to neutralise the 500 c.c. of the extract.

	mould, heated.	mould, not heated.	difference.
1st 500 c.c. ...	47·5	7·5	40·0
2nd 500 c.c. ...	16·25	5·0	11·25
3rd 500 c.c. ...	10·0	3·75	6·25

The curves of these numbers were plotted, and it was seen that the curve of the heated mould would meet that of the unheated mould at the fifth 500 c.c., and that, at the fourth, there would be a difference of 3 c.c. The total differences would, therefore, amount to 60·5 c.c. of N/100 acid for the total acidity developed during sterilisation and *removable by washing with water.* In terms of the organic matter of the mould, this means that 100 grams during sterilisation developed an acidity equal to 6·05 c c. of normal acid, equivalent to 0·36% grams of acetic acid.

A portion of the sterilised leaf-mould, containing 10 grams of organic matter, upon being gradually moistened with water, was found to form a fairly coherent ball when pressed in the hand after the addition of 15 c.c. of water to each portion. Accordingly, 15 c.c. of water containing 6 c.c. of N/10 sodium bicarbonate were added to each portion, which was thoroughly mixed and pressed down. Suspensions of the bacteria in 1 c.c. of water were subsequently added, mixed, and pressed.

After an incubation of five days, extracts were made, and their effect upon the growth of *Bac. prodigiosus* noted.

EXPERIMENT xvii.

Soil-organism	Bac. T.P.2,		Rhizobium.		None.	
Reaction of extract ...	acid.	neutral.	acid.	neutral.	acid.	neutral.
Extract, boiled ...	106	—	60	—	152	—
Extract, raw	100	77,930	100	41,960	100	85,800
Extract, raw, 80% ...	132	70,580	281	35,420	108	89,310
Extract, raw, 20% ...	1,677	4,390	5,342	12,740	1,000	9,950
Water-control ...	1,471	—	200	—	1,316	—
Extract/water ratio ...	0·07	—	0·5	—	0·07	—

The numbers in the control and in the T.P.2 tests are virtually the same, and evidently no growth of the bacillus had occurred. The numbers with Rhizobium are different, not only in the acid extract, but also after it had been neutralised with soda. The fact that Rhizobium can grow in the partially acid leaf-mould is a point worth noting. It is needless to discuss the possible formation of toxins with these leaf-moulds, and the remaining portions of the tests were discarded until further work had been done.

The addition of the bicarbonate of soda to the portions of leaf-mould did not neutralise the soluble acidity, for when the raw extracts were tested, it was found that the T.P.2 test had an acidity equal to +0 62° in the extract. The control had +0·63°, and Rhizobium +0·35°. It is, perhaps, to be expected that, in a substance like rotted leaf-mould, there will be a mixture of humic acids, some soluble in water, some partially soluble, and some insoluble in water. The humates are so complex that it was a mistake to consider that even all the water-soluble acid would have been obtained by water-extraction, unless the time-factor had been taken into account, and days instead of hours been occupied in the extraction.

The necessity for having a neutral vegetable-mould was emphasised, especially in the last two tests, and some experiments were made with the object of getting a better idea of the true acidity.

THE ACIDITY OF HEATED LEAF-MOULD.

A number of portions of the leaf-mould, each weighing four grams, were bottled, and some were heated for two hours at 130°. A sterile and an untreated portion were repeatedly shaken up with a standard alkaline solution at intervals during the time of contact, and filtered. The filtrates were tested for residual alkalinity or, when neutral liquids were used, for acidity. The numbers represent cubic centimetres of normal acid in, or derived from, 100 grams of the dry, organic matter of leaf-mould.

Calcium bicarbonate.—The acidity was first tested by the method of Hutchinson and MacLennan,* which consists in having the portions in contact with a solution of bicarbonate of calcium for a certain time, and subsequently determining the amount of lime that had been removed from solution

Heated	93·3
Control	91·7

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* Journ. Agric. Sci., vii., 75.

Sodium bicarbonate.—Portions were moistened with 10 c.c. of alcohol, and treated with 100 c.c. of water containing 1 gram of bicarbonate of soda, for five days.

Heated	165
Control	121

Other portions were moistened with 5 c.c. of alcohol, and treated with 200 c.c. of water containing 0·8 grams of bicarbonate.

Heated	82·4
Control	75·5

Alcohol.—Portions were shaken up with 200 c.c. of neutral spirit and allowed to stand overnight.

Heated...	9·4
Control	4·0

Water.—Portions were shaken up with 500 c.c. of water and allowed to stand overnight.

Heated	24·1
Control	9·2

Lime-water.—Portions were treated with 200 c.c. of N/21 lime-water and allowed to stand overnight.

Heated	383
Control	362

The numbers obtained with lime-water were so high, that the experiment was repeated. The four grams of leaf-mould were shaken with 300 c.c. of approximately N/24 lime-water, and due allowance was made for the amounts removed in the portions of fluid abstracted.

Normal alkali, in c.c., absorbed by 100 grams of dry organic matter.

Days.	1/8	1	2	3	4	5	7	9
Heated	340	403	423	432	442	448	456	462
Control	355	395	410	418	426	432	440	444

This confirms the previous test in showing that a comparatively large amount of lime is removed from solution, and that more is absorbed by the sterilised than by the unsterilised mould. The organic matter has absorbed from 12 to 13% lime [CaO], and about 90% of the total was absorbed within two days.

The difference in the amount of base absorbed from the hydrate, as against the bicarbonate, led to a test being made with bicarbonate of magnesia. A quantity of freshly precipitated and washed carbonate was suspended in water, and a current of carbon dioxide was passed through for several hours. The solution was filtered, and 200 c.c were added to 4 grams of soil in stoppered bottles. The solution of bicarbonate of magnesia was approximately twelfth normal The bottles were shaken frequently, and the portions abstracted from day to day and boiled with an excess of N/20 sulphuric acid for ten minutes, and titrated with N/20 soda in presence of phenolphthalein.

Magnesium bicarbonate—Normal alkali, in c.c., absorbed by 100 grams of dry organic matter.

Days.	3	5	7	10
Heated	99	99	105	104
Control... ...	89	89	99	99

The numbers are closely akin to those obtained with calcium bicarbonate, and much under the tests with lime-water.

Baryta-water.—The action of lime-water was controlled by a test made with baryta-water, in which 300 c.c. of approximately N/15 alkali were added to each 4-gram-portion of mould.

Normal alkali, in c.c., absorbed by 100 grams of dry organic matter.

Days.	1	2	3	5	6	7	8	9	12
Heated... ...	389	408	419	434	442	445	448	414	464
Control	365	382	391	400	405	417	418	425	433

These numbers run closely with those of the lime-water test

The set of experiments show that vegetable-mould, originally of an acid reaction, is made more acid by the action of heat, such as by sterilisation for two hours at 130°. The acid substances are partly soluble in alcohol and in water. They consist of two kinds, one of which is capable of being neutralised by the bicarbonates of the alkaline earths. The other makes itself evident when in contact with the hydrates of the earths. The mould which was examined removed from four to five times more alkali from the hydrate than from the bicarbonate.

At the close of the baryta-water experiment, the control-soil was rapidly filtered on the pump, washed with a small quantity of water, transferred back to the bottle and shaken with 300 c.c. of water, and tested from time to time.

3 hours	26·5
1 day	36
2 days	36

Of the 433 c.c. removed from 100 grams of dry, organic matter, 36 were given up to water, and we may, therefore, consider the difference of roughly 400 c.c. as being in combination.

The sterilised leaf-mould was also filtered and shaken with 200 c.c. of twentieth-normal hydrochloric acid. This removed the following amounts of normal lime.

3 hours	328
1 day	343
2 days...	343

Deducting this from the total baryta absorbed, viz., 464 c.c, we have 120 c.c., which is close to the amount absorbed from the bicarbonates. It is evident that the kind of humic acid, which fixes the bulk of the lime from a solution of the hydrate, forms with it a feeble combination. This is destroyed by mineral acids but is not affected to any extent by water. The combination seems to be too definite in its quantitative relations for a simple case of adsorption.

From the experiments, it was concluded that the organic matter of the leaf-mould contained humic acids, and, of these, about one-quarter were capable of decomposing the bicarbonates of the earths, while three-fourths were too weak to do this but could combine with the earthy hydrates. Heating the mould increased the amount of acid, and the increase was largely soluble in water.

HUMUS WITH CALCIUM CARBONATE.

According to the earlier lime-water test, in which 100 grams of dry organic matter absorbed 383 c.c. of N/1 alkali from lime-water, it appeared that a neutralisation of the acids of the leaf-mould would be obtained by adding 2 grams of calcium carbonate to each portion containing 10 grams of dry organic matter, and that neutralisation would be certain if 2·5 grams were added. A set of bottles were prepared, each receiving the equivalent of 10 grams of dry organic matter, and 2·5 grams of calcium carbonate as precipitated chalk. The bottles were sterilised for two hours at 130°, then moistened and stirred with 15 c.c. of water, and steamed for an hour. Subsequent tests showed that sterilisation had been complete, and that the extracts furnished by the tests were neutral to phenolphthalein. Sets were infected with certain micro-organisms and incubated at laboratory temperatures for varying times. It will be remembered that the organisms T.P.2 and Actino. 14 were chosen because they inhibited the growth of spreading bacteria and moulds on agar-plates. A test made at the beginning of this experiment showed that T.P.2 had lost its toxic power, while Actino. 14 had not. In view of this, the bottles of T.P.2, which had been infected, were incubated in an atmosphere of carbon dioxide, to see if this would have any influence in restoring the toxicity. Several of the portions, which were tested on the eighteenth day, were unfortunately destroyed.

EXPERIMENT xviii.

Soil-organisms ...	T.P.2 (in CO_2).			Rhizobium.		Soil-suspension.		Actino. 14.			Pink yeast.		None (control-soil).	*Penicillium cladosporioides.*		
Incubation in days ...	4	11	26	4	11	7	21	7	14	53	8	26	21	7	14	26
Extract, boiled ...	45	62	25	42	61	7	16	42	28	12	60	22	20	47	36	15
Extract, raw	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Extract, raw, 80% ...	76	91	68	81	87	82	58	108	84	81	85	78	55	102	79	101
Extract, raw, 20% ...	76	75	31	38	54	9	15	17	33	22	61	22	33	60	16	8
Water-control ...	0·7	0·5	0·3	0·3	0·3	0·5	1·4	0·4	0·4	0·2	0·4	0·3	0·3	0·2	0·06	0·04
Extract/water ratio ...	142	205	342	322	322	197	73	225	232	586	260	360	293	477	1,580	2,200

A general glance over the results leads to the belief that no toxins are formed by the organisms. It may be that the excess of carbonate of lime has brought about a condition in which the preservation of the toxins is not possible. The outstanding feature of the experiment is the increased nutritive effect obtained with *Penicillium cladosporioides.* The extract/water ratio increased very rapidly, indicating that the mould had been actively attacking the organic matter and producing substances which stimulated the test-organism, *Bac. prodigiosus*, to an increased production.

The amount of unacted-upon carbonate in the treated leaf-mould led to the belief that too much had been added, and that an excess of carbonate was not desirable.

HUMUS NEUTRALISED WITH LIME-WATER.

A quantity of sifted leaf-mould was soaked in lime-water for an hour, 5 litres of lime-water being used for every 500 grams of leaf-mould. A trial test showed that this proportion furnished a neutral extract, although, when the bulk was prepared, the extract of the mould was faintly acid. This was possibly caused by the subsequent sterilisation. At the end of an hour, the suspension was stirred and decanted on to a filter, and the organic matter washed, and at the same time separated from the heavier sand by repeating the procedure with water. The residual organic matter was dried, sifted, and bottled.

At this stage, the mould contained moisture 40·42%, ash 18·80%, and organic matter 40·48%, so that 24·5 grams contained 10 grams of organic matter. This quantity was put up into a number of four-ounce bottles, which were heated for two hours at 130°. Most of the moisture was driven off by the heating. A test showed that the heated mould formed a coherent mass, upon being pressed in the hand, when a weighed portion contained 20 grams of water, and this was accepted as being the quantity requisite for a full bacterial growth. After the heating, the water was raised to 19 c.c., the remaining 1 c.c. being left for the infecting suspension. The water was thoroughly incorporated, and the bottles were steamed for an hour. Sets were infected with several micro-organisms and kept at room-temperature, 15°.

EXPERIMENT xix.

Soil-organisms ...	*Penic. cladosp.*			Rhizobium.			Actino. 14.		*Fusarium* sp.			Control leaf-mould.	*Pen. clado.* + Rhizobium.		*B. mycoides.*	B.A.17.
Incubation in days ...	10	17	31	10	20	38*	20	38*	20	31	31†	10	10	26*	6	6
Extract, boiled ...	63	128	16	85	42	56	70	51	42	32	7	58	43	41	39	50
Extract, raw ...	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Extract, raw, 80% ...	187	132	32	100	54	77	76	94	118	98	28	58	82	58	50	84
Extract raw, 50% ...	—	—	18	—	—	49	—	64	—	44	27	—	26	35	33	56
Extract, raw, 20% ...	38	51	11	30	13	30	22	18	13	9	3	30	3	21	25	31
Water-control ...	1	1	1	1	1	8	5	6	1	2	1	1	1	7	1	1
Extract/water ratio...	475	440	670	299	585	13	22	16	295	42	204	394	248	14	556	469
Reaction of extract...	+0·1	+0·04	–0·04	+0·18	+0·08	+0·06	+0·02	+0·08	+0·0	+0·0	+0·3	–0·02	+0·0	+0·04	+0·1	+0·1

* Grown at 19° instead of 22°. † Extracted with 250 c.c. of water instead of 500 c.c.

The behaviour of *Pen. cladosporioides* was different in this experiment from that in the presence of an excess of chalk. It did not decompose the organic matter so quickly, but the rise in the dilution-curve was more pronounced. This suggested the idea that, if the nutritive effect could be kept down, the curve might be more accentuated Use was made of Rhizobium for growing with the Penicillium because, when the former was tested at the same time, viz., on the tenth day, the nutritive ratio was lower than either the latter or the control-test. The double growth kept down the ratio, but there was no elevation of the dilution-curve. The growing Penicillium brought about an alteration in the reaction of the extract. The reaction of the control-test seems to indicate, that the bacteria and moulds cause the medium to furnish acid extracts which, in time, may become alkaline.

The effect of using different amounts of water in preparing the extract was shown in the case of the mould infected with Fusarium species. Two tests were extracted at the same time, one with 500 c.c., the other with 250 c.c. of water. The stronger extract gave the higher nutritive ratio, as 204 : 42, while the weaker solution showed a tendency to produce a rise in the dilution-curve.

On the whole, the neutralised leaf-mould did not come up to expectations in serving as a suitable medium for the demonstration of toxin-production by the selected micro-organisms.

When an extract is diluted and subsequently sown with bacteria, it will give a count in proportion to the amount of dilution. But if the extract is acid, the dilution will be less acid, and the count will not be in proportion, but will be more or less according to the effect of the change in the acidity upon the growing bacterium. It is difficult to say just what this difference from the normal would be, especially with such weakly acid extracts as in Expt. xix. The neutralisation of an extract so strongly acid as +1·0 is well seen in Expt. xvi., in which the dilution to one-fifth raised the count from 150 to 300-fold. A set of experiments were made to obtain some definite information regarding the influence of slight variations in the reaction.

The Influence of Reaction upon Bacterial Growth.

An extract of the same vegetable-mould as in Expt. xix. was prepared, and the acidity was determined in the following manner. Twenty-five c.c were pipetted into a beaker, an equal volume of distilled water was added, and the beaker was covered. It was boiled for ten minutes to expel the carbon dioxide, and rapidly cooled. Three drops of phenolphthalein were added, and N/100 soda was run in until a difference in the tint was manifest. An end-point was not aimed at; just the difference in the tint from a yellowish to a faint brown. From the reading, 0·05 c.c. was deducted as being necessary to produce the change of tint over the neutral point. For example, 25 c.c. of an extract gave a tint with 0·15 c.c. of N/100 soda. Deducting 0·05 c.c., the reading becomes 0·1 c.c. for the neutral point. With 0·4 c.c., the tint was a pronounced red, and the final deep purple was obtained with 0·9 c.c. The neutral quantity 0·1 c.c., when calculated to normal acid per litre, gives 0·04 c.c., which, by Fuller's scale, is represented by +0·04. A good, white light is required during the titration to observe the change of tint. The method appears to be correct, for when the extracts were neutralised by the findings of the method, they always gave the highest counts after incubation with the test-bacterium.

After determining the reaction of the extract, quantities of 100th normal lactic acid or bicarbonate of soda were added to 10 c.c. portions of the extract, and sterile water to bring the volume up to 11 c.c. One c.c. of a suspension of *Bac. prodigiosus* was added, and this brought the volume up to 12 c.c., upon which the quantities of acid and alkali, which were added, had been based. The bottles were incubated at 22° for 20 hours, when counts were made, and these were calculated in terms of the neutral extract.

EXPERIMENT XX.

Reaction of extract (Fuller's scale).	Growth of *Bac. prodigiosus*, 20 hours at 22°.			
	a	b	c	average.
−0·3	56	43	53	50
−0·2	50	67	60	60
−0·1	93	71	70	78
0·0	100	100	100	100
+0·1	86	88	77	83
+0·2	33	44	21	33
+0·3	3	10	3	5

The numbers in the three tests are not uniform, but they serve to show the probable variation that the effect of dilution has upon an acid or alkaline extract. For example, in the ten days' test with *Penic. cladosp.* (xix.), the numbers with 80% were 187, and with 20%, 38. The reaction-curve passes through 86 for +0·1, 91 for +0·08, and 99 for +0·02. A slight calculation shows that the numbers at the 80% dilution are higher by 6%, and at the 20% dilution higher by 15% than they should be on account of the reduction of the acidity by the mere dilution. In these weakly acid extracts, however, small differences such as these are negligeable, as the counts themselves are liable to greater fluctuations.

A stage has been reached in the investigation at which it is made clear that bacteria and moulds do not produce toxins, or, if they do, the toxin is not capable of being demonstrated either in nutrient solutions or in vegetable-humus. Any resemblance to toxicity is probably caused by an alteration in the reaction of the medium, and, to such alterations of reaction, the test-organism is very sensitive.

THE GROWTH OF AMŒBÆ.

The attempt to obtain toxic substances among the byproducts of certain bacteria and moulds had not been so successful as had been wished; in fact, it had been decidedly unsatisfactory. Either the methods of producing the desired bodies were at fault, or the micro-organisms were not such as would give the desired results, although they had been selected as being the most likely to do so. It is known that bacteria can give out bacteriolytic substances, as for example, *Bac. pyocyaneus*, and moulds may be capable of doing the same. But these are not the only inhabitants of the soil. There are certain protozoa, and with the failure to obtain a decided and undoubted production from the bacteria and moulds, the attention was turned to the soil-fauna.

With regard to the possible activity of the members of the soil-fauna in this direction, we are faced with the fact, that the introduction of certain species of protozoa, *e.g.*, the Amœbæ and Colpodæ into sterile soils, does not bring about the condition that holds before sterilisation. The bacterial numbers, which become greatly increased as a result of the sterilisation, do not become reduced to the previous level when the protozoa are present. It is true that Goodey* has lately shown that the inhibiting factor, which determines the reduction of the bacterial numbers, becomes evident when the numbers of amœbæ approach and exceed 50,000 per gram of dry soil, but, at the same time, he says that the sterilised or disinfected soils are not suitable media for the production of the factor. The treatment of the soil with heat or with the volatile disinfectants so alters the soil, that it is not immediately suitable for developing the inhibiting factor, whatever it may be.

I had considered the possibility of soil-amœbæ being able to produce substances akin to the immune bodies of the animal pathologist, but, as experimental work failed to reveal any sign of toxic substances, and such immune bodies must be included in this category, I simply record the fact that such a possibility had been entertained, and that experiments with, and without, "vaccines" had been negative.

Some difficulty was met with in obtaining a "pure" culture of soil-amœbæ. Upon a former occasion, they had been cultivated in quantity in 1% hay-infusion, without any trouble, but, upon repeating the procedure, it was found that the medium was not well adapted for the purpose. The single cells generally disappeared overnight. The trouble was traced to the medium being too nutritive, thus permitting the accompanying bacteria to become too numerous and render the medium too alkaline. A

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* Proc. Roy. Soc., 89 (B.616), p.297.

hay-infusion, in which the bacteria had grown for some time, had changed from having a faint original acidity of $+0{\cdot}25$ to an alkalinity of $-2{\cdot}4$. It was naturally assumed that the alkalinity developed overnight had been the cause of the disappearance of the amœbæ, but, when either saccharose, lactose, lactic acid, humic acid, or sodium phosphate was added, the trouble still remained, although it was not so pronounced in the presence of humic acid. The addition of potassium nitrate, mono- or di-hydrogen phosphate, or ammonium phosphate to make a 0·05% solution with the hay-infusion, also resulted in the disappearance of the amœbæ. It seemed at one time as if the smallest droplets gave the most satisfactory growths, that one amœba in a small droplet had a better chance of growing than one cell in a large droplet, and it was concluded that the hay-infusion was too strong. It is a recognised rule, in growing amœbæ, that a poor medium should be used in order to prevent the protozoön being overwhelmed with bacteria, but 1% hay-infusion is by no means considered to be a rich medium, especially when made from a rather poor sample of couch-grass. However, experiments showed that 0·2% hay-infusion was well adapted for growing amœbæ in mass-culture, although it produced rather delicate forms in single-cell work. One of my most successful starter-cultures was obtained by gradually adding 1% hay-infusion so that the bacteria were kept under as much as possible. An equally good starter was obtained by growing the cells in a 2% infusion of exhausted leaf-mould, the same as was used in some experiments about to be recorded.

During this part of the investigation, the effect of adding sodium chloride to the hay-infusion was tested. In one instance, the addition of 0·2% was beneficial, while a larger quantity destroyed the amœbæ. In another instance, the addition was injurious. A good culture-fluid was found in tap-water containing 0·05% asparagin with 0·11% K_2HPO_4. Although two of the original five cells died overnight, the remaining three cells increased to 39 in another day. In view of this, an experiment was made in which the asparagin was replaced by chloride, sulphate or nitrate of ammonia, nitrate of potash and urea. A number of amœbæ were added to each droplet, and a trace of chalk. All the cultures did well, and, in course of time, the mobile forms encysted. The cells of the urea-test were vegetating long after the others, and the amœbæ in the ammonium chloride test also persisted longer, and finally disappeared without forming cysts.

A preliminary experiment was made with an extract of a partially exhausted leaf-mould, using a growth of amœbæ derived from a single cell. Although the solutions were tested from time to time in the customary manner for the influence of boiling and dilution, no definite information was obtained, and it was concluded that the culture-solution was too poor in nutrients to show or develop any signs of toxicity.

Vegetable-mould neutralised with lime (p.168) was then used. Each test contained the equivalent of ten grams of dry organic matter with an amount of water sufficient to cause the soil to adhere loosely to the sides of the containing bottle. This meant 73% of moisture. It was apparent from the results that the mould became too acid for the continued growth of the amœbæ. Forty thousand were added to each bottle, and, in five days, they had increased to 1·6 millions, in twelve days they had decreased to 136,000 mobile forms, and, by the twentieth day, they all had encysted. While this was going on, the extract, originally neutral, became more and more acid, doubtless due to the carbon dioxide, produced by the activity of the bacteria introduced with the amœbæ, reacting with the calcium humate, and liberating free humic acid.

The test was repeated with similar results. On the sixth day, the amœbæ had increased forty-four fold, and the reaction of the extract was − 0·04 ; on the thirteenth day, the amœbæ had encysted, and the reaction was + 0·1. The bacterial numbers gave no information.

Better results were obtained with an infusion of hay made by diluting a 1% infusion with tap-water to make a 0·2% solution. Tests were made on the sixth, twentieth, and forty-second days, but, as the two latter gave somewhat normal dilution-curves, they are not recorded.

EXPERIMENT XXI.

Soil-protozoön.	*Amœba limax.*	Numbers corrected for alkalinity.
Extract, boiled ...	575	575
Extract, raw	100	100
Extract, raw, 80% ...	387	277
Extract, raw, 50% ...	962	489
Extract, raw, 20% ...	3,252	1,205
Water-control ...	5,522	1,821
Bacteria added at start	712	204
Extract/water ratio ...	0·018	—
Reaction of extract ...	−0·38	−0·0

The figures are instructive, inasmuch as they show a considerable reduction in the number of bacteria originally added. There was something in the solution which was strongly toxic towards the test-organism added to the extract. It is unfortunate that the extract was so alkaline, for this undoubtedly clouds the issue, but, even when an allowance is made for it, according to the information previously obtained with extract of vegetable mould (p. 172), a strongly rising dilution-curve is still apparent.

The alkalinity was determined by boiling 25 c.c. of the extract with 35 c.c. of distilled water and 1 c.c. of centinormal sulphuric acid for ten minutes, rapidly cooling the solution, adding 1 c.c. of centinormal soda, and titrating back until the tint became that of the control. Phenolphthalein was used as the indicator. It gave a true indication of the reaction in extracts of leaf-mould, but, as will be shown subsequently, it is not so good for solutions of hay-infusion.

The experiments so far showed that some means must be adopted to eliminate the excessive alkalinity of the fermented cultures. On a previous occasion, humic acid had been used, but, as it had been soluble, it had not served the desired purpose. On standing, however, a solution of the acid had precipitated, and this precipitate of insoluble humic acid was washed and used. The employment of soil for maintaining a neutral reaction was suggested by the fact that, when it is put into hay-infusion and incubated, there is developed a mixed flora and fauna, the appearance of which is so healthy, that a pronounced acidity or alkalinity of the infusion is unlikely.

In one test, a small amount of sodium phosphate was added to the hay-infusion, but, from the appearance of the amœbæ, the salt seemed to have enhanced the alkaline effect, at any rate it favoured bacterial growth and rapidly destroyed the amœbæ.

The neutralisation of the alkalinity with lactic acid proved to be useless, for, in three days, the culture was as alkaline as before the addition.

The advantage to be gained by using insoluble humic acid or soil was tested with solutions obtained by diluting a 1% infusion of hay with nine volumes of water, that is they contained one part of hay per thousand.

EXPERIMENT xxii.

Protozoön	*Amœba limax.*							
Medium	Hay-infusion with humic acid.			Hay-infusion with soil.				
Test	1	2	3	4	5	6	7	8
Duration of test in days	10	14	24	8	12	15	22	36
Extract, boiled	635	503	869	955	1,749	2,160	637	3,477
Extract, raw	100	100	100	100	100	100	100	100
Extract, raw, 80%	107	115	108	117	151	106	87	122
Extract, raw, 50%	104	182	117	160	169	313	109	190
Extract, raw, 20%	89	203	129	264	451	665	156	494
Water-control	55	86	137	302	398	1,036	288	332
Bacteria added at start	9·6	40	20	52	188	99	42	35
Extract/water ratio	1·8	1·1	0·09	0·33	0·25	0·1	0·34	0·3
Reaction of extract	+0·0	+0·02	-0·04	+0·02	-0·02	-0·02	-0·05	+0·03

The tests were started with 500 c.c. of 0·1% hay-infusion, either a small quantity of washed humic acid (about 0·03 gram) or 25 grams of sterile soil and 10 c.c. of an amœba-culture. The latter represented from 30,000 to 50,000 mobile forms as estimated by the counts of later starter-cultures. The amœbæ in the earlier periods were not counted, but they grew well, and a count made on the sixteenth day showed 10,000 per c.c. in the humic acid, and 5,600 in the soil test. On the twenty-fourth day, the flasks contained 6,600 and 3,600 per c.c. respectively.

The results show a low reaction, and it was assumed that the fluids were approximately neutral. The humic acid tests do not exhibit any pronounced degree of toxicity as judged by the effect of boiling, or dilution, or by the relation of the raw extract to the water-control. They are of the indefinite type which leads one to further experimenting in the hope of obtaining something more definite.

In the soil-tests, we have a direct evidence of toxicity in the twelve days' culture. The filtered extract was directly toxic, reducing the number of bacteria added at the start from 188 to 100. The effect of boiling the extract for an hour under a condenser, and of diluting the raw extract is also well shown in the increased nutritive effect. The toxic nature of the twelve days' culture is confirmed by that of the fifteen days', for, although the added bacteria are not decreased, they did not increase.

A trial was made to see if humus, such as vegetable-mould, would be useful for maintaining an approximate neutrality. Four grams of lime-treated mould were tried against 50 grams of sterile soil. In fourteen days, the humus test showed a reaction of − 0·4, and the soil − 0·03. Humus was therefore useless for the purpose. There was no evidence of toxicity in the extracts.

While dilute hay-infusion has been found to be very good for growing the amœbæ, and for obtaining evidence of toxin-formation, it seemed advisable to see if a simple nutrient would be as good. The preliminary tests in the cultivation of the amœbæ had shown that they grew well in urea and ammonium chloride and, with these, calcium nitrate was included as a nutrient, which would probably not produce an alteration in the reaction of the culture-medium. Solutions of urea, 0·02%, ammonium chloride, 0·036%, and calcium nitrate, 0·056% in tap-water, were prepared. These contained equivalent quantities of nitrogen. To 500 c.c. of these solutions, 50 grams of soil and 25 c.c. of an amœba-culture containing 75,000 mobile forms were added. Unfortunately the amœbæ did not increase in numbers and were rarely more than 330 per c.c. Extracts were prepared on the seventeenth day when all hope of their increase had been given up. The extracts had the following reactions, urea, − 1·36, ammonium chloride, + 0·24, and calcium nitrate, + 0·04. There was no evidence of toxicity other than could be accounted for by the reaction. The experiment did not indicate that any of these chemicals would be of any value in the research.

THE INFLUENCE OF AERATION.

With the idea of determining the influence of aëration upon the production of toxin, a quantity of dilute (0·2%) hay-infusion was infected with a culture of amœbæ, 50 grams of soil were added, and the bottle containing the test was attached to an aspirator, which caused a few bubbles of air to pass through the liquid every few minutes. A control-bottle was allowed to stand in the laboratory. They were ordinary litre-bottles, and the 500 c.c. of infusion was 2¾ inches deep. Portions of the fermented liquids were filtered through porcelain on the fifth day, and again on the eighth day, with the following results.

EXPERIMENT xxiii.

Treatment	Aërated.		Not aërated.	
Duration of test in days ...	5	8	5	8
Extract, boiled	33	122	1,690	9,550
Extract, raw	100	100	100	100
Extract, raw, 80% ...	113	126	102	137
Extract, raw, 50% ...	117	144	160	429
Extract, raw, 20% ...	108	356	229	600
Water-control	74	242	152	574
Added at start	17	21	38	49
Extract/water ratio ...	1·3	0·4	0·6	0.2
Reaction	+0·2	+0·06	–0·06	–0·02

The solutions were twice the strength of those of Experiment xxii., but whether this accounted for a slow growth of amœbæ in the non-aërated test or not, cannot be said. None were seen on the fifth day, 330 on the eighth, and 2,300 per c.c. on the twelfth. In the aërated test, the amœbæ grew well; 3,000 were noted on the fifth, and 9,300 per c.c. on the seventh day. Aëration induced an acid, and its absence an alkaline reaction. The acidity was so high on the fifth day that, on the sixth, the aëration was stopped. This appeared to have had an effect upon the dilution-curve.

The greater growth of amœbæ and the smaller probability of the production of a toxic effect in aërated cultures raised the idea that, like yeast-cells, the reproductive may be inversely proportional to the physiological activity. So another experiment was started, and, as a variation, a flask was included which was infected with a culture of bacteria only, derived from a protozoön-free droplet of a starter. The extracts were tested on the sixth day.

EXPERIMENT XXIV.

Micro-organism ...	*Amœba limax.*		Bacteria only.
Method	Aërated.	Not aërated.	Not aërated.
Extract. boiled ...	1,168	2,039	3,453
Extract, raw	100	100	100
Extract, raw, 80% ...	75	109	106
Extract, raw, 50% ...	99	123	87
Extract, raw, 20% ...	103	199	260
Water-control	87	100	78
Added at start... ...	15	17·5	13·7
Extract/water ratio ...	1·15	1·0	1·27
Reaction	+0·04	−0·05	+0

The numbers bear out the contention that, if toxicity is to be obtained, it will not be as the result of aëration. The reaction went on as in the previous case, aëration producing acidity, and no aëration, alkalinity in hay-infusion. The examination of the culture-fluids showed that the amœbæ had begun to encyst in the aërated, and that 1,000 mobile forms per c.c. were in the other.

A further test was made upon the same lines; as a variation, a deep layer of fluid was used without aëration in order to accentuate the conditions. The method at this time had been to use 700 c.c. of fluid contained in a bottle of about 1,200 c.c. capacity, and, in this, the fluid had a depth of 9 cm. In the deep test, 1,700 c.c. were used, and in an ordinary winchester this had a depth of 16 cm. In the latter, the amœbæ grew slowly, the first indication being obtained on the thirteenth day, when 330 per c.c. were noted. On the seventeenth, they had risen to 1,000. The aërated test showed 5,300 on the fourth, and, without aëration, the first evidence, 330 per c.c., was obtained on the eleventh day.

EXPERIMENT XXV.

	No amœbæ.		*Amœba limax.*							
	No aëration.		No aëration.		Aërated.		No aëration, deep layer.			
Period of incubation in days	4	7	4	7	4	7	6	9	13	26
Extract, boiled	757	837	518	1,883	420	64	6,193	863	1.286	734
,, raw	100	100	100	100	100	100	100	100	100	100
,, ,, 80%... ...	86	84	95	91	92	53	261	131	105	120
,, ,, 50%... ...	168	81	147	221	95	193	145	163	157	177
,, ,, 20%... ...	579	141	559	224	157	227	177	131	162	302
Water-control	210	118	125	261	175	86	137	175	71	215
Added at start	83	18	49	41	69	13	54	27	15	28
Extract/water ratio ...	0·47	0·85	0·80	0·38	0·57	1·15	0·73	0·57	1·40	0·46
Reaction...	–0·02	–0·3	–0·04	–0·3	–0·04	+0·04	–0·04	–0·3	–0·34	–0·26

Taking the figures as a whole, there is not sufficient difference between them to justify the consideration that any toxin had been produced by the amœbæ, for rises in the dilution-curve are obtained in their absence. In view of later experience, the rises might well have been caused by the reaction of the culture-fluid.

About this time, it became evident that the method of determining the reaction by the use of phenolphthalein, as the indicator, might be faulty when hay-infusion was used, and that results based upon the reaction of a medium such as extract of vegetable-mould did not hold for another medium, such as hay-infusion. The method had been to add a few drops of phenolphthalein to a portion of the extract, and boil for ten minutes. If the solution became purple, another portion was boiled with acid, and titrated back. If it only became slightly reddened or tinted, it was titrated without boiling with acid. When methyl-orange was employed as the indicator, the reaction-numbers were much higher.

It became necessary to examine the influence of various strengths of hay-infusion, as a direct toxic action had been found in a 0·1% solution, and had not again been obtained in 0·2% solutions. The bottles received 700 c.c. of infusion, 60 grams of sterile soil, and 20 cc. of a starter containing 112,000 mobile amœbæ.

EXPERIMENT XXVI.

Strength of infusion ...	0·05%.		0·1%.		0·2%.		
Duration of test ...	5	8	7	10	7	10	17
Extract, boiled ...	610	135	729	353	1,016	2,038	1,028
,, raw... ...	100	100	100	100	100	100	100
,, ,, 80% ...	—	111	94	219	98	425	111
,, ,, 50% ...	377	118	174	216	143	586	167
,, ,, 20% ...	150	69	298	28	343	136	250
Water-control ...	122	61	219	86	400	154	181
Added at start ...	16	8	28	11	51	20	28
React'n, phenolphthalein	– 0·02	– 0·03	– 0·02	– 0·02	– 0·02	– 0·05	– 0·06
,, methyl-orange ..	– 0·52	– 0·23	– 0·32	– 0·30	– 0·52	– 0·39	– 0·52
Extract/water ratio ...	0·8	1·6	0·5	1·1	0·2	0·6	0·5
Amœbæ per c.c. ...	500	1,000	1,830	2,000	660	5,600	2,000

There was no direct toxic effect in any of the tests, and, so far as the possibility of obtaining such by using different strengths of infusion are concerned, the strongest appears the most likely. The ten-days' extract of the 0·2% solution gave more favourable numbers than any of the others. In this, the amœbæ were the most numerous.

A further test with 0·1% hay infusion was made, but in it the amœbæ did not grow quite so well as on the former occasion when the direct toxic action was obtained. The counts showed 830 per c.c. on the seventh, and 1,000 on the eighth day. No evidences of toxicity were obtained on the eighth or twenty-first days, and it must be concluded, that a definite toxicity cannot be demonstrated by growing bacteria or amœbæ in the usual culture-fluids.

THE INFLUENCE OF REACTION.

Much has yet to be found out regarding the influence of reaction upon bacterial growth, and the reason for the rise in the dilution-curves of the extracts. As the infusions and culture-solutions are generally made with tap-water to supply a small quantity of saline matter accepted as being necessary for the growth of micro-organisms, a beginning was made with it. Tap-water is known to be alkaline, but the extent of the influence of its faint alkalinity is not known. The nutrients were increased by preparing infusions of hay, and these were made sufficiently weak to enable useful counts to be obtained. A 1% infusion of hay was diluted with 99 parts of porcelain-filtered, distilled and tap-water, thus obviating heat-effects. Portions were treated with lactic acid and with ammonia so as to bring up the final volume to a definite reaction, and sown with a definite number of cells of *Bac. prodigiosus*. They were incubated at 22° for 20 hours, and counted. In tabulating the results, the highest counts were taken as 100.

EXPERIMENT XXVII.

Reaction.	Distilled water.	Tap-water.
+0·3	11	16
+0·2	18	29
+0·1	44	100
+0·05	59	—
0·0	100	5
−0·05	44	—
−0·1	28	0·1
−0·2	7	0·05
−0·3	0·6	0·02
Reaction of the untreated diluted infusion to methyl-orange	±0·0	−0·20
To phenolphthalein, direct	—	−0·03
To phenolphthalein, indirect	—	−0·14

The distilled water test shows that the bacteria grow best in a neutral solution, and the tap-water test that neutrality is obtained when approximately +0·1° of acid has been added. The curves of these numbers are steep on both sides of the approximately neutral line, indicating that a slight difference in the reaction of an extract will make a great difference in the growth-numbers. As it is impossible to obtain a neutral reaction in the cultivated extracts, it would be necessary to neutralise them before dilution in such tests as have been made. It is not clear how this could be done, for, in the solution under examination, the bacteria showed 0·1° of alkalinity, methyl-orange showed 0·2°, phenolphthalein by direct titration after boiling, 0·03°, and by indirect or back titration, 0·14°.

The experiment would be incomplete without the inclusion of others showing the influence of diluting distilled and tap-water infusions with distilled water, as is customary.

Experiment xxviii.

	Distilled water.		Tap-water.	
			Raw.	Boiled.
	a	b	a	b
Solution, boiled	26	—	1,020	131
,, unboiled	100	100	100	100
,, ,, 80%	75	86	140	234
,, ,, 50%	—	42	1,160	207
,, ,, 20%	27	18	2,880	182
Distilled water-control	2	3·5	263	32
Added at start	0·4	2	50	20
Solution/water-ratio	47	28	0·4	2·5
Reaction to methyl-orange ..	– 0	– 0	– 0·16	– 0·24
Reaction to phenolphthalein, direct	– 0	– 0	– 0·05	– 0·11
Reaction to phenolphthalein, indirec	– 0	– 0	– 0·16	– 0·24

The boiled tap-water infusion, "b," was boiled three times upon successive days, as is usual in preparing such culture-media. Tests "a" were made eleven days before tests "b." By an accident, the "b" tests were incubated at 26° instead of 22° as in "a," and this should be borne in mind when considering the increase of the unboiled numbers over the start.

The distilled-water numbers are considered to be normal, for they show a gradual fall as the nutrients are weakened by dilution with water. The tap-water curves rise as the alkalinity is weakened. The numbers of the raw tap-water test indicate that, after all due allowances are made, it is of a toxic nature, which is probably not entirely traceable to the alkalinity. The numbers of the boiled-water test are not so pronounced, and are much the same as have been obtained in previous experiments with bacterial and protozoön cultures. It should, however, not be forgotten that many of these gave normal curves.

A set of experiments were started when it had become evident that, in all probability, the reaction had more to do with the symptoms of toxic effect than anything else. In the endeavour to get round any individual action of the bacteria, flasks of dilute (0·1%) hay-infusion, made with distilled water to avoid the action of tap-water, were seeded with an amœbæ-culture, and with a bacterial culture derived originally from a protozoa-free droplet of soil-suspension. The latter were thus controls. The amœbæ-cultures were twice seeded with amœbæ, once, at the start, and again on the second day, as the first seeding did not seem to have been successful. They grew slowly at 18°, and exhibited a twenty-fold increase on the tenth day, and a fifteen and ten-fold increase on the thirteenth day with the humic acid and humic acid + soil respectively. They were tested on the fourteenth day.

EXPERIMENT XXIX.

	Humic acid.		Humic acid + soil.	
	Amœbæ.	No amœbæ.	Amœbæ.	No amœbæ.
Extract, raw	100	100	100	100
,, ,, 50%	192	125	184	183
Water-control	133	82	98	88
Added at start	16	10	11	10
Extract neutralised with lactic acid	104	127	198	243
Extract/water-ratio	0·75	1·2	1·0	1·1
Reaction to methyl-orange	−0·15	−0·28	−0·21	−0·28

The addition of soil to the culture-fluids had no influence, one way or the other, in increasing or decreasing the numbers, and its use appears to be of no value. The experiment shows pretty clearly that any toxic effect is not caused by the amœbæ, but rather by the bacteria which always accompany the protozoa. It is doubtful if the alkalinity, as indicated by methyl-orange, is a true index, but, if accepted as true, the neutralised solutions were certainly more nutritive than the unneutralised, for the numbers were higher. With a better indicator, a lower reaction might have been obtained and higher numbers furnished in the neutralised tests. At any rate, it is pretty safe to conclude, that the rise in numbers upon dilution is largely, if not entirely, due to the lessening of the alkalinity of the filtered extracts.

REACTION-EXPERIMENTS.

The reaction of the soil-extract is never constant, but varies from day to day, probably within certain limits. For example, an extract was made on November 30th, 1917, by taking 300 grams of garden-soil and 300 c.c. of distilled water. The two were shaken 300 times during an hour, and filtered. The reaction to methyl-orange was − 0·14, although a paste of the soil was acid to litmus.

A similar extract, made on December 6th, had a reaction to methyl-orange of − 0·24. This extract was examined, with the following results.

EXPERIMENT XXX.

Soil-extract, boiled	21
,, raw	100
,, ,, 80%	100
,, ,, 50%	64
,, ,, 20%	12
Water-control	0·5
Added at start	0·7
Extract/water ratio	206

Quantities of lactic acid and of carbonate of soda were added to vary the reaction, and the treated extracts were seeded with the test-organism in the usual manner. The following numbers were obtained after the usual 20 hours' incubation at 22°.

EXPERIMENT XXXI.

Acid or alkali added.	Net reaction.	Bacterial growth.
+0·4	+0·16	1·5
+0·3	+0·06	6·3
+0·2	−0·04	17
+0·1	−0·14	49
+0·05	−0·19	100
0·0	−0·24	81
−0·05	−0·29	31
−0·1	−0·34	15
−0·2	−0·44	1·3

The true neutral point was reached by adding 0·06° of acid, that is to say, the methyl-orange indication was − 0·19 in excess.

The effect of shaking up various quantities of soil and water was tested, to see the differences in the reaction of the extracts. Round numbers were taken, but, as the solid contained 8% of moisture, a correction was made.

Proportion of soil to water, round numbers ...	2 : 1	1 : 1	1 : 2
Proportion of soil to water, calculated for dry soil...	1 : 0·63	1 : 1·17	1 : 2·26
Reaction to methyl-orange	−0·24	−0·18	−0·12
Reaction to phenolphthalein, direct ...	−0·044	−0·016	−0·008

Curves of these numbers show that the reaction of the soil-water, equivalent to a ratio of 1 : 0·087 for the dry soil to 8% of moisture, would be between − 0·4 and − 0·5 for methyl-orange, and about − 0·09 for phenolphthalein; yet the soil was acid to litmus.

The reaction to phenolphthalein was examined somewhat closely, after the suspicion was raised that the reaction of the solution had more to do with the phenomenon of toxic action than had been supposed to exist. It was found to be untrustworthy, as much depended upon the rate at which the solutions were boiled, previously to cooling and titration. For example, covered beakers containing 50 c.c. of tap-water were boiled slowly and rapidly, cooled and titrated.

Duration in minutes ...	10	20	30
Slow boiling	−0·022	−0·048	−0·071
Rapid boiling	−0·076	−0·105	−0·118

Much, therefore, depends upon the method and time of boiling in expelling the carbon dioxide. In the tests previously recorded, the extracts were boiled in an open beaker for ten minutes at a speed intermediate between slow and rapid boiling. They probably do not indicate the true alkalinity, but, for that part, it has been shown that the same would have occurred by using methyl-orange.

A twenty-one-days' culture of bacteria and amœbæ was filtered, and the extract treated with lactic acid in decreasing quantities, seeded with the test-organism, incubated and counted. It had a reaction to methyl-orange of − 0·16°, and to phenolphthalein, direct, of − 0·04°.

EXPERIMENT xxxii.

Lactic acid added.	Net reaction.	Bacterial counts.
0·31	+0·15	8
0·26	+0·10	19
0·21	+0·05	41
0·16	0·0	46
0·11	−0·05	40
0·06	−0·10	100
0·0	−0·16	53

The experiment shows that, in the case of a fermented culture-fluid, the lessening of the alkalinity by 0·06° produced neutrality. The methyl-orange indication was −0·10° too high. A high indication was also obtained with soil-extract in Experiment xxxi., and with tap-water in Experiment xxvii.

The acidity of the extracts of sterilised vegetable-moulds (Experiments xv., xvi.) led to an examination being made of the extracts of soil which had been sterilised in the same manner, viz., for two hours at 130°.

Two hundred gram-portions were put into sterile bottles with 10 c.c. of a suspension of *Amœba limax*, containing 10,660 mobile forms per c.c., and 40 c.c. of water. The soil thus had an excessive amount of moisture, 20%; it usually contains from 8 to 10%. The bottles were kept at laboratory-temperature, which varied from 18-23°.

Extracts were made in the usual manner by adding 200 c.c. of distilled water, shaking frequently during an hour, and filtering through porcelain. The extracts were seeded with *Bac. prodigiosus*, incubated and counted.

EXPERIMENT xxxiii.

Duration of test in days	3	53
Extract, raw	100	100
Extract, raw, 50% ...	240	48
Water-control	1	1·2
Added at start	0·16	0·14
Extract/water ratio	110	153
Reaction to methyl-orange ...	+0·3	−0·8

The point to be noted is the change in the reaction of the extracts. It changed from being comparatively strongly acid on the third day, to strongly alkaline on the fifty-third. When the extract of the latter was treated with lactic acid to neutralise the apparent alkalinity, the number obtained was 0·07 as against 100 for the non-neutralised extract; that is, for every seven bacteria in the neutralised, there were 14,000 in the alkaline extract. The acid had clearly been added in excess, the − 0·8° being far from a true indication.

This confirms the result obtained in another place, that the reaction of a soil-extract, as judged by methyl-orange, is not the true reaction. Mobile amœbæ were seen in the soil on the fifty-third day.

Conclusion.—It has been shown that certain soil-bacteria, moulds, and amœbæ, all reasonably supposed to be capable of furnishing substances of a toxic nature, were grown in various media and under varying conditions; and, in all cases, the signs of toxicity which became manifest could be attributed to an alteration in the reaction of the media.

The test-organism, *Bac. prodigiosus*, grows best in a neutral medium, and an indicator is required which will indicate strict neutrality. The methyl-orange numbers are too high, and the phenolphthalein too low. Small divergences from the neutral point strongly affect the growth.

The humus of leaf-mould contains two types of humic acid; one absorbs alkali from alkaline carbonates, and the other from alkaline carbonates and hydrates. These were present to the extent of one part of the former to three of the latter. Heating the humus increases the amount of acid, and the increase is largely soluble in water.

The effect of reaction is quite of a different order from the evidence of toxic action obtained in former researches.

I am indebted to Mr. W. W. L'Estrange for kind assistance during the later stages of the work.

ON CERTAIN SHOOT-BEARING TUMOURS OF EUCALYPTS AND ANGOPHORAS, AND THEIR MODIFYING INFLUENCE ON THE GROWTH-HABIT OF THE PLANTS.

By J. J. Fletcher and C. T. Musson.

(Plates iv.-xxvi.)

The Eucalypts, representing about 230 recognised species, contribute one of the dominant, phanerogamic elements to the Australian flora. They are an assemblage of plants remarkable in many ways, widely distributed over an entire continent, extending also to the circumjacent islands; and now acclimatised to some extent in other countries. One of the astonishing things about them is the liability of the seedlings of so many species to shoot-bearing galls or tumours of an uncommon type.

Their specially distinctive characters result from a fortuitous combination of some simple, natural, and favouring conditions present in quite young seedlings. Firstly, they originate in the axils of the cotyledons only, or, in addition, in a few pairs of leaf-axils successively above these, where the buds are, as paired but at first independent, proliferating outgrowths of cambium-tissue; and, as a rule, the outgrowths, or the axillary stem-nodules, as we may call them at this stage, succeed in taking possession of the dormant buds, and incorporating them in the stem-nodules. This is how the latter, as well as the composite tumours to which they may give rise, come to have buds or shoots.

Secondly, the young seedlings usually have opposite and distichous leaves; and, correspondingly, the stem-nodules are also opposite and distichous; but as, under favourable conditions, the latter grow faster than the stem thickens, the paired nodules meet and fuse, and the fusions then encircle the stem.

Thirdly, as a rule, the first and second internodes do not length too much or too soon to permit of the concrescence of the fused pairs, giving rise to composite, shoot-bearing, stem-encircling tumours. The third and succeeding internodes are more variable, but often permit of the addition of a fourth and a fifth pair of fused nodules to the concrescence of the first three pairs. More than five pairs, if developed, are apt to be left isolated, and are only of minor or of no importance. Three to five pairs are the really effective and important ones.

Fourthly, the hypocotyl is not too long, so that, as the composite, stem-encircling tumour increases in size, and grows downwards, it is able to tamper with as much of the root-system as it encounters, encircling and fusing with the upper portion of the tap-root, and the proximal portions of any lateral roots that come in its way, intercepting more or less of the water they may contain, at the expense of the seedling-stem, and to the advantage of the tumour and its inhabitants. In this stage, they are composite, stem-encircling, shoot-bearing, root-incorporating [but not root-emitting] tumours.

The stem-nodules of seedlings of refractory species, or of refractory individuals of any species, may not get beyond the first stage. In such cases, the proliferation slows down, and the axillary stem-nodules come to a standstill. A mild attack has run its course without accomplishing anything of importance, or interfering with the growth-habit of the seedlings.

Seedlings of susceptible species, from accidental or other causes, may not get beyond the second stage, through the composite, encircling tumours failing to incorporate roots. In such cases, the composite tumours may last for some time, but not as long as those which can complete the third stage.

In the Non-Mallee Eucalypts, the last stage may last for some years, until the plants are getting ready to enter on the young sapling stage, but not indefinitely. In the Mallees, however, it may persist throughout life, and the tumours may attain an enormous size. But the distinction between the two groups of Eucalypts does not correspond to inherent differences in their tumours, as such; but to differences in the kind of roots incorporated in the two cases. In other words, the Non-Mallees have ordinary roots; the Mallees have water-storing roots.

In all three stages, the buds may remain dormant, or they may develop shoots, according to circumstances. In the first case, an appropriate stimulus will readily cause shoots to develop. Anomalies, eccentricities, and examples of erratic behaviour are common, and very instructive.

In addition to the axillary stem-nodules, unpaired, not definitely localised nodules sometimes develop at a lower level than the cotyledons, either on the hypocotyl or on the taproot, of some seedlings. These are very suggestive of wound-infection, and are sometimes obviously pathological. This is particularly the case in most seedlings of two of the Bloodwoods, in which very extensive root-invasion may take place.

In all these cases, we can find no escape from the conclusion, that the exciting cause of the nodules is attributable to parasitic soil-organisms, probably of the same species, finding vulnerable points for attack under slightly different conditions; and causing the cambium-tissue to proliferate and grow outwards. The nodules are not caused by insects, or other visible parasites. They are outgrowths of proliferating tissue, and not natural growths. They may be a nuisance to the plants, and may temporarily or permanently interfere with the natural growth-habit. Moreover, if possible, when opportunity offers, they are brought to a standstill.

The root-nodules of four young seedlings, of which three are figured. in every case have incorporated the basal portion of a young root. They suggest analogy to what Beyerinck has observed in studying the root-nodules of Leguminosæ—"The splitting of the primary bark for the emission of the side-roots is the special means of entrance of *B. radicicola*" [Erwin Smith, "Bacterial Diseases," ii., p.103].

The vulnerability of the axils may be due to a weak spot which arises in connection with the differentiation of the buds, or which is exposed about the base of the petioles when the young leaves expand. Until serial, transverse, and superficial, longitudinal sections through the axillary region of series of seedlings have been studied, it is useless to speculate further.

In the belief that soil-organisms are responsible for the problem we are interested in, we began a search for records of similar or analogous cases.

Dr. F. Erwin Smith, in the second volume of his important treatise on "Bacteria in relation to Plant-Diseases" (1911), discusses, in detail, wound-infections (p.51), and also infections through natural openings, grouped as nectarial, waterpore-, stomatal, and lenticellate infections. But we failed to find any reference to axillary infections. As we came to know later, axillary infections had not then come under the author's notice.

It was with great interest that we unexpectedly met with a paper by Mr Clayton O. Smith, of California, in which he not only mentions the possibility of axillary infection in the axils of the cotyledons, in stone-fruits, but he gives particulars about the axillary nodules of some Eucalypt seedlings which came under his notice. We quote all that the author has to say about these, and about cognate matters, for three reasons. The paper is not contained in the Society's library, and we know of only one copy of it in Sydney. It contains the first satisfactory record known to us of the realisation of the fact, that the stem-nodules are axillary; as well as the only records, that we know of, of the successful inoculation of Australian plants, including Eucalypts, from cultures of soil-organisms. It is also of interest to note what an experienced plant-pathologist thought of the stem-nodules. Mr. Clayton Smith does not mention the fusion of the axillary knots, or that they had shoots, or that they incorporated roots. *E. tereticornis* is the only species mentioned, and seedlings of this species are sometimes more or less refractory. It may be, therefore, that with only limited material available, and without Australian experience of Eucalypts to guide him, he may have unknowingly experimented with seedlings that were not as satisfactory for the purpose as others might have been.

"Further Proof of the Cause and Infectiousness of Crown Gall." By Clayton O. Smith. Univ. Cal. Publications, College of Agric., Agric. Experim. Station Bulletin No.235 (Dec. 1912).

"Bacterial Nature of [the] Disease" (p.534).—There is now abundant proof, that these knots [Crown-Gall on the 30 Hosts enumerated] are caused by a bacterial organism that enters the tissue through some injury, or possibly at the point where the cotyledons of such seeds as those of the stone-fruits are attached to the young plant. In Eucalyptus seedlings, the natural knots often appear opposite each other where the cotyledons have previously been attached, also the quince knots appear first at the node about the old leaf-scar. All the evidence we have, goes to show that some injury or weakness is necessary for infection to take place."

[Legend of Text-fig.21, p.549].—"Artificially caused galls on forest red gum [*Eucalyptus tereticornis*]. Crown Gall has not been known to attack the various species of Eucalyptus in nature. The significance of swellings found frequently at the crown of young gum trees is not yet understood. They do not appear to be detrimental to the tree."

Victoria Bottle Tree (*Sterculia diversifolia*) [fig.20], and Flame Tree (*S. acerifolia*) were successfully inoculated (p.552).

"Forest Red Gum (*E. tereticornis*) [fig.21].—Seedlings of from four to six feet were inoculated. The first successful inoculations were made May 16, 1910. On March 25, 1912, there was one large knot and one very small one at points of inoculation. September 2, 1911, inoculated a seedling about one half inch in diameter. February 20, 1912, there were two small knots. On March 26, 1912, one of these knots had grown rapidly in size, the other had not changed."

"Inoculations were made on small seedlings, July 20, 1910, on the branches. Typical roundish knots or galls had developed on September 5, 1910."

[Silky] Oak (*Grevillea robusta*) (p.552), gave negative results. "This is probably due to the slow growth of the tree."

Under the heading of *Other Galls that are at present little understood* (p.552).—"*Eucalyptus Knot* (pp.553-554)— Galls occur frequently on the small seedlings. These are hard knots that occur always at the nodes. There will often be a gall on each side of the plant where cotyledons or the opposite leaves have previously been. We have had small seedlings with these natural galls under observation for about three years. In some cases there is an increase in size in the knots, which still continue to be hard, and do not in any way appear to weaken the trees. In many cases, the diseased trees have completely outgrown the disease, and in these instances there has been but little increase in size of [the] original knots. From our observations, the disease does not seem to seriously injure the growth of the tree. Numerous attempts to isolate a pathogenic organism have resulted in failure, although we still believe the galls may be caused by such an organism."

Quite recently three papers by Dr. Erwin F. Smith, of the U.S. Department of Agriculture, have come to hand, which have a very important bearing on the problem of the shoot-bearing tumours of Eucalypts.* These also are to be found only in a few libraries. They are important because they relate to the first records of natural, axillary, shoot-bearing tumours caused by soil-organisms; and axillary and other special tumours produced by artificial inoculations. We give the following extracts from these:—

Dr. Erwin Smith says in his paper published in August, 1916: "Last winter, I discovered that when growing plants are inoculated in the vicinity of dormant buds, a new type of tumor is produced. This tumor bears, on its surface, diminutive abortive shoots (vegetative or floral) and in its interior, along with the cancer-cells, numerous fragments of embryonic tissues, variously fused and oriented, often upside down and curiously jumbled These tumors have never been seen by the writer in nature, or at least if seen, not recognised as crown-gall tumors, but undoubtedly we shall now find them." [Then follows reference to a footnote "As this goes to press, I have had confirmation of this belief, having received from a florist in Massachusetts, a crown-gall of the rose showing abortive shoots growing out of stem-tumor."] Dr. Smith continues—"These tumors have all

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* "Further Evidence as to the Relation between Crown-Gall and Cancer," Proc. Nat. Acad. Sci. U. S. A., ii., p.444 (August, 1916). "Mecanism of Overgrowth in Plants," Proc. Amer. Phil. Soc. Philadelphia. lvi., No.6, p.439 (August, 1917). "Embryomas in Plants (produced by Bacterial Inoculations)," Bulletin Johns Hopkins Hospital, xxviii., No. 319, p.279 (September, 1917).

been produced with *Bacterium tumefaciens*. . . . . . . The plants chiefly experimented on have been Pelargonium, Nicotiana, Lycopersicum, Citrus, and Ricinus. All of these and some others (Mangifera, Allamanda, etc.) have yielded teratoid tumors from inoculations in leaf-axils."

In a later paper, Dr. Erwin Smith refers again to the accidental circumstance which suggested to him the desirability of inoculating plants in leaf-axils and growing-points, in addition to internodes, as he had been doing for years. "We had found indeed, as early as 1908-9, and had produced by bacterial inoculation, plant-tumors bearing roots, but the full meaning of this discovery, as related to cancer, did not occur to me until early in 1916, when I found crown-gall tumors bearing leafy shoots on some of our inoculated hothouse geraniums. Beginning with this discovery, I made numerous inoculations in the leaf-axils of various plants, which resulted in the production of leafy tumors, and subsequently I produced them on leaves and on cut internodes where no buds occur normally. Tumors bearing roots have also been produced by us on the top of plants, and in one cut internode of Tobacco I succeeded in producing a tumor which bore flower-buds. These perishable root-bearing and shoot-bearing tumors I regard as plant-embryomas, and have so described them [Journ. Cancer Research, April, 1916, p.241]."

We have not had access to the paper last mentioned. But in the Johns Hopkins Bulletin for September, 1917, Dr. Erwin Smith has given further particulars, and numerous illustrations of the embryomas resulting from his inoculations, together with two (fig.63) of "Pelargonium teratoid tumors originating naturally . . . on gardener's cuttings bedded in earth for propagation. The specimens came from a gardener's house near Baltimore."

We give the following brief extract from this paper—"In April 1916, I announced the discovery of a new type of crown-gall, *i.e.*, one containing numerous leafy shoots, and showed that I could produce it at will by making my bacterial inoculations in leaf-axils where there is a dormant bud. . . . . . I have since discovered that leafy crown-galls occur in nature on various plants, *e.g*, on the rose, and on the carnation."

If the shoot-bearing, axillary nodules of Australian Eucalypts are caused by parasitic soil-organisms, under natural conditions, then they seem to be comparable with the five cases of "leafy tumours" [on Geranium, Pelargonium (two), Rose, and Carnation] due to axillary infection by the organism causing Crown-Gall under natural conditions cited, by Dr. Erwin Smith.

Were it not that, by a fortuitous combination of circumstances, the axillary stem-nodules are able to fuse in pairs, the fused pairs to concresce, and the re-inforced, composite, stem-encircling tumours thus enabled to incorporate roots and so last for some considerable time or even permanently, both the nodules, and any shoots they might develop, would be short-lived and abortive; as they actually are in refractory seedlings; and as the shoots on the lower pairs of concrescences also are.

They are not exactly comparable with the embryomas produced by Dr. Erwin Smith's inoculations in leaf-axils and growing-points. But the circumstances and conditions in the two cases are not parallel. Erwin Smith's experiments were mostly, but not entirely, carried out with soft-tissued plants, which responded promptly; the organisms were introduced by needle inoculations right into the tissues of the plants, causing profound disturbances; and the inoculations were made in upper axils.

But in the natural inoculations in the lower axils of the young seedlings of Eucalypts, which furnish some of the most valued hardwood timbers, we are inclined to think that the organisms are confined to the outgrowths, and the encircling tumours to which they give rise, and probably do not invade the tissues of the seedlings. The tumours do not kill the seedlings, or even seriously damage their tissues. They are a drag on the normal development of the plants, especially so when shoots do not develop, and by interfering with the water-supply, and also by their shoots preventing the development of the normal branching. In the Mallees, so much water is intercepted by the tumours, that the seedling-stem is dwarfed; and, by the persistence of the shoots, the growth-habit is permanently distorted, so that the plants are prevented from realising their potentialities as trees. The seedling-stem may possibly be sometimes crowded out and got rid of.

But the stem-nodules, as well as the composite tumours to which they give rise, are complex tumours, composed of both somatic cells and germ-cells; and the latter are totipotent, because in the persistent composite tumours of the Mallees, the tumour-shoots complete their growth, flower and fruit, and produce seed. Even in the Non-Mallees, if the seedling-stem is lost, two tumour-shoots may take its place, attain to tree-size, and flower and fruit. But they do not prematurely disclose their embryonic possibilities, in the way that some of Erwin Smith's artificially produced monstrosities did. Also the production of these tumours in Eucalypts under natural conditions is a matter of long standing. The Mallee Scrubs, which must have been the developments of centuries, were in their prime, when civilised man first saw them, nearly 101 years ago.

We may next briefly review the Australian contributions to a solution of the problem we are interested in. These relate chiefly to the Mallees. The earliest descriptions of the make-up of these curious plants, by Allan Cunningham,* Tenison-Woods,† and Baron von Mueller,‡ are subject to the drawback that, when these botanists visited the untouched Mallee-Scrubs, there was no opportunity of seeing uprooted plants. Two of the Baron's definitions will suffice. Under *E. oleosa* (Dec. vii.): "Shrubby or somewhat arborescent. . . . . . . It is this species which forms a large ingredient of the 'Mallee-Scrub,' constituting tall bushes branched from the root." Under *E. stricta* (Dec. x.): "Shrubby or somewhat arborescent . . . .; habit that of the Mallee-Eucalypts, with many stems from one root."

Mr. J. Ednie Brown,§ in 1882, gave his interpretation of the "root" of the Mallees, from which the stems are said to rise, as "being apparently a kind of dwarf trunk, the stems of our description [under *E. gracilis.* "A Mallee tree with several stems"] representing its branches."

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* Oxley's Journal (in the entry for June 10, 1817), p.63 (1820).

† "Geological Observations in South Australia," p.33 (1862). Also, Proc. Linn. Soc. N. S. Wales, vii., p.566 (1883).

‡ "Eucalyptographia," under the various Mallees (1879-84).

§ Forest Flora of South Australia, Part v. (1882).

A little later, Mr. Tepper, of Adelaide, offered another explanation of it*—"*Eucalyptus oleosa* is a species with an underground rootstock, from which numerous small stems, generally crooked and semi-sarmentose, spring. When these are destroyed by fire, &c , a host of fresh ones spring up from the caudex." But no details are given of the characters of the supposed rootstock.

We owe to Mr. N. B. McKay† an interesting description of the underground, composite, stem-encircling tumour of a Mallee, even though it is incomplete, inasmuch as no particulars about the shoots, or the incorporated roots are given. We have looked in vain, however, for a more satisfactory one. He says —"The indigenous timber-growths on the Mildura horticultural areas consist, for the most part, of blue bush, 'bull' mallee, balar, pine, and needle-bush. . . . . A well established bull mallee is a problem to the ordinary grubbing contractor. The butt is a great flattened bulb of curly timber, sometimes 8 or 10 feet through. It is set firmly into the soil, and even if all the roots were cut off, the tree would stand in its place just the same, as the upper growth is very insignificant compared with the base. Chopping mallee out is an obvious impossibility, and, as the wood is full of moisture, it would be an endless task to attempt burning it out. Dynamite and rack-a-rock have proved equally useless. Before, or rather behind, the traction-engine, the difficulty disappears. . . . . . When all the stumps are uprooted, the adhering earth is knocked off, and they are readily burned."

Three items in this are worth notice. Firstly, that the butt is a "flattened" bulb: that it is to say, it increases in size horizontally rather than vertically. Secondly, it is a bulb of "curly timber": it is not a case of a simple, localised thickening of the stem, but results from the proliferation of cambium-tissue. Thirdly, "the wood is full of moisture": it is a water-charged tumour, because of the incorporation of water-storing roots.

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* "Remarks on the 'Manna' or Lerp Insect of South Australia." Journ. Linn. Soc. Lond., Zoology, xvii., p.109 (1883).

† Eighth Progress Report of the Royal Commission (of Victoria) on Vegetable Products, 1890.

The late Professor R. Tate, in a paper entitled "A Review of the Characters available for the Classification of the Eucalypts,"* etc., under the section "Habit," expressed some views, which should have provided a new starting-point for considering the make-up of the Mallees. Unfortunately, they were so severely condensed as to be cryptic, and quite failed to influence his successors. Tate says—

"The Eucalypti comprise two habits of growth, viz., trees and shrubby trees, to which I apply the vernacular names of *Gums* and *Mallees.* I do not know if I am correct in so doing, as I have failed to find any definitions of these well-known terms." "I have constantly observed in seedlings and growths of one or two years of such gums, as *E. rostrata*, *leucoxylon*, *viminalis*, a large inflation of the base of the stem, either at the surface or just below the surface of the soil. In the species named, this is eventually outgrown; but, in the mallees, it persists and increases in size proportionately with the development of the branches which are emitted from it—in the mallee, this rudely globose bole is partially subterranean."

It is the third and fourth sentences that are important. These embody Tate's version of the problem we are interested in, compressed to an irreducible minimum. The chief difficulty arises from the fact that no attempt is made to explain the nature or the significance of the basal inflations. A non-committal name is given to them, but they remain of problematical import. Nor is any reason given for their being transient in the seedlings of Non-Mallees, and persistent in the Mallees. Nevertheless, he recognised the difference. Apparently his seedlings were not young enough to show the axillary stem-nodules before they had fused in pairs, and the fused pairs had concresced; and they were not old enough to show that basal inflations were able to incorporate roots. It was, presumably, from necessity, and not from choice, that he confined his observations to seedlings of "one or two years." If he had mentioned this, and supplemented it by pointing out the importance of studying seedlings in trying to understand such complicated structures as the adult

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* Report Aust. Assoc. Adv. Sci., vii., p.544 (1898).

Mallees present, those who came after him might have been induced to follow his lead, and to extend his incomplete observations. Even what he actually says ought to be sufficient to make anyone cautious about identifying the persistent basal inflation of the Mallees as a "rootstock," without first investigating the transient basal inflations of such Non-Mallees as have them.

Unfortunately his excessive reticence obscured what merit his observations may have; and his successors, in attempting to explain the make-up or constitution of the Mallees, either adopted Mr. Tepper's idea that the Mallees have "rootstocks," without offering any explanation of their peculiarities; or else they make use of one or other of the older definitions, which, though excusably deficient when they were first offered, are now out of date.

As far as we can ascertain, Mr. Maiden is the only writer who has taken any notice of Tate's statement quoted above. On the first page of his "Critical Revision of the Genus Eucalyptus" (1903), the author gives substantially Tate's views, almost in the original words, but without any comment other than "This classification is chiefly of practical use in Professor Tate's own State (South Australia) and in Western Australia."

In Plate 57, fig.12 (of Vol. ii.) of the same work (1911), an illustration of a young seedling of *E. paniculata*, with a pair of axillary stem-nodules still unfused, will be found. This, we believe, is the only illustration of a Eucalypt seedling with stem-nodules, or any stage of them, which has hitherto been published. In the explanation of the Plate (p.131), fig.12 is referred to as—"Bulbous swelling in seedling. . . . . . This swelling is very common in seedlings belonging to this genus, and the cause has not been investigated so far as I am aware. It is presumably to be attributed to the action of bacteria." Allowing for the fact that there is a pair of independent, bulbous swellings, and not merely one, and that they are the first stage in the formation of Tate's transient basal inflation of a Non-Mallee, we agree with Mr. Maiden that they are presumably attributable to the action of bacteria. But we should say exactly the same about a similar seedling of a Mallee, with the first pair of axillary nodules or bulbous swellings present.

The difficulty which confronts anyone who tries to interpret the axillary, bulbous swellings of seedlings of Eucalypts, whether Mallees or not, and Angophoras, from the standpoint that the Mallees have rootstocks, is exemplified by the following quotation from a recent paper by Dr. Hall*—"The origin of the peculiar rootstock of the Mallee can be well seen by observing the seedling. In nearly all the Eucalyptus seedlings, and also in the Angophoras, there is developed, especially if growth is checked, a small woody swelling in the stem at the point of attachment of the cotyledons. A number of buds will develop on this, and shoots start from them. If the growth of the seedling proceeds in the form of one main stem, this swelling is soon obliterated, but, in the Mallee, these secondary shoots grow almost as quickly as the main stem, and so, instead of a tree in the ordinary sense, we have an enlarged rootstock, from which spring numerous stems, all more or less of the same size." The author is here trying to explain Tate's problem of the transient and persistent basal inflations of the Non-Mallees and the Mallees. If the small woody swelling at the attachment of the cotyledons of the seedlings of Mallees is the initial stage in the formation of a persistent rootstock, is not the woody swelling of the seedling of Non-Mallee Eucalypts and Angophoras also the initial stage in the formation of a transient rootstock?

The following statement from Tubeuf and Smith's "Diseases of Plants" (p.299) may be mentioned. "In the Botanic Garden at Amsterdam, the roots of several species of *Eucalyptus* exhibited woody tumours from which proceeded outgrowths resembling 'witches' brooms.' These contained the mycelium of an *Ustilago* which produced spores in the cortical tissues." If the tumours here referred to are of the same kind as those we are interested in, we consider that the presence of Ustilago under the circumstances mentioned, is to be regarded as merely indicative of a saprophytic intruder. As pointed out by Erwin Smith and his colleagues, a varied assortment of lodgers commonly infest crown-galls.

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* "The Evolution of the Eucalypts in relation to the Cotyledons and Seedlings." These Proceedings, 1914, p.517.

NON-MALLEE EUCALYPTS.

Seedlings of some species of Eucalypts are exempt from tumours. We have met with six of these, referred to later on. As mentioned in our introductory remarks, tumours, which accomplish all they can do, pass through the three stages of—(1) axillary, shoot-bearing stem-nodules; (2) composite, shoot-bearing, stem-encircling tumours; and (3) composite, stem-encircling, shoot-bearing, root-incorporating tumours.

Axillary Stem-nodules.—Five young seedlings, with one or more pairs of stem-nodules, with the cotyledons, or some of the leaves *in situ*, are shown in Plate iv. The cotyledons and lowest leaves have usually disappeared by the time the nodules become recognisable, as in the two series of seedlings shown in Plate v. When they are absent, therefore, it is to be understood that the opposite and distichous arrangement of the nodules corresponds to a similar arrangement of the cotelydons and leaves, in whose axils the nodules developed. Figs. A1 and A2 are seedlings of *E. corymbosa*, each of which has only one pair of nodules. Both nodules of the older one have a shoot with several pairs of leaves. Older seedlings of this species are shown in Plate xi. Figs. B1, B2, and B3 are seedlings of *E. hemiphloia*, one with two, and two with four pairs of stem-nodules. These supplement the series of the upper row of Plate v.; they are shown here simply because they happen to have one or several leaves *in situ*.

The upper row of Plate v. shows a gradational series of five young seedlings of *E. hemiphloia* not old enough to show more than three pairs of nodules. The three youngest (from right to left) show the successive development of one, two, and three pairs of axillary nodules. The first pair of the second seedling have made good progress, and are obviously more advanced, that is older, than the second pair. This is not so evident in the third seedling, which has a bend in the axis. The fourth example shows a further advance. The nodules of the first pair have grown unequally, so that one is bigger than the other, though of the same age; while fusion between them has made some progress. The second and third pairs have made fair progress. The fifth example shows still further advance.

The first pair have nearly completed their fusion, except superficially; the second pair are still small; while the presence of the third pair, in the axils of the second pair of leaves, can be made out. One shoot has developed on each nodule of the first and second pairs. Another seedling with two pairs (B1), and two older ones with four pairs (B2 and B3) are shown in Plate iv. The first pair of B3 have made good progress, and have nearly completed their fusion. Another, but a rather poor specimen which could not be photographed while it was fresh, with five pairs of stem-nodules, and three root-nodules, is shown on the left of Plate xii. All the specimens of this series were nursery-seedlings; and we have been able to ascertain, that seedlings 3-4 months old, with from 4-7 pairs of foliage-leaves, may or may not have one pair of recognisable nodules. Bush-seedlings of *E. corymbosa*, about 3-4 months old, with four pairs of foliage-leaves, will usually show one pair of recognisable nodules, as in fig. A1.

The lower row of Plate v. shows a similar series of bush-seedlings of *E. sideroxylon*. The younger ones show, in order, one, two, and three pairs of stem-nodules. The fourth shows a more advanced stage of three pairs, the nodules of the second pair being about as large as those of the first. The fifth seedling has four pairs. One of the first pair has grown more than its fellow. One of the second pair seems to have come to a standstill, while the other has grown downwards into the interval between the nodules of the first pair, and shows signs of commencing to fuse with one of them. The third and fourth pairs are still small.

An interesting growing seedling of *E. tereticornis*, with three pairs of nodules, and no shoots, is shown in Plate vi., fig 2. The opposite and decussate arrangement of the pairs of nodules is well seen. The first pair have developed well, and fairly equally; and have fused basally, leaving only a superficial interval still to be filled. The visible member of the second pair is small, and seems likely to fuse with the first pair before fusing with its fellow. A notched, white card has been placed in position to give a white background.

The total number of pairs of stem-nodules present in seedlings depends on the number of axils affected, and on the age of the seedling. Seedlings of some species, as a rule, may have more than those of other species at about the same stage; but seedlings of the same species may similarly differ. Occasionally one may find a seedling of a species liable to have them, and old enough to show them, without any at all. One nodule of a pair is often missing. Apparently, therefore, sometimes the conditions which lead up to the production of nodules fail, or inoculation was prevented, or did not take place. Sometimes, after the first pair, the change from a pair of opposite, to two alternate leaves may result in the appearance of two incomplete pairs.

Plate vii. shows a set of miscellaneous, hardy bush-seedlings from poor virgin soil, which are remarkable for the numbers of pairs of axillary stem-nodules present; for the slow progress of the lower pairs in most of them, considering how many pairs are present, and consequently for delayed fusions and concrescences; and for variation in the lengthening of the internodes. The first five (left-right) are somewhat older than might be expected from their small size. The first three are *E. eugenioides*, the third of which shows fusions and concrescence of nodules, while the other two have done very little even in the fusion of nodules of the same pair. Some of them have shoots. One nodule on the lower side is missing from the third pair of the first seedling. The fourth and sixth are *E. piperita*, and show well, what is very characteristic of seedlings of this species, numerous pairs, most of which are crowded up through the non-lengthening of other internodes besides the first and second. A later stage is shown in Plate xii., fig.2; but, in this case, matters were complicated by the death of the seedling-stem at an early stage, and its replacement by two tumour-shoots, as is usual; these are remarkable for having pairs of axillary nodules (some stage of three pairs in each case) the lower ones fairly close together. Seedlings of this species sometimes have very shapely, large tumours.

The fifth and seventh are seedlings of *E. hæmastoma*. One nodule is missing from each of the fifth and sixth pairs of the smaller specimen. The larger one shows considerable lengthening of the third and fourth internodes; also a root-nodule (*r.n.*) from which on one side, near the base, a root (*r.*) emerges, which does not come out very well in the photograph. The nodules of the lowest pair furnish a good example of unequal progress.

The remarkable seedling in Plate x., fig.*a*, has eight pairs; the seventh and eighth are indicated, but had not completed their growth when the specimen was secured. This was a pot-seedling, about 2 feet high, and somewhat older than the others shown in Plates ix. and x. It is the most remarkable, refractory seedling we have seen.

The remarkable seedling of *E. eugenioides*, about 4 feet high, shown in Plate xix., has twenty nodules (possibly twenty-two), fourteen stem-nodules, in addition to the concrescence, comprising at least three pairs (possibly even four); four pairs are incomplete, one nodule of each having failed to develop—potentially about twelve pairs. The nodule marked 1 is solitary, and was about to fuse with the concrescence. The rest were not likely to have accomplished anything whatever, even in the way of fused pairs. Another, fine, but much younger specimen of the same species, about 2 feet high, has twelve pairs, but the uppermost are not very far advanced, and there are indications of some others to follow; the first three pairs have nearly completed their concrescence. This specimen was obtained too late to be included in the series shown in Plate vii. For its total number of complete pairs, this is the most remarkable seedling we have seen.

Sometimes, but rarely, an extra nodule makes its appearance, so that instead of the first pair, there is a whorl of three. When this happens, the second node may, or may not, also show a whorl of three. We have four seedlings, two of which show one whorl of three; and two have two whorls of three. The explanation of this condition is that the cotyledons of both Eucalypts and Angophoras occasionally show anomalies, such as three cotyledons, fused cotyledons, or with one cotyledon partially or completely "split." When this happens, the first pair of leaves may be normal, or dislocated, or replaced by a whorl of three leaves. The significance of these anomalies, for our purpose, is the provision of an additional one or two axils for the collection of soil or dust; or the loss of an axil.

Plate xi. shows a series of seedlings of two of the Bloodwoods (*E. corymbosa* and *E. eximia*) which differ from any other seedlings of Eucalypts that we have seen, in that they have, usually, only one pair of effective, axillary nodules, though there are sometimes two, and occasionally more in late stages; but they almost always have an unpaired, not definitely located nodule below the level of the cotyledons. Figs. 1 and 2 represent two young seedlings, somewhat older than the two shown in Plate iv. One of them has only one axillary nodule; we have other seedlings like it. Both are too young to show the unpaired nodule. When it does appear, it is sometimes much closer to the axillary nodules than at others. Occasionally, it is far enough away to indicate that it possibly developed on the taproot, rather than on the hypocotyl. It seems to be probably a case of wound-infection due to a possible tendency of the bark of these young seedlings to crack in growing. The nodule extends upwards, fusing harmoniously with the fused, axillary stem nodules; and grows downwards also, partially, or by degrees, entirely encircling the axis. The fusion usually ends abruptly. It may be an inch long, or four inches, and in one case about eight inches. In late stages, it increases in diameter, but continues to be cylindrical in shape. One specimen has two unpaired nodules, one below the other. The lower one is evidently a root-development.

The presence of more than one pair of axillary nodules is unusual in *E. corymbosa*. But we have one advanced seedling which has five pairs [first pair (one with a shoot) fused, and the fused pair fused with the unpaired nodule, as usual; one nodule of the second pair with a shoot, and fused with the concrescence, its fellow very small, and solitary; the nodules of the third, fourth, and fifth pairs small, unequally developed, and not fused].

One seedling of *E. eximia* (Plate xi., No.6) has two pairs of axillary nodules, which is unusual, (though we have another like it) and a pair of root-nodules; but, apparently, the unpaired nodule is absent in this case, unless it is represented by one of the root-nodules. Both root-nodules have incorporated a root, but that of the smaller one was accidentally broken off short, and its stump is hidden from view.

In seedlings of some species and in some individuals of the same species, the axillary stem-nodules appear sooner and progress faster, than is the case in others, or the period of incubation is shorter Sometimes this may be due, in some degree, to unfavourable conditions; but in other cases it seems to be a constitutional matter. Hence, it is possible to distinguish between susceptible, and resistant or refractory species, or individuals. The majority of the species whose seedlings are known to us, are susceptible, some more so than others The best examples of refractory species that we have met with are *E. robusta* and *E. longifolia*, of both of which we have seen nursery-seedlings in quantity; but we have been unable to get bush-seedlings. Advanced seedlings of these two species are shown in Plates ix. and x. The seedling of *E. robusta*, with eight pairs, (Plate x., fig. *a*) is the most remarkable refractory seedling we have seen.

Axillary nodules develop not only on the stems of seedlings, but also on tumour-shoots, showing that the first few leaf-axils of tumour-shoots repeat the conditions offered by the early axils of seedling-stems. Fig.3 (not numbered) of Pl. vi., shows the tumour of a seedling of *E. resinifera*, whose stem, with one pair of unincorporated nodules, and any shoots that may have been present, was scorched and killed by a bush-fire. Two tumour-shoots, as is usual in such a case if the seedling stem is centrally situated, replaced the stem; these were about 7 and 10 inches high, and were doing well when the specimen was taken. Both have the first pair fused with the tumour. The larger has a second pair, unfused, and unequally developed. The smaller has a second pair, one only of a third pair, a fourth pair, and also a fifth pair. [The numbers on the Plate indicate only the conspicuous ones; the fifth pair of the smaller one, not being very well shown in the photo, was not numbered]. The tumour itself may represent probably three fused and concresced pairs.

Another case is shown in fig.2 of Pl xii. This also is a case of two tumour-shoots taking the place of a seedling stem after injury, not by fire in this case. Each of them has three pairs of axillary nodules.

Still another case is illustrated in Pl. xviii. The large tumour-shoot at the back, a little to the left of the stem, has six nodules, of which four are visible—the first pair not fused; the second pair dislocated, probably due to a pair of leaves becoming alternate; one only of a third pair, and one of a fourth pair, with a shoot. Another tumour-shoot, hidden in the photo, also has a good pair.

These three seedlings show, then, that axillary nodules may develop on tumour-shoots which develop in the ordinary way, or on second-growth shoots, whose development has been accidentally stimulated.

The Nodule-Shoots.—Until the morphology of the seedlings, and the histology of the nodules and composite tumours have been investigated, one can attempt to interpret macroscopic characters only with reserve. The shoot-bearing character of the nodules is due to the fact that the axillary outgrowths take over and incorporate the dormant buds (or the bud-forming tissue), which, otherwise, would be smothered. But so many shoots sometimes develop on a single nodule, or on a fused pair, that we are inclined to think that the nodules sometimes carry away bud-forming tissue, rather than simply differentiated buds; and that the stimulus which is responsible for the proliferation of the cambium to form the nodules, may also cause the bud-forming tissue to proliferate and spread.

On the other hand, sometimes the growing nodules fail to take over the buds. Three good examples are shown in the two Stringybark seedlings in Pl. xii. Another is shown on the stem of the seedling of fig.1 of Pl. xiv. Also two others in the refractory seedling, *c*2 of Pl. x.; for the two futile nodules of the third pair, and the two branches just above them, belong to the same pair of axils. There are some other examples on the remarkable seedling in Pl. xviii., particularly the pair of which one is numbered 4. In such cases, the bud and the nodule develop separately; if the bud perishes, the nodule is left stranded on the stem. If both develop successfully, it is noticeable that the nodule is usually on the outer side of the branch in the external angle between the branch and the stem, fused to both. This suggests that, as the nodule develops on the outside of the bud, and between the latter and the attachment of the peticle of the leaf, the supposed weak spot in the axils, which makes inoculation possible, may arise in connection with the differentiation of the bud; or that there may be a weak spot about the attachment of the petiole, which is exposed when the leaf expands; or, perhaps, both are concerned. Serial, transverse, and longitudinal sections are required to settle the matter.

In general, the conditions which favour or retard the development of ordinary branches in leaf-axils, favour or retard the development of nodule-shoots; and, particularly, sufficient room to allow of free exposure of the plants to light; and damage to the growing-point, or removal of the greater part of the stem. Defoliation, under some conditions, may also stimulate the production of nodule-shoots.

Two very young seedlings of *E. hemiphloia*, with only the first pair of stem-nodules present, are shown in figs. C1 and C.2 of Plate iv. One shoot promptly developed on each nodule after the growing-points suffered injury, in each case. Sometimes two, or even three, shoots will develop on at least one nodule of seedlings like these.

Pl. xxv., fig.1, shows a flourishing pot-plant of *E. tereticornis*, growing under very favourable conditions, which exhibits profuse branching, as well as nodule-shoots.

An advanced pot-seedling of *E. hemiphloia*, with a well-developed, complete encircling tumour, without any shoots, was unintentionally neglected, and the pot allowed to become so dry, that the leaves wilted, and were cast off. On receiving attention, the plant revived; but, before the new leaves appeared, five young shoots promptly developed on the tumour.

Though the buds usually remain dormant on the nodules of refractory seedlings like those shown in Plates ix. and x., injury to the growing-point, or removal of the greater port of the stem will cause shoots to develop.

The presence of shoots is of great importance both to the stem-nodules, and to the resulting, composite tumours, for they are not then entirely dependent on the seedling-stem for nutriment. A large, revived, belated nodule (A2), whose fellow is missing, is shown on the advanced seedling in Pl. xix. The seedling-stem (*s.st.*) perished, whereupon the main nodule-shoot took up the running, and this gave the nodule a chance of making a fresh start. This is the largest, individual nodule we have yet seen. The photo is reduced by somewhat more than one-third. Composite tumours at first are usually more or less pyriform in shape, especially if they have no shoots, or only insignificant ones (Pl. xii., fig. on the right). Some of the later stages of the *E. sideroxylon*-series show how the upper portion of the tumour fills out when there is a good series of shoots round the summit. As long as the shoots last, and continue to grow, the composite tumours may be expected to progress proportionately.

The number of nodule-bearing shoots on a seedling, like the number of shoots on individual nodules, if the conditions are favourable, is sometimes surprising. The oldest nodules are likely to show them first, and to have most shoots. The basal pair, or only one of them, will very often show one or more, when the others are without them. But the nodules of any pair, or one of them, may have shoots, when the others have none. Both, or one, of several pairs may have at least one shoot. Or the buds may remain dormant, and no shoots at all may develop, as in most refractory seedlings.

It would be unusual to find more than one branch in a leaf-axil, though, of course, there may be reserve-buds. Three shoots are often present on a single nodule, but there may be as many as seven, or even more, in different stages. Fig. 1 of Pl. vi., shows a very attractive bush-seedling of *Angophora lanceolata*, probably not under two years old, photographed while fresh. As shown, it is less than half the natural size, the stem-height above the encircling tumour being about 10½ inches. The tumour is the result of the complete fusion of the first pair only. The nodules of the second pair, still very small, unfused, and without shoots, are to be seen, rather indistinctly, a little above, but there is no third pair. Eight shoots are present, four on each side, but two of one group are dead.

An inspection of the figures of the *E. sideroxylon*-series will give an idea of the way in which shoots develop about the summit of the tumours, when they are complete in late stages When specimens like these are scorched by a bush-fire, and the stem, and any shoots that may be present, are killed, provided, of course, that the underground portions, including the tumours, are not hopelessly injured, fresh second-growth shoots may come up freely, when the conditions become favourable. Fig.3 of Pl. vi., is an example of a scorched seedling. Two second-growth shoots only are present here. The growth-habit of such plants, especially if they are scorched a second time, or oftener, and recover, if they succeed in attaining any size, necessarily is much modified. In the quotation from Mr. Tepper's paper, the second-growth shoots of the Mallees, under similar circumstances, are mentioned.

The shoots of all the pairs except those which supply them at the summit of late stages of the encircling tumours, are doomed to perish at an early stage, except under exceptional circumstances, because the tumours are gradually pulled underground. Even those on the summit cannot last indefinitely, as a rule, unless water-storage roots are incorporated.

The nodules, when quite small, are smooth. As they increase in size, the surface becomes warty, due to local proliferation. As the warty protuberances increase in size, they meet and fuse, and fill up the vacant spaces. In this manner, by constant local proliferation at the periphery, the nodules, or the composite tumours to which they give rise, increase in size. The latter, when doing well, are excessively warty. This is indicated in some of our illustrations, but the warts do not always show up as conspicuously as they do in the specimens.

The nodules and the surface of tumours, when fresh, are readily sliced with a knife; but, when dry, they are hard and woody. The tumours when fresh, and doing well, contain a good deal of moisture; but, when drying, gaping, longitudinal cracks, often from top to bottom, appear.

Later Stages.—Growing nodules very readily fuse with any other suitable living tissue with which they make contact; so that finally, when the fusion is complete, there is no visible line of demarcation. As the nodules of a flourishing pair progress, they increase steadily in size, growing upwards slightly, but more evidently outwards, backwards, and downwards, until they meet and fuse, thus encircling the stem. Similarly the fused pairs grow downwards, covering up and fusing with the portion of the stem involved, until the several fused pairs have concresced. As the basal portion of the concrescence grows downwards, it finally encircles and fuses with the upper portion of the taproot, and the proximal portions of any lateral roots that it may encounter. We have an example of two seedlings growing so close together that the encircling tumours came into contact and fused. If two such seedlings survived and attained tree-size, they might furnish an example of apparently one tree with two stems.

The opposite and decussate arrangement of the stem-nodules, corresponding to the disposition of the cotyledons and leaves, is an ideal arrangement for the production of well-balanced, symmetrical, composite, encircling tumours, provided—(1) that all the pairs of stem-nodules are complete; (2) that the nodules develop promptly; (3) that they grow comparatively equally and uniformly, and make the necessary fusions, and the fused pairs the necessary concrescences, at the right time, and in the right way; and (4) that the internodes, especially the lower ones, do not lengthen too soon or too much. But if one or several of these provisoes fail, the final result will be correspondingly modified. If plenty of material is available, very suggestive and instructive anomalies, of almost every conceivable kind, may be obtained.

Incomplete pairs of nodules are common. If several nodules or pairs are missing, any resulting composite tumour will be correspondingly smaller. A good example is shown in Pl. xiii., fig.2, of the *E. sideroxylon*-series (about half nat. size). This is a concrescence of the fused first pair and of one nodule only of the second pair, and this, though it is included, did not make much progress and contributed very little, and is still recognisable (in the specimen though not in the photograph).

One nodule missing from the first pair, which is chiefly responsible for the basal portion of the encircling tumour, is a fruitful cause of the production of lopsided tumours. An example is shown in Pl. xiv., fig.3, in which the left nodule of the first pair is missing. Unfortunately the photograph is slightly blurred. A missing nodule from the uppermost pair, may interfere with the symmetry of the summit of the tumour. We have a seedling with three incomplete pairs only, one nodule from the top and the bottom pairs on the same side being missing. At the best, all that these could give rise to, is a half-encircling tumour.

Fig. *c* of Pl. viii., appears to be a case in which one nodule of the first pair (on the left) did not develop. The seedling-stem having been broken off, a normal branch in the axil without a nodule then assumed the erect position, and took the place of the seedling stem. The single nodule present, made fair progress. It shows indications of about a dozen shoots, some of them dead. The large shoot, just to the left of the stump of the stem, belongs to the latter.

Sometimes a nodule, instead of growing downwards and fusing with the stem, will grow downwards and outwards, away from the stem, even in erect seedlings. Three bent seedlings are shown in Pl. viii. They have stem-encircling tumours, resulting from the fusion of the first pair, which has grown outwards and downwards away from the stem. There is only one pair in fig.*a*. Figs. *b*1, *b*2, show some indication of others poorly developed. There are no incorporated roots in these specimens, nor, we think, was there any likelihood of its happening. In arranging the specimens for being photographed, some of the lateral roots were unintentionally left in unnatural positions.

Inequality in the comparative rate of growth of the nodules of the same pair, as well as in the comparative growth of successive pairs, is also a fruitful source of anomalous developments. One nodule of a pair may come to a standstill, while the other goes on growing; or both may progress, but one of them faster than its fellow (as in No.7 of Pl. vii.). Nodules of the same pair may fuse sooner on one side than on the other; or they may fail to fuse at all on one side. Encircling tumours, as they grow downwards, may progress faster on one side than on the other.

If the nodules do not develop promptly, while the tissues are quite young, that is, if the period of incubation is longer than usual, the nodules seem to make slower progress, when they do appear. Meanwhile, the lower internodes may have lengthened to such an extent that the concrescence of pairs may be delayed or even prevented. Angophora seedlings frequently offer very characteristic examples of this kind of thing.

The *E. sideroxylon*-series (Pl. v., lower row, and Pls. xiii.-xvii.), of which the earliest, the last, and as many intermediate stages, as space will allow, are shown, are intended to indicate the course of events in a susceptible species. With the exception of the tumour in Pl. xvii., all the photographs were taken when the specimens were fresh. They are variously reduced, from about one-third to one-half, or even more in the larger ones. They are intended to show the composite tumours, with recognisable portions of the seedling-stems and tumour-shoots, and, especially, various stages in the capture of lateral roots.

The smaller of the two crossed seedlings (Pl. xiv., fig.2) shows the first and second fused pairs of nodules concresced; the third pair have not yet completely fused; one nodule from the fourth pair is missing. The growing-point was injured. The taproot is caught between a lateral root and the tumour, so that it cannot be freed without trimming the latter. There was enough soil between the two tumours to prevent fusion. The larger specimen has lost its seedling-stem, and two of the tumour-shoots, one on each side, are taking the lead. No roots had been incorporated in either specimen.

The seedling in Pl. xiii., fig.1, with a stem-height of 20 inches, has three pairs almost completely concresced, and two pairs not yet fused. Two roots are just incorporated, and another was ready to be.

The two seedlings on the right (Pl. xiii., fig.3) show incomplete concrescences at the top; and an early stage of the incorporation of a root.

Fig.2 of the same Plate (reduced by nearly one-half) is a fine seedling, with a stem-height of 37 inches, the two longest tumour-shoots about 13 inches. It is a good example of a small tumour resulting from a shortage of axillary nodules. Only three developed, of which the only one of the second pair (hidden at the back of the photo) made little progress, and contributed practically nothing to the tumour. Small though it is, the tumour has captured three good, lateral roots Two others, which were accidentally broken off, and whose bases are hidden by the lateral root on the right, were about to be captured. The seedling-stem had a good canopy of foliage, and had got well ahead of the tumour-shoots, so that it would probably have got rid of the latter sooner than seedlings with larger tumours.

The seedling in fig.1, Pl. xiv., (reduced by about one-half) has a concrescence of probably two pairs, with three incomplete pairs above (one of which is hidden). The downward growth of the concrescence on one side, is much in advance of that of the other, as shown on the left. The uppermost is a good example of a belated nodule which failed to get possession of the bud; both it, and the branch above it, belong to the same axil. Several of the shoots have done well. Two lateral roots have been incorporated; and several others would have been later on.

Fig.3 of Pl. xiv., is an example of a lopsided tumour due to the absence of one nodule of the first pair. Unfortunately the photo is slightly blurred. It has not incorporated any roots. Shoots are numerous. The seedling-stem may possibly be missing.

Fig.1. of Pl. xv., is a very complete concrescence (reduced by somewhat over one-third). Two lateral roots are just incorporated.

Fig.2 of the same Plate (only slightly reduced) has the concrescence incomplete behind except at the top. One good root has been incorporated on the right. The root on the left with a bifurcation, and the one above it, would have been incorporated if the concrescence had been complete behind.

Fig.3 of Pl. xv., is a good example of a late stage.

Fig.1 of Pl. xvi , shows a fine seedling, with a stem-height of 5 feet above the tumour. The latter is shown (nat size) in Pl. xvii. The strongly developed taproot is now well established, the lateral roots being insignificant by comparison. The seedling-stem has been able to increase its initial lead, and to develop its upper branches, so that their crown of foliage fairly completely overshadows the tumour-shoots, preparatory to getting rid of them by the process of natural pruning. The lateral roots are so insignificant that the tumour must be largely dependent on the seedling-stem for most of its water. When the leaves of the crown of foliage belonging to the seedling-stem and its branches have overshadowed the tumour-shoots, and are transpiring freely, the latter seem to suffer in consequence. When the shoots have been got rid of, the tumour, as such, gradually comes to a standstill. The tumour of this example is shown in Pl. xvii. (nat. size), and is a fine specimen.

Fig.2 of Pl. xvi., shows the size of two, more advanced seedlings, 6-7 feet high, side by side. The one on the left, which had got rid of its tumour-shoots, was dug up (inadvertently the taproot was cut off rather too short), and held beside a slightly taller, undisturbed specimen, which had one shoot left. This was afterwards uprooted and examined. It will be noticed that, at this stage, the tumour is completely out of sight underground. These photos were taken early in October, 1914, at which time the plants were about six years old. Three and a half years later, other examples of the same batch as those in fig.2, were promising saplings 9-12 feet high.

The last stage of an advanced seedling of *E. tereticornis* is shown in fig.2 of Pl. xxi.; this has one small shoot left. The plant was uprooted carefully, placed on a stump, and photographed immediately. It was growing near the specimens shown in Pl xvi. In this case, the seedling-stem appears to be excentric, consequent upon lopsided growth of the tumour; and the shoots were all on one side. One nodule was not incorporated in the tumour. The difference in size between the taproot and the incorporated or other lateral roots is well shown.

Pl. xx., shows another but older stage of the same species; but, in this case, matters are complicated by the death of the seedling-stem. A few inches of the latter were *in situ* when the plant was found, but were accidentally broken off in packing-up a number of specimens. The stump of it is just discernible in the photo. There were a number of shoots, but, in this case, one of them took the lead, and was 6 feet high. At the base of it is a remarkable, encircling insect-gall. At first, we took this to be a case of the fusion of pairs of axillary nodules on a tumour-shoot, followed by concrescence; and that it might be an example of what Tate meant, when he said seedlings and "growths" have basal inflations. On cutting it transversely, four radial cavities were exposed, two of which contained living coleopterous pupæ, one in each cavity; the other two contained only exuviæ or excrement. Apparently, the mother-insect oviposited at intervals all round the base of the shoot.

Of the two advanced seedlings of *E. eugenioides* in Plates xviii. and xix., the first has not yet got rid of the tumour-shoots, which are situated at the back, as the specimen is shown. The other one had got rid of them; in this case, the death of the seedling-stem gave rise to complications.

Tate, in his brief way, said that Non-Mallees, which have basal inflations, grow out of them. Apparently, he was relying on experience, and not speaking from observation. The only author who mentions what takes place, as far as we can find, is Ednie Brown, who in his "Forest Flora of S.A.", under *E. leucoxylon* (Part ii.), says—"During the first two years of its growth, the plant has a low-lying or spreading habit, not at all prepossessing in its favour, when looked upon in the light of a future timber-tree. About the third year, however, a straight and upright 'leader' comes away from the centre of the apparent bush, which, after this, soon assumes the form of a promising young tree."

What is here described as a straight and upright leader, is simply the seedling-stem coming into its own, and getting rid of the tumour-shoots. Otherwise, if the seedling-stem is destroyed, two, strong leaders usually come away; that is two, tumour-shoots take the lead, as we have already pointed out, and as is shown in several of our Plates. The author was apparently not aware of the presence of what Tate, some years afterwards, called the basal inflation of seedlings of this species. We should think, also, that he probably underestimated the age of his plants.

MALLEES.

The Mallee-Scrubs of the interior, where alone fruitful investigation can be carried out, are remote from, and inaccessible to us; and, consequently, our material for the study of the tumours of this group is very incomplete. Nevertheless, there is something to be learnt from it We regret that we have been unable to procure seedlings of the big Mallees, such as *E. oleosa*, *E. dumosa*, and several others

Plate xx., shows four advanced seedlings of three species. Figs. 1*a* and 1*b* are seedlings of *E. stricta* from the higher part of the Blue Mountains (about 3,000 feet), 2½-3 feet high, from a batch of seedlings, that we had had under observation for three years, from the time when they were too young to show nodules. The younger one (1*a*) has five pairs of axillary stem-nodules, the concrescence of the three oldest pairs not yet completed. The lengthening of the third and fourth internodes has kept the two upper pairs apart. Another example, about the same size, has a more complete concrescence of three or four pairs, then two incomplete pairs separated by the lengthening of the internodes; and above, two pairs, close together, followed by an incomplete pair; but all these are small, and there are no fusions among them. The older one (1*b*) has a more complete concrescence in the aspect shown; but one nodule of the first pair is missing (at the back), and the encircling tumour is consequently lopsided, and smaller than it otherwise would have been. Three and a half pairs seem to be present, and a fifth, small pair, doing little, are indicated at a higher level. One shoot is present, and one root was in process of incorporation.

Fig.2 is a seedling of *E. Moorei*, about 2 feet high, also from the Blue Mountains. The concresced portion, not quite complete at the summit, represents three or possibly four pairs. The uppermost pair is incomplete, the nodule at the back missing. We have younger seedlings of both species in various stages with up to five and six unfused pairs. We are inclined to think that the slow progress of the nodules of the seedlings of these two species is, in some degree, due to the low ground-temperatures and frequent frosts on the higher part of the Blue Mountains during the months of April-October.

Fig. 3 is a seedling of *E. fruticetorum* from Wyalong, for which we are indebted to Mr. Cambage—the only seedling he could find. We cannot make out the presence of more than one pair of stem-nodules, which fused on one side (in front, in the photo), but not on the other. The interval separating them at the back is about ¼ inch wide; and there is a depression at the top which is suggestive of the loss of a branch. The tumour had about eight shoots, and there are three branches low down on the stem. No roots had been incorporated. One specimen is not enough to enable one to judge whether this is merely an exceptional case, or whether one pair is the usual number for this species. The "Mallee-root" shown in Pl. xxiv., also from Wyalong, likewise has a tumour of one pair not fused on one side. We do not know the species, but it may perhaps be *E. fruticetorum*; and represent the latest stage of a seedling like Fig.3.

Plate xxi , fig.3, shows the most satisfactory example we have had from Wyalong (much reduced). This is a specimen of one of the small Whipstick Mallees (*E. viridis*) locally called Blueleaf-Mallee. For the stage at which it has arrived, it may probably be regarded as a fair example of a susceptible Mallee. It is not as plump as it might be, but it was collected in a drought. It was trimmed for convenience in transmission to Sydney, but the following dimensions may help to understand its importance: stem-height above tumour, about 6½ inches; diameter of stem above tumour, ½; length of tumour, about 3¾; diameter, 1¾; diameter of taproot below tumour, $\frac{9}{10}$. The best aspect of it is shown; at the back, the downward growth is not so satisfactory as in front. The seedling-stem appears to be excentric because of the smaller development on the right side. It has two branches low down; and there are three tumour-shoots. Four lateral roots have been incorporated; but they are insignificant in comparison with the well-developed taproot. All the stem-nodules have been included; the concrescence may well represent five pairs; there is a cavity near the summit, which appears to have been caused by borers.

Fig.1 of Pl. xxi., shows the youngest of four examples of *E. Behriana*, received from Wyalong. Unfortunately, the stem of every one of these was hopelessly damaged; and consequently the specimens are not typical examples, but they are all we can get. The youngest (× ½ about) has the seedling-stem broken off short, just above the level of the second pair of stem-nodules, one of which is now missing. The nodules of the first pair are back and front, and unfused. The posterior one has one shoot. The front one also had one, but this was broken off short. The surviving nodule of the second pair developed five shoots, the largest of which has two branches, and made good progress. It has fused with the nodules of the first pair, and has grown downwards to much below the level of the first pair. This nodule and its shoots were keeping the plant going.

Two older examples differ in age. The smaller has half an inch of the stump of the stem left. There appear to be two pairs of nodules. The first pair made some progress, but did not fuse. One of them has three shoots, two of which are 5·6 inches long. This nodule was keeping the plant going. One of the second pair fused with the nodule with shoots; the other made little progress. The bark on the nodules is very thick, and adherent.

The larger one is more difficult to understand, as the stem is almost completely missing. There are shoots up to 10 inches, in two places, on the margin of what is left. There is one pair of futile nodules, one much better developed than the other, on opposite sides of what is left of the stem, which is about 1 inch thick. Both this specimen and the preceding one have a long piece of the root intact. The smaller one has two, nearly opposite, lateral roots, and one above and one below these, not far away. But the larger one has three promising lateral roots at different levels, two on opposite sides of the taproot, and a middle one in a direction at right angles. An encircling tumour would have to make considerable growth before incorporating all of them.

For the large specimen shown in Pl. xxiii., in the natural position, as we think (rather than viewed with the taproot vertical), we are again indebted to Mr. Cambage. The best aspect of it is shown. A farmer, in grubbing up the plant, with one blow from his axe, delivered just behind the base of the big shoot shown in the figure, split off a large piece at the back, on which there was probably another shoot, situated on the right of the base of the dead seedling-stem. At the back, just to the left of the mark X on the photo, there is a longitudinal concavity, showing the site of the missing shoot. The remains of the original stem, now exhibiting signs of decay, indicate that it must have been about 3 inches in diameter when it perished. The taproot is well developed. One lateral root, with a branch, is seen to the right. This can hardly be said to be incorporated. At the back, there are four roots or indications of them, one of which is incorporated, and one partially, while two others are too low down. The development of the shoot present evidently stimulated the growth of the tumour all round its base. The rest seems to have come to a standstill after the death of the seedling-stem. What strikes us about this specimen, is the paucity of shoots; and that there is not such a satisfactory arrangement of lateral roots, at about the same level, as is shown in the specimen in Pl. xxiv. The loss of the seedling-stem doubtless complicated matters, and makes the interpretation of this incomplete specimen difficult.

E. Behriana is described as being sometimes a Mallee, 8-15 feet high, and sometimes a tree up to about 35 feet high. Our four specimens seem to us to be more or less refractory cases, whose root-system is not quite like that of the typical Mallees, in respect of the main lateral roots advantageously situated for incorporation in the encircling tumours. If either or both these conditions occur often, such may be responsible for the fact that *E. Behriana* is sometimes a tree. This species is well worth investigation with adequate material.

Magarey,* in describing the method of the Blacks in obtaining water from the roots of the Mallees, says—"The roots of these water-trees run out from the stem for 40 feet to 80 feet, and lie at a depth only of from 2 inches to 9 inches below the surface. The position of these lateral roots is frequently marked by a 'rise' or 'bulge' of the soil right over the root. The roots are

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* "Australian Aborigines' Water-Quest." Proc. R. Geog. of Aust., South Australian Branch, iii., p.67 (1899). Also Rept. Aust. Assoc. Adv. Sci., vi., 1895, p.647.

easily raised. A native goes to a water-tree, and tries the ground at from 4 ft. to 5 ft. from the stem; or if guided by a 'bulge' or a 'crack,' finds the root at once" (p.69). . . . . "Each such mallee tree has usually from four or five to seven or eight side-roots running out from the stem at a few inches' depth from the surface" (p.70).

Plate xxii. shows a "Mallee-root." We do not know the species, but it was one of the smaller ones, and may, perhaps, be *E. fruticetorum.* It is not a particularly fine specimen, but it is the only one we can get. In the absence of any published illustration of the kind, as far as we know, we make no apology for showing this one; as there is something to be learnt from it, as there is from any undamaged "Mallee-root." The specimen was placed on its side, and photographed from in front. The scale is shown by the rule at the bottom. We interpret this to be a case of a not quite completely encircling tumour, resulting from one pair of stem-nodules which fused on one side (at the top of the photo), but did not fuse on the other side; hence the breach in the continuity of the tumour (at the bottom). There are four, important, more or less horizontally running, lateral, water-storing roots, two (at the top) coming off very close together; and two others (below) at a fairly wide angle. They are almost on the same level round the taproot. The tumour, composed of only one pair of nodules, was unable to encircle any of them completely; but it fused with the upper part of all of them, sufficiently, probably, to tap the water. The site of the seedling-stem is indicated by the light spot, which represents the posterior aperture of the hollow, flattened taproot, of which about six inches are left. The site of one shoot is well shown, over the lower lateral root on the right. The rest of the upper part of the tumour was so badly smashed, that it is difficult to locate exactly the situation of any other shoots that may have been present; but, notwithstanding the fact that the two upper roots are very close together at their junctions with the taproot, we believe that there was one over each of the other lateral roots. It seems, to us, a reasonable conclusion, that an uninjured, flourishing Mallee will, as a rule, have as many shoots as there are lateral, water-storing roots wholly or partially incorporated in the encircling tumour, and that the former are situated over the latter.

In an adult Mallee, the shoots and the stem, if present, are all approximately the same height, and diameter. But in the seedling shown in Pl. xxi., fig.3, the seedling-stem has so far maintained its initial lead. There must be some intermediate stage, therefore, when the shoots are able to overhaul the stem. Possibly this may come about when the lateral, water-storing roots are sufficiently developed, to supply more water in the aggregate, than the taproot alone is able to do. Such questions as these cannot be profitably discussed without satisfactory material, and observation on Scrub plants.

F. Mueller, Maiden, and Cambage, and others, have recorded instances of Eucalypts of species which are ordinarily Mallees, sometimes being trees; but we have failed to find any explanation of such cases. From our point of view, it is not difficult to understand that infection may fail to take place occasionally, or that, from accidental causes, or because the individuals were refractory, it may have been followed by little in the way of results.

The root-waterstoring arrangements of Eucalypts, whether Mallees or not, as well as of other Australian plants, in arid regions, are in need of scientific investigation. Little is known of this important subject, beyond what explorers, travellers, and early colonists gleaned from the Blacks, and have put on record. Naturally the Blacks chose the roots of the big Mallees. But it is a reasonable supposition, in the absence of scientific evidence, that the smaller Whipstick Mallees also stored water, though not on a scale sufficient for the Blacks to attempt to exploit it. Inferentially, all the Mallees must have water-storing roots, otherwise it is inexplicable how the tumours of the Mallees can keep their shoots, and persist.

Eucalypts may have water-storing roots, however, without being Mallees. The only author who mentions this fact, that we are aware of, is K. H. Bennett. In his description of the method of obtaining water from Eucalypt roots, as practised by the Aborigines of the arid country between the Lachlan and Darling Rivers,* he says "The Eucalypti consist of a gum (the

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* These Proceedings, 1883, viii., p.214.

largest of the back country trees), a box, and a mallee. The first-named was the most preferred, as yielding the greatest quantity." The name of the species is not given, but it is said somewhat to resemble "the red gum in appearance—the leaves being narrower and of a silvery colour," and to grow "chiefly on sandy or light loamy soil, and throws out numerous lateral roots at a depth of from six to twelve inches from the surface of the ground." As the Blacks could not get at the water in the water-charged tumours of the Mallees, it is intelligible enough that they preferred to operate on the roots of a water-storing Gum. It is desirable that seedlings of this species should be examined, so that it may be determined whether they are exempt from axillary stem-nodules, or refractory; or, if susceptible, how they are able to get rid of the tumour-shoots. Seedlings of some of the Eucalypts of Central Australia mentioned in Spencer and Gillen's "Across Australia," also are well worth attention, particularly those of *E. terminalis* and *E. eudesmoides*, because these, perhaps, may be examples of water-storing Gums, like Bennett's.

We are not aware that analyses of the root-water of the Mallees have been published. Magarey mentions that, when freshly obtained, the root-water is clear, but that, after standing for some time, it becomes discoloured, and turbid (*l.c* , p.70). Is the turbidity merely due to a chemical precipitate on exposure to the air, or is it a biological phenomenon?

Another matter that is deserving of consideration is, the possible significance of the abundance of Lerp-manna on the foliage of some of the Mallees, at certain seasons and under certain conditions, as indicating the presence of some form of sugar in the sap, likely to be a source of nutriment to parasitic microbes. Particulars about its occurrence are given by Tepper, in the paper already mentioned; and in the Catalogue of the Victorian Exhibition, 1861, Report on Class iii., p.25, under the head of "Manna."

Pl. xxv., fig.2, and Pl. xxvi., show views of two growing Mallees, with as much soil, as was possible with pocket-knives and hands, scraped away from the base. The first and second of the three probably represent *E. oleosa*. They were taken in the Scrub, 50 miles north of Adelaide, by Mr. A. G. Edquist, to whom we are indebted for them. The third, in which the handkerchiefs of the party formed the background, is of a Mallee (*E.* sp.) at Wyalong, for which we are indebted to Mr. W. J. Moffat, who also, most kindly, did his best to obtain seedlings at Wyalong for us, and who sent us the Mallee-root figured. The published illustrations of Mallees, that we have seen, fail to give any idea of what is out of sight underground.

ANGOPHORAS.

We have obtained good series of seedlings of four species, *A. cordifolia*, *A. intermedia*, *A. lanceolata*, and *A. subvelutina.* They are alike, in that they are somewhat refractory. The stem-nodules are slow in appearing, that is the incubation-period is longer than in the Eucalypts we know best. Some bush-seedlings of a batch, that were over a year old, showed just recognisable stem-nodules; but others showed nothing at all. Nevertheless, when they are old enough, it would be surprising to find them without some. The nodules are not only slow in appearing, but they grow rather slowly after they do appear. Hence it is common to find examples on which only the first pair have fused (Pl. vi., fig.1); and one of these often grows more than the other, so that the fusions are lopsided. Meantime, the internodes have had time to lengthen, so that, even if there were fusions of the pairs above the first, there is little chance of concrescences. We have some advanced seedlings, however, which show large and complete tumours. Anomalies are common. We have one seedling with six incomplete pairs, and nothing else. We have not seen young root-nodules, like those figured in three Eucalypt seedlings; and we have not seen later stages of them in Eucalypts. But we have examples of Angophora seedlings with what appear to be late stages, unmistakably on the root, and incorporating roots.

Though, in this paper, we are confining our attention to Eucalypts and Angophoras, we may just mention that we have specimens of about ten species of other genera which appear to be similarly afflicted. We have been able to get young stages, with paired, axillary nodules, of some of them; but it is difficult to get young enough seedlings of the others. We hope to offer some observations on these on another occasion.

List of Species, exempt or liable, as far as known.

We give a list of the species of which we have seen seedlings, or in two cases, of seedlings which have come under the notice of Mr. Cambage. We offer this list in the hope that biologists in the other States will investigate the condition of the seedlings of Eucalypts accessible to them, which we cannot get, and, especially seedlings of the Mallees; and record their observations.

Group i., *Exempt Species.*—Six species are known to us at present—*E. oreades* from the Blue Mountains, *E. pilularis*, *E. punctata*, *E.* sp., from the foot of the Blue Mountains on the western side; together with *E. gigantea* Hooker (*E. Delegatensis* R. T. Baker), and *E. fastigata*, both from the Federal Capital Territory [collected by Mr. Cambage]. We have obtained seedlings of the first two in abundance; of the third, a fair number; of the fourth, only one, but it is a fine example. Mr. Cambage has kindly given us four examples of *E. gigantea*, and twelve of *E. fastigata*, most of them quite old enough to show that they are free from stem-nodules.

The seedlings of these six species, as far as we have seen, are exempt from stem-nodules. We prefer to speak of them as exempt, rather than as immune, until their axillary conditions have been investigated, and inoculations carried out. The seedlings of *E. oreades*, as well as the two lots of Mr. Cambage's seedlings, up to the stage presented, are just ordinary seedlings, inviting no comment. But seedlings of *E. pilularis*, *E. punctata*, and *E.* sp., as they increase in size, invariably as far as we have seen, gradually come to show a pyriform thickening of the base of the stem (of the wood to some extent, but especially of the bark, as may be seen in transverse sections) over a distance of several inches, according to age. This is not pathological, and seems capable of a simple explanation. The capacity of the root-system of these seedlings for receiving the elaborated sap seems to be unequal to the capacity of the stem for delivering it; so that there appears to be a stagnation of the sap about the base of the stem, such as might be caused by a constriction or a cincture. The enlargement of the stem ends at its junction with the taproot, and does not involve the lateral roots. Transverse cracks appear in the bark, and flakes often come away, when large specimens are dried, though the wood does not crack. But the large, composite tumours of seedlings liable to them, crack longitudinally, sometimes almost to the centre, when drying, as already mentioned. Mr. Cambage's specimens are not old enough to show this development, if they have it in later stages.

GROUP ii.—Two Bloodwoods, *E. corymbosa* and *E. eximia*, which have but one effective pair of axillary stem-nodules, as a rule; though other unimportant ones may appear in late stages; but the fusion of this pair, almost invariably fuses with an indefinitely located, unpaired nodule at a lower level; and the resulting, composite tumour extends downwards, partially or entirely surrounding the axis, and incorporating lateral roots.

GROUP iii.—Species liable to attack, but susceptible or refractory in varying degrees. This group will include all the Mallees, and the three species mentioned by Tate (*E. viminalis*, *E. rostrata*, and *E. leucoxylon*), of which we have not seen specimens.

County of Cumberland and the Blue Mountains.—*E. hæmastoma*, *E. tereticornis*, *E. Deanei*, *E. saligna*, *E. maculosa*, *E. rubida*, *E. Luehmanniana*, *E. squamosa*, *E. crebra*, *E. paniculata*, *E. siderophloia*, *E. sideroxylon*, *E. amygdalina*, *E. piperita*, *E. hemiphloia*, *E. longifolia* (nursery-seedlings), *E. resinifera*, *E. robusta* (nursery-seedlings), *E. capitellata*, *E. eugenioides*, *E. Sieberiana*, *E. Moorei*, *E. stricta*; and seedlings of several species not identified. We have not been able to get seedlings of *E. botryoides* and *E. maculata*.

Berrima and Moss Vale.—*E. amygdalina*, *E. coriacea*, *E. dives*, and *E. Macarthuri* [all collected by Mr. Cambage; who has also given us two specimens of *E. coriacea* from Jindabyne, N.S.W.]. We are indebted to Mr. E. Cheel for a fine late stage of *E. Sieberiana* from Hill Top.

Marulan.—*E. cinerea* (Argyle Apple), and fine seedlings of three unidentified species locally known as Yellow Box, Broad Peppermint, and Snappy or Brittle Gum [collected by Mr. H. H. Solomon].

Wyalong, N.S.W.—*E. Behriana*, *E. fruticetorum*, *E. viridis* [collected by Mr. W. J. Moffat and Mr. Cambage].

Queensland.—Axillary stem-nodules have been recorded by Mr. Cambage on a seedling of *E. pallidifolia*;* and he has in-

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* Journ. Proc. R. Soc. N. S. Wales, xlix., p.435 (1916).

formed us that he has a plant of *E. pruinosa* with stem-nodules, in his bush-house, raised from seed, which he collected in Tropical Queensland.

West Australia.—A pot-plant of *E. macrocarpa* (Pl. x., fig.*b*) which died; we are indebted to Mr. A. G. Hamilton for this specimen. We have seen a flourishing pot-plant of *E. ficifolia*, with two pairs of stem-nodules; but were unable to see how it compares with the two Bloodwoods referred to above, in respect of the presence of an impaired nodule.

New Zealand.—In reply to a request, addressed to a friend in New Zealand, for information about Eucalypt seedlings raised from seed there, we were kindly supplied with five, representing as many species, from the nursery of T. Horton, Ltd., at Hastings or Pahiatua, we are not quite sure which. They are seedlings, from 10-18 inches high, of species that we had not previously seen. Three are labelled *E. Gunnii*, *E. globulus*, and *E. Stuartiana*. The first has two pairs of stem-nodules; the first pair nearly fused, and both have shoots; the stem was broken off just above the second pair. The second, though it is the largest seedling of the lot, has only one pair, unfused. The third has the first pair only, fused on one side. The fourth is wrongly labelled *E. coriacea*, as the leaf-characters are different from those of specimens of this species, from two localities, given to us by Mr. Cambage. This has the first pair very large and warty, not completely fused; one of the second pair very small; and a third pair, very small, and unequal in size. The fifth is labelled "Red-flowering Gum," with an unfamiliar botanical name that we cannot trace in any list of Eucalypts, known to us. This has the first pair large, but not fused, one with two shoots; a second pair, very small, one with a shoot; and the third pair still smaller.

These are the first and only seedlings with stem-nodules from outside Australia that we have seen; or that we know of, except Mr. Clayton Smith's Californian specimens, already mentioned. The interesting thing about them is, that they show substantially what we are accustomed to see in Australian specimens. We have not seen any Tasmanian seedlings, but we shall expect to hear that seedlings of *E. globulus* in Tasmania are liable. We appeal to biologists in other countries, where Eucalypts are acclimatised, to examine seedlings for the presence or absence of axillary stem-nodules; and to record their observations.

The problem, in which we hope our illustrations (certainly an advance upon what has hitherto been attempted, though there is scope for supplementing them), will arouse some interest, is not a simple problem, that can be solved by anyone single-handed. Even when the systematic botanist has done his share, the problem, in its entirety, requires team-work—the active co-operation of the field-botanist, the phytopathologist who is an expert bacteriologist, the morphologist, and the biochemist. The time is ripe for its consideration. The Mallee Scrubs are steadily vanishing in the more accessible districts of several of the States. The investigations of Erwin Smith and some of his colleagues, on Crown-Gall, reported in detail as to technique, the histology of the tumours, &c., and well illustrated,* are available for the bacteriologist as a starting-point. In addition, there are Erwin Smith's "Bacterial Plant-Diseases" (3 vols. already published), besides his numerous papers on the subject of plant-tumours, as well as Clayton Smith's paper; so that there is ample literature to begin with.

In Coville and Macdougall's "Desert Botanical Laboratory of the Carnegie Institution," in Hornaday's "Camp-Fires on Desert and Lava," and in Vols. xiii., and xvi., of Contributions from the U. S. National Museum, a number of characteristic, North American desert-plants are described, and in many cases illustrated. Some are said to have thickened, underground trunks, or to be shrubs with numerous stems from a single root, or with several stems clustered at the top of a thick, black root, or with numerous stems given off from a thickened root. Some of them, to us, are suggestive of the appearance and habit of the Australian Mallees. If the seedlings of the most remarkable of them have not been investigated, we would call the attention of American botanists to the advisability of examining these, in order to test the current interpretations of the adult condition;

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* "Crown Gall of Plants: its Cause and Remedy," and "The Structure and Development of Crown-Gall: a Plant-Cancer." Bulletin, Nos. 213 (1911) and 255 (1912), Bureau of Plant Industry, U.S. Dept. of Agriculture.

and to ascertain whether any of them are comparable with the Australian Mallees.

We are greatly indebted to our correspondents at a distance, for their kindness and trouble in sending us such material as they were able to get. But we are specially indebted to Mr. Cambage, not only for material, but for his valuable help in identifying a number of our seedlings, and in other ways. We have also to thank Principal Potts for the opportunity of getting samples of seedlings of four species from seed-beds at the Hawkesbury College which have been of great use to us; and to Mr. A. A. Lawson for help in completing our series of photographs.

Corrigendum.—Page 191, line 31—*for* length *read* lengthen.

EXPLANATION OF PLATES IV.-XXVI.

Figs. A1, A2.—Nodules in axils of cotyledons (*E. corymbosa*).

Figs. B1-B3.—Nodules in leaf-axils (*E. hemiphloia*).

Figs. C1, C2.—Nodule-shoots after injury to growing-points of seedling-stems (*E. hemiphloia*).

Plate v.

(Upper row, right-left).—Gradational series of five young seedlings, with from one to three pairs of axillary nodules (*E. hemiphloia*).

(Lower row).—Five similar seedlings of *E. sideroxylon*.

Plate vi.

Fig. 1.—Stem-encircling tumour, with shoots (*Angophora lanceolata*); no roots incorporated yet.

Fig. 2.—Three pairs of axillary nodules (*E. tereticornis*).

Fig. 3.—Second-growth tumour-shoots with axillary nodules (*E. resinifera*).

Plate vii.

Miscellaneous, remarkable seedlings. (Left-right), 1-3, *E. eugenioides*; 4 and 6, *E. piperita*; 6 and 7, *E. hæmastoma*; (nat. size).

Plate viii.

Four anomalous seedlings (a, *E. resinifera*; b1, b2, *E. hemiphloia*; c, *E. sideroxylon*); nat. size.

Plate ix.

Refractory seedlings (*E. robusta*) with from one to six, futile nodules; (nat. size).

Plate x.

Another series of refractory seedlings. (Left-right); a, *E. robusta*; b, *E. macrocarpa*; c1, c2, *E. longifolia*; (nat. size).

Plate xi.

(Left-right), 1-4, *E. corymbosa*; 5-8, *E. eximia*; (*a*, cotyledonary, axillary nodules; *x*, unpaired nodule: *r.n.*, root-nodule); nat. size.

Plate xii.

(Left-right), three root-nodules, *r.n.* (*E, hemiphloia*); 2, two tumour-shoots with axillary nodules (*E. piperita*); three examples of failure, on the part of the nodules, *a'*, to capture the buds, *ax. sh.*, (*E. eugenioides*).

Plates xiii.-xvii.

E. sideroxylon-series, continued from the lower figure of Plate v. (See pp.216-219).

Plate xviii.

E. eugenioides: belated, axillary stem-nodules at nine levels, in addition to the concrescence (*a*); (× $\frac{3}{4}$).

Plate xix.

E. eugenioides: a belated stem-nodule (A2) and its main shoot, getting their chance on the death of the seedling-stem (*s.st.*).

Plate xx.

E. tereticornis: encircling insect-gall on large tumour-shoot (after the seedling-stem perished); nat. size.

Plate xxi.

Fig.1.—*E. Behriana* (sometimes a tree).

Fig.2.—Non-Mallee (*E. tereticornis*); last stage.

Fig.3.—A Mallee (*E. viridis*).

Plate xxii.

Mallees: 1a, 1b, *E. stricta*; 2, *E. Moorei*; 3, *E. fruticetorum.*

Plate xxiii.

Tumour of *E. Behriana*; (× $\frac{2}{3}$).

Plate xxiv.

A small "Mallee-Root" from Wyalong, N.S.W. (*E.* sp.).

Plate xxv.

Fig.1.—Seedling of *E. tereticornis*, with nodule-shoots, and precocious branching.

Fig.2.—A Mallee (*E. oleosa* ?); photo taken 50 miles north of Adelaide.

Plate xxvi.

Fig.1.—A nearer view of the basal portion of the Mallee shown in Plate xxv., fig.2; the soil has been scraped away from the base.

Fig.2.—Basal portion of a Mallee (*E.* sp.) at Wyalong; the soil has been scraped away. White background furnished by handkerchiefs.

ORDINARY MONTHLY MEETING.

May 29th, 1918.

Professor H. G. Chapman, M.D., B.S., President, in the Chair.

Letters were communicated from Professor S. J. Johnston, returning thanks for congratulations on his appointment to the Chair of Zoology in the University of Sydney; and Dr. A. B. Walkom, returning thanks for congratulations on his attaining the Doctorate of Science.

It was resolved that the congratulations of the Members should be tendered to Dr. T. Griffith Taylor, of Melbourne, on the award, to him, of the David Syme Prize for 1918.

The Donations and Exchanges received since the previous Monthly Meeting (24th April, 1918), amounting to 15 Vols., 43 Parts or Nos., 7 Bulletins, 2 Reports, and 7 Pamphlets, received from 42 Societies, and two private donors, were laid upon the table.

NOTES AND EXHIBITS.

Mr. Fred Turner exhibited a specimen of *Pennisetum longistylum* Hochst., an Abyssinian grass now acclimatised in the neighbourhood of Chatswood. More than twenty-five years ago the exhibitor found this highly ornamental grass near the old battery in the Sydney Domain, but the plants were afterwards destroyed during the levelling of the ground, after the removal of the cannons.

Mr. Froggatt exhibited an immature specimen of the Spiny Stick-Insect, *Extatosoma tiaratum* Macl., from Rollings Plains, N.S.W., a remarkable example of protective mimicry. Also specimens of a common grass in the Holbrook district, N.S.W., very thickly infested with the larvæ of a *Cecidomyia* fly, allied to the Hessian Fly. Inspector F. F. Foster, of the Stock Branch, who collected the specimens, reports that it is very abundant.

Mr. Basset Hull showed a small collection of Land and Freshwater Mollusks, obtained by Gunner F. B. Hull at various points in France, on the Western Front.

Mr. E. Cheel exhibited a series of specimens.—(1) Seedling-plants of *Hakea dactyloides* and *Banksia serrata* from Hill Top, Main Southern Line, and specimens of roots from full-grown plants of *Grevillea montana* from Hill Top, and *G. punicea* from the Sydney District, to show their peculiar roots, which exhibit an excessive production of small, fibrous roots, originating, at intervals along the main roots, in clusters, somewhat resembling the "Hairy-root Disease of the Apple-tree"; these are being investigated for Mycorhiza.—(2) Seedling-plants of *Tephrosia grandiflora*, which have a simple ovate leaf, followed by a trifoliate leaf, then a pinnate leaf, although only about 2 inches high; they have comparatively large, triangularly-shaped nodules on the rootlets, measuring from 5-7 mm. across.—(3) Two forms of *Oxalis corniculatus*, with the following distinctive characters: (*a*) Plants with small, pale green leaves, and small, lemon-yellow flowers: (*b*) Plants with larger leaves, which, together with the stems, are of a purple or bronze-green colour, and each petal more or less spotted or splashed at the base with four purplish marks. Corolla slightly larger, and of a deeper yellow than those of (*a*). It is interesting to note, that Sigeroka Nohara, in a paper entitled "Genetical Studies on Oxalis" (Journ. College of Agric. Imperial University of Tokyo, vi., p.165, 1915), has come to the conclusion that *O. corniculata* is a composite species, which, so far as his investigations, extending over a period of about six years, have shown, includes at least four different biotypes. The plants common in the Sydney District agree in some respects with those in the neighbourhood of Tokyo, but the small-leaved form seems somewhat different from those mentioned by Nohara.—(4) Specimens of *Rubus laciniatus* Willd., commonly known as the "Cut-leaved or Parsley-leaved Bramble," from near Raymond Terrace, collected during a recent visit to

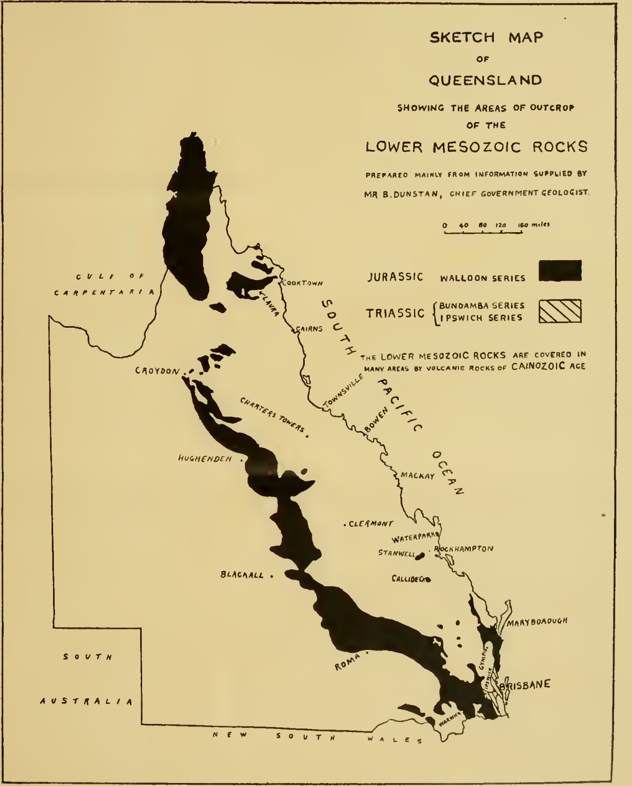
Newcastle. The plants are fairly common along the roadside, about five miles out on the Gloucester Road, and do not appear to have been collected since January, 1882, when the late Mr. E. Betche obtained specimens at Gloucester.—(5) Examples of *Rosa bracteata* Wendl., from near Raymond Terrace. Specimens identical with the above were exhibited, and recorded from Kembla Grange, Cook's River, and Armidale (These Proceedings, 1912, p.137; and 1916, p.633), under the name *Rosa turbinata* Ait.; but further investigation shows that, although they are identical with specimens in the National Herbarium from Montpellier under the latter name, the determination is erroneous.—(6) Fresh specimens of *Styphelia tubiflora*, from Cronulla, showing variation in the colour of the flowers, from creamy-white in some plants, pink and cream in others, and the normal blood-red. Although the individual plants showed the above-mentioned distinctive colours, they were growing within a radius of 15 feet of each other, and were very marked.

Mr. Hedley showed a photograph of the cenotaph in memory of Major A. C. Innes (ob. 1857), and Mrs. Innes (née Margaret Macleay, daughter of Alexander Macleay: ob. 1858), in the old church at Port Macquarie. References to Major and Mrs. Innes, and to their home at Lake Innes, in 1836, will be found in James Backhouse's "Narrative of a Visit to the Australian Colonies," p.406 (1843).

Mr. A. G. Hamilton communicated some particulars about so-called "glow-worms," probably larvæ of a Tipulid fly, found on damp, rocky ledges on the banks of a creek near Bundanoon. They are said to be found also in deserted coal-mines.

Mr. Waite, a visitor from Adelaide, called attention to the first Part of the Records of the South Australian Museum, at Adelaide, recently issued.

[Printed off, June 27th, 1918.]

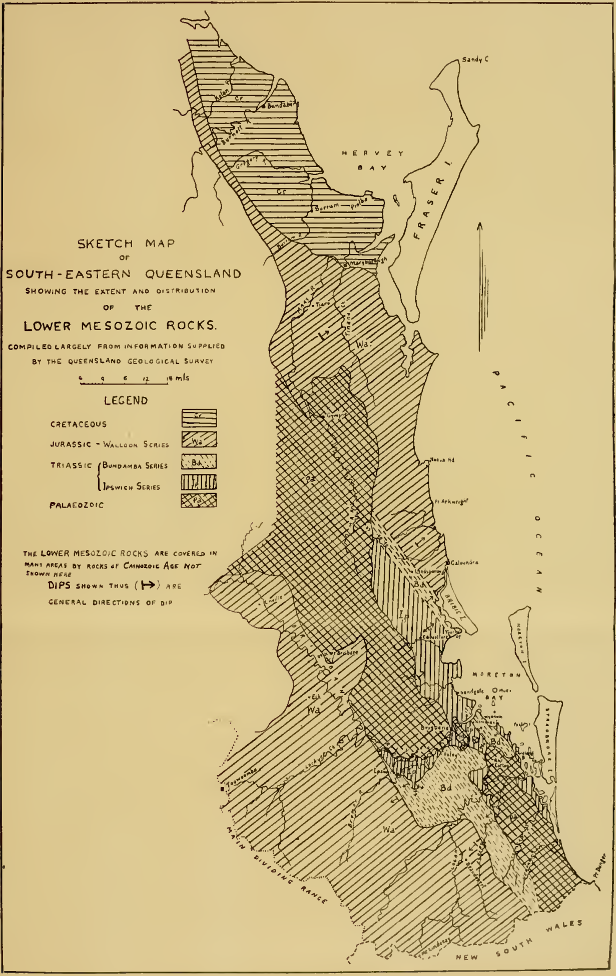


SKETCH MAP
OF
QUEENSLAND
SHOWING THE AREAS OF OUTCROP
OF THE
LOWER MESOZOIC ROCKS

PREPARED MAINLY FROM INFORMATION SUPPLIED BY
MR B. DUNSTAN, CHIEF GOVERNMENT GEOLOGIST.

JURASSIC	WALLOON SERIES	■
TRIASSIC	BUNDAMBA SERIES IPSWICH SERIES	▨

THE LOWER MESOZOIC ROCKS ARE COVERED IN MANY AREAS BY VOLCANIC ROCKS OF CAINOZOIC AGE



SKETCH MAP
OF
SOUTH-EASTERN QUEENSLAND
SHOWING THE EXTENT AND DISTRIBUTION
OF THE
LOWER MESOZOIC ROCKS.
COMPILED LARGELY FROM INFORMATION SUPPLIED
BY THE QUEENSLAND GEOLOGICAL SURVEY

LEGEND

CRETACEOUS	Cr
JURASSIC - WALLOON SERIES	Wa
TRIASSIC { BUNDAMBA SERIES	Bd
IPSWICH SERIES	Ip
PALAEOZOIC	Pz

THE LOWER MESOZOIC ROCKS ARE COVERED IN MANY AREAS BY ROCKS OF CAINOZOIC AGE NOT SHOWN HERE

DIPS SHOWN THUS (↦) ARE GENERAL DIRECTIONS OF DIP

Fig. 1.

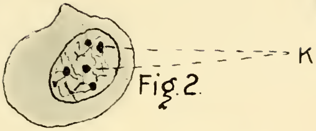


Fig. 2.

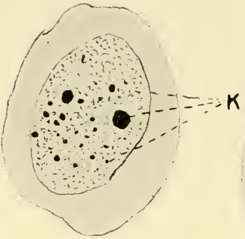


Fig. 3.

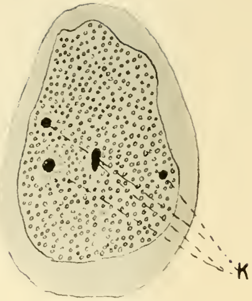


Fig. 4.

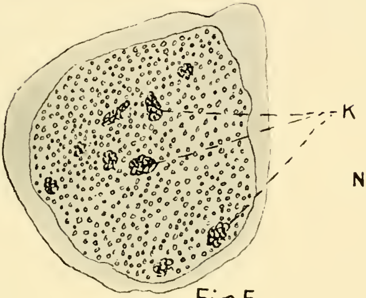


Fig. 5.

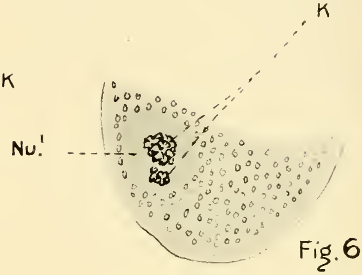


Fig. 6.

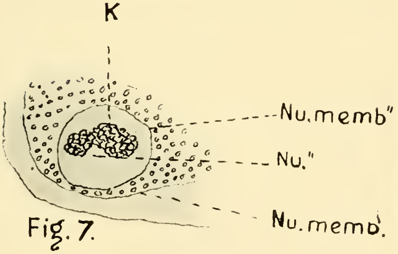


Fig. 7.

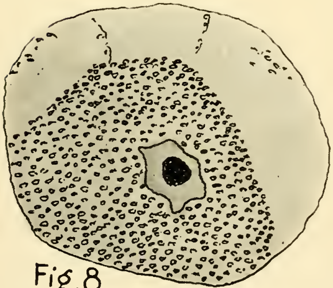


Fig. 8.

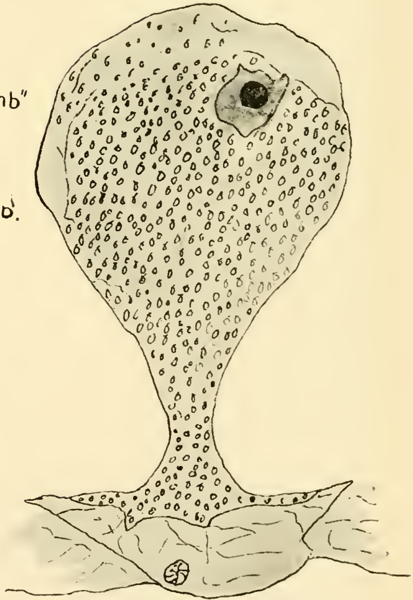


Fig. 9.

The Origin of Yolk in the ova of *Ubrius hilli* Kestv.

A1, A2. Nodules in axils of cotyledons *(E. corymbosa)*. B1-B3. Nodules in leaf-axils *(E. hemiphloia)*.
C1, C2. Nodule-shoots after injury to seedling-stem *(E. hemiphloia)*.

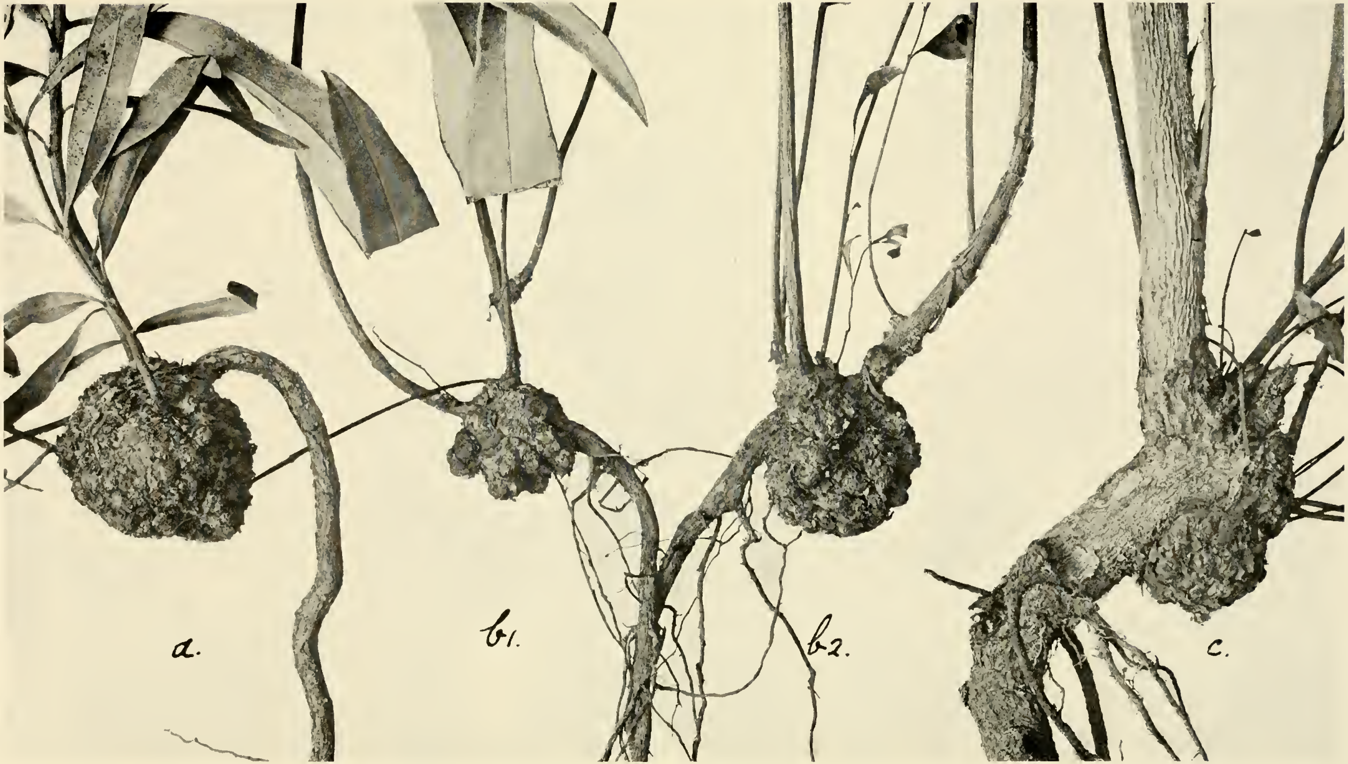
(Upper row, right to left). Five seedlings, with from one to three pairs of nodules *(E. hemiphloia).* (Lower row). Five similar seedlings of *E. sideroxylon.*

1

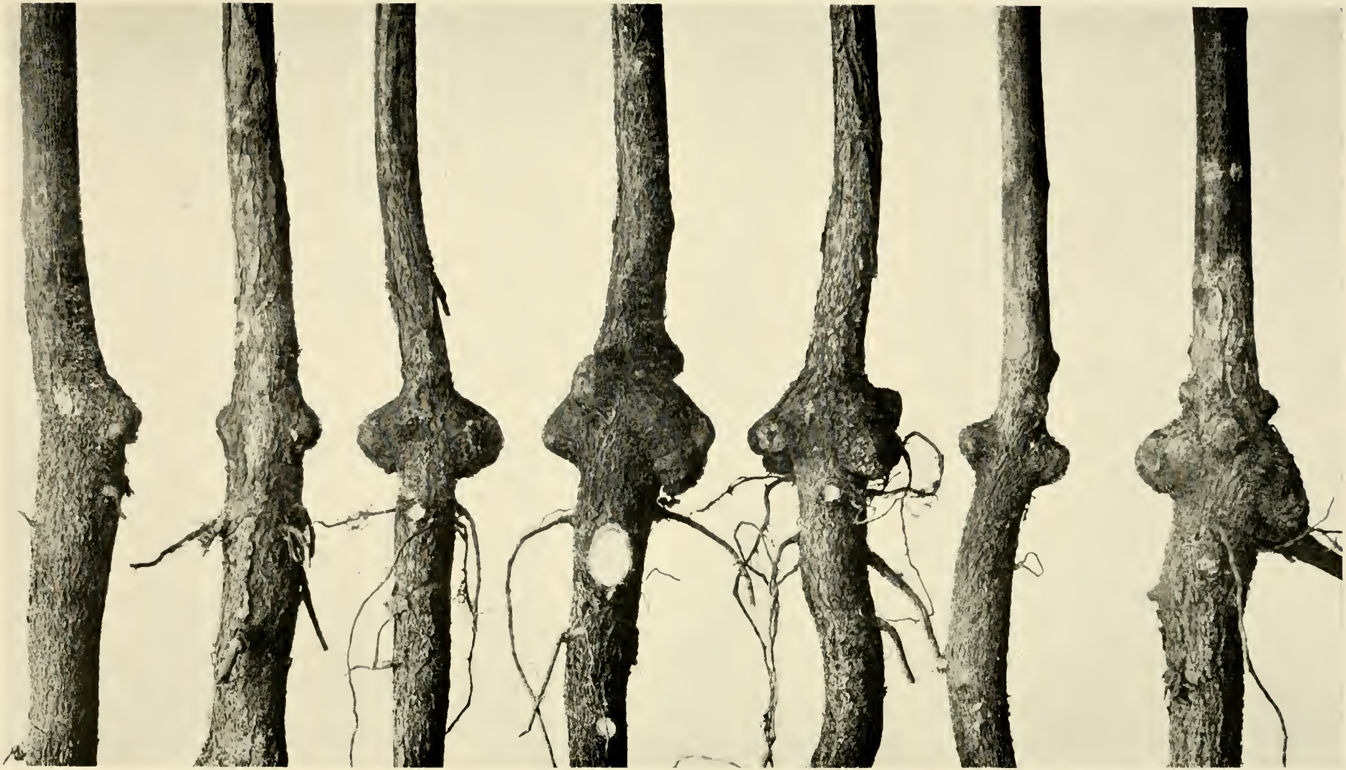
2

1. Stem-encircling tumour with shoots *(A. lanceolata)*. 2. Three pairs of nodules *(E. tereticornis)*. (Lower fig.) Second-growth tumour-shoots with axillary nodules *(E. resinifera)*.

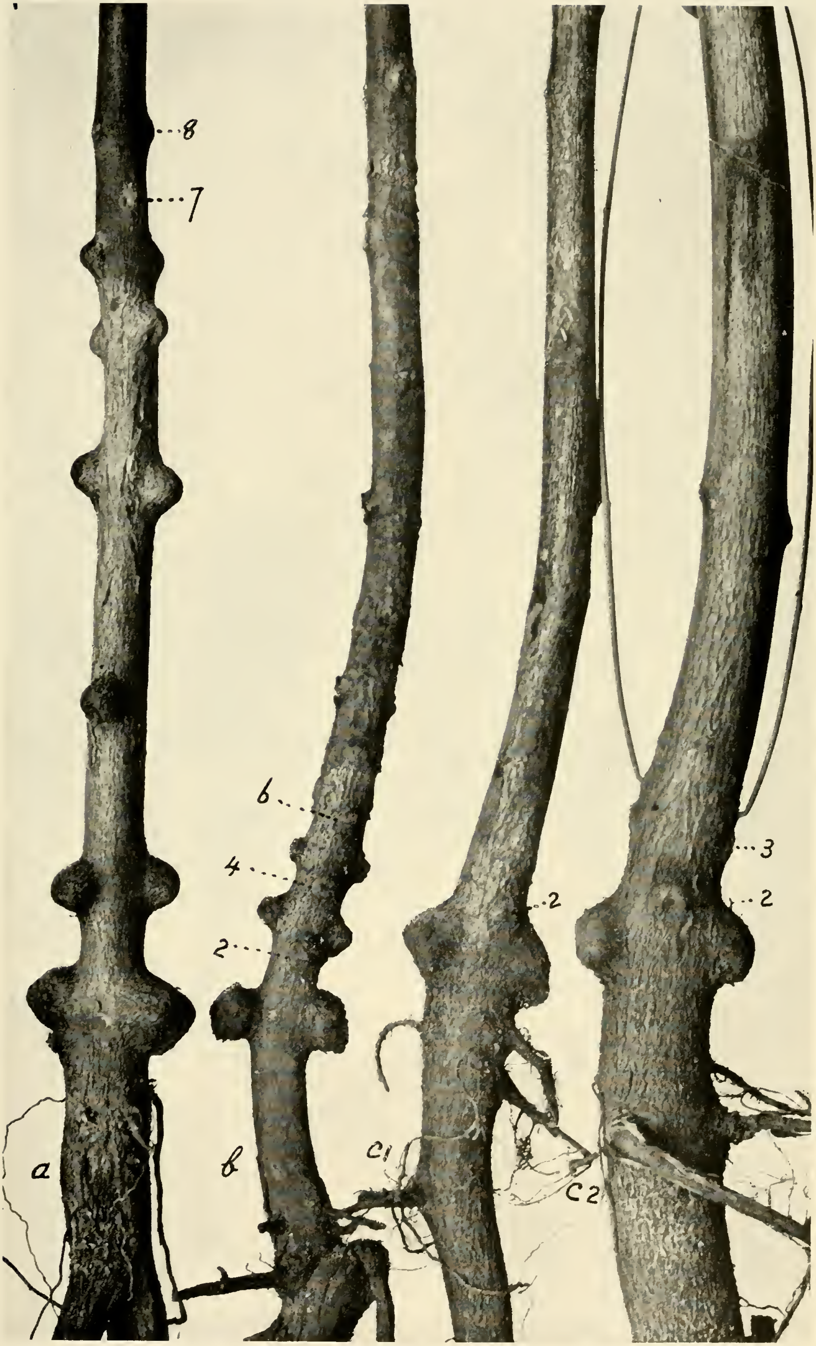
Miscellaneous, remarkable seedlings. (Left to right), 1-3, *E. eugenioides;* 4 and 6, *E. piperita;* 5 and 7, *E. hæmastoma;* (nat. size).



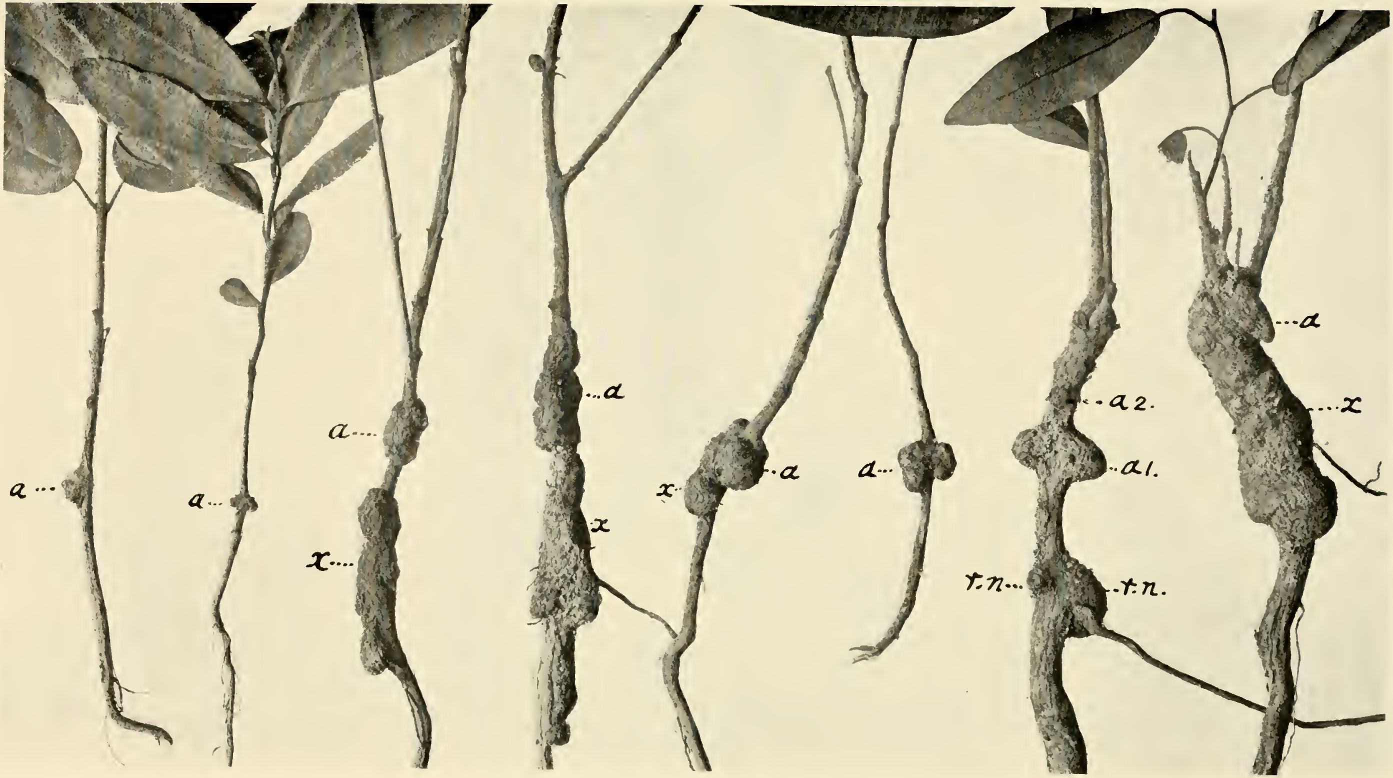
Anomalies: a, *E. resinifera;* b1, b2, *E. hemiphloia:* c, *E. sideroxylon* (nodules missing on one side); nat. size.



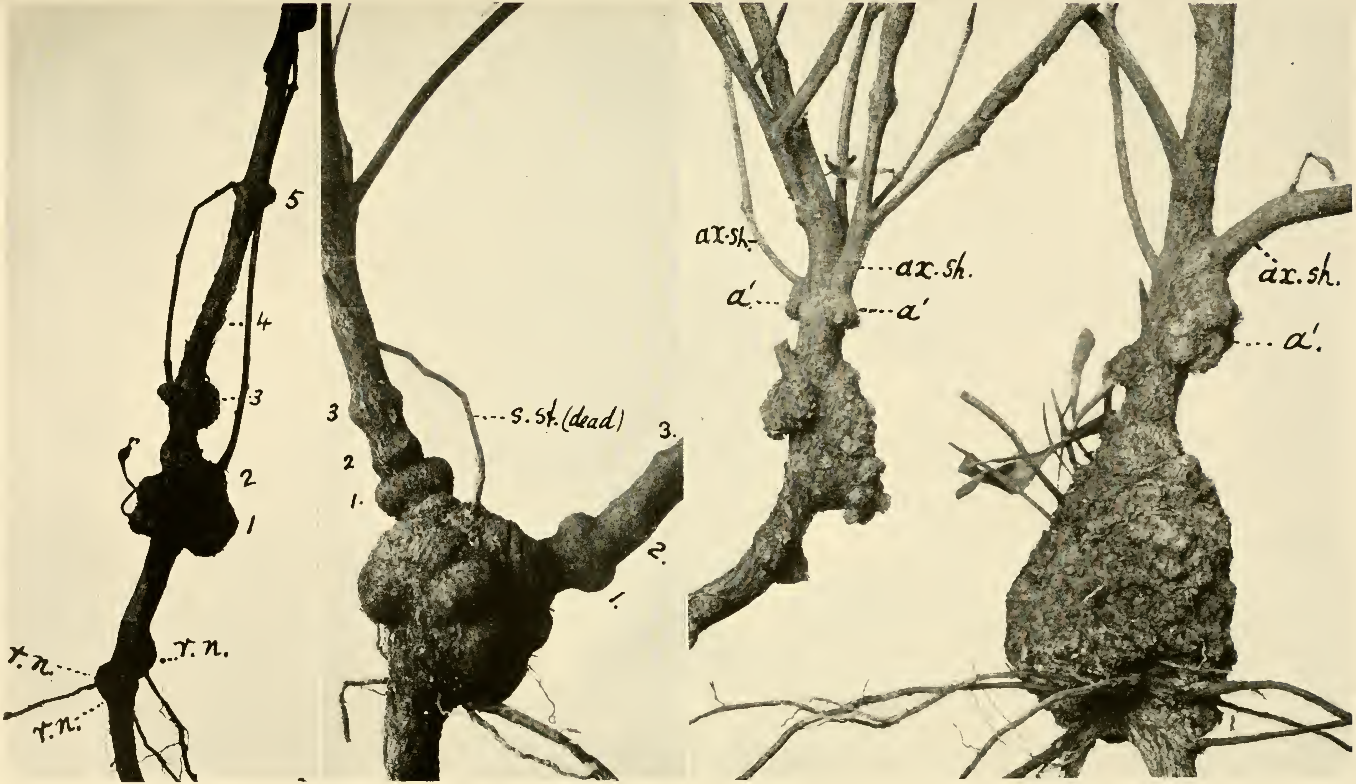
Refractory seedlings *(E. robusta)* with one to six, futile, axillary nodules; (nat. size).



Refractory seedlings: a, *E. robusta;* b, *E. macrocarpa;* c1, c2, *E. longifolia;* (nat. size).



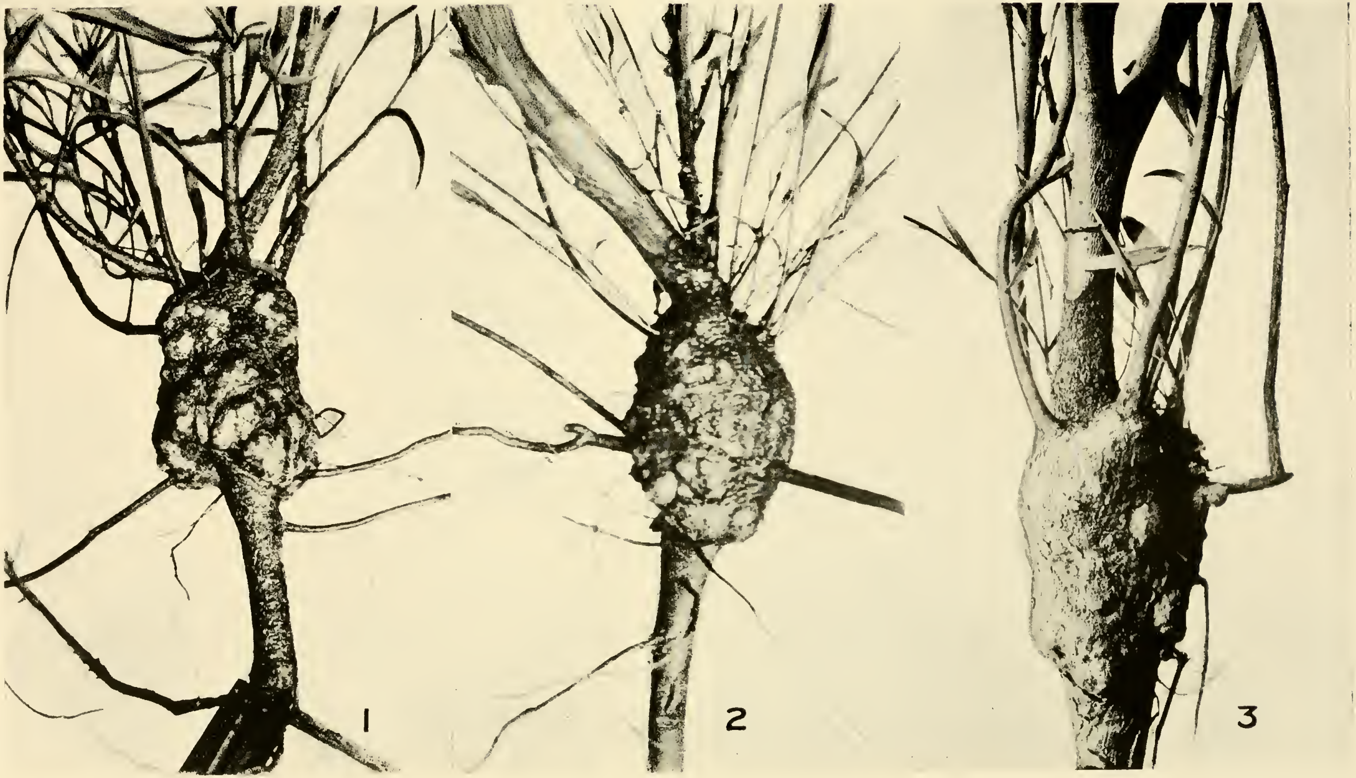
(Left to right) 1-4, *E. corymbosa*; 5-8, *E. eximia* (*a*. cotyledonary, axillary nodules; *x*, unpaired nodule; *r.n.*, root-nodule); nat. size.



(Left-right): 1, seedling with three root-nodules; 2, two tumour-shoots with axillary nodules; 3-4, three examples of failure, on the part of nodules (*a^1*), to capture buds (*ax. sh.*).

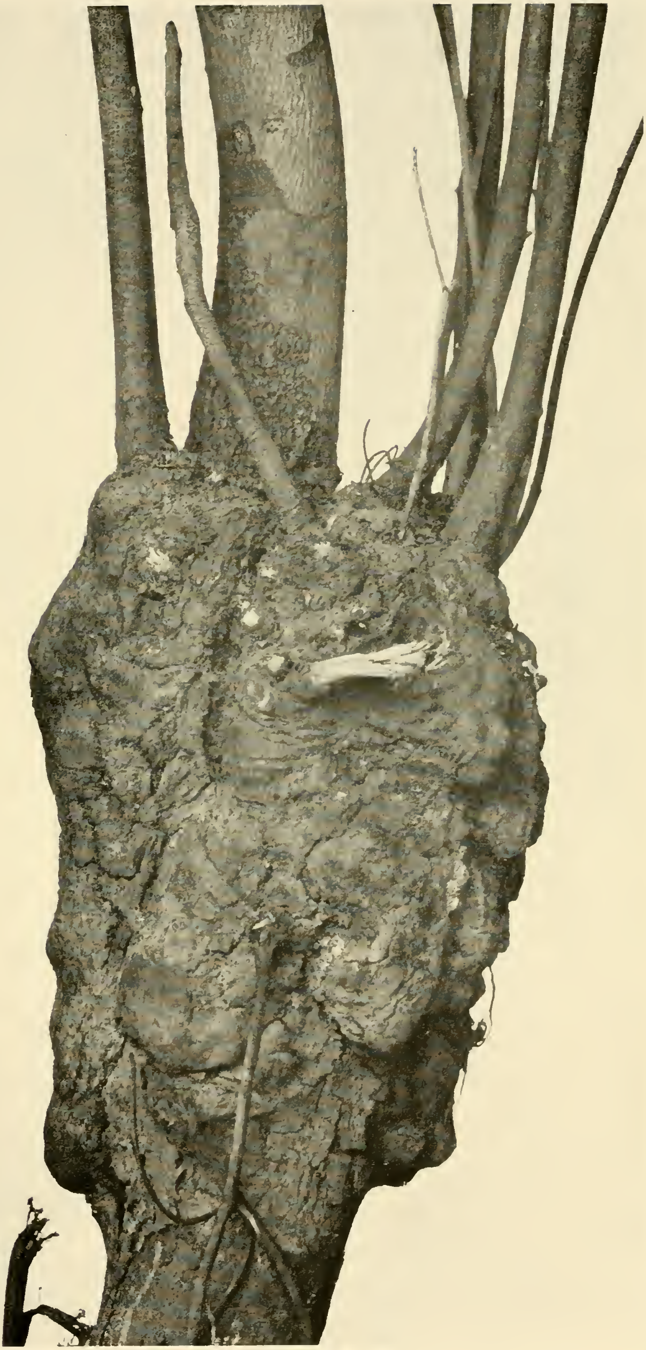
E. sideroxylon-series, continued from lower figure of Pl. v.

E. sideroxylon-series, continued.

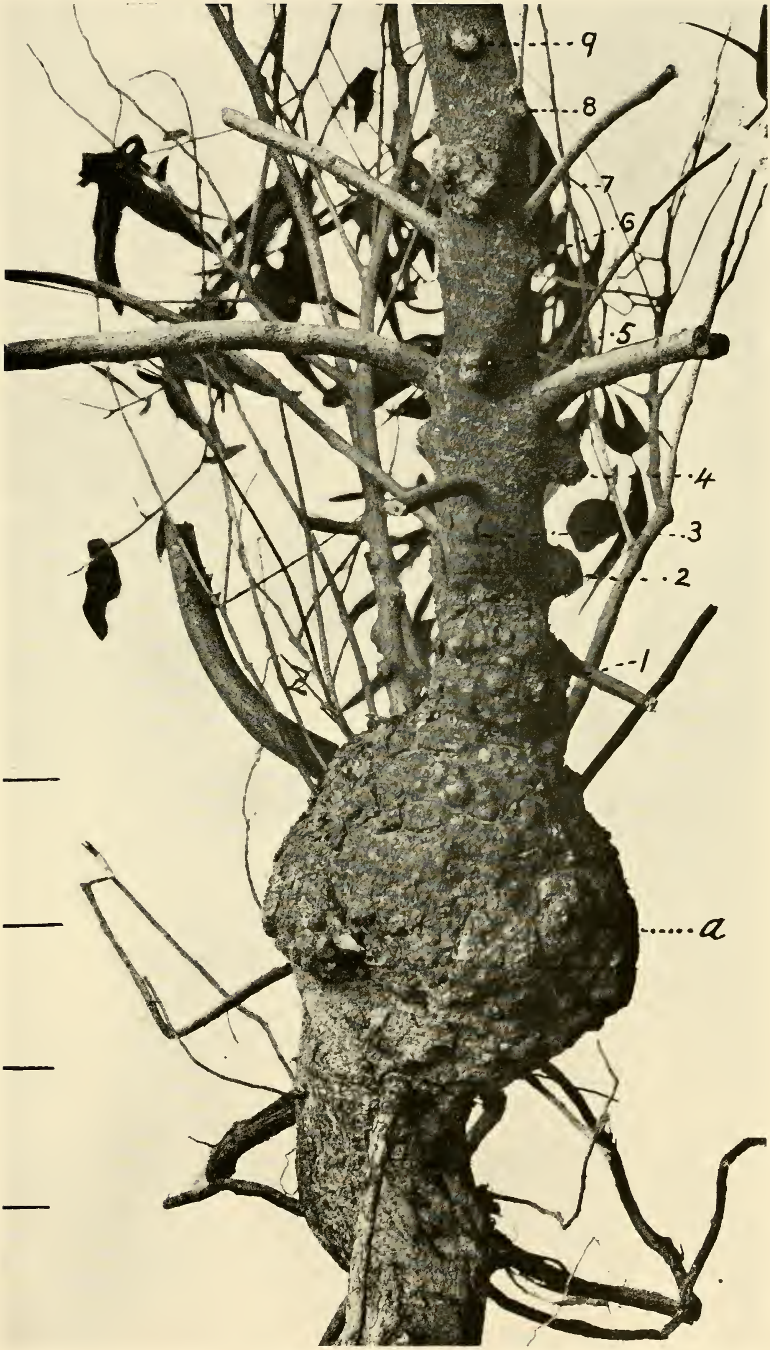


E. sideroxylon-series, continued (late stages).

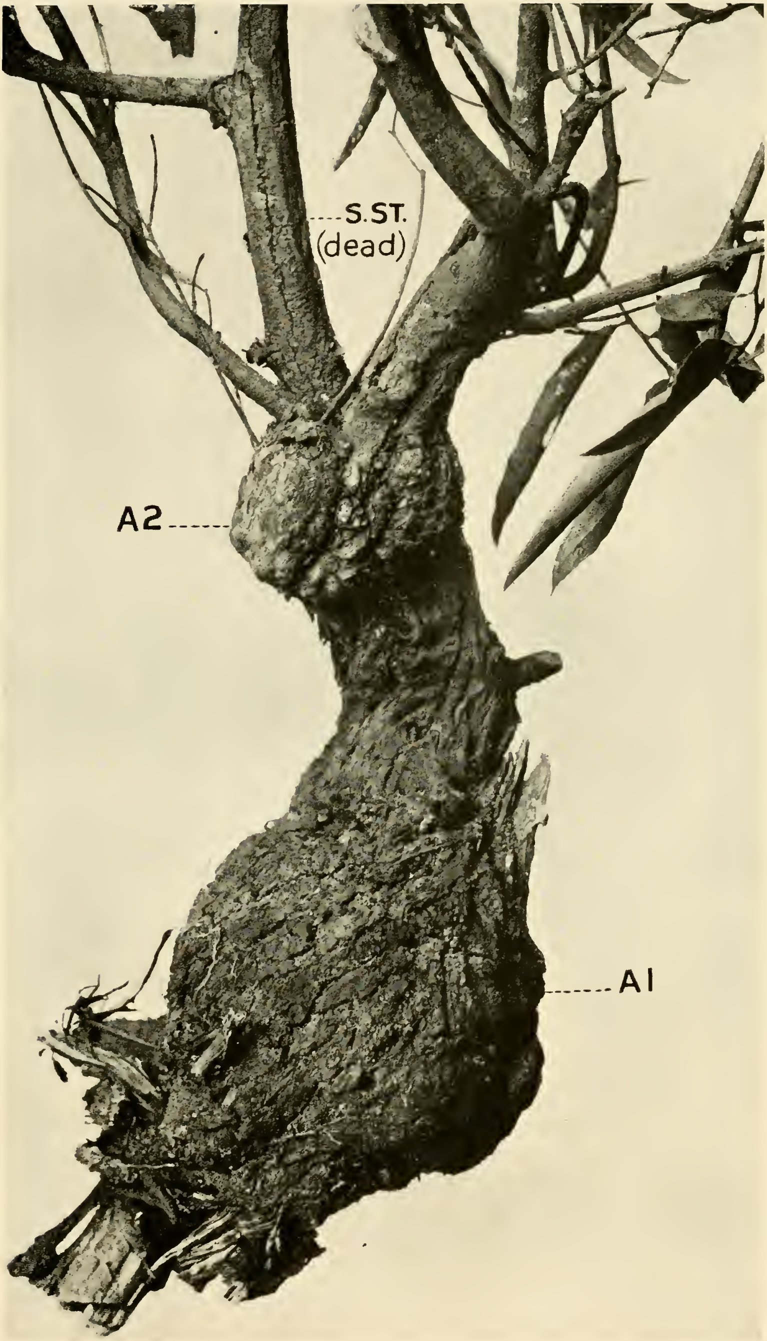
E. sideroxylon-series, continued. Fig. 1, seedling-stem nearly ready to get rid of tumour-shoots. Fig. 2, last stages.



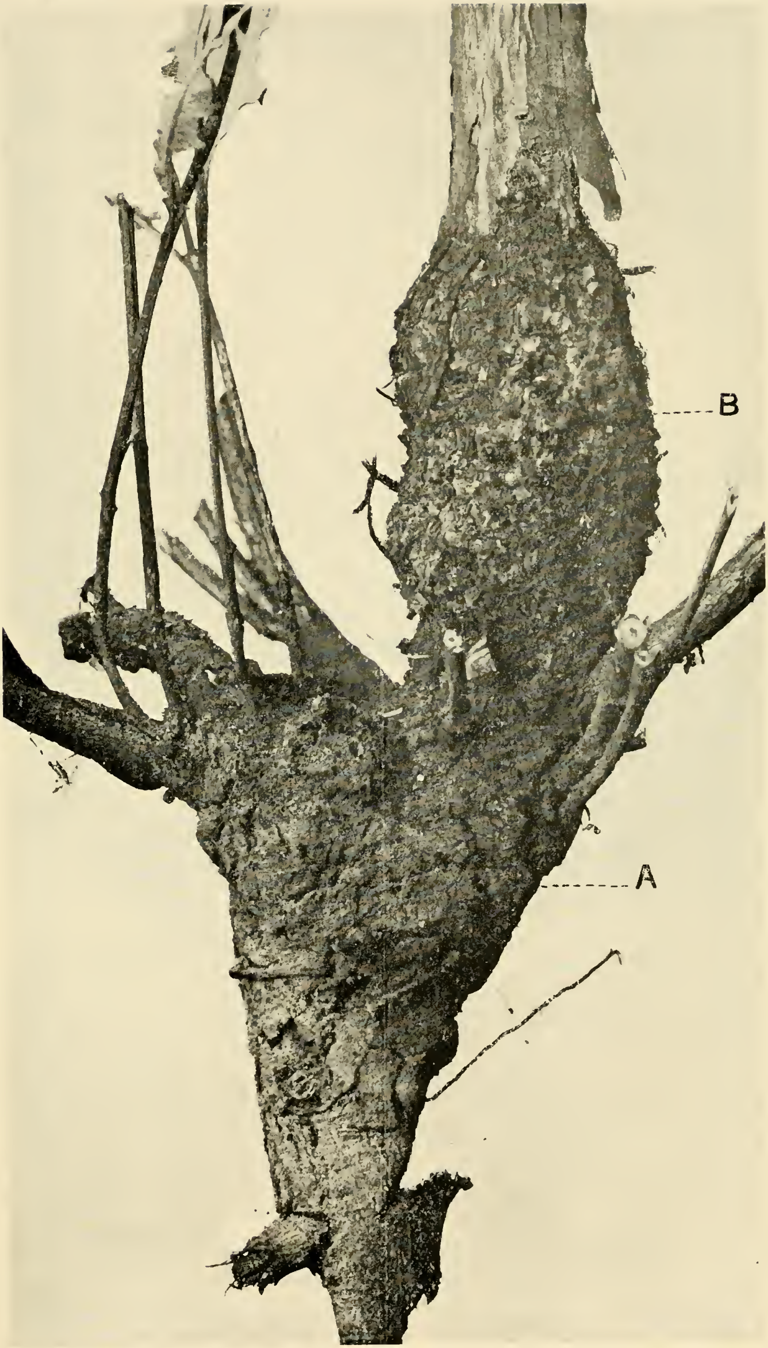
E. sideroxylon-series, concluded: tumour of plant shown in Pl. xvi., fig. 1; (nat. size).



E. eugenioides: belated, axillary stem-nodules at nine levels, irrespective of the concrescence, *a.*



E. eugenioides: a belated stem-nodule (A2) and its main shoot, getting their chance on the death of the seedling-stem *(s. st.)*

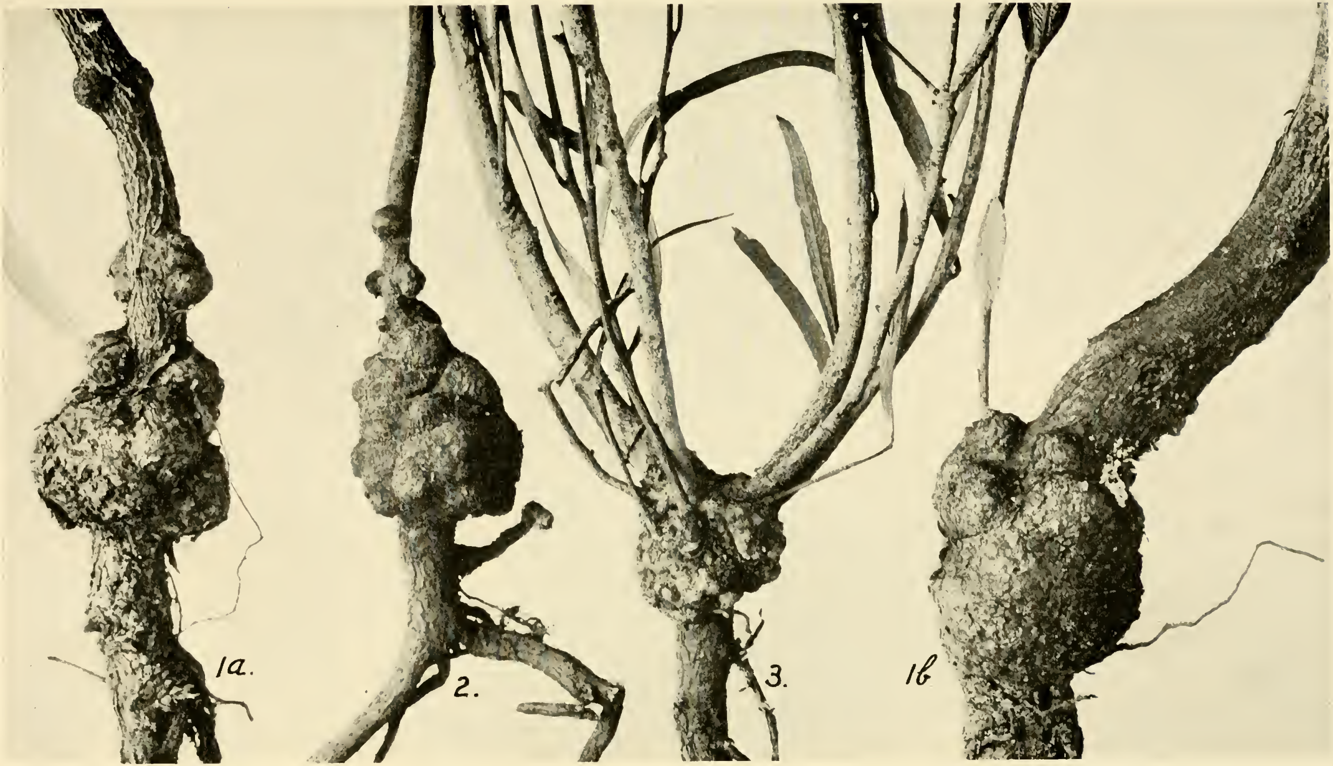


E. tereticornis: encircling insect-gall on large tumour-shoot (after the seedling-stem perished); nat. size.

1. *E. Behriana* (sometimes a Mallee).

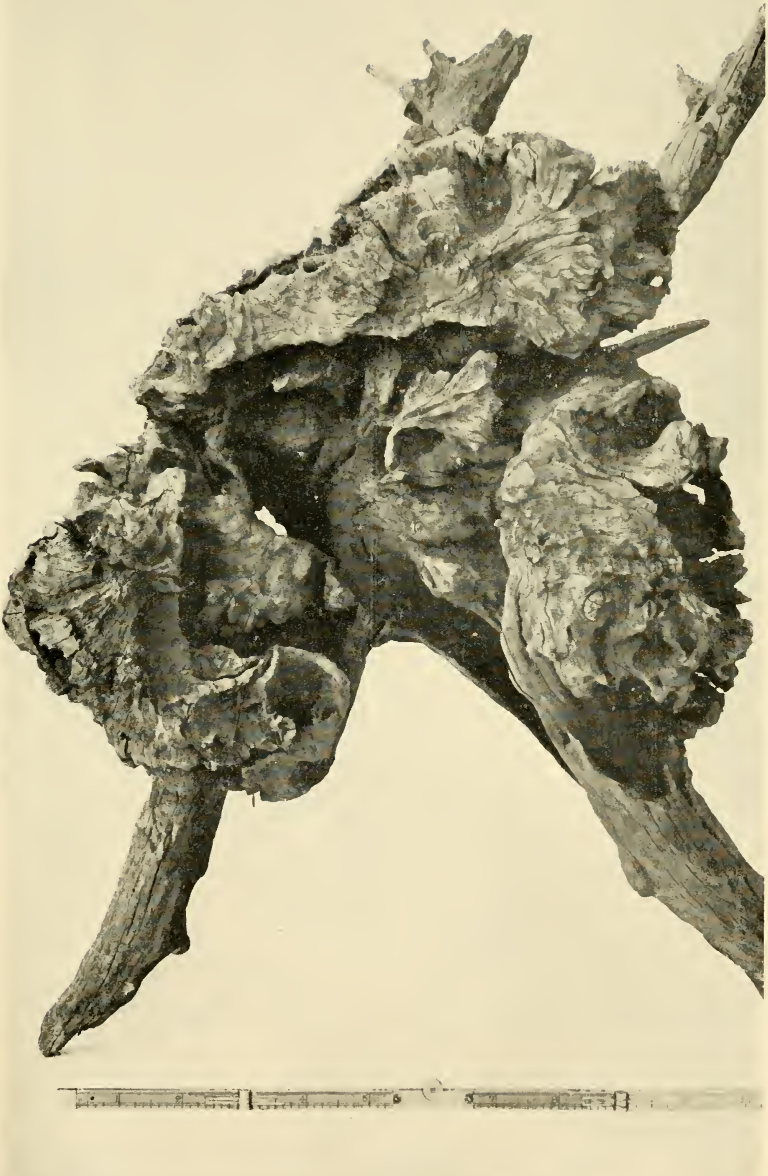
2. Non-Mallee *(E. tereticornis)* last stage.

3. A Mallee *(E. viridis)*.



Mallees: 1a, 1b, *E. stricta*; 2, *E. Moorei*; 3, *E. fruticetorum*; (nat. size).

Tumour of *E. Behriana*; (×⅔).



A small "Mallee-Root" from Wyalong, N.S.W. (*E.* sp.).

1. Nodule-shoots, and precocious branching *(E. tereticornis)*.

2. A Mallee; soil scraped away from the base.

1

2

Fig. 1. Nearer view of basal portion of the Mallee in preceding Plate.
Fig. 2. Similar view of another Mallee (white background furnished by handkerchiefs).

ON THE SEASONAL DISTRIBUTION OF SOME QUEENSLAND SPECIES OF *ARCELLA* Ehrenberg.

By C. D. Gillies, M.Sc., Biology Department, University of Queensland.

(Communicated by Dr. T. Harvey Johnston.)

(With four Text-figures).

(1.) General

The Rhizopodan genus *Arcella* Ehrenberg, is represented in the fauna of freshwater pools of Queensland so far investigated, by four well differentiated forms, viz., *A. vulgaris* Ehr., *A. discoides* Ehr., *A. mitrata* Leidy, and *A. artocrea* Leidy. On account of the present condition of Rhizopodan taxonomy, these terms are to be interpreted in this paper as follows:—

A. vulgaris Ehr., small, hemispherical forms in which the test may be either smooth or gibbose.

A. discoides Ehr., flat, disk-like species, with the alveoli of the test very small.

A. mitrata Leidy, test normally polygonal; alveoli conspicuous; pylome with a double invagination.

A. artocrea Leidy: under this appellation is included a number of large forms in which, typically, the basal portion of the test is rim-like. This feature ranges from being well developed to absent, but, in a series, there is no questioning the identity of the latter variant in spite of the loss of the rim. The fundus of the test is hemispherical, and the alveolar markings are conspicuous. These forms may be regarded as the Queensland representatives of the species described by Leidy under this name.

A. dentata Leidy, has not been observed, though it has been searched for. This may be on account of its rare occurrence, for

Leidy [(**2**) p.177], Kofoid [(**1**) p.100], and Wailes [(**3**) p.129], all refer to its scarcity.

In this paper are presented the results of a preliminary inquiry into the seasonal distribution of the four forms met with in Queensland. The various collections examined were preserved in weak formalin, and, for identification and counting, an ocular of medium power, and a 2/3 objective, usually were found sufficient. In this investigation, any *Arcella*-test not containing the organism was rejected.

DATA.

(1). Brisbane Botanical Gardens.

These observations, extending from September 29th, 1916, to 29th December, 1917, have been made by the monthly examination of material from a lagoon near the old Bird-House. Gatherings were usually taken about the end of each month, but, on 6th October, 1916, and 12th September, 1917, supplementary material was obtained, and, to avoid as much as possible the introduction of disturbing factors, the collections were made near the northern extremity of the major axis of the lagoon, which is elliptical in shape.

	(a) 29th Sept., 1916.		(b) 6th Oct., 1916.	
	Actual No. counted.	Percentage.	Actual No. counted.	Percentage.
A. vulgaris	1	2·5	0	0
A. discoides	3	7·5	0	0
A. mitrata	2	5	16	16
A. artocrea	34	85	84	84
Total	40	100	100	100

	(c) 30th Oct., 1916.		(d) 28th Nov., 1916.	
A. vulgaris	0	0	0	0
A. discoides	1	2	43	86
A. mitrata	20	40	7	14
A. artocrea	29	58	0	0
Total	50	100	50	100

	(e) 28th Dec., 1916.		(f) 30th Jan., 1917.	
	Actual No.	Percentage.	Actual No.	Percentage.
A. vulgaris ...	74	71·85	84	84
A. discoides ...	5	4·85	0	0
A. mitrata ...	20	19·42	13	13
A. artocrea ...	4	3·88	3	3
Total ...	103	100·00	100	100
	(g) 28th Feb., 1917.		(h) 29th March, 1917.	
A. vulgaris ...	37	37	67	67
A. discoides ...	1	1	2	2
A. mitrata ...	8	8	19	19
A. artocrea ...	54	54	12	12
Total ...	100	100	100	100
	(i) 2nd May, 1917.		(j) 31st May, 1917.	
A. vulgaris ...	71	71	77	77
A. discoides ...	4	4	5	5
A. mitrata ...	19	19	10	10
A. artocrea ...	6	6	8	8
Total ...	100	100	100	100
	(k) 23rd June, 1917.		(l) 1st Aug., 1917.	
A. vulgaris ...	41	40·60	31	62
A. discoides ...	0	0	3	6
A. mitrata ...	43	42·57	8	16
A. artocrea ...	17	16·83	8	16
Total ...	101	100·00	50	100
	(m) 31st Aug., 1917.		(n) 12th Sept., 1917.	
A. vulgaris ...	82	82	35	70
A. discoides ...	0	0	0	0
A. mitrata ...	1	1	4	8
A. artocrea ...	17	17	11	22
Total ...	100	100	50	100

(o) 28th Sept., 1917.

	Actual No.	Percentage.
A. vulgaris ...	3	21·43
A. discoides ...	1	7·14
A. mitrata ...	3	21·43
A. artocrea ...	7	50·00
Total ...	14	100·00

Only 14 Arcellæ were counted on this occasion, consequently the percentage values are not so significant as in the preceding tables.

	(p) 2nd Nov., 1917.		(q) 30th Nov., 1917.	
	Actual No.	Percentage.	Actual No.	Percentage.
A. vulgaris ...	6	18·18	1	20
A. discoides ...	3	9·09	1	20
A. mitrata ...	15	45·45	2	40
A. artocrea ...	9	27·28	1	20
Total ...	33	100·00	5	100

In figs.1-4, the lines connecting the values of this date with those of 2nd November on the one hand, and 30th December on the other, are broken to indicate that little importance should be associated with them, as the total number actually counted is too small to convey much meaning. On this occasion, Arcellæ for counting were extremely rare.

(r) 29th Dec., 1917.

	Actual No.	Percentage.
A. vulgaris ...	26	52
A. discoides ...	5	10
A. mitrata ...	14	28
A. artocrea ...	5	10
Total ...	50	100

(2). *Locality*, Bribie Island. *Date*, early in April, 1915.

	Actual No.	Percentage.
A. vulgaris ...	23	60·53
A. mitrata ...	15	39·47
Total ...	38	100·00

TABLE i.

	29th Sept.	6th Oct.	30th Oct.	28th Nov.	28th Dec.	30th Jan.	28th Feb.	29th March.	2nd May.	31st May.	28th June.	1st Aug.	31st Aug.	12th Sept.	28th Sept.	2nd Nov.	30th Nov.	29th Dec.
A. vulgaris	2	0	0	0	72	84	37	67	71	77	41	62	82	70	22	18	20	52
A. discoides	8	0	2	86	5	0	1	2	4	5	0	6	0	0	7	9	20	28
A. mitrata	5	16	40	14	19	13	8	19	19	10	42	16	1	8	21	46	40	10
A. artocrea	85	84	58	0	4	3	54	12	6	8	17	16	17	22	50	27	20	10
Totals	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

The seasonal distribution of the four species in percentages. Brisbane Botanical Gardens; 29th Sept., 1916-29th Dec., 1917.

(3). *Locality*, Beerburrum. *Date*, 29th June, 1917.
Two living Arcellæ observed, both *A. vulgaris.*

(4). *Locality*, Chelmer. *Date*, 29th Aug., 1917.
Eight living Arcellæ observed, all *A. vulgaris.*

(5). *Locality*, Graceville. *Date*, 29th Aug., 1917.
Twenty-three living Arcellæ observed, all *A. vulgaris.*

(6). *Locality*, Cooroy. *Date*, 6th Oct., 1917.
Fifty living Arcellæ observed, all *A. artocrea.*

(7). *Locality*, West Burleigh. *Date*, October, 1917.
Twenty-three living Arcellæ observed, all *A. artocrea.*

(8). *Locality*, Maryborough. *Date*, 24th Nov., 1917.
Twenty-two living Arcellæ counted, all *A. vulgaris.*

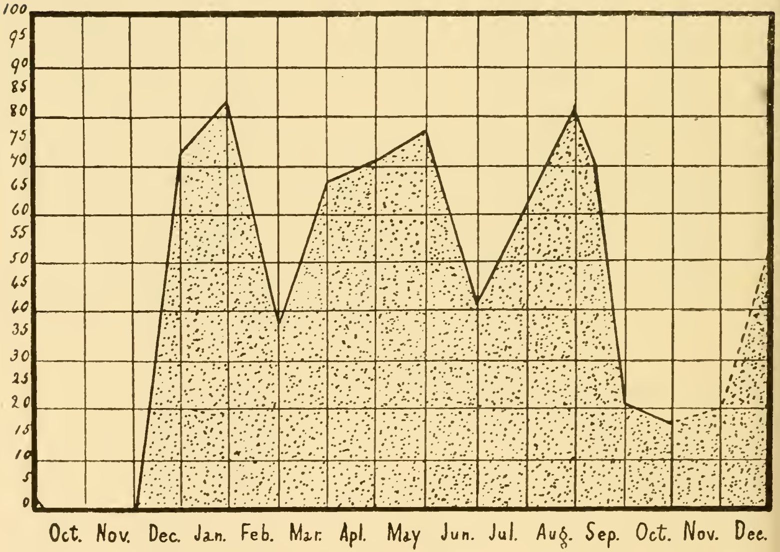


Fig. 1.—Percentage-frequency of *Arcella vulgaris* in Arcellan fauna. Brisbane Botanical Gardens: Sept. 29th, 1916, to Dec. 29th, 1917.

(3.) Conclusions.

Figs. 1-4 are graphical representations of the data given in Table i., and each species is graphed separately. It will be seen that the polygons are constructed on percentages. In taking the observations, when the Arcellæ were sufficiently abundant, 100 counts were made; but, on a number of occasions, this was not done through the scarcity of the genus, the extreme case being in connection with the gathering of 30th November, 1917, when only five counts were recorded.

Fig.1, *A. vulgaris*. The graph shows two primary minimum periods (29th Sept.-28th Nov., 1916, and 28th Sept.-?Nov., 1917), and a long maximum period (28th Dec., 1916-12th Sept., 1917) with three secondary maxima (30th Jan., 31st May, 31st Aug., 1917), and two secondary minima (28th Feb. and 28th June, 1917). The highest point of the curve is 84% (28th Jan., 1917), and the lowest zero (6th Oct., 30th Oct., 28th Nov., 1916).

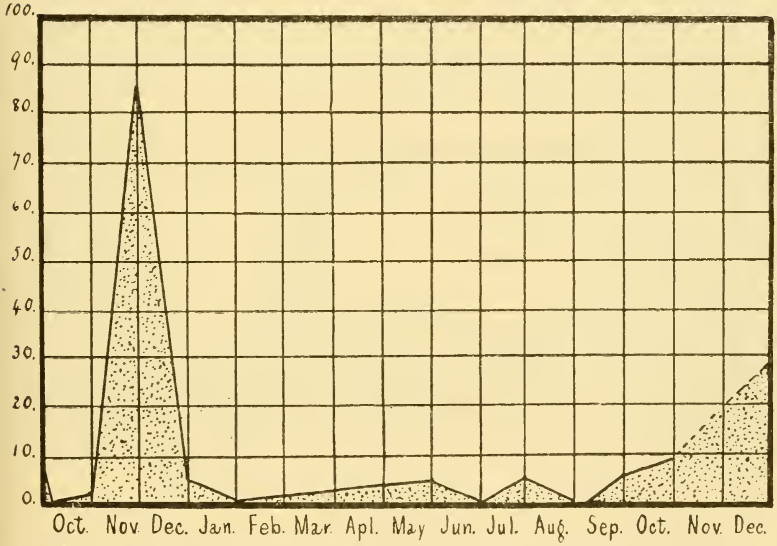


Fig.2.—Percentage-frequency of *A. discoides* in Arcellan fauna. Brisbane Botanical Gardens: Sept. 29th, 1916, to Dec. 29th, 1917.

It seems probable that the primary maximum and minimum periods are typical for the species in Southern Queensland, because, in the occasional material collected in the maximum period Dec.-Sept., the dominant form is *A. vulgaris* (*see* Bribie

Island, Chelmer, Graceville, Beerburrum, and Maryborough).* Furthermore, material gathered during the minimum period Sept.-Dec., shows a different dominant form (*see* Cooroy and West Burleigh). A feature of considerable importance in this connection is, that the most southerly and the most northerly locality are about 190 miles apart, viz., West Burleigh and Maryborough

Fig.2, *A. discoides*. The values in this graph are mostly small, and, out of eighteen observations, eleven range from 0·5% (6th Oct., 30th Oct., 28th Dec., 1916; 30th Jan., 28th Feb., 29th March, 2nd May, 31st May, 28th June, 31st Aug., 12th Sept., 1917). There is only one prominent maximum (86%, 28th Nov., 1916).

Until more data are collected in the case of this species, and of *A. mitrata*, it is considered premature to draw conclusions, though there is reason to believe November is a maximum period.

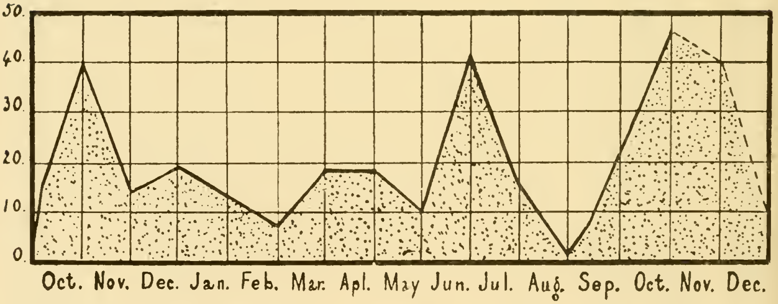


Fig.3.—Percentage-frequency of *A. mitrata* in Arcellan fauna. Brisbane Botanical Gardens: Sept. 29th, 1916, to Dec. 29th, 1917.

Fig.3, *A. mitrata*. Three maxima are present (30th Oct., 1916; 28th June, 2nd Nov., 1917) and of these, two (30th Oct., 1916, and 2nd Nov., 1917) occur during the maximum period of *A. vulgaris*. On only one occasion did the percentage fall below 5% (1% 31st Aug., 1917). It is the most consistent form of the

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* 24th Nov. is sufficiently near December to be included in the maximum period.

four, as it occurs throughout the year, and its numerical range is the least (*see* Table ii.).

TABLE ii.

	Highest values.	Lowest values.	Range.
A. vulgaris	84% (30th Jan., 1917)	0%	84
A. discoides	86% (28th Nov., 1917)	0%	86
A. mitrata	46% (2nd Nov., 1917)	1%	45
A. artocrea	85% (29th Sept., 1916)	0%	85

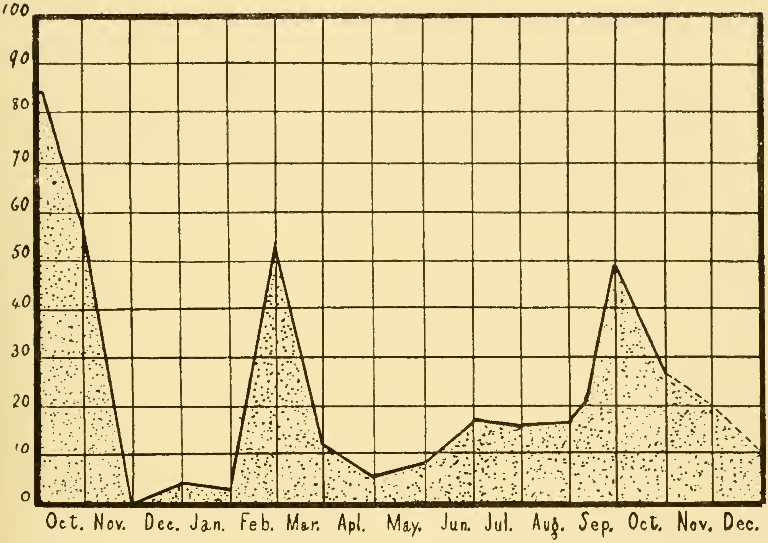

Fig. 4.—Percentage-frequency of *A. artocrea* in Arcellan fauna. Brisbane Botanical Gardens: Sept. 29th, 1916, to Dec. 29th, 1917.

Fig. 4, *A. artocrea.* Three maxima are present (29th Sept., 1916, 28th Feb., 28th Sept., 1917), the highest point of the curve being 85% (29th Sept., 1916), while the lowest is zero (28th Nov., 1916) The period September-October seems to be a dominant one for this form in Southern Queensland, as it includes two of the maxima, viz., 29th Sept., 1916, and 28th Sept., 1917; and in material from Cooroy and West Burleigh (*see* 6, 7) gathered in October, 1917, the *only living Arcellæ* present were *A. artocrea.* Furthermore, the two localities are about 130 miles apart. Again in the occasional material collected outside the period September-October [*see* (2), (3), (4), (5), (8), the dominant form is *A. vulgaris,* not *A. artocrea.*

It is hoped by the collection of more data that deductions may be made in connection with *A. discoides* and *A. mitrata,* as well as in supplying confirmatory evidence in regard to *A. vulgaris* and *A. artocrea.*

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ON THE LEAF-ANATOMY OF *SCÆVOLA CRASSIFOLIA*, WITH SPECIAL REFERENCE TO THE EPIDERMAL SECRETION.

By Marjorie Isabel Collins, B.Sc., (Syd.), Demonstrator in Botany, the University of Adelaide.

(Plates xxvii.-xxviii., and six Text-figures.)

Introduction.

Scævola crassifolia forms a prominent element in the sand-dune flora near Adelaide, where it occurs in association with *Spinifex hirsutus*, with such shrubs as *Olearia axillaris*, *Leucopogon Richei*, etc., and with smaller plants such as *Pelargonium australe*, *Lotus australis*, *Œnothera biennis* (introduced), and *Senecio lautus* (**3**, p.584).

In habit, *S. crassifolia* is a low, spreading shrub, which is able, by lateral growth, to occupy large areas of the dune. Its older woody stems form a dense undergrowth, in which a quantity of blown sand and dried leaves of Posidonia are accumulated, thus helping to build up the dunes. *S. crassifolia* is able to survive burial in sand by an upward elongation of the stem, and by the development of adventitious roots.

Owing to the extreme stickiness of the buds and young leaves, the varnishing or lacquering of the surface of older leaves, the dullness of surface, and the succulence of mature leaves, it was thought that an examination of the leaf-anatomy would prove interesting. The investigation was carried out in the Botanical Laboratory of the University of Adelaide, at the suggestion of Professor Osborn, to whom I am much indebted for his constant help and encouragement.

Summary of Previous Investigations.

Despite its particular interest, the N.O. Goodeniaceæ has received but scant attention at the hands of botanists. As early as 1876, Vesque(**5**) published an account of the anatomy of *Goodenia ovata*, which, however, was restricted to an investigation of the anomalous stem-structure. With this, he compared the stems of *Scævola crassifolia*, *S. Plumieri*, *S. microcarpa*, and *S. spinescens*, but there is no investigation of leaf-anatomy in any of these species.

In the Systematic Anatomy of the Dicotyledons (i., p.471), Solereder gives a brief account of the leaf-structure of the Goodeniaceæ, based upon his own observations of *Goodenia ovata*, *Selliera radicans*, *Scævola Plumieri*, and *Dampiera Brownii*, and upon those of Briquet in the case of *Brunonia*. He records that the stomata may occur upon both surfaces, or upon the lower surface only, and that the number of subsidiary cells, when these are present, is four, two of which are placed parallel to the pore, the other two being applied to the narrow ends of the guard-cells. In form, the leaf is found to be typically bifacial, as exemplified by *Dampiera Brownii*, but is sometimes centric, as in *Scævola Plumieri*. Silicified groups of cells are common, in the formation of which certain epidermal and the adjacent mesophyll-cells take part. As well as the ordinary clothing-hairs, which are characteristic of most members of the Order, peltate, glandular hairs have been observed in *Goodenia ovata* and *Scævola Plumieri*. These are described as being "shortly stalked, peltate glands, the shield of which consists of a few cells separated by radial walls."

The above account is a summary of our present knowledge of leaf-anatomy in the Goodeniaceæ. It is interesting to note that, in none of the plants hitherto investigated, has any copious, epidermal secretion been described. In *S. crassifolia*, however, the buds and young leaves are coated on both surfaces with a thick layer of sticky resin, which is secreted by numerous, stalked, glandular hairs.

The secretion of mucilage or resin, or both together, has long been recognised as a method of bud-protection. Groom(**2**) has given an interesting account of the mucilage- and resin-secreting organs of buds. This work is restricted to those plants which bear "colleters" or "villi" on the stipules. These "colleters," which are almost invariably pear-shaped, multicellular bodies, in which a peripheral palisade-layer secretes the mucilage or resin, are only functional in the bud, and fall off with the stipules. Only in one case—that of *Wormia Burbidgei* (Dilleniaceæ)— does Groom record an instance of the secretion being derived from glandular hairs on the leaves themselves, but, of this, no description is given. Volkens(**6**), however, has described many plants in which the secretion is not only derived from glandular hairs on the leaves themselves, but is also produced for a long period of time, sometimes till maturity of the leaf. It is to Volkens that we owe what knowledge we have of "leaf-lacquering" as a xerophytic adaptation.

In the present investigation, the development of the leaf is traced from the earliest stages to the mature condition, with special reference to the glandular covering in the juvenile state, the function, and fate of its secretion.

Morphology of the Shoot.

A shoot of *Scævola crassifolia* is characterised by the vertical arrangement of the leaves, which is consistent from the leaves in the bud to those farthest away from the growing apex. The leaves are all ovate, more or less toothed, petiolate, the base being closely applied to the stem on its upper side. The leaf-teeth are more marked in the bud and young leaves than in the mature leaves, in which they are often obliterated by secondary increase in thickness. The terminal bud is small, and, during the growing season (August to October, the Spring months about Adelaide) it is hidden by the rapidly expanding young leaves. Later, when this activity ceases, the bud is hidden at the base of the most distal leaf. The leaves in the bud are not folded about one another; they are opposite and vertical, the morphological upper surface of one leaf being closely glued to the upper surface of the next youngest leaf.

The whole growing region of the shoot in *S. crassifolia* is covered with a sticky secretion, which gradually dries up farther away from the stem-apex. As the leaves become expanded from the bud, they increase rapidly in surface-area, and later lose their extreme stickiness. They are, at this stage, characterised by glistening patches of drying secretion, which give them their varnished or lacquered appearance.

The mature leaves are large, thick, and succulent, and present a dull surface. Despite the fact that the secretion tends to dry up on the expanded portion of the older leaves, the leaf-base is always distinctly sticky, even in the mature leaves. In this manner, the axillary buds are covered by secretion.

The young flower-buds are borne in dense, terminal spikes. As is usual in the Goodeniaceæ, the calyx is inconspicuous, and the corolla protects the essential parts of the flower. In *S. crassifolia*, each flower is situated between two bracteoles, and is subtended by a bract, which is glued to the exposed surface of the bud by means of its sticky secretion. The glandular hairs, from which the secretion is derived, are of the same nature as those on the leaves.

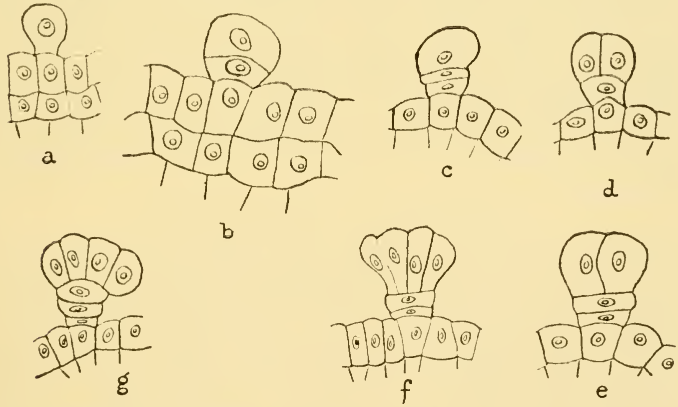
Distribution of the Actively Secreting Glands.

It is in the buds that the glandular hairs reach their maximum development. Upon examination of a section through the apex of a shoot, it will be seen that the rudimentary leaves, even before they are completely differentiated from the stem-apex, are provided with numerous, closely-set, mature, actively secreting, glandular hairs. These hairs are more abundantly developed on those surfaces which are exposed earliest. In the bud, there is a continuous production of glandular hairs, the various stages in development being found mingled with the mature glands. These developmental stages are not restricted to the youngest portions of the bud, nor to any particular part of the leaf, but, as will be seen later, apparently any epidermal cell up to a certain stage in development, may form a gland (Pl. xxvii., fig.1). In this manner, new glands are provided to keep pace with the increase in surface of the leaf, the secretion of which will prevent the sticky coat from being broken at any point.

Once the young leaves are freed from the bud, glandular hairs are no longer formed; upon such leaves only, the mature condition is found. The distance between these glands tends to increase as the leaf-surface increases in area by the differentiation of the leaf-tissues. In the older leaves, the glands lose their activity, except as mentioned above, in that region where the leaf-base clasps the stem. There, the glands remain active throughout the life of the leaf. A section through this region shows an abundant development of glandular hairs of the same nature as those on the young leaves. By the activity of these glands, the axils of the leaves are filled with secretion, and provision is made for the protection of the axillary buds. At the junction of the stem and leaf-base is a circlet of long, multicellular clothing-hairs (Pl. xxvii., fig 2). These were tested for resin and mucilage, with negative result.

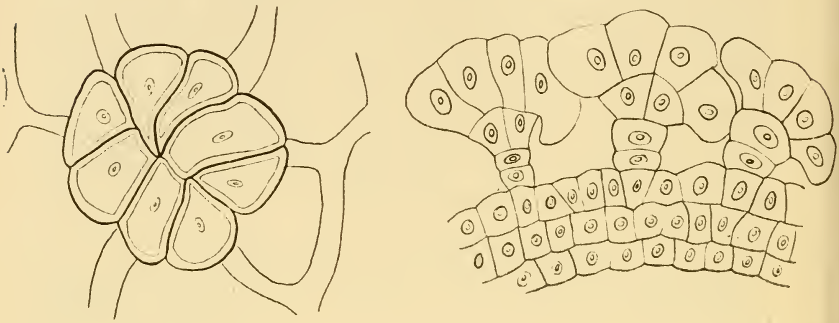
THE DEVELOPMENT OF THE GLANDS.

That the glands are hairs, is evinced in the manner of their origin from a single epidermal cell. Any epidermal cell may form a gland. The cell enlarges, the nucleus divides, and a horizontal wall is formed separating two cells, the uppermost of which becomes considerably enlarged and spherical in outline (Text-fig. 1,*a*). A second, horizontal wall cuts off the rudiment of the stalk at the base of the spherical cell, which latter is destined to become the head-cell of the gland (Text-fig. 1,*b*). At this stage, either a second stalk-cell is formed (Text-fig. 1,*c*), fol-



Text-fig. 1.—Stages (*a-g*) in the development of the glandular hairs; (× 530).

lowed by a median, vertical division in the head-cell (Text-fig. 1, *c*), or the latter division takes place before the formation of the second stalk-cell (Text-fig. 1, *d*). A third stalk-cell is now formed, either preceded or followed by the ultimate divisions in the head-cells (Text-fig. 1, *f*, *g*).



Text-fig. 2: *a*, surface-view of a mature gland; *b*, part of section through young leaf, to show crowding of mature glands, and overlapping of shields; (× 530).

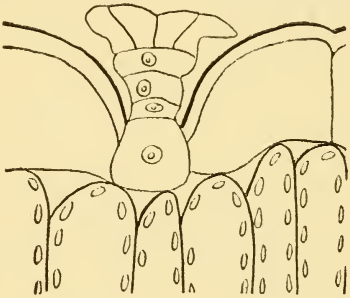
The head of the mature gland forms a shield of eight cells, only four of which are seen in transverse section (Text-fig. 2, *a*). The shield, which is ultimately reflexed at the sides, is borne upon a stalk of three tiers of cells, the two lower tiers being composed each of a single cell, while the upper is composed of two cells, which grow out laterally to support the head-cells (Text-fig. 2, *b*).

THE NATURE OF THE SECRETION.

The secretion, which covers both upper and lower surfaces of the leaf, is a yellowish, translucent, homogeneous substance, which is soluble in alcohol. It is very sticky when fresh, and gives the characteristic red colouration of resin when tested with Alkanna root-extract. A test for mucilage, carried out with corallin-soda, gives a negative result. The secretion reaches its maximum thickness in the bud, every available space between the young leaves being filled up. This fact, which is probably a result of the continuous production of glands in the bud, indicates that the secretion of resin in *S. crassifolia* is primarily concerned with bud-protection.

The secretion is still mobile upon the young leaves outside the bud, but since no new glands are being formed to keep pace with the increase of leaf-surface, it becomes spread out over a greater area and, consequently, more attenuated. The thickness of the film of secretion varies in different parts of the same leaf, in leaves of different age, and in different plants. It often reaches a thickness nearly twice the height of the glands, *i.e.*, about 76μ. (Pl. xxviii., fig.3).

In the older leaves, the glands lose their activity, the secretion becomes less mobile, and, in drying up, cracks along radiating lines. It is at this stage that the leaves present a lacquered appearance. The glands, being no longer functional, cease to grow, whilst the neighbouring epidermal cells enlarge considerably, and, as a result, the glands ultimately appear to be sunken (Text-fig.3). The dried secretion falls off when the leaf reaches its succulent condition, small patches, of negligible quantity, being restricted to the region of the glands.

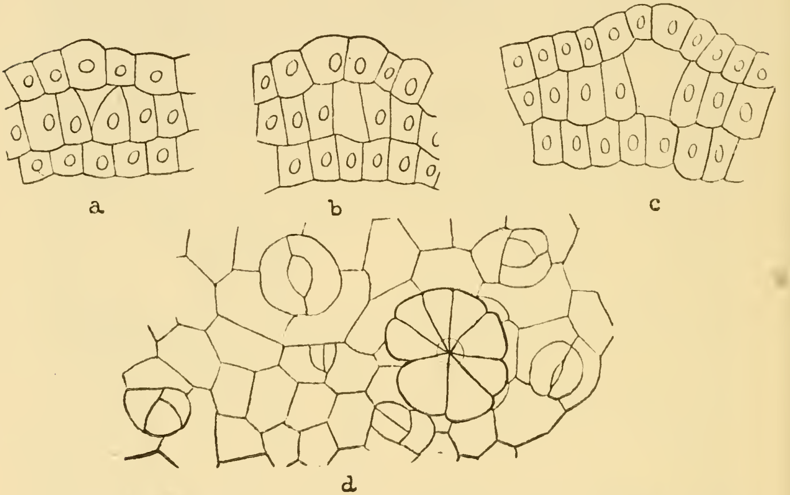


Text-fig.3.—Sunken, glandular hair in a mature leaf; (×530).

The Development of the Stomata.

It is obvious that any stomata which are present on the young leaf coated with its sticky secretion, cannot be functional. In correlation with the rapid growth of the leaf-area, new stomata are continually being formed. Thus, in a section parallel to the surface of a young leaf, all stages in development of the stomata may be studied, as well as a small percentage of stomata which have already reached maturity (Text-fig.4).

Solereder (**4**, Vol. ii., pp.1079-1080), when classifying stomata, refers the Goodeniaceæ to two groups; (1) where there are no subsidiary cells, and (2) where subsidiary cells are formed parallel to the pore. In *S crassifolia* there are no subsidiary cells. A single epidermal cell divides by an oblique wall into two cells of unequal size. The larger of these cells remains an epidermal cell, while the smaller is the mother-cell of the guard-cells. The only further division which takes place is that which forms the two guard-cells. The mature stoma is surrounded by a variable number of epidermal cells (Text.fig.4*d*). The stomata reach their full development when the flow of secretion has ceased. Those which mature first, are rendered functionless, for a time at least, owing to the blocking of their pores with resin. It seems highly probable that many of those stomata, in which a plug of resin is found enclosed in the stomatal aperture, will never function (Pl. xxviii., fig.4). Only those stomata which are belated in development, and are freed before reaching maturity, by the drying-up and cracking of the resin, are entirely unblocked by the secretion.



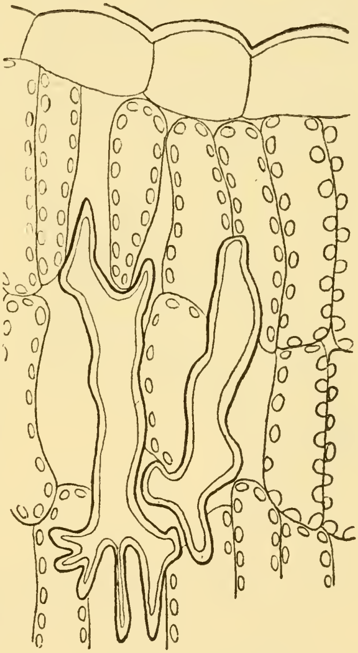
Text-fig.4.—Stages (*a-c*) in the development of the stomata, as seen in transverse section of young leaf: *a*, initial stage, showing mother-cell of the guard-cells; *b-c*, showing development of two guard-cells; no pore is formed; *d*, surface-view of young leaf, showing stages in development of stomata; (× 300).

In those plants with lacquered leaves, which Volkens(**6**) described, such as species of *Brachylæna*, *Baccharis*, *Escallonia*, etc., the stomata are belated in development; and, in a few cases in which the secretion remains active until maturity of the leaf, the stomata become elevated until they project above the surface of the secretion. The mature stoma of *S. crassifolia* remains at the surface-level of the leaf. There is little of interest to remark in the structure of the mature stoma, a small, outer chamber being formed in the usual way, by an overhanging lip of cuticle.

INTERNAL DEVELOPMENT OF THE LEAF.

As in the case of the stomata, the development of the leaf-tissues is belated. In a young leaf just freed from the bud, there is no internal differentiation except that of the vascular system. The leaf, at this stage, is made up of a compact mass of rounded cells, the vascular strands occupying a median position. It is only when the secretion becomes less active, that differentiation of the leaf-tissues takes place.

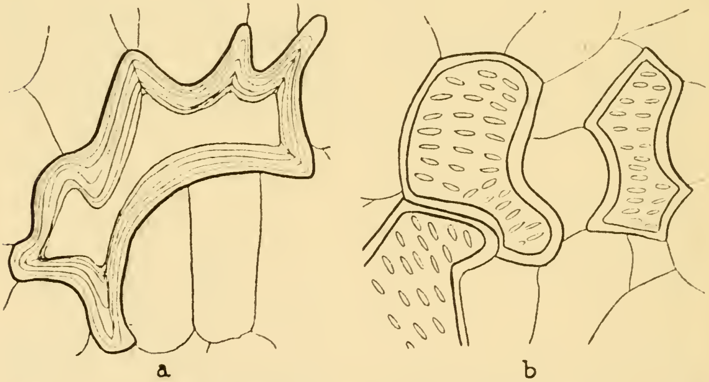
The fully-grown leaf of *S. crassifolia* is very thick and succulent, owing to the development of secondary, water-storage parenchyma. The epidermal cell-walls show a great development of cellulose, but are only moderately cuticularised. There is no spongy mesophyll, the greater part of the leaf being made up of several rows of palisade-cells. A tissue of rounded cells, amongst which are situated the vascular strands, occupies a median position in the leaf, and is bounded on either side by, sometimes, as



Text-fig.5.—Section of mature leaf showing occurrence of branched mucilage-cells in the palisade-tissue; (× 300).

many as five rows of palisade-cells. This central tissue is remarkable in the very old leaves, as its cells become enlarged, lose the greater part or all of their chlorophyll, and take on the function of water-storage. Those cells immediately surrounding the vascular strands are the first to assume the new function (Pl. xxviii., fig.5). From this central, water-storage tissue and from the palisade-tissue, special water-storage organs, such as mucilage-cells and water-storage tracheides are differentiated.

Mucilage-cells.—In the early stages of differentiation, certain cells, particularly in the palisade-region, develop mucilaginous walls. These cells keep pace with the growth in thickness of the leaf by branching in all directions, producing, thus, a peculiar and striking result (Text-fig.5). Text-fig.6*a* shows one of these branched mucilage-cells swollen after treatment with potash, and stained with corallin-soda to show successive deposits of mucilage in the cell-wall.



Text-fig.6: *a*, single mucilage-cell after treatment with potash, and stained with corallin-soda, to show stratification of mucilage; (×230): *b*, a group of water-storage tracheides from the central tissue of the mature leaf; (×400).

Water-storage tracheides.—Restricted to the central tissue are special water-storage tracheides occurring both at the bundle-ends, and in groups, quite independent of the bundles. They are of the type with thickened walls bearing transversely elongated pits (Text-fig.6,*b*).

At the midrib, the tissues of the leaf merge into a compact chlorenchyma of rounded cells. The vascular strands are strengthened on both the upper and lower surface by a bundle of fibres.

Crystals of calcium oxalate are found in the cells of the leaf in very small quantity.

Conclusion.

The secretion of resin by glandular hairs in the bud and young leaves, and the lacquering of older leaves by the ultimate drying-up of this secretion, have been shown by Volkens (**6**) to be peculiar to some xerophytic plants. *Scævola crassifolia*, being a sand-dune plant, may be regarded as a xerophyte.

The chief ecological factors with which a dune-plant has to contend, have been summarised by Cowles (**2**, pp.107-111). They are, (1), intense illumination, both direct and reflected; (2), the great divergence in the temperature-extremes, which is still further increased by the low specific heat of sand; (3), the drying action of the wind, and the injurious effects of wind-blown sand; (4), the porous nature of the sand, and its consequent low water-capacity. The third and fourth of these factors are, perhaps, the most potent. In South Australia, however, the first factor may have some considerable importance, since there are often periods of several days with cloudless sky, while the glare from the sun is still further intensified by the whiteness of the coastal sands.

As we have seen, *S. crassifolia* is able to survive burial in sand by an upward elongation of the shoot, and by the development of adventitious roots. By virtue of their thick, sticky secretion, the buds and young leaves are protected from desiccation, as are also the older leaves, owing to their succulence. A further protection from intense illumination is suggested by the yellow colouration of the secretion. The polished surface of older leaves, caused by the partially dried secretion, also serves to reflect certain rays of light.

The low water-capacity of the sand is compensated, to some extent, by the water-storage tissues of the older leaves.

SUMMARY.

i. *Scævola crassifolia* is characterised by the development of peltate, glandular hairs, which secrete resin in great quantity. These hairs reach their maximum activity in the buds and young leaves.

ii. As the leaves become older, the glands become less active, the secretion loses its mobility, dries-up, and gives the surface of the leaf a lacquered appearance.

iii. The mature leaves of *S. crassifolia* are thick and succulent. The glands are sunken, and no longer functional on the blade of the leaf. They retain their activity only in the region of the leaf-base, protecting the axillary buds. Special xerophilous adaptations are found in :

(*a*). The secondary increase in size of the epidermal cells.

(*b*). The massive development of palisade-tissue.

(*c*). The development of special water-storage cells, such as mucilage-cells, water-storage tracheides, and ordinary, thin-walled, water-storage cells.

EXPLANATION OF PLATES XXVII.-XXVIII.

All figures were made at table-level, with the aid of Zeiss' camera lucida, with mirror at its greatest inclination, and with tube at 160 mm. Leitz objectives 3 and 6, and oculars 2 and 4 were used.

Plate xxvii.

Fig. 1.—A slightly oblique section through a bud, to show development of glandular hairs : *a*, stem-apex; *b*, rudimentary leaf; *c*, leaf-base; *d*, petiole of slightly older leaf; *e*, glandular hair; (× 160).

Fig. 2. —Section across sheathing base of a mature leaf, to show development of glandular and clothing hairs; (× 160).

Plate xxviii.

Fig. 3.—Part of section through young leaf, to show depth of secretion and outline of glandular hairs; (× 530).

Fig. 4,—Section of a lacquered leaf, to show patch of secretion blocking mature stoma; (× 300).

Fig. 5.—Section of a mature leaf : *p*, palisade-tissue; *c*, central water-storage tissue; *m*, mucilage-cell; *t*, water-storage tracheides; (× 100).

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A FOSSIL INSECT-WING FROM THE ROOF OF THE COAL-SEAM IN THE SYDNEY HARBOUR COLLIERY.

By R. J. Tillyard, M.A., D.Sc., F.L.S., F.E.S., Linnean Macleay Fellow of the Society in Zoology.

(One text-figure.)

In the Journal and Proceedings of the Royal Society of New South Wales, Vol. xlv., 1911, p.554, Mr. W. S. Dun records the occurrence of a species of *Tæniopteris* in the roof of the Coal-seam in the Sydney Harbour Colliery at Balmain (Upper Permian). An excellent figure of the actual specimen, reproduced from a photograph, is given in Plate xli., in the same paper. The writer concludes with the following note:—"Associated with the leaf is the impression of an insect's wing, a description of which will be submitted later."

Recently Mr. Dun has very kindly passed this specimen over to me for description, and I desire to thank him for the opportunity of studying it.

The wing lies upon the smooth surface of a very dark, hard shale. Its position is best located by the following note. Measure 18 mm. from the distal preserved end along the mid-rib of the frond of *Tæniopteris*, and, from the point so obtained, erect a perpendicular on the side on which the centre of curvature of the frond lies. The distal end of the insect-wing lies at a distance of 20 mm. along this perpendicular.

The wing can be actually seen in the reproduction mentioned above, but it is so faint in outline that it would not be noticed unless some measurements were given to assist one in locating it. The same may be said to be the case with the actual specimen. Once it has been located, a careful examination with a hand-lens will show the presence of the main veins, and, in certain lights, of cross-veins also. All of these, except only the radius, are exceedingly delicate in outline, so that it is by no means easy to make an accurate drawing of the fossil.

The portion preserved consists of a considerable part (probably about three-fifths) of a slender wing, with the costal margin well marked right up to the apex. The posterior border is missing, except for a short piece lying towards the base of the fossil. The space between the radius and the costal margin is distinctly coloured brownish. This is almost certainly due to the preservation of brown pigment originally located in this area of the wing.

In attempting to place this fossil correctly, I have had to rely upon only two or three important characters, since the base of the wing, which may be presumed to have held the most definite venational structures, is missing. First of all, I have relied upon the absence of the subcostal vein from all the distal portion of the costal space. Secondly, the well-marked radius, evidently very strongly built, has running below and parallel to it a well-developed radial sector, giving off obliquely descending branches at fairly wide intervals. Combining these characters with a third, viz., that the cross-veins are fairly wide apart, regular, and somewhat oblique, we should have little difficulty in making a very close comparison between this fossil and the interesting family *Elcanidæ*, of the Order Orthoptera, from the Mesozoic strata of England and Germany.

Handlirsch defines the *Elcanidæ* as follows* (his text is in German):—This family . . . . . is characterised by the possession of long, typical Locustoid antennæ, well-developed jumping legs, and also, in the female, a long ovipositor. On the other hand, up to the present, no wing has been found with a stridulating organ.

The wing-venation resembles in many respects that of the Acridioidea more than that of the Locustoidea existing to-day.

The forewing is characterised by a costal vein slightly removed from the border, and, therefore, by a precostal area. The subcosta is greatly shortened; the radius is free, and sends branches towards the free anterior border; its sector arises near the base,

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* Die Fossilen Insekten, p.412.

and runs nearly parallel with the main stem towards the tip; it sends a variable large number of branches sharply from below towards the apical border. Media and cubitus strongly reduced, consisting of small branches. Anal field somewhat small, with few veins.

The hindwing is similar to the fore in respect of the structure of the radius, media, and cubitus, but appears to have undergone a vast reduction of the subcosta, and to possess no precostal area. Its anal field is large and fan-like.

Stiff cross-veins divide the wing-areas into quadrilateral cells. Most of the wings are spotted.

It will be seen that, owing to the fragmentary nature of the wing, many of the above characters are not available as tests. On the other hand, the part preserved agrees very closely with the definition. The small portion of the posterior border preserved is of some value to us, since it points to the fossil representing a *forewing*. For, in the hindwing, we should have expected to see, in this position, part of the anal fan which is so conspicuous in this family, but which is evidently absent here.

Handlirsch lists forty species of the family *Elcanidæ* from the Lias, and twelve from the Upper Jurassic. All but one of these are placed in the genus *Elcana* Giebel, the only other genus being *Parelcana* Handl I propose to place the fossil here described in a new genus, *Elcanopsis*, with the characters given below.

Order ORTHOPTERA.

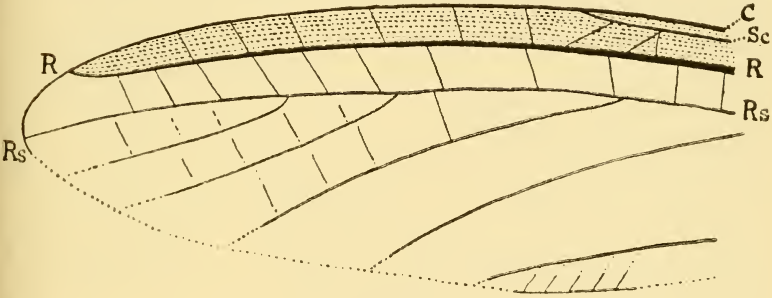
Family ELCANIDÆ.

Genus Elcanopsis, n.g. (Text-fig.1).

Characters of forewing as in *Elcana* Giebel, except the following:—Sc towards its distal end lies very close to C, not nearer to R as in *Elcana*. Wing not spotted, but marked with brown pigment along the costal space. Branches of Rs few in number, and placed fairly wide apart. Cross-veins not very numerous or close together.

Genotype, *Elcanopsis sydneiensis*, n.sp. (Upper Permian : Balmain Colliery, Sydney Harbour).

The occurrence of an Elcanid genus in the Upper Permian is of considerable interest, since the insect-fauna already known from the Upper Permian of Newcastle, New South Wales, contains only types which would be regarded as of Mesozoic age if they had been found in the Northern Hemisphere. It is also interesting to note that the Upper Jurassic members of the family approach, in their venational type, the *Acridiidæ* of the present day, whereas the Liassic species differ more widely from these last, in that the number of branches of the radial sector, and the number of cross veins, is considerably less, and the species are of a smaller size In these characters, the new genus is the most reduced of all; so that the supposition now naturally arises that the modern Acridioid type of venation may have been formed by addition of new elements to what was originally a much simpler and more open type of venation.



Text-fig. 1.

Elcanopsis sydneiensis, n.g. et sp., portion of forewing; (×13·5). Upper Permian Coal-Measures: Balmain Colliery, Sydney Harbour. C, costal border; R, radius; Rs, radial sector; Sc, subcosta; the area covered by the brown pigment is shaded.

ELCANOPSIS SYDNEIENSIS, n.sp. (Text-fig. 1).

Total length of fragment, 7 mm. Greatest breadth, 2·7 mm.

Forewing with the distal end of Sc preserved, and apparently ending up on C at about the middle of the costal border. R very strongly built, very gently curved, the tip slightly turned upwards. Apparently six very poorly preserved cross-veins between R and C, beyond the end of Sc, and two oblique ones between Sc and R basad from these. Nine or ten cross-veins preserved between R and Rs; some of these fairly distinct. Rs a slender but well-preserved vein, parallel to R, and having four descending branches placed somewhat wide apart. The cross-veins between these branches mostly not visible, but indications of them here and there in a good light. A portion of a fairly strong vein is preserved near the posterior border, but this vein cannot be named with certainty. It appears to be connected with the border by means of a series of oblique cross-veins.

Type, in Coll. Geological Survey of New South Wales, Sydney.

Postscript (added June 14th, 1918).—In my paper on the "Permian and Triassic Insects from New South Wales, in the Collection of Mr. John Mitchell," These Proceedings, 1917, xlii., Pt. iv., p.725, I named *Schizoneura* as one of the genera of the fossil flora of the Upper Coal-Measures of the Newcastle District. The name was taken from the list given in Süssmilch's "Geology of New South Wales," on p.135, where also the genus *Tæniopteris* is included. As several geologists have taken exception to the inclusion of this genus in the Permian Flora, I take this opportunity of pointing out that I did *not* state that the genus *Schizoneura* occurred at the horizon of either the Belmont or Newcastle Insect-Beds. I have to thank Mr. W. S. Dun for explaining the exact state of the case to me. It appears that *Schizoneura* is found only at the very top of the Permian Beds, in beds that might well be considered as the passage-beds between the Permian and Triassic, but which should be classed as Permian as long as we define the presence of *Glossopteris* as the criterion by which to separate the Palæozoic from the Mesozoic in Australia. The same is true of *Tæniopteris*, which is associated with the insect-wing described in this paper; it should be noted especially that the species, though unnamed, is certainly *not T. Daintreei* McCoy, (= *T. spatulata* McClelland), which is characteristic of the Jurassic. The horizon of the wing described in this paper is, therefore, some 600 feet vertically above that of the Belmont Insects previously described, and more than 800 feet above that of the Newcastle Insects. Whether, therefore, *Elcanopsis* be considered to be a Permian genus or not, there can be no question that these other insects are such.—R.J.T.

THE PANORPOID COMPLEX.

A Study of the Phylogeny of the Holometabolous Insects, with Special Reference to the Subclasses Panorpoidea and Neuropteroidea. [Introduction].

By R. J. Tillyard, M.A., D.Sc., F.L.S.. F.E.S., Linnean Macleay Fellow of the Society in Zoology.

Introduction.

Section i.—Definition of the Complex.

In his great work upon the Phylogeny of the Orders of Insects. Handlirsch (2) divides the whole of the Holometabola into four Sub-classes, as follows:—

Sub-class.	Orders.
Hymenopteroidea	Hymenoptera.
Coleopteroidea	Coleoptera.
Neuropteroidea	Megaloptera, Raphidioidea, Neuroptera.
Panorpoidea	Panorpatæ, Phryganoidea, Lepidoptera, Diptera, Aphaniptera.

In making this division, Handlirsch widely separates the first two of these Sub-classes from the last two, placing between them not only what we may, for convenience, term the three Amphibiotic Orders (Odonata, Plectoptera, and Perlaria), each of which he elevates to the rank of a Sub-class, but also the Embidaria, which he also considers to be a Sub-class. For the Hymenopteroidea and Coleopteroidea, Handlirsch indicates a descent from a Blattoid type of ancestor. For the Neuropteroidea and Panorpoidea, he is more inclined to a Palæodictyopterous type of ancestor; indeed, he definitely states his belief that the Neuropteroidea are descended directly from the Palæodictyoptera, while he considers the Panorpatæ, and hence the Panorpoidea also, to have been derived from the obscure Megasecoptera of the Upper Carboniferous – an Order which, at the best, can be regarded only as a specialised side-branch of the Palæodictyoptera.

We are thus faced with the fact that, in Handlirsch's opinion, the Holometabola are a composite group of polyphyletic origin. Such a view is, indeed, fairly generally held amongst entomologists; for no satisfactory reason seems to have been brought forward why the evolution of the resting-pupa should not have been accomplished more than once, along several quite distinct lines of ascent.

Having for a very long time carefully read and studied Handlirsch's views, I have to confess that, in spite of many excellent arguments brought forward, there seems to me to be much that is unsatisfactory in them. As examples, I might refer to his discussion of the origin of the Hymenoptera, which fails to convince me in a single point. The same may be said of the suggestion that the Panorpatæ are derived from the Megasecoptera. It seems to me that any unbiassed student of the Phylogeny of the Holometabola must come to the following conclusions :—

(1) That the origin of the Hymenoptera is still about as great a mystery as it well can be; and that Handlirsch's solution of this problem has many inherent defects that make it unacceptable.

(2) That the origin of the Coleoptera from a Blattoid type of ancestor is a fair probability; but that much more research of an intensive character must be carried out before this theory can be either proved or disproved.

(3) That the origin of the Neuropteroidea from Palæodictyopterous ancestors is extremely probable; nevertheless here also any researches that tend to strengthen the argument would be very welcome.

(4) That the origin of the Panorpoidea from the Megasecoptera is not supported by a single piece of evidence worth considering; but that the possibility of the relationship between Neuropteroidea and Panorpoidea being exceedingly close requires reconsideration, and the coincident possibility of the Panorpoidea

having had Palæodictyopterous ancestors also requires careful investigation.

My own researches upon the Neuropteroidea and Panorpoidea, as far as they have gone, have convinced me that these two Subclasses have a great deal in common. They have also revealed the possibility of the Hymenoptera, and even the Coleoptera, having a closer relationship with the Panorpoidea than is generally suspected. Not only do many signs point to the Mecoptera (Panorpatæ) as being a central Order round which all the rest of the Holometabola may be more or less closely grouped, but the Palæontological evidence also points unmistakably in the same direction. For fossil Mecoptera of the genus *Permochorista*, closely allied to the existing Australian genus *Tæniochorista*, have now been proved to exist in the Permian of Newcastle, New South Wales(**6**); whereas no other Holometabolous insects are known from Palæozoic strata at all. Even admitting the incompleteness of the fossil record, we must be immediately struck with the fact that the Mecoptera existed in Permian times in Australia, in a form very similar to that of to-day. This points to the Order having arisen well before Permian times. The earliest known Neuropteroidea are Upper Triassic, the earliest Coleoptera also Upper Triassic, the earliest Trichoptera the same, and the earliest Hymenoptera Upper Jurassic. Even if we grant that it is a reasonable expectation that all these Orders will one day be found to have had representatives in earlier strata, yet the same probability holds for the Mecoptera.

Reviewing the whole case, it seems to me that the time is ripe for a careful study of the whole problem, as far as the evidence will admit, from the point of view of the Mecoptera as the central Order; that is to say, the Order which has preserved, both in its larval, pupal, and imaginal structures, the largest number of archaic characters derived from the original ancestor or ancestors of the Holometabola, whatever they may have been.

It is to suggest this point of view that I have selected as title the somewhat elastic term "The Panorpoid Complex." By this title, I intend to convey that the research entered upon in this paper has, for its main object, the complete working out of the relationships of the Order Mecoptera to those other Orders which stand in closest relationship to it. In accepting Handlirsch's division of the Holometabola into four Sub-classes, it is to be understood that I do so only provisionally, for the convenience of sifting and allocating the evidence that this arrangement naturally offers. And, as it is obvious that the main weight of the argument must centre around those Orders which are clearly most closely associated with the Mecoptera, so it will be clear that the Orders comprising the Panorpoidea must be most fully reviewed. There is, however, a great deal of evidence to be obtained from a study of the Neuropteroidea; and this Sub-class can by no means be denied full consideration in the argument. With respect to the Coleoptera and the Hymenoptera, the evidence to be obtained from them at the present time is comparatively scanty, and has little weight compared with that derived from the other Orders, though it may help to throw some light upon the larger problem of the origin of the Holometabola as a whole. These ideas I have tried to convey in the sub-title selected for this paper.

If, then, we accept provisionally, for clarity of argument, the two Sub-classes Neuropteroidea and Panorpoidea, in the sense that Handlirsch defined them (but with some modifications in the nomenclature of the Orders composing them), we may then proceed to define the "Panorpoid Complex" as *that assemblage of Orders whose ancestral characters can be shown to possess close affinity with the characters preserved to a great measure in the Order Mecoptera*, without in any way binding ourselves to the inclusion of any particular Order in the Complex. The Complex itself is an elastic assemblage of Orders; and any particular Order may be included in it, or removed from it, according as the weight of evidence may determine.

Throughout this paper, I shall use the name Mecoptera for the Panorpatæ of Handlirsch, and Trichoptera for his Phryganoidea. The Raphidioidea I hold to be not sufficiently distinct from the Megaloptera to deserve ordinal rank, since van der Weele's work (**7**) indicates the strong probability of their origin from the more ancient Sialoid stem. Hence I shall merge them into the Order Megaloptera, which will then consist of two Sub-orders, viz , the Sialoidea (aquatic) and the Raphidioidea (terrestrial). The term Neuroptera is now so ambiguous, being still used in present-day writings to indicate so many different and heterogeneous groups of Orders, that I have no hesitation, for the sake of clearness of argument, in substituting the name Planipennia for it, although I do definitely subscribe to the opinion that the name Neuroptera ought by now to be strictly confined to this Order only.

For the purposes of this paper, I shall definitely include my new fossil Order, Protomecoptera, within the Sub-class Panorpoidea, to which it clearly belongs. The type (and so far the only representative) of this Order is *Archipanorpa magnifica* Tillyard, from the Upper Trias of Ipswich, Queensland. Whether this type should constitute a new Order, or only a Sub-order within the Order Mecoptera, it will undoubtedly conduce to clarity of argument if we employ the term Protomecoptera in the sense in which I originally defined it(**5**).

The scheme adopted in this paper may now be exhibited as follows :—

Sub-class PANORPOIDEA :

Orders Protomecoptera (fossil only), Mecoptera, Trichoptera, Lepidoptera, Diptera, and Aphaniptera.

Sub-class NEUROPTEROIDEA :

Orders Megaloptera (including the aquatic Sub-order Sialoidea, and the terrestrial Sub-order Raphidioidea) and Planipennia (= Neuroptera, *s.str.*).

Section ii.—GENERAL PRINCIPLES.

Most of the work that has been done in Entomology upon the Phylogeny of any given Order has naturally been carried out by experts upon the Order in question, with little reference to outside Orders. As an example of this, we may cite Meyrick's numerous works on the Lepidoptera, which, apart from their systematic aims, have also attempted to show the origin of the Order, as a whole, from the Trichoptera. In the whole of this work, Meyrick makes allusion to only one genus (*Rhyacophila*) of the supposedly ancestral Order, and, indeed, suggests, in more than one place, that the whole of the Lepidoptera are descended from this still existing and abundant genus of Caddis-flies. Throughout the work, the characters of the Lepidoptera are subjected to a searching scrutiny and criticism, but the same tests are not applied to the Trichoptera, which are, nevertheless, an equally important factor in the problem[**3**, **4**].

It has, for long, seemed to me that a problem of this kind, attacked in this manner, *i.e.*, by intensive study of the internal differences within the Order in question, without an equally intensive study of the differences existing within the Orders supposedly ancestral to it, could not possibly yield a complete and accurate solution. The alternative, chosen by some few authors in recent years, has been to pass in review the supposedly archaic characters of related Orders, and to attempt to derive from this evidence some idea as to the standing of one Order to another. As an example of this, I need only mention again Handlirsch's famous attempt to give us a complete Phylogeny of the whole of the Orders of Insects, as well as a Phylogeny of the Class Insecta itself(**2**).

It will be at once admitted that this second method is the right one. It has, however, one obvious disadvantage. In order to carry it out successfully, the author should be equally expert upon all the Orders that he reviews. But no man could hope to attain the knowledge in half-a-dozen or more Orders that can be attained in one by a life-study of it. Hence we see that, while the outlook of such an author will be a broader one than that of the expert in one Order only, yet the evidence brought forward cannot all be accepted at the same face-value; and the chances of misinterpretations at vital points is evidently very much greater.

As an example of this, we might contrast the treatment of the Phylogeny of the Lepidoptera by Meyrick on the one hand, and by Handlirsch, on the other. First of all, Meyrick confines himself almost entirely to wing-venation. By an exceedingly full analysis of the different types within the Order, he arrives at the conclusion that the homonomously-winged Jugatæ represent the oldest type, within the Order. Having then discovered, in the living genus *Rhyacophila* of the Order Trichoptera, a venation with apparently all the essential characters of the Jugatæ, he claims that the Jugatæ, and therefore all the Lepidoptera, are to be regarded as having had a Rhyacophilous ancestor.

If the characters considered by Meyrick were the only ones that concerned the question, and if the Orders Trichoptera and Lepidoptera were so isolated from all the other Orders of Insects that there could be no question of affinities in any other direction, Meyrick's solution might be accepted as correct, in spite of its having been based mainly upon the wing-venation only. But this is not the case. As we shall see, the Order Mecoptera has quite equal, if not superior, claims to be regarded as the ancestral type from which the Lepidoptera sprang, while the claims of the Planipennia, in certain directions, may by no means be overlooked. Moreover, no attempt was made to test the claim, which surely can legitimately be made, that the Trichoptera themselves are a by no means unspecialised Order, with almost as much right to being considered an end-term in a Phylogenetic Series as the Lepidoptera themselves.

Many of these objections to the method of procedure adopted by Meyrick are overcome by the method which Handlirsch followed. This author, first of all, considers the relationships of the Trichoptera with the Mecoptera, and concludes that the former are an offshoot of the latter. He then propounds the question as to whether the Lepidoptera are to be legitimately regarded as the derivatives of the Trichoptera themselves, or whether we are compelled to go further back, to the older Mecoptera, in order to indicate their ancestors. His review of this question is, in its way, a masterly exposition of the facts, as far as he knew them; and his conclusion, that the Lepidoptera are not descended from the Trichoptera, but directly from the older Mecoptera, cannot fail to commend itself to all biologists, if the facts that he quotes are really correct.

Here, then, comes in the question which I have already mentioned, viz., the amount of equipment of specialised knowledge of all the Orders taken into consideration, necessary for an author who would decide this problem. Having carefully read through the whole of Handlirsch's work, I was at once struck with his evident lack of specialised knowledge of the two Orders most fundamental to the whole question, viz., the Trichoptera and the Mecoptera. The characters of these two Orders are reviewed very superficially in comparison with those of the Lepidoptera and Diptera; in fact, the whole of their phylogeny is decided within the limits of a single page of print. And, on that one page, I find statements made which, as far as my knowledge of these Orders goes, are incorrect. Such, for example, is the statement on p 1254, that the jugum appears in the Mecoptera as well as in the Lepidoptera, and that on p.1253, that the Mecoptera retain the archaic homonomous wings and archaic mouth-parts. In my studies of the Mecoptera, I have found that none of these statements are justified, and I shall have to deal with them more fully in the part of this paper devoted to that Order.

We are thus faced with the situation of having to choose between the limited outlook, but greater accuracy in detail, of the solution offered us by the specialist in one Order, of whom I take Meyrick as a conspicuous example, since he shows in a most remarkable degree the combination of both these characteristics; and the wider outlook, but occasional inaccuracy in detail, of the solution offered us by the non-specialist, whose aim should be to regard all the Orders coming under his review as equally entitled to careful examination and consideration.

It will be at once obvious, without any further argument, that neither of these alternatives is entirely satisfactory. Before we can deal satisfactorily with the phylogeny of a group of Orders, we must attain, as far as possible, to the specialist's knowledge in every one of them. Such knowledge, in the present advanced state of Entomology, is unattainable within the lifetime of any single man. We must, therefore, ask ourselves, firstly, whether we may legitimately attack a problem of such magnitude, equipped with anything less than the maximum of attainable knowledge on all Orders; and, secondly, whether, if this first question be answered affirmatively, we can indicate with any certainty which portions of that knowledge are essential, and which are not.

Now there will be, in any group of Orders, some which show definite specialisation above the others; as, for instance, the Lepidoptera and Diptera above the Trichoptera and Mecoptera. All entomologists are agreed upon this. Is it more necessary to attain to the specialised knowledge of the lower groups, or of the higher groups? It will be seen that Meyrick was a specialist in the higher of the two Orders which he discussed, while the same is true of Handlirsch, in a more general way, since he, everywhere, shows a far more intimate knowledge of the Lepidoptera and Diptera, but especially of the latter, than he does of the Trichoptera and Mecoptera. Would it not be preferable for the author, who is to attempt a satisfactory solution of this problem, to throw the main weight of his studies on to the side of the more archaic Orders, which, unfortunately for the progress of Entomology, have been so neglected for many years, and to be content to attain to a first-hand knowledge of only the more archaic types within the more highly specialised Orders?

I believe that this question must be answered in the affirmative, for some very good reasons. Firstly, the knowledge of the more archaic Orders is the only sure foundation upon which the Phylogeny of the higher Orders can be built. Any attempt without this knowledge is merely building up a house without laying secure foundations. Secondly, the connections sought for in the tracking out of the ancestry of the higher Orders must be those between some members (either existing or extinct) of the more archaic Orders and the *least specialised families* of the higher Orders. Thirdly, if at any time the problem transcends the attainable bounds of knowledge of the investigator who has adopted the course here advocated, he can always call in the advice of the specialist, who possesses just that very type of knowledge, in his own group, which would render the Phylogenist's task too overwhelming for him, on the principle of "not being able to see the wood for the trees." And, finally, there are already, in Entomology, specialists enough in all the higher

Orders; so that the chance of being brought to a full-stop, because nobody in the world can supply the gap required, is so unlikely a possibility that it may be dismissed without further thought.

That being so, I decided that the investigation into the Phylogeny of the Panorpoid Complex was a task that I might venture to undertake, and that its difficulty and immensity would be more than compensated for by the advantage to Entomology in general, if a satisfactory solution could be found. Having, then, decided to confine myself to researches within the limits indicated in the previous paragraph, I have carried out an exhaustive survey of the older Orders under review, viz., the Planipennia, Megaloptera, Mecoptera, and Trichoptera, and have been content to study, in the immense Orders Diptera and Lepidoptera, mainly the older families only. The survey has been extended far enough to give me some idea of the position and inter-relationships of all the important families of each of these Orders; but intensive study has been chiefly confined to the older families, together with other more specialised types in which I thought I could recognise characters of value as evidence on the question at issue. Further, it will be at once evident that the equipment of the author who attempts to solve this immense problem will not be complete unless he masters what there is to know about the Fossil Record of the Orders in question, and of their possible ancestral Orders. This also I have endeavoured to do. The fortunate circumstance of my having in my hands a large amount of new and unique material of this kind from the Permian and Triassic strata of Eastern Australia has been one of the chief factors in my decision to undertake this task; indeed, it has almost imposed the obligation upon me, since nobody who has not studied these fossils could possibly be so favourably placed for discussing this question as I happen to be, simply through this great good fortune.

It will, I think, be readily granted that the *Order* is the only satisfactory unit upon which a study of this kind can be based. We have, therefore, to consider what view of an Order we must take, in dealing with it as a separate unit in a paper such as this.

Now there are, in any given Order, many diverse groups. Some of these will exhibit very high specialisations in one or more directions; others will show unexpected archaisms, which may make it exceedingly awkward to frame a comprehensive definition of the Order. As an example of this, we may take the evolution of the mouth-parts within the Order Lepidoptera. In the great majority of the families within this Order, the mandibles are absent, the maxillary palps absent, the galeæ produced into a long sucking-tube or haustellum, and the labial palps present and more or less highly specialised. But, in the *Micropterygidæ*, the mandibles are present, as are also the typical maxillæ of older Holometabolous Orders, with five-jointed palpi, and unspecialised galeæ and laciniæ There is, therefore, no reason, from the Phylogenetic view-point, why we should not consider the Lepidoptera as, *at bottom*, essentially a mandibulate Order, when we come to discuss its relationship with the other Orders of the Panorpoid Complex.

It must, therefore, be evident that, for the purposes of this paper, the usual definitions of Orders to be found in text-books not only will *not* serve our purpose, but may actually be misleading. I propose to overcome this difficulty by the use of Archetypes (German, *Ur-typus*). For each Order that comes under review, we must define an archetype, which shall include in itself all the most archaic characters found within the Order. Having done this, we may reasonably discuss the relationships of the archetypes of the various Orders, with some prospect of a successful issue.

In following out this line of argument, we can lay down two guiding principles:—

(1) The Phylogeny must not be determined from one set of characters only (*e.g.*, wing-venation), however important that set of characters may be. But it must be determined by a review of as many characters as possible.

(2) The greatest care must be exercised in the determination of the characters of the Archetype. For instance, in the case of the jugum and frenulum in Lepidoptera, it is not sufficient to adopt the jugum as the more archaic character, merely because

it is found in those Lepidoptera which have the most archaic wing-venation. If a mistake is made here, the whole Phylogeny is bound to go wrong. As a corollary, it should follow that characters in which the evidence of archaism or specialisation may be uncertain, with a division of opinion upon the point amongst those entomologists who have studied it, must be either definitely cleared up by means of new evidence, or they must be entirely omitted from the argument.

The Determination of Archetypes.

We may exhibit this principle as follows :—

Let a, b, c, d, ... etc., represent a series of characters which are constant throughout the Order in question.

Let p, q, r, s, ... etc., represent a further series of characters which are not constant throughout the Order, but show definite lines of evolutionary advance in one or more directions.

Taking any one of these characters p, after examination of its structure in various families, let P represent the most archaic condition, while p', p'', etc., represent various specialised conditions of the same.

Any family within the Order can now be defined by the characters

$$a, b, c, d, \text{etc.}, \ldots\ldots p, q, r, s, \ldots\ldots \text{etc.},$$

where p can have any of the values P, p', p'', etc., q any of the values Q, q', q'', etc., and so on.

For instance, one family may be defined by

$$a, b, c, d, \ldots\ldots p', q'', R, s''', \ldots\ldots$$

The Archetype of the Order, which may or may not still be existing (the greater the number of characters taken, the less likely is it to be still existing) will be defined by

$$a, b, c, d, \ldots\ldots P, Q, R, S, \ldots\ldots$$

The Determination of the Phylogeny of separate Orders.

The same principle as above may be followed in this case, *provided we take the characters of the Archetype as the characters of the Order it represents*, for the purposes of the Phylogeny.

In this case, the characters a, b, c, d, ... etc., which were constants throughout any single Order, will now be variables for the different Archetypes; also P, Q, R, S, ... not having the same values for different Orders, we may omit these letters, and consider that the whole series of characters is comprised in a single (longer) series of variables a, b, c, d, e, f, ... etc. Taking a group of Orders, we may now represent the most archaic value of the character a by A, while a', a'', etc., represent various specialised conditions of the same. Then we shall be able to write the Archetypes of different Orders in this way

Archetype of Order 1:—A, b'', C, d', e', F, g'' . . . (say).
Archetype of Order 2:—a', b', C, d'', E, f''', G . . . (say).
Archetype of Order 3:—A, B, c', D, e'', f', g' . . . (say); and so on.

The condition that any one Order may be *ancestral* to another can now be determined by comparing the Archetype of the supposedly higher Order with any supposedly ancestral group lying within the bounds of the Lower Order. But, as the characters of the Archetype of the supposedly ancestral Order are even more archaic than those of the supposedly ancestral group lying within that Order, the determination may be made, once for all, by comparing the Archetypes of the two Orders. The following rule may be laid down:—

The condition that one Order may be truly considered ancestral to another, is that *there must not exist a single character in the Archetype of the former, which is more highly specialised than the corresponding character in that of the latter.*

For example, consider the case of Orders 1 and 3 above. The character A is common to both Archetypes. For the character b, the Archetype of Order 3 is the older (B against b''). But for the character c, the Archetype of Order 1 is the older (C against c'). Hence, clearly, neither of these two Orders can be considered as ancestral to the other; and we must go back, for their common ancestor, to an Order (probably no longer existing) whose Archetype shows the characters A, B, C, ...

The Recognition of Embryonic Structures.

It would seem necessary here to call attention to the fact, which seems to have been quite ignored by most of those entomologists who have not studied other Classes of Animals, that it is not necessary to be able to trace back a structure to the embryo without a break, in order to prove that it is derived from an embryonic structure. Particularly does this apply to appendages within the Phylum Arthropoda. Examples of this are the well-known observations on the re-development of limbs from latent embryonic rudiments in Crustacea, *e.g.*, the mandibular palp in Decapod larvæ, and the maxillipedes of the Stomatopoda. In fact, the rudiments may appear in the embryo, disappear later on, and then reappear again in the imago, as in the case of the thoracic legs of the genus *Chalicodoma* and other genera in the Order Hymenoptera.

Thus we see that it is *not* sufficient proof that a structure is not derived from an embryonic rudiment to show that it does not develop directly from that rudiment; whereas, it *is*, most certainly, quite sufficient proof that it is so derived, if we can trace it up from the embryo, through the larva and pupa, without a break, to the imago (or, if the structure in question is only a larval one, then it need only be traced from the embryo to the larva).

We may take, as an example of this, Lubbock's observation upon the development of the lateral gills in *Chloëon*, which, he proved, did not begin to develop until the third instar of the larva. Many entomologists have used this as proof that these gills cannot be homologous with the original segmental abdominal appendages, which are represented in the embryo, and then disappear. This argument is quite fallacious, and must be carefully avoided, since it is a frequent temptation to use it. Further, there is another potential fallacy in this kind of argument. *Chloëon* is a highly specialised member of the Order Plectoptera. May it not be quite possible that the break between the embryonic appendages and the formation of the gills, which is so conspicuous in this genus, may be very much reduced, if not completely removed, in the case of the development of the larva of some much more archaic type, such as *Oniscigaster*, not yet studied ?

Meyrick's Law.

In 1893, Comstock (**1**) gave the name "Meyrick's Law" to the following statement, which was first enunciated by Meyrick in 1884:—"When an organ has wholly disappeared in a genus, other genera which originate as offshoots from this genus cannot regain the organ, although they might develop a substitute for it."

Stated in this manner, this law may be accepted, provided it is clearly understood what its limitations are. These may be stated as follows:—

(1) It must be capable of proof that the organ in question has *wholly* disappeared from the assumed ancestral genus. For instance, a concealed rudiment of an organ may reappear, after a more or less lengthy period of suppression during the course of evolution of the group. It will be clear that this fact alone must make the application of the law exceedingly problematical, except in the case of very simple and easily examined structures or organs.

(2) Great care must be exercised in determining what is to be regarded as a *substitute* for an organ, as contrasted with an actual redevelopment of the original organ from a concealed rudiment.

(3) The converse of the law is not necessarily true; *i.e.*, if a genus B shows the loss of certain organs in comparison with another genus A, we are not entitled to state, without further evidence, that B is descended from A; we may only state that A is more archaic than B in respect of the characters in question.

How little the importance of the safeguards in the original statement of this law has been regarded may be gathered from Meyrick's own later work. In 1895(**3**), we find him enunciating three "laws" as his guiding principles in the determination of the Phylogeny of the Lepidoptera. These are stated as follows:—

"(1) *No new organ can be produced except as a modification of some previously existing structure.*"

"(2) *A lost organ cannot be regained.*"

"(3) *A rudimentary organ is rarely redeveloped.*" (p.10).

Of these, No.2 is Meyrick's Law restated without its original safeguards. This, taken in conjunction with the other two, forms a very generalised statement covering a very much wider field than the original one, and open to far graver objections. As regards Law No.1, this can only be accepted as true in its very widest sense, *i.e.*, that there must be pre-existing living material, or cells, as a basis from which any new structure is to be developed; and, in that sense, it ceases to have any value, and becomes a truism. With respect to Law No.2, this ceases to be true when the restrictions contained in the original statement of the law are removed. To mention only one obvious example. The thoracic legs of certain Hymenoptera (e.g., *Chalicodoma*) appear in the embryo; they then disappear throughout larval life, but reappear again in their complete form in the imago. Thus, in this case, as in many others, "a lost organ *is* regained"; and a bald statement to the contrary is not only not a law, but it is not true. Moreover, it may not be argued that the law is true when applied to Phylogenetic problems only, and not to Ontogeny. For, if there is any truth in the Biogenetic Law at all, it is certain that what occurs in Ontogeny is of the same nature, and governed by many of the same laws, as what occurs in Phylogeny; and if we frequently find that lost organs *are* regained in the course of Ontogeny, then it follows that we may by no means assert that the same possibility cannot hold for Phylogeny. With respect to Law No.3, it is only necessary to remark that there is probably no Phylum in which rudimentary organs are so often redeveloped as in the Arthropoda, and that this is particularly true of appendages.

It would seem much wiser to do without any attempt to formulate laws (so-called) for the solving of Phylogenetic problems, and to treat each case, as it presents itself, upon its own merits. In most cases, for instance, it is quite capable of definite proof that, in a given phyletic series, an organ originally present has been lost, and never regained in any of the descendant genera. In other cases, not so numerous it is true, it is capable of proof, by reference to palæontological evidence, that lost organs have been regained, or, perhaps, that organs which, on the strict application of Law No.2, would have to be regarded as originally present and subsequently lost, are really new developments not present in the ancestral form. In such cases, a rigid application of the law would result in a complete inversion of the phylogenetic conclusion.

Meyrick himself applied his law chiefly to the problem of wing-venation in the Lepidoptera. In a case like this, where almost the whole course of evolution is towards reduction and simplification, there is not much danger in its use. Yet even here caution is necessary. It is not true, for instance, that veins which have once been lost cannot be re-developed; nor is it true that new cross-veins cannot be formed in a wing-area in which no such structures existed in the ancestral form. One has only to examine the tracheation of the pupal wing in the Lepidoptera to see that there is an immense field of possibilities in both these directions, owing to the persistence of the finer tracheæ, ramifying in all directions beneath the wing-membrane. As long as these tracheæ persist, so long must the possibility of an imaginal venational meshwork reappearing be held to exist. Moreover, in a case in which the wing is changing its shape, so that a certain part of it may become broadened, it is exceedingly likely that one or more of the tracheæ underlying the veinlets of this area will become lengthened and strengthened, so that it may eventually lead to the replacement of an original short veinlet by a longer oblique branch, which, on Meyrick's interpretation, would have to be regarded as an original archaic branch of the main vein from which it springs. One of the best examples of this is the effect of the widening of the costal area in the *Psychopsidæ*, in which an originally fairly simple series of veinlets has become greatly lengthened and enlarged, most of its units branching many times; and all of them connected together by newly developed series of cross-veins, which were certainly not present in the ancestral form.

The above example shows us that, even in so restricted a study as that of Wing-Venation, Meyrick's Law can only be used with great caution. It must be restricted to *areas of the wing that are undergoing reduction.* In the present state of evolution of the Insect-Wing, it is certainly true that the tendency is towards reduction in the great majority of cases. But this cannot always have been the case. Bearing in mind the complex nature of the wing-venation in the most archaic types of insects, we are bound to conclude that, at the beginning of the evolution of the wing, there must have been a period of great enlargement, with a rapid and abundant production of veins in all parts (following upon the rapid increase in the tracheation of the developing organ). After this had reached its maximum, there began a period of arrangement and reduction, during which the very beautiful and perfect wing-types at present existing were evolved. We may term the process by which any part of a wing becomes broadened, with consequent production of further venation in that area, Platygenesis (Gr. πλατύς, broad); while the opposite process, in which the wing-area in question becomes reduced or narrowed, with consequent reduction or elimination of some of its existing venation, may be termed Stenogenesis (Gr. στενός, narrow). The development of the costal space in the *Psychopsidæ*, of the enlarged anal area of the hindwing in Anisopterid Odonata, and of the wide *anal fan* in the Orthoptera, Perlaria, and other insects, are good examples of Platygenesis; while the process of Stenogenesis can be followed out very fully in such an evolutionary series as the Diptera Nemocera.

Scheme of the Work.

We have already stated that phylogenetic conclusions, to be acceptable, must be based upon an examination of as many characters as possible. In undertaking an analysis of a large number of characters, two methods of procedure are possible. We may either select each Order in turn and study its characteristics fully, with a view to the determination of its Archetype; or we may select any given set of characters, as, for instance, those offered by the Wing-venation, and study them as they are exhibited throughout the whole of the Orders under discussion; proceeding to deal with other sets of characters in subsequent parts of the work.

This second method must obviously be the one chosen, for only by it can the necessary comparisons be made between the same sets of characters in different Orders. Thus we have to postpone the definition of Archetypes until the whole of the characters selected have been surveyed; and the final decision as to the phylogenetic relationships of the various Orders will not become fully apparent until the work is completed. Meanwhile, it seems advisable to select the characters for study in such a way that the work can be subdivided up into a series of parts, each complete in itself, and suitable for separate publication. Working on these lines, we may conveniently begin with those characters which have been most used in phylogenetic discussions, and proceed to deal with the rest in a definite order. Thus we shall at first confine our attention to a study of the Wings alone, and these will occupy two or more parts of the work. Next to these, we shall take the Mouth-parts. Subsequent parts will deal with other imaginal structures; and, lastly, the structure of the larva and pupa will be reviewed. As regards the structure of the egg, and the Embryology, it is to be regretted that so little is known about the latter in the case of the more archaic Orders. As our knowledge stands at present, the evidence available on this point, for the purposes of this paper, is so incomplete, that it can have little bearing upon the main result.

The investigations into this problem were actually begun about two years ago, and are still going on. I feel that I can safely leave the completion of the more specialised parts of the work to a later date; because, if I waited until they were all finished, the main conclusions of this work would not, perhaps, see the light of publicity for some years. The results already attained are, to my mind, of such importance that I have no hesitation in placing them in the hands of the scientific public, and their value will not be lessened by delay in the completion of the whole fabric of my work.

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6. ————. 1918.—"Permian and Triassic Insects from New South Wales in the Collection of Mr. John Mitchell." *l.c.*, 1917, xlii., Pt. iv., pp. 720-756.

7. Weele, H. W. van der, 1910.—Megaloptera, in Coll. de Selys, Fasc. v. Brussels, 1910.

Note.—A bibliography will be supplied for each part, with the reference numbers running consecutively; but those papers which are not referred to in any given part will be omitted from the bibliography for that part.

ORDINARY MONTHLY MEETING.

June 26th, 1918.

Professor H. G. Chapman, M.D., B.S., President, in the Chair.

A letter from Dr. T. Griffith Taylor, Melbourne, returning thanks for congratulations on the award to him of the David Syme Prize for 1918, was communicated to the Meeting.

The President communicated some news of Lieutenant Goldfinch, a Soldier-Member in hospital in England, forwarded by Dr. A. J. Turner. It was resolved that a friendly message of sympathy should be sent.

The Donations and Exchanges received since the previous Monthly Meeting (29th May, 1918), amounting to 42 Parts or Nos., 8 Bulletins, 3 Reports, and 12 Pamphlets, received from 39 Societies, Institutions, etc., were laid upon the table.

THE PANORPOID COMPLEX.

Part i.—The Wing-coupling Apparatus, with special reference to the Lepidoptera.

By R. J. Tillyard, M.A., D.Sc., F.L.S., F.E.S., Linnean Macleay Fellow of the Society in Zoology.

(Plates xxix.-xxx., and sixteen Text-figures.)

There can be little doubt that, in the original Pterygote Insects, fore- and hindwings were independent in flight, and the muscles controlling them were innervated from two separate sources, viz., the ganglia of the meso- and metathorax respectively. Coincidence of action or beat, then, between fore- and hindwings, without which flight would scarcely have become possible, must have been maintained through coordination of the two sets of nervous impulses sent out from these two ganglia.

Now, in those Orders in which the wings were more or less hairy, the development of a fringe round the border of the wing would undoubtedly increase the sense of touch in these organs; since the macrotrichia, or larger setæ of the wing, are of the type known as *sensillæ*, and were evidently developed at first as tactile organs. Hence it came about that, in the course of evolution, a further coordination was able to be established between the posterior portion of the base of the forewing and the anterior portion of the base of the hind.* Such coordination did not, at first, take the form of a definite linking-up of the two wings, but

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* It should be borne in mind that the structures here to be discussed were originally present on *both* wings; *e.g.*, frenular bristles occur at base of *forewings* of certain Mecoptera, as well as of hindwings; and a jugal lobe is present at bases of *both* wings in certain Trichoptera and in *Micropterygidæ*. But it is only on the *posterior* border of the forewing and the *anterior* border of the hind that they can come into contact, and so develop into a coupling-apparatus.

consisted merely in the greater development of the sensillæ of this region of the two wings, their contact acting as a guide in flight, much as the reins act in the driving of a horse, or the touch of the hand of one person in guiding another in the dark.

To these structures, whether they act merely as a *guide*, or whether they are more fully developed so as to *link* the two wings quite closely together, I propose to give the name "Wing-coupling Apparatus," which I have already used in dealing with the Planipennia(**12**).

The complete, archaic wing-coupling apparatus consists of four distinct parts, two belonging to the forewing, and two to the hind. These are:—

In the forewing

(1) The area of contact with the hindwing or its bristles.

(2) The bristles developed along the border of that area.

In the hindwing

(3) The area of contact with the forewing or its bristles.

(4) The bristles developed along the border of that area.

In the case under discussion, *i.e.*, when the two areas of contact are located at the bases of the wings, we may name the parts as follows:—

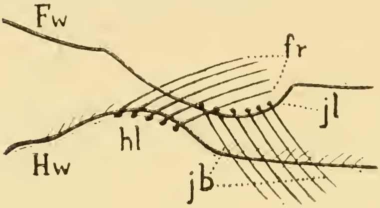
(1) The area of contact of the forewing with the hind, in so far as it projects beyond the general contour of the posterior border, may conveniently be termed the *jugal lobe*, a term I have already employed in the paper mentioned above(**12**). A specialised form of this area, in which it becomes an elongated, narrow process passing *below* the costa of the hindwing, is termed the *jugum*, this being the term first applied to such a process by Comstock in the Lepidoptera(**1**).

(2) The bristles projecting from this area towards the hindwing may be called the *jugal bristles*.

(3) The area of contact of the hindwing with the fore, in so far as it projects beyond the general contour of the anterior or costal border, may be termed the *humeral lobe*. I had previously employed the term *jugal process* for this area in the Planipennia (**12**). But I now consider that this term is open to objection; as

it would certainly conduce to clearness, if the adjective *jugal* were to be employed only in connection with the forewing. As authors who have written upon the Lepidoptera have generally alluded to this part of the hindwing as the *shoulder* or *humerus* (a somewhat too general term), there can be little objection in replacing it by the term here proposed.

(4) The bristles projecting from this area towards the forewing may be called the *frenulum*. This term is already in general use in the Lepidoptera, and should now be adopted for the homologous structures in other Orders.



Text-fig. 1.*

The relationships of these four parts to one another, in an ideal archaic coupling-apparatus, may be seen from Text-fig. 1, it being understood that, owing to the slightly higher level of the forewing, the frenulum passes *beneath* the jugal lobe, but the jugal bristles lie *above* the costa of the hindwing.

We may now profitably study the formation of the coupling-apparatus in the wings of the different Orders comprising the Panorpoid Complex. From this discussion, we are compelled to omit the Protomecoptera (in which the bases of the wings have so far not been discovered in the fossils known), and the Aphaniptera, in which the wings have been lost.

Order MECOPTERA. (Text-figs. 2-4).

This is the only Order extant in which all four parts of the ideal coupling-apparatus can still be recognised. In Text-fig. 2, I have figured the coupling-apparatus from the wings of two very archaic families, found only in Australia. In the family *Choristidæ* (Text-fig. 2*a*), there is a slightly projecting, but quite

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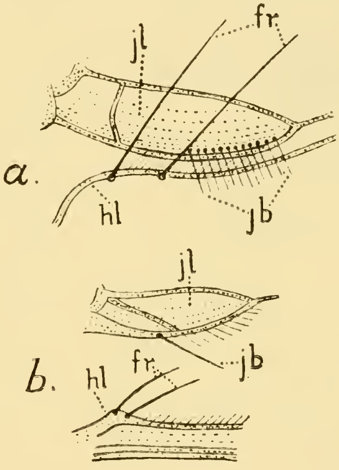
[*] Ideal archaic wing-coupling apparatus at bases of wings: *fr*, frenulum; *Fw*, forewing; *hl*, humeral lobe; *Hw*, hindwing; *jb*, jugal bristles; *jl*, jugal lobe. (Jugal bristles rest above costa of hindwing, but frenular bristles pass beneath jugal lobe of forewing).

definite, *jugal lobe* (*jl*), from the more distal portion of which arises a set of about a dozen small, but stiff and closely set, *jugal bristles* (*jb*), which make contact with the costa of the hindwing in flight. In the hindwing, there is a small but quite definite *humeral lobe* (*hl*), from which spring the two enormous bristles of the *frenulum* (*fr*). These latter, during flight, pass under—and, indeed, quite beyond the interior border of—the jugal lobe of the forewing. The whole apparatus is eminently suitable for maintaining contact between the two wings in flight, without in any way linking the hindwing *firmly* to the fore.

In the wings of the family *Nannochoristidæ* (Text-fig.*2b*), which are specialised by reduction, we meet with much the same structures. But in this case there is a single, strong, jugal bristle on the forewing, instead of a set of weaker bristles. The flight of these insects is the strongest of any in the Order, and the wings are closely linked together. The linking is accomplished by the two sets of bristles. The frenulum passes *under* the jugal lobe, while the jugal bristle passes above the bases of the frenular bristles, and presses down upon the costal area of the hindwing, thus forming a very neat and perfect coupling-apparatus.



Text-fig.2.[*]

In the archaic *Meropidæ*(Text-fig.3), there is a peculiar specialisation not found anywhere else, to my knowledge, within the Insecta. The jugal lobe bears a very distinct, black tubercle, projecting from its border. This tubercle appears to have been

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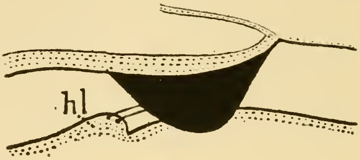
[*] Wing-coupling apparatus in Mecoptera. *a*, In *Tæniochorista pallida* E.-P., wings connected, viewed from beneath. *b*, In *Nannochorista dipteroides* Till., wings disconnected. (Both × 83). Lettering as in Text-fig.1.

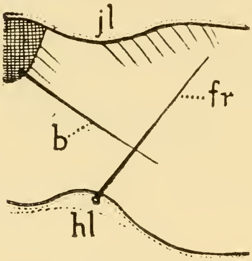
formed by fusion of an original set of jugal bristles, as seen in *Chorista*. A frenulum is also present, but reduced in size.

In all other representatives of this Order, the jugal bristles appear to be either absent or very weakly formed; and the whole coupling-apparatus shows a gradual reduction from disuse, probably owing to a progressive weakening in the flight of these somewhat lazy insects.



Text-fig.3.[*]

The culmination of this tendency is to be seen in the highly specialised *Bittacidæ*, in which fore- and hindwings have again returned to complete independence in flight, the wings becoming greatly narrowed and elongated, with petiolation of their bases. The coupling-apparatus is here only represented by a vestige of the humeral lobe, from which projects a single frenular bristle, which crosses a similar bristle developed from the extreme base of the forewing (Text-fig.4).



Text-fig.4.[†]

Reviewing the above evidence, it is clear that the Archetype of the Order Mecoptera must have had the complete archaic coupling-apparatus fully developed, very much as it still exists in the ancient *Choristidæ* to-day.

Order PLANIPENNIA. (Text-fig.5).

In this Order, the coupling-apparatus is again best developed in the more archaic families, notably in the *Hemerobiidæ* (Text-fig.5). Jugal bristles are absent; but the frenulum is represented either by one or two strong bristles (*fr*). These bristles

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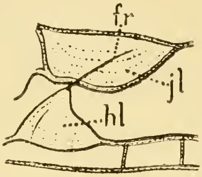
[*] Wing-coupling apparatus in *Merope tuber* Newm., viewed from above, showing the large, black tubercle at base of forewing: *hl*, humeral lobe; (× 40).

[†] Reduced wing-coupling apparatus in *Harpobittacus tillyardi* E.-P: *b*, bristle developed from extreme base of forewing; other lettering as in Text-fig.1; (× 40).

project from the apex of a very strongly developed humeral lobe (*hl*). During flight, this latter lobe, together with its frenulum, passes under the jugal lobe of the forewing, which is hollowed out beneath for its reception.

The same type of coupling-apparatus is to be found in all the other families, but it is generally much reduced in size, and does not appear to be functional. The tendency in the evolution of this Order has been to combine a progressive narrowing of the wings with a gradual return to complete independence of fore- and hindwing in flight. In the highest families, *Myrmeleontidæ* and *Ascalaphidæ*, the bases of the wings become shortly petiolate, and the original coupling-apparatus can only be made out as an extremely reduced remnant at the very bases of the wings.



Text-fig.5.*

For this Order, then, we must assume an Archetype in which the archaic coupling-apparatus was complete in all except one particular, viz., that the jugal bristles were absent.

Order MEGALOPTERA. (Text-figs.6-7).

Throughout this Order, the hairy vestiture of the wings, both macro- and microtrichia, has been very much reduced. The most archaic type of coupling-apparatus known to me within the Order is to be found in a genus not yet described, but allied both to the *Corydalidæ* and the *Sialidæ*. This possesses both jugal and humeral lobes, of small size, the latter with a few small hairs, the remnants of the frenulum. In *Sialis*, the two lobes are present, but apparently hairless.

In the *Corydalidæ* (Text-fig.6), as exemplified by *Archichauliodes*, the only genus that I have been able to study, the humeral lobe is much reduced, but the jugal lobe becomes a definite angular projection (*jl*) which presses down upon the costa of the hindwing. Further, the forewing overlaps the hind for a con-

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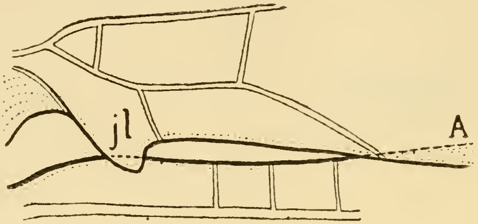
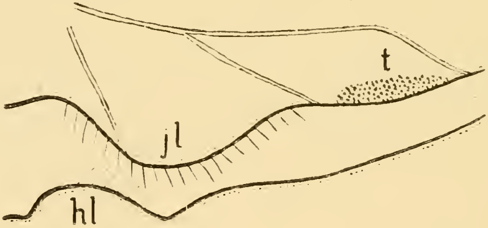
* Wing-coupling apparatus in *Drepanacra humilis* McL., viewed from beneath; (× 24). Lettering as in Text-fig.1.

siderable distance beyond the base; and, by pressing down upon it, serves to increase the strength of the coupling in this rather powerfully-flying insect. This latter type of wing-coupling, which occurs also in many Trichoptera, and in some of the most highly specialised Lepidoptera, I propose to term *amplexiform* (Lat. *amplexus*, an embrace). It is always correlated with the disappearance of the frenulum.



Text-fig. 6.

Wing-coupling apparatus in *Archichauliodes guttiferus* Walk., viewed from above; (× 12). *A*, beginning of amplexiform overfold; *jl*, jugal lobe.



Text-fig. 7.

Reduced wing-coupling apparatus in *Raphidia maculicollis* Steph.; (× 40): *hl*, humeral lobe; *jl*, jugal lobe; *t*, roughened tubercular patch.

In the highest family of the Order, the terrestrial *Raphidiidae*, both jugal and humeral lobes are present, but without bristles. There is, however, a very peculiar patch of roughened tubercles, situated on the posterior margin of the forewing, just beyond the jugal lobe (Text-fig. 7, *t*). This may possibly help in maintaining contact between the wings in flight.

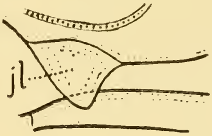
From the above evidence, we must presume that the Archetype of the Megaloptera possessed a somewhat reduced coupling-apparatus, in which the two lobes were present, the jugal bristles absent, and the frenular bristles probably quite vestigial.

Order TRICHOPTERA. (Text-figs.8-9).

In this Order, the original wing-coupling apparatus undergoes some remarkable developments, which have attracted very little notice from entomologists, so far. In all the oldest families, one can only recognise the jugal lobe, which is the *anal lobe* of systematists in this Order. This appears as a strongly projecting lobe at the base of the forewing, in such genera as *Rhyacophila* (Text-fig.8, *jl*). There are neither jugal bristles nor frenulum; and the humeral lobe is suppressed, or else only slightly developed.

In no case does this jugal lobe pass under the hindwing during flight; it merely rests upon the costa from above.

In the great majority of genera, the jugal lobe is absent or vestigial, and new elements of wing-coupling have made their appearance. This new type of wing-coupling is *amplexiform*, *i.e.*, it is brought about by an overfold of the whole length of the anal area of the forewing upon the costa of the hind. But besides this, there are many cases in which the amplexiform coupling is strengthened by one of two new devices, as follows:—



Text-fig.8.[*]

(1) Between the anal vein of the forewing, and the anal border, there may be developed a single row of stiff hairs, all pointing forwards and outwards, on the underside of the wing. The row of hairs upon the costal margin of the hindwing is also stiffened; so that, during flight, further strength is given to the amplexiform coupling by the intermingling of these two sets of stiff hairs. I have seen this type of coupling in an archaic Australian genus of the family *Phryganeidæ*, not yet named.

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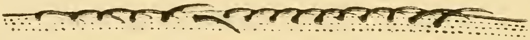
[*] Wing-coupling apparatus in *Rhyacophila dorsalis* Pict., viewed from above; (× 12): *jl*, jugal lobe.

(2) Much more commonly, and especially noticeable in the families *Leptoceridæ* and *Sericostomatidæ*, is a type of coupling which I propose to term *multihamulate* (Text-fig.9). In this, the row of hairs along the costa of the hindwing becomes specialised, for a greater or less length, by the development of the hairs into stiff *hooks*, which grapple the anal margin of the forewing, and so bring about a very perfect form of wing-coupling. This type will be recognised as that which also occurs universally throughout the Order Hymenoptera.



Text-fig.9.

Row of hooklets developed along the middle portion of the costal margin of the hindwing in *Oecetis* sp., (Australia); (× 83).

There are many genera in this Order in which certain of the macrotrichia become developed into series of large, stiff bristles, closely resembling those of a typical frenulum. These most frequently occur along the main veins, or portions of them. Bearing this in mind, I have searched very carefully for a true frenulum in this Order, but I have not succeeded in finding one. In the males of the remarkable and highly specialised genus *Plectrotarsus*, whose systematic position within the Suborder Inæquipalpia is still a matter of dispute, I have found a set of two or three strong bristles in the position of the frenulum. But they are absent in the female, and they play no part in the coupling of the wings, which is of an advanced amplexiform type, with the jugal lobe quite small and non-functional. In two other very spiny genera, viz., *Chimarrha*, and an unnamed Australian genus having whorls of numerous spines upon the tibiæ, there are also stiff bristles in the position of the frenulum, at least in the males. Those of the former genus are long and slender, and are arranged in two or more irregular rows, quite unlike a true frenulum; while those of the latter are also very long and slender, irregularly placed, and lying flat along the wing, parallel to the costa. In neither case do they play any part in wing-coupling.

These developments must be regarded as isolated specialisations, which must be expected to occur throughout an Order in which all parts of the wing remain so well provided with hairs as in the Trichoptera.

From the above evidence, we must conclude that the Archetype of the Trichoptera already possessed a highly reduced coupling-apparatus, in which only one of the four original parts was represented, viz., the *jugal lobe*. This type may be designated as the *archaic jugate type* of wing-coupling.

Order DIPTERA.

In this Order, owing to the loss of the hindwings, there is no longer any need for a coupling-apparatus. But we can recognise the jugal lobe of the forewing, in the form of the basal lobe known as the *alula* in this Order.

It is clear, therefore, that the Archetype of the Diptera resembled that of the Trichoptera in possessing the *archaic jugate type* of wing-coupling, in which only the jugal lobe is present.

We might note here, parenthetically, that, in the other Holometabolous Order (the Coleoptera), in which flight is carried on by only one pair of wings, there may still be found evidences of the original presence of a jugal lobe; *e.g.*, in certain *Hydrophilidæ*, where this lobe is quite large and conspicuous, though it does not seem to perform any definite function.

Order LEPIDOPTERA.

(Text-figs.10-16, and Plates xxix.-xxx., figs.1-8).

We have kept this Order to the last, because, within it, there are developed the most surprising and interesting of all the specialisations arising from the old type of basal coupling-apparatus, which we have already studied in the other Orders of the Complex.

It has been frequently stated that certain families of Moths, viz., the *Micropterygidæ* (*sens. lat.*, including the *Eriocraniidæ*) and the *Hepialidæ*, are distinguished from all other Lepidoptera by the nature of their wing-coupling apparatus. To these, Meyrick(**9**) has lately added a third family, the *Prototheoridæ*, which he claims to be intermediate between the other two. These families together form the Suborder Jugatæ* of Comstock, or the group Micropterygina of Meyrick. The latter author (**3**, p.797) thus defines the character of the wing-coupling apparatus in this group:—"Forewings with an oblique membranous dorsal process (jugum) near base, forming with the dorsal margin a notch or sinus, which receives the costa of the hindwings. Hindwings without frenulum."

This may be taken as a standard definition of the *jugate type* of wing-coupling; provided that we add what is perhaps not quite apparent at first sight, that this true jugum passes *under* the costa of the hindwing, and so forms the notch or sinus abovementioned, in which the costa is held as in a finger-and-thumb grip. The nature of this coupling-apparatus is best understood by referring to Text-fig.11.

As contrasted with this *jugate* type, the rest of the Order is usually regarded as forming a single Suborder Frenatæ,* in which the majority of the families possess a frenulum, but no jugum. A good definition of this character has been given by Meyrick (**3**, p.4):—"Generally from or near the base of the costa of the hindwing rises a stiff bristle or group of bristly hairs, termed the *frenulum*, of which the apex passes under a chitinous catch on the lower surface of the forewing, termed the *retinaculum*, thus serving to lock the wings together; the frenulum is commonly single and strong in the male, multiple and weak in the female; the retinaculum in the female is commonly represented by a group of stiff scales."

However, certain families of the Frenata, including the great division Rhopalocera or Butterflies, do not possess this frenulum. In these forms, the coupling of the wings in flight is brought about by the downward pressure of the posterior margin or dorsum of the forewing upon the costa of the hind, the latter, on its part, pressing strongly upwards from beneath. The humeral

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* I fail to understand the use of the *feminine* plural, since these words are adjectives, and should agree with the neuter plural noun *Lepidoptera*. I propose, therefore, in future, to write them *Jugata* and *Frenata*, respectively.

lobe of the hindwing is generally fairly large in these forms, thus allowing a greater area of the hindwing to pass under the fore than would be the case if it were normal in size. Thus it will be seen that the type of coupling here represented is that which I have already termed, in the Megaloptera and Trichoptera, *amplexiform*. I propose to use this term to distinguish these groups from those possessing a frenulum, without in any way thereby indicating a belief that the amplexiform groups in the Lepidoptera constitute a single line of descent. For it must be evident that there is no reason why the frenulum may not have been lost independently along several distinct lines of descent, leaving us at the present time with several isolated amplexiform groups, each of which has its nearest relationship, not with the other *Amplexiformia*, but with a different frenate group.

As an illustration of this, we find, in the *Castniidæ*, a family in which both the frenulum and the humeral lobe are well developed. From such a group, either a typical Frenate group or a typical Amplexiform group might be descended; the former by reduction of the humeral lobe, the latter by loss of the frenulum.

Considering that the condition of the wing-venation is of greater importance than the structure of the wing-coupling apparatus, for the purposes of classification, I have already, in a preliminary report on this research (**13**), suggested that the primary division of the Lepidoptera into two Suborders should be based upon the former instead of the latter. I therefore defined two Suborders as follows:—

i. Suborder HOMONEURA.

Venation of fore- and hindwings closely similar and of primitive design. (Families *Micropterygidæ* (*sens. lat.*), *Prototheoridæ*, and *Hepialidæ*).

ii. Suborder HETERONEURA.

Venation of hindwing reduced, and differing widely from that of the forewing. (All the other families).

The reason for discarding the older terms Jugata and Frenata, in favour of this new division, will be more fully appreciated when we have completed our study of the *Micropterygidæ*.

Adopting, then, the above terminology, we may now proceed to study in more detail the type of wing-coupling apparatus to be found in the two divisions or Suborders.

i. Suborder HOMONEURA.

Family MICROPTERYGIDÆ (*sens. lat.*).

(Plate xxix., figs.1-4, and Text-fig.10).

In this family, I made preparations from the wings of all five genera available to me, viz., *Sabatinca*, *Micropteryx*, *Mnemonica*, *Eriocrania*, and *Mnesarchæa*.

I should like here to thank the many kind correspondents who have supplied me with specimens of this family, at all times difficult to obtain; and, in particular, Mr. Meyrick, for a series of set specimens representing all five genera; Mr. A. Philpott, for various New Zealand species, both set and in spirit, and for his valuable observations on the flight of *Sabatinca*; and Mr. K. J. Morton, of Edinburgh, for a large number of spirit-specimens, which yielded excellent mounts and dissections.

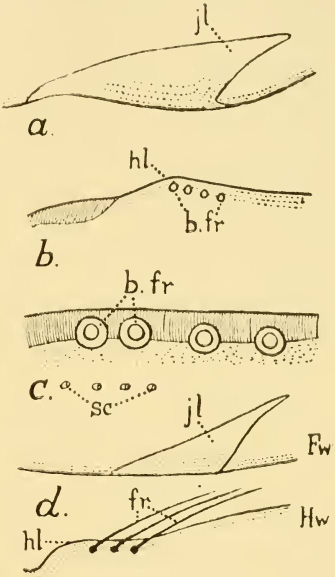
In dealing with this family, I was at once struck by the behaviour of the so-called *jugum* in cleared and mounted specimens. Instead of arranging itself as a free lobe at the base of the dorsum of the forewing, I found that it always insisted upon remaining twisted under the wing itself, and that this position could only be altered with difficulty, by drawing the jugum out from under the wing with a needle. (Plate xxix., fig.1, and Text-fig.10*a*, *d*).

Referring to figures of this jugum already published, I found that Comstock (**1**), Forbes (**8**), and Meyrick (**3**, **4**) had all figured it as a projecting lobe, whereas Packard (**10**, **11**) alone had depicted the true position; though without, apparently, any idea of its significance.

Turning next to the examination of cleared and descaled mounts of the hindwing, I found invariably from three to six large bases of insertion (Plate xxix., fig.3, and Text-fig.10, *b.fr.*)

of a circular shape, situated along the costal border in the region of the humeral lobe, this latter being only a slight prominence. Comparing these with the bases of insertion of neighbouring scales (*sc*), I found that they were of very much greater size, as well as of more regular shape. It was evident, therefore, that they were not the bases of either typical scales or of hairs, but that they must belong to a series of strong *bristles*, which had been removed during the process of descaling. This led me to infer the presence of a true *frenulum* in this family.

The next step was to examine set specimens from the underside, under a fairly high power of the microscope. To do this, I clipped off the pin close to the underside of the thorax, and then inserted the head of the pin into a piece of indiarubber, so that the moth was exposed ventral side uppermost. By this means the lens could be brought close down upon the wings, without touching the pin.



Text-fig. 10.*

The immediate result of this examination was the discovery of a set of strong bristles, nearly always three or four in number, more rarely two, five, or six, constituting a *true frenulum*, but directed outwards and upwards at a very slight inclination to

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[*] Wing-coupling apparatus in *Sabatinca incongruella* Walk., (New Zealand, fam. *Micropterygidæ*): *a*, base of dorsum of forewing in ♀, viewed from beneath; (× 83): *b*, base of costa of hindwing in ♀ (descaled); (× 83): *c*, portion of the same enlarged, to show insertions of frenular bristles (*b.fr.*) and insertions of scales (*sc.*) from a part of the same wing for comparison; (× 320): *d*, bases of wings in ♂, the forewing viewed from beneath, the hindwing from above; (× 83): *fr*, frenulum; *hl*, humeral lobe; *jl*, jugal lobe. (*Cf.* Plate xxix., figs. 1-4).

the costa of the wing (Text-fig.10, *fr*). *It is these bristles, and not the costa of the hindwing itself, which become engaged in the slit or sinus formed between the jugum and dorsum of the forewing.* Although the difficulty of setting these tiny moths in the natural position must be very great, I actually found three specimens in which one or both wings had become engaged in the natural manner; and one of these came from Mr. Meyrick's own collection.

Wishing to have my result tested in the field, I wrote at once to Mr. A. Philpott, of Invercargill, N.Z., asking him to investigate the coupling-apparatus in the wings of the living insect, and sending him careful drawings of my results. The only species that he was able to study was a new species of *Sabatinca*, of which he reported that the coupling apparatus was exactly the same, in structure and position, as that of *S. incongruella*, represented in my drawings. He also added some valuable notes on the habits of flight and rest in this species.*

We come, then, to the following conclusions with regard to the *Micropterygidæ*:—

(1) In so far as it is a fact, that a definite and well-developed frenulum is present in this family, they are of a *frenate* rather than a *jugate* type.

(2) In so far as the so-called jugum does not pass backwards under the hindwing, so as to engage the costa in a finger-and-thumb grip, it is not a true jugum, but must be termed a *jugal lobe;* also, for the same reason, these moths are not true *jugate* types.

(3) Since the jugal lobe is turned forwards under the forewing, and acts as a catch for the frenulum, it is clear that it should be regarded as an archaic form of *retinaculum*, analogous to, but not homologous with, the retinaculum found in the true Frenate forms.

(4) From this, it will be seen that the *Micropterygidæ* combine in themselves certain characters belonging to both Jugate and Frenate types.

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* These are given in an Appendix to this Part, on p.318.

I propose, therefore, to designate the kind of wing-coupling apparatus found in this family as *Jugo-frenate*.

Apart from the specialisation shown in the actual underfolding of the jugal lobe, and the consequent alteration in the direction of the frenular bristles, so as to lie more nearly parallel with the costa of the hindwing, it will at once be seen that this type of coupling is the exact homologue of that found in the older Orders Mecoptera and Planipennia. It agrees more closely with the latter, since both have lost the jugal bristles; but differs from it in the larger number of frenular bristles, and in the less definite development of the humeral lobe.

Thus we come to the logical conclusion, that the archaic jugo-frenate type, found in the older Orders of the Panorpoid Complex, is represented, at the very base of the Lepidoptera, by a somewhat more specialised jugo-frenate type, in which the retinacular nature of the jugal lobe, already existing in the Planipennia, is more accentuated by underfolding, so that the frenular bristles are held in a firmer grasp.

Having now fully reviewed the position in the *Micropterygidæ*, we may pass on to consider the more specialised families.

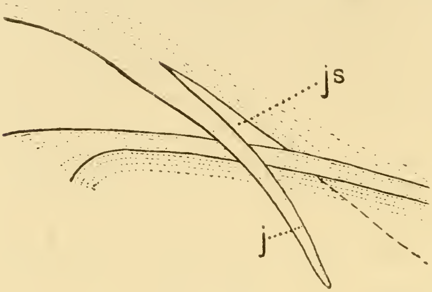
Families HEPIALIDÆ and PROTOTHEORIDÆ.

(Plate xxx., fig.5, and Text-figs.11-12).

In the *Hepialidæ*, I have studied all the Australian genera available, together with the Palæarctic genus *Hepialus*, of which I possess a number of specimens. In the *Prototheoridæ*, through the kindness of Dr. Péringuey, Director of the South African Museum, Capetown, I have received two specimens for study, one of which proved to belong to Mr. Meyrick's *Prototheora petrosema* (**9**), while the other appears to represent a new species, not yet described.

The typical *jugum* found in the great majority of the *Hepialidæ*, and also in the genus *Prototheora*, is shown in Text-fig.11, and also in Plate xxx., fig.5. It is a long and fairly stiff finger-like process (in most species carrying very long and abundant hairs), which projects well below the costa of the hindwing during flight, and engages it in a strong finger-and-thumb grip.

The resulting flight is, in most cases, exceedingly swift and strong; indeed, there is one Australian species common enough about Sydney, *Perissectis australasiæ* Don., in which the males fly so swiftly as to be almost invisible, and are most difficult to catch. One has only to watch, too, the manœuvres which both sexes carry out during courting, to be convinced that dexterity of flight is carried very far in this family, and is certainly not surpassed by the greater number of Heteroneurous forms. We may, therefore, regard this true jugate type as a high specialisation, very superior to the jugo-frenate type of the *Micropterygidæ*.



Text-fig. 11.*

In the genus *Prototheora*, I find no difference from the typical jugate type of the *Hepialidæ*. The jugum is long and narrow, and the costa of the hindwing is quite devoid of bristles.

In the new (undescribed) species of the *Prototheoridæ* which I examined, there is a more primitive type of jugum, in the form of a triangular lobe, only slightly more prominent than that to be seen in many Trichoptera. As in this latter Order, this lobe does not act as a true jugum, but appears to rest upon the upper surface of the hindwing, just overlapping the costa. I do not know whether this character is a constant for this species, having only examined one specimen. It should be noted that, in studying a long series of *Hepialidæ*, a very similar development manifests itself occasionally in one or both wings, especially in the genera *Charagia* and *Porina*. Such occasional developments are to be regarded as strictly atavistic, and indicate the evolution of the highly specialised *jugum* from the older *jugal lobe*.

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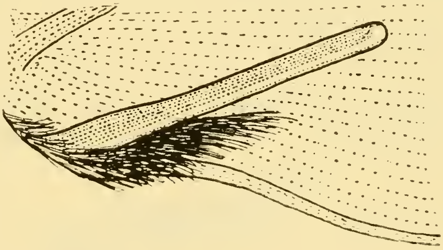
* Wing-coupling apparatus in *Charagia eximia* Scott, viewed from beneath, with hairs removed; (× 12): *j*, jugum; *js*, jugal sinus. (*Cf.* Plate xxx., fig.5).

Some interesting deviations from the normal jugate type may now be noted in the *Hepialidæ:—*

(1) In the genus *Pielus*, the jugum is a hard chitinous rod, somewhat truncated at its tip, and placed so as to project definitely beneath the anal area of the forewing (Text-fig.12). It is quite impossible to make this rod pass under the costa of the hindwing, either in the living or freshly-killed insect. But it will fit quite easily *above* the costa of the hindwing, near the base, where there can be found, in specimens that have been on the wing, a deep groove worn in an oblique direction in the dense hairs that clothe the area around the humeral cross-vein.

It would appear, then, that this genus differs from the rest of the family in having the jugum resting *above* the costa, not beneath it, and also in the structure and position of the organ itself. We should, therefore, regard this genus as highly specialised.

(2) In the genus *Leto*, some specimens show a very weakly formed jugum of very small size for the bulk of the insect; while others have none at all. The bases of the wings are densely clothed with long, soft hairs. The method of coupling in these magnificent insects, which are said to have great powers of flight, appears to be practically *amplexiform*, the anal field of the forewing being bounded anteriorly by a very strongly developed 1A, and overlapping the costa of the hindwing to a considerable extent in flight.



Text-fig.12.[*]

(3) In the small moths of the genus *Fraus*, the jugum is very short, yet it undoubtedly secures the costa of the hindwing in

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[*] Jugum of *Pielus hyalinatus* Don., ♀, viewed from beneath, to show natural position under anal area of forewing; (×6).

the typical manner. Of the New Zealand *Porina umbraculata*, Mr. Philpott writes, "the jugum is so small as to seem worthless as a coupling in the manner of finger-and-thumb."

Thus we see that there is a considerable diversity in the form and function of the jugum, as developed in the *Hepialidæ*.

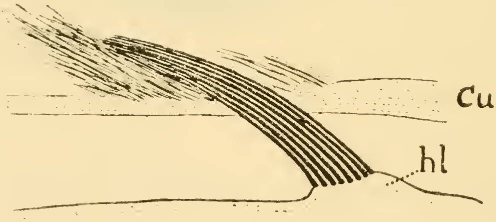
The discussion as to how the highly specialised jugum of the *Hepialidæ* is related to the jugo-frenate type of coupling-apparatus found in the *Micropterygidæ* is best left until we have dealt with the Heteroneura.

ii. Suborder HETERONEURA.

A. FRENATE TYPES. (Plate xxx., figs.6-8, and Text-figs.13-16).

Meyrick's excellent definition of the frenate type has already been quoted on p.296. We may now profitably study, in more detail, the differences between the female and male types.

These differences are clearly correlated with differences in the power and frequency of flight. In those forms in which the female flies but little, the frenulum remains small, and composed of a number of separate bristles, while that of the strongly-flying male may be very large and strong. But in other forms, in which both sexes fly almost equally well, the frenulum of the female may be almost as strongly formed as that of the male, though never consisting actually of a single bristle.

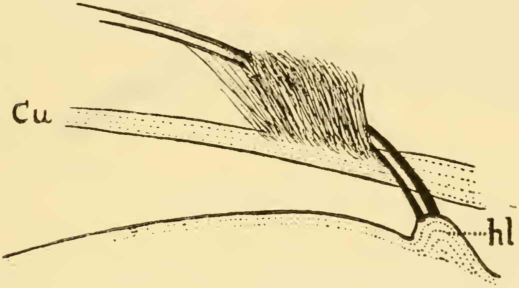


Text-fig.13.

Wing-coupling apparatus of *Hippotion scrofa* (Boisd.), ♀, showing frenulum of eight separate bristles, and retinaculum of hairs arising from cubitus (*Cu*); viewed from beneath; (× 16): *hl*, humeral lobe.

Text-fig.13 shows the *frenulum* of a female Sphingid (*Hippotion scrofa* Boisd.). The bristles composing it are eight or nine in number, all quite separate, but closely set together, as shown in the figure.

The *retinaculum*, or catch, which holds these bristles in place, is a very generalised structure, being nothing more than the somewhat stiffened hairs or scales which arise from the underside of the cubital vein of the forewing, and run obliquely forward and distad. The manner in which the frenulum is held in place by these hairs is closely similar to that by which the jugum of *Pielus* is held in its groove by the hairs on the costa of the hindwing.

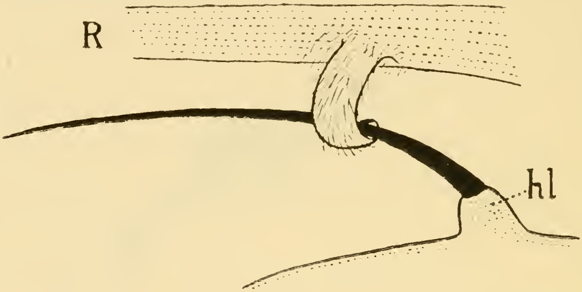


Text-fig.14.

Wing-coupling apparatus of *Plusia verticillata* (Guér.), ♀, showing frenulum of two strong bristles, and retinaculum of stiff hairs arising from cubitus (*Cu*); viewed from beneath; (×30): *hl*, humeral lobe.

In the Noctuid genus *Plusia*, in which males and females fly almost equally well, we may see a much more highly specialised coupling-apparatus in the female. Here, the frenulum is composed of only two (sometimes three) bristles, apparently formed by the fusion of an original greater number, and almost as long as those of the male. The retinaculum, too, is more strongly developed, the hairs being stiffer and more closely set, so as to form a very definite catch for the frenulum (Text-fig.14).

Turning next to the males, we find, in every case, a highly specialised condition present (Plate xxx., fig.8, and Text-fig.15). Here, the frenulum is represented by a single huge bristle, which may even reach to more than half the length of the wing, as in the family *Psychidæ*. As Packard (**10**) has already shown, if this apparently single bristle be cut across near its base, the separate interior channels of the bristles of which it is actually composed can be easily recognised. Thus, we see that the large, male frenular bristle is not formed by hypertrophy of one of the original series at the expense of all the rest, but by fusion and lengthening of the whole set. The longitudinal fluting visible along the somewhat flattened basal part of this bristle is also evidence of its composite nature.



Text-fig. 15.

Wing-coupling apparatus of *Hippotion scrofa* (Boisd.), ♂, showing single, strong, frenular bristle, engaged in hasp-like chitinous retinaculum developed from the radius (*R*); viewed from beneath; (× 14); *hl*, humeral lobe.

The *retinaculum* in the male is a highly specialised structure, having no homologue in the female, or in any other insect. It consists of a strong, curved, chitinous catch, directed posteriorly towards the hindwing, and developed from the underside of the strong radius of the forewing, not very far from its base. This structure is hasp-shaped, and forms a very efficient catch for the frenulum, which is able to slide to and fro within its grasp, during flight, without running any risk of becoming detached (Text-fig. 15).

It is curious to note the difference in action required for the coupling of the wings in the two sexes, owing to the difference in position of the retinaculum. In the female, we must move the *hindwing* sharply forward, and then let it fall gently back, so that the frenulum may become engaged in the catching hairs.

But it is necessary to move the *forewing* sharply forward, if one desires to secure the coupling of the two wings in the male. In doing this, the stationary frenulum is caught up by the moving hasp-like retinaculum; and the grip, once effected, is not easily lost.

We may summarise these results briefly as follows:—

Female.—Unspecialised *frenulum* of from two to nine separate bristles set closely together. Unspecialised *retinaculum* of stiff hairs or scales directed anteriorly, and developed from the underside of the cubitus of the forewing.

Male.—Specialised *frenulum* of a single, large, composite bristle, formed by fusion of the original series of separate bristles. Specialised *retinaculum* in the form of a chitinous hasp, directed posteriorly, and developed from the underside of the radius.

B. Amplexiform Types.

The groups which have lost the frenulum and adopted the *amplexiform* type of wing-coupling (in which connection is maintained simply by overlapping of the anal area of the forewing upon the well developed costal area of the hind, including the enlarged humeral lobe) may be arranged in three super-families; viz., the Saturniina, the Lasiocampina, and the Papilionina or Rhopalocera. These three do not appear to be very closely related.

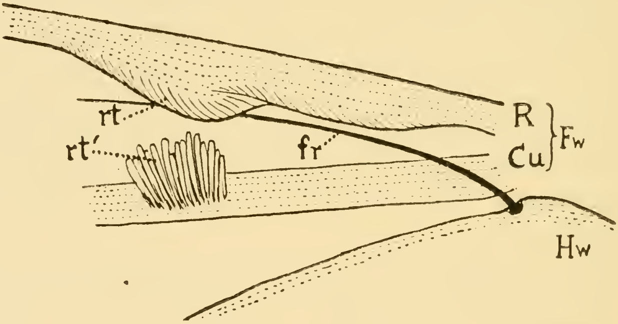
The Saturniina comprise the large and highly specialised group of the Atlas Moths or Emperors. These possess neither frenulum nor proboscis, and have a highly specialised venation. Meyrick places them as the last of his series Notodontina; but this arrangement does not seem to be generally accepted by other Lepidopterists.

The Lasiocampina form a natural group, if the *Eupterotidæ* and *Drepanidæ* be included in them. In the former family, a frenulum is present; in the latter, most of the genera show a small or reduced frenulum. In the other two families, the *Endromidæ* and *Lasiocampidæ*, the frenulum is absent. These last show a very high specialisation of the amplexiform arrangement, in certain genera. For instance, in *Lasiocampa*, the humeral lobe is greatly enlarged, and is supported by a series of recently formed ribs or cross-veins.

The Papilionina form another natural group, whose origin appears to be much in doubt. Meyrick and Hampson consider them to be derived from the *Thyrididæ*. The *Hesperiidæ*, however, grade so closely into the *Castniidæ* in Australia, where forms like *Euschemon* are of Hesperiid structure in all but the possession of the frenulum, that it is difficult to cast aside the belief, held by the opposite school of Lepidopterists, that the *Castniidæ* closely approximate to the ancestral form from which the higher Butterflies, through the *Hesperiidæ*, have been derived.

C. THE FAMILY CASTNIIDÆ.

Much light can be thrown upon the evolution of the two types of frenulum, in the male and female of Heteroneura respectively, as well as upon the origin of Amplexiform types, by the study of the family *Castniidæ*.* In this family, both the humeral lobe and the frenular bristles may be seen well developed, in such a genus as *Synemon* (Text-fig. 16). In the males of this genus, the



Text-fig. 16.

Wing-coupling apparatus of *Synemon hesperoïdes* Feld., ♂, viewed from beneath; (×14): *fr*, frenulum; *Fw*, forewing; *Hw*, hindwing; *rt*, retinaculum developed from radius (*R*); *rt′*, retinaculum developed from cubitus (*Cu*); in ♀, this latter alone occurs.

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* For the supply of material for study in this family, I am indebted to Mr. Geo. Lyell, F.E.S., of Gisborne, Vic.

frenulum is of the usual type, *i.e.*, elongated, and with all the bristles fused together into a single, strong bristle. In the female, there are two long and delicate bristles (as in *Plusia*) accompanied usually by several shorter bristles at their base. The retinaculum of the female is of the usual type, consisting of a patch of forwardly projecting scales, developed on the underside of the cubitus of the forewing; but this retinaculum is situated so far from the wing-base, that only the two longer bristles can become engaged in it, and the connection appears to be easily lost during flight In the male, this retinaculum of scales upon the cubitus is *retained quite conspicuously* (Text-fig.16, *rt′*), together with an additional development of a *slight overfolding* of the edge of the radius in a backward direction (*rt*). Usually, during flight, the frenulum of the male is caught in the curve of this overfold, as shown in the figure. But if, at any time, the frenulum slips out of this somewhat precarious hold, it is then caught up by the still existing retinaculum on the cubitus, and the insect can continue its flight in the manner of the female.

Thus we see that, in *Synemon*, the type of coupling-apparatus for the wings is much closer, in the two sexes, than it is in other frenate moths; and we can scarcely doubt that the condition in the male of this genus is that which preceded, in the males of other frenate moths, the more specialised condition that we find in them at present.

If now, we turn to the genus *Euschemon*, which is claimed by some authors as a moth, by others as a butterfly, we find that the male has a well-developed frenulum and retinaculum of the type found in other frenate moths, *i.e.*, more highly specialised than in *Synemon*. But, on examining the female, I was surprised to find no trace whatever of a frenulum or retinaculum; and it it is evident that this sex couples its wings in the amplexiform manner of the Butterflies, by means of its large humeral lobe. Thus, judged only on the form of its wing-coupling apparatus, the male of *Euschemon* is a frenate moth, the female a butterfly. This genus, then, exactly bridges the gap between the old subdivisions Heterocera and Rhopalocera. That this is not a mere chance convergence, I shall hope to prove in detail later on, when we come to consider the question of larval forms; the larva of *Euschemon* being, in almost every respect, that of a typical Hesperiid.

From the above evidence, the origin of the Amplexiform type of wing-coupling in the Butterflies is naturally suggested as follows. The ancestors of the Butterflies must have had a wing-coupling apparatus of the type seen in *Synemon* at the present day. By developing a manner of flight differing from that of the moths, principally in the greater amplitude of wing-stroke but lesser number of vibrations per second, the delicate, elongated bristles of the frenulum in the female first began to fail to hold the wings in position. The retinaculum being already too far out for the shorter bristles to be of any use, the whole frenular apparatus would then rapidly become aborted, and the insect would depend upon the pressure exerted by the large humeral lobe of the hindwing for keeping the wings in position. That is to say, the Amplexiform type of wing-coupling first became adopted in the female only, as we see it in *Euschemon* at the present day. Next, considering the question of the male, evolution could still proceed along one of two directions: either the overfolding of the radius might continue to increase, until an efficacious, hasp-shaped retinaculum (of the type seen in most male frenate moths) had been developed, thus saving the stronger frenulum of this sex from extinction; or the line of evolution might follow that of the female, presumably by the change in the method of flight making it impossible for even this strong frenulum to continue its hold upon the retinaculum, at a time when the latter had not yet reached the hasp-shaped stage. In that case, frenulum and retinaculum would, in the end, become aborted, as in the female, and we should arrive at the full Amplexiform type exhibited by the Butterflies in both sexes.

The following Table will exhibit, in a concise manner, the differences in the condition of the wing-coupling apparatus studied above:—

Group	Sex	Frenulum	Retinaculum on cubitus	Retinaculum on radius
Typical Heteroneura	♀	short unfused bristles	present	absent
	♂	single long bristle (original bristles fused)	absent	present
Castniidæ :— *Synemon*	♀	two long and several short bristles, unfused	present	absent
Synemon	♂	single long bristle (original bristles fused)	present	present, weakly formed
Euschemon	♀	absent	absent	absent
Euschemon	♂	single long bristle (original bristles fused)	absent	present, as a strong hasp
Papilionina Saturniina* Lasiocampina* (*partim*)	♀ ♂	absent	absent	absent

FORM OF THE COUPLING-APPARATUS IN THE ARCHETYPE OF THE LEPIDOPTERA.

Reviewing all the above evidence, it becomes clear that the oldest existing form of coupling-apparatus, viz., that of the *Micropterygidæ*, is already specialised in a direction from which

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[*] It is not suggested here that the evolution of the amplexiform type in the Saturniina and Lasiocampina has been along the same lines as that of the Papilionina. In the Lasiocampina, at any rate, a study of the conditions to be seen in the *Drepanidæ* would suggest a direct descent from Eupterotid-like ancestors with the frenate wing-coupling apparatus fully developed. Thus the Papilionina are probably of remoter origin than either the Saturniina or the higher families of the Lasiocampina.

the true Jugate and Frenate types cannot possibly be derived, because of the alteration of the direction of the frenular bristles, and the turning-under of the jugal lobe. We must conclude, therefore, that the Archetype of the Lepidoptera possessed a primitive jugo-frenate type of coupling-apparatus, of the form found in the Planipennia; *i.e.*, with all parts present and normal, except the jugal bristles, which were absent.

GENERAL CONCLUSIONS.

Reviewing the evidence afforded by all the Orders of the Panorpoid Complex, we may legitimately arrive at the following conclusions:—

(1) The original coupling-apparatus was situated at the bases of the wings, and was of a primitive *jugo-frenate* type, in which each wing developed a slight lobe towards the other, and these lobes bore projecting bristles which came into contact, and so set up a tactile connection between the two wings, to help in the coordination of the act of flight. By increase in the size of the lobes, or the length of the bristles, the connection became of a more intimate kind, a certain amount of pressure being exerted to keep the wings in position during flight.

In this primitive type, there were originally four elements represented, viz., the *jugal lobe* with its *jugal bristles* on the fore-wing, and the *humeral lobe* with its *frenulum* on the hind.

(2) The only Order which has retained this ancient type of coupling-apparatus in its entirety is the Mecoptera; and, in this Order, the apparatus is only fully functional in the two archaic families *Choristidæ* and *Nannochoristidæ.*

(3) By loss of the jugal bristles, and by increase of the size of the two lobes, there arose the modification of the jugo-frenate type seen in the Planipennia. This also is only fully functional in the older families, such as the *Hemerobiidæ.*

(4) By loss of the frenular bristles, reduction of the humeral lobe, and increase in the size of the jugal lobe, there arose the series of types seen in the Megaloptera, Trichoptera, and the true Jugate Lepidoptera (*Hepialidæ* and *Prototheoridæ*).

These parallel reductions must be conceived of as having taken place quite apart from one another phyletically, and probably at quite different geological periods. Though passing through the same series of reductions, these three groups arrive at quite different final results, as may be seen by comparing *Raphidia* (Text-fig.7) with *Oecetis* (Text-fig.9) and with *Charagia* (Text-fig.11).

(5) The highest specialisation of the old jugo-frenate type, still preserving the original characters of that type, is the jugo-frenate type of the *Micropterygidæ*, in which the jugal lobe is folded under the forewing, so as to become directed forward and outward, and the frenulum becomes engaged in the groove so formed. Thus the jugal lobe functions as *the most archaic form of retinaculum yet discovered.*

(6) The origin of the specialised jugum of the *Hepialidæ* and *Prototheoridæ* is not to be traced directly from the Micropterygid type, but from an older, unspecialised, jugo-frenate type, such as we find in the Planipennia. The jugal lobe remains projecting outwards and downwards, not turned forwards to pass under the forewing. At first, it rested upon the costa of the hindwing, as in the older forms of Trichoptera. The frenulum, being useless, disappeared. A later and higher specialisation led to the lengthening and narrowing of the jugum, and finally to its adopting the position seen in most of the *Hepialidæ.*

(7) From this, it follows that no existing type within the Lepidoptera of to-day represents the true ancestral form or Archetype of the Order. That Archetype must have possessed an *unspecialised, jugo-frenate coupling-apparatus*, probably without jugal bristles, as in the Planipennia to-day. The development of the specialised jugo-frenate type of the *Micropterygidæ*, on the one hand, and of the specialised *jugate* type of the *Hepialidæ* and *Prototheoridæ* on the other, must have proceeded upon divergent lines.

(8) The frenate forms amongst the Lepidoptera are also derived from the archetypic jugo-frenate form, and not directly from the *Micropterygidæ*, as is proved by the bristles of the frenulum maintaining their original direction. This line was

evolved simply by loss of the archaic jugal lobe, with correlated reduction in size and strength of the hindwing, as it became more and more dependent upon the fore in flight.

The most ancient type of frenate coupling is that preserved for us in the females of the whole series, where the bristles remain short and unspecialised, and the retinaculum is formed simply from the brush of stiff hairs or scales, that project forwards from the underside of the cubitus on the forewing.

In the males, there is a higher degree of specialisation, the frenular bristles becoming fused together and greatly lengthened, while a new and more effective retinaculum is developed from the underside of the radius in the forewing, in the form of a posteriorly projecting hasp or catch of chitin.

(9) The amplexiform types amongst the Lepidoptera Heteroneura are to be regarded as a series of separate developments (probably three in number) from originally frenate ancestral forms. Of these, the most evident connection would appear to be that uniting the frenate *Castniidæ*, with their well developed humeral lobe and clubbed antennæ, with the very similar but non-frenate *Hesperiidæ*.

(10) The only portion of the original coupling-apparatus left in the highly specialised Order Diptera is the jugal lobe, which becomes enlarged to form the *alula*.

We may now exhibit, in the form of a short Table, the state of the coupling-apparatus in the various existing groups, to which we must add the Archetypes of the several Orders, as these results will be required in the final discussion on the Phylogeny of the Orders. (See pp.316-317).

SUGGESTED CLASSIFICATION FOR THE LEPIDOPTERA.

The characters here studied, though not suitable for the main subdivision of the Order into two Suborders, may be legitimately used for the subdivision of the first of the two Suborders which we have based upon the wing-venation, viz., the Homoneura. They cannot, however, be used in subdividing the Heteroneura, since the three Amplexiform groups do not lie along one single line of descent.

We may, therefore, adopt the following classfication:—

Order LEPIDOPTERA.

1. Suborder HOMONEURA.

Venation of fore- and hindwings closely similar and of primitive design.

Division A. JUGO-FRENATA.—With archaic jugo-frenate coupling-apparatus consisting of jugal lobe, humeral lobe, and frenulum; the jugal lobe turned under the forewing, and acting as a retinaculum for the forewing......Family *Micropterygidæ* (s.lat.).

Division B. JUGATA.—With specialised jugate coupling-apparatus; the frenulum absent, the jugal lobe elongated and narrowed, usually passing beneath the hindwing.......................
.........Families *Hepialidæ* and *Prototheoridæ*.

2. Suborder HETERONEURA.

Venation of fore- and hindwings dissimilar, that of the hindwing being strongly reduced in comparison with that of the forewing. Coupling-apparatus of frenate type, except in three of the highest groups, in which the frenulum is absent and the coupling is of the amplexiform type.

(Division of the immense number of forms into superfamilies and families must be based upon wing-venational and other characters).

Table showing the Condition of the Parts of the Wing-coupling Apparatus in the various Orders of the Panorpoid Complex, including their Archetypes.

Order.	Type (see below)	Parts of the Coupling-apparatus. (+ present, × vestigial, − absent).				Additions.
		Jugal lobe	Jugal bristles	Humeral lobe	Frenulum	
MECOPTERA†:—						
Archetype	JF(a)	+	+	+	+	
Choristidæ & *Nannochoristidæ*	JF(a)	+	+	+	+	
Meropidæ	JF(t)	×	+ (fused to form tubercle)	×	+	
Other families	JF(r)	×	×	×	×	
PLANIPENNIA:—						
Archetype	JF(b)	+	−	+	+	
Existing families	JF(b) or (r)	+ or ×	−	+ or ×	+ or ×	
MEGALOPTERA:—						
Archetype	JF(r)	+	−	+	×	
Sialidæ	JF(r)	×	−	×	−	
Corydalidæ	J(a)	+	−	−	−	amplexiform overfold.
Raphidiidæ	JF(r)	+	−	×	−	roughened tubercular area on forewing.

† Though the condition of the wing-coupling apparatus is not known for certain in the fossil Order Protomecoptera, we must conclude that its Archetype resembled that of the Mecoptera in this character.

TRICHOPTERA :—						
Archetype… … …	J(a)	+	–	–	–	
Older existing types …	J(a)	+	–	–	–	
Higher types …	A	× or –	–	–	–	amplexiform overfold.
	M	–	–	–	–	minute hooks along costa of hindwing.
DIPTERA :—						
Archetype… … …	J(a)	+	–	–	–	
Existing families … …	J(d)	+	–	–	–	
LEPIDOPTERA :—						
Archetype … …	JF(b)	+	–	+	+	
HOMONEURA :—						
Jugo-frenata … …	JF(c)	+	–	+ or ×	+	
Jugata … … …	J(s)	+	–	–	–	
HETERONEURA ;—						
Frenata … … …	F	–	–	+ or ×	+	retinaculum.
Amplexiformia … …	A	–	–	+	–	

In the second column of the above Table, the explanation of the abbreviations is as follows:—

A = amplexiform type.
F = frenate type.
J = jugate type.
  (a) its archaic form.
  (d) with jugal lobe forming *alula*.
  (s) its specialised form, with jugal lobe forming a true jugum.

JF = jugo-frenate type.
  (a) its archaic form.
  (b) the same with jugal bristles absent.
  (c) its specialised form, with jugal lobe turned under forewing, and direction of frenular bristles altered.
  (r) with parts reduced.
  (t) with jugal bristles fused to form a large tubercle.
M = multihamulate type.

APPENDIX.

Note on the habits of flight and resting position of *Sabatinca.*

The following note, communicated to me in January last by Mr. A. Philpott, of Invercargill, N.Z., throws some new light upon the habits of this archaic genus:—"Since returning home, I have been watching for the new species of *Sabatinca* in a little bit of bush near my house. The weather is still broken, but on sunny days I have been able to learn a little about this species. I have seen several, always on or near certain mossy logs. The moth sits with its wings held roof-wise over the body. The head and thorax are held high up, as if ready to jump. When taking flight, the insect seems to spring into the air with closed wings, and then to fly forwards in a rather feeble and fluttering manner. They do not fly far; five or six feet is a rather long distance for them. The antennæ are always held widely separated, pointing obliquely forward and upward. I am keeping some in a jar with moss, in an endeavour to get some eggs and larvæ, but with no result so far. When touched, these captives spring an inch or two sideways, backwards, or forwards with equal ease. The feeble fluttering flight of this species, and I suppose it to be characteristic of the genus, is in marked contrast to the strong, dashing, swift motion of the *Hepialidæ.* The jugal lobe is folded back as in *S. incongruella*; the frenulum is similar to your drawing.

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EXPLANATION OF PLATES XXIX.-XXX.

Plate xxix.

Fig.1.—Jugum of *Micropteryx aruncella* Scopoli, viewed from beneath; (× 150).

Fig.2.—Frenulum of same, viewed from beneath; (× 125).

Fig.3.—Humeral lobe and bases of insertion of frenular bristles in *Sabatinca incongruella* (Walker); (× 250).

Fig.4.—Frenulum of *Micropteryx thunbergella* Fabr.; (× 125).

(Photomicrographs from descaled, cleared and mounted specimens. The jugal lobe in Fig.1, and the humeral lobes in Figs. 2 and 4, have become cracked across near their bases, owing to the pressure of the coverglass upon old and brittle material. Owing to the same cause, the frenular bristles have become pressed down upon the hindwing, and their correct directions somewhat altered).

Plate xxx.

Fig.5.—Jugum of *Charagia eximia* Scott, viewed from beneath; (× 8).

Fig.6.—Frenulum and retinaculum of *Cephenodes janus janus* Miskin, ♀, viewed from beneath; (× 5).

Fig.7.—Frenulum and retinaculum of *Hippotion scrofa* Boisd., ♀, viewed from beneath; (× 7).

Fig.8.—Frenulum and retinaculum of *Hippotion scrofa* Boisd., ♂, viewed from beneath; (× 6).

(Photomicrographs from set specimens, not descaled. In Fig.7, the black bristles of the frenulum appear white, owing to the incidence of strong artificial light directly upon them).

THE GEOLOGY AND PETROLOGY OF THE GREAT SERPENTINE BELT OF NEW SOUTH WALES.

PART vii. THE GEOLOGY OF THE LOOMBERAH DISTRICT AND A PORTION OF THE GOONOO GOONOO ESTATE.

BY W. N. BENSON, B.A., D.SC., F.G.S., PROFESSOR OF GEOLOGY AND MINERALOGY IN THE UNIVERSITY OF OTAGO, N.Z., LATE LINNEAN MACLEAY FELLOW OF THE SOCIETY IN GEOLOGY.

WITH TWO PALÆONTOLOGICAL APPENDICES BY F. CHAPMAN, F.R.M.S., A.L.S., PALÆONTOLOGIST TO THE NATIONAL MUSEUM, MELBOURNE.

(Plates xxxi.-xxxviii., and five Text-figures).

CONTENTS.

INTRODUCTION AND ACKNOWLEDGMENTS.

In previous papers of this series, the writer has described and given geological maps of the Districts of Nundle and Tamworth (**1**, **3**, **5**, and **6**). The former was the first studied, and broad subdivisions only were made in the stratigraphical succession. In the latter, every zone of rock of any importance was mapped, in the endeavour to obtain as detailed a knowledge as possible of the exact sequence of formations and tectonic structures developed. The present communication serves a twofold purpose It completes the preliminary mapping of the serpentines of the main line of intrusions from Warialda to Hanging Rock, a distance of over 130 miles; and secondly, it carries the detailed tracing of the horizons determined in the Tamworth District through into the Nundle District, permitting a more accurate correlation of the several formations in the two districts than was formerly possible, and thereby indicating that a much greater complexity exists in the Nundle region than was assumed.

Several features of interest occur in this district, which are but barely represented beyond it. Firstly, there is the occurrence of the Loomberah Limestone, which runs throughout the length of the district, and extends into the Nundle region. It is an horizon absolutely distinct from that of the Nemingha or Moore Creek Limestones, with a different lithology, and a different and interesting fauna characterised by the presence of numerous pentameroid shells, and a group of corals which do not occur in the limestones of the two other horizons. In this, and in the Nemingha limestones below are several species of *Tryplasma*, hitherto very rarely observed in the Devonian rocks of this State,* while, in the latter, is a very rare feature, namely, the occurrence of *Foraminifera* in Devonian rocks.

Apart from the faunal peculiarities of this region, the development of igneous rocks is of interest; there are here important

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* Other recorded occurrences of *Tryplasma* in Devonian rocks in New South Wales are as follows:—

1. An undescribed species found by Mr. Surveyor Campbell in the Parish of Cuerindi, a few miles south-east of Manilla (Ann. Rep. Dept. of Mines, 1915, p.189).

2. *T. lonsdalei* var. *scalariformis*, found by Cullen and the writer in Nemingha Parish (This Series, Part v. *See* Bibliography).

3. An indefinite species in the Crawney Limestone, collected by Cullen (Mem. Geol. Surv. N. S. Wales, No.13, p.101).

The second of these belongs to the horizon of the Nemingha Limestone. The first and third are almost certainly on the Moore Creek Limestone horizon. So that it has now been ascertained that *Tryplasma* may occur in all three Middle Devonian Coral-limestones.

masses of keratophyre, which extend into the Nundle District, but are barely represented in the Tamworth District. Several varieties of dolerites, not yet seen elsewhere in the Devonian rocks of New South Wales, appear in this area. Again, we have the most typical instance of highly altered pillow-lavas yet discovered in the Serpentine Belt. The serpentine, too, is by no means as continuous in this region as elsewhere, but is broken into small, isolated lenticles, and the line of separation of the Eastern and Western series becomes obscure. Finally, we may note the occurrence of peculiar tectonic features in this region, developed to a greater degree than in adjacent areas.

The writer is much indebted to Mr. G. McA. King, the General Manager of the Peel River Company, for permission to enter and study the geology of portion of the estate of that Company, and to numerous farmers in the Parish of Loomberah for similar kindness. In particular, he is indebted to Mr. Ponto, of Pendene, for kind hospitality, and to Mr. David Carter for help in securing the rich collection of fossils obtained from his property. This was supplemented by specimens from the collection of Mr. S. M. Tout, who was the first to bring the Loomberah limestones under scientific notice.

Mr. Etheridge has very kindly examined the Tryplasmas recorded herein, and Mr. F. Chapman, the Chætetes and Foraminifera. To Mr. Dun, the writer is indebted, not only for the determination of all the other fossils, and the valuable notes included in this paper, but also for his constant interest in the work, and helpful discussion of the stratigraphic problems that arose. To the chemists of the Geological Survey are due the analyses of the limestones cited on pp.334 and 338, which were obtained from specimens collected by the writer. To all these gentlemen, his best thanks are due. Mr. Mingaye's very complete rock-analyses, cited on p.368, add great value to the petrological studies.

Previous Literature.

The references to this region by previous writers have been very scanty. It was visited by the Rev. W. B. Clarke in 1853, and the occurrence of *Phillipsastræa* on Cope's Creek was observed (**8**). Professor De Koninck determined this as *P. verneuilii* (**9**). The duties of Mr. F. Odernheimer, who made a private survey of the land belonging to the Peel River Land and Mineral Company, must have involved the investigation of this region, but no special attention is directed to it in his paper "On the Geology of a part of the Peel River District in Australia," published in 1855 (**10**). Stonier mentioned the occurrence of serpentine near Black Jack, 1892 (**11**). The present writer described the southern portion of this district in 1911 (**1**), and 1913 (**3**) in his papers on the Nundle District, gave petrological details of the occurrence of keratophyres on Silver Gully, and the pillow-lavas near the Peel River in 1915 (**5**), and included the northern edge of the district in the area covered by his paper on the Tamworth District, later in the same year (**6**). In this paper, the position of the Loomberah Limestone, as a definite horizon distinct from the Nemingha and Moore Creek Limestones, was first remarked.

Preliminary notes on the fossils collected from the limestones of this district by Mr. S. M. Tout and the writer were made by Mr. Dun (**12**); and a number of analyses of specimens of this limestone were given by the chemists of the Geological Survey (**13**). Dr. Jensen cites the results of some investigations not yet published in detail, which were made by Mr. Guthrie, on the nature of the soils in the regions of the limestones in this district (**14**).

Beyond these, no references to the district in geological literature are known to the writer.

PHYSIOGRAPHY.

The region lies for the most part west of the Peel River, stretches from the south of the Parishes of Nemingha and Tamworth, and includes all the Parish of Loomberah and a large region comprising the north-eastern corner of the Peel River Company's estate. Its eastern margin is, in fact, marked by the deep meandering valley of the Peel River, an underfit stream with broad alluvial flats between spurs, sometimes sharpened, but more generally blunted (*cf.* **15**). To the east of this, the land rises up into a peneplain-surface of about 3,500 feet in height, cut in hard rocks, chiefly siliceous phyllites, and very much dissected by deep valleys, some following the structure of the country, others oblique thereto. West of the river, the topography is more complex. The geological formations are arranged in parallel zones of resistant and less resistant rocks, so that there is a succession of ridges, the ridge of the Eastern series directly west of the Peel River, running north from Wallaby Mountain by Woolomin, composed chiefly of siliceous phyllites and jasper, the ridge of tuffs associated with the Loomberah limestone, and the ridge of tuffs and agglomerates which form the Pyramid Hill Range. To the south, a fourth ridge of conglomerate intervenes between the last two. These ridges are separated by the open valleys of Sandy Creek and Reedy Creek respectively. To the south of these creeks, there is a series of more youthful streams, which cut athwart the grain of the country, and flow generally north-easterly or east-north-easterly into the Peel River. Of these, Cope's Creek is the most important. The lower portion of the creek is thus roughly parallel to the series of dip-faults (*see* p.360) which cut through the country and may originally have been determined by one of these. Pipeclay Creek, Silver Gully, and Hyde's Creek belong to the same transverse system of streams. The same holds even more clearly for the creek north and west of Wallaby Mountain.

GENERAL GEOLOGY.

To understand the significance of the features observed in this district, those to the south and north must be reviewed. Along a line of section drawn westwards from the serpentine near Bowling Alley Point, the following sequence was observed (*see* 3):—

i. The Lower Banded Radiolarian Claystones.

ii. The Lower Bowling Alley Tuffs and Breccias, in which there are numerous intrusions of dolerite and spilite.

iii. The Limestone.

iv. The Upper Banded Radiolarian Claystone, interstratified with a large amount of tuff and breccia, and abundant intrusions of spilite and dolerite.

v. Upper Bowling Alley Tuffs and Breccias, with some cherts. With these are two lenses of limestone considerably west of the main zone.

vi. Mudstones of the Nundle Series, gradually passing up from the cherts associated with the Upper Breccias and including a conglomeratic zone which forms Nundle Sugar Loaf, two miles west of the township.

In putting forward this sequence, it was noted that there seemed a possibility of considerable repetition occurring within it. The distinction between the phyllites and jaspers east of the serpentine (the Eastern or Woolomin Series), and the rocks to the west of it, seemed very clear.

In the Tamworth District, however, further facts were discovered. Parts of the Eastern Series were recognised as being merely infolded and highly crushed equivalents of western rocks, and the Western Series itself was subdivided as follows(**6**):—

(*a*) The Lower Middle Devonian series of radiolarian cherts and claystones, with intercalated tuffs containing the Nemingha Limestone, which is often closely associated with a very ferruginous tuff or agglomerate.

(*b*) The Igneous Zone, consisting chiefly of breccias, agglomerates, and tuffs with dolerites and spilites.

(*c*) An Upper Middle Devonian Series of radiolarian cherts and claystones, containing, in its lower part, the Loomberah limestone, and, in its middle or upper part, the Moore Creek limestone. In the portion of this Upper Middle Devonian Series which lies above the Moore Creek limestone (as, *e.g.*, the clay-shales of Tamworth Common), the cherty character of the sediments is entirely lost.

(*d*) The Baldwin Agglomerates, which form the base of the Upper Devonian Series.

(*e*) The Barraba Mudstones, forming the Upper Devonian Series proper. These are often difficult, indeed impossible, to distinguish lithologically from the rocks of the upper portion of the Upper Middle Devonian.

It was further shown that there are several repetitions of zones (*a*) and (*b*) in the region lying immediately west of the Serpentine. When, however, we attempt to trace these subdivisions through the Loomberah District, and to apply them to the succession in the Nundle District, we are met with difficulties, for the new factors entering into the geology of the Loomberah District add to the complexity of the problem. Firstly, there is a general absence of serpentine throughout the region, so that the boundary between the Eastern and Western Series is not a distinct and unmistakable line of fault separating altered and unaltered rocks, but merely a zone of transition, crushing, and silicification. Secondly, even where the serpentine does occur, the rocks immediately west of it have, in many cases, as highly altered a character as those to the east. Thirdly, there is developed a large amount of keratophyre, forming an intrusive mass or masses, one of which apparently is just below the horizon of the Nemingha limestones. The southern end of this zone of keratophyre lies in the Hyde's Creek complex, and a further occurrence of it extends from Silver Gully to Pipeclay Gully (**5**, pp.133-137). The northern end of the zone is that complex near MacIlveen's homestead in the south-eastern portion of Tamworth District(**6**, p. 572). With this keratophyre is often associated a great amount of ferruginous and chalcedonic jasper derived from magmatic solutions. Finally, there is to be considered the extremely disturbed and broken character of the faulting, breaking-up the stratigraphical succession, so that it is not possible to determine the extent of repetition of series that is present.

To simplify the reading of the detailed discussion of the several formations, it may be well to state, at the outset, that the facts appear to justify the following conclusions concerning the stratigraphical relationships of the rocks in the Tamworth, Loomberah, and Nundle Districts.

1. That the lower part of the Nundle Series does not correspond with the Barraba Series, but to the upper part of the Tamworth Series, namely, that lying between the Moore Creek limestones and the Baldwin Agglomerates.

2. That the ridge of conglomerate forming Nundle Sugarloaf west of that township, corresponds to the conglomerate which

runs along the eastern foot of the Pyramid Hill Range (the Scrub Mountain conglomerate). This may be approximately coeval with the Baldwin Agglomerates.

3. The mudstone west of these may be correlated with the Goonoo Goonoo or Barraba mudstones.

4. That the great masses of agglomerate and tuff, being derived from eruption at various centres, do not form continuous horizons except in rare cases, and great care must be used in stratigraphical correlation based on the lithological features of pyroclastic rocks. Hence arises the difficulty of determining the exact horizon to which must be referred the Pyramid Hill group of tuffs, etc., or of recognising definitely the horizon of the Baldwin Agglomerates.

5. The Moore Creek Limestone is not represented in the Nundle District, but its appropriate horizon is probably not far from the township of Nundle itself.

6. The Loomberah Limestone is represented by the two western lenses of limestone near the head of Silver Gully, to which special attention was called during the first survey of the Nundle District(**3**, p.574).

7. The main line of limestone which passed through to Bowling Alley Point and continues to Hanging Rock, belongs to the Nemingha or Lower Middle Devonian Limestone.

8. That the pyroclastic rocks which lie directly above the spilites and dolerite of the Upper Bowling Alley Claystones represent the "Igneous Zone" of the Tamworth District.

9. The Lower Bowling Alley Tuff-Breccias, Dolerites, etc., are a repetition of the same "Igneous Zone" and its associated intrusive rocks.

10. Much of the Middle Devonian (Tamworth) Series may be recognised in an altered state in the regions east of the serpentine in all three districts.

The Eastern Series.

In the Loomberah District, we will describe with the Eastern Series, not only all those rocks lying east of a line joining all the outcrops of serpentine, but the lithologically identical masses which lie to the west of that line, the rocks of the Transitional

Zone (a name indicating a local feature only), distinguished by their greater alteration, fracturing, and silicification, from the normal breccias, tuffs, and cherts of the rest of the Tamworth Series. The actual western margin of the Eastern Series is thus difficult to define, and that laid down on the map (Plate xxxii.) is not a sharply marked feature. There is clear evidence that very much of this Series consists of merely highly altered forms of similar types of rock such as occur in the Tamworth Series; while there are few rocks, if any, so utterly distinct as to demand their inclusion in a definitely older, possibly Lower Devonian formation, (the suggested Woolomin Series, a term we have now abandoned).

Most notable are the masses of tuff and breccia, which occur in the hills east of the Peel River, between Nemingha Creek and Dungowan, continuing those already noted in the north-eastern portion of Nemingha Parish(**6**, p.547). These cross the Peel River in the neighbourhood of Dungowan, and strike through the hills west of the river till they come to the Wallaby Mountain and Cope's Creek. Some of these are very similar indeed to the normal tuff-breccias of Middle Devonian age, while others, notably a great mass of almost schistose, highly crushed rock running across the western end of Wallaby Mountain, consist of a coarse tuff with abundant inclusions of limestone drawn out into long lenticles. This may represent the Nemingha limestone, but there are also instances where such a tuff is associated with the Loomberah limestone. Some of the masses of tuff are very silicified, and one instance of jasperised, ferruginous agglomerate appears as if it might be the equivalent of the red tuff of East Gap Hill, described in Part v. (pp.564-6). This is to be found on the hills east of the Dungowan Hotel, associated with a little vesicular keratophyre.

Again, in Portions 52 and 146 in the south-eastern angle of the Parish of Nemingha, three hundred yards east of the serpentine, is a large belt of agglomerate, together with porphyritic or granular spilite, inclosing a lenticular mass of limestone a hundred yards long and twenty yards wide, with somewhat the reddish crystalline character of the Nemingha marbles, associated with ferruginous tuffs with limestone-fragments such as have been already mentioned. Traces of a Stromatoporoid, of *Favosites multitabulata*, *Heliolites*, and a large cyathophylloid coral were observed. These are insufficient to determine whether the limestone belongs to the Nemingha or Loomberah horizon. It runs due north, and is cut off to the south by a marked cross-fault, which also truncates the adjacent serpentine. Limestone again appears on the ridge in Portion 52, Loomberah, associated with chert and spilite, all in a very shattered condition. This lies in the transitional region between the Serpentine Line and the Tamworth Series, but probably represents an altered form of the Nemingha Zone.

The great masses of jaspers, which are such a marked feature of the Eastern Series in the Nundle District, are especially well developed in the Wallaby Mountain, west of Woolomin, where a strong band strikes across the mountain, forming the long ridge which deflects the outlet of Cope's Creek, rising into the high cliffs that form the eastern side of the mountain, and dying out in the valley to the north. Other jasper-belts occur east of this, nearer to Woolomin, and further long bands traverse the Parish of Woolomin, and others occur east of Dungowan, though the last are not so extensive as elsewhere. They result from intense silicification along zones of shattering, and are not primary deposits.

The igneous rocks, other than tuff, namely the dolerites, spilites, and keratophyres, occurring east of the serpentine, and especially in the transitional zone west of the serpentine, are discussed below (p.342).

The Tamworth Series.

The region occupied by rocks of this division forms the greater portion of the area considered, and, throughout this area, the dips are nearly vertical or inclined to the W.S.W. at angles of about 60°-70°, with only here and there a narrow band dipping in the opposite direction. The total width of this region is over four miles, so that, were no repetition of strata present, a thickness of nearly 20,000 feet must occur, which is several times greater than was shown to be probable in the Tamworth District. We must conclude, therefore, that considerable repetition by strike-faulting is present, though admitting that the sequence from east to west is, in the main, an ascending one in the time-scale.

We shall now endeavour to trace through from the Tamworth to the Nundle District, several horizons already recognised in the succession of Middle Devonian strata.

The Nemingha Limestone.—The main limestone of the Loomberah District is clearly a continuation of the mass of limestone which runs through Beedle's Freehold and the Gap at Nemingha (**6**, pp.587-9), and then commences by the eastern corner of Portion 60,* Parish of Loomberah, appearing from beneath the river-alluvium, and running thence to the south-east through Portions 59, 58, and 57. It is a brecciated pink limestone associated, in Portion 59, with a small amount of very ferruginous, more or less brecciated keratophyre or porphyritic andesite, lying on the eastern side of the limestone; and, to the west, is an intrusion of porphyritic dolerite with phenocrysts of labradorite. The outcropping mass of limestone is 77 yards wide, but it is impossible to determine the thickness of the limestone owing to the absence of any evidence of the angle of dip, though adjacent rocks dip at high angles. It is broken by cross-faults, throwing it for short distances. In Portion 58 (Mr. David Carter's property), the limestone has been duplicated by a fault or faults, and a short band of the same horizon occurs four hundred yards north-east of the main zone. The eastern mass is the more clearly exposed, and covers an area four hundred yards long by sixty yards in width. Both bands of limestone have a western wall of keratophyre-breccias, ferruginous rocks apparently greatly altered by percolating solutions (the Nemingha Red Breccia). Both masses of limestone, for the most part, lie in ploughed land, and, in the boulders of limestone brought to the surface, a large series of fossils was obtained, which confirm the correlation of this limestone with the Nemingha horizon. These were

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* Unless otherwise stated, all references to Portion-numbers in the sequel refer to Portions of the Parish of Loomberah.

determined by Mr. W. S. Dun, Mr. Etheridge, and Mr. F. Chapman. The following forms were recognised :—

PROTOZOA.

Foraminifera—

Psammosphæra neminghensis, sp.nov., Chapman.
Valvulina plicata Brady.
V. bulloides Brady.
V. oblonga, sp.nov., Chapman.
Pulvinulina bensoni, sp.nov., Chapman.

Radiolaria—

An indeterminate species.

CŒLENTERATA.

Zaphrentis sp.
Tryplasma congregationis Eth.fil.
T. lonsdalei Eth.fil.
T. vermiformis Eth.fil.
A cystiphylloid coral.
Syringopora porteri Eth.fil.
S. auloporoides Eth.fil.
Favosites gothlandica Lamarck.
F. multitabulata Eth.fil.
F. pittmani Eth.fil.
F. crummeri Eth.fil.
Alveolites sp.
Heliolites porosa Goldf.
H. interstincta Linn.
An indeterminate Stromatoporoid.

ECHINODERMATA.

Numerous Crinoid ossicles.

BRACHIOPODA.

Atrypa sp.
Zygospira sp.

Concerning the *Tryplasma lonsdalei*, Mr. Dun remarks that it is apparently a solitary form of the *T. lonsdalei*-type, but the tabulæ are more irregularly and widely spaced than in the normal form. The wall is thick, and there are short, septal spines. The diameter of the corallite is 5 mm.

Several interesting features are seen in this Table. The two species of *Syringopora* named have, so far, been collected only from the Moore Creek limestone, to which also *F. crummeri* has heretofore been confined. The recognition of three definite species of *Tryplasma* is an advance on the single form recorded previously from this horizon (**6**, p.552); while the occurrence of Foraminifera is a very welcome feature, since, apart from forms occurring in the Devonian limestones of Germany and South Devonshire, no other occurrences of Devonian Foraminifera are known. They were found in a small mass of oolitic limestone about four inches in diameter. The granules, according to Mr. Chapman, form a little more than half the bulk of the rock; "they vary in diameter from 0·46 to 0·7 mm., and only a small proportion are due entirely to oolitic accretion, whether originally of algal origin or not it is impossible to say, on account of their present mineralised condition. The nucleus of the oolitic grain, in more than one case, was seen to consist of an ossicle of a crinoid. There is a fair amount of iron-staining in the rock-structure which seems to be entirely secondary, as the stain is developed more strongly along incipient fracture-lines than in the grains themselves." (See Appendix i.). The ferruginous matter has doubtless been introduced from the associated Nemingha Red Breccias.

The analysis of the limestones from this outcrop are given below (p.334).

Nearly a mile south of the occurrence in Portion 58, the limestone appears again, associated with red, ferruginous keratophyre-breccia crossing the western end of Portion 55; this outcrop is nearly half a mile in length.

The next outcrop is considerably to the east as well as south of the above, and is probably separated from it by considerable dip-fault, though the intervening alluvium and ploughed land hide the details of the outcrops. This mass is quite small, occurring near the corner of Portions 53 and 52.

The limestone on Portion 35 has been moved still further to the east, and is separated from the last-mentioned occurrence by a large intrusion of dolerite. A small fault traverses this mass, cutting it into two portions, one nearly 600 yards long and 60 wide, the other 300 yards long and 40 yards wide. The chemical composition of a specimen of this mass is given below (No.1787).

A small mass of limestone next appears a mile to the south, being found in a well sunk by the creek in Portion 32.

No more limestone appears for over a mile, until, in the southern part of Portion 31, a great band of red breccia is associated with a small amount of limestone on its eastern side. The red band broadens as it continues southwards into the Peel River Company's Estate, and the limestone now appears to the west, as well as to the east, of the Red Breccia, which is here more than a quarter of a mile wide. An important mass of limestone lies on the western side of Sandy Creek, half a mile south of the boundary of Loomberah Parish. It consists of three portions, largely of red encrinital limestone. The aggregate length of the outcrop is 600 yards, and the width 80 yards. The dip is apparently W.40°S. at 50°. The upper portion is rather ferruginous; the lower, grey portion is either massive or brecciated. (*See* analyses 1785, 1786, *infra*).

At the foot of Black Jack, the limestone and tuff is suddenly cut off by a fault, which throws it half a mile to the east. On the south side of the fault, the two masses of limestone, separated by the breccia, are half a mile apart, but very soon they are brought together again by a second great fault, and they continue over the shoulder of Black Jack, making bold outcrops (analysis 1788), and pass thence down into Cope's Creek. The limestone appears on the other side of the valley, and continues to Pipeclay Creek. This is the portion of the zone which was described when considering the Geology of the Nundle District (**3**, p.574). In Cope's Creek, the limestone occurs in rather irregularly placed masses in the red breccia, and one large lenticle has been torn off and enveloped in keratophyre. It is possible that Clarke's specimen of *Phillipsastræa verneuilii* was obtained here.

Throughout its length, this limestone keeps the characters which mark the Nemingha limestone. It is usually thoroughly crystalline, so much so that, except for the fossiliferous masses on Mr. Carter's property and south of Cope's Creek, no recognisable fossils have been obtained. The rock is generally white, pink, reddish or mottled; less commonly, it is grey. It is often highly brecciated, and in particular in Cope's Creek, the rock is clearly made up of fragments of corals and of crinoids. The colouration of the rock appears due to the introduction of ferruginous solutions. The composition of the stone is shown in the following Table; the analyses are due to the chemists of the Geological Survey(**13**).

	1781	1782	1783	1785	1786	1787	1788
$CaCO_3$	97·46	98·21	97·68	94·03	97·54	97·55	98·21
$MgCO_3$	0·7	0·69	0·64	0·90	0·71	0·79	0·50
$MnCO_3$	0·04	0·06	0·04	0·08	0·05	0·04	0·04
Fe_2O_3, Al_2O_3 ...	0·32	0·24	0·18	0·95	0·17	0·28	0·24
Gangue	1·56	0·98	1·42	4·02	1·52	1·48	1·24
	100·09	100·18	99·96	99·98	99·99	100·14	100·23

1781-2—Red Marble, Portion 58, Loomberah.
1783—Pink Marble, Portion 58, Loomberah.
1785—Pink Marble, 1½ miles N.N.W. of Black Jack Mountain.
1786—Red Marble, 1½ miles N.N.W. of Black Jack Mountain.
1787—Pink Marble, Portion 35, Loomberah.
1788—Pink Marble, east side of Black Jack Mountain.

Concerning the depth of origin of this limestone, we have to note the absence of evidence of littoral conditions though the limestone is often brecciated. Radiolarian chert is directly associated with it. Mr. Chapman's remarks on this point may be noted. (*See* Appendix i.).

The Loomberah Limestone.

A second definite zone is that of the Loomberah Limestone. Just beyond the north-western corner of the Parish of Loomberah, namely, in Portion 10, Parish of Calala, is a belt of limestone about a hundred yards long and ten to twelve feet thick, containing *Heliolites*, *Tryplasma*, and crinoids. It dips W.5°S. at 70°. To the east of it are several bands of tuff and a sill of dolerite, the whole lying within normal radiolarian cherty claystones. Followed to the south-east, the limestone ceases, and the tuff-breccia becomes rich in fragments of limestone. It is displaced by several cross-faults. In Mr. Carter's property (Portion 58), the limestone comes in again, forming a very important band. This is about a quarter of a mile in length and 150 feet thick. Its western end is very highly crystalline, so much so that the rock has passed into a white marble, but, towards the east, it is less crystalline, and consists of an extraordinary assemblage of broken fossils. Fragments of large pentameroid shells are the predominant feature, but intermingled with them are abundant masses of *Stromatoporoids*, of fragments of coral, and even angular or rounded pebbles of chert, the whole giving very clear indication of rather turbulent conditions of formation, as if they were reef-breccias (*see* Plate xxxiv., fig.1). In spite of this, there is no indication of an unconformity, the radiolarian cherts which lie immediately above the limestone dipping W.25°S. at 70°, those immediately below W.26°S. at 65°, which, considering the variability of the dip, may be taken as proof of conformity. Possibly the shallow-water limestone indicates the occurrence of a regression of the sea. In cases such as this there is no reason to expect a mass of coarsely clastic sediment at the base of the overlying transgressive sediment (*see* **16**, p.458).

The second characteristic of this limestone is its remarkable fauna, which is quite unlike that of any horizon yet discovered in the Devonian rocks of New South Wales. The following list indicates the forms recognised by Messrs. Chapman, Dun, and Etheridge. Of particular interest is the presence of *Tryplasma*, as determined by Mr. Etheridge, and *Chætetes*, described by Mr. Chapman.*

Zaphrentis, sp.ind.
Zaphrentis(?) sp. (Sp. et subgen. nov.?).
Tryplasma sp. Intermediate between *T. delicatula* Eth.fil., and *T. vermiformis* Eth.fil.
Cyathophyllum sp.

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* In a private communication, Mr. Chapman says—"It is interesting to note your opinion of the hydrographic conditions at Loomberah. *Chætetes*, to my mind, played the same part in the coastal reefs of the Palæozoic, as *Heliopora* does at the present day."

Diphyphyllum robustum Eth.fil.
D. porteri Eth.fil.
Form allied to *Omphyma.*
Spongophyllum, sp.nov., Dun.
Phillipsastræa grandis, sp.nov., Dun.
Favosites gothlandica Lamarck.
F. gothlandica with multitabulate habit.
F. multitabutata Eth.fil. (rare).
Favosites, sp.nov.(?), a form with very irregular habit.
Favosites, sp.nov., a dendroid form distinct from those in other Devonian horizons in this area.
Litophyllum konincki Eth.fil.
Dania sp.
Chætetes stelliformis, sp.nov., Chapman.
Heliolites porosa Goldf.
Plasmopora sp.
Stromatoporella loomberensis, sp.nov., Dun.
S. bensoni, sp.nov., Dun.
Actinostroma australe, sp.nov., Dun.
A Treptostomatous Bryozoan.
Pentamerus (*Conchidium*) cf. *knightii.*
Pentamerus cf. *sieberi.*
Strophomena cf. *rugata.*
Atrypa sp.
Murchisonia sp.

The band of tuff or breccia, directly below this limestone, may be traced south almost continuously to Cope's Creek, displaced here and there by cross-faults. There is frequently a considerable amount of limestone-fragments in this tuff-breccia, but only occasionally are there any large masses of limestone, such as those in Portions 23 and 33 (the latter of which contains small forms of *Favosites multitabulata.* The limestone also occurs in Portion 32, and in several localities west of Black Jack. One of these masses has a maximum width of sixty feet, dipping nearly vertically , and contains pentameroid shells. *Cyathophyllum, Heliolites*, a Stromatoporoid, globular masses of *Favosites gothlandica* and *Tryplasma*(?) which characterise the horizon, and, in addition, there was a section exposed of a form very similar to *Cystiphyllum vesiculosum* which unfortunately could not be removed for more careful examination.

South of this, where the limestone is split into two bands by a zone of tuff, the feature noted in Portion 58, namely, the abundance of fragments and pebbles of chert in the limestone, is again present. It must also be mentioned that, throughout the length of the zone of the Loomberah limestone, the chert overlying it contains numerous small intrusions of tuff.

The tuff associated with the limestone may be traced down into the valley of Cope's Creek, and beyond it to the south. Here, probably, was obtained the specimen of *Phillipsastræa verneuilii* recognised by De Koninck. The small patch of limestone occurring on the top of the hill, a mile and a half W.S.W. of the Permo-Carboniferous sandstone at Reichel's homestead, near Bowling Alley Point, probably belongs to this series. It has been already pointed out that it does not lie on the same horizon as the Nemingha limestone. . A lenticular mass of limestone occurs near Cann's Plains Creek, still further to the south, and probably belongs to the same horizon (**3**, p.574). Thus we can trace the Loomberah horizon intermittently from the north-west of the Parish of Loomberah, to within two miles of Bowling Alley Point, and have thus obtained a second definite horizon linking the geology of the Tamworth District to that of Nundle.

But there is still another mass of limestone that may possibly belong to the same horizon, though so altered by recrystallisation in the region adjacent to the serpentine, that no traces of fossils have been found in it. This is the lenticular mass of white marble in the south-eastern corner of the Parish of Nemingha, Portion 121, mentioned previously (*see* **6**, p.560). It is about four hundred yards long and sixty yards in width as a maximum measurement, the main visible portion being only two hundred by twenty yards in length and breadth.

The chemical composition of the Loomberah limestone is seen from the analyses below, which were made by the chemists of the Geological Survey(**13**).

	1395	1220	1784
$CaCO_3$	98·85	94·91	95·43
$MgCO_3$	0·42	0·83	1·27
$MnCO_3$	0·04	—	0·11
$Fe_2O_3 + Al_2O_3$	0·22	0·80	0·60
Gangue	0·64	3·55	2·45
	100·17	100·09	99·86

1395—Limestone, Portion 121, Nemingha (horizon not certain).
1220—Limestone, Portion 58, Loomberah.
1784—Limestone, Portion 23, Loomberah.

Scrub Mountain Conglomerate.

For about a mile west of the zone of the Loomberah limestone, the sediments are a succession of cherts, radiolarian claystones and tuff, the latter sometimes broadening out into coarse agglomerates, as in the case of the agglomerate to the west of the upper portion of Cope's Creek. In Reedy Creek, however, the rocks lose their cherty nature to a great extent, becoming mudstones almost indistinguishable from those of the Barraba Series.

There is one very marked horizon in this portion of the section, a zone of conglomerate which may be termed the Scrub Mountain Conglomerate. It commences in Portion 17 and continues to the south-east. It is made up of usually rounded or sub-angular pebbles chiefly of a richly felspathic keratophyre, a strongly trachytic type of which was found to contain phenocrysts of felspar with abundant minute crystals of augite in the base(1474); there is also some beautiful granophyre(1477, 1479), and, most interesting of all, an angular fragment of radiolarian chert. This last is not like the usual cherts of the Tamworth Series, being free from any sign of banding, but small amounts of a rather similar rock do occur here and there in the Eastern Series.

All these lie in a tuffaceous matrix. This has not yet been studied microscopically, but from a macroscopic examination there did not appear to be the same close relationship between the tuffaceous matrix and the inclusions (the former derived by the attrition of the latter) that was so marked a feature of MacIlveen's complex, or in the Baldwin Agglomerates (*see* **6**, pp.573, 578). This, however, requires thorough investigation. Should the matrix really prove to be clastic, not merely pyroclastic, the occurrence in it of the radiolarian chert and the keratophyres, etc., might indicate another regression of the sea at this point, and the exposure and erosion of Lower or Middle Devonian rocks some distance east(?) of this region. The possible significance of this is considered later (pp.341, 355).

The zone is very continuous. It forms the long ridge in Portions 17 and 18, and, southwards from thence, it makes up the little hills which sharply mark the ends of the ridges that separate the western tributaries of Reedy Creek. About four miles south of the boundary of the Parish of Loomberah, it rises as a long spur into Scrub Mountain, and south-east of here it forms Rodney Mountain, beyond the limits of the map herewith, and further to the south-east it rises into Nundle Sugarloaf, and crosses the Peel River to form the western end of the Yellow Rock Hill south of that township. The last three occurrences of the conglomerate have been already noted (**3**, p.581). Thus the Conglomerate affords another horizon which can be traced through from the Loomberah Parish into the region mapped in the Nundle District. Small fragments of the conglomerate occur here and there adjacent to Reedy Creek; they are perhaps due to repetition by *schuppen*-faulting. Round Mountain, which rises from beside the Main North Road on the northern edge of the Goonoo Goonoo Estate, ten miles due south of Tamworth, is apparently composed of this conglomerate.

The Pyramid Hill Tuff.

West of the Scrub Mountain Conglomerate and stratigraphically above it, the mudstones are interstratified with numerous bands of tuffs of moderate grain-size, and these, being resistant to erosion, form the long ridge which runs south-eastwards from Pyramid Hill. This structure of the range is that of a faulted syncline. To the west of it there extends the broad, low, undulating region composed chiefly of mudstones, extending to the foothills of the ridges of Carboniferous rock that pass through the Currabubula district. These are the mudstones of the Burindi Series (on the extreme west), and the Barraba Series which forms the greater portion of the Tamworth and Goonoo Goonoo Plains. To the south-east, the tuff of the Pyramid Hill Range apparently extends into the hills west of Nundle.

The Stratigraphical Position of the Nundle Mudstones.

The difficult question to be decided is the stratigraphical position that must be assigned to the Pyramid Hill tuff. The synclinal structure of the range, the lithological character of the component rocks and the consequent topographic features, recall the tuffs which form the hills west of the Tamworth Common. These tuffs, etc., have been correlated with those occurring south of the river in Portion 27, Calala(**6**, p.580), and lie near, but not on, the same line of strike as the Pyramid Hill tuff. The beds which occur between the tuff of Portion 27, Calala, and the nearest Loomberah limestone, are quite similar to those between the Loomberah limestone and the Pyramid Hill tuffs, save for the absence of the Scrub Mountain conglomerate. The first impulse, therefore, would lead one to correlate the Pyramid Hill tuff with the tuffs in the Tamworth Common, and, therefore, with the Baldwin Agglomerate(**6**, p.579). Such a correlation would place all the mudstones of the Reedy Creek Valley, together with the Nundle conglomerate, into the upper portion of the Tamworth (Middle Devonian) Series, and would further demand that none of the region mapped in the Nundle district should belong to the Barraba Series, to which the western group of mudstones (the Nundle Series) had previously been referred.

But the study of the tuffs and breccias within the Devonian Series shows that they do not always form on a single horizon, but (what might have been anticipated) they formed at different times, spreading out on either side of their centres of eruption, and, therefore, lie at varying horizons. Apparently there were epochs when eruption was more continuous and widespread than at other times, giving more or less definite igneous zones, but stratigraphical correlation on the petrological features of pyroclastic rocks alone is exceedingly unsafe. It is quite possible that the Pyramid Hill tuff belongs to a period of eruption rather more recent than that of the Baldwin Agglomerates, and that the true horizon of the base of the Barraba Series lies at some indefinite horizon between the Loomberah limestones and the Pyramid Hill tuff. As the outbreak of the huge eruptions, which formed the Baldwin Agglomerate of the Manilla-Bingera region, might reasonably be expected to have been associated with some crust-movement in adjacent districts, we may put forward the suggestion that the Scrub Mountain conglomerate (the lithology of which seems to point to the occurrence of some crust-movement) might be considered contemporaneous with the Baldwin Agglomerates. This hypothesis has the merit of involving a less radical change than the former one in the conception of the range of characters of the Upper Middle Devonian rocks, and is, therefore, adopted in the map. But it cannot be considered as more than tentative, lacking as yet confirmatory evidence. On this hypothesis, the portions of the Nundle Series lying south-west of Nundle Sugarloaf and Yellow Rock Hill (**3**, Plate xxii.) belong to the Barraba Series.

The Devonian Igneous Rocks.

Igneous Rocks in the Eastern Series.—The igneous rocks in the Eastern Series must be first briefly discussed, before passing on to the more important rocks west of the serpentine. They consist, for the most part, of bands of more or less schistose breccias and agglomerates, which are fairly abundant, and are particularly well seen in a zone which runs nearly due north from the western end of Portion 42, Loomberah, to the eastern end of Portion 46; while less noteworthy masses occur, east of the Peel River, in the Parishes of Gill and Nemingha. Massive igneous rocks have a more restricted occurrence. Spilites are found a mile north of Dungowan Hotel in Portion 52, Gill. Vesicular keratophyre occurs near by in Portion 51, and in Portion 43 of the Parish of Loomberah is a very small lenticle of a quartzose dolerite* with zoned andesine-felspar. Larger bands of fine-grained dolerite and spilite cross the valley north of Wallaby Mountain and the hills to the east.

Igneous Rocks in the Transitional Zone.—More complex than these are the features of a series of igneous rocks which lie along the zone of passage between the Eastern Series, the zone elsewhere represented by the Serpentine Line. The most northerly of these masses are the group of dolerites and spilites by the Loomberah Bridge in Portion 56, which occupy the greater part of the small spur east of Sandy Creek. A very good exposure of the spilite is seen in the road-cutting on the east of the hill, in which typical pillow-structure is exposed (*see* Plate xxxiii.). The pillows are about two feet in diameter, and have generally a number of vesicles, often filled with calcite, arranged in concentric rows within the pillow. The rock itself is greatly altered, as described below (p.365). For this reason, the pillow-lavas are more like the pillow-lavas seen by the writer in Cornwall† than any others in the Great Serpentine Belt (**5**, p.131). The dolerite which occurs on the west side of the spur is also greatly altered. The original ophitic structure has been preserved in spite of the mineralogical changes. Magnetite is the only original mineral; the augite has become platey chlorite, and the felspar has been changed either to a mass of calcite with a small amount of albite; or to much-strained quartz or chalcedony with chlorite, spherulitic if in large patches, and sometimes associated with a little carbonate. The dolerite itself is sometimes slightly vesicular. These sills of spilite and dolerite are separated by banded jasperised cherts or highly siliceous cherts which dip W.4°N. at 60° on the east side of the hill, but dip E. at 60° on the west side of the hill.

Southwards of these, in the eastern end of Portions 55 and 54, and again on the boundary of 53 and 52, are further intrusive masses. Spilite occurs on either side of the hill of chert and jasper in Portion 54, but further to the east keratophyres are found.

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* See footnote to p.364

† For description of these lavas, see (**17**).

Small intrusions of rather vesicular spilite occur at the south-western corner of Portion 48, but the next important mass of spilitic rock is the complex series of intrusions which runs through the western ends of Portions 39, 38, and 62, and are associated with serpentine in a complex fashion. The spilite occurs in a series of overlapping lenticles, decreasing in size from north to south; the rock is vesicular, full of secondary chert, in most irregular strings and veinlets (*cf.* 5, p.127). These lenticles are separated from one another by narrow zones of more or less silicified, crushed chert, into which the serpentine has been injected. In one instance, on the northern end of the complex, the serpentine appears to be injected into the spilite (though the abundance of drifted blocks makes the observation uncertain), while at the southern end a small patch of vesicular keratophyre, 10 yards long and 5 yards wide, has apparently been caught up and included in the ultrabasic rock. The whole structure seems to have resulted from the shattering of a mass of spilite and keratophyre, by a series of oblique faults, into which the cherty crush-breccias were dragged and the ultrabasic rock injected.

South of these are the long, undisturbed, lenticular intrusions of dense spilite on the western slopes of Wallaby Mountain, and crossing the creek at its base. These are quite typical of the non-vesicular spilites in the Eastern Series.

The keratophyres of the Transitional Zone are first seen in the eastern end of Portions 53 and 54, and occur again on the boundary of Portions 53 and 52. (A small mass of Nemingha limestone lies just west of this last). In the first of these, they are vesicular with amygdules filled with quartz, chalcedony, chlorite, and calcite. They become abundant, however, in the Water-Reserve between Portions 51 and 52, are vesicular with abundant quartz in the amygdules, and microscopic examination shows the abundance of quartz in the groundmass. To the south, the mass of keratophyre broadens out into the largest area of igneous rock within the limits of the map. Though only about two hundred yards wide at the northern end of Portion 35, it becomes half a mile in width to the south, and continues thus through Portions 36 and 37, at the southern end of which it is cut off by a fault, which throws it eight hundred yards to the east. Thence it continues for a mile further, exhibiting some very interesting features described below (p.345). This belt of keratophyre forms the western margin of the Transitional Zone; except where jasperised, the rocks to the west of it obviously belong to the Tamworth Series. In Portion 52, a small amount of such jasperised rock occurs, the relations of which have been obscured through the ploughing of the land. More distinct is the small mass of jasper in Portion 35, in contact with a keratophyre rather rich in magnetite.

The main mass of the keratophyre is a rock of fine to medium grain-size, consisting chiefly of albite, a few phenocrysts lying in a trachytic or spongy base, dotted with finely crystalline magnetite. A little quartz is present in the base together with some chlorite. Occasionally, the rock is quite coarsely crystalline, and contains a little augite, approaching the character of albitic quartz-dolerite (1414).

Along the eastern margin of this intrusion in Portion 36, the rock is distinctly brecciated, this facies passing imperceptibly into the massive rock. In microscopic examination, it has the character of a flow-breccia, and sometimes appears to have been originally more or less glassy. Fragments of albite occur with very irregular outline and often slight strain-structure, also irregular fragments of quartz and small grains of uralitised augite, lying in a cryptocrystalline base (1411). In some specimens, the matrix is the predominant portion; in others, the larger fragments of crystals, evidently derived from a shattered dolerite and quartz-keratophyre, form the dominant feature of the rock. With such large fragments of single crystals may be associated chips broken from a minutely trachytic keratophyre (1406), such as are so abundant in the keratophyre-breccias of Pipeclay Creek (**5**, pp.151-156).

In places, the keratophyre becomes enriched in magnetite, and a dark magnetite-keratophyre occurs by the jasper in Portion 35, as noted above, and in the south of Portion 37. The best examples of magnetite-keratophyre, however, are to be found in a small complex, half a mile south of the south-eastern corner of Portion 37, on the head of Bog Hole Gully, in which are exhibited many of the features noted in the Hyde's Creek complex (**5**, pp.133-4). The keratophyre varies from a purely felspathic type to a type irregularly blotched with areas enriched in magnetite, in a matrix of evenly coloured rock. There is also a mass of more or less homogeneous magnetite-keratophyre, which is, however, rather slaggy or vesicular, the openings being filled with calcite (*see* p.373). The margin of this irregular group of intrusions is strongly jasperised, and the jaspers contain irregularly distributed masses of hæmatite. There can be little doubt that here also the ferruginous jasper has been developed by solutions emanating from the keratophyre.

Towards the southern end of the zone of keratophyre, where it is sharply cut off by a fault, the rock becomes much brecciated, and peculiar spherulitic masses are developed, which, when microscopically examined, prove to result from intense secondary silicification (*see* pp.374-375). The rock is traversed by numerous veins of quartz, and, in optical continuity with the grains in these veins, there are roughly circular areas in which quartz has entirely replaced the minutely granular groundmass of the rock, and forms a matrix in which lie embedded the more or less idiomorphic felspar-laths. Each of these areas weathers out like a spherule.

Some long strips of highly silicified claystones are enveloped in this mass.

The Igneous Rocks of the Western Series.

1. The Pyroclastic Rocks.

The Igneous Zone.—One of the most continuous and stratigraphically useful lithological horizons in the Tamworth District is the Igneous Zone, which there lies about 800-1,600 feet above the horizon of the Nemingha limestone. This is not a definite horizon, but merely a lithological zone in which pyroclastic rocks were constantly present, and were often associated with intrusive rocks. This zone is not so clearly marked in the Loomberah District, but seems to be here represented by a fairly continuous band of pyroclastic rocks, which lies a short distance below the Loomberah limestone. Sills of dolerite do not occur in this, but lie a short distance below it, as, for instance, in Portion 61, Loomberah (here the felspar is a labradorite with a marginal zone of oligoclase), and in Portions 59, 58, 24, and 35, in which also the felspars are free from albitisation. The tuffs, however, are more continuous than the intrusive rock, and may be traced right through into the Nundle region.

The Nemingha Red Breccia.—A second igneous zone occurs in the Loomberah District, which is of more distinctive nature and stratigraphical value than the one last noted. It is in close association with the Nemingha limestone, and may be termed the Nemingha Red Breccia. It is especially marked by the presence of a deep red colour. The breccia of which it is composed has evidently been subjected to the action of solutions rich in iron, soda, and carbonates, which have introduced much magnetite and hæmatite into the rock-fragments, and converted their felspars into albite and carbonates. The zone appears first well developed in Portion 58 (Mr. Carter's property), the breccia lying along the western side of each band of limestone (*see* p.330).

It occurs again in the western corner of Portion 55 near the Jasper Knob, and traces of it are seen in the fields south of here. It does not form a definite band, however, until Portion 32 is reached, and there it is marked by a mass of porphyritic dolerite. From this point, it extends to the south, closely associated with the limestone, which at first lies on the east side only, but, nearer Black Jack, appears also west of a band of red breccias five hundred yards in width. Half a mile north of Black Jack, the limestone and breccia-zone is thrown nearly half a mile to the east and its width is nearly doubled, but a second fault crossing the northern face of the mountain while moving the centre of the band of breccia about a hundred yards further to the east, causes it to return to a width of approximately three hundred yards. It is here greatly broken, and numerous masses of Nemingha limestone occur in it. The same horizon has been traced across Cope's Creek, and as far as Silver Gully. Here, the quartz-keratophyre breccia, associated with the limestone, described and figured in a previous paper (5, p.137), belongs to this horizon. In the southernmost extension of the zone, the strong impregnation of the rock by ferruginous solutions, and its consequent red colour, are not always present.

We find in this another zone, which can be traced all through the Loomberah District, and into the Nundle District. It is also seen, in all probability, in the Tamworth District. The masses of red, ferruginous breccia associated with the southernmost masses of the Nemingha limestone in the south-east of the Tamworth Region, doubtless belong to this zone, and it is a matter of great difficulty to determine how much of the pyroclastic rocks on East and West Gap Hills in that parish rightly belong to the Nemingha Red Breccias or to the Igneous Zone.

The Silver Gully Agglomerate.—A short distance westward of this zone, commencing at Black Jack, is a second mass of coarse breccia associated with limestone, which, however, is nearly always in the form of small fragments except on Black Jack itself. This may be traced southwards across Cope's Creek, and obtains a great width in Silver Gully. A small lenticle of limestone appears on the slope to the north of this creek. It is apparently heavily faulted near this creek. Beyond Silver Gully, it continues as a narrowing band containing small lenticular patches of limestone, but is cut off by a fault before reaching Hyde's Creek.

Though the limestones on this zone are of the Nemingha-type, though in small lenses, the lithology of the breccias, the occurrence of fragments of coarse dolerite, etc., and the absence of red colouring, are features so distinct from those of the Nemingha Red Breccias, that the two masses cannot be considered to be on the one horizon. We may conclude, therefore, that the Silver Gully Agglomerate is a third horizon of pyroclastic rocks, intermediate in position between the Igneous Zone and the Nemingha Red Breccias.

This intermediate horizon appears to be repeated on the hills west of Wallaby Mountain. It commences immediately south of the fault which truncates the keratophyre, and here is nearly half a mile wide, and includes a band of a peculiar porphyrite (*see* p.369, specimen 1435). In lithological character, the agglomerate is very like that in the band described last. It may be traced continuously to the south, becoming narrower all the way, until it dies out near the Pipeclay Gully.

Massive Igneous Rocks.

The Keratophyres.—The most striking feature of the massive igneous rocks is the occurrence of a second long zone of keratophyres extending from near the northern end of the map to the southern. The northernmost occurrence in this zone appears to be the few small sills at the head of Oakey Creek, in the Parish of Nemingha; but, further south, there is the keratophyre-complex by MacIlveen's, which clearly belongs to the zone here discussed. It has been already described (**6**, pp.571-3). South of the Peel River, keratophyre appears again in Portion 55, Loomberah, where there is a very inconspicuous outcrop of vesicular, magnetite-bearing keratophyre to the west of Sandy Creek. Beside it, there rises Jasper Knob, a huge mass of jasper, sometimes almost saccharoidal or miarolitic, with chalcedonic quartz and finely divided platey hæmatite, not at all smooth and uniform like the jaspers of the Eastern Series. The hill is about 200 yards long and over 100 yards in width, and is crowned by great crags of jasper rising about 150 feet above the creek. To the north and south, the country-rock is more or less jasperised claystone. There can be no doubt that the presence of the jasper is due to the impregnation or replacement of the claystone by ferruginous solutions emanating from the keratophyre, just as was shown in earlier papers (*e.g.*, **5**, pp.133-4, 137, 164; **6**, p.572). There is, however, a remarkable disproportion between the size of the mass of jasper and the small amount of visible keratophyre.

Passing to the south, no more keratophyre belonging to this zone appears for a distance of about four miles. Then it is seen forming the low ridge in the east of Portion 31, the red breccias and Nemingha limestone occurring along its western margin. It is here a porphyritic rock, with large phenocrysts of acid oligoclase in a finely trachytic base, in which a little quartz is present. From this point, it may be traced across Reedy Creek to the point where it is cut off by the important cross-fault mentioned below (*see* p.351). This portion of the zone includes a very unusual facies of keratophyre, namely, an aphanitic rock with a semi-perlitic fracture. Microscopical examination proves that this is a minutely crystalline variolite (*see* 1405, p.369).

The zone is then thrown to the east, about 600 yards, by the above-mentioned fault, but, a short distance further to the south, it has been thrown back to the west, and continues along the eastern side of the Nemingha limestone across Cope's Creek. In this portion east of Black Jack, it is not entirely uniform, some portions being rather less acid than others (see, *e.g.*, the description of 1383, p.370).

The keratophyre continues south of Cope's Creek, its intrusive nature being rendered clear by the large block of limestone 600 yards south of the creek, which has been torn off from the Nemingha horizon and enveloped by it. It may be traced from this point down to Pipeclay Creek, where it is extremely siliceous, and thence to Silver Gully. The features of this region have already been briefly described (**5**, pp.137 and 154-5). Of particular interest in this southern extremity of the keratophyre zone is the occurrence of the Silver Gully keratophyre-complex (jaspers, magnetite-keratophyre, etc.) which is intrusive into the limestone. The brecciation of the keratophyre, and its passage into what seem to be breccias connected with the Nemingha Red Breccias, are subjects well worthy of detailed study, which the writer, by his removal from Australia, is unfortunately prevented from making.

The Dolerites.

Three separate types of dolerite occur within this area, grouped into three intermittent lines of intrusion. They may be termed—reading from north to south—the Hypersthene-, the Porphyritic, and the Albitic Dolerite.

The Hypersthene-Dolerite.—This belt of dolerites has been already mentioned as lying a short distance below the Igneous Zone. Its northernmost occurrence is by the river-bank in Portion 61, whence it may be traced through Portions 59, 58, and 57. The largest mass lies nearly three miles further to the south, namely, in Portions 24 and 35. This is an almost granitoid rock characterised by the presence of strongly zoned plagioclase, chiefly labradorite, and hypersthene in association with augite and ilmenite. An analysis of this rock, 1387, is given below (p.368).

It is not clear whether any of the dolerites further to the south, such as that in Portion 37, should belong to this group, though they were originally possessed of basic felspar, now partly changed to albite and prehnite.

The Porphyritic Dolerite is intimately associated with the Nemingha Red Breccias, and, therefore, has invaded a somewhat lower horizon than the hypersthene-dolerite. It appears in typical form, east of the limestone in Portion 59, as a handsome, dark green rock (1407). It has pale green phenocrysts of acid labradorite and dark chloritised augite, while the peculiar spongy fabric of the base suggests a relationship to the keratophyres. A much larger mass occurs in Portion 32. This occurs intrusive into the Nemingha Red Breccia. In between these two masses, the large and small fragments of porphyritic rocks in the Nemingha Red Breccia have features strongly suggestive of close association with, if not original membership of this group of intrusions. The ferruginous, albitising solutions have, however, strongly attacked the rocks, changing pyroxenes into iron-ores and carbonates, while plagioclases, originally basic, have passed into albite and carbonates. These have thus become keratophyres through the alteration of dolerite-porphyrites, a process analogous to that described by Neithammer(**18**) and E. B. Bailey (**19**), and they are associated with fragments of normal trachytic keratophyres, more or less impregnated with ferruginous solutions.

It is possible that these porphyrites may be connected with the porphyritic spilites on East Gap Hill, in the Parish of Nemingha(**6**, pp.596-8). The latter pass without break into a red breccia identical in all respects with the Nemingha Red Breccia. The porphyritic rocks are not, however, identical. The East Gap Hill rock has suffered to a greater or less degree from metamorphosing solutions, which have replaced the basic felspar by albite and minutely granular quartz-mozaic.

This correlation would involve some alteration in the details of the tectonics and stratigraphy assumed previously for the neighbourhood of East and West Gap Hills (*see* below).

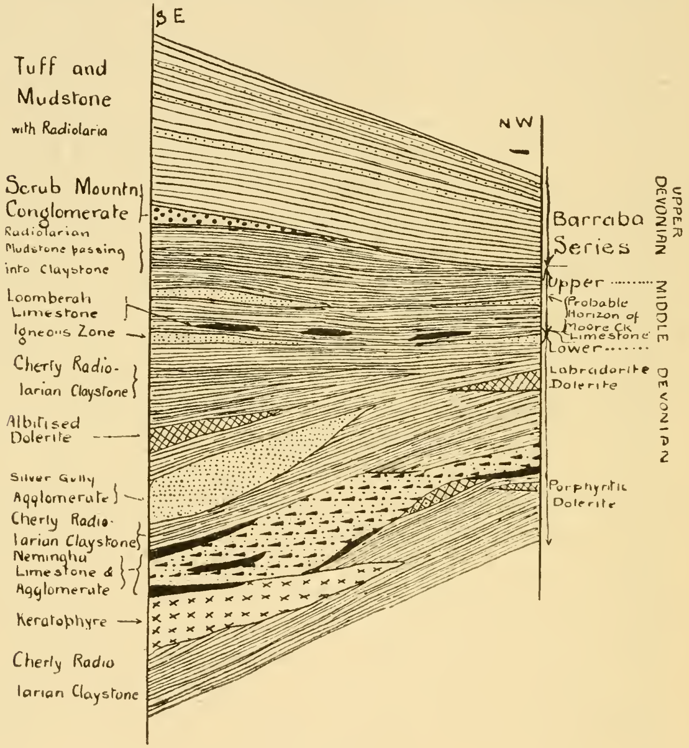
The Albite-Dolerite.—This zone commences to the west of the keratophyre in Portion 37, and occurs first in a series of small isolated lenses running south-east until the first great cross-fault is reached. No more appears for half a mile to the south of this, but, beyond the second cross-fault, a large sill appears, and continues thence without a break across Cope's Creek to Pipeclay Creek, a distance of over two miles. The sill is nearly 200 yards in width, and its dip is approximately vertical. At its southern end, the dolerite is faulted against the eastern mass of the Silver Gully agglomerate, and a great ridge of coarsely crystalline, ferruginous jasper has developed in the plane of movement. (The appearance of this ridge would lead one to expect that a little ferruginous keratophyre would be found along its western face. Time has not permitted the writer to search for this).

Petrologically, this zone is rather varied; a specimen taken from the northern portion shows a mixture of sub-ophitic and sub-variolitic textures, with clear albite, and augite (1378); but west of Black Jack, in the main zone of rock, a dolerite occurs (1376), the albite of which is very dusty and associated with prehnite, and has evidently been derived from a more basic felspar, with associated alteration of the augites to chlorite.

This zone of dolerite, lying as it does between the Serpentine Line and the Nemingha Limestone, is probably to be correlated with the dolerites that extend from the mouth of Sheep Station Creek (three miles south-east of Pipeclay Creek) to beyond Hanging Rock (*see* **3**, Plate xxi.). We may also consider that it finds a repetition in the zone of dolerites and spilites that lie west of the Nemingha Limestone, and extend from near Bowling Alley Point across Moonlight Hill and Tom Tiger into Swamp Creek. In these, many examples of the sub-ophitic to sub-variolitic albite-dolerites have been observed (**5**, Pl. xxv., fig.2).

Summary of Devonian Stratigraphical Succession.

Before attempting to draw up an amended columnar section (Text-fig. 1; see also **6**, p.549), we must point out the uncertainty of some of the data upon which it is based. Owing to the rarity of exposures showing the angle of dip, reliance must be based upon the correlation of certain leading zones with other zones, the horizons of which have been determined in the Tamworth District. This correlation is often lithological only, and the zones compared are sometimes pyroclastic accumulations, which may vary greatly when traced in a lateral direction, or may



Text-fig. 1.
Generalised columnar section of the Devonian rocks of the Loomberah District.

completely disappear, or they may even be sills, which, in addition, may transgress from one horizon to another, while the presence of an indeterminable amount of strike-faulting permits frequent repetition or complete disappearance of some beds. Hence detailed accuracy is impossible. One must either leave the succession a chaos, or attempt to piece together the isolated fragments of evidence, making as few and as reasonable assumptions as possible. The latter course appears preferable.

If reference be made to the earlier columnar section (*loc. cit., supra*), the lowest portion of phyllites, jaspers, etc., may fairly be correlated with such rocks in the Eastern Series as are not comparable with Western types. They are separated from the Nemingha Limestone by the intrusive mass of the eastern keratophyre, a great irregular sill, and an unknown width of transitional rocks. There is possibly a fault west of this, causing the disappearance of all but the small mass of the Nemingha Limestone in Portion 52, which itself would then be a repetition of a portion of the main zone of the Nemingha Limestone. Beneath this main zone, there is also keratophyre closely similar to that to the east of it, and tentatively correlated therewith. The Nemingha Red Breccia reaches its maximum thickness near Black Jack, and is possibly there near the point of its eruption. The Nemingha Limestone is not confined to one horizon only, such as the base of the Red Breccia, but may occur in large lenses at various levels within this breccia, though since the breccia must have been rapidly formed, all such lenses of limestone are practically coeval (*cf.* **6**, p.575). The depth of the sea during the deposition of these limestones must have been considerable to permit of the rapid accumulation of such a thickness of breccia, though Mr. Chapman's remarks suggest (*see* p.390) that this locally may have risen above sea-level and permitted the formation of oolitic limestone. Such local production of islands of pyroclastic material was shown to be probable in the Tamworth District. The intrusion of the porphyritic dolerite seems to have been closely connected with the formation of the Nemingha Breccias.

The deposition of radiolarian cherts and claystones followed, but was shortly interrupted by the outbreak of the volcanic action which formed the Silver Gully Agglomerate extending from Black Jack to Hyde's Creek, the centre of eruption being probably near the southern margin of the map herewith (Plate xxxii.).

Further radiolarian sedimentation followed, with minor volcanic outbreaks, until the more extensive eruptions occurred which have produced the pyroclastic rocks of the Igneous Zone, which are not as thick in the region under discussion as they are in the districts to the north and to the south. Associated, apparently, with this eruption was the intrusion of several dolerite-sills lying below the horizon of the pyroclastic rocks of the Igneous Zone. The sills exposed within the Loomberah Parish are of normal composition, that to the south of Loomberah being albitic. Whether the keratophyres below the Nemingha Limestone were injected at this period or not, cannot be determined at present; they were evidently formed under a considerable cover of sediment. All the tuffs contain fragments of coarse- and fine-grained keratophyric material (but not fragments of ferruginous jasper).

Radiolarian sedimentation ensued once more, and the deposition of the Loomberah Limestone followed, the limestone rising in places above the surface of the sea, so that it has distinctly the features of a littoral formation. Nevertheless, the radiolarian mudstones above and below it are quite of the normal type, the former containing abundant small intrusions of acid tuff

Following the deposition of the Loomberah Limestone is a series of radiolarian claystones and tuff. The most important centre of eruption was near the head of Cope's Creek, the bands dying away rapidly to the north, but continuing some distance to the south. A less important centre of eruption lay near the north-western end of the area mapped, in Calala Parish. Above these agglomerates, the radiolarian claystone gives place to a radiolarian mudstone, softer, and not quite so finely granular as the former rock. No sign of the Moore Creek Limestone is present, though it might be expected near this region of change in character of sediment. In this series occurs the zone of the Scrub Mountain Conglomerate, which, commencing in the south-west of Loomberah Parish, may be traced to beyond Nundle. There is at present no evidence to show the change in geographic condition which led to the development of this formation, but the suggestion has been made above (p.341) that it represents a conglomerate laid down by a sea transgressing over a region which has been upwarped during the eruption of the immense masses of pyroclastic material forming the Baldwin Agglomerates, which extend intermittently from Tamworth to Bingara. If this be so, the Scrub Mountain Conglomerate is approximately coeval with that outbreak.

No angular or lithological unconformity, however, has been recognised between the mudstones above and below that conglomerate. The mudstones above this region (which, if the presumed stratigraphic position of the conglomerate is correct, belong to the Barraba Series) are exactly like those below. They contain the Pyramid Hill tuffs, the centre of eruption of which was near the Pyramid Hill Range, for they die out to the north-west and also to the south-east, as is indicated by the topography of the regions beyond the area mapped. Higher beds than this have not been traced in this region.

The Serpentines, etc.

The band of serpentine in the south-eastern corner of the map of the Tamworth district, continues for nearly a mile till, near the main road in Portion 83, Nemingha (behind Mr. White's residence), it is sharply cut off by a small fault, which has displaced the eastern series a distance of about 100 yards to the north-west. The serpentines of the above band are of varying width, and largely schistose, and do not show any relief. A noteworthy feature is the occurrence in the serpentine, in Portion 105, of a very coarse pegmatitic mass of albite and quartz, which has been shattered and seamed with further veins of quartz. Similar albitic veins occur elsewhere in the serpentine (**4**, pp.691-2). South of the above-mentioned fault, no continuous zone of serpentine is met with. A small lenticle, about 60 yards in length appears in Portion 54, Loomberah, and then no sign of serpentine until Portion 39. Here, nearly six miles from the last occurrence, the serpentine is found in intimate relation with a mass of vesicular spilite. A single band of spilite has apparently been broken by oblique faults, and, into these, peridotite has been injected. The northernmost patch appears actually to invade the spilite, but the rubbly nature of the exposure renders this uncertain. The masses of serpentine to the south have been thrust between the fragments of the sheared mass of spilite, and, beyond these, serpentine occurs here and there in the line of shearing passing southwards up a small gully. Again there is a gap of two miles free from serpentine. It then appears south of Cope's Creek, as a narrow zone, widening to the south, extending through a small saddle into the watershed of Pipeclay Creek. This mass of serpentine contains abundant intrusions of dolerite, of the type frequently present in such association, already described from the neighbourhood of Bowling Alley Point, and Moonbi (**5**, pp.156-7; **6**, pp.615-6).

No further serpentine is seen till on the southern side of the flat opening at the mouth of Hyde's Creek, when a small patch appears on the north side of the Peel River in Portion 9, Parish of Dungowan, and is continued south of the river for a couple of hundred yards, until it is cut off by the southern boundary-fault of this ancient senkungsfeld-area (see below, p. 360). Its further development commences in Sheep Station Creek a mile east of here, and continues to Hanging Rock, as already described (**3**, pp. 582-5).

Granophyre.

A single narrow vein of creamy-white granophyre occurs in Portion 35, and is, perhaps, to be correlated with the veins of granophyre and porphyry associated with the granite in the Nundle District, though the nearest known occurrence of this is ten miles away. It consists of fairly idiomorphic but very kaolinised plagioclase, zoned but apparently acid in the main. These form prisms 0·8 × 0·1 mm. in cross-section, with interstitial quartz and sometimes granophyric intergrowth. Small, brown-green prisms of hornblende also occur, with fibrous extensions, and rarely large grains of magnetite.

The Permo-Carboniferous Sandstones.

Nothing need be added to what has already been published concerning these rocks(**3**, pp.586-7) save in regard to their relation to the faulting, which is discussed in a later section(p.360).

Tertiary Basalt.

The occurrence of the Tertiary basalt is confined to a few localities. It is found only in necks and dykes. The largest neck is the mass of Black Jack itself, a roughly circular area of basalt in which a thickness of about 300 feet of this rock are exposed. There is absolutely no sign of underlying gravels, and the varying height of the lower limit of the exposed basalt seems to depend on the relation of the surface-topography to the margin of a vertical column of rock. Half a mile to the north is another small plug of basalt cutting through the limestones. This is only 100 yards in diameter. A third occurs near the mouth of Hyde's Creek(**5**, p. 172).

Finally, a small dyke of basalt has been noted near the head of Reedy Creek, running in a direction parallel to the trend of the dip-faults. These are quite normal olivine-basalts, concerning which no special petrological features are worthy of record.

Recent Drift and Alluvium.

These terms are employed in the same sense as before(**6**, pp. 590-592). The greatest accumulation of drift is in the large flat near the head of Reedy Creek, a topographic feature whose significance is not quite clear. The alluvium of the flood-plain of the main river includes about eleven feet of loam lying above gravel, which, in the single test known to the writer, reached a thickness of thirty feet. The thickness of the upper stratum of loam is subject to rapid variation. Mr. R. H. Dowe informed the writer that in Portion 59, a fence four feet in height was completely covered in twenty-five years, while nearby, in the hole left by a tree which had burnt down to the roots, it was obvious that the flood-plain level had risen at least eight feet during the life of that tree.

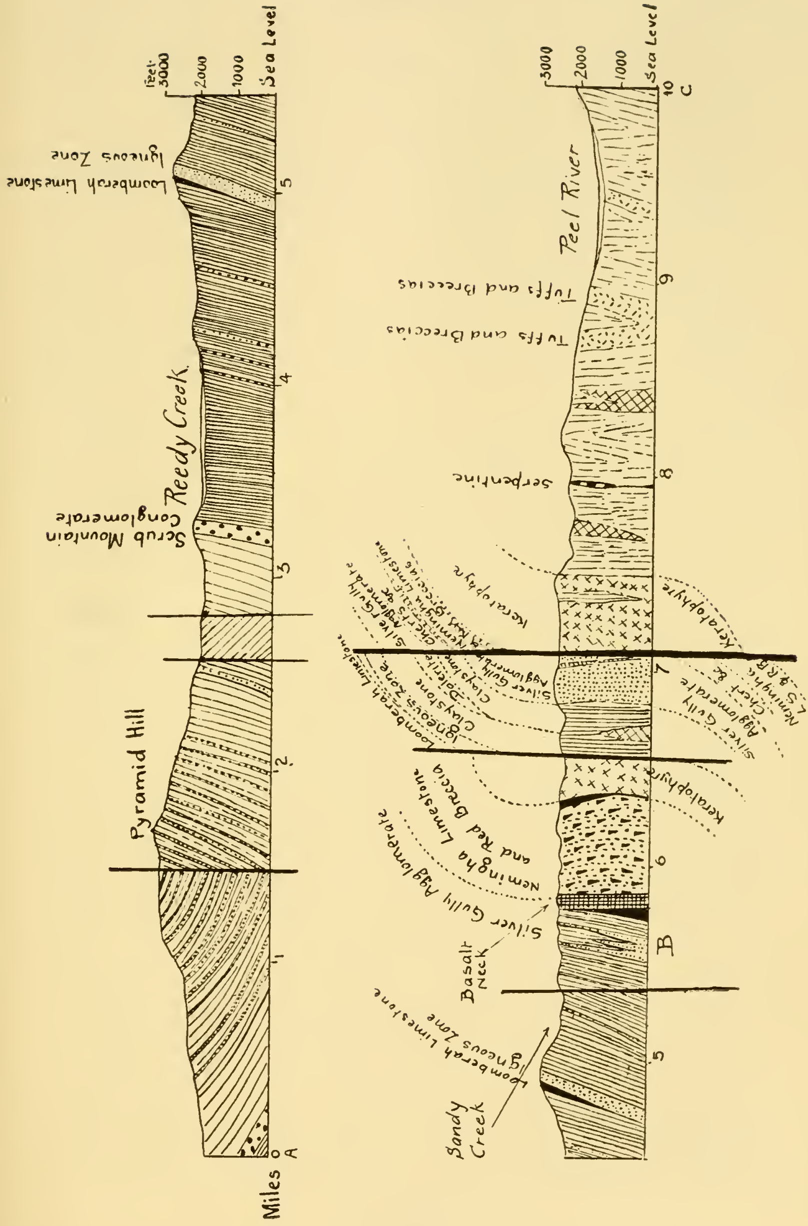
Folding and Faulting.

We are now in a position to summarise the tectonic structure of the district, as deduced from the assumptions made in our stratigraphical correlations. The most obvious fact is a general close folding along an axis running in a direction averaging N. 22° W.-S. 22° E. (magnetic). The folding force came from the east, and the eastern side is most affected. There is a median zone of great crushing into which the serpentines have been injected, and a western zone with a dip at first nearly vertical though predominantly westerly, decreasing in amount as we pass in that direction.

East of this Serpentine Line, however, the strike N. 22° W. is by no means universal, but a more nearly meridional strike is quite common, as shown by the calcareous breccia on the south-west of Wallaby Mt., which runs obliquely to the Serpentine Line, or by the tuffs, etc., outcropping by the roadside in Portion 43, or by the northern end of the serpentine mass in Cope's Creek. This recalls the virgation of strike in the Parish of Nemingha (**6**, map), or that in the region of Mundowey on the Namoi (**2** or **7**, map). But superposed upon this oblique strike is the regional strike shown in the great lines of shear in which are developed the red jaspers, such as those that form the cliffs of Wallaby Mt., and extend to the mouth of Cope's Creek.

We concluded that the eastern mass of keratophyre, in the zone west of the Serpentine Line, may have a fault along its western margin concealing the limestones, for the most part. Another probably occurs along the east side of the western keratophyre. Between these, the chert dips E. 35° N. at 85° in places, and is, therefore, slightly overfolded (see Text-fig. 2). West of the limestone, the beds dip to the west, but there is doubtless a considerable amount of repetition by strike-faulting, with, occasionally, a reversal in dip.

The Pyramid Hill Range structurally is a great syncline, cut by one or more strike-faults. The analysis of the probable folding and strike-faulting thus indicates a structure comparable with that of the Tamworth District and regions further north.



Text-fig.2.
Geological section across the Loomberah District along the line ABC on Plate xxxii.

We have now to consider a second group of faults, concerning which little has yet been mentioned. These run in a direction approximately at right angles to the main line of strike. One is thus reminded of Suess' discussion of flaw-faults or "blatter"(**20**), and might suggest that they were here caused by the differential folding thrust exerted between the Tamworth region, buttressed by the Moonbi Granite, and the Nundle region buttressed by the Duncan's Creek Granite; for, in those regions, strike-faults, such as occur in the Loomberah region, are not nearly so strongly marked a feature. Against this, however, is the absence of any definite evidence as to the relative age of these faults and the granite-masses, and the certainty that considerable vertical, as well as horizontal, movement must have occurred along the fault-planes. The dip-faults are clearly younger than the folding and strike-faulting, and, though the evidence is not yet conclusive, the displacement of the serpentine from its position on the Peel River, near Warden's (Portion 9, Dungowan), to the mouth of Sheep Station Creek, half a mile to the east, may well be due to the marked dip-fault which runs from Hyde's Creek to the Peel River. The dip-faulting then would be later than the intrusion of the ultrabasic rock. Furthermore, it was concluded that the large open area at the mouth of Hyde's Creek owes its origin to the removal, by the river, of an in-faulted block of soft Permo-Carboniferous rocks among the harder Devonian beds(**3**). The southern boundary of this area is marked by the above-mentioned dip-fault; the northern boundary is parallel thereto, and, in all probability, has been determined by a similar fault. The eastern and western limits of this area are sufficiently nearly parallel to the main strike to suggest that they were determined, in some degree, by movement along lines of strike-faulting. Hence part at least of the movement along these fault-planes must have occurred after the deposition of the Permo-Carboniferous Sandstones. This, however, was perhaps posthumous movement on fault-planes first formed during the late Carboniferous folding. The author's removal from the State has prevented his completing the detailed study of the faults around this down-thrown area.

(Continued on p. 363.)

NOTES AND EXHIBITS.

Mr T. Steel exhibited the gizzard of a Muscovy duck with a lateral, vermiform appendage, three-quarters of an inch in length.

Mr. Fred Turner exhibited a specimen of *Geranium molle* Linn., a European annual weed, found growing in Moore Park, in 1891, a species not included in the late Dr. Woolls' "Plants Indigenous and Naturalised in the Neighbourhood of Sydney" (1891).

Mr. J. L Froggatt showed specimens of the common House-fly (*Musca domestica* Linn.) bred from maggots collected from stale and rotten liver in which blowfly-maggots had previously fed and matured, at Moree, N.S.W.; the first time, as far as the exhibitor could ascertain, that this species had been reported as breeding in purely animal matter.

Mr. W. W. Froggatt exhibited specimens of three introduced beetles of economic importance—*Anobium domesticum* Fourer, a wood-borer, introduced from Europe in timber, recently found damaging floors in several localities; *Rhizopertha dominica* Fabr., an Indian beetle, becoming a serious wheat-pest in South Australia, and at Sydney; *Sphenophorus striatus* Fahrs., a Brazilian beetle, whose larvæ attack the basal portion of the stems of Banana-plants in Southern Queensland and in the Tweed River district. Mr. Froggatt also communicated particulars respecting recent migrations of mice in inland districts, and of small, carnivorous Marsupials (*Phascogale flavipes* Waterh.) which prey on them.

Dr. Tillyard showed a specimen of shale with a fossil insect-wing, from the roof of the coal-seam of the Sydney Harbour Colliery, described in a recent paper.

Mr. Fletcher showed a series of Brachyscelid galls from one branch of a tree of *Eucalyptus resinifera*, some of which had incorporated leafy branchlets.

ORDINARY MONTHLY MEETING.

JULY 31st, 1918.

Professor H. G. Chapman, M.D., B.S., President, in the Chair.

Miss **HEATHER SHERRIE**, B.Sc., Science Research Scholar, University of Sydney, was elected an Ordinary Member of the Society.

The Donations and Exchanges received since the previous Monthly Meeting (26th June, 1918), amounting to 2 Vols., 28 Parts or Nos., 1 Bulletin, 1 Report, and 5 Pamphlets, received from 27 Societies, etc., were laid upon the table.

THE GEOLOGY AND PETROLOGY OF THE GREAT SERPENTINE BELT OF NEW SOUTH WALES.

Part vii. The Geology of the Loomberah District and a portion of the Goonoo Goonoo Estate.

By W. N. Benson, B.A., D.Sc., F.G.S., Professor of Geology and Mineralogy in the University of Otago, N.Z., late Linnean Macleay Fellow of the Society in Geology.

With two Palæontological Appendices by F. Chapman, F.R.M.S., A.L.S., Palæontologist to the National Museum, Melbourne.

(Plates xxxi.-xxxviii., and five Text-figures).

[Continued from p.360].

Petrology.

The only rocks of special interest, to which attention will be devoted in the sequel, are the massive Devonian Igneous rocks. It was hoped to make a complete study of the rocks which occur as fragments included in the coarse Silver Gully Agglomerate and the Scrub Mountain Conglomerate, but the securing of sufficient material was prevented by want of time. The attention of future investigators is directed to this point. Of the massive rocks, we find, in this region, several types not elsewhere noted in the Middle Devonian Series, namely, hypersthene-dolerite; porphyritic dolerite with basic felspar; various types intermediate between dolerite or spilite, and keratophyre; a semiperlitic variolite; and a peculiar pseudospherulitic or blotched, silicified, pyroxenic keratophyre. The conclusions previously reached, as to the mode of origin of magnetite-keratophyres, and their relation to normal keratophyres, and jaspers are quite confirmed.

Dolerites and Spilites of the Eastern Series and the Transitional Zone.*

In Portion 43, there occurs a very quartzose dolerite, No. 1398. The felspar occurs in perfect prisms and prismoids. It is an andesine only slightly zoned and very turbid. The augite is in idiomorphic grains, with a normal optic axial angle. It is more or less replaced by chlorite. Ilmenite forms large angular grains; and quartz is very abundant in large interstitial grains, and is never granophyric. The spilite (1390) which occurs in Portion 36 by the western boundary of Portion 47, is a very fine, even-grained

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* In a review of the earlier parts of this series of papers, Professor Johannsen (Journ. of Geol., 1917, p.494) writes:—"The term dolerite is apparently used in a different sense from that common in the United States, where it signifies a coarse-grained basalt containing a basic plagioclase. The writer speaks of albitization proceeding inwards in the felspar, by which he apparently means that the sodic rims are secondary. It would seem more probable that the zonal rims are primary. The rock thus appears to be an augite-andesite." It is, therefore, desirable to state that the albitic rocks indicated are structurally, and in their mode of occurrence, similar to those termed albite-diabases by Flett and Dewey (Geol. Mag., 1911), and differ from them chiefly in the better preservation of the pyroxene. Subsequent research has shown that they are associated with rocks with basic plagioclase, which are quite similar to, say, the Devonian diabases of Germany. The name dolerite was adopted in conformity with Dr. Harker's practice (*see* Petrology for Students, 4th Edition) to indicate the original nature of the rock. The term augite-andesite might have been misleading. The secondary nature of the albite was inferred partly from comparison with the analogous rocks studied by Flett and Dewey. Subsequent work led the writer to doubt the universality of the albitisation, and the present investigation leaves him with the feeling that the albite may sometimes be a primary magmatic crystallisation, sometimes the result of secondary post-volcanic replacement by magmatic solutions. Analyses show that such albitisation is accompanied by an addition of soda. In the case of analcite, it has been shown that these two stages merge into one another, and it is suggested that the same may hold in regard to albite.

rock with small phenocrysts of augite and albite. In structure, it is closely comparable with the usual types of spilite in the Eastern Series, but it has been rather crushed. The highly altered pillowy spilites and associated dolerites in Portion 56 remain to be mentioned. The dolerite (1377) was originally ophitic, and though the rock has been completely decomposed, the structure has been retained. The felspar has been replaced by strained quartz and chlorite, the latter when forming a large area being generally spherulitic. The silica is sometimes chalcedonic, and may have narrow margins of carbonate. A second form of alteration is to calcite, with a small amount of residual albite. The augite is entirely changed to platey chlorite. A little magnetite remains. The spilites forming the pillows are represented by Nos. 1112 and 1124. In these, the original structure is more or less lost, owing to the decomposition of the constituent minerals. Traces, however, indicate that the felspar formed prisms, which are now replaced either by chlorite (1124) or a clear, colourless, intermediate material (1112), which is perhaps a zeolite. The pyroxene was idiomorphic (1112) or ophitic (1124), and is now changed to chlorite in green plates with spherulites, or associated with dolerites or calcite. The formation of chlorite is accompanied by the separation of magnetite.

The Igneous Rocks in the Tamworth Series.

The Dolerites.

The Dolerites with basic felspar occur in the northern of the two series of intrusions already described, those with albite are in the southern intrusions. The freshest example of the first group is a rock (1387) from the large intrusions in Portions 24, 35. It has a structure intermediate between the granitoid and subophitic. The felspar is strongly zoned, the main portion being labradorite, the margins of the grains oligoclase. The ferromagnesian minerals are abundant, augite in sub-idiomorphic grains being predominant. Hypersthene, however, occurs in considerable amount in large, roughly idiomorphic grains (upon which the augite is sometimes moulded), occasionally containing idiomorphic plagioclase. The hypersthene is decomposing peripherally in the usual manner. Biotite occurs in very small amount in minute plates. Titaniferous magnetite is abundant in irregular masses moulded to some extent upon the felspar and pyroxenes. Apatite forms abundant large prisms, and quartz occurs in a considerable amount in granular mass in interstices. A very complete analysis of this rock by Mr. Mingaye is given below. It is of particular interest as being the first instance of a hypersthene-bearing rock observed in the Devonian series.

Closely related to this, but less rich in coloured constituents is the coarsely granular dolerite in Portion 61 (1384). In this, the rhombic pyroxene is entirely decomposed, and is represented by pseudomorphs of talc and chlorite. Prehnite also occurs as an alteration-product. The small patch of dolerite east of the keratophyre in Portion 37, is apparently of compound nature, containing both normal and albitic dolerites. The first of these is exemplified by specimen No. 1409, a coarsely granular dolerite, with a felspar chiefly labradorite, though clear patches of oligoclase-andesine occur. The felspar is largely altered to prehnite. The augite has been partly altered to form chlorite, and crystals of magnetite are present. Quartz and hypersthene are absent.

The Albitic Dolerites.—The albite-dolerite in the occurrence mentioned above is a very clear, fresh rock (No. 1378), fine-grained, and with a glomero-porphyritic to ophitic fabric, with small, fine-grained, sub-variolitic patches. The felspars give no sign of zoning; they are quite fresh albite-oligoclase, and, in the variolitic areas, there are skeletal extensions from the ends of the crystals consisting apparently of albite. The pyroxene is often quite undecomposed; at other times, it is replaced by chlorite. There are peculiar spherulitic aggregates of hæmatite in the variolitic portions. Ilmenite occurs in small crystals. Closely related to the above is the dolerite (No. 1394) occurring by the boundary of the Peel River Company's Estate, a mile due south of the last occurrence. The felspars, though albite, are a little dusty. The augite-crystals are partly chloritised, forming irregular crystals.

These two rocks clearly belong to the same group of dolerites as figured in Part iv., Plate xxv., fig. 2.

The next mass of dolerite (No. 1393), half a mile to the south-east of the point of occurrence of No. 1394, is a rock of medium grain-size, with albite-felspar, interstitial quartz occasionally granophyric, and augite almost completely changed to chlorite; a little magnetite also is present.

The dolerite in the belt of rocks which crosses Cope's Creek, is exemplified by No. 1376. Though the felspar in this rock is now a very dusty albite, it has certainly been derived from a more basic mineral. It is sometimes a little spongy, containing prehnite, which also occurs interstitially in large clear patches. The augite is entirely replaced by chlorite; ilmenite and apatite occur in rather large grains.

The Porphyritic Dolerites, generally closely associated with the Nemingha limestone, may be illustrated by the description of three specimens. It occurs in Portion 59, immediately east of the limestones, and is a fresh-looking, dark green rock with phenocrysts of felspar and augite(No.1407). The felspar is an acid labradorite, and is only slightly zoned. The augite-phenocrysts are, in parts, quite fresh, while some are completely changed to pseudomorphs of chlorite, and carbonates in one instance, with a further replacement of the centre of the pseudomorph by quartz and chalcedony. There are also small phenocrysts of magnetite. The base has a spongy fabric similar to that of quartz-keratophyre. It consists of short laths of dusty labradorite, an abundance of minute crystals of magnetite, and a good deal of interstitial quartz.

The following analyses, generously contributed by Mr. J. C. H. Mingaye, F.I.C., F.C.S., show the composition of this rock, and also that of the dolerite with basic felspars.

	No. 1387.	No. 1407.
SiO_2	51·14	58·17
Al_2O_3	14·47	16·07
Fe_2O_3	3·60	2·60
FeO	8·28	3·96
MnO	0·22	0·18
NiO, CoO	abs.	abs.
MgO	5·80	3·22
CaO	9·64	8·18
BaO	*trace	0·07
SrO	†present	†trace
Na_2O	2·43	2·22
K_2O	0·57	1·90
Li_2O	abs.	abs.
$H_2O -$	0·34	0·22
$H_2O +$	2·52	1·78
CO_2	abs.	0·93
F	—	—
TiO_2	0·75	0·55
ZrO_2	abs.	abs.
P_2O_5	0·08	0·16
FeS_2	abs.	0·07
SO_3	abs.	abs.
Cl	*trace	*trace
Cr_2O_3	*trace	abs.
V_2O_3	0·03	0·02
	99·87	100·30
Specific gravity	2·929	2·763

* Less than 0·01%. † Spectroscopic reaction only.

No. 1387—Dolerite with hypersthene and basic felspar, Portions 24, 35, Parish of Loomberah.

No. 1407—Porphyritic Dolerite, Portion 59, Parish of Loomberah.

These analyses should be compared with those given on page 602 of the fifth paper of the present series (**6**).

No. 1416, from Portion 32, is very similar in general character to No. 1407, though rather more decomposed. The presence of chlorite replacing the inner portion of a zoned plagioclase-phenocryst is a noteworthy feature.

What appear to have been originally similar rocks, though now altered by the ferruginous and albitic solutions which traversed the Nemingha Red Breccia, occur in fragments by the limestone in Portion 58. Specimen No. 1116 is a good example of these. It has a sub-variolitic to pilotaxitic base, consisting of small laths of acid plagioclase, from which grow-out skeletal felspars or sub-radiating microlites, with finely divided interstitial magnetite, together with larger well-formed magnetite crystals, interstitial quartz, and a very little chlorite. Here and there are irregular areas of calcite. The large phenocrysts of felspar are entirely replaced by albite, dotted with calcite. The trace of the original zoning is very obvious.

A peculiar type of porphyrite occurs interstratified in the agglomerates between Black Jack and Wallaby Mountain. It is a dense fine-grained, black rock (No. 1435) with phenocrysts of fresh augite, usually singly twinned, and large crystals of plagioclase which are extremely full of inclusions of chlorite, apparently replacing augite-grains, or portions of glassy groundmass, containing skeleton-crystals of ilmenite. The groundmass of the rock has a basaltic texture more like that of some lamprophyres than of spilites. It consists of long prisms of augite and of plagioclase with skeleton-ilmenite, together with a considerable amount of platey chlorite.

Variolite is represented by a single example (No. 1405). It occurs in the Peel River Company's Estate half a mile to the south-west of the southern corner of Portions 31 and 37 (Loomberah). It is a dark green, aphanitic rock with a very poorly developed perlitic fracture. Microscopically, it proves to be an extremely finely crystalline rock, composed of sub-radiating sheafs of minute felspar-microlites, with fine grains of magnetite arranged among them. There are a few small phenocrysts of albite and augite.

The Keratophyres.

The keratophyres may be grouped into five main divisions. i.The pyroxenic keratophyre. ii.The keratophyre proper. iii.The magnetite-keratophyre. iv.The nodular siliceous keratophyre. v.The keratophyre-breccia. These pass into one another.

The pyroxenic keratophyres are those fine- and coarse-grained types of rocks, which are intermediate in composition between the dolerite-spilite group, on the one hand, and the felspathic keratophyre on the other. They may or may not contain quartz. As instances of these may be described specimen No. 1414. This is a pinkish rock of medium grainsize and syenitic appearance, occurring a quarter of a mile south of the point where Sandy Creek enters the Parish of Loomberah. It is granitic in texture, consisting of grains of albite up to 1 mm. in diameter, irregular prisms of augite partly uralitised or altered to chlorite, prisms of apatite, and a minor amount of sphene in irregular grains.

The western keratophyre-zone is exemplified by two rocks, which may be classed with the pyroxenic keratophyre-group. At the northern end of this zone, in Portion 31, the keratophyre (No. 1415) is porphyritic with phenocrysts of albite, augite, now completely chloritised, and ilmenite associated with small crystals of apatite in a glomero-porphyritic aggregate lying in a pilotaxitic base of laths and small phenocrysts of albite with interstitial quartz. Further south, on the same belt, just east of Black Jack, occurs a rock (No. 1383) rather more pyroxenic than this. It is dark green in colour, consisting of well crystallised albite-laths, generally about 0·2 mm. in length, together with small phenocrysts of the same mineral 1 mm. in diameter, partly replaced by chlorite zonally arranged. Interstitially between the felspar-laths is a small amount of devitrified glass. The augite occurs in small grains often more or less chloritised, and, in addition, there is a fair amount of magnetite. The keratophyre of this zone is, however, usually more acid than this, as instanced by specimens described below, and the highly siliceous rocks near Pipeclay Creek.

Bearing in mind Neithammer's suggestion (**18**), supported by E. B. Bailey (**19**), that keratophyres are often only albitised porphyrites, we may include in this group specimen No. 1123 from the Nemingha Red Breccias (Portion 58). It is closely allied to No. 1116 described above (p. 369), and contains idiomorphic phenocrysts of plagioclase, in which a little original andesine remains, though most is replaced by albite or calcite. There are also small phenocrysts of fresh augite and magnetite. The groundmass is extremely fine-grained, with a trachytic structure dotted with finely crystalline magnetite.

The keratophyres proper, which consist essentially of acid plagioclase, are rather less abundant than other rocks. They usually have present in them some other mineral, and as this becomes sufficiently important to distinguish the rocks, the necessity arises of adding a qualifying mineral name to the term keratophyre. The keratophyre on the border of Portions 35 and 36, Loomberah, is one of these containing the least amount of minerals other than albite. It consists of minute laths of albite in pilotaxitic to trachytic groundmass, in which a few small phenocrysts of albite-magnetite and chlorite apparently replace augite. The felspars of the groundmass are also associated with a very small amount of interstitial quartz, and there appears to be a small intergrowth of the felspar-laths with quartz, forming little irregularly-shaped patches with the same optical orientation throughout. The groundmass is cut by a few fine-grained veins of clear albite. The most felspathic of the keratophyres associated with the Nemingha Red Breccia (No. 1123) is a highly porphyritic rock with phenocrysts of plagioclase, now albite, with a large amount of calcite, a little perfectly fresh augite, and a few large grains of magnetite lying in a groundmass of very finely trachytic felspar, dotted with magnetite dust and containing a very little interstitial quartz. Finely divided calcite is also distributed in cloudy masses throughout the rock, which has evidently been greatly affected by carbonating solutions. No. 1413, from near the head of Bog Hole Gully, indicates the most felspathic member of the group of ferruginous keratophyres, recalling the features of the brecciated keratophyres from Hyde's Creek (No.1296, described in an earlier paper; 5, p.151), though the nodular structure is not so well developed. It comes from near the southern end of the eastern mass of keratophyre. The more ferruginous types of this series are considered below.

Quartz-keratophyres are more numerous. Some, such as No. 1434 from the mass of keratophyre east of Black Jack, contain small phenocrysts of albite in a base of not very fine grainsize. This is spongy in texture, consisting of laths of albite, with a small amount of magnetite-dust; rather larger, well formed laths lie in the mass of microlites, together with large grains of quartz often with chalcedonic margins. Exactly similar rocks have been described from Pipeclay Creek, a mile and a half further to the south-east along the same band of rock (**5**, pp. 155-6). Another type of quartz-keratophyre occurs in the creek in the Water Reserve between Portions 51 and 52. This is exemplified by specimens Nos. 1388 and 1421. The former contains quartz, forming a general groundmass, in which are laths of albite with a general trachytic arrangement, sometimes less abundant than the quartz, but generally more so. Scattered about is chlorite (replacing augite), and crystals of magnetite. Lines of shearing traverse the rock, and the magnetite is often congregated in these.

As a final example of siliceous keratophyres, we may instance No. 1404, from the extreme southern end of the eastern mass of keratophyre. This is a very fine-grained rock, crushed slightly and intersected by veins of quartz, often very narrow. The groundmass consists of irregular patches of minutely granular, untwinned grains of felspar, in which are embedded innumerable minute laths of acid plagioclase with a more or less trachytic arrangement; between these is a small amount of finely divided magnetite-dust, and small irregular grains of quartz occur among this. There are phenocrysts of albite, and a few irregular patches of chlorite. The magnetite also occurs in the lines of crushing, being evidently introduced secondarily.

The magnetite-keratophyres may be subdivided into those which contain quartz, and those which do not. We will consider the latter first. Near the head of Bog Hole Creek, in the south-eastern end of Portion 37, is a small mass of hæmatitic iron-ore, and by it is a very hæmatitic keratophyre (No. 1427), which consists of fine-grained, trachytic albite-laths, with small phenocryst-laths 0·5 mm. in length, densely impregnated with more or less oxidised magnetite. The rocks contain angular patches of trachytic keratophyre, almost free from iron-ore. The latter is aggregated in the cracks. Analogous specimens occur elsewhere, generally not so oxidised.

The complex of magnetite-keratophyres at the head of Bog Hole Gully, contains the same variety of rocks as does that near Hyde's Creek, previously described (**5**, pp. 150-154). Nodular keratophyres occur (No. 1410), in which the rock is made up of fragments of trachytic keratophyre, very enriched in magnetite in the centre of each fragment, but free from it at the margin. Between the fragments are strings of more coarsely crystalline keratophyre and calcite, apparently introduced at the same time as the secondary magnetite, *i.e.*, during or immediately after the brecciation. The calcite is thus to be considered as derived from the magmatic solutions. In another example (No. 1420), the magnetite-keratophyre is amygdaloidal, the vesicles containing calcite or quartz, and deep green epidote, and occasionally large grains of magnetite. The magnetite is rather unevenly distributed, but, in the irregularly bounded regions in which there is very little finely divided magnetite, there is a roughly proportional amount of large ragged aggregates of magnetite, sometimes surrounded by calcite, and in particular, the magnetite is aggregated into crevices and around the vesicles as described from MacIlveen's complex (**6**, p.600). Associated with this same complex, is the quartz-bearing keratophyre very poor in magnetite (No. 1413) described above.

The Quartz-magnetite-keratophyres are of several types. The most common is exemplified by specimens from the Water Reserve, between Portions 51 and 52, by one (No. 1417) from near the Jasper Knob in Portion 55, and by No. 1401 in Portions 35, 36. All these rocks are vesicular, the vesicles being filled usually with quartz and chalcedony, together with a little epidote and occasionally felspar. Rarely, they are filled with chlorite and quartz. The groundmass of the rock consists of a spongy mass of laths of acid plagioclase with interstitial quartz, dotted with minute crystals of magnetite. The phenocrysts are albite sometimes undergoing replacement by quartz, magnetite, rarely augite (No. 1401). A frequent feature occurs around the margin of the vesicles or in large irregular cracks. The spongy texture of the groundmass here becomes exceedingly minute in grainsize, and very dark with finely divided magnetite. The groundmass is a mosaic of minute interlocking grains of quartz. If felspar be present, it is entirely untwinned, and the abundance of the magnetite prevents its recognition by the bright-line method. The distribution of lath-shaped areas in the rock free from magnetite, which were doubtless originally felspar, indicates a general poorly developed trachytic structure. Large areas rich in magnetite appear to replace pyroxene-phenocrysts, and, in addition, there are abundant phenocrysts of albite. This rock is possibly an altered form of an augite-porphyrite.

The group of the *Silicified-Nodular* or *Blotched Keratophyres* comprises a series of very remarkable rocks occurring in the southern end of the eastern zone of keratophyre. In hand-specimen, they are very fine-grained or aphanitic green rocks with masses of silica, weathering out into beads set irregularly or in long rows as in spherulitic rhyolite, or covering the whole surface of the rock with a network-pattern of cracks weathered out between more resistant silicified patches. Microscopically, the rock, in its unaltered state, would be classed among the more basic pyroxenic keratophyres. It has a trachytic base of small laths of acid felspar, with an abundance of chlorite pseudomorphs after granular augite, and scattered small grains of magnetite. In this base are phenocrysts of albite, sometimes arranged in groups (the glomeroporphyritic structure), a few irregular masses of chlorite, which possibly represent original pyroxene-phenocrysts, and some small phenocrysts or aggregates of magnetite. Well defined prisms of apatite often appear in the vicinity of the phenocrysts. The resistant portions of the rock prove to be rounded or irregular regions in which the pyroxene has been completely removed, and the felspar-laths remain apparently unaltered, lying in a matrix of quartz which is in optical continuity over an irregularly bounded area. Each resistant region or "pseudospherulite" may consist of several such areas of quartz. Where the rock is traversed by a small vein of quartz cutting through one of these replacement-areas, the quartz in the matrix of the rock, on either side of the vein, will often be in optical continuity with that in the vein. Sometimes, the rock contains only a few of such replacement-areas (*e.g.*, No. 1408), which are generally rather sharply bounded, but, in other specimens, the whole of the groundmass is replaced (No. 1425), and very little indeed of the coloured constituents remain.

In addition to these veins of quartz, there are occasionally (*e.g.*, in No. 1386) to be found veins less than 0·5 mm. in diameter, which consist of a fine-grained mosaic of water-clear albite, which may be associated with a little calcite.

The brecciated keratophyres which occur along the eastern margin of the eastern keratophyre zone, have already been sufficiently described (*see* p. 344).

No further remarks need be added to the description of the Devonian pyroclastic rocks given in previous papers. A number of peculiar forms of alteration of the rock-fragments in the Nemingha Red Breccia have been noted, but the general conditions attending the development of that formation are now sufficiently well established, and these details are merely confirmatory.

NOTES ON THE LOOMBERAH FOSSILS.

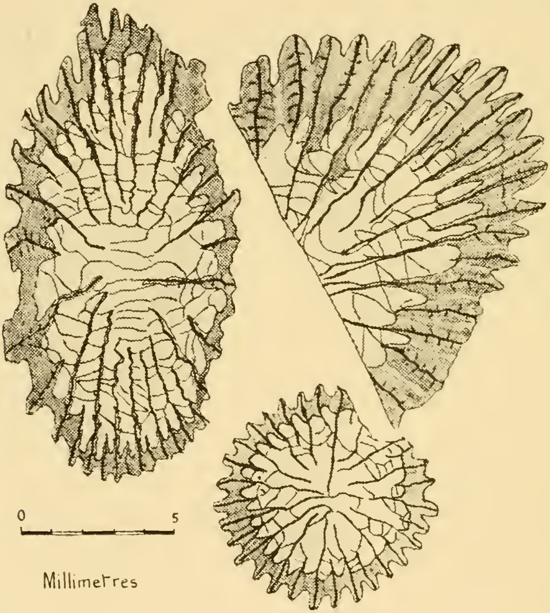
As pointed out above, the fauna of the Loomberah limestone has been found by Mr. W. S. Dun to contain a number of new and interesting forms, concerning which he has kindly contributed the following valuable notes, and to these are added further remarks by the present author, which are placed between brackets:—

"This limestone is, in most cases, of detrital origin, and, especially in the case of the Rugose Corals, the preservation is so unsatisfactory that, although many of the forms are new, the specimens are so imperfect, that it is impossible to obtain sufficient evidence to make the diagnosis proper to a new species."

"*Zaphrentis*, sp. ind.—One specimen. The transverse section shows 61 septa, with a dense pseudocolumella, and limited stereoplasma. (*See* Plate xxxv., fig. 6.) The longitudinal section shows very irregularly placed tabulæ strongly concave."

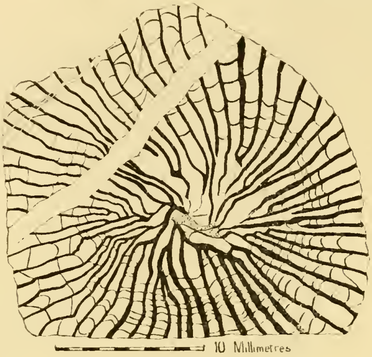
"*Zaphrentis*, (?) sp.—A single specimen of a very interesting

Zaphrentoid coral. It is simple, with a diameter of 13 mm. There are 38 septa, with thick septal walls. The costæ are very pronounced, projecting for about 2 mm. The bases of the septa are thick for a limited distance, the greater extent being free from stereoplasma, fluctuate, and not quite reaching to the centre. This is a most distinct form, and may constitute a new subgenus of Zaphrentis, but the material available is too limited to enable a satisfactory diagnosis to be drawn up." (*See* Plate xxxiv., fig. 1, and Text-fig. 3.)



Text-fig. 3.
Transverse and oblique sections of *Zaphrentis* sp. nov. (? subgen. nov.), (× 4), Loomberah Limestone.

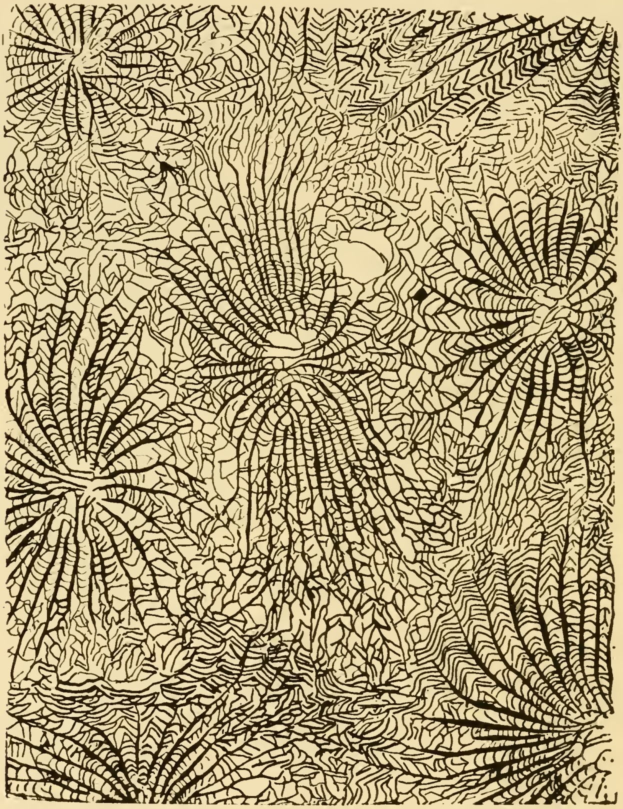
"*Cyathophyllum*, sp. ind.—A large, simple type, the transverse section only being available. Diameter, 16·5 mm. The septa have limited stereoplasma, and there are 58, comprised in two cycles. The shorter septa are irregular in length, and frequently anastomose with the primaries. The dissepimental structures are limited in number and irregular (*see* Text-fig.4). There is no Australian Cyathophylloid of this type hitherto described. The specific characters are the sparse development of dissepimental tissue, the steroplasmic layer on all septa being developed to a rather abnormal extent."



Text-fig.4.
Transverse section of *Cyathophyllum* sp. nov., (×2), Loomberah Limestone.

"*Spongophyllum*, (?) sp.nov.—An aberrant type of *Spongophyllum*, in which the structure of the corallite-wall is masked, its place being taken by dense vesicular tissue. (See Pl. xxxv., figs.2 and 3, and Text-fig.5). The septa are more persistent than in other Australian Spongophylloids, and, in most cases, spring from the replaced wall, there being a space of about 5mm. of vesicular tissue separating the septal ends of adjoining corallites. Dissepimental tissues are dense, and the vesicles are small. The septa in the central area are 24-30 in number. To the naked eye, this remarkable coral has the general appearance of a *Phillipsastræa* but, under the lens, the septa are seen to be non-confluent. The absence of a true wall may not necessarily separate it from the Spongophyllums, as specimens of the typical *S. bipartita* from the Silurian of Yass, have, in some cases, a portion of the corallite-wall undeveloped. It is even possible that this may represent a stage between *Spongophyllum* (sensu stricto), and *Endophyllum*."

[A recent statement by Dr. S. Smith appears to illustrate this remark (**21**)—"Among the Rugose colonial corals there are certain genera, or certain species within a genus, in which the corallites have lost their epitheca, and are united by their dissepimental tissue. The septa of adjacent corallites in the astræiform colony tend to become confluent, but all stages of this development, from that in which it is incipient to that of perfect confluence, are to be found. In some cases, on the other hand, the septa of one corallite do not extend to those of another, and leave an intervening space to the sole occupation of the dissepiments. Astræiform colonies make their appearance in widely divergent stocks, and at different periods of time; being, it would seem, the ultimate terms in a progressive development along a well-defined line."]



Text-fig. 5.
Transverse section of *Spongophyllum* sp.nov., (× 4), Loomberah Limestone.

"*Phillipsastræa grandis*, sp.nov.—A very large type of *Phillipsastræa*, the centre of the corallites being 2 cm. apart" [2·5, 1·7, and 1·6 cm. in three adjacent corallites in the specimen illustrated in Plate xxxv., figs. 4 and 5.] "The septa are variable in length and number; there are 23-28 of the longer, and the shorter reach to the limit of the central area. This species is quite distinct from any of the Australian forms I have seen, and no closely allied species from extra-Australian regions are known to me." [There is a species, *P. gigas*, occurring in the Lower and Upper Middle Devonian beds of North America, Onondaga and Hamilton Series, in which the centres of adjacent corallites are more than 2 cm. apart (**22**); but further details concerning this form are not available here. *P. verneuilii*, which was recognised by De Koninck (**9**) in a specimen obtained by the Rev. W. B. Clarke, from Cope's Gully, near Hanging Rock, had from 28-32 septa, and the centres of the adjacent corallites are 10-12 mm. apart. It is extremely probable that this form came from a development of the Loomberah limestone near the head of Cope's Creek, just outside the limits of the area mapped in Plate xxxii.]

"*Favosites gothlandica.*"

"*Favosites*, sp. ind. (sp. nov.?).—Transverse sections of one specimen only are available. This form is distinct from any of the types of the Australian Devonian rocks, and is remarkable for the very irregular form of the corallites. (*See* Plate xxxv., fig.7). Additional material will probably prove it to be a new species."

[In addition to the forms recognised by Mr. Dun, mention may be made of a very interesting slide, which, unfortunately, has been mislaid, and cannot here be figured. It was cut from a form, apparently *F. gothlandica,* but in which the wide spacing of the tabulæ was replaced for a distance of about 6 mm., by closely packed tabulæ, as near together as in *F. multitabulata*. The change occurred quite sharply on one side, and more gradually on the other, and at the same level in adjacent corallites, as if brought out by a rapid change and slower reversion in the local conditions.]

"*Plasmopora* sp.—A single specimen of a small *Plasmopora* is contained in the collection. It is quite indeterminable specifically, though distinct from forms in the Nemingha limestone, and the Murrumbidgee beds."

[*Heliolites porosa.*—This occurs in numerous large masses, the exact shape of which is not apparent. Measurements of the dimensions of the parts of the form agree exactly with those given by Mr. Etheridge for corals of this species in the limestone of Moore Creek (**23**).

Chætetes stelliformis, sp.nov., Chapman.—An account of this form is given in Mr. Chapman's interesting note in the second appendix to this paper. While he refers to the rarity with which it occurs out of the Carboniferous system, it is interesting to note that De Koninck remarks that the specimen of *Campophyllum flexuosum* received by him from Quadong was enveloped in a mass of some size of *Chætetes goldfussi* (**9**, p.54)].

"The Stromatoporoids, which form the best index of the age of the Loomberah limestone, are well preserved. They are represented by the forms *Stromatoporella loomberensis*, *S. bensoni*, and *Actinostroma australe*, all new forms, and an indefinite species. The appearance of these is distinctly Devonian, the forms closely resembling typically Middle Devonian species. As has been pointed out by Heinrich (**24**), the discrimination of the different species of Stromatopora is extremely difficult, and the final test is the conventional use of measurements of the interlaminar spaces, and the spacing of pillars. Numerous averages of measurements have been taken in the case of Professor Benson's specimens, and it is thought that the erection of new species is justified." [As will be seen from the photographs in Plates xxxvi., xxxvii., and xxxviii., all enlarged two and a half diameters, and from macroscopic examination, the following appear to be the characteristics of these species:

Stromatoporella loomberensis.—The cœnosteum is roughly hemispherical, sometimes reaching as much as 20 cm. in diameter. It is divided into concentric latilaminæ, about 3 mm. wide. The vertical section (Plate xxxvi.) shows that the laminæ are very definite and continuous, except for the occasional presence of crossing zooidal tubes. There are about sixteen laminæ in the space of a centimetre. They are connected by radial pillars, which extend perpendicularly across all the laminæ making up a latilamina, and may continue even beyond these. These pillars also lie about sixteen in the space of a centimetre. Occasionally, there are Caunopora-tubes, one of which (appearing in figure 8) is about 3 mm. in greatest diameter. A tangential section shows the presence of astrorhizæ.

Stromatoporella bensoni (Plate xxxvii.).—The shape of the cœnosteum cannot at present be stated. The latilaminæ are less definitely marked than in the preceding species. The laminæ are so spaced that about fifty occur in a centimetre, while the radial pillars are also about the same distance apart. They continue across several laminæ, at times as many as thirty or forty. The narrow, tabulate, zooidal tubes also continue across as many as ten laminæ, but are difficult to distinguish from the ordinary interpillar spaces. Small astrorhizæ are recognisable in the vertical section. The Caunopora-tubes are abundant, and have a diameter of about 0·5 mm., and show infundibuliform tabulæ. This form appears to be similar in some respects to *Parallelopora dartingtonensis* (Carter), from the Middle Devonian of Devonshire.

Both these forms of *Stromatoporella* show a more definite network, and more continuous radial pillars than the majority of the forms discussed by Nicholson (**25**).

The cœnosteum of *S. loomberensis* is unusually large, and its laminæ and pillars are unusually far apart; in *S. bensoni*, on the other hand, they appear to be closer together than is normal for the genus. In addition to the two forms mentioned, there is a large form apparently belonging to this genus, in which the preservation is less perfect. In this, the laminar and pillar-spacing is farther apart than in the case of *S. loomberensis*, there being about ten laminæ and nine pillars in the space of a centimetre. The pillars are apparently short.

Actinostroma australe (Plate xxxviii.) is characterised by well developed horizontal or slightly wavy laminæ, with scarcely noticeable latilamination. The type-specimen is a flattish fragment, so that the form of the cœnosteum is not ascertainable. There are thirty-eight laminæ in the space of a centimetre, joined by pillars extending across as many as fifty laminæ, in some instances. The laminæ and pillars together form a rectilinear meshwork. There are about thirty-five pillars in a centimetre. No zooidal tubes are recognisable, but there are numerous Caunopora-tubes, about 0·25 mm. in diameter, with infundibuliform tabulæ. This form is extremely like *A. clathratum* Nich., and especially that variety of the species which occurs in the Middle Devonian rocks of Germany. This latter species has also been recognised by Professor Nicholson in the Devonian rocks of Western Australia. Until the publication of his Monograph (**25**), it was usually considered to be *Stromatopora concentrica* Goldfuss. The specimen here described as *A. australe* may come from the Loomberah limestone, but it is more probable that it was found in Portion 163 of the Parish of Nemingha, "Beedle's Freehold," in the Nemingha limestone.]

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EXPLANATION OF PLATES XXXI.-XXXVIII.

Plate xxxi.

Topographical Map of the Loomberah District.

Plate xxxii.

Geological Map of the Loomberah District.

Plate xxxiii.

Pillow-lavas exposed in the road-cutting by the Loomberah Bridge, eleven miles south-east of Tamworth.

Plate xxxiv.

Fig. 1.—Section of the Loomberah Limestone, showing its fragmental character; and transverse sections of *Zaphrentis*, sp.nov., (? subgen. nov.), Z, Treptostomatous Bryozoans, B, valves of *Pentamerus*, P, and indeterminate fragments; (× 3/2).

Fig.2.—Transverse section of *Spongophyllum*, (?)sp.nov., from the Loomberah Limestone; (×3/2).

Fig.3.—Longitudinal section of *S.*(?), sp.nov.; (×3/2).

Plate xxxv.

Fig.4.—Approximately longitudinal section of *Phillipsastræa grandis*, sp. nov., Dun; (×3/2); Loomberah Limestone.

Fig.5.—Transverse section of *P. grandis*, sp.nov.; (×3/2).

Fig.6.—Transverse section of *Zaphrentis*, sp.ind.; (×3/2); Loomberah Limestone.

Fig.7.—Transverse section of *Favosites*, sp.nov.; (×3/2); Loomberah Limestone.

Plate xxxvi.

Fig.8.—*Stromatoporella loomberensis*, sp.nov., Dun; vertical section; (×5/2).

Fig.9.—*S. loomberensis*, transverse and partially tangential section showing astrorhizæ; (×5/2).

Both from the Loomberah Limestone.

Plate xxxvii.

Figs.10-11.—*Stromatoporella bensoni*, sp.nov., Dun; transverse sections showing Caunopora-tubes; (×5/2).

Plate xxxviii.

Fig.12.—*Actinostroma australe*, sp.nov., Dun; transverse and partially tangential section showing Caunopora-tubes; (×5/2).

Fig.13.—*A. australe*, vertical section; (×5/2). Probably from the Nemingha Limestone.

Appendix i.

DEVONIAN FORAMINIFERA; TAMWORTH DISTRICT, NEW SOUTH WALES.

By FREDK. CHAPMAN, A.L.S., F.R.M.S., Palæontologist to the National Museum, Melbourne.

(Plates xxxix.-xli.)

Introduction.

At the request of Dr. W. N. Benson, B.A., F.G.S., I am giving the details of foraminiferal evidence which I noticed whilst examining some micro-sections of limestone from the Nemingha horizon of the Tamworth Series The method of studying foraminifera from rock-slices, without accompanying specimens showing the exterior of the test, is not entirely satisfactory, but the fact that these organisms are of Devonian age is, in itself, of sufficient importance to merit a record of the occurrence, foraminifera being extremely rare in Devonian faunas.

The Rock-structure and its Stratigraphical Association.

The foraminifera under notice occur in a well-developed oolitic limestone in which granules form a little more than half the bulk of the rock. The granules vary in diameter from 0·46 to 0·7 mm., and only a small proportion are entirely due to oolitic accretion; whether originally of algal origin or not it is impossible to say, on account of their present mineralised condition. The nucleus of the oolite-grain in more than one case was seen to consist of an ossicle of a crinoid. The majority of the grains, however, are microgranulitic in structure, either in the nucleus, or more rarely throughout the entire granule. Certain of these, from their more irregular outline, and often without an external coat of concentric oolitic deposit, led me to suspect their foraminiferal relationship, which conclusion is borne out by further study of the specimens. Some of the perfectly spherical grains are, I feel convinced, of a radiolarian nature, and here and there one can detect a central sphere. There is a fair amount of iron-staining in the rock-structure, which seems to be entirely secondary, as the stain is developed more strongly along incipient fracture-lines than in the grains themselves.

From Dr. Benson's work on the rocks of the Tamworth District,* it is seen that the Nemingha horizon can be correlated with the lower part of the Middle Devonian.

Previous Records of Devonian Foraminifera.

In turning to consider the occurrence of foraminifera in other parts of the world, we find only one authentic record of these minute fossils, viz., that of Terquem's, who figured and described a few forms from the Middle Devonian of Paffrath in the Eifel.† On p.417 of Terquem's note, he states that the foraminifera were found in some sand contained in a *Megalodon*-shell. They were in the condition of casts. The material was probably referable to foraminifera and ostracoda, but generally indeterminable. Some spheres covered with thick and sharply pointed spines he referred to *Orbulina*. These were very common, and measured 0·48 mm. in diameter. A pyriform cast was referred to *Lagenulina* (a subgenus of *Lagena*). A cristellarian was also noticed by Terquem, presenting the arrangement of chambers seen in *Cristellaria vetusta* from the Lias. A fusiform cast was compared to *Fusulina*; and numerous globular casts, consisting of two or three chambers, were identified as *Globigerina*. Judging from my own observations of radiolarian structures in the Devonian of Silesia and Bavaria, I am inclined to think that Terquem's prickly Orbulinæ may have more than a fancied relationship to the orbicular radiolarians. In connection with the present work, I have recently examined some disintegrated limestone from Paffrath, from shells in the National Museum, and

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* "The Geology and Petrology of the Great Serpentine Belt of New South Wales. Part v. The Geology of the Tamworth District." Proc. Linn. Soc. N. S. Wales, 1915, Vol. xl., Pt.3, pp.540-624, Pls. xlix.-lviii.

† Terquem, O.—"Observation sur quelques fossiles des epoques primaires." Bull. Soc. Geol. France, ser.3, Vol. viii., 1880, pp.414-418, Pl. xi.

have succeeded in finding a small but representative series of foraminifera, radiolaria, and ostracoda which I hope to describe shortly.

The only other allusion to Devonian foraminifera that I have so far come across, is that by E. Wethered, in his paper on the limestones of South Devon.* In speaking of the organic constituents of the *Goniatite* limestone (Upper Devonian) from a quarry at Whiteway Farm, near Chudleigh, Mr. Wethered says —"The specimens collected as typical of this limestone show it to be quite different in structure from the beds below. There is a fine crystalline groundmass in which are several fragmentary remains of organisms. One of these appears to be a foraminifer, and it is especially interesting as being the only one found in my slides of the South Devon limestones. The Goniatite limestone seems to have been formed by an accumulation of small shells, foraminifera, etc., which have been filled in with a fine calcareous mud." Wethered does not, however, refer the foraminifer he saw to any particular genus.

Description of the Foraminifera.

Fam. ASTRORHIZIDÆ.

Subfam. SACCAMMININÆ.

Genus PSAMMOSPHÆRA Schulze.

PSAMMOSPHÆRA NEMINGHENSIS, n.sp. (Plates xxxix , figs.1-2; xl., fig.10; xli., figs.11-12).

Description.—Test rudely spherical to elongate flask-shape. Wall composed of granular particles neatly fitted together, forming one or two layers, and distinct from the large crystalline grains of the matrix more or less completely infilling the cavity of the test. Apertures apparently between the components of the test-wall or, more rarely, as a slight protuberance on the surface.

Diameter, circ. 0·4 to 0·75 mm.

Observations.—The above form has a certain resemblance to

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* "On the Microscopic Structure and Residues Insoluble in Hydrochloric Acid in the Devonian Limestones of South Devon." Quart. Journ. Geol. Soc., Vol. xlviii., 1892, pp.377-387.

Saccammina, but it never has the orifice so strongly protuberant. *Psammosphæra*, as a genus, has not been found in fossil deposits older than the Jurassic, from which system Dr. Haeusler* has recorded the living species *P. fusca* Schulze. The present species is less than half the size of the Jurassic and recent forms.

P. neminghensis is by far the commonest foraminifer in the Nemingha limestone, representing about 90 per cent. of the entire foraminiferal remains.

Fam. TEXTULARIIDÆ.

Genus VALVULINA d'Orbigny.

VALVULINA PLICATA, Brady. (Plate xxxix., figs.3, 4).

Valvulina plicata Brady, 1873, Mem. Geol. Surv. Scotland, Expl. Sheet 23, pp.66, 95, etc.; Idem, Pal. Soc. Mon., Vol. xxx., 1876, p.88, Pl. iv., figs.10, 11. Chapman, 1907, "Notes on Fossils from the Collie Coal-field," Bull. Geol. Surv. W. Austr., No.27, p.16, Pl. ii., figs.10*a-c*.

Observations.—Several specimens occur in the microscope-slides, which compare closely with Brady's species from the Lower and Upper Carboniferous Limestone of England and Scotland, as well as in the *Fusulina*-beds (Carboniferous) of Iowa, U.S.A. The writer has described a diminutive specimen of the above species from the Carbopermian Sandstone associated with Glossopteris leaves from Collie, W. Australia.

An example occurs in one of the slides, which indicates a plastogamic union of two individuals, as frequently seen in *Discorbina*, *Vaginulina*, and other genera.

VALVULINA BULLOIDES Brady. (Plate xxxix., figs.5, 6, 7).

Valvulina bulloides Brady, 1876, Pal. Soc. Mon., Vol. xxx., p.89, Pl. iv., figs.12-15. Chapman and Howchin, 1905, "Mon. Foram. Permo-Carboniferous Limestones of N. S. Wales," Mem. Geol. Surv. N. S. Wales, Pal., No.14, p.13, Pl. i., figs.9*a-c*.

Observations.—This species closely resembles a high and tumid *Globigerina*, but is easily distinguished by the open umbilical cavity on the lower surface, and the valvuline aperture.

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* Quart. Journ. Geol. Soc., Vol. xxxix., 1883, p.26, Pl. ii., fig.1.

V. bulloides was previously confined to the Carboniferous and Carbopermian. Dr. H. B. Brady records from the *Fusulina*-beds of the Upper Coal-Measures of North America, the Calcaire de Namur of Belgium, and the Fusulina-Limestone of Miatschkovo, near Moscow. The same species was described by Mr. Howchin and the writer from the Carbopermian limestone (Branxton Stage of the Upper Marine Series), of Wollongong, N. S. Wales.

Not uncommon in the Nemingha Limestone.

VALVULINA OBLONGA, sp.nov. (Plate xl., fig.8).

Description.—Several examples of an elongated valvuline type occur in the slides. They remind one of a short, stout *Haplophragmium*, or the *Lituola nautiloidea* Lam., figured by Dr. Brady from the Carboniferous of Northumberland,* but show the depressed base and characteristic aperture of these Devonian and Carboniferous modifications of *Valvulina.*

The longer diameter of a fairly complete specimen in section is 1 mm.; the shorter diameter, 0·65 mm.

PULVINULINA BENSONI, sp.nov. (Plate xl., fig.9).

Description.—This species differs from the majority of the test-sections in the micro-slides of the Nemingha limestone in having a finely granulate shell-wall, which may, at one time, have been of hyaline structure. The section figured shows a certain amount of depth, although sliced, and indicates a pulvinuline type of shell with few, lobulate chambers, and a wavy, peripheral margin. It was probably depressed on the superior face, and slightly conoidal on the inferior.

The nearest Palæozoic form to this seems to be *P. broeckijana* Brady,† from the Carboniferous Limestone of Namur, Belgium, but differs essentially in its rounder outline and less inflated chambers. It belongs to the *Pulvinulina elegans* group, and, from its size and contour, indicates a shallow-water variant of that type of shell.

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* Pal. Soc. Mon., Vol. xxx., 1876, p.63, Pl. viii., figs.7*a*, *b*.

† Pal. Soc. Mon., Vol. xxx., 1876, p.140, Pl. vi., figs.12*a-c*.

Summary.

The components of the Nemingha limestone appear to be largely foraminiferal, comprising, so far as the evidence from microscope rock-sections shows, an abundant species of *Psammosphæra* — *P. neminghensis*; and the following more or less sparsely represented — *Valvulina plicata* Brady, *V. bulloides* Brady, and *V. oblonga*, sp.nov.; whilst *Pulvinulina* appears to be present in *P. bensoni*, sp.nov.

The genus *Psammosphæra* is more at home in deep rather than in shallow water, though it has been found in depths as little as 45 fathoms. The other genera indicate a fairly shallow-water habitat.

One special point of interest stands out conspicuously in the foraminifera of this limestone, viz., the rather strong resemblance of the rare Devonian foraminiferal fauna to the Carboniferous and higher beds of the Palæozoic.

Radiolaria seem to form a considerable proportion of the granules in the Nemingha limestone, but their mineralised condition precludes any reference to definite genera.

As regards the probable depth at which the rock was formed, one might reasonably assume it to be of moderately deep water origin from the occurrence of *Psammosphæra* and the radiolarians. On the other hand, oolitic grains are indicative of quite shallow-water areas, though this latter constituent is by no means predominant, and may not materially affect the above conclusion. The general condition of deposition must have been such as would obtain in a moderately deep inland gulf with quiet sedimentation and accumulation of ooze-forming organisms; and it is just possible that the oolite-grains may have been blown into the area of deposition from dunes of shore-sand origin in the vicinity.

In conclusion, I would tender my sincere thanks to Dr. Benson for giving me the opportunity of examining this interesting limestone, and facilitating this attempt to describe a unique faunula by furnishing the microscope-preparations.

EXPLANATION OF PLATES XXXIX.-XLI.

Plate xxxix.

Fig. 1.—*Psammosphæra neminghensis*, sp.nov. Section through test showing shell-wall and introverted aperture.

Fig. 2.—*P. neminghensis*, sp.nov. Section showing interior thickened with secondary calcitic deposit.

Fig. 3.—*Valvulina plicata* Brady. Section through and a little above the base.

Fig. 4.—*V. plicata* Brady. Two tests, probably in plastogamic union.

Fig. 5.—*V. bulloides* Brady. Flattened and almost complete test.

Fig. 6.—*V. bulloides* Brady. Median section.

Fig. 7.—*V. bulloides* Brady. Nearly complete test.

All figures magnified 52 diams.

Plate xl.

Fig. 8.—*Valvulina oblonga*, sp.nov. Basal section; (× 52).

Fig. 9.—*Pulvinulina bensoni*, sp.nov. Almost complete test; (× 52).

Fig. 10.—Section through *Psammosphæra neminghensis*, showing relative thickness of test; (× 144).

Plate xli.

Fig. 11.—Section of Nemingha limestone with oolite-grains, *Psammosphæra*, and (?)radiolarian; (× 28).

Fig. 12.—Ditto, with oolite-grains and *Psammosphæra*; (× 28).

Appendix ii.

NOTE ON A NEW SPECIES OF CHÆTETES.

By FREDK. CHAPMAN, A.L.S., F.R.M.S., Palæontologist to the National Museum, Melbourne.

(Plate xlii.)

Introduction.

The genus *Chætetes*, founded by Fischer in 1837,* is almost entirely confined to the Carboniferous. Nicholson, in his "Tabulate Corals of the Palæozoic Period,"† says "The species of *Chætetes* as here defined, are not known to occur out of the Carboniferous (and possibly the Devonian) rocks," but he does not specify any occurrence from the latter system. Zittel states that the genus is also found in the Lias and Upper Jurassic.‡

It is, therefore, deeply interesting to find an Australian species of the *C. radians* type in the Loomberah Limestone,§ which, if Dr. Benson's final conclusions bear out his preliminary investigations, belongs to the upper part of the Middle Devonian. The peculiar habit of the corallites in this genus, in showing partial fission of some of the calices by imperfect partitions which are tooth-like projections in horizontal section, is well shown in the present species. Further, it is important to note that our species shows the presence of a dark line in the septal wall, notwithstanding its supposed absence from that of *C. radians*.||

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* Oryct. de Gouv. de Moscou, p.159.

† London, 1879, p.266.

‡ *See* Zittel. Traité de Paléontologie, 1883, Vol. i., Pt. i., p.623. Also Eastman-Zittel, Text-book of Paleontology, Vol. i., 1913, p.118.

§ *See* Proc. Linn. Soc. N. S. Wales, 1915, xl., Pt.3, pp.546, 549, and 559.

|| Eastman-Zittel says (*op. cit.*, pp.117)—"Walls thoroughly amalgamated, common to adjacent corallites." Nicholson (*op. cit.*, p.263) says "Rough fractures (generally, but not always) expose the interior of the tubes; and thin sections, whether transverse or longitudinal, show that the walls of contiguous corallites are entirely and undistinguishably amalgamated or fused with one another, the originally duplex character of the partition between neighbouring corallites being in no case recognisable."

CHÆTETES STELLIFORMIS, sp.nov. (Plate xlii., figs.1-3).

Description.—Corallum massive, moderately large. Corallites crowded, slender, and gently curved. In cross-section roundly polygonal and occasionally elongated, averaging about 0·5 mm. in diameter; with one to four, but generally three, blunt peg-like teeth projecting into the cavity, representing imperfect fission of the calices by longitudinal partitions on the calicular wall. Tabulæ well developed, from 0·5 mm. to 1·5 mm. apart, sometimes in continuous planes across the corallum, but often more irregular and strongly curved. Unlike other species of *Chætetes*, a fine but distinct dark line is seen dividing the walls of the cells (see remarks *antea*).

Observations.—This coral is of the type of the abundantly distributed *Chætetes radians* Fischer, from the Lower Carboniferous of Russia, England, and elsewhere,* but is distinct in many points, as in the more roundly polygonal calices, the more numerous longitudinal partitions appearing as projecting tooth-like processes in cross-section, and in the strong fusion-points where calice-wall and tabulæ meet. In longitudinal section, this latter feature is very marked, and, at the point of junction, forms a stout cross with pointed arms.

Chætetes depressus, Fleming sp.,† is characterised by much smaller calices, measuring 0·2 mm. to 0·26 mm., or about one-half the diameter of *C. stelliformis*. The diameter of the calices in *C. radians*, on the other hand, is practically the same as that in *C. stelliformis*, viz., about 0·5 mm. In the excellent figures of *C. radians* given by Dr. Nicholson in his "Tabulate Corals,"‡ those of the Russian Carboniferous specimens show a much thicker calicular wall than in *C. stelliformis*, whilst the

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* Oryct. de Gouv. de Moscou, 1837, p.160. Pl. xxxvi., fig.6. See also Lonsdale, in Murchison, Verneuil and Keyserling, Geol. Russia in Europe, Vol. i., 1845, p.595, Pl. A, fig.9.

† *Favosites depressus* Fleming, Brit. Anim., 1828, p.529. *F. capillaris* John Phillips, Geol. Yorkshire, 2nd Pt., 1836, p.200, Pl. iii., figs.3-5. *Alveolites depressa* Fleming sp., Edwards and Haime, Mon. Brit. Foss. Corals, Pt. iii.; Mon. Pal. Soc., 1852, p.158, Pl. xlv., figs.4, 4*a*.

‡ *Supra cit.*, Pl. xii., figs.4, 4*a-d*.

tabulæ are remarkably regular and horizontal, as distinguished from the irregular and strongly curved tabulæ in the Australian Devonian species. On the same Plate, Nicholson has figured (fig. 4*c*,*d*) sections of a coral from the Carboniferous of Shap, Westmoreland, which he refers to *C. radians*, and which approaches the Australian species in its thin walls and more conspicuous projections.

EXPLANATION OF PLATE XLII.

Chætetes stelliformis, sp.nov.

Fig. 1.—Exterior of fractured surface of specimen, showing small size of corallites, their gently curved habit and interrupted platforms of tabulæ; 1⅐ nat. size.

Fig. 2.—Transverse section of corallum, showing strong development of partitions and occasional fission of corallites; (× 16).

Fig. 3.—Longitudinal section, showing complex nature of wall, curved tabulæ and longitudinal partitions; (× 16).

STUDIES IN AUSTRALIAN *MECOPTERA.*

NO. ii. THE WING-VENATION OF *CHORISTA AUSTRALIS* Klug.

BY R. J. TILLYARD, M.A., D.Sc., F.L.S., F.E.S., LINNEAN MACLEAY FELLOW OF THE SOCIETY IN ZOOLOGY.

(Plate xliii.; and four Text-figures).

In collecting the evidence required for my work upon the Panorpoid Complex, it was found necessary to examine the pupal tracheation of examples of all the Orders there studied. The only Order in which this had not yet been done (for at least one example of the Order) was the Mecoptera; in which so little is known of the life-histories, that it appears that only two observers, Brauer in Austria and Miyaké in Japan, have ever succeeded in following up the complete life-history of any single species. Neither of these authors was seized with the importance of making a study of the pupal wing-tracheation, although it is evident that the opportunity was offered to both of them.* The work of both was carried out upon the genus *Panorpa*, which is abundant enough in the Northern Hemisphere, but does not occur in Australia.

It was therefore necessary for me to set about the discovery of the pupa of some Australian representative of the Order. The only species that is at all common round Sydney is *Harpobittacus tillyardi* Esb.-Pet. But this belongs to a family that is, in many ways, the most highly specialised of all the Mecoptera; whereas, for my purposes, it was clear that an archaic representative of the Order was to be preferred. I therefore decided to follow up the life-history of the rare *Chorista australis* Klug, of which I

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* Brauer's work was done long before the Comstock-Needham Theory of Venation saw the light. Miyaké's work is of recent date, but its objective was not venational, and the pupal wings were not examined.

had obtained only about seven specimens in the course of as many years.

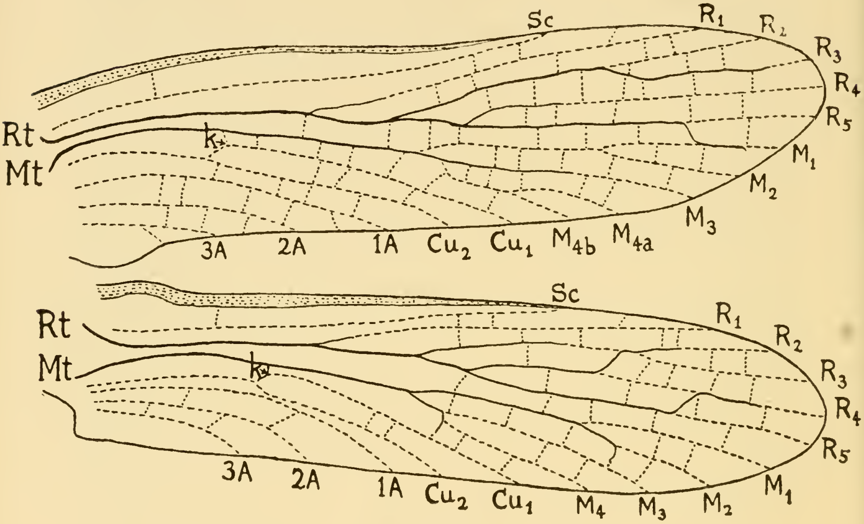
Last year, I had the good fortune to find this rare species fairly commonly, for the first time since I had begun collecting insects around Sydney (about fourteen years). More fortunately still, the area in which they occurred was a very restricted one, only about a quarter of a mile from my house at Hornsby. In this locality, I took, in the course of three weeks' collecting in April, 1917, nearly one hundred specimens of this species. Several of the females laid eggs, but unfortunately none of these were fertile. I therefore watched carefully to see where the females appeared to be ovipositing, and determined to select a small area where there would seem to be a probability of finding the larvæ in February and March of this year.

As nothing is known of the life-history of this species, I worked upon the supposition that its larva would behave much as that of *Panorpa*; *i.e.*, that it would become rapidly full-fed, and then burrow into the ground and remain there for the greater part of the year, only pupating a week or two before the emergence of the imago. This supposition proved to be fairly correct. Digging and sifting of the soil in which the larva was expected to occur was begun in February and continued into March. The details of this arduous but interesting work are best left to be given in a full account of the life-history, which I hope to publish later on. Meanwhile, it will be sufficient to say that, one day in March, freshly turned pupæ were obtained, and that these were at once made use of for the purposes of this paper.

Owing to the shape of the pupa, and the direction of the wing-sheaths, which are laid more parallel to the abdomen than is usual in pupæ, it was not found practicable to use the method adopted previously in the case of *Chrysopa.* It was necessary to separate the wings from one another carefully, and to cut them off at their extreme bases with sharp scissors. As the wings are excessively delicate, this was not easy to do successfully. The photomicrographs obtained show how the delicate wings became creased near their middles, in the endeavour to separate the glued extremities; and also how, in the forewing, a portion of the fat-body, lodged in the extreme base of the wing, got carried over on to the wing when the cover-slip was let down upon it. Apart from this, the results obtained were quite satisfactory.

The Mecoptera are generally regarded as being an extremely archaic Order of Insects; and rightly so, for both in their general structure and in their Palæontological record, the evidence tends to emphasise the fact that they are quite as old as any existing Holometabola, if not older. Within the Order, the genus *Chorista* is one of the most archaic types still extant, and shows close relationship to forms found in the Permian. I was therefore quite prepared, and indeed expectant, to find a very primitive and complete tracheational development in the pupal wings of this insect; and I was relying upon this to solve certain problems concerning the fusion of some of the main veins near the base of the wing, which cannot be determined with certainty from the imaginal venation. But the result obtained was quite different from what was expected; and, if there is any truth at all in the Comstock-Needham Theory of Wing-Venation, we must regard *Chorista* as a very highly specialised type in this one particular, if not in any other.

The facts of the case can be gathered very readily from a reference to the photomicrographs in Plate xliii., as well as the drawings in Text-fig.1. *There are only two main tracheæ entering the wing-rudiment.* One of these belongs to the costo-radial group, and passes into the main stem of the radius. In the forewing, after giving off a very short and slender branch to R_1, it passes on along the radial sector. At the forking of Rs into R_{2+3} and R_{4+5}, it follows the upper branch, giving off a fairly strong branch-trachea along the lower. Arriving at the forking of R_2 from R_3, it bends weakly down into the latter, and does not reach the tip of the wing. The lower branch of this trachea passes along R_{4+5} into R_5, giving off a short branch to R_4, and finally ends up by bending down into R_{5b}. In the hindwing, there is only a minute vestige of the branch into R_1. The main trachea passes on into Rs; arriving at the fork of the sector, it gives off only a weak branch into R_{2+3}, and passes on into R_{4+5}. Branches of about equal strength are given off to both R_4 and R_5. The former passes up along a cross-vein into R_2, while the latter performs a similar evolution nearer to the apex of the wing, ending up in R_4.



Text-fig.1.

Wings of a pupa of *Chorista australis* Klug, ♀, freshly-turned; (×21). Semi-diagrammatic, the tracheation represented by continuous black lines, the imaginal venation by dotted lines; *k*, the point at which Cu_1 meets a short cross-vein from M, eventually fusing with M in the imaginal venation: *Mt*, median trachea; *Rt*, radial trachea. For rest of lettering, *see* p.408.

The second main trachea of the wing is of smaller calibre, and belongs to the cubito-anal group. It enters the wing-rudiment along the media. In the forewing, it is quite unbranched, and passes finally into M_3 in an almost straight line. In the hindwing, it gives off short branches to the cubital fork and also to M_{3+4}, and its distal end passes into a cross-vein below M_2.

A second pupa was examined and its wings photographed, but the negatives obtained were not very satisfactory. In this case, the distal endings of some of the tracheæ were different from those recorded above; *e.g.*, the trachea in R_2 of the forewing passed down into R_4 viâ a cross-vein. The median trachea of the forewing also gave out a short branch to the cubital fork.

Only two pupæ were available for study. There can be little doubt that further minor variations would have been found had a longer series of pupæ been examined.

There is only one conclusion to be come to from this result. It is, that the Mecoptera, as exemplified by the archaic genus *Chorista*—and, therefore, presumably, by other existing genera—are highly specialised as an Order along the same lines that we find in the Hymenoptera, Trichoptera, and Diptera, viz., by the reduction of their wing-tracheation. The cause of this reduction is almost certainly the same in all four Orders, viz., that the tracheæ do not grow into the wing-rudiment until the latter has been fully formed, with the venational scheme completely laid down. In such a case, there is no longer any need for a tracheational scheme, to guide in the laying down of the venational scheme originally based upon it; the only necessity is to supply the wing with oxygen. Consequently, there will be a tendency to reduce the tracheal supply to the minimum necessary for this purpose; and, also, for the tracheæ to cease to follow their original paths, and to take instead the path of least resistance. Both these tendencies are well illustrated by the case here studied.

The same tendency, with many stages still preserved to us, has been noted already in the Order Plectoptera; an Order which, curiously enough, approaches most closely to the Holometabola, in that it possesses, in its sub-imaginal stage, what appears to have been Nature's first attempt to evolve a true resting-stage or pupa. The pupa of the archaic Mecoptera closely resembles the imago in everything except the form of its mouth-parts and the non-expansion of its wings. Thus it only differs from the subimago of the May-flies in being unable to fly, and in slightly less mobility of its free appendages. In the Order Plectoptera, there are a number of genera known in which the remaining wing-tracheæ all come off from a single stem. This must be regarded as a higher specialisation than that found in the Mecoptera, or in any Holometabolous Order. For, in all of these, it would appear that *two* is the minimum number of wing-tracheæ yet reached in the course of evolution, *i.e.*, one from each of the main tracheal groups.

It is interesting to compare the courses of these two tracheæ in the four Holometabolous Orders which show reduction. Of the four, the only one which retains the media intact and separate from the base onwards is the Mecoptera. In this Order, the trachea belonging to the cubito-anal group passes into the media, which is as far forward as it could possibly get. This shows clearly that, in the ancestral form of the Mecoptera, the median trachea had already become attached to the cubito-anal group, as it has in most Orders of Insects. In the Hymenoptera, the media is suppressed in the imaginal venation, and only a bare vestige of its trachea is to be seen in a very ancient family, the *Siricidæ*. The principal trachea of the cubito-anal group passes along the cubitus, and may or may not be accompanied by a separate anal trachea below it. In the highest forms, this latter becomes fused with the cubital trachea; so that the condition of two tracheæ only, in the wing-rudiment, is there fully reached. In the Trichoptera and Diptera, in which the media is fused basally with either the radius or the cubitus for a greater or less distance, the trachea of the cubito-anal group passes likewise along the cubitus.

From a study of this character only, then, it is clear that the Mecoptera present a more archaic stage than that seen in the Trichoptera and Diptera; and hence there is no evidence here *against* the presumption that both these Orders are derived from the older Mecoptera, as Handlirsch supposed. The Hymenoptera, on the other hand, cannot be derived from the Mecoptera, since they show a more archaic stage in the *Siricidæ* and some other families (where more than two tracheæ are still present), even though they stand far in advance of the Mecoptera in having the media eliminated from their venational scheme.

Turning now to the Orders Lepidoptera and Planipennia, we see that both of these preserve the complete set of tracheæ in the pupal wing. In this character, then, they are both of them much more archaic than the Mecoptera and the other three Orders discussed above. It must be clear, therefore, on this character alone, that the Lepidoptera cannot be descended either from the Mecoptera, as Handlirsch supposed, or from the Trichoptera, as Meyrick would have it.

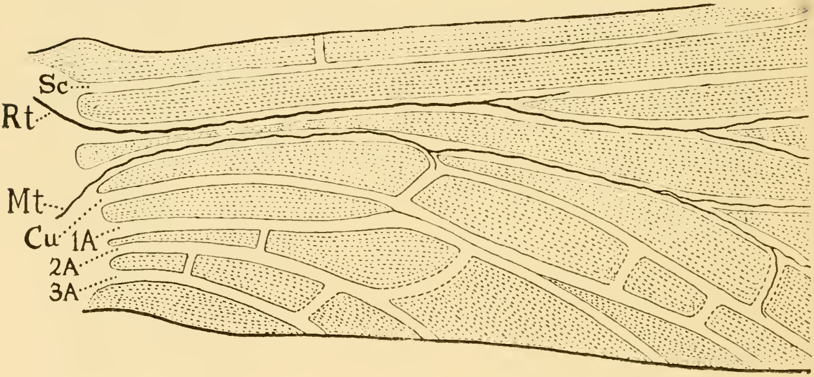
Let us now return to the question of the interpretation of the imaginal wing-venation in *Chorista.* The tracheation having failed us, what other evidence have we to go upon in working this out?

First of all, it may be stated that the main scheme of venation in *Chorista*, like that of the Trichoptera, is so primitive that there can be no hesitation in naming the veins, even though we cannot call upon the tracheæ as evidence. The subcosta, the radius, the radial sector with its dichotomous branches, and the anal veins can all be named without any misgivings. It is only the media and cubitus that offer a difficult problem. By referring to Text-fig. 1, it will be seen that the main stem of the media, in both fore- and hindwings, is continued straight on by a strongly convex vein right to the wing-border. All the rest of the media lies anteriorly to this. The media being properly a concave vein, it follows that there is at once a strong supposition that this straight prolongation of the media is really Cu_1, and that the result has been brought about by a fusion of this latter vein, not far from its original at the cubital fork, with the main stem of the media.

If we examine the imaginal venation carefully, we shall see at once strong evidence in favour of this view. Picking up the base of the cubitus, which is a very weakly chitinised vein, and following it to the cubital fork (*cuf*), we see that the apparent cross-vein from this point to the media may very well be the basal portion of Cu_1, arching up to unite with the media at the point *k*, and then leaving it again as the straight, strong, convex vein in question. If that be so, then Cu_2 in the forewing is the vein that continues the line of the stem of Cu; while, in the hindwing, it must fuse with 1A for a short distance, and then separate from it again towards the wing-margin.

We must now ask for definite proof that this supposition is the correct one. That proof is forthcoming from two separate sources, viz., the pupal wing-venation, and the imaginal wing-venation. We may take these two separately.

(1) *Evidence from the pupal wing-venation:*—In the freshly turned pupa, less than one day old, the fusions of veins that take place in the imaginal venation are not completed, but only just beginning. (The photomicrographs in Plate xliii., are from a pupa at least three days old; those taken from a freshly turned pupa showed the separate veins much more distinctly, but unfortunately the negatives were partially spoilt through the use of stale developer, and are not good enough to reproduce).



Text-fig.2.

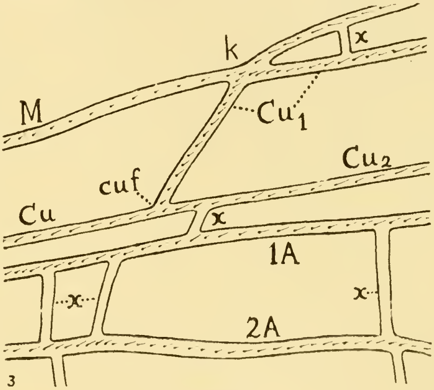
Basal part of hindwing of same pupa as in Text-fig.1, (× 43), to show the radial (*Rt*), and median (*Mt*) tracheæ, the approach of Cu_1 to M, and the partial fusion of Cu_2 with 1A.

Text-fig.2 shows a camera-lucida drawing of the basal part of the hindwing of a freshly-turned pupa. In this, the separate veins Cu_2 and 1A can be clearly seen running alongside one another for some distance, and then diverging again towards the wing-margin. This fixes the position of *cuf* at the point already selected. The upwardly arching branch above *cuf* is seen to be connected with the media by a *short cross-vein* descending from the latter vein. In this pupal tracheation, then, the line of the median stem is not continued by Cu_1, but by the true media; it is only a rearrangement of the positions of these parts in the imaginal venation that brings Cu_1 into the position of continuing the line of M.*

The case for the forewing is still simpler. Here there is no fusion of Cu_2 with 1A, and the parts of the cubitus can be seen to be quite separate from both M and 1A.

(2) *Evidence from the imaginal venation:*—The evidence that I propose to bring forward here is of quite a novel kind, and does not appear to have been used hitherto in any research upon wing-venation; yet it is of the utmost value.

In the wings of all Holometabolous Insects, two kinds of hairs or setæ are developed. These I have called *macrotrichia* and *microtrichia* respectively.† The former are, in most cases, restricted to the veins; the latter are spread indiscriminately, and much more abundantly, over the whole of the wing. In the Mecoptera, the macrotrichia are found upon all the main veins and their branches, but *never upon the true cross-veins.* Hence



Text-fig.3.

Part of the imaginal venation of the forewing of *Chorista australis* Klug, in the region of the cubital fork (*cuf*), to show distribution of the macrotrichia; (×27): *k*, the point at which Cu_1 has fused with M; *x*, cross-veins.

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[*] Compare the somewhat analogous condition in the forewing of *Myrmeleontidæ*, where Cu_{1a} captures M_2 close to its origin.

[†] "Mesozoic Insects of Queensland, No.1." These Proceedings, 1917, xlii., Part 1, p.195.

we have, here, a fine criterion for determining whether any supposed cross-vein is really such, or not.

Let us apply this to the basal portion of Cu_1, which, arching up in the imaginal wing-venation to meet M, might well be mistaken for a cross-vein. From Text-fig.3, we see that all the cross-veins around it are destitute of macrotrichia. Not so this vein, however; for it is seen to carry a series of closely-set macrotrichia, which are continued along the rest of Cu_1.

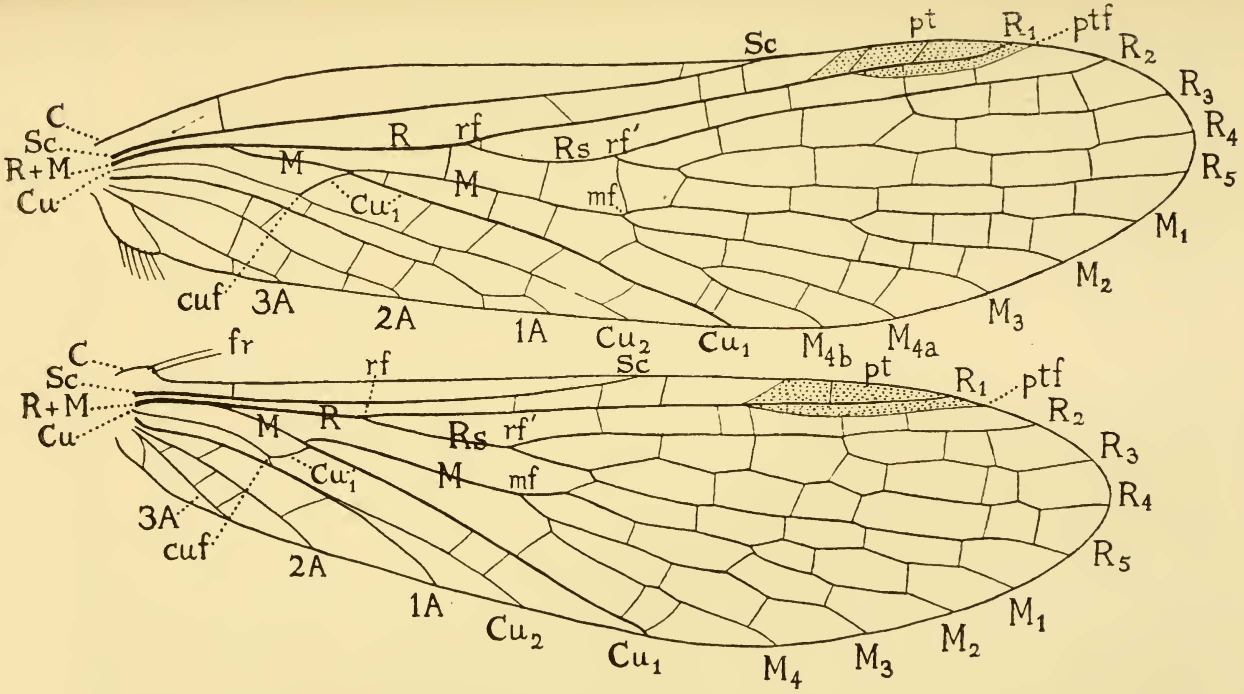
Further, it will be seen that the macrotrichia developed upon the media are less in number than those upon the cubitus, for any given length; those upon the cubitus being about twice as numerous. In this character also, the continuity of Cu_1 from *cuf* up to its fusion with M, and thence along the strong, convex vein already mentioned, is clearly indicated.

Putting the two sets of evidence together, there can be no doubt that the correct interpretation of the condition of the media and cubitus is that which is given in the Text-figures.

Description of the Wing-Venation. (Text-fig.4).

Having solved the above problem, we can now name all parts of the wing-venation without any doubt whatever. The result is shown in Text-fig.4. It will be seen that the wing-venational type is essentially similar to that of the Lepidoptera, Trichoptera, and Diptera, except for the fact that a considerable number of unspecialised cross-veins are developed as supports between the main veins. These cross-veins cannot be regarded as part of the original venation, since they do not carry macrotrichia, and are absent or very weakly developed in the oldest genera, both fossil and recent.

The *Subcosta* (*Sc*) is a straight vein terminating about halfway along the costal margin in the hindwing, somewhat beyond halfway in the forewing. In *Chorista*, it gives off only a single cross-vein in the costal space, near the base (occasionally, as in Text-fig.4, a second near its distal end). This is the homologue of the *humeral cross-vein* in Lepidoptera and Trichoptera, and is a true cross-vein, since it does not carry macrotrichia.



Text-fig. 4.

Imaginal venation of wings of *Chorista australis* Klug, with wing-pigmentation omitted; (×7½). Lettering as on p. 408.

The *Radius* (*R*) is a strong convex vein branching at the radial fork (*rf*) into R_1 and Rs. The main stem, R_1, reaches the wing-margin well before the apex. Around its distal end is formed the *pterostigma* (*pt*), a hardened membranous area bounded by the costal margin above and the *pterostigmatic furrow* (*ptf*) beneath. Within this area are sometimes developed one or more *pterostigmatic veinlets*, which are also parts of the original venation, not cross-veins, but true branches of R_1, since they carry macrotrichia. The *Radial Sector* (*Rs*) has the typical dichotomous branching seen in the Trichoptera, giving rise, in each wing, to four branches, R_2, R_3, R_4, and R_5 respectively. The separation of R_2 from R_3 takes place far distad, under the pterostigma; that of R_4 from R_5 much further basad, not far from the first forking of Rs into R_{2+3} and R_{4+5}. All these branches are connected and strengthened by a number of cross-veins, whose position varies greatly in different individuals.

The *Media* (*M*) resembles the radial sector in the manner of its branching, as in Trichoptera; except that, in the forewing of *Chorista*, the most posterior of its four branches, M_4, divides into two parts, M_{4a} and M_{4b}. The cross-vein connecting M_4 near its base with Cu_1 carries no macrotrichia, and must, therefore, be regarded as a true cross-vein, and not a branchlet from Cu_1. Hence there is no evidence for the existence of the two branches of Cu_1, which I have called Cu_{1a} and Cu_{1b}, and which are to be found in the most archaic Lepidoptera and in the Planipennia, but not in the Trichoptera.

The *Cubitus* (*Cu*) is two-branched, as in Trichoptera. The anterior branch, Cu_1, arches upwards to connect with M, and then continues the line of M to the wing-margin as a strong, convex vein. The posterior branch, Cu_2, in the forewing, simply continues the line of the main stem of Cu. In the hindwing, however, it fuses for some distance with 1A, and then separates from it, and runs beneath Cu_1 to the wing-margin, at about half-way along the wing.

Three *Anal Veins* are developed in each wing. These remain quite distinct throughout their courses, except for the partial fusion of 1A with Cu_2 already mentioned in the hindwing.

A number of cross-veins, irregularly placed and excessively variable in different individuals, are developed as supports between the branches of the media, the cubitus, and the anal veins.

It should be noted that, in the imaginal venation, the main stem of the media is fused with the radius for a short distance. In the pupal venation, these can be seen to be quite distinct.

SUMMARY.

(1) The tracheation of the pupal wing of *Chorista australis* is highly specialised by reduction, there being only two main tracheæ entering the wing. Of these, one belongs to the costo-radial group and passes into the radius; the other belongs to the cubito-anal group and passes into the media.

(2) In the freshly-turned pupa, the fusions of veins that are found in the imaginal venation are not accomplished, and hence it is possible to interpret the whole of the venation with certainty.

(3) Main veins and their branches, in the imaginal venation, carry macrotrichia; cross-veins do not. From this, it is demonstrable that an apparent cross-vein below M is in reality the basal portion of Cu_1.

(4) The imaginal venation is specialised in having M fused basally with R for a short distance; in having Cu_1 continuing the line of the main stem of M, the short basal portion of Cu_1 resembling a cross-vein below M; and also in the partial fusion of Cu_2 with 1A in the hindwing.

(5) The rest of the venation is of a generalised type, closely resembling the typical Trichopterous plan, but with an extra branch to M_4 in the forewing. Cross-veins are fairly numerous, but variable in position and number in different individuals.

EXPLANATION OF PLATE XLIII.

Fig. 1.—Wings of a pupa of *Chorista australis* Klug, ♀, three days old; (× 18).

Fig. 2.—Basal part of forewing of same; (× 43). Note the Alar Trunk-Trachea at extreme base of wing, giving off the two wing-tracheæ.

Fig. 3.—Basal part of hindwing of same; (× 32).

(Photomicrographs of the freshly dissected wings in water).

EXPLANATION OF COMSTOCK-NEEDHAM VENATIONAL NOTATION, AS USED IN THE TEXT-FIGURES.

1A, 2A, 3A, the three anal veins—C, costa—Cu, cubitus; Cu_1 its upper, and Cu_2 its lower branch—*cuf*, cubital fork—*fr*, frenulum—M, media; M_1, M_2, M_3, M_4, its four branches, the last of which divides into M_{4a} and M_{4b} in the forewing—*mf*, median fork—*pt*, pterostigma—*ptf*, pterostigmatic furrow—R, radius, dividing into R_1, its main stem, and Rs, the radial sector; this latter has four branches, R_2, R_3, R_4, and R_5—*rf*, radial fork—*rf′*, fork of radial sector—Sc, subcosta.

THE "SPRINGING" OF TINS OF PRESERVED FRUIT.

By W. W. L'Estrange and R. Greig-Smith, D.Sc., Macleay Bacteriologist to the Society.

It occasionally happens in the canning of fruit that some of the tins, after a time, begin to swell. Normally, the top and bottom of the container are slightly concave, indicating a partial vacuum within If, however, one or both is convex, the tin is abnormal and is alluded to as a "springer." Such cans are rejected, and, as there may be many sprung tins, the loss may be considerable to the canner. The cause is generally ascribed to leaking containers, but as some fruits are more prone to produce "springers" than others, it appeared that much might be gained from a study of the phenomenon. It is certainly curious that, while pears and some varieties of plums with tight stones are frequently affected in this way, peaches and other stone-fruits are but rarely so, even when they are processed or manufactured in precisely the same way. Our attention was called to the matter, and an examination was made of some of the affected tins.

But before dealing with the results of this examination, it may be well to briefly describe the method of processing the fruit. The pears, generally the Bartlett variety, are picked, pared, cut in two, cored, in some cases sliced, and washed in running water. They are then put into empty containers, and placed on a travelling belt which carries them past a tap from which boiling syrup is run in up to within a quarter or half-an-inch of the top. They pass on to a machine which automatically fits on the lids and turns the edges. The cold pears reduce the temperature of the syrup, which is generally at 160°F., when the lid is fixed and the container made tight. The tins are put into baskets and passed through a boiler. The passage occupies 24 minutes, and the tins are in the boiling water zone for 16 minutes. On emerging from the boiler, the ends are bulged, but they become concave as the tins cool, while stacked on the floor near the boiler. When cold, they are taken to the store, and built up in tiers so that any springers may be detected. After a time, they are labelled and despatched.

The springers appear to be of two kinds. One contains syrup in an actively fermenting condition; the other is quite still, but the syrup has a sharp, slightly acid taste noticeable only to the expert taster, and the fruit is apparently quite fit for human consumption. The fact that one or both ends of the container are bulged is, however, sufficient to cause the condemnation of the tin.

The time during which the fruit is cooked seems to be sufficient to thoroughly pasteurise the contents of the tins, but to gain some definite information upon the matter, two tests were made in the laboratory with fresh pears. These were peeled, halved, and cored. The bulb of a thermometer was inserted in the body of one of the halves and the tin was filled up with boiling syrup, and put into boiling water. The temperatures of the pear and of the syrup were read off at intervals.

	Temperature in °C. of the	
	pear	syrup
At start	18°	81°
2 minutes	27°	84°
5 minutes	42·5°	87°
10 minutes	65·5°	90·5°
15 minutes	78°	92°
20 minutes	85°	94·5°
24 minutes	89°	95°
Container taken out and placed on bench		
28 minutes	90°	87·5°
30 minutes	90°	85·5°
35 minutes	88°	78·5°
40 minutes	85°	74°

The conditions were not quite the same as in processing under factory-conditions, inasmuch as there was no lid on the container, and it was not completely submerged in the boiling water.

For this reason, these temperatures are lower than would occur in practice, but even as, in the experiment, the pears and the syrup were over 70°C. for at least 30 minutes, and over 85° for 20 minutes, the exposure was quite sufficient to pasteurise the contents

One point about the experiment was, that the tin was put into the boiling water immediately the syrup was added; whereas in practice, a certain time must elapse before the tin is capped, put into a basket and pushed into the boiler, where it is some four minutes before the zone of boiling water is reached. It was considered that an interval of ten minutes would completely cover this interval, and, accordingly, in another laboratory-test, the container was allowed to stand for ten minutes after receiving the boiling syrup, and before it was put into the boiling water.

	Temperature in °C. of the	
	pear	syrup
At start	45°	47°
5 minutes	50°	67·5°
10 minutes	67°	80°
15 minutes	76°	85°
20 minutes	80·5°	88°
24 minutes	83°	89·5°
Container taken out and placed on bench		
28 minutes	84°	87·5°
30 minutes	83·5°	86°
40 minutes	79°	78°

Even with the ten-minute interval before placing the tin in the boiling water, the fruit and the syrup were well over 70° for at least 25 minutes, and this should be enough to destroy all vegetating yeasts and bacteria.

A number of faulty tins, ten in all, were received in October, 1916. They consisted of pears, greengages, and plums. They were examined bacteriologically, and no growths were obtained from the contents of seven. A tin of pears contained a small active yeast, *Saccharomyces Zopfii*, which has been shown to be responsible for the "puffing" of tins of golden syrup in America.

It actively fermented fruit-syrup, and was undoubtedly the cause of the springing of this particular tin. Another tin of pears contained a mixture of inactive yeasts and moulds. As they did not ferment fruit-syrup, it was clear that the cause of the trouble had disappeared. A tin of greengages contained inactive bacteria and moulds, and, as in the previous case, the agent which had caused the fermentation had died or had been killed. Several of the containers showed clear evidence of having leaked at some time.

A second lot of six faulty tins of pears was obtained in June, 1917, and the notes upon these are as follows.

No.1. The container had a faulty lid, the tinplate was spongy, and foaming syrup was oozing out of a central pin-hole. The syrup was actively fermenting and contained yeasts.

No.2. The container had a small quantity of syrup, the bulk having apparently leaked out. The syrup contained yeasts and, when set aside under aseptic conditions, it fermented vigorously.

No.3. The contents appeared to be normal, but the syrup contained bacteria and yeasts.

No.4. The fruit appeared normal, but the syrup was thin, and contained bacteria and yeasts.

Nos.5 and 6. The contents were normal, and the syrup contained bacteria only.

All the containers, with the exception of No.6, showed signs of having leaked at some time. No.6 was the only one that appeared to be intact.

The bacteria in the tins were the same. On dextrose agar, they grew as short, irregular rods, and as chains, especially in the condensed water. They were Gram-positive, and, as they had no action upon any sugar, they could not have been responsible for the springing of the retainers.

The yeasts were all of the culture-type, that is, they were varieties of *Saccharomyces cerevisiæ*. This type is associated with the manufacture of beer, and one would not expect to find it in a factory where there is so much fruit utilised. In a factory such as a fruit-cannery, wild yeasts and torulæ should be present in abundance, and it certainly was extraordinary to find only culture- or beer-yeasts in the preserved pears. It was subsequently discovered that, adjoining the cannery, there is a factory, where a large amount of ginger-beer is produced. It is safe to conclude that the yeasts came from this source.

In October, 1917, a third lot of six tins of pears was examined, and, with one exception, all of them showed signs of leakage. The contents were sterile, and, from the presence of soldered vent-holes on two of the containers, it was concluded that the lot had been reprocessed, that is to say, they had been put through the boiler after evidence of springing had been detected. One of the tins contained a strongly foaming, sterile syrup, and as this was oozing from one of the ends, it was evident that the re-processing had been of recent date.

We had an opportunity of inspecting the processing of pears in February, 1918, and, from our observations, we concluded that the root of the trouble lay with the closing of the containers. The margin of the lid is painted with a mixture containing flour or starch, and when the closing machine overlaps the edges of lid and container-top, the mixture fills up the spaces between the interlocked edges. The joint appears to be tight, and doubtless the starchy mixture makes a good lute. But the pressure exerted by the air contained in the tin (it constitutes from one-twelfth to one twenty-fourth of the contents) must be considerable during the passage of the container through the boiler. The luting mixture is supposed to form a jelly in contact with the hot water, on the one side, and the hot syrup on the other, and it is quite reasonable to suppose that the jelly may be forced out of the joint by the pressure of the contents. The tins appear to be sound immediately after processing; it is when they are stacked in the store-room, that they show signs of leakage. In the case of pears, about every second tin leaks more or less; with plums, about every tenth tin is faulty; and, with peaches and apricots, the leaks are few in number. As the processing is the same in all cases, one is driven to the conclusion that the juice of pears and, in less degree, that of plums, has a solvent action upon the luting jelly, and that another mixture should be employed.

The experimental evidence shows that the duration and temperature of the processing are sufficient to absolutely free the contents from active yeasts. Their entry into the containers is most likely to occur while the tins are cooling down or shortly after. It is reasonable to suppose that the original air of the tin has been partly or entirely expelled during processing, and the vacuum created during cooling draws in the air of the factory with its suspended yeasts and other organisms. It is entirely a matter of chance as to the number of organisms and the activity of the organisms that may be in the indrawn air. There may be none, or they may be inactive, and the tin will not leak. There may be one or more, and, if these are active gas-producers, the tin will "spring." It is quite possible that some of the tins might be so imperfectly closed that they would leak under any circumstances, but the scarcity of leaks and springers among the tins of stone-fruits shows that this is of very rare occurrence.

The behaviour of the pears and plums, as compared with apricots and peaches, points to the use of a more insoluble luting material, and, failing this method of overcoming the trouble, there is the alternative and probably better plan of allowing the tins to cool after processing in a current of filtered, sterile air, and, when cold, painting the joints with a lacquer-varnish. Thus the entry of yeasts into the tins would be prevented during the cooling, and the varnish would make them germ-tight and germ-proof.

NOTES AND EXHIBITS.

Dr. Cleland exhibited the first four parts (Vol. i.) of "Epigraphie Médicale: Corpus Inscriptionum ad Medicinam Biologiamque Spectantium," publié par Professeur Raphael Blanchard (Paris, 1909-15). – Also specimens of *Anestellorhina augur* (*Calliphora oceaniæ*), one of the Australian Blowflies troublesome to sheep, bred from an Agaric (*Pleurotus* sp.) which had probably been infected during exposure for two days in a room—the interest of the exhibit being that the flies had been reared on a purely vegetable medium.

Mr. Steel communicated the following Note on the abnormal gizzard of a Muscovy duck, exhibited at the last Meeting (*antea*, p.361). "On subsequent dissection of the exhibit, it was found that, while the organ was of the usual shape and dimensions externally, the internal cavity was only about one-third of the normal capacity, and the gizzard-walls correspondingly thick. The vermiform appendage was hollow, and was tightly packed with a hard, brown substance, which broke up on treatment with hot sodium hydrate, but exhibited no traces of vegetable tissue, nor of definite structure, being apparently a secretion from the walls of the appendage. The appendage was completely isolated from the cavity of the gizzard by a layer of white, fibrous tissue, about ¼ inch in thickness, this being the thickness of the side-walls of the gizzard at the area of attachment. The specimen has been placed in the Museum of the Department of Veterinary Science, University of Sydney."

Mr. Fletcher, on behalf of Mr. Musson and himself, showed seedlings of a number of species of plants, not Eucalypts or Angophoras – including *Elæocarpus cyaneus*, *Leptospermum flavescens*, *Callistemon pinifolius* and *C. salignus*, *Melaleuca nodosa* and *M. genistifolia*, *Tristania neriifolia*, *Syncarpia laurina*, *Backhousia myrtifolia*, *Casuarina* sp., *Santalum obtusifolium*, and several not identified—which seem to be afflicted, in a similar manner, with composite, shoot-bearing tumours.

The President offered a cordial welcome to Mr. R. W. Bretnall, a Soldier-Member recently returned after service abroad.

ORDINARY MONTHLY MEETING.

August 28th, 1918.

Professor H. G. Chapman, M.D., B.S., President, in the Chair.

Messrs. John Hopson, Junr., Dalkeith, Eccleston, N.S.W.; and Frederick P. Dodd, Kuranda, North Queensland, were elected Ordinary Members of the Society.

The Donations and Exchanges received since the previous Monthly Meeting (31st July, 1918), amounting to 2 Vols., 44 Parts or Nos., 7 Bulletins, 1 Report, and 5 Pamphlets, received from 37 Societies, etc., and two private donors, were laid upon the table.

NOTES AND EXHIBITS.

Mr. W. W. Froggatt showed a fine series of Coccid galls on Eucalypts, commonly known as Brachyscelid galls, attributable to members of the genus *Apiomorpha*; a remarkable gall due to Cynips on Live Oaks in California; and an undetermined, living snake from Moree, N.S.W.

Mr. Fletcher exhibited specimens of *Melaleuca Deanei* F.v.M., and photographs of the largest plants seen (about 8-9 feet high, and 4-5 inches in diameter at the base); and specimens of *Petrophila sessilis* Sieb.—two of the rarer plants of the Lane Cove District, to be met with only in small, isolated groups.

The Secretary communicated a letter from the Dalley Branch of the Australian Society of Patriots at Newcastle, advocating the reservation of Pulbah Island in Lake Macquarie. Mr. J. Mitchell, who had visited the island, offered some favourable remarks. Further consideration was postponed.

[Printed off, September 4th, 1918.]

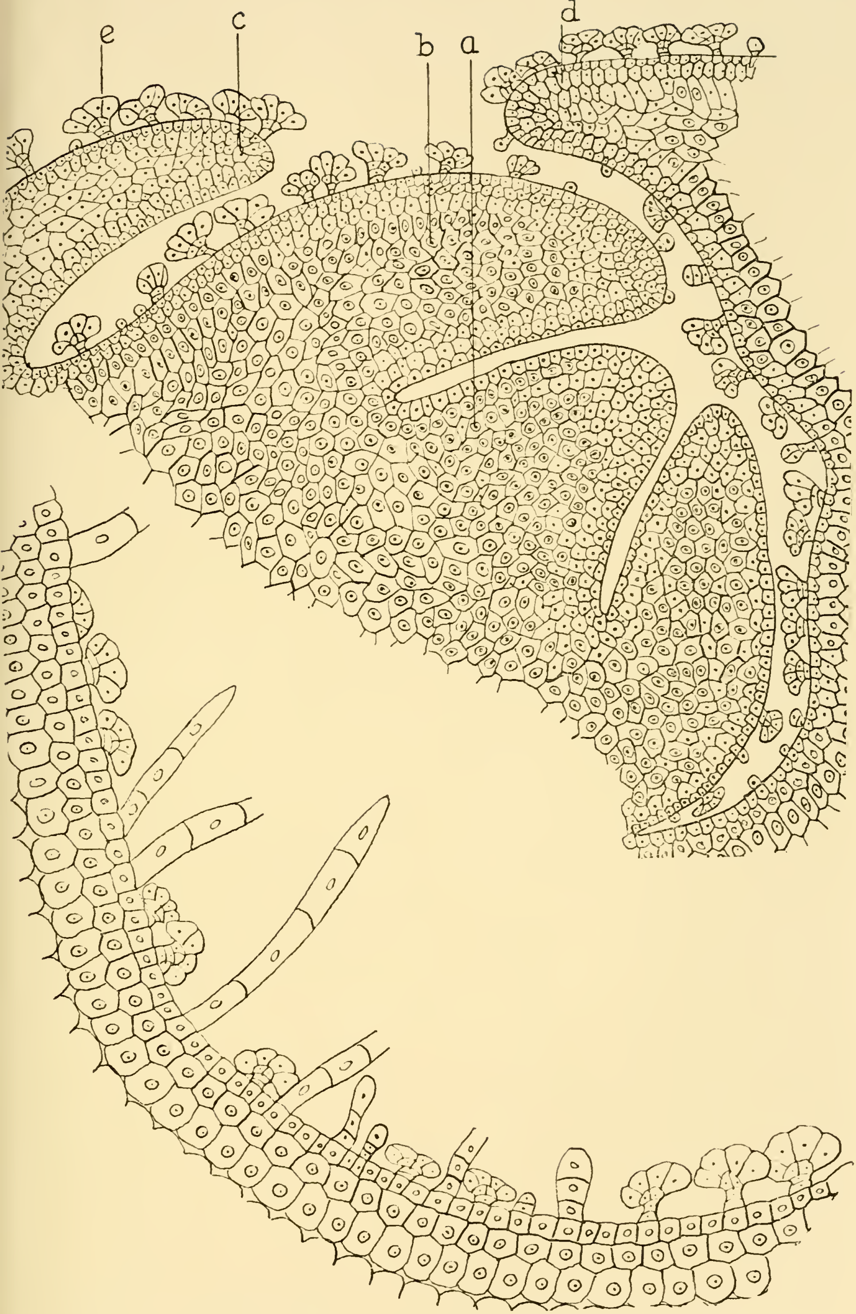
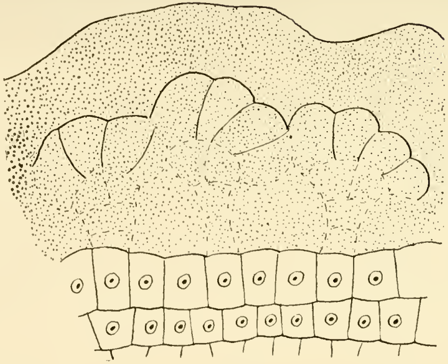


Fig 1. A slightly oblique section through a bud of *Scævola crassifolia*, to show development of glandular hairs.

Fig. 2. Section across sheathing base of a mature leaf, to show development of glandular and clothing hairs.



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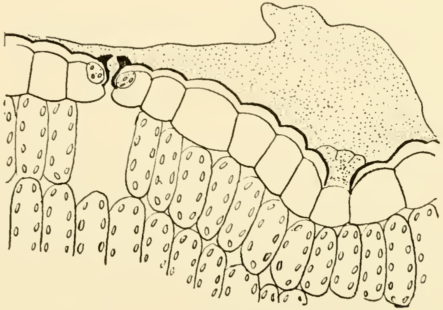

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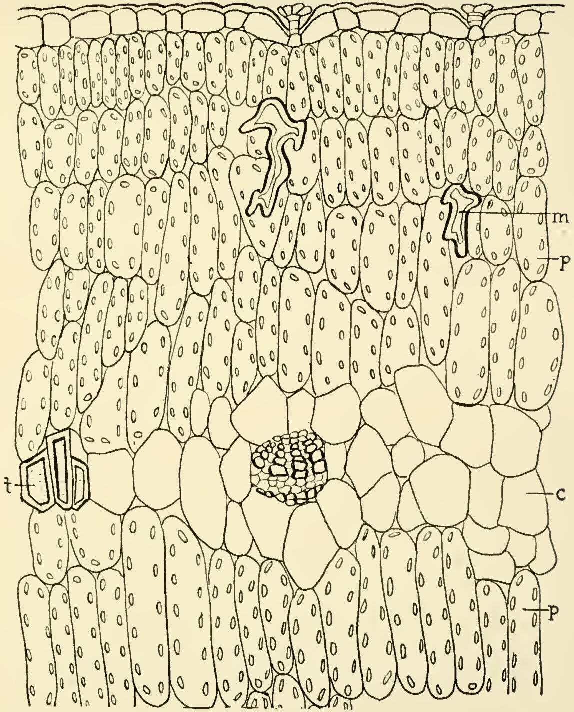
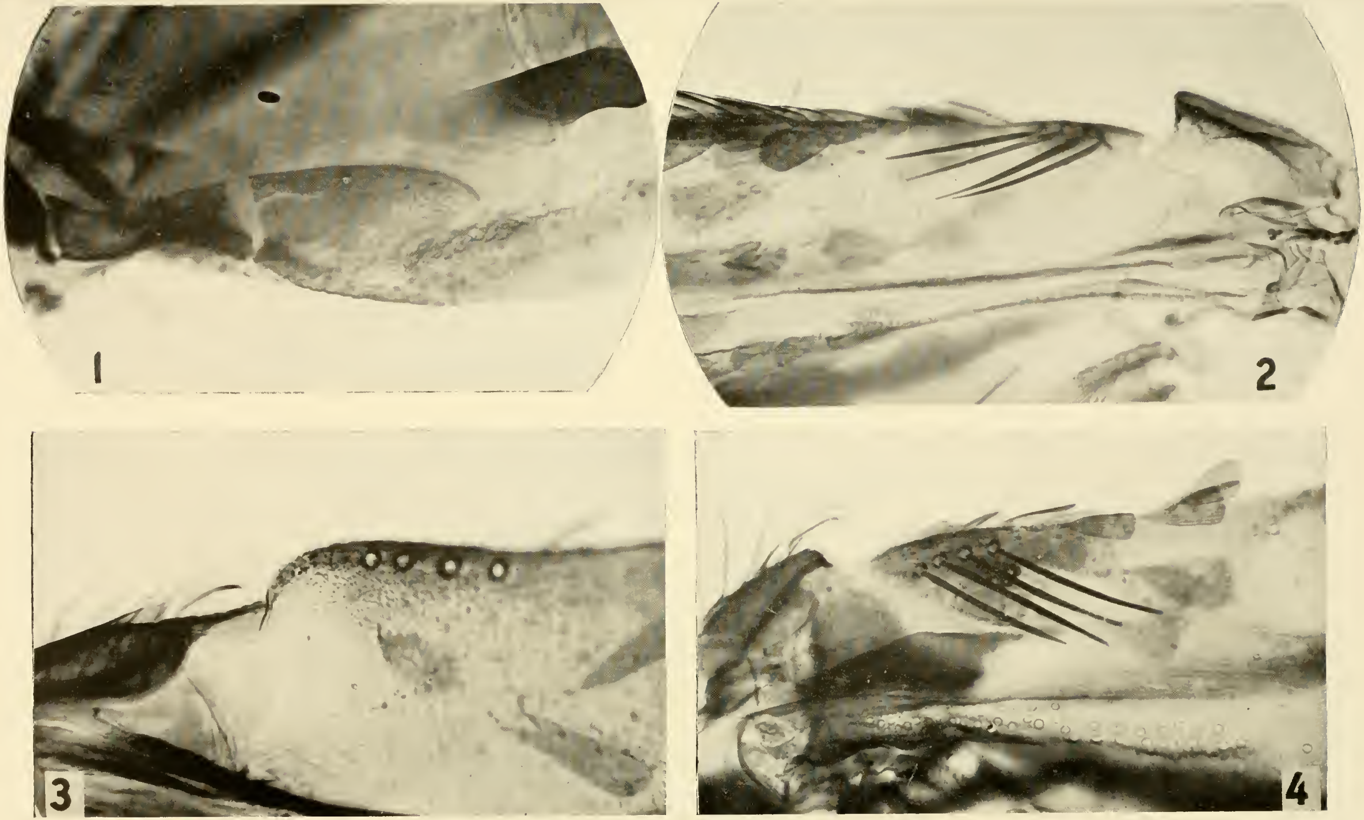
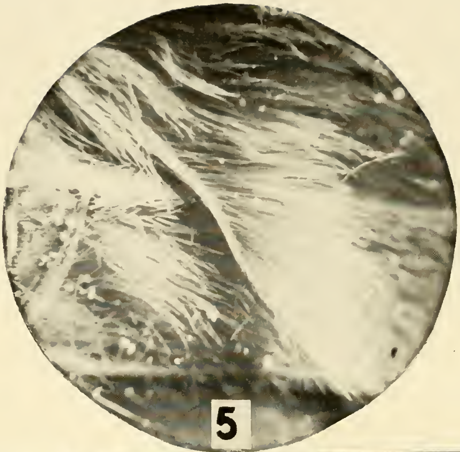
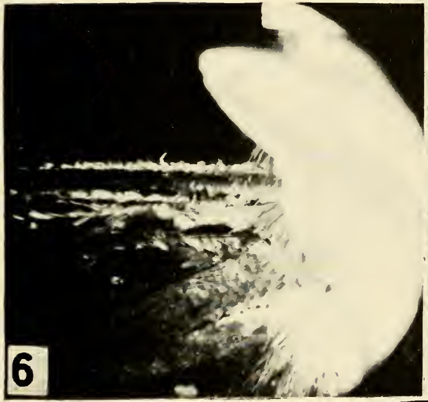


Fig. 3. Part of section through young leaf of *Scævola crassifolia*, to show depth of secretion and outline of glandular hairs.
Fig. 4. Section of a lacquered leaf, to show patch of secretion blocking mature stoma. Fig. 5. Section of a mature leaf.



Figs. 1-4. Jugo-frenate Wing-coupling Apparatus (*Micropterygidæ*).





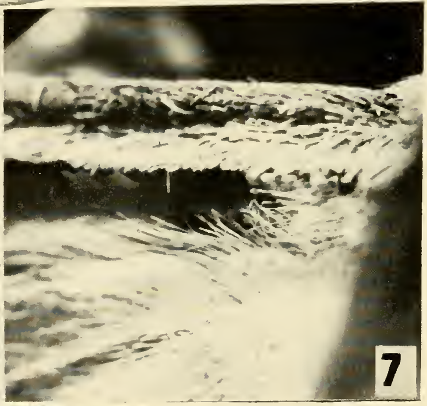
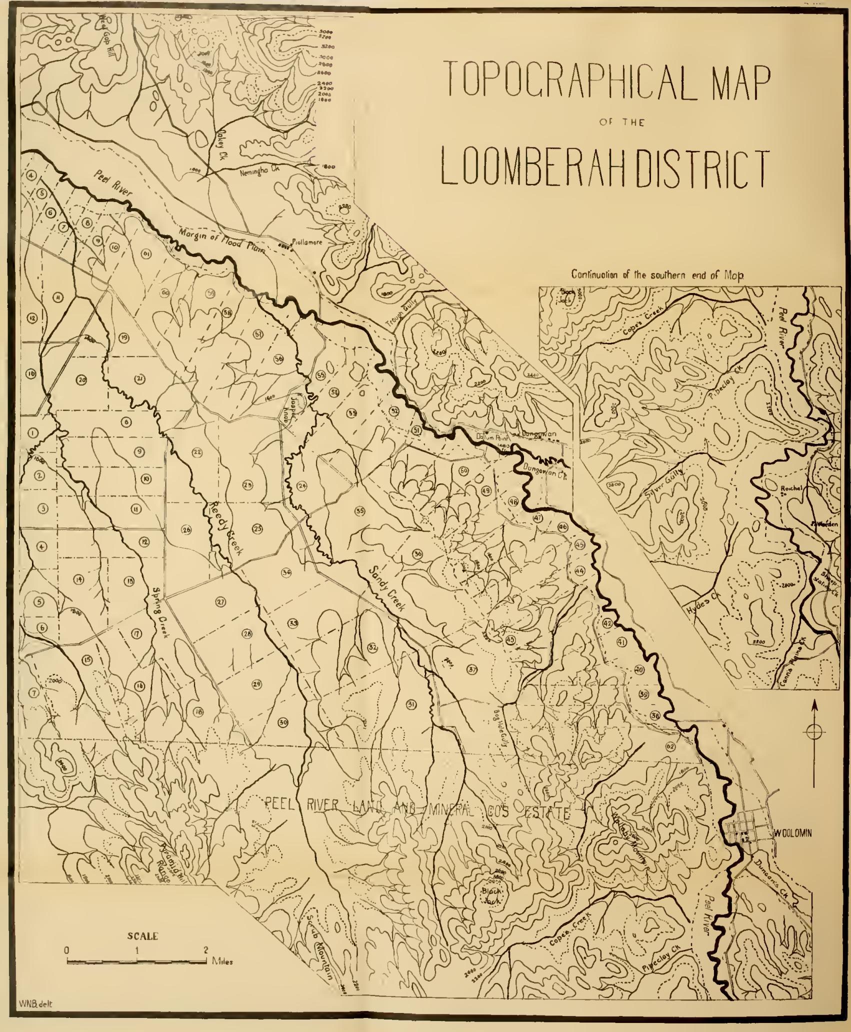


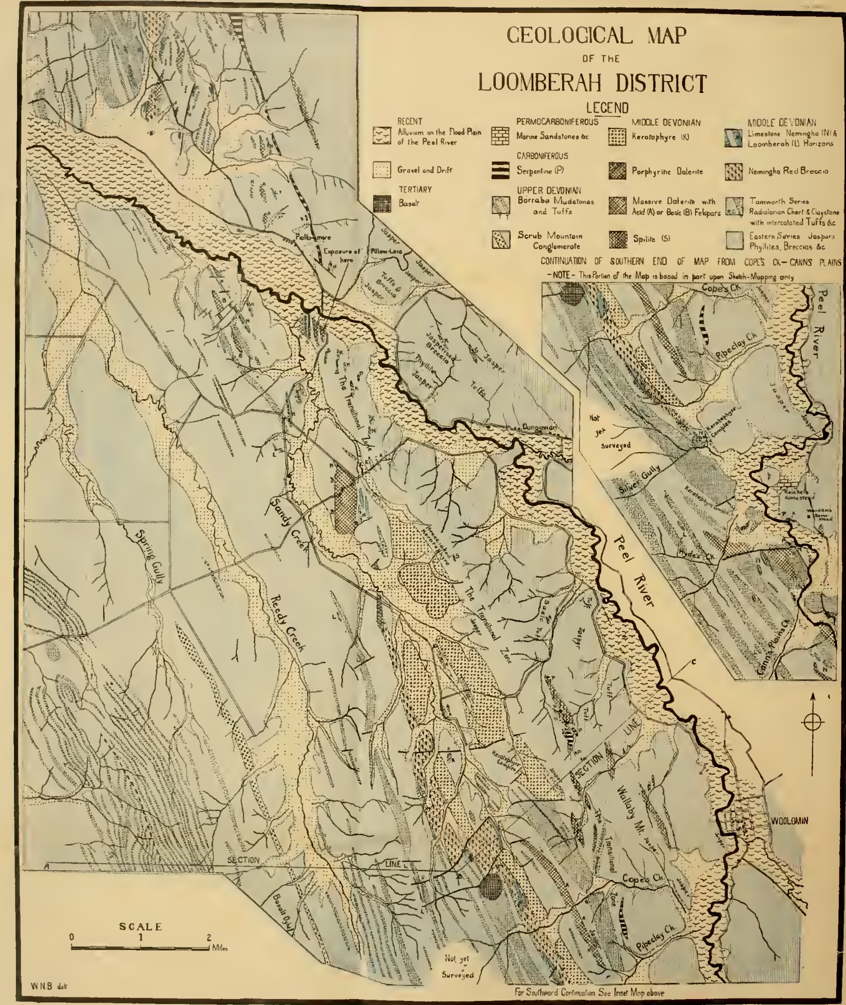
Fig. 5. Jugate (*Hepialidæ*), Figs. 6-8, Frenate (*Sphingidæ*) Wing-coupling Apparatus.

TOPOGRAPHICAL MAP

OF THE

LOOMBERAH DISTRICT





GEOLOGICAL MAP
OF THE
LOOMBERAH DISTRICT

Pillow-lavas by Loomberah Bridge, 11 miles south-east of Tamworth.

1.

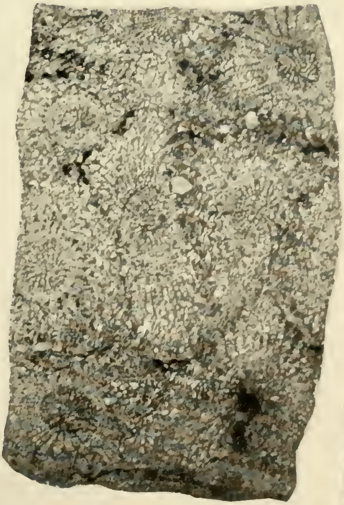


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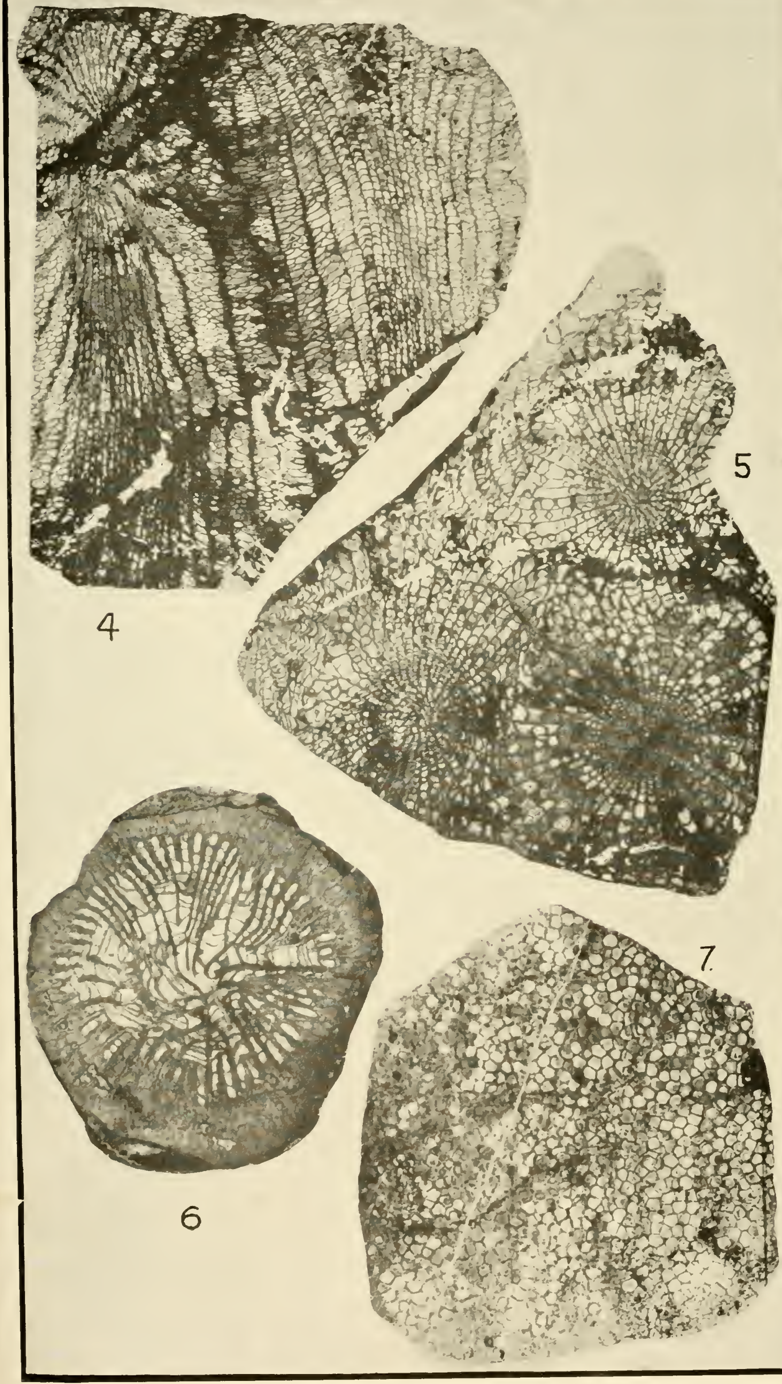
Fig. 1. *Zaphrentis* sp. n. (? subgen. nov.). Fig. 2. *Spongophyllum*, (?) sp. n.
Fig. 3. *S.* (?) sp. n.



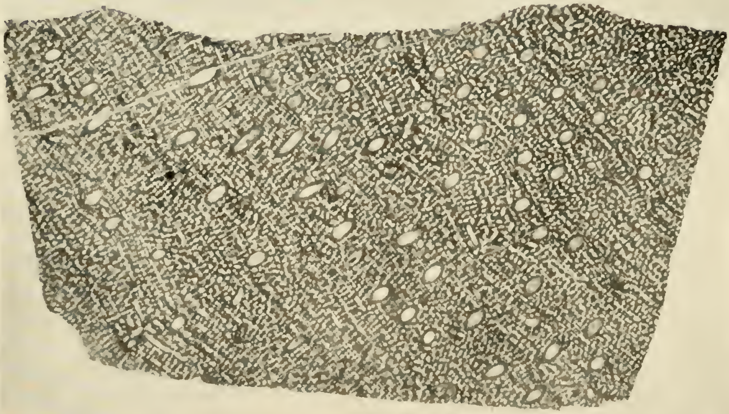
Figs. 4-5. *Phillipsastræa grandis*, sp. n. Fig. 6. *Zaphrentis* sp.
Fig. 7. *Favosites*, sp. n.

8.

9.

Figs. 8-9. *Stromatoporella loomberensis*, sp. n.

10.



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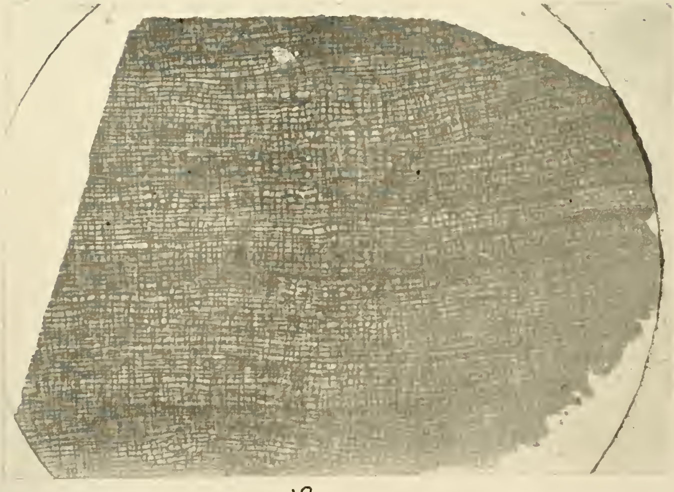
Figs. 10-11. *Stromatoporella bensoni*, sp. n.

12.



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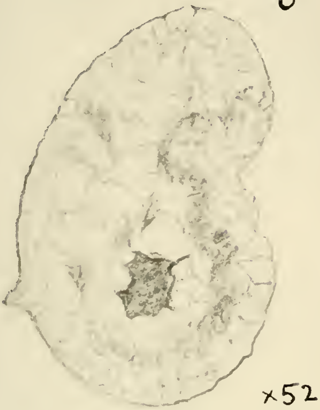
Figs. 12-13. *Actinostroma australe*, sp. n.

F.C. del.

Foraminifera from Nemingha Limestone; (× 52).

8



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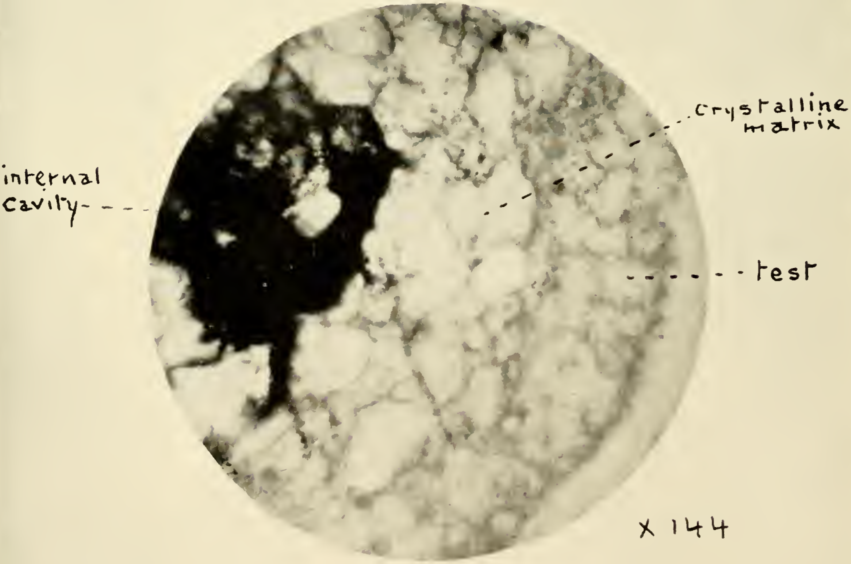
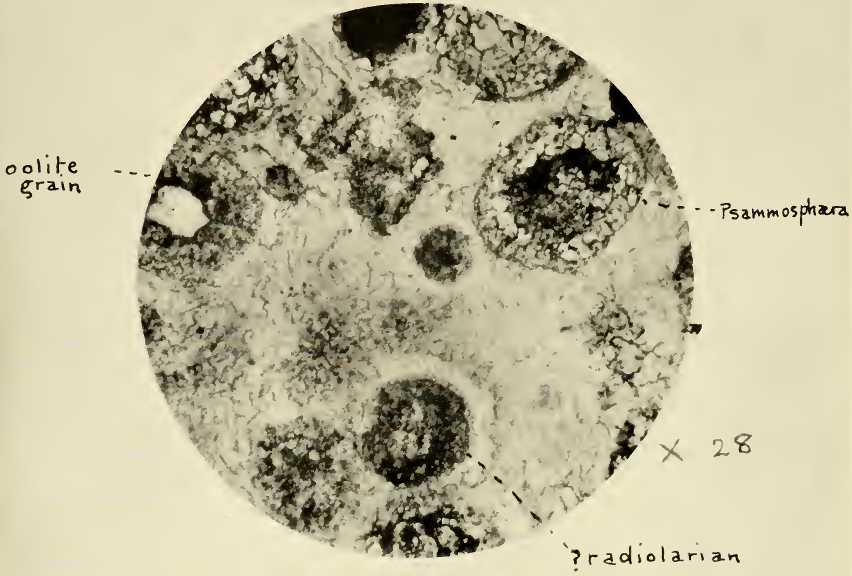


F.C. *del. et photo.*

Foraminifera from Nemingha Limestone.

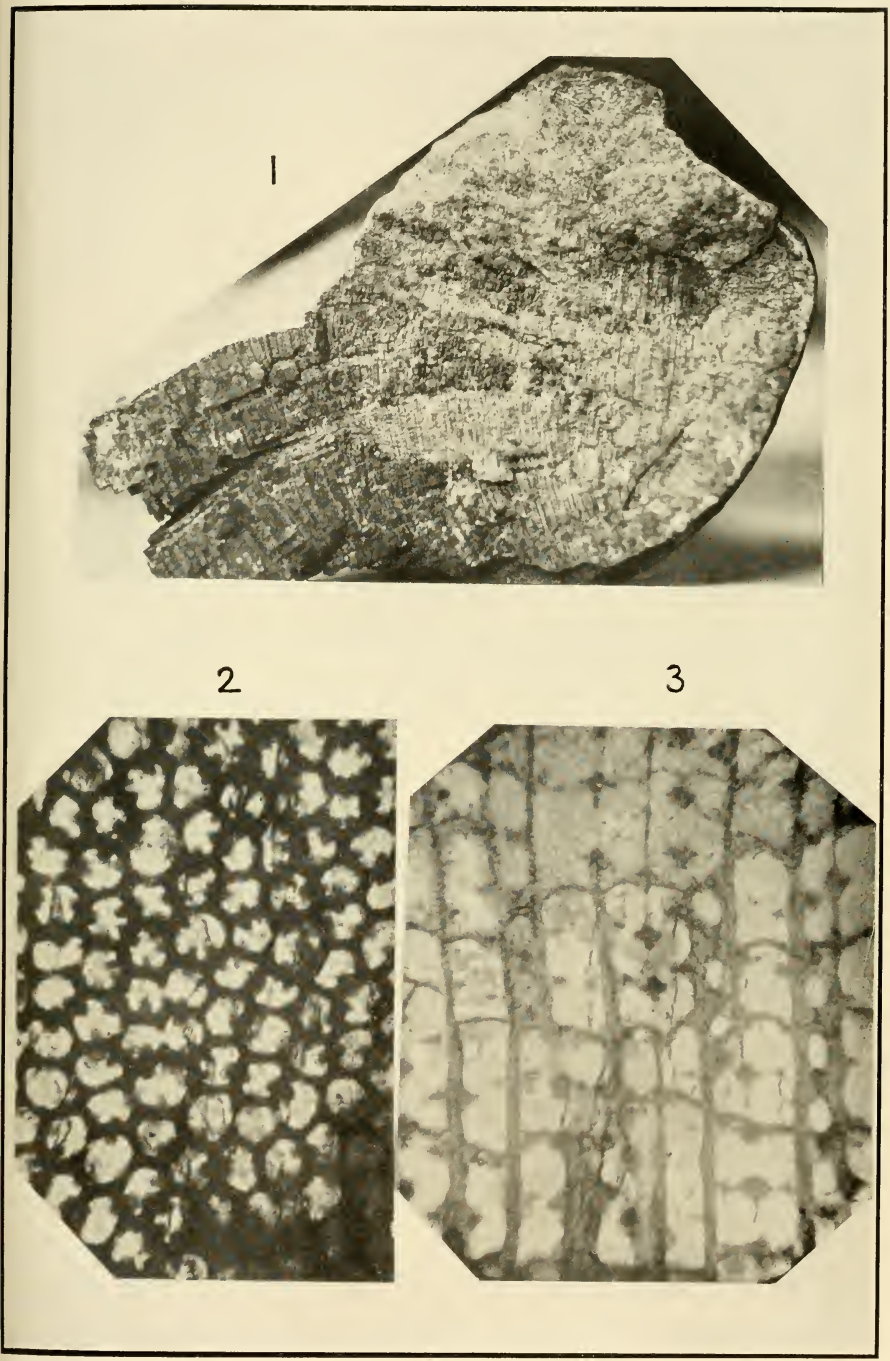
11



12

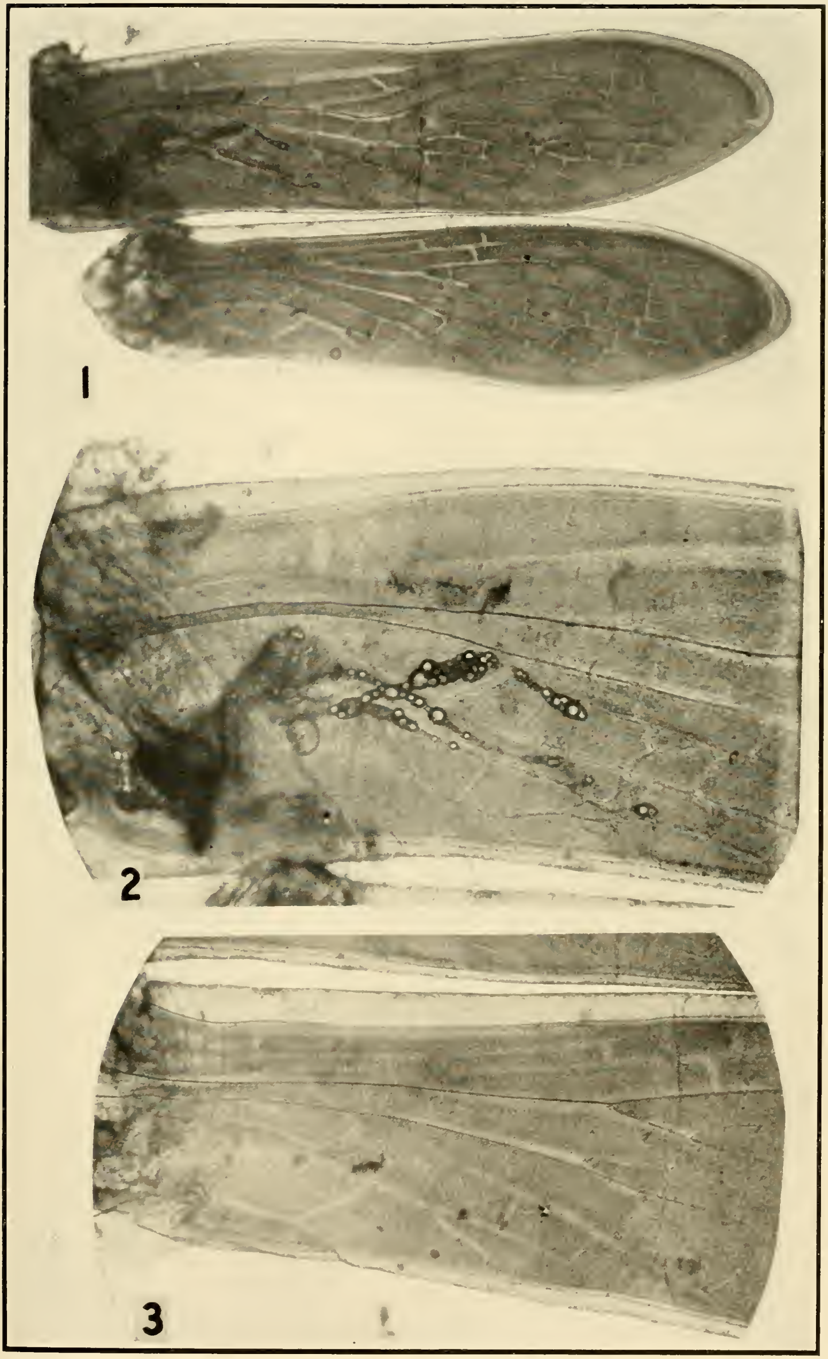
F.C. photo.

Sections of Nemingha Limestone.



F.C. photo.

Chætetes stelliformis, sp. n.; Loomberah Limestone.



Pupal Wing-tracheation of *Chorista australis* Klug.

MESOZOIC INSECTS OF QUEENSLAND.

No.3. Odonata and Protodonata.

By R. J. Tillyard, M.A., D.Sc., F.L.S., F.E.S., Linnean Macleay Fellow of the Society in Zoology.

(Plates xliv.-xlv., and Text-figures 11-16).

Since the publication of No.2 of this Series(**4**), Mr. Dunstan has completed the delamination of the rock taken from the Ipswich Fossil Bed, in the course of gathering together the material forming the *third* collection(**3**) of these fine fossils. The whole of this collection, with the single exception of the Coleopterous elytra, is now in my hands for study. Amongst the very fine material received in the last consignment are two interesting fossil Odonata, these being the only Dragonflies found at Ipswich since the discovery of *Mesophlebia antinodalis* Till., described in a former paper(**2**).

The former consignment also contained a very fine fossil, which is of such unique structure that it is not easy to place it in any of the accepted Orders, either fossil or recent. This fossil has been studied by me for a long time; and I have definitely concluded that it is best placed in the Protodonata, of which it must form a new Suborder. The present paper deals with this fossil and the two Dragonflies above-mentioned.

Recently, Dr. A. B. Walkom, of the University of Queensland, Brisbane, has published his thesis upon the Lower Mesozoic Rocks of Queensland(**5**), in which he discusses very fully the age of the Ipswich Beds. There can be very little doubt that his placing of these beds as Upper Triassic is correct, and as such I am content to accept them. It will be more and more evident, as the description of the fossil insects proceeds, that they consist of a definitely Mesozoic Fauna, not unlike that of the Lias of

England, together with a number of older forms, apparently relics of the old Carboniferous Fauna, such as we know from Commentry in France. The three insects described in this Part illustrate this intermingling of forms very clearly.

Order **ODONATA**.

Suborder **Zygoptera.**

Family LESTIDÆ.

Subfamily TRIASSOLESTINÆ, n.subfam.

Wings with the bases strongly reduced, petiolate; the whole of the area between Cu and the posterior margin, below the quadrilateral, free of veins; and, hence, no anal bridge present. Quadrilateral narrow, placed very obliquely to the long axis of the wing; its upper side short, its lower long, and hence its distal angle very acute; Cu_1 and Cu_2 arising together from this angle. Arculus complete, with $M_{1\text{-}3}$ arising from the top of the quadrilateral.

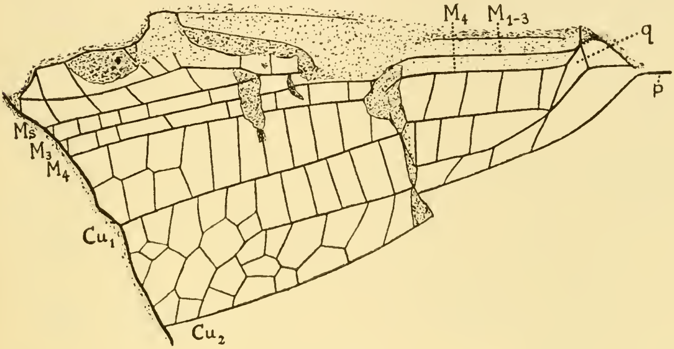
Genus TRIASSOLESTES, n.g. (Text-figs. 11, 12*b*).

A complete antenodal cross-vein in line with the arculus; (this is probably the second of the series). Distal side of quadrilateral continued straight to the posterior border of the wing, by an oblique cross-vein. $M_{1\text{-}3}$ arching slightly upward as each branch is given off; M_3 arises about six cells distad from the level of the quadrilateral; Ms arises from $M_{1\text{-}2}$ about four cells further distad than M_3. Discoidal field fairly wide, with M_4 and Cu_1 slightly divergent; a single row of cells to beyond the level of the origin of Ms, followed further distad by two rows. Between Cu_1 and Cu_2, a single row of cells at first, to about level of origin of Ms. Cu_2 curves strongly downwards distally to meet the posterior border of the wing; between it and the wing-border, one row of cells basally, increasing to two distally. [Anterior and distal portions of the wing missing, including nodus and pterostigma].

Genotype, *Triassolestes epiophlebioïdes*, n.sp. (Upper Triassic, Ipswich, Queensland).

TRIASSOLESTES EPIOPHLEBIOIDES, n.sp. (Text-figs.11, 12*b*).

A well-preserved fragment, 18·5 mm. long, greatest width (distally) 8·5 mm.; consisting of the greater portion of the basal half of the wing, but without the extreme base. The anterior part, including the costa, subcosta, and radius, missing. The preserved portion includes the quadrilateral, the media and cubitus with their branches, and the posterior border of the wing. The anal vein appears to be completely fused with the latter.

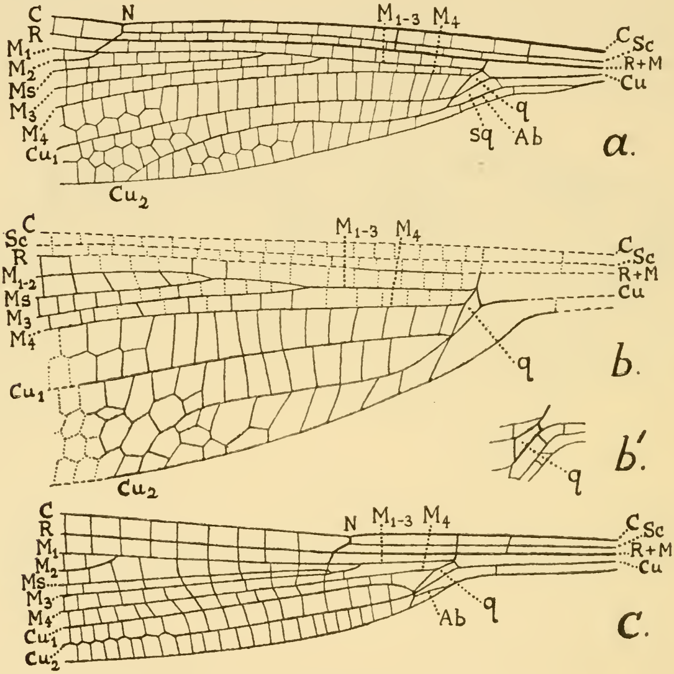


Text-fig.11.

Triassolestes epiophlebioïdes, n.g. et sp., (Triassic, Ipswich, Q.), preserved portion of wing; (×5). Cu_1, Cu_2, branches of cubitus; $M_{1\text{-}3}$, upper, and M_4, lower sector of arculus; Ms, Zygopterid sector: *p*, petiole; *q*, quadrilateral.

The appearance of the fossil may be seen from Text-fig.11. The veins are all beautifully preserved, but unfortunately the wing lies upon some plant-remains, which appear to have been hard twigs or stems, and which have caused the fossil to rest upon a very uneven surface; with the result that, in one place at least, the wing has become crumpled or torn transversely, so that the continuity of the main veins is badly broken. The veins can, however, be followed across the break, and picked up on the other side of it. Distally also, in the region of $M_{1\text{-}2}$, the wing lies upon an uneven surface, and the position of both main veins and cross-veins is somewhat distorted.

Eliminating the effect of these inequalities, it is not a difficult task to restore the wing to its correct form, as far as it is preserved for us. The result is to be seen in Text-fig. 12*b*, to which I have added the probable courses of the veins that are missing in the fossil. For purposes of comparison, I have shown also the



Text-fig. 12.

(*a*) *Epiophlebia superstes* (Selys), (Recent, Japan), forewing; *b′*, region of quadrilateral of hindwing of same. (*b*). *Triassolestes epiophlebioïdes*, n.g. et sp., (Triassic, Ipswich, Q.), restored wing, with missing parts shown by dotted lines. (*c*) *Synlestes weyersi* Selys, (Recent, Australia), forewing. The basal portions of all three wings shown for comparison with one another, (all × 4). Ab, anal bridge; C, costa; N, nodus; R, radius; *sq*, subquadrangle. Rest of lettering as in Text-fig. 11.

corresponding areas of the forewings of *Epiophlebia superstes* (Selys), and *Synlestes weyersi* Selys, both of which show certain points of resemblance with this interesting new fossil.

Comparing the fossil first of all with *Epiophlebia*, we note that the fossil wing was considerably broader, and probably also somewhat longer. The region of the quadrilateral is closely similar in both, but the quadrilateral of the fossil wing is placed more transversely to the wing-axis, and the lower portion of the arculus is much more transversely placed than in *Epiophlebia*. The quadrilateral of the fossil resembles that of the forewing of *Epiophlebia* (Text-fig.12*a*) much more than it does that of the hindwing (*b*′); but, in other respects, particularly in the strong distal curvature of Cu_2, the fossil wing more resembles the hindwing. A close resemblance to *Epiophlebia* is shown in the levels of the origins of the branches of M, and in the shape and venation of the discoidal field and the two longitudinal areas of the wing lying below it.

The fossil, however, differs entirely from *Epiophlebia*, and, indeed, from all known *Lestidæ*, in possessing a broad and absolutely free area between Cu and the posterior border, below the quadrilateral. As the wing is excellently preserved in this region, there can be no doubt about this character, which places the fossil, in this respect, as more highly specialised by reduction than any known Zygoptera, except only the subfamily *Protoneurinæ* of the family *Agrionidæ*.

Where the nodus was placed, we cannot tell for certain. But, if we were agreed that the comparison with *Epiophlebia* would hold also for this character, we might expect that it was situated somewhere near the extreme distally preserved portion of the fossil, *i.e.*, considerably distad from the level of the origin of Ms.

The comparison with *Synlestes* is by no means so close, as can be seen from Text-fig.12*c*. The wing of *Synlestes* is exceedingly narrow, and differs from that of the fossil in having Ms arising from M_3 close to its origin, in the very narrow quadrilateral, in the upward arching of Cu_1 from the distal angle of the quadrilateral, in the consequent narrowing of the discoidal field, and in the length and straightness of Cu . But, in its extreme reduction of the anal bridge (*Ab*), *Synlestes* shows the nearest existing approach to the high specialisation seen in the fossil; and, on this account, the comparison is of value.

While placing this fossil as more closely allied to *Epiophlebia* than to any known Dragonfly, fossil or recent, it seems to me that the characters exhibited by it require its elevation to subfamily rank. But, if the area below the quadrilateral had possessed an anal bridge, I should have been content to place it in the subfamily *Epiophlebiinæ*.

The Lestid affinities of the fossil appear to me to be beyond doubt. As it appears that some students of the Odonata have been unwilling to accept my removal of *Epiophlebia* to the family *Lestidæ*, I should now like to draw their attention to this fossil, which was unknown at the time that I made this suggestion. The combination of Epiophlebiine characters from the quadrilateral distad, with the extreme reduction of the base, which characterises this fossil, should surely be regarded as a further link in the chain of evidence for the Lestid affinities of *Epiophlebia*.

Type, Specimen No. 205*a*, (Coll. Queensland Geological Survey).

Horizon: Upper Triassic, Ipswich, Q.

ODONATA INCERTÆ SEDIS.

Genus PERISSOPHLEBIA, n.g. (Text-fig. 13).

Between C and R, beyond pterostigma, an irregular double row of cells. Between R and M_1, beyond level of pterostigma, at first an irregular triple row of cells, followed by a more regular double row. Below M_1, a strong convex sector is developed towards the apex of the wing, three rows of cellules from it. This is probably M_{1A}. Close below this sector, and only a single row of cells' width from it, there is a parallel concave sector. Both the above sectors converge towards M_1 as they approach the apex of the wing. Some three or four rows of cells below the concave sector, there is a diverging convex sector, which is probably M_2.

[Only a fragment of the wing is preserved, embracing a portion beyond the pterostigma].

Genotype, *Perissophlebia multiseriata*, n.sp. (Upper Triassic, Ipswich, Q.).

So little of the wing of this fine Dragonfly is preserved, that it would be inadvisable to name it, were it not for the very remarkable characters exhibited by the preserved portion of the wing. It may be stated as a general rule, both for recent and fossil Odonata, that the spaces between C and R, on the one hand, and between R and M_1, on the other, from the level of the pterostigma to the apex of the wing, are only filled by a single row of cells. As exceptions to this, we may note the Liassic genus *Petrothemis* Handl., in which the distal portion of the space between C and R is filled with three rows of minute cells, and the basal portion of the space between R and M_1 carries two rows of cells near the pterostigma, decreasing to one row only towards the apex; and the very densely-veined *Aeschnidiidæ*, in which the upper of the two spaces in question has only one row of cells, but the lower has two.

Hence we see that, on this character alone, *Perissophlebia* stands as the most densely veined of all known Odonata.

A second character, that is very exceptional in Odonata, is the arrangement and direction of the longitudinal veins lying below M_1. These are so strongly developed that they would appear, at first sight, to be portions of main veins. But a little consideration of the position of the pterostigma shows us that the preserved portion of the wing represents only a very small piece of a very large wing. The lowest of the three sectors seen below M_1 in the fossil is concave, and may very probably be M_2; the other two are almost certainly not branches of M, but intercalated sectors. Of these latter, the upper one, being strongly convex, very probably corresponds with the *postnodal sector*, M_{1A}, found in recent Zygoptera and in *Petalura*; while that below it might be either a concave supporting sector, or a branch from M_2 itself. In any case, the directions of these three veins, two being parallel to one another but converging towards M_1 distally, and the third being parallel to M_1, are quite exceptional in the Odonata.

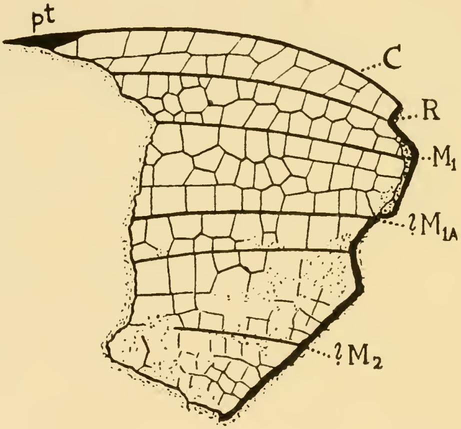
It is clear then that, in spite of the small amount of the wing preserved, the characters there shown are quite marked enough to warrant the giving of a name to the fossil.

Perissophlebia multiseriata, n.sp. (Text-fig.13).

Total length of fragment, 8·5 mm.; greatest breadth of same, 8·5 mm.

A small portion of the pterostigma preserved appears to point definitely to the fact that it was sharply angulated at its upper distal angle; a character that is exceptional amongst fossil Odonata.

Most of the fragment is very well preserved, with the cross-veins clearly visible; but, in the lower portion, they are partly obliterated.



Text-fig. 13.

Perissophlebia multiseriata, n.g. et sp., (Triassic, Ipswich, Q.). Preserved portion of wing, (× 7½). M_1, postnodal sector.

The distance from the tip of the pterostigma to the apex of the wing, and the great width of the wing beyond the level of the pterostigma, both point to the fact that it is a fragment of a very large wing, probably as large as, or larger than, that of *Petalura gigantea* Leach.

Type, Specimen No.203 *a-b* (part and counterpart). (Coll. Queensland Geological Survey).

It is impossible to place this fragment definitely; but I would suggest a likely relationship with *Petrothemis singularis* Handlirsch, which is itself unplaced, owing to absence of the basal half of the wing. A figure of this latter fossil is given in Handlirsch's Atlas(**1**), Plate xlii., fig.9. It is a much smaller wing than that of *Perissophlebia*, and comes from the Upper Lias of Dobbertin, Mecklenberg.

Order **PROTODONATA.**

Suborder **Aeroplanoptera**, subordo nova.

Insects with strongly veined wings, traversed by numerous parallel longitudinal veins, with a network of irregular cross-veins, well developed near the base only; in the rest of the wing, the cross-veins tend to become weak, and almost disappear distally. Costal border strongly developed, coriaceous at base. Radius with a single sector. Media with many dichotomous branches. Cubitus two-branched.

This Suborder is at once distinguished from all the rest of the Protodonata (which may be termed the Suborder Meganeuroptera, from the dominant family) by the close, parallel veining of the wings, the dichotomous branchings of the media, and the two-branched cubitus. In this latter character, it agrees with the Order Odonata; whereas the rest of the Protodonata have only a simple cubitus.

Family AEROPLANIDÆ, fam.nov.

Wings excessively elongated and narrow, the parallel longitudinal veins strongly developed and close together. Subcosta weak, in a deep groove just in front of the exceedingly strongly developed radius. The single radial sector arising from near the base *by a double root.* Media seven-branched in both wings, but the method of branching is different in fore- and hindwings. Radius and media just fused at bases. Cubitus with its two branches arising close to the base and diverging gradually. A single anal vein present, below which is developed an anal field with irregular veining, supported by a curved recurrent supplement.

Genus Aeroplana, n.g. (Plates xliv.-xlv., Text-figs. 14, 15).

Characters of the family, with the following additions. First and second origins of Rs arising not far apart, the portion between them somewhat curved concavely to R. First dichotomy of M at same level as first origin of Rs. In forewing, the anterior branch of M gives rise to three branches, by two dichotomies which take place at some distance from the first; the posterior branch also gives rise to three branches, which arise much closer to the original forking. The middle of these three last branches forks again, a little further distad. Thus there are seven branches in all, three arising from the anterior branch, and four from the posterior. In the hindwing, the anterior branch of M remains simple for a considerable distance, but finally divides into two only; the posterior branch, on the other hand, soon divides again into two, of which the upper branch gives rise to three branches by two separate dichotomies, the lower to two only. Thus there are also seven branches of M in the hindwing, but of these only two arise from the anterior branch, and five from the posterior.

The two branches of Cu diverge very slightly from one another at first, both tending to diverge also from the radius, in the same manner that the media does. A little further distad, close to the level of the first origin of Rs, Cu_2 begins to curve strongly away from Cu_1, forming a wide bend, and later on again approaches Cu_1, to run parallel to and beneath it.

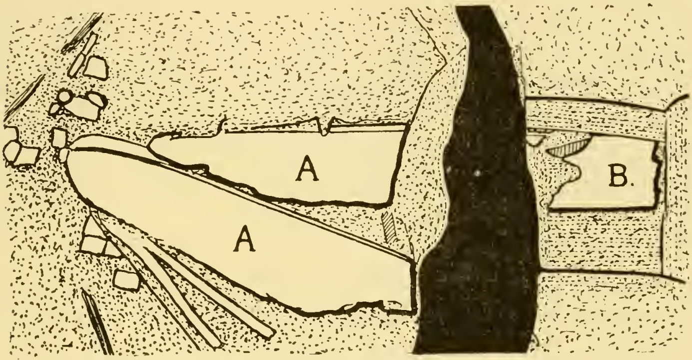
Just distad from the first dichotomy of M, in the hindwing only, a weak, curved supplement runs back obliquely to join Cu_1, resembling in form the anal supplement below A, but on a smaller scale.

Genotype, *Aëroplana mirabilis*, n.sp. (Upper Triassic, Ipswich, Q.).

AEROPLANA MIRABILIS, n.sp. (Plates xliv.-xlv., Text-figs. 14, 15).

Total length of fossil as preserved, from base of hindwing to end of isolated piece of forewing, 41·5 mm. Total length of preserved portion of hindwing, 26 mm.; greatest breadth of same, 5 mm.

The insect lies upon the somewhat uneven surface of a dark grey shale, in such a position that it is crushed down somewhat dorso-laterally, the hindwing apparently covering the thorax, and having its costal margin passing under the posterior border of the forewing. This latter wing, however, lies at a slightly higher level; so that, in the process of delamination, its posterior border was lifted off, exposing the whole basal portion of the costal margin of the hindwing. Around the bases of the wings there are scattered a number of chitinous pieces, some belonging to the head, and some to the thorax of the insect. These are so much crushed that they cannot be recognised with certainty; but there are two very concave impressions close together, one circular and the other an irregular oval, which may represent portions of the compound eyes. Below the hindwing, there are two narrow elongated fragments, one about 14 mm. long, the other about



Text-fig 14.

Aëroplana mirabilis, n.g. et sp., (Triassic, Ipswich, Q.). Sketch of the whole fossil *in situ*, (×2) to show the relative positions of the different parts. A, A, principal portions of the fore- and hindwings, figured in Plate xliv., fig. 12; B, distal portion of forewing, figured in Text-fig. 15. To the left of the wings are shown the crushed portions of the head and thorax. The fossil remains are left unshaded, the rock itself is lightly shaded, and the deep break between the parts A and B is shown in black. The rock around B has been partly cut away with a penknife.

11 mm., which appear to represent the broken-off costal borders of the other pair of wings.

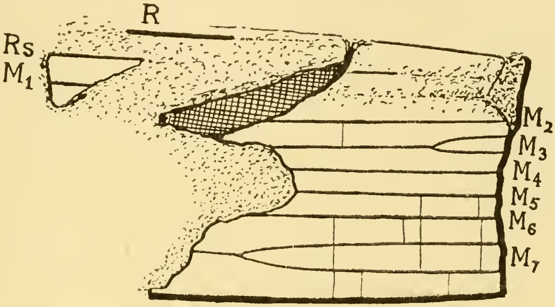
Mr. Dunstan tells me that, in the search for this fossil, the rock broke transversely across the two wings, leaving a considerable gap between them. On the other side of this break, Mr. Dunstan prospected with his penknife, and was fortunate in picking up a further (more distal) portion of the forewing, lying exactly in line with the more basal portion. This part was glued into position on çardboard with the rest of the fossil, as shown in Text-fig.14. Mr. Dunstan assures me that this part is not, at the most, more than a sixteenth of an inch out. If that be so, as it certainly would appear to be from the shape of the wing, then it is clear that the wings of this insect were excessively long and narrow, being in shape not unlike the planes of a modern aëroplane. This character suggested to me the name of the genus.

The general character of the wings of the fossil can be well seen from Plate xliv., fig.12. The hindwing is very complete as regards its basal portion, and exhibits a large number of interesting characters. We may most profitably study this wing first.

The costal space appears to be strongly convex, and was probably formed of very hard chitin, since the few cross-veins in it are indistinct, and the whole area appears to have been coriaceous in texture. The convex curvature of this area ends posteriorly in the deep groove of the subcosta, behind which the radius rises strongly up again as a convex vein. The two separate bases of Rs are both strongly marked veins, but the base of the media appears as a very weak vein diverging from R. The bases of Cu and A are strong veins.

In the whole of the basal region of the wing, up to a level just beyond the second origin of Rs, the cross-veins are strongly marked and easily followed. The meshwork here is of a typical Palæodictyopterous type, the cells formed being very irregular in shape. The development of the recurrent supplements between M and Cu, and again between A and the posterior border, in the hindwing, are clearly interesting attempts to strengthen the wing in the region of greatest curvature of the main veins.

Beyond the level of the origin of Rs, the cross-veins become weaker, and are difficult to make out. In the figure in Plate xliv., I have indicated every possible cross-vein of which I can find traces, by examination in lights of different directions and intensities. Some of these may not be true cross-veins, while there may be others present which I have missed.



Text-fig. 15.

Aëroplana mirabilis, n.g. et sp., (Triassic, Ipswich, Q.). Distal portion of forewing beyond the transverse fracture of the rock shown in Text-fig. 14; (× 7½).

The preserved part of the forewing is very similar to the hind, except for the different manner of branching of the media, which has been already mentioned. Careful measurements of corresponding portions of fore- and hindwings show that their widths are almost the same, the forewing being slightly wider than the hind, as judged by the perpendicular distance between Rs and Cu_1. But this may have been offset by a somewhat wider anal area in the hindwing.

The isolated distal portion of the forewing is shown in Text-fig. 15. The main veins are well-preserved, yet there are few indications of cross-veins. It seems probable that the cross-veins became weaker and weaker towards the distal end of the wing, and finally became obsolescent near the tip, so that most of them are not preserved in the fossil. It will be seen that there are two bifurcations in this distal part of the wing; these have to be taken into account in the restoration of the fossil, which I have attempted below.

Type, Specimen No. 126*a*. (Coll. Queensland Geological Survey).

Horizon: Upper Triassic, Ipswich, Q.

Restoration of the Wings of Aëroplana mirabilis, *n.sp.*
(Plate xlv., figs. 13-14).

In attempting to restore the complete wings of this remarkable fossil, I have made two assumptions which appear to be fairly well justified, viz., that the shape and venation of the fore- and hindwings were approximately the same (with the principal differences preserved to us in the fossil as it stands), and that the isolated portion of the forewing, shown in Text-fig. 15, lay close to the apex of the wing.

Even with this latter proviso accepted, and taking full advantage of the possibility of an error of one-sixteenth of an inch in Mr. Dunstan's placing of this fragment, it will be apparent that the length of the wings, in comparison with their breadth, is enormous, the ratio being approximately 7 : 1.

In filling in the gap between the basal half of the forewing and the distal preserved portion, it is necessary to bear in mind the possibility of one or more veins having reached the costal or posterior border, respectively, in the interval. To determine this, I examined the veins in the distal fragment carefully, with the result that I found the uppermost to be more strongly built than the others. This should, therefore, be the radius, as is also evident from its level on the wing itself. Hence, if we assume that there have been no other dichotomies of veins in the missing part of the wing, the veins below R in this part of the wing must be, in consecutive order, Rs and the seven branches of M. Of these last, it will be seen that M_3 and M_7 branch again. There remain, then, as veins that have reached the posterior border of the wing before this level, the two branches of Cu, and A.*

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* This interpretation assumes no further dichotomies of M in the missing portion of the wing.

On the above suppositions, we may restore the two wings as shown in Plate xlv., figs.13-14, the missing portion of each wing being made approximately the same as the corresponding portion present in the other.

The total length of the wings, as restored above, would be about 46 mm. each. If, then, the insect were of slender build, with a narrow thorax, the total expanse of the wings must have been about 96 mm., or nearly four inches. This is very small for a Protodonate; but the fossil bears the marks of a reduced type.

Affinities of the Fossil.

This fossil is certainly one of the most puzzling of all the Ipswich Insects. As far as I know, there is nothing in the whole range of insect-venation, either fossil or recent, that shows any close relationship to it. In finally determining to place it in a new Suborder within the Protodonata, the following points have weighed with me:

(1). The differences in the branchings of the media, in the two wings preserved, are sufficient proof that we have a fore- and a hindwing preserved, not two forewings or two hindwings.

(2). Which wing is the fore and which is the hind, is not capable of absolute proof. But, unless the insect is altogether twisted out of shape, the more anterior one should be the forewing, as I have assumed it to be.

(3). The close similarity evident between fore- and hindwing in venation, as well as in shape, puts several Orders out of court at once; notably the Orthoptera, the Perlaria, and the Homoptera.*

(4). In considering the type of venation exhibited, there would appear to be characters belonging to three Orders, viz., the Protodonata, Planipennia, and Mecoptera. These characters had to be carefully weighed, with reference to known types of each Order.

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* We might note here the existence, in Australia, of Homoptera belonging to the subfamily *Derbinæ* of the family *Fulgoridæ*, with the forewing narrowly elongate as in *Aëroplana;* also, a similar elongation occurs in both wings in the genus *Stenobiella* of the family *Trichomatidæ*, in the Order Planipennia.

(5). In the above comparison, due allowance must be made for reduction of the original venation, owing to the extreme narrowing of the wing.

Taking, then, the Mecopteran characters first, it will be seen that these may be practically summed up in the dichotomous nature of the branchings of the media. But, in the Mecoptera, the radial sector undergoes a similar series of dichotomous branchings. We must assume, then, that this type of branching is not in itself evidence of Mecopteran affinities, unless accompanied by other definite characters. That this is certainly so is shown by the archaic *Psychopsis illidgei*, which belongs to the Planipennia, but which has, nevertheless, a media dichotomously branched, in a manner not unlike that of the fossil.

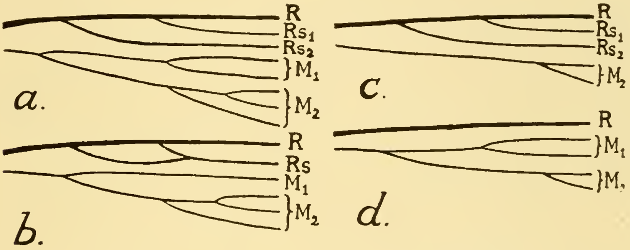
The Planipennian affinities suggested are the general appearance of the wings as being those of a "lacewing," with their numerous parallel longitudinal veins supported by, for the most part, delicately formed cross-veins; the great strength of the radius, and the close, parallel situation of the subcosta in a deep groove in front of it; and also the correspondence between the branchings of M in the fossil and in *Psychopsis illidgei*, already mentioned.

The principal characteristic of all known Planipennia, however, is the large number of descending branches of the radial sector. It is these veins that form, in this Order, the majority of the parallel longitudinal or oblique veins traversing the wing. But, in the fossil, Rs is unbranched. This alone seems quite sufficient to prevent us placing the fossil within the Planipennia. Further, in all archaic Planipennia, the series of cross-veins between C and Sc is oblique; whereas, in the fossil, those that can be seen are at right angles to the main veins, as in Odonata and Protodonata.

A further argument against both Mecopteran and Planipennian affinities for this fossil is the absence of any signs of *macrotrichia* upon the main veins. Even the strongly built radius, which is exceptionally well preserved, shows no signs whatever of having carried these structures.

The Odonata themselves cannot be brought into consideration, since the fossil evidently lacks the essential discoidal cell, not to mention a nodus, which is almost certainly absent also. We are therefore driven back to consider the claims of the Protodonata.

The strongly built, probably coriaceous, border is already known in the Carboniferous genus *Meganeura*. The new fossil also resembles this genus in the manner in which M appears basally as a very weak vein diverging gently from the strongly built R. The Protodonata, like the Odonata, are notable for the unbranched condition of Rs. Now, in *Meganeura*, there are, in the forewing, *two* radial sectors arising fairly close together, and running closely parallel for a considerable distance. If, owing to the narrowing of the wing, in the course of evolution, these two sectors were to fuse together, we might expect to get some such formation as we find in this new fossil, viz., a single Rs with two origins. In the hindwing of *Meganeura*, however, we find that Rs is entirely absent. But there is a peculiar anterior branch of M, which takes its place, and which branches dichotomously exactly in the same way that the corresponding branch of M in the hindwing of the new fossil does. All these



Text-fig. 16.

Diagrams to show the structure of the radius and media in Protodonata: *a*, suggested ancestral condition, from which there can be derived:—*b*, the condition found in *Aëroplana mirabilis*, n.g. et sp., by fusion of the two radial sectors (Rs_1, Rs_2) near their bases; *c*, the condition found in the forewing of *Meganeura monyi* Brongn., with radial sectors still separate, but anterior branch of media (M_1) eliminated; and *d*, the condition in the hindwing of the same species, with the radial sectors eliminated but the media not reduced.

conditions, viz., that in the forewing of *Meganeura*, that in the hindwing of the same genus, and that in the hindwing of *Aëroplana*, can be easily obtained by reduction from the type of venation shown in Text-fig.16, *a*, as may be seen from *b*, *c*, and *d* of the same Text-figure.

The rest of the media in *Meganeura* differs widely from that of *Aëroplana*, as is only to be expected when one considers the difference in the shape of the wings.

The cubitus in *Meganeura* (and probably in other Protodonata so far known) is simple. But it is a sinuously curved vein, resembling the Cu_2 of *Aëroplana* in its general course basally. Both genera have only a single main anal vein. But in *Meganeura*, as in other Protodonata, both Cu and A give off numerous descending branches, which are absent from *Aëroplana*.

We can only conclude that there is a certain amount of evidence of affinity between *Meganeura* and *Aëroplana*, though that evidence is by no means strong. The numerous points of difference are so evident that it will scarcely be necessary to enumerate them. There are, then, only two courses open to us: either we must place *Aëroplana* in the Order Protodonata, as a very highly specialised member, far removed from any known type of that Order; or we must make a new Order for it. In choosing the former alternative, while at the same time emphasising the unique character of the new fossil by placing it in a new Suborder, Aëroplanoptera, I have taken a course which will serve to indicate the degree of affinity of the fossil to the rest of the known Protodonata, while leaving it open to any other entomologist, if he considers this affinity insufficiently established, to raise the new Suborder to the status of an Order.

In conclusion, it seems to me quite possible that this extraordinary fossil may have held much the same position in the Order Protodonata, with respect to the *Meganeuridæ*, that the advanced *Agrionidæ* hold to-day, within the Order Odonata, with respect to such gigantic, archaic types as *Petalura*. If that be so, its existence in the Upper Triassic—at a time when, it is to be presumed, the rest of the Order had died out—need occasion us no surprise, but is rather to be expected; just as we may expect that the more advanced Dragonflies of to-day will remain in existence, long after *Petalura* has become extinct.

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4. ———————"Mesozoic Insects of Queensland. No.2. The Fossil Dragonfly *Æschnidiopsis (Æschna) flindersiensis* (Woodward), from the Rolling Downs (Cretaceous) Series. *Op. cit.*, 1917, xlii., Part 4, pp.676-692.

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EXPLANATION OF PLATES XLIV.-XLV.

Plate xliv.

Fig.12.—*Aëroplana mirabilis*, n.g. et sp. Principal preserved portions of the wings; (×7).

Plate xlv.

Figs.13-14.—*Aëroplana mirabilis*, n.g. et sp. Restoration of fore- and hindwings; (×4). Fig.13, forewing; fig.14, hindwing.

1A, analis; C, costa; Cu_1, Cu_2, the two branches of the cubitus; M_1-M_7, the seven principal branches of the media; R_1, main stem of radius; Rs, radial sector; Sc, subcosta.

Postscript (*added July 12th, 1918*).—The following important changes of nomenclature have to be made:—

Mesopanorpa Tillyard, 1918 (Type, *M. wianamattensis* Tillyard, Upper Triassic of Glenlee, N.S.W., Mecoptera,) becomes *Mesopanorpodes*, n.n.; preoccupied by *Mesopanorpa* Handlirsch, 1908 (Type, *M. hartungi* Brauer, Redtenb. & Ganglb., Middle Jurassic of Ust Balei, Siberia). The family *Mesopanorpidæ* Tillyard becomes the family *Mesopanorpodidæ*, n.n. (*See* Tillyard, These Proceedings, 1917, xlii., Pt.4 (1918), pp.746-7).

Creagris Hagen, 1860 (Type, *C. plumbeus* Oliv., Neuroptera Planipennia, Europe) becomes *Creoleon*, n.n.; preoccupied by *Creagris* Nietner, 1857, a genus of Coleoptera, Fam. *Carabidæ*. I am indebted to Mr. T. G. Sloane for this discovery. (*See* Tillyard, These Proceedings, 1918, xliii., Pt.1, p.122). The tribe *Creagrini* becomes the tribe *Creoleontini*, n.n.—R.J.T.

Postscript (*added August 7th, 1918*).—The title of Part ii. of this series of Studies should be amended as follows:—

For "*Æschnidiopsis* (*Æschna*) *flindersiensis* (Woodward)", write "*Æschnidiopsis flindersiensis* (Woodward), [*Æschna*]." It was never intended to convey the suggestion that *Æschna* is a subgenus of *Æschnidiopsis*, and hence the order of the names must be altered as here shown.—R.J.T.

THE CARBONIFEROUS TRILOBITES OF AUSTRALIA.

By John Mitchell, late Principal, Technical College at Newcastle, New South Wales.

(Plates xlvi.-liii.)

Introduction.

For many years, my collection has contained a number of Carboniferous Trilobites new to science. When the opportunity of describing them presented itself, my first intention was to confine myself to these specimens. On subsequent consideration, it occurred to me that palæontological knowledge would be increased by extending the scope of my paper so as to embrace all previous work on the Carboniferous Trilobita of Australia, to describe all new forms that might be available from other sources, and review, redescribe, and redetermine, where it might seem necessary, those species referred to by previous authors. It will be found, in the course of this paper, that, in a number of instances, my views are widely divergent from those of previous authors; and, while regretting this divergence, it has not arisen through rashness or want of reflection on my part; and I may candidly affirm that my inability to reconcile the determinations of previous authors with my own, in some cases, was the only unpleasant part of the work expended on this paper. My aim is to clear the literature on the Australian Carboniferous Trilobita, to date, of errors which have undoubtedly become incorporated therein. This aim is one not likely to be fully realised, but it will be my endeavour at least to lessen them, and, if I succeed in doing this, I shall be satisfied. That the present paper is free from errors is not one of my expectations, for with reference to my conclusions in respect to *P. woodwardi*, I am not by any means satisfied; and I shall await with some anxiety, the discovery of better petrifactions of the remains of this species, to make certain what its complete form actually was.

The discovery of the genus *Brachymetopus* in the Mount Morgan district will be of much assistance in establishing the geological age of that area, and also in correlating its sedimentary rocks with those of other localities. For reasons which will be obvious, the name *Phillipsia dubia* has been discarded by me.

To Messrs. W. S. Dun, Palæontologist, Department of Mines, Sydney, B. Dunstan, Chief Government Geologist, Brisbane, and H. A. Longman, Director of the Queensland Museum, Brisbane, I am indebted for specimens placed with me for inspection and description, and for which I tender to them my thanks. To Mr. R. Etheridge, J.P., Director and Curator of the Australian Museum, and to Mr. Dun, my thanks are tendered for affording me access to literature. I am very grateful to General A. W. Vogdes, of San Diego, U.S.A, Bibliographist and Authority on Palæozoic Crustacea, for supplying me with notes on the classification, and a list of the Carboniferous Trilobites described to date. Lastly, I wish to express my thanks to Mr. F. R. Cowper Reed, M.A., F.G.S., Acting Keeper of the Sedgwick Museum, Cambridge, England, for supplying me with a number of his valuable papers, from which I have received much help.

BIBLIOGRAPHY OF AUSTRALIAN CARBONIFEROUS TRILOBITES.

(1).—1847. Prof. McCoy (Ann. Mag. Nat. Hist., xx., p.231, Pl. xii., fig.1) described *Brachymetopus strzeleckii* and referred to the occurrence of the genus *Phillipsia* in Australian Carboniferous rocks.

(2).—1872. R. Etheridge, Senr., (Quart. Journ. Geol. Soc., Vol. xxviii., p 338, Pl. xviii., fig.7) described *Griffithides dubius*, which, from the description, would appear to be an abnormal species.

(3).—1877. De Koninck (Foss. Pal. Nouv. Galles du Sud, Pt. 3, p. 348, etc., Pl.24, figs. 8, 9, 9*a*, 10, 10*a*, 10*b*, and 10*c*) described and figured *Griffithides* (*Phillipsia*) *eichwaldi* Fischer, *Phillipsia* (*Griffithides*) *seminifera* Phillips, and *Brachymetopus strzeleckii* McCoy.

(4).—1892. R. Etheridge, Junr., (Geol. and Pal. Queensland and New Guinea, pp. 214-216, Pl. xxi., figs.11-14; Pl. viii., figs.

5, 6; and Pl. xl., figs. 4, 5, 6) described the following: – *Phillipsia dubia*, *P. woodwardi* Eth. fil., *Phillipsia*(?) sp. ind., for which he suggested the specific name *Griffithides seminiferus* var. *australasica*, from Queensland. Also in the same year [Mem Geol. Surv. N. S. Wales, Pal., No.5, Pt. ii., pp.126-130, Pl. xxi., figs. 1-4, 5 (and Text-fig. 5), 6, 7, 8; Pl. xxii., figs.12-15], the same author described *Phillipsia dubia*, *P. grandis*, *Phillipsia* spp. ind. (two, *a* and *b*), and *Griffithides*, sp. ind.

(5).—1903. F. R. C. Reed, M.A., F.G.S. (Geol. Mag., Dec. iv., Vol.x., No.467, pp.193-197) redescribed *Brachymetopus strzeleckii* McCoy, and added valuable remarks on its generic and specific position.

(6).—1917. R. Etheridge, Junr., (Geol Surv. of Queensland, Publication No.260) made additional reference to the occurrence of *Phillipsia grandis* in Queensland.

(7).—Besides the above descriptions and determinations, R. Etheridge, Junr., referred a fragment of a pygidium from West Coerdawandy and the Yaltra Mtns., on the Gascoigne River, West Australia, to his species *Phillipsia grandis* (MS.).

Critical Review of the Carboniferous Trilobites of Australia, previously described.

Order **TRILOBITA.**

Family PROETIDÆ.

Genus Brachymetopus McCoy, 1847.

1. Brachymetopus strzeleckii McCoy, Ann. Mag. Nat. Hist., xx., 1847, p.231, Pl. xii., fig.1.

Since this species was described by McCoy, no specimens of it, or of any other member of the genus, appear to have been found by collectors, though on the occasion of the first find at Dunvegan, N. S. Wales, quite a number seem to have been obtained.

Genus Phillipsia Portlock, 1843.

To Prof. McCoy we owe the first reference to the occurrence of this genus in Australia (*loc. cit. antea*).

2. PHILLIPSIA EICHWALDI De Kon., (non *P. eichwaldi* Fischer) Foss. Pal. Nouv. Galles du Sud, 1877, Pt.3, p.348, t.24, f.9.

Under the name of *Griffithides* (*Phillipsia*) *eichwaldi*, De Koninck described a trilobite from Colo Colo, N.S.W., and determined it to be *P. eichwaldi* Fischer; but, as the writer points out further on, this determination was evidently incorrect. Mr. Etheridge, Junr., expressed a similar view (Etheridge, Junr., Mem. Geol. Surv. N. S. Wales, Pal. No.5, Pt. ii., 1892, p.124). There is little doubt that the presence of this trilobite in Australia remains yet to be established.

3. PHILLIPSIA DUBIA Etheridge, Junr., (non *Griffithides dubius* Etheridge, Senr.) Geol. and Pal. Queensland and New Guinea, 1892, pp.214-215, Pl. vii., fig.5; Pl. xliv., fig.4.

Phillipsia dubia Etheridge, Junr., (non *Griffithides dubius* Etheridge, Senr.) Mem. Geol. Surv. N. S. Wales, Pal. No.5, Pt. ii., 1892, p.126, Pl. xxi., figs.1-4, Pl. xxii., figs.12, 13.

The above two forms were considered by Mr. Etheridge, Junr., to be specifically identical with *Griffithides dubius* Etheridge, Senr.; and the latter to be generically misplaced. The writer regrets that, with this determination, he cannot agree with Mr. Etheridge. It appears to him that neither of the above trilobites is specifically identical with *Griffithides dubius* Eth. Senr., nor with each other. Mr. Etheridge, Junr., when describing the trilobite from Binge Berry, Rouchel Brook, New South Wales (*loc. cit. antea*) pointed out that it differed from the Queensland form in having eighteen to twenty axial rings in the pygidium instead of eight to ten, which is the number in that of the Queensland form. This alone is sufficient to separate them specifically; but the head-shields of the two also differ. Both forms are here treated as separate species. The writer's view regarding the Queensland *Phillipsia dubia* is, that it cannot at present be generically or specifically joined with *Griffithides dubius*; and that the latter species must still be recognised. Only the discovery of a number of specimens of this form, showing the stages of development from the immature to the mature state, can satisfactorily establish the proper position generically and specifically of *Griffithides dubius* Eth. Senr.

4. PHILLIPSIA GRANDIS Etheridge, Junr., Geol. and Pal. Queensland and New Guinea, 1892, p.215. Etheridge, Junr., Mem. Geol. Surv. N. S Wales, Pal. No.5, Pt. ii., 1892, Text-fig.5, and Pl. xxi., fig.5. Etheridge, Junr., Geol. Surv. Queensland, Publication No.260, pp.11-12, Pl. iii., fig.3.

It is unfortunate that Mr. Etheridge placed these two forms specifically together. They are quite different, and are so treated by the writer. In describing them, their differences will be fully shown. As the Queensland form was the one for which the specific name *grandis* was first suggested by Mr. Etheridge, it is proposed that it should continue to be known by this name. To the New South Wales one, a new specific term will be given.

The name *grandis* is quite appropriate for either of the forms; because their pygidia are larger than those of any other known Carboniferous trilobite.

5. PHILLIPSIA WOODWARDI Etheridge, Junr., Geol. and Pal. Queensland and New Guinea, 1892, p. 215, Pl. 7, figs.11, 13; Pl. 44, figs. 5, 6.

This is a singular species, to which some reference will be made later on.

6. Besides the foregoing species of *Phillipsia*, which have been specifically determined, Mr. Etheridge described two pygidia from Binge Berry, Rouchel Brook, and near Paterson, respectively, and referred them to this genus, but did not give them specific rank.

7.(a) PHILLIPSIA sp. ind. (*a*), Etheridge, Junr., Mem. Geol. Surv. N S. Wales, Pal. No. 5, Pt. ii., 1892, p.129, Pl. xxi , figs. 6-8.

(b). PHILLIPSIA sp. ind. (*b*), Etheridge, Junr., *op. cit.*, p. 129, Pl. xxii., fig.14.

Both of these will be redescribed and named.

Genus GRIFFITHIDES Portlock, 1843.

8. GRIFFITHIDES DUBIUS Etheridge, Senr., Quart. Journ. Geol. Soc., 1872, xxviii., p.338, t.18, f.7.

The writer is of the opinion that this species should still be recognised. Its description is the first record of the genus in Australian rocks.

9. GRIFFITHIDES SEMINIFERUS De Koninck (*non* Phillips, species) Foss. Pal. Nouv. Galles du Sud, 1877, Pt.3, p.348, t.24, f.9, 9*a*.

That this determination on the part of De Koninck was incorrect, there is really no doubt. It is fully dealt with in the observations on the relationship of *Phillipsia collinsi* to other species, described further on.

10. GRIFFITHIDES SEMINIFERUS var. AUSTRALASICA Etheridge, Junr., Geol. and Pal. Queensland and New Guinea, 1892, p.216, Pl. vii., fig.14.

The material used by Mr. Etheridge for his description of the above is before me, and, after close examination of it, I am doubtful of the correctness of Mr Etheridge's conclusions. The pygidia, by which his conclusions were greatly influenced, have each thirteen and eleven axial and pleural divisions respectively; and, in this respect, agree with pygidia placed by me with his *P. woodwardi*. All these pygidia agree in their ornamentation. As regards the cephalon associated on the specimen with these pygidia, it does not appear to differ in any essential from two of those included by Mr. Etheridge in his *P. woodwardi*, except that, in the latter, the granulation has been worn off by weathering. On the glabella of the former, it is true, no anterior or mesial glabellar furrows are visible, but this glabella is a very imperfect intaglio. If it should ultimately be shown that this fossil is a good species, it will not, even then, be closely related to *Gr. seminiferus*, because it possesses supplementary basal lobes, and the latter does not. This difference certainly places them specifically apart. It may be stated that, so disposed was I to the opinion that this was a separate species, that I had written a description of it under a new name, but not being able to discern any difference in the pygidia now under discussion, and those I have placed with *P. woodwardi*, I deferred final judgment.

11. GRIFFITHIDES SWEETI Etheridge, Junr., Proc. Linn. Soc. N. S. Wales, 1894, p.528, Pl. xxxix., f.3.

The writer has not seen the original specimen. Judging from the description and illustration, it is a very unusual type. See description further on.

12. GRIFFITHIDES sp. ind., Etheridge, Junr., Mem. Geol. Surv. N. S. Wales, Pal. No.5, Pt. ii., 1892, p.130, Pl. xxii., figs.15, 16.

It is not improbable that this may be identical with *Phillipsia collinsi.*

From the foregoing review, the following conclusions have been drawn, viz.:—

i. That, of the nine species of Australian Carboniferous trilobites previously described and named, only the five following are worthy of recognition.

1. *Brachymetopus strzeleckii* McCoy.
2. *Griffithides dubius* Eth. Senr.
3. *Griffithides sweeti* Eth. Junr.
4. *Phillipsia woodwardi* Eth. Junr., Geol. et Pal. Queensland and New Guinea, p.215, Pl.7, figs.11, 13.
5. *Phillipsia grandis* Eth. Junr., of which the type is the Mt. Morgan form. Mem. Geol. Surv. N. S. Wales, Pal. No.5, Pt. ii., 1892, p.128, Pl. xxi., fig.5.

ii. That the two determinations made by the late Prof. De Koninck are incorrect, and scientifically valueless.

Family PROETIDÆ Steinb.

Genus PHILLIPSIA Portlock, 1843.

Dr. H. Woodward's* description of the genus is as follows:—"General form oval; glabella with nearly parallel sides, marked by either two or three pairs of short lateral furrows; the posterior angles, forming the basal lobes, always separated by a circular furrow from the rest of the glabella; eyes large, reniform, surface delicately faceted; cervical furrow deep; free cheeks separated from the glabella by the axal (facial) suture, which forms an acute angle with the circular border of the cheek in front of the

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* Mon. Brit. Carb. Trilobites, 1883-4, p.11.

glabella; whilst the facial suture cuts obliquely across the posterior margin, just behind the eye, leaving a small pointed portion fixed to the glabella by the neck-lobe; angles of the cheeks more or less produced, margin of head incurved, forming a striated and punctured rim. Thoracic segments nine in number, the axis distinctly marked off from the side-lobes or pleuræ by the axal furrows; the abdomen or pygidium usually with a rounded border, the axis composed of from 12 to 18 coalesced segments."

PHILLIPSIA COLLINSI, sp.nov.

(Pl. xlvi., figs.1-5; Pl. xlviii., figs.8, 9; Pl. lii., fig.4).

Sp. Chars.—Complete form elongately ellipsoidal.

Cephalon sub-semielliptic, moderately inflated, densely tuberculated; glabella sub-oblong or sub-bellshaped, narrow, upper surface flat, steep and straight-sided, densely crowded with prominent tubercles of variable sizes; medially the tubercles are arranged in four sublongitudinal rows, those on the anterior part are subconcentric; front gently rounded and bearing a concentric row of tubercles; lateral lobes and furrows distinct, the basal pair altogether circumscribed, and bearing a varying number of tubercles, one usually much larger than the others; limb narrow, with a gentle upward turn, smooth or very finely granulate; neck-furrow distinct, narrow, and deep behind the basal lobes; neck-ring strong, moderately arched and tuberculate, its lateral extensions being narrow; fixed cheeks very small, eye or palpebral lobes bounded by tubercles; eyes apparently crescentic; free cheeks unknown. Axial furrows distinct; facial sutures anteriorly very gently sinuate (almost straight) and close to the axial furrows; posteriorly straight, and almost at right angles to the axial line, and at last cutting the fixed-cheeks with a sharp backward turn.

Thorax oblong, moderately inflated and granulated; axis prominent, the rings centrally and at the bases mildly curve forward; bases feebly tuberculated, width equal to that of one side-lobe, median sulci of the rings narrow; pleuræ convex, medial furrows of each segment wide and shallow, and reaching the distal end, which is rounded; each posterior segmental ridge bears a row of tubercles, as do also the axial rings; axial furrows distinct.

Pygidium semi-ellipsoidal, moderately tumid and strongly tuberculate; proportion of length to width equals 3 : 4 approximately; axis has fourteen rings, prominent, dorsally depressed, sides steep, contracting very gradually posteriorly to about half the anterior width, terminating bluntly and somewhat overhanging the border, the rings bearing tubercles which vary in number with their spread from two or more on the posterior ring, to eight on the anterior ones, and not exactly forming longitudinal rows; axial furrows pronounced; pleuræ very convex, arching from the axial grooves at first gently and then steeply to the narrow furrow separating them from the border, where all the segments, except the anterior pair, end, segments ten in number, each succeeding one having a gently backward trend, and diminishing in length till the last two pairs are represented by mere tubercles. Each segment bears a row of tubercles along the posterior ridge varying in number with its length, from one to ten, and perhaps in some instances more; medial segmental furrows wide and shallow, reaching to the faint furrow within the border; the border itself is fairly wide, and thickened, and, in normal specimens, has the same convexity as the pleural ribs; it bears a row of conspicuous tubercles usually placed in line with each rib, and three to five behind the axis, these tubercles being occasionally elongated or double; when the thickened portion is removed, the undersurface shows concentric striations, which is a common feature in the Proetidæ. Only the first pair of the pleural segments interrupts the continuity of the border.

Obs — This species is quite singular. Its outstanding features are : — 1. The narrow, straight-sided glabella. 2. The crowded and conspicuous tuberculation of the glabella. 3. The equality of the lengths of the pygidium and thorax. 4. The width of the thorax, which equals half the total length of the complete individual. 5. The closeness of the eyes to the axial groove. 6. The straightness of the anterior branches of the facial sutures, and their parallelism to the axial furrows.

Dimensions: total length of an individual not quite mature, one inch; width, half an inch; cephalon, one-quarter inch; thorax and pygidium, each three-eighths of an inch.

In the proportions of length to width, and the character of the pygidial granulation, this trilobite agrees with *P. gemmulifera* Phillips, with which it also agrees in the equality of the lengths of the thorax and pygidium. In other specific features, they differ. In the cephalons and pygidia of *P. collinsi* and *P. truncatula*, there is much common to the two. They agree in possessing narrow, straight-sided and tuberculate glabellæ, eyes close to the axial furrows, and similarly tuberculated pygidia; but the tuberculation on the glabella of the former is much more pronounced than it is on the latter, and the sinuate course of the anterior branches of the facial sutures of the latter is more pronounced than that of the former. The pygidium of *P. truncatula* has seventeen or eighteen annulations in the axis, and fourteen divisions in each pleura; but in *P. collinsi*, these parts number fourteen (or thirteen and a terminal piece), and ten respectively. In the former, the pygidium has no border, and the pleural ribs extend to the periphery; on the other hand, the latter species has a very distinct pygidial border, which, except in the case of the anterior pairs, the pleural ribs do not cross. The tubercles of the pygidial axis of the former are arranged in longitudinal rows; this is not quite so with those of the latter. Of the North American Phillipsiæ, the nearest relative to ours appears to be *P. insignis*, which apparently has the same number of divisions in the axis and pleuræ of the pygidium, as are in the similar parts of *P. collinsi*. The tuberculation of the axial rings is much alike in the two species. In other respects, they differ rather widely. The only Australian Carboniferous trilobite fragments bearing any resemblance to *P. collinsi* are two pygidia described and figured, but not named, by Mr. Etheridge, Junr.* The one pygidium he placed in the genus *Phillipsia* (*loc. cit.*, Pl. xxii., fig.14). It agrees with *P. collinsi* in possessing fourteen rings in the pygidial axis, and in having a tuberculate test; but differs in having a continuous, smooth, flattened border, and

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* R. Etheridge, Junr., Mem. Geol. Surv. N. S. Wales, Pal. No.5, Pt. ii., 1892, pp.129-130, Pl. xxii., figs.14, 15.

twelve pleural segments, and less disparity between length and width of the pygidium.

The pygidium (*loc. cit.*, Pl. xxii., fig.15) placed by Mr Etheridge in the genus *Griffithides*, bears a resemblance to the present species in the character of its border and granulation, and in having the same number of pleural segments; but its axis has less rings, and ends in a sharp point.

Lastly, referring to De Koninck's *P.* (*Griffithides*) *seminifera* (*non* Phillips sp.)* from Colo Colo. The dimensions, number of rings in the axis of the pygidium, character of the granulation generally on the pygidium and thorax agree closely with similar features of *P. collinsi*; but the two forms widely differ in the outlines of their glabellæ and pygidia, if De Koninck's figures are to be relied upon, which is doubtful, as they do not agree with the text. In the former, the glabella is represented as being conical in outline; and, in the latter, it is said to have an anterior width slightly less than that of its base. Whatever *Phillipsia* (*Griffithides*) *seminifera* De Koninck, may have been, it is practically certain it was not *Griffithides seminiferus* Phillips; but it may have been identical with the present species.

Named after Mr. Collins, C.C.M., Lecturer in Coalmining and Mine Surveying at the Newcastle Technical College.

Loc. and Hor.—Glen William Road, one mile from Clarencetown, Parish Parr, County Durham. Lower(?) Carboniferous.

PHILLIPSIA COULTERI, sp.nov.

(Plate xlvi., figs 6-10).

Sp. Chars.—Complete form subelliptic.

Cephalon sub-semielliptic, fairly inflated, finely granulated: glabella subrectangular, rounded in front, lateral furrows and lobes not visible, owing to the loss of the part bearing them, and the exposure of the hypostome; neck-furrow shallow, its lateral extensions across the cheeks shallow and wide; neck-ring narrow; axial furrows faint. Fixed cheeks small. Free cheeks relatively large, strongly inflated, steep between the eye and border-furrow, which is wide and shallow, outer edge of border only moderately

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* Pal. Foss. Nouv. Galles du Sud, 1877, p.267, Pl. xxix., figs. 9, *9a*.

thickened. Eyes prominent, large, crescentic and faceted. Genal angles rounded. Hypostome alate, shield like, and striated in the fashion common to Phillipsiæ.

Thorax 11 mm. wide and 9 mm. long, appearing to have been finely granulated, with a few scattered tubercles; straight-sided. Axis very strongly and acutely arched, rings, centrally and basally, strongly inclined anteriorly, each one bearing along the medial line a rather prominent tubercle, giving the axis throughout a serrated character; spread equal to that of one side-lobe, mildly tuberculate, height and width diminishing gradually posteriorly, axial grooves faint. Pleuræ gently rising from the axial grooves to the fulcra, thence steeply deflected, mesial furrows of the somites shallow and wide, and reaching the extremities, which are rounded; along the fulcral line each rib bears a tubercle on the posterior ridge, and there is evidence of the presence of general fine tuberculation or granulation.

Pygidium semielliptic, length 8 mm., width 10 mm. Axis very prominent, the first ring having a medial forward trend, rings eight or nine, counting the end-piece, which is buttress-like, and ends at the border in a rather fine point, and bears a subconspicuous tubercle. Pleuræ with seven divisions, all rather inconspicuous in the specimen (decorticated) serving for this description, moderately convex; mesial furrows very shallow and reaching to the faint furrow within the border, each segment bearing a tubercle at the fulcral angle, and showing traces of other tuberculation, as do also the axial rings; the border is relatively wide, steep, gently thickened, and bounded inwardly by a faint furrow, and is crossed only by the first pair of ribs.

Obs.—Though the glabellar furrows and lobes are not visible in the specimen described, the shape of the glabella and character of the hypostome leave no doubt as to its being a Phillipsia, and the specimen is one of the finest of this genus yet discovered in Australia. It differs so widely from other Australian species that there is no need to detail its relationship. It bears no close relationship to any of the American Phillipsiæ referred to in Brigadier General A. W. Vogdes' Monograph.*

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* "The Genera and Species of North American Carb. Trilobites," Annals N. Y. Acad. Sci., 1888, vi.

The species has been named after Mr. E. Coulter, of Katoomba, an enthusiastic student of geology, who discovered and presented the specimen to the author.

Loc. and Hor.—Stroud-Dungog Road, near Dungog, Parish Howick, County Durham. Lower Carboniferous.

PHILLIPSIA BREVICEPS, sp.nov.

(Plate xlvi., figs.11, 12; and Plate li., fig.2).

Sp. Chars.—Complete form unknown.

Cephalon apparently subsemicircular, finely granulated. Glabella straight-sided, rounded in front, very gently convex, highest just in front of the neck-furrow, smooth, though a lens shows evidence of microscopic granulation, two pairs of lateral furrows visible, basal and mesial. The former very shallow and circumscribing the basal lobes, which are large and pyriform; the other narrow; neck-furrow narrow and shallow; neck-ring relatively wide, decidedly arched backwardly and lobed at its bases; frontal limb narrow and gently recurved. Fixed cheeks very small, eye-lobes small, and abutting the axial furrows. Facial sutures anteriorly rather straight and close to the axial furrows; eyes of moderate size only, judging by the size of the palebral lobes.

Thorax unknown.

Pygidium sub-semielliptical, moderately convex, very finely granulated; width 10 mm., and length 7 mm. respectively. Axis prominent, consisting of thirteen rings, and a very narrow end-piece, spread equal to that of each side-lobe, contracting very gradually posteriorly, and terminating short of the border, rounded and bluntly, with half its anterior width; some of the rings bear very fine tubercles, barely distinguishable without the aid of a lens; side-lobes moderately convex, with ten, or doubtfully eleven, pairs of segments, of which the medial furrows are distinct, and, in the case of the four anterior pairs, at least reach the edge and interrupt the narrow border; a few of the posterior segments bear very small tubercles at their junction with the border, and three similar tubercles occur behind the axis, on the axis itself centrally the posterior ridges also bear fine tubercles.

Obs.—As will be apparent from a comparison of the above description with that of *P. derbiensis* Martin, the two fossils agree in several important features. For example, in both the glabella is parallel-sided and practically smooth, anterior facial sutures rather straight and close to the axial furrows, eyes reniform, pygidial axis with thirteen rings, and ten segments in the pleuræ; and the pygidial borders obsolescing before reaching the articulating face: in the equality of maximum widths of the axes and pleuræ of the pygidia (this is only true in the case of the above species when the pleuræ are measured obliquely, and not the actual horizontal widths; if measured in the latter way, the axis is wider than one pleura) and the faint tendency to ornamentation on these parts. Against these resemblances, there are the following differences to be considered. The length of the glabella of the local species, measured from the neck-furrow to its front, is equal to its width between the axial furrows across the basal lobes; in that of *P. derbiensis*, these dimensions are respectively about 4 : 2. The eye-lobes are shorter, and the frontal border wider, neck-ring more intensely arched posteriorly in the local form than in the British one. The distinct lobation of the bases of the neck-ring, relatively short cephalon, and the almost equality of the lengths of the cephalon and tail are very marked features in the local species, separating it from the other. Then there is the distinct, though fine, granulation, more or less tuberculation of the pygidium of the form now described, as against a practically smooth one in the other. Further, judging from the anterior pair of pleural segments of the pygidium, the thoracic pleural ribs were not imbricated, in the case of the local species. Although undoubtedly closely related to each other, I have concluded that the differences between them are sufficient to justify their separation specifically.

The glabellæ of the above species and *Proëtus missouriensis* are much alike. I am indebted to Brigadier General Vogdes' paper (*op. cit.*, *antea*) for the references made to American Carboniferous trilobites.

Loc. and Hor.—Neighbourhood of Port Stephens, probably from near Bulladelah. Carboniferous.

PHILLIPSIA PROXIMA, sp.nov.

(Plate xlvi., figs.15, 16).

Sp. Chars.—Pygidium semielliptical, fairly convex, practically smooth, so fine is the granulation. Length 12 mm., width 15 mm. Axis strongly convex, rings twenty, tapering posteriorly very gradually, and ending bluntly at the border, with a spread of about half that of the anterior ring; axial furrow shallow, but distinct. Pleuræ gently convex, consisting of twelve pairs of ribs, the last one or two very short and faint, all terminating at the border, which is continuous to the articulating face and subdepressed; medial furrows of the segments, except in the cases of a few of the posterior pairs, well defined, anchylosing ridges also fairly prominent; furrow separating border and pleural ribs distinct.

Obs.—This pygidium agrees with that of *Phillipsia eichwaldi* Fischer, in the continuous smooth and somewhat depressed border, and the character of the pleural segments. The most important differences between them are—(1) the pygidium of *P. eichwaldi* is just as wide as long, is distinctly granulated, and the distal axial end does not seem to be prominent. The pygidium above-described has a length only four-fifths of its width, and is practically smooth. The total length of the pygidia of mature individuals of the former, as shown by the beautiful figures in Dr. H. Woodward's work* is 9·5 mm., that of the latter is 12 mm. The large number of rings in the axis of ours places it far apart from the other. Named because of its close resemblance to *P. eichwaldi* Fischer, in shape.

Loc. and Hor.—Glen William Road, near Clarencetown, Parish Parr, County Durham. Lower Carboniferous.

PHILLIPSIA(?) ROBUSTA, sp.nov.

(Plate xlvii., figs.1 and 8).

Phillipsia grandis Eth. fil., Mem. Geol. Surv. N. S. Wales, No. 5, Pt. ii., 1892, p.128, text-fig.5 (*non* Pl. xxi., fig.5).

Sp. Chars.—Cephalon and *thorax* unknown.

Pygidium subsemicircular, strongly convex, very finely granu-

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* Mon. Brit. Carb. Trilobites, 1883-4, Pl. iv., figs. 9 and 13.

late, greatest width 44 mm., length 26 mm., (the width here given is what the writer considers to be the normal, and is calculated from the width of the left side-lobe and half the spread of the axis, because the right side-lobe is distorted). Axis fairly prominent, evenly arched without any decided backward or forward inclination of the annulations, of which there are fourteen; the furrows of these are wide and V-shaped in section, ridges high, edged, and bore some small tubercles, bases not tuberculate. Axial furrows shallow. Pleuræ very convex, arching strongly from the axial furrows, and showing no decided fulcra; segmental divisions twelve pairs, which reach to the border, and are only gently directed posteriorly, except in the case of the last two pairs; their mesial furrows are V-shaped, wide, and reach to the border, ridges high and chisel-edged, and show no sutures, hence the pleural segments in this pygidium were very completely fused: some of the ridges exhibit evidence of very fine and sparse tuberculation, anterior pair faceted. Border continuous, wide, steep, and its undersurface concentrically striated.

Obs.—This pygidium was described and figured by R. Etheridge Junr.,[*] and considered by him to be identical with a pygidial fragment from near Mt. Morgan, Queensland, and for which he had previously suggested the name *Phillipsia grandis*.[†] Mr. Etheridge figured this Queensland specimen, when dealing with some New South Wales trilobites.[‡] The writer is unable to accept Mr. Etheridge's determination of the identity of these two pygidia, for the following reasons. 1. The part of the pleural lobe preserved on the Queensland pygidium shows fifteen segments, and, when complete, without doubt had several others, as against twelve in the New South Wales one. 2. Though the Queensland tail, when complete, was apparently longer than that of the New South Wales specimen, the greatest width of its pleural lobes was only 10 mm., as against 15 mm. for that of

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[*] Mem. Geol. Survey N. S. Wales, Pal. No.5, Pt. ii., 1892, p.128, text-fig.5 (*non* Pl. xxi., fig.5).

[†] Jack and Etheridge, Geol. and Pal. of Queensland and New Guinea, 1892, pp.215, 216.

[‡] Mem. Geol. Survey N. S. Wales, Pal. No.5, Pt. ii., 1892, Pl. xxi., fig.5.

the latter. 3. In the Queensland one, the pleural segments along the ridges are separated by very distinct sutures; in the other, this is not so. 4. In the Queensland one, the border is not nearly continuous, for the three anterior pairs of pleural segments reach to the edge of the lobes, and these are the only ones which are perfect on the portion of the left and pleural lobe of the specimen. 5. The mesial furrows and ridges of the pleural segments are not alike in the two. 6. In the Queensland tail, there were not less than sixteen or more axial rings, but fourteen only in that of the other. 7. The axial grooves are deeper in the specimen from Queensland, than in the one from New South Wales. The two agree in the character of their granulations; but that of the Queensland one is the coarser.

That the Queensland pygidial fragment represents a new species of either Phillipsia or Griffithides, there is no doubt; and, to it, my proposition is to apply the name *Phillipsia grandis*, first suggested for it by my friend, Mr. Etheridge.

P. robusta differs from all species of this genus, or of Griffithides known to me. Mr. Etheridge, too, noted (*loc. cit.*) how different it was from foreign Carboniferous trilobites.

Loc. and Hor.—Swain's Conditional Purchase, seven miles south-east of Carroll, County Buckland (D. A. Porter). Carboniferous.

PHILLIPSIA(?) STROUDENSIS, sp.nov.

(Plate xlvi., fig.14; Plate li., fig.11).

Sp. Chars.—*Cephalon* and *thorax* unknown.

Pygidium semielliptic, densely and finely granulate, moderately convex; greatest width 17 mm., length 15 mm. Axis only moderately convex. Consists of twenty annulations, a few of the anterior of which have a very gentle forward inclination, centrally and basally; contraction posteriorly very gradual, terminating bluntly, and rounded at the border, with half the anterior width (3 mm.), medial furrows of the rings wide and shallow; anchylosing ridges not very prominent, but distinctly granulated, anterior spread slightly less than that of one side-lobe. Axial furrows faint. Pleuræ moderately convex, segments fifteen, the last faint, anterior pair faceted, all finely and distinctly granulate, reaching to the border, and gently inclined backward (falcate). Medial furrows wide and shallow, reaching the border, ridges low. Border continuous, narrow anteriorly, gently increasing in width posteriorly, flat, densely and finely granulate.

Obs.—This is a fairly large pygidium, as the dimensions given will show; but it is, in this respect, exceeded by both of the forms placed by Mr. R. Etheridge Junr., under the name of *P. grandis*; but it has no specific relations with either of them. In the number of axial rings, it agrees with *P. elongata*, but not in other features. It is different from all the British Phillipsiæ the writer has been able to compare it with; and the same is true as far as the North American species are concerned.

Loc. and Hor.—Stroud, County Gloucester, N.S.W., associated with *Orthis resupinata* and *Spirifer striatus*. Lower(?) Carboniferous.

Phillipsia superba, sp.nov.

(Plate xlviii., fig.15; Plate lii., fig.3).

Complete form unknown.

Sp. Chars.—*Cephalon* semicircular or very nearly so, microscopically granulate, practically smooth; length 6 mm., width just on double its length. Glabella subfiddle-shaped, or suboblong with a very gently rounded front, practically smooth, very slightly convex, and decidedly contracted at the middle; three glabellar furrows (doubtfully four), anterior pair or pairs very short, mesial pair falcate and very faint, posterior pair faint at their origin; inwardly wide and deep. Anterior and mesial lobes ill-defined, the latter indistinctly separated from the basal pair, which are small, reniform, and prominent, standing out from the posterior part of the glabella, like tubercles. Neck-furrow distinct, with a decided central and basal forward curve, its lateral extensions straight and well-defined, joining with the lateral furrows of the free cheeks within the genal angles. Neck-ring strong, convex, centrally and basally anteriorly inclined, bases also gently tuberculate; lateral extension narrow and not prominent. Axial grooves relatively narrow, deep, and sinuate. Limb narrow, with gently thickened and mildly raised margin. Facial sutures anteriorly gently sinuate, and posteriorly shortly obliquely curved. Fixed cheeks very small, palpebral lobe almost linear, but convex. Free cheeks relatively fairly large, subdepressed, border wide, depressed; margin very slightly thickened, furrow shallow, linear; bands just within the border, and the similar bands under the shallow, wide furrows beneath the eyes, bear rows of granules. Genal angles apparently rounded. Eyes relatively large, reniform and faceted.

Obs.—This cephalon is clearly separated from all other known Australian Phillipsiæ. In the shape of the glabella and possibly in the possession of four glabellar furrows, relative size and situation of the eyes, it bears likeness to *P. eichwaldi*; but it differs from that species in having a nearly semicircular cephalon, rounded genal angles, and in the absence of distinct cephalic granulation, and of genal spines. Also, it resembles *P. derbiensis* Martin, in the form of the glabella, small free cheeks, and character of its facial sutures, small palpebral lobes, rounded genal angles, and widely differs in other respects. No North American Phillipsiæ known to the writer, have any close relationship with this one.

Loc. and Hor.—Supposed to have been obtained near Dungog, N.S.W.

PHILLIPSIA(?) WATERHOUSEI, sp.nov.

(Plate xlviii., figs.16-18; Plate lii., fig.7).

Complete form oval.

Sp. Chars.—*Cephalon* subsemicircular, greatest length and width approximately 2 mm., and 4 mm., respectively; finely and densely granulated. Glabella subcylindrical, narrow, very convex, anteriorly sloping to the border rather steeply, basal glabellar furrows small; the anterior and mesial pairs are visible on the cover, basal lobes small, neck-furrows wide and deep, lateral extensions similar; neck-ring strong, very convex, its lateral extensions also strong; frontal limb narrow and close to the glabella. Facial sutures, anteriorly, only gently diverging laterally in their course, posteriorly short and oblique. Fixed cheeks small. Free cheeks moderately large and strongly inflated, borders relatively wide and depressed; genal angles produced into spines apparently extending almost to the distal end of the thorax. Eyes crescentic, relatively large, faceted and depressed. Axial grooves shallow.

Thorax apparently has the normal number of somites, eight being plainly recognisable by the aid of a lens, the whole surface finely granulated. Axis strongly and rather acutely arched, as wide anteriorly as one side-lobe; posteriorly diminishing gradually, the fourth ring appears to be much stronger than the others, and resembles in this respect the neck-ring; all the rings are directed anteriorly, and bear a row of very fine granules on the ridges. Side-lobes strongly convex, ridges and valleys of the segments strong and deep respectively, ridges bearing rows of fine granules; segmental extremities faceted. Axial furrows narrow.

Pygidium subtriangular, fairly inflated, granular throughout in a way similar to the thorax; axis prominent, diminishing rapidly posteriorly, and terminating at the border with a moderately fine point; the rings appear to be eight in number. Side-lobes convex, made up of six pairs of segments, apparently. Border narrow, steep and continuous.

Obs.—In so small a specimen, it is a difficult matter to clearly distinguish its features; but, under a lens, they become discernible. The glabella in shape slightly resembles that of a Griffithides; and had it not been for the presence on it of three pairs of glabellar furrows, I would have placed it in this genus. It is the smallest and most perfect Carboniferous trilobite belonging either to Phillipsia or Griffithides obtained in Australia. It may represent only an immature individual, but still mature enough to have all its chief parts developed.

In the shape of the glabella and of the pygidium, this species is not unlike *Phillipsia leei* Woodw., and *P. minor* Woodw.

Dedicated to J. Waterhouse, M.A., Government Inspector of Schools.

Loc. and Hor.—Probable Paterson or Dungog District, N.S.W. Carboniferous.

PHILLIPSIA ELONGATA, sp.nov.

(Pl. xlvii., figs.3-5; Pl. xlviii., fig.14; and Pl. l., figs.4-7).

Phillipsia dubia Eth. fil., Mem. Geol. Surv. N. S. Wales, Pal.

No. 5, Pt. ii., 1892, pp.126, 127, Pl. xxi., figs. 1-4, and Pl. xxii., figs. 12, 13.

Complete form elongately oval.

Sp. Chars.—Cephalon sub-semielliptic, smooth, only moderately inflated, greatest length 12 mm., width between the genal angles 18 mm. Glabella long, narrow, sub-bellshaped, convex and prominent, highest between the anterior lateral furrows, and from thence sloping to the front, which is gently rounded; lateral furrows distinct, first pair short, linear and gently curved, middle pair linear with a posterior curve, posterior pair wide, shallow and circumscribing the basal lobes, which are relatively small and suboval. Neck-furrow shallow, its lateral extensions shallow. Neck-ring narrow, with a strong forward inclination, its lateral extensions also narrow. Frontal border fairly wide, especially at the antero-lateral angles. Facial sutures strongly sinuate anteriorly, and posteriorly obliquely crossing the fixed cheeks nearly in a line with the outer edge of the thorax. Axial furrows deep. Fixed cheeks small. Eye-lobes small, crescentic and elevated. Free cheeks relatively large, depressed, border wide, space between the border and furrow beneath the eyes short and steep; and immediately under the eye is a groove. Eyes large, subcrescentic, very distinctly faceted, and wider behind than in front. Genal angles spinate, the spines evidently long. Thorax with the normal number of somites; length two-thirds of the greatest width, sides subparallel, surface smooth or very finely granulate. Axis prominent, rings with a distinct forward inclination centrally, and showing slight indication on the ridges of granulation, spread equal to one side-lobe; axial furrows faint; side-lobes sloping gently from the axial furrows to the fulcra, thence sloping fairly steeply. Mesial furrows of the somites distinct, and reaching to the extremities, the anterior somites shorter than the posterior ones.

Pygidium sub-semielliptic, convex, greatest width nearly equal to the greatest width of the thorax, and consequently just on one-third greater than the thoracic length. Axis very prominent, tapering gradually, and ending just within the border at half the anterior width, rather prominently and rounded; annulations twenty, strongly arched; axial furrows distinct; side-lobes strongly convex, their greatest width equals the anterior spread of the axis; segments fourteen, all terminating at the inner boundary of the narrow border.

Obs.—This very fine trilobite was described by Mr. R. Etheridge,* and was determined by him to be identical with his *P. dubia*,† remarking, however, that the form now dealt with differed from the Queensland one in the possession of eighteen to twenty annulations in the pygidial axis, while the former had only eight to ten. This of itself appears to the writer a sufficient difference to justify the separation of the two forms specifically, for, in no instance, has he found any Phillipsia, or indeed any member of the Proëtidæ, presenting such a wide variation in the axial annulations of its pygidium as is exhibited by these two forms. But there are other differences between the two forms of even greater specific importance than this one. The eyes and front limb of the glabella of *P. elongata* are relatively very much larger than those of *P. stanvellensis* (*P. dubia* Eth. fil.). In the former, the facial sutures are more sinuate, the free cheeks more depressed, eyes more squat on the cheeks, lateral furrows of the free cheeks wider than they are in the latter. The neck-ring and thoracic axial rings in the former are non-tuberculate basally; in the latter, these are tuberculate; the glabella of the former, too, is relatively longer and straighter-sided than is the case in the latter. The former has a relatively narrower pygidial border, and is of a much larger growth than the other.

The two forms, in many of their features, belong to the same typical group of Phillipsiæ, in which the glabellæ diminish in width anteriorly, and are sub-bellshaped, and the facial sutures strongly sinuate in front of the eyes. The British *P. truncatula* is a good representative of the group.

Loc. and Hor.—Binge Berry, Rouchel Brook, Hunter River, County Durham: (?)Allyn River, half a mile north-east of Gresford; County Durham (Cullen).

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* Mem. Geol. Survey N. S. Wales, Pal. No.5, Pt. ii., 1892, pp.126-8.

† Geol. and Pal. Queensland and New Guinea, p. 215, Pl. 8, fig. 5.

Phillipsia rockhamptonensis, sp.nov.

(Plate xlix., figs. 9, 10; Plate l., figs. 8, 9).

Phillipsia dubia Etheridge, fil., Geol. and Pal. Queensland and New Guinea, 1892, pp.214-215, Pl.44, fig.4.

P. woodwarai Eth. fil., *op. cit*, p. 215, Pl.44, fig.6.

Complete form oblong-ovate.

Sp. Chars.—*Cephalon* sub-semicircular, appearing to have been very finely granulated. Glabella subcylindrical or conical, widest across the basal lobes, two lateral furrows visible on the left side, basal pair wide, deep, and very distinctly joining the neck-furrow, basal lobes small, very prominent and sub-pyriform; neck-furrow deep centrally and shallowed laterally by a very mild swelling behind the basal glabellar lobes, which can barely be said to be supplementary lobes, its lateral extensions shallow; neck-ring stronger and more convex than any of the axial rings, very faintly tuberculate at its base, front limb narrow, the margin being upturned and gently thickened; axial grooves narrow; fixed cheeks small; eye-lobe relatively large and granulated; free cheeks fairly large, only moderately tumid, depressed but posteriorly high and sloping steeply into the posterior furrow, distinctly channelled under the eyes, lateral furrows wide, lateral borders of moderate width, mildly tumid, under-surface striated; facial sutures not distinguishable anteriorly, and posteriorly obliquely crossing the fixed cheeks rather close to the axial grooves; eyes of medium size, reniform, faceted, prominent and vertically narrow, genal angles bearing long spines.

Thorax oblong, length equal to the width of the axis and one side-lobe, granulations microscopic, somites of the normal number, axis strongly convex, wider than one side-lobe, diminishing posteriorly very gently and uniformly, anterior width in the specimen under notice being 5 mm., and the posterior width 4 mm.; each individual ring has a decided anterior trend centrally and tuberculate bases, ridges and valleys narrow, and on the former the articulating seams are plainly visible; side-lobes convex, steeply deflected from the fulcra, segmental ends strongly faceted, axial grooves narrow.

Pygidium sub-semicircular or sub-semielliptic, length 7 mm., greatest width 12 mm., convex, distinct indications of granulation present; axis prominent, strongly convex, diminishing rapidly posteriorly, ending prominently near the margin of the border with about one-fourth of its anterior spread, its rings are twelve; axial grooves distinct; side-lobes convex, consisting of eight pairs of segments, the last two pairs being rather indistinct, first pair faceted; border of moderate width, gently tumid, continuous to the anterior pair of segments; undersurface striated.

Obs.—This fossil was included by Mr. Etheridge with his species *Phillipsia dubia* (*op cit.*), but not separately described. For so placing it, there appears to me to be insufficient reason. That the trilobite here described is not identical with Mr. Etheridge's *P. dubia* (*P. stanvellensis* mihi) may be made plain by an explanation of their differences.

(1). The free cheeks and eyes are different, as are their glabellæ; for though the glabella of the present species is not perfect, there is sufficient of it preserved to show that, anteriorly, it neither contracts nor droops as does that of *P. dubia* (*P. stanvellensis*).

(2). The neck-furrows of the two also differ.

(3). The axis of the former is wider than one side-lobe; in the latter, the axis is narrower than one side-lobe.

(4). The axis of the former is much less prominent than that of the latter.

(5). In the former, the length of the thorax is much greater than its cephalic or pygidial length; in the latter, both the cephalon and pygidium are longer than the thorax.

(6). In the latter, the anterior pleural segments of the pygidium show distinct bifurcation; this is not visible in the former.

(7). The genal angles of the former are strongly spinate; those of the latter are not yet proven to be so.

(8). The middle lobe of the one is wide and moderately convex; that of the other, narrow and very convex.

(9). The angulation of the free cheeks of the former posteriorly, and their steep slope into the furrow are very marked, but this is not so in the latter.

The above differences clearly separate the two species. From all other Australian species, it is easily distinguished.

Loc. and Hor.—Rockhampton district, Corner Creek, Great Star River, Queensland. Carboniferous.

PHILLIPSIA STANVELLENSIS, sp.nov.

(Plate xlviii., figs.10-13; Plate li., figs.8-10).

Phillipsia dubia Eth. fil., Geol. and Pal. Queensland and New Guinea, 1892, pp.214-215, Pl.8, fig.5.

Complete form elongately ellipsoidal.

Sp. Chars.—*Cephalon* sub-semielliptic, strongly inflated, practically smooth, length 6 mm., width between the genal angles 9 mm. Glabella bell-shaped or subconical, high posteriorly, with a steep anterior droop to the front limb, microscopically granulated, three pairs of lateral furrows, basal pair shallow, the others faint; basal lobes very prominent, relatively small and round, mesial pair subquadrate and about equal in size to the basal pair, front pair well-defined. Neck-furrow shallow centrally, but rather deeper behind the basal glabellar lobes, its lateral extensions across the fixed cheeks shallow; neck-ring narrow, strongly arched, and its bases tuberculated, lateral extensions weak; front limb narrow, gently thickened, and turned almost on to the front of the glabella; facial sutures anteriorly only moderately sinuate, posteriorly oblique and crossing the fixed cheeks in a line with the fulcra of the thoracic segments. Free cheeks relatively large and steep, border moderately wide and strong, lateral furrows linear and faint. Eyes of moderate size, densely and finely faceted, subcrescentic, and rising steeply from the shallow grooves of the cheeks just below them. Genal angles acute, but apparently not spinate.

Thorax: length two-thirds of width approximately, and anterior and posterior widths equal; number of somites small, smooth. Axis very prominent, rings arched forward both centrally and basally, bases also tuberculate, centrally each ring is rather acute, which gives to the axis when viewed sideways a mildly serrated aspect; ring-furrows rather deep, ridges high and narrow (in decorticated specimens), greatest width 3 mm., and is wider than the pleuræ if measured horizontally. Axial grooves linear. Side-lobes between the axial grooves and fulcra almost horizontal, thence nearly perpendicular; somites apparently faceted, medial grooves very shallow, ridges feeble.

Pygidium semielliptic, length 6 mm., width 7 mm., smooth. Axis very prominent, made up of twelve if not thirteen annulations, but not more than ten usually visible owing to the slenderness of the posterior ones. Posteriorly it contracts gradually, and ends a little short of the border with about half the anterior width; in some specimens, the rings centrally show emargination and other indications of having borne fine tubercles. Axial grooves faint. Side-lobes convex, consisting of eight pairs of segments whose valleys and ridges are inconspicuous, and the ends, as they approach the border, bifurcate, or, more correctly, the sutures widen out and make the segments appear to have free ends; the individual segments have little or no backward curve, and the last two pairs are indicated merely by a very faint ridge and tubercle; border continuous and relatively wide, concentrically and finely striated underneath, only slightly thickened and separated from the segments by a fine suture.

Obs.—This beautiful trilobite was originally described by R. Etheridge, Junr., and with it was joined *Griffithides dubius* Etheridge, Senr., for reasons not explained. All the evidence available leads me to conclude that the two are not specifically the same, and to regret that this very typical Phillipsia above-described should have been in any way linked with *Griffithides dubius* Eth. Senr. An examination of the figure given of this latter trilobite reveals that the glabella has three continuous lateral furrows, and a shape altogether unlike the former species; and, further, the latter is represented as having thirteen or fourteen axial rings, and an equal number of pleural segments in its pygidium; while the former has only twelve and eight, respectively, in the similar parts of the pygidium. These differences place the two apart.

As may be observed (*antea*, under the description of *P. elongata* mihi), I have had to disagree with Mr. Etheridge in determining that, and the above form to be specifically the same, for which divergence of opinion reasons are given.

P. stanvellensis is so different from all foreign and other Australian species that it is not necessary to detail its relationships with them.

The outstanding features of the species are. 1. The dunce's hat-shaped, prominent, smooth and anteriorly drooping, and narrow glabella. 2. The slightly elevated glabellar basal lobes. 3. The moderate size, and fine but distinct faceting of the eyes. 4. The very prominent axis. 5. The shallowness of the medial furrows, and slenderness of the ridges of the pleural segments. 6. The bifurcation of the pleural segments of the pygidium. 7. Twelve and eight divisions in the axis and pleural segments, respectively, of the pygidium. 8. The equality of the lengths of head and pygidium.

Loc. and Hor.—Corner Creek, Great Star River, Queensland. Carboniferous.

PHILLIPSIA GRANDIS Eth. fil.

(Plate xlvii., fig.2; Plate l., figs.1-3).

Phillipsia grandis Eth. fil., Geol. and Pal. of Queensland and New Guinea, 1892, pp.215-216.

Etheridge, Junr., Mem. Geol. Survey N. S. Wales, Pal. No.5, Pt. ii., 1892, Pl. xxi., fig.5 (*non* text-fig.5, p.128).

Etheridge, Junr., Geol. Survey of Queensland, Publication No. 260, pp.11, 12, Pl. iii., fig.3.

Complete form unknown.

Sp. Chars.—What appears to be a portion of a cephalon of this species is preserved on a rock-fragment from near Mt. Morgan, Queensland, associated with a very nearly perfect pygidium, free cheeks, a small portion of the anterior of the glabella, and the greater part of the hypostome (*in situ*), but so little of the glabella remains that none of its features can be recognised; except that it was sparsely granulated, sloped gradually anteriorly, and was of unusual size. The hypostome was large, striated, and apparently granulated; free cheeks very large, strongly granulated, the granules in many instances joining and producing rugosity; posterior furrows very wide and shallow; lateral border very wide; and the undersurface bearing six or seven concentric striæ, posterior border narrow; the genal angles appear to have been spinate. The length of the cephalic shield was approximately 30 mm.

Thorax: greatest width approximately 45mm., length 27mm., finely granulated. Axis moderately convex, and had a spread of 15 mm., and hence equal to one side-lobe. These lobes were fairly convex, greatest width 15 mm., and the mesial furrows of each pair of the segments were wide and shallow; along the articulating faces (ridges), the sutures are plainly visible in decorticated specimens.

Pygidium: greatest width 41 mm., length 34 mm.; semi-elliptic, moderately convex; axis mildly convex, tapering very gradually posteriorly, ending bluntly at the inner edge of the border, much narrower than one side-lobe, practically two-thirds as wide as one side-lobe, the width being 11 : 15, rings apparently eighteen, strong, densely and finely granulated, valleys narrow; axial furrows narrow and distinct; pleuræ moderately convex; ribs, fifteen pairs, reaching to the thickened outer margin of the border, and having a decided backward curve in the portions traversing the border; mesial valleys fairly deep, ridges strong, and bearing two or more rows of closely placed granules, and articulating sutures plainly visible, each succeeding pair gradually inclining posteriorly, border wide but ill-defined, not continuous and concave, margin thickened and upturned.

Obs.—The first fragment of this gigantic Carboniferous trilobite was briefly described by Mr. Etheridge, Junr.,* and for it he suggested the specific name *grandis*. Subsequently,† he described a pygidium from New South Wales, which he placed specifically with the Queensland pygidial fragment. Very reluctantly, I have to disagree with this latter determination of Mr. Etheridge, and am compelled to give the New South Wales fossil separate specific rank. A recent discovery of a nearly perfect tail, portions of a cephalic shield, and thorax, in the Mt. Morgan area, Queensland, has much simplified the task of separating the two forms. This recently discovered specimen

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* Geol. and Pal. Queensland and New Guinea, 1892, pp.215-216.

† Mem. Geol. Survey N. S. Wales, Pal. No.5, Pt. ii., 1892, p.128, text-fig.5, and Pl. xxi., fig.5.

was submitted by Mr. Dunstan, Chief Government Geologist, Department of Mines, Brisbane, to Mr. Etheridge, who described it briefly,* placing it with *P. grandis.* This same specimen has been used for the above description. It will be seen that, in the description of the parts of the fossil, we are not in agreement, our dimensional estimates, strangely, differing rather widely.

The dimensions arrived at by myself are :—

Cephalic shield, length 30 mm.
Length of thorax, 20 mm.
Greatest width, 45 mm.
Length of tail, 34 mm.
Greatest width, 44 mm.
Total length of trilobite, 84 mm., or nearly 3½ inches. A giant, certainly, among Carboniferous trilobites.

The reasons for separating the pygidium from Swain's Selection, near Carroll, N.S.W., from the Queensland forms, are fully entered into under the re-description of the New South Wales form, under the name of *Phillipsia robusta* mihi.

The distinguishing features of the present species are—1. Its great size. 2. The largeness of the free cheeks, their ornamentation, and great width of their borders. 3. The relatively narrow pygidial axis. 4. The mild tuberculation of the bases of the thoracic and pygidial axial rings. 5. The slight tuberculation of the pleural segment at the inner margin of the border, and their claw-like shape, as they cross the border. 6. The plainly visible sutures along the articulating ridges of the pleural segments, and the fine and close granulation of these ridges. 7. The strongly ridged and furrowed somites of the pygidium.

As Mr. Etheridge has pointed out, it is uncertain still whether this trilobite belongs to the genus *Phillipsia* or to *Griffithides,* but the evidence available indicates the former.

Loc. and Hor.—Crow's Nest, near Mt. Morgan, Queensland. Carboniferous.

PHILLIPSIA WOODWARDI Eth. fil.

Phillipsia woodwardi Eth. fil., Geol. and Pal. Queensland and New Guinea, 1892, p.215, Pl. vii., figs.11, 13; Pl. viii., fig.6; and Pl. xliv., figs.5-6.

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* Geol. Survey Queensland, Publication No.260, 1917, pp.11-12, Pl. iii., fig.3.

Griffithides seminiferus var. *australasica* Eth. fil., (in part) *op. cit.*, p.216.
(Pl. xlvii., fig.9; Pl. xlix., figs.1-8, 13-14; Pl. l., figs.10-11; Pl. li., figs.12-14; Pl. lii., fig.1; Pl. liii., figs.8-9).

Here is Mr. Etheridge's description of this species (*loc. cit.*):—"*Sp. Char.* Glabella round, without any lateral inflection of the margin, moderately convex in the middle line, and a little arched posteriorly; neck furrow strong and deep, with more or less complete basal furrows; anterior furrows present, but faint; anterior border thick and upwardly turned, leaving a wide depression between it and the front of the glabella."

In his observations, Mr. Etheridge remarks:—"The pygidium referred to is much larger than that described as *P. dubia*, but otherwise resembles it." In the text, there is nothing to show what pygidium is here referred to, for no description of it is given; but no doubt he refers to the pygidium illustrated in Plate xliv., fig.6; and if so, the determination, in my opinion, is incorrect. This pygidium belongs to the trilobite described by me as *Phillipsia rockhamptonensis*, and is shown in Pl. l., fig.8.

The following is a more amplified description of the type-cephalon of the species. Outline subsemicircular, surface granulated. Glabella wider across the basal lobes than it is long, very convex both transversely and longitudinally, the front lobe (the portion anterior to the anterior pair of the lateral furrows) semicircular, highest between the mesial pair of lateral furrows. Three pairs of lateral furrows present, anterior and mesial relatively wide, shallow and straight, basal pair wide and deep; anterior and mesial lobes narrow, basal pair large, subfusiform, much lower than the glabellar centre, overhanging the axial and neck-furrows; limb very large, border strongly thickened and upturned, furrow wide and deep. Neck-furrow deep; neck-ring strong, convex, sharply curving anteriorly, as it approaches the axial furrows; sides gradually thickening towards their origin. Frontal limb very wide, border strongly thickened and upturned, and separated from the glabella by a wide and pronounced furrow, strongly expanded antero-laterally. Facial sutures anteriorly directed outwards at an angle of about 25°. Fixed cheeks appear to have been small, and strongly tumid. Axial furrows deep. Other parts not known.

As Mr. Etheridge pointed out, this head-shield bears a strong resemblance to that of some Proëti. The enormous limb is its most striking feature. The discovery of a complete specimen will be of much scientific interest. It may be noticed here that neither of the figures, Pl. vii., fig.13, Pl. xliv., figs.5, 6 (*loc. cit.*) are correct representations of the fossils they are intended to depict. For example, in the case of the first of these, the glabella is much too blunt in front; and supplementary lobes, which are present on the fossil, are not shown in the figure. With reference to figs. 5 and 6 of Pl. xliv., in the case of fig. 5, the glabella is represented as of a battle-axe shape, instead of being rather quadrate, or only gently rounded in front, and the glabellar basal lobes are exaggerated in size. In fig.6, the axis is shown terminating much too short of the border, and, in the pleural lobes, too many segments are shown. Photographs of the original specimens, from which the drawings of the figures above referred to were made, will be found in the Plates of this paper.

At present, I hesitate to recognise the portion of a cephalon determined by Mr. Etheridge to belong to this species, and represented in Pl. vii., fig. 13, for the following reasons. The glabella of this specimen is much more convex and narrower in front than the type-specimen. Further, this glabella is just as long as wide across the basal glabellar lobes. On the other hand, the typical glabella of the species is much wider across these same lobes than it is long. The glabella in question is not correctly represented by the figure above referred to, as will be seen from the photos of it now produced.

Since Mr. Etheridge described this species, much additional material has been secured, and this has been placed with me by Mr. Dunstan, Chief Government Geologist, Brisbane, for classification. Included in the collection is a large number of pygidia, all possessing similar specific features; and these were collected from the same localities from which all the known cephalic fragments of the species have been obtained. In part, owing to the association in this way of these heads and tails, and because the great convexity of the pygidia referred to, which would indicate the possession of a very convex cephalon by the species they belong to, and, further, because no other head-shields reasonably preserved occur in association with these remains, with which they appear to have near relationship, I have determined to place them with Mr. Etheridge's *P. woodwardi*, and, for this reason, the species is redescribed hereunder.

Complete form not yet certainly known, but it may be assumed to have been oblong-ovate.

Cephalon sub-semicircular, highly inflated, surface granulated throughout. Glabella subquadrate, wide and mildly rounded in front, strongly convex, highest between the mesial lobes, sloping strongly anteriorly, and overhanging the furrow of the limb in front; three pairs of glabellar furrows present, the anterior and mesial pairs rather wide, shallow and straight; basal pair wide and deep; anterior and mesial lobes narrow; basal pair large, subfusiform, much lower than the glabellar superficial centre, overhanging the axial and neck-furrows latero-posteriorly; limb very large, border strongly thickened and upturned, furrow wide and deep; neck-furrow wide and deep; neck-ring strong, convex, bases strongly curving anteriorly under the glabellar basal lobes; supplementary lobes present, though not conspicuous in the most typical specimen. Facial sutures anteriorly directed outwards at an angle of about 25°. Fixed cheeks would appear to have been of moderate size, and posteriorly strongly inflated. Free cheeks fairly large, strongly and thickly granulated, especially on the part between the lateral and ocular furrows; this part, too, is high, and rather acutely angulate postero-laterally, flat superficially, laterally and posteriorly steeply falling into the lateral and posterior furrows, which are wide and deep; border much thickened and upturned, striated, posterior border (extension of the neck-ring) strong, genal angles apparently blunt; eyes of moderate size, apparently crescentic and faceted, somewhat sunk into the ocular furrow.

Thorax: for certain not known, but the following is the description of one attached to a pygidium identical with a number of others assumed to belong to this species: suboblong, granulated, longer than the pygidium, all the segmental ridges appear to have borne tubercles; number of segments normal. Axis prominent, ring-bases non-tuberculate, with a strong anterior inclination centrally, ridges and valleys well defined, apparently as wide as one side-lobe. Side-lobes strongly convex and steep between the fulcra and margins, all parts densely granulated, segments anteriorly angulate at the fulcra; mesial furrows wide, ridges relatively narrow and faceted, and mildly thickened posteriorly.

Pygidium very strongly convex, length to width approximately 2 : 3, granulated; axis prominent, evenly arched, anterior spread about equal to the greatest width of one side-lobe, posteriorly diminishing in width very gradually, and ending prominently and bluntly a little short of the border; number of rings thirteen, and each bore a row of small tubercles quite conspicuous on unweathered specimens; axial grooves wide and deep. Side-lobes convex, consisting of eleven pairs of segments, the ridges of each pair bearing rows of small tubercles varying from two or three on the shorter, to eight or perhaps nine on the longer ones. Border continuous, mildly thickened, convex and steep.

Obs.—At the outset, I admit that the pygidia here joined with Mr. Etheridge's type-cephalon of the species may yet prove to be a wrong conclusion; but should it happen so, I am inclined to believe, too, that the heads (Pl. li., figs.12, 13) will also prove not identical with the type one; but should that happen, I am fully satisfied that these latter heads, and the tails here dealt with, will prove to belong to the one species. The heads now joined with the typical one possessing the very characteristic frontal limb, cannot, for certain, in the absence of this limb, be said to belong to the species.

While completing the above description, the specimen No.712, belonging to the Queensland Museum, Brisbane, is before me; and the trilobite fossil remains on it consist of two pygidia, one thorax and pygidium conjoined but incomplete, a fragmentary head in intaglio, and a part of a free cheek. (On the same specimen, occurs the tail of a Brachymetopus, the first recorded from Queensland). These fossils were those which chiefly served Mr. Etheridge to found his varietal species *Griffithides seminiferus* var. *australasica* on. After a close study of these remains, I am compelled to dissent from his conclusions concerning them. They cannot belong to the above species, because the glabella possesses supplementary basal lobes, a feature by some palæontologists thought to be of generic significance, and which *G. seminiferus* does not possess. Again, these pygidia have thirteen rings in their axis, and eleven pairs of segments in the pleuræ. In these parts, *G. seminiferus* has twelve and nine respectively. These differences alone would render the specific identity of the two forms invalid, but these are not the only differences between them. As far, then, as the fossils under present consideration afford evidence, Mr. Etheridge's varietal species fails. The part of the cephalon on this same specimen of rock is very imperfect, but it shows, on the glabella, similar but clearer granulation, because the granules are not worn off by weathering, similar glabellar basal and supplementary lobes to that and those respectively found on the cephalons here determined to belong to *Phillipsia woodwardi.* The only features not visible on the glabella of the fragmentary cephalon, to make its identity with the latter certain, are the mesial and anterior glabellar furrows; but these are barely visible on some glabellæ of *P. woodwardi.* Lastly, the pygidium represented in Plate viii., fig.6 (*op. cit.*), which was considered by Mr. Etheridge to be a normal pygidium of his *P. dubia* (*P. stanvellensis* mihi) is here joined with the present species by me. It is undoubtedly inseparable from the other pygidia now joined with the species above described, and certainly is not at all closely related to the pygidia of *P. stanvellensis* mihi (*P. dubia* Eth. fil., *op. cit.*, Pl. viii., fig.5).

Mr. Etheridge has already called attention to the Proëtus-like aspect of the cephalon of the present species. The singular form of this part of the fossil makes it unnecessary to point out in detail the features which separate it from other species of *Phillipsia.*

Loc. and Hor.—Stoney Creek, Stanwell; Crow's Nest and Trilobite Ridge, Mt. Morgan, Queensland, etc. Associated with

Brachymetopus dunstani. Middle or Lower Carboniferous probably.

PHILLIPSIA MORGANENSIS, sp. nov.

(Pl. xlix., figs.11, 12; Pl. li., fig.1).

Sp. Chars.—*Cephalon* sub-semicircular, very finely granulated, greatest length and width 8 mm., and 16 mm., respectively. Glabella subconical or sub-bellshaped, mildly convex, finely and densely granulated, longer than wide; three pairs of lateral furrows distinctly shown, basal pair very deep and wide, anterior and mesial pairs short and only gently curved posteriorly; anterior and mesial lobes of moderate size, basal pair fairly large, with small complementary lobes present; neck-furrow deep and wide, the extensions laterally also fairly deep and wide; neck-ring strong, moderately convex, strongly curving anteriorly at its bases; facial sutures anteriorly very straight, posteriorly short and oblique, frontal limb narrow and close to the glabellar front; fixed cheeks very small, with small eye-lobes. Free cheeks rather large, only moderately tumid, finely granulated, both borders and lateral furrows large, the former being moderately thickened, finely granulated on the upper and striated on the undersurface, the latter being shallow, ocular furrow wide and shallow. Eyes of moderate size, finely faceted, vertically narrow, and decidedly higher behind than in front. Genal angles obtuse. Hypostome shield-like, narrow, not alate, posteriorly glossiform and corrugated, no striæ visible, widest at two-thirds of its length from the front edge.

Thorax not known in a complete state, but one, on which a pygidium and a free cheek rest, shows the following features—moderately convex, finely granulated. Axis moderately convex, diminishing in width and height gradually posteriorly, wider than one side-lobe, rings strong, valleys narrow and having an anterior inclination, bases non-tuberculate, axial furrows linear. Side-lobes not well shown, but the segmental ridges and furrows were strong and deep respectively.

Pygidium widely triangular, mildly convex and granular, length 7 mm., and greatest width 12 mm. Axis mildly and evenly convex, anterior width equal to that of one side-lobe, diminishing gradually in width and height posteriorly, and ending short of the margin inconspicuously with about half its anterior width, rings apparently eleven; ridges not prominent. furrows also faint, some of the anterior ones have centrally a backward trend. Axial furrows linear. Side-lobes convex, consisting apparently of nine pairs of segments (eight only are visible on the best available specimen), front pair faceted, ridges and furrows fairly distinct, and having successively only a moderate backward trend.

Obs.—This trilobite belongs to the type of *Phillipsia* which had the glabella narrower in front than posteriorly, which seems a common characteristic among the Australian members of the genus, and, in this respect, shows a closer relationship to the typical genus of the Proëtidæ, than do the Phillipsiæ of Europe, and, perhaps also, America. A singular feature in the present species is the form of the hypostome assumed to belong to it. None similar to it has come under my notice. The one nearest to it is one figured by Dr. H. Woodward* with other illustrations of *Phillipsia eichwaldi*, but evidently not belonging to that species. The straightness of the anterior branches of the facial sutures, and their mild outward divergence as they reach the frontal limb, are striking features of the species. A study of the description and illustrations of the species will render its separation from other Australian Phillipsiæ simple. In contour, the glabella is not unlike what that of the glabella placed with *P. woodwardi* (Pl. xlix., fig.7) would be, were it not so convex; but, in the former, the glabella is longer than it is wide across the basal glabellar lobes; in the latter, these dimensions are equal. No foreign species has come under my notice with which it seems necessary to compare it.

Loc. and Hor.—Trilobite Ridge, Mount Morgan, Queensland. Carboniferous (Lower?).

PHILLIPSIA CONNOLLII, sp.nov.

(Pl. li., figs.4-7).

Phillipsia grandis Eth. fil. (MS.).

Only an incomplete pygidium known.

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* Mon. Brit. Carb. Trilobites, 1883-4, Pl. iv., fig.7.

Sp. Chars.—*Pygidium* semielliptic, moderately convex, and microscopically granulated. Axis very prominent, consisting of ten, possibly eleven rings, not as wide as one side-lobe, evenly arched, and slightly flattened dorsally, ending at the border very prominently and rather acutely, ridges and valleys of the rings quite distinct. Axial grooves shallow. Side-lobes mildly convex, consisting of eight or nine pairs of segments, which are only very gently directed backward, and terminating at the border, except in the case of the anterior pair, which encroaches on it. Mesial furrows and the ridges of the segments moderately defined. Border proportionately wide and continuous, mildly convex, horizontal, and apparently wider laterally than behind, separated from the ribs by a shallow furrow. Greatest width 13 mm., length 9 mm., anterior width of axis 3 mm.

Obs.—This pygidium was placed by Mr. Etheridge, Junr., with his *Phillipsia grandis*, but to this species I find it has no close relationship. In its wide border, and the number of axial rings and pleural segments, it bears strong resemblances to our *Griffithides convexicaudatus*, but its axis is much more prominent and relatively narrower, than is that of the latter. The axial and pleural divisions are more clearly defined in the former than they are in the latter; the border in the former is flat, and in the latter very steep. The shape or outline of the pygidia of these species is very different. In number of axial and pleural divisions, this species is related to both *P. coulteri* and *P. stanvellensis*, but not otherwise. In possessing very prominent and relatively narrow axes, *P. stanvellensis* and the present species agree. I am not aware of any foreign Carboniferous trilobite having a pygidium closely resembling this one.

Named after Mr. Connolly, who discovered it.

Loc. and Hor.—Gascoigne River, West Australia (Connolly). Carboniferous.

PHILLIPSIA ROUCHELENSIS, sp.nov.

Phillipsia sp., ind. (*a*), Eth. fil., Mem. Geol. Surv. N. S. Wales, Pal. No.5, Pt. ii., 1892, p.129, Pl. xxi., figs. 6, 7.

(Pl. xlviii., figs. 4, 5, 6, 7).

Cephalon and thorax unknown.

Sp. Chars.—Pygidium sub-semicircular, width 15 mm., length 11 mm.; smooth and moderately inflated. Axis moderately convex, tapering very gradually, and terminating bluntly with a spread rather greater than half that of the first ring; anterior width about equal to that of one side-lobe; consisting of eighteen rings, some of which show traces of having been very mildly tuberculated; axial furrows faint. Side-lobes convex, with no decided fulcra, segments thirteen, or doubtfully fourteen, mildly recurved, not crossing the border; border of moderate width, steep, smooth, and separated from the pleural segments by a fine suture.

Obs.—This pygidium was briefly described by Mr. Etheridge (*loc. cit.*), but not specifically named, though he stated that it possessed certain features which clearly indicated that it was a new species. It differs from all other species of Phillipsia and Griffithides known to me.

Loc. and Hor.—Binge Berry, Rouchel Brook, near Muswellbrook; County Durham.

PHILLIPSIA DUNGOGENSIS, sp.nov.

Phillipsia sp. ind. (*b*), Eth. fil., Mem. Geol. Surv. N.S. Wales, Pal. No.5, Pt. ii., 1892, p.129; Pl. xxii., fig.14.

(Plate xlvii., figs.6, 7).

Complete form unknown.

Sp. Chars.—Pygidium sub-semicircular, very moderately convex, finely granulated throughout, greatest width 22 mm., length 16 mm. Axis mildly convex, consisting of fourteen annulations, the furrows and ridges of which are respectively shallow and low, diminishing very slightly in width posteriorly, the end being wide and rounded, bases of the rings not tuberculate, anterior width less than one side-lobe; axial furrows fairly distinct. Pleuræ gently inflated and sloping from the axial furrows; segments twelve pairs, which are very completely fused, the four anterior pairs reaching to the outer margin, medial furrows wide and shallow, ridges not prominent and showing no sutures; border narrow and continuous.

Obs.—This is another of the pygidia described by Mr. Etheridge, Junr., (*loc. cit.*) but which he did not specifically name. It resembles no other Australian Carboniferous form at all closely; and, so far as I have been able to ascertain, it stands apart from the pygidia of foreign species of the genera Phillipsia and Griffithides.

Loc. and Hor.—Greenhills, near Dungog; County Durham. Carboniferous.

Genus GRIFFITHIDES Portlock, 1843.

Geol. Report, Londonderry, &c., p.310.

The following is Portlock's original description of the genus—"*Cephalothorax* semi-oval, longitudinal: glabella strongly marked and gibbous, rounded in front, narrowed posteriorly into an obsolete neck with a furrow more or less distinct on each side. *Cheeks:* triangular spaces very slightly convex. *Wings* either ending in an angle posteriorly or prolonged backwards in a flattened spine. *Eyes* near the axis, not large, lunate, smooth(?). The minute neck tubercle sometimes present."

"*Thorax.*—The pleuripedes are compound, in number nine, or with the neck segment ten."

"*Pygidium.*—Fully developed and strongly resembling that of Phillipsia."

General A. W. Vogdes (*loc. cit.*) gives the following brief summary of the generic features of this genus:—1. Glabella short, tumid. 2. No short lateral furrows on the glabella. 3. Basal lobes distinct. 4. Eyes small, placed close on the glabella, reniform. 5. Axis of pygidium has 10 to 17 segments.

GRIFFITHIDES CONVEXICAUDATUS, sp.nov.

(Pl. xlvi., fig.13; Pl. xlviii., figs.1-3; Pl. lii., figs.5, 6).

Sp. Chars.—Complete form suboval with straight sides *Cephalon* sub-semicircular, apparently finely granulated and strongly inflated. Glabella subpyriform, tumid; basal furrows faint; basal lobes relatively small; neck-furrow shallow, its lateral extensions deeper, and communicating with the lateral furrows of the free cheeks; neck-ring wider than the axial rings of the thorax, its lateral extensions narrow but prominent. Axial grooves faint Fixed cheeks very small and high; palpebral lobe high, narrow, convex, and very faintly separated from the basal lobe. Free cheeks high, sharply rising from the narrow lateral furrows, lateral border narrow, thickened and raised. Eyes reniform, short fore and aft, high and prominent, separated from the upper and flattened part of the cheeks by a faint sulcus, apparently faceted. Facial sutures anteriorly follow the course of the axial grooves, posteriorly oblique passing out in a line with the fulcra of the thoracic pleuræ. Limb narrow and pressed to the front of the glabella. Genal angles bear very short spines.

Thorax fairly convex, finely granulated, rectangular, length practically two-thirds of greatest width, anterior and posterior widths approximately equal, somites nine. Axis prominent, widely and evenly arched transversely, width or spread throughout about equal, the last two rings only being slightly contracted, a little wider than one side-lobe, centrally the rings have a gentle forward arch, and bear a row of inconspicuous granules, bases non-tuberculate; axial furrows shallow. Side-lobes sloping very gently from the axial furrows to the fulcra and thence fairly steeply, median furrows of each segment narrow and shallow, but reaching just to the margin, ends faceted.

Pygidium sub-semicircular, evenly and very convex, finely granulate, length equal to length of thorax, and to about three-fourths of its own greatest width (9 : 13); axis convex, bearing eleven annulations, diminishing posteriorly very gradually in width and prominence, ending bluntly and rounded a little short of the border. Its length equals seven-ninths of the pygidial length, annulations faint, especially towards the distal end. Side-lobes strongly convex, anteriorly having a spread approximately equal to that of the axis, possessing eight ribs, only the first three pairs being at all conspicuous; all, except the first pair, stop at the faint furrow separating them from the wide, convex, smooth border.

Obs.—The individual, which served for the above description, measured 25 mm., of which the cephalon was 7 mm., the thorax and pygidium 9 mm. each; width of thorax 14 mm. The specimen was not quite complete, being minus part of the right front quarter of the cephalon.

This fossil agrees very closely with one described by De Koninck from the Upper William River,[*] and determined by him to be *Griffithides* (*Phillipsia*) *eichwaldi*. The total lengths of the two fossils exactly agree, as also do the widths of the thoraces; but there are some discrepancies in the dimensions of the separate parts. De Koninck gives 10 mm. and 8 mm., respectively, for thorax and pygidium of his specimen; whilst 9 mm. is the length of each of these parts in the specimen under review. The two have nearly the same number of annulations in the pygidial axis, and probably the same number of pleural ribs, a similar wide pygidial border; also the same relative length to width of their pygidia, and an identical frontal projection of the glabella on to the border. In the characters of granulation and of thoraces and pleural ribs of the pygidia, they also agree. If, at this, the discussion of their relationship stopped, the identity of the two would have to be accepted as conclusive, as I believe it actually to be. But against these agreements have to be placed some important differences, which make their specific identity difficult to reconcile. For instance, De Koninck states that his specimen has only eight thoracic segments, that the anterior annulation of the thoracic axis has a width[†] of 3 mm., and not one of the annulations has a width less than 1 mm. The present specimen has the normal nine somites, and the widest annulation of the thoracic axis does not exceed 1 mm. De Koninck's figure of his specimen shows it to have had a very globular frontal glabellar lobe, and, in this, differs from the one above described. Again, De Koninck's text does not agree with his illustration. The former indicates his specimen to have eight thoracic somites, and the pleural lobes to have a width equal to that of the thoracic axis; but his figure shows nine somites, and pleural lobes much narrower than the axis. These important discrepancies make it impossible to accept his

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[*] Foss. Pal. Nouv. Galles du Sud, Pt. i., 1876, pp.278-9, Pl. xxiv., fig.8.

[†] The writer assumes the width of the axial rings to be their measurement along the longitudinal line of the axis.

description as having any scientific value, for there is no evidence to show whether his text or figure is correct, the type-specimen having been destroyed in the Garden Palace fire of 1882.

The next consideration is whether the present fossil, or even De Koninck's, is specifically identical with *P. eichwaldi* Fischer. Accepting the types given by Dr. H. Woodward* as fully reliable, the author does not believe it a difficult task to prove the negative.

1. Dimensions.—The relative lengths to widths of the parts of the author's fossil and that of *P. eichwaldi* Fischer, are, respectively, for cephalon 14 : 28 and 17 : 27; thorax 17 : 28 and 17 : 31; pygidium 9 : 13 and 1 : 1.

The dimensional differences, as these measurements show, place the fossils apart; but these are not nearly so important specifically as the following. The pygidium of *P. eichwaldi* is semi-elliptical, and the length equal to the width: that of the author's is sub-semicircular; that is, if the centre of the junction of the second axial ring with the third be taken for centre, the portion of the pygidium posterior to this forms a semicircle; and the length is only two-thirds of the width, approximately. There are up to sixteen rings in the axis, and twelve to fourteen pleural divisions in the pygidium of *P. eichwaldi;* while, in the local one, these divisions are eleven and eight, respectively. Then, in the former, the pygidial border is depressed; in the latter, the curve of convexity of the pleuræ continues uninterruptedly across the border to the outer edge. In the former, also, the genal spines are long; in the latter, *very* short, only extending past the first thoracic segment. These differences are sufficient to prove that the author's specimen is not *P. eichwaldi* Fischer, and the same conclusion may be drawn in respect to De Koninck's fossil.

In several respects, this species resembles *Griffithides globiceps* Phillips; but the proportionate lengths of the thorax and pygidium of the latter are different from those of the former; as also is the proportionate length of the cephalon to these same parts. In the former, there is no lobe connecting the eye-lobe with the

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* Mon. British Trilobites, Pt. i., 1883.

glabella, though, indeed, the eye or palpebral lobe is very close to, and only faintly separated from, the basal lobe of the glabella. The eye, too, is relatively larger, the pygidial border is wider, and the glabellar frontal lobe less globular; the free cheek border and glabellar limb narrower, and the eyes less prominent and more posteriorly situated in the former than in the latter. The British species, too, was much larger than the New South Wales one.

The specific name was chosen for it because of the strong convexity of its pygidium.

Loc. and Hor.—Glen William, about two miles from Clarencetown, Parish Parr, County Durham. Lower Carboniferous.

GRIFFITHIDES SWEETI Eth. fil.

Griffithides sweeti Eth. fil., Proc. Linn. Soc. N. S. Wales, (2), Vol. ix., Pt.3, pp.528-9, Pl. xxxix., fig.3, 1894.

(Pl. liii, figs.1, 2).

Through the courtesy of Mr. G. Sweet, of Melbourne, the type-specimen of the species is before me, and I regret that, owing to the incompleteness of its cephalon, it fails to elucidate certain difficulties met with in considering the thoraces and pygidia from the Mt. Morgan area, assumed to belong to *Phillipsia woodwardi* Eth.fil., or to settle whether *G. sweeti* Eth. fil., and that species are not identical. All the numerous pygidia obtained from the Mt. Morgan area, except those which belong to *P. stanvellensis*, *P. rockhamptonensis*, and *P. morganensis*. have thirteen axial, and eleven pleural divisions; and, after most careful and repeated inspection, I have to conclude that Mr. Etheridge's *G. sweeti* has the same number of divisions in the axis and pleuræ of its pygidium; also the same kind of pygidial border and furrow; and, in fact, its pygidium cannot be separated from pygidia which are the most plentiful in the Mt. Morgan district, and which I have tentatively considered to belong to *P. woodwardi*, or at least to those cephalons represented on Pl. li., figs. 12 and 13, because these, too, were the most plentiful cephalons occurring in the same area. As regards the head-shield of *G. sweeti*, sufficient of it has not been conserved to enable one to say positively whether its features place it with the Phillipsia or the Griffithides type; but, except for the uncertainty of the presence on its glabella of the normal lateral furrows of the Phillipsian genus, it does not differ from the head-shields above referred to, which are considered to belong to *P. woodwardi* Eth. fil. Further, it will be found that *G. sweeti*, as far as present evidence admits, cannot be separated from *Griffithides seminiferus* var. *australasica* Eth. fil. This, I think, will be conceded after the description and figures of the latter have been studied in conjunction with my remarks on the latter, under *P. woodwardi*; and an examination of Plate li., fig.14, which is a photo of Mr. Etheridge's type-specimen, which shows two tails, the greater portion of a thorax and tail conjoined, an intaglio of a portion of a head, and, between the two tails and on the left top corner, is a view in relief of this intaglio.

We are up against a problem here, which can be solved only by the discovery of better material; and when it is solved, it seems to me that a new genus or subgenus will be needed for the reception of this trilobite with the ten thoracic somites.

The following is a fuller description of the species than is given by Mr. Etheridge. It will be seen from the photographs of this species now given, that it was not as correctly figured as it might have been.

Complete form suboval.

Sp. Chars.—*Cephalon* incomplete, apparently granulated throughout, with granules of uniform size. Glabella incomplete, moderately tumid, mesial and anterior furrows not visible (though there appears to be a faint trace of the mesial pair); basal furrows deep, joining the neck-furrow; basal lobes fairly large, suboval; supplementary lobes of moderate size, and suboval; neck-furrow wide and fairly deep; neck-ring stronger than any of the axial rings of the thorax. Fixed and free cheeks absent.

Thorax consisting of ten segments, finely and evenly granulated; axis prominent, diminishing posteriorly very little in prominence, and barely at all in spread; each ring, except the last, has centrally a slightly forward direction, the last ring is stronger than the others, non-tuberculate; axial furrows shallow.

Side-lobes, between the axial furrows and fulcra, rising very gently, and thence are depressed almost at right angles, segmental ends strongly faceted, and the ridges and valleys strong and deep respectively, segments strongly angulate at the fulcra, the whole thoracic surface was finely granulated.

Pygidium subelliptic, finely granulated, strongly convex: axis prominent, rings thirteen, the anterior one being somewhat overlapped by the last thoracic one, decreasing in spread gradually and ending prominently at about half of its anterior spread, a little short of the border; axial furrows distinct, side-lobes strongly convex, granulated, consisting of eleven segments, each very gently and increasingly curving posteriorly, segmental ridges strong, valleys deep; ·border entire, steep, very finely granulated, middle thickened and relatively wide, separated from the pleural segments by a narrow furrow, accentuated by punctations at each segmental end.

GRIFFITHIDES DUBIUS Etheridge Senr.

Griffithides dubius Etheridge Senr., Quart. Journ. Geol. Soc., 1872, Vol. xxviii., p.338, Pl. xviii., fig.7.

Phillipsia dubia Eth. fil., Geol. Pal. Queensland and New Guinea, 1892, pp.214, 215, Pl. 7, fig.12.

(Pl. liii., fig.7).

The original description is as follows:—"Body elongated, oval, length about twice the width, sides parallel. Axis width of pleuræ. Thoracic segments 10 to 12. Pygidium rounded, margins entire; axis composed of ten segments, not extending quite to the posterior margin. Cephalic portion much crushed; glabella small and round anteriorly, furrows indistinct. Owing to the crustaceous test being removed, we have no means of arriving at the condition of the original ornamentation; there are, however, indications of tubercles upon the axis of the pygidium."

"*Loc.* Don River, Queensland. *Form.* Carboniferous."

The whereabouts of the type-specimen I have not been able to discover, and, consequently, cannot add anything to the above description.

In the possession of ten or more segments in the thorax, it resembles *G. sweeti* Eth. fil., and, certainly, in this respect, is not a normal *Griffithides* or *Phillipsia.* This peculiarity, too, very decidedly separates it from *P. stanvellensis* mihi (*P. dubia* Eth. fil.).

Family PROETIDÆ.

Genus BRACHYMETOPUS McCoy, 1847.

Ann. Mag. Nat. Hist., xx., p 229, Pl. xii., figs. 1*a*, 1*b*.

McCoy's description of the genus is as follows :—"*Gen. Char.* Cephalothorax truncato-orbicular; limb narrow, produced backwards into flattened spines; glabella smooth, cylindrical or ovate, about twice as long as wide, not reaching within about its own diameter of the front margin; one pair of small, basal, cephalothoracic lobes, or none. Eyes reniform, in the midst of the cheeks (? smooth); eye-lines unknown. Surface strongly granulated; one tubercle on each side of the anterior end of the glabella, the marginal row and a circle round each eye being larger than the rest. Body-segments unknown. Pygidium nearly resembling the cephalothorax in size and form, rather more pointed, strongly trilobed, and with a thickened prominent margin; axal lobe about as wide as the lateral lobes, of about seventeen narrow segments; lateral segments about seven, divided from their origin, each terminating in a large tubercle at the margin." Genotype, *Br. strzeleckii.*

In this description, characters are included which are merely specific. H. Woodward* supplies the following amended description of the genus :—"General form elliptical; headshield semicircular and slightly pointed, about one-third wider than long; glabella small, somewhat elevated, one-third the width of the entire shield and about one-half the length, having a basal lobe on each side, but no short lateral furrows on the glabella; neck-furrow distinctly marked, equal in width to the posterior border of the free cheeks; eyes small, smooth, equal to half the length of the glabella; no facial sutures visible, only the axal furrow surrounding the glabella and the neck-furrow; free cheeks slightly

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* Mon. Brit. Carb. Trilobites, 1883-4, pp. 46-7.

convex, nearly twice as long as they are broad, with no visible suture separating them from one another in front of the glabella: margin broad and slightly grooved, angles of cheeks produced posteriorly into spines. The entire surface of the head covered irregularly with a small bead-like ornamentation."

"Thoracic segments unknown, probably nine."

"Pygidium consisting of a variable number of segments, from ten to seventeen, according to species, the axis tapering rapidly to a bluntly rounded extremity, each segment of axis ornamented with bead-like granulations, ribs with a double furrow extending nearly to the border which is smooth and rounded."

This description also includes quite a number of features that possess only specific significance.

General A. W. Vogdes* summarises the characters of the genus thus:—1. Glabella short, tumid. 2. No short lateral furrows on the glabella. 3. Basal lobes distinct. 4. Eyes small, placed close to the glabella. 5. Axis of the pygidium has ten to seventeen segments.

To this may be added—6. Facial sutures absent. 7. Axial furrows continue round the glabella-front. 8. Ornamentation bead-like.

R. F. Cowper Reed† has suggested a genus or subgenus (*Brachymetopina*) for the European forms without defined cephalic margins, and non-spinate pygidial margins.

BRACHYMETOPUS STRZELECKII McCoy, 1847.

Brachymetopus strzeleckii McCoy, 1847, *op. cit.*, p.231, Pl. xii., fig.1. De Koninck, Foss. Pal. Nouv. Galles du Sud, 1877, p.352, Pl. xxiv., figs.10, 10*a*, *b*, *c*. Vogdes, Trans. Acad. Sc. St. Louis, Vol. v. (1892), p.617. Etheridge, R., Junr., Mem. Geol. Surv. N. S. Wales, 1892, Pal. No.5, Pt. ii., p.124. Reed, Geol. Mag., N.S., Dec. iv., Vol. x., 1903, pp.193-196.

(Plate liii., figs.3-6).

McCoy's brief description is as follows :—"*Sp. Char.* Glabella

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* "North American Carboniferous Trilobites." Ann. New York Acad. Sci., vi., 1888, p.70.

† Geol. Mag., N.S., Dec. iv., Vol. x., p.196.

widest at the base, with one very minute obscurely marked cephalothoracic furrow at the base on each side; all the segments of the pygidium with an irregularly tuberculated ridge along the middle; lateral segments forming large tubercles where they join the thickened limb, opposite each of which there is a short slender spine projecting from the margin."

The following is a fuller description of the species by F. R. C. Reed (*op. cit.*):—" Head-shield semicircular, moderately convex, with strong raised rounded border increasing slightly in width towards the front, and separated off by a deep furrow. Genal angles furnished with slender divergent smooth spines, less than half the length of the head-shield. At its base is a pair of small nodular basal lobes, in most specimens quite inconspicuous. Two large tubercles are situated in a line down the middle of the glabella, followed by a similar median one on the occipital segment. Occipital segment strong, rounded, separated off by a deep furrow. On cheeks at anterior end of glabella is a pair of large tubercles one on each side. No facial sutures visible. Eyes prominent, reniform, less than half the length of the glabella, distant from the axial furrows about one-third the width of the cheeks, and about their own length from posterior margin. Surface of head-shield, including glabella, border and neck-segment, rather coarsely tuberculated. An indistinct ring of larger tubercles surrounds the eyes, and a large tubercle is situated at each end of eyes on inner side. Thorax unknown. Pygidium semicircular, slightly convex, with spinose margin. Axis broad, conical, about one-third the width of the pygidium at front end, tapers rather rapidly to obtuse point, nearly touching the border: consists of 9-10 segments, of which eight rings are distinct and completely tuberculated across: the 1st, 3rd, 5th, and 7th have, in addition, a large median tubercle. Lateral lobes consist of six (? seven in some) pairs of pleuræ, of which the last pair is very small: each pleura is gently curved and is divided unequally by a strong longitudinal furrow into a broader, raised, rounded, posterior ridge, and a narrower anterior ridge. The posterior ridge of each pleura crosses a distinct, raised, rounded border, which surrounds the pygidium and bears a large tubercle at the spot where it crosses, and a single median one behind the axis. The posterior pleural ridges are prolonged into short, recurved, equidistant, and subequal spines, projecting beyond the margin. (In one specimen there seems to be a median spine behind the axis. In another immature example the anterior two or three pairs of spines are half as long as the whole pygidium). Surface of pygidium rather coarsely tuberculated; the posterior ridge of each pleura bears 4-5 tubercles, and the anterior ridge 5-6 smaller ones. The axial rings bear each 5-7 tubercles."

" Dimensions:—

Length of head-shield	3·0 mm.
Width of head-shield	4·5 mm.
Length of pygidium	2·5 mm.
Width of pygidium	4·0 mm.

For affinities, see *op. cit.*

To quote Reed further, he remarks that "McCoy gave as generic characters the circle of tubercles round the eyes and pair of large tubercles at the front end of the glabella, but these may well be considered as of lower classificatory value, and likewise the relatively greater length of the glabella as compared with the European species. It does not, however, seem possible to regard the peculiar pygidial characters in the same light, though, as Vogdes (Trans. Acad. Sc. St. Louis, Vol. v. (1892), p. 617) says, we have many other genera of trilobites with spinose and non-spinose representatives. The fewer number of segments in the pygidium, and the raised spinigerous border separate it from all the European forms."

"The genus or subgenus *Phætonides,* as now understood, is partly distinguished for analogous reasons from the typical *Proëtus;* and it seems open to question whether the European species of *Brachymetopus* should not be regarded as constituting a distinct group or subgenus for which the name of *Brachymetopina* may be suggested."

Personally, I do not think that pygidial characteristics alone are sufficient grounds upon which to found even a subgenus

Loc. and Hor.—Dunvegan, Burragood, and Glen William, N.S.W. (Etheridge, Junr., Cat. Austr. Foss., Camb., 1878, p.41). Carboniferous.

BRACHYMETOPUS DUNSTANI, sp.nov.

(Pl. xlix., figs.15, 16; Pl. lii., figs.1, 2).

Complete form unknown.

Sp. Chars.—Cephalon: length and width 3 mm., and 4 mm., respectively; semielliptic, surface covered with tubercles of varying size, only mildly convex; glabella conical, densely and evenly granulated, very mildly convex, basal furrows well defined and joining the neck-furrow, basal lobes small, greatest width about one-fourth that of the cephalon, length about half that of the cephalon; the surrounding axial furrow relatively deep, cheeks gently convex, bordering the furrow surrounding the glabella; they bear eleven tubercles of uniform size, and follow a course inside of the eyes to the posterior margin; from the front of the eyes there branches from this main bead-like chain of tubercles two other sets (one on each side) of five each, which are arranged along the outer boundary of the eyes; the one or two tubercles in front of, and the one in line with, the back of each eye, appear to be larger than the others of these sets; besides these rows there are a few tubercles bordering the inner edge of the marginal furrow, and the thickened border bears a chain of these small bead-like tubercles of uniform size, and about twenty-five in number, the rest of the surface being finely granulated. The eyes are small, crescentic, close to the glabella and posterior margin; neck-furrow shallow, as are also its lateral extensions; neck-ring fairly robust and granulated, lateral extensions relatively strong and narrow; border-furrow wide and deep; border strongly tumid and tuberculate; angles, if not spinate, are acute.

Obs.—The above Brachymetopus is the first and only specimen of the genus collected from the Carboniferous rocks of Queensland. It occurs at Trilobite Ridge, Mt. Morgan, Queensland, associated with other genera of trilobites. In several features it resembles *Br. strzeleckii* McCoy, the prototype, and agrees with this species and *Br. Maccoyi* in possessing a well-defined cephalic marginal border, bounded inwardly by a well-defined furrow.

The tuberculation, too, on this border is similar in the three species. Dimensionally, this species agrees closely with *Br. strzeleckii*, judging from the dimensions given by Reed,* so also does it in part in the character of the ornamentation, but in part in this respect, it differs very widely, as the description shows.

The chief differences between our species and *Br. strzeleckii* are—1. The character of the ornamentation. 2. The more conical shape of the glabella in ours, and the absence of the large longitudinally placed tubercles on this part. 3. The more acutely rounded cephalon, particularly at the front. 4. The eyes are situated closer to the posterior border, and perhaps to the glabella. 5. The lateral extensions of the neck-ring are narrow and prominent. Without doubt, the two forms are closely related.

Since writing the above, I have found, on some of the Queensland specimens from Rockhampton and Mt. Morgan districts, several pygidia and a portion (cheek) of a cephalic shield, which belong to the genus Brachymetopus. One of these pygidia, which is fairly well preserved, I am assuming to be specifically identical with the cephalon above described. Its description is as follows.

Pygidium semicircular, only mildly convex, strongly tuberculate. Axis moderately prominent, contracting gradually posteriorly, ending short of the border bluntly, with less than half its anterior width; it bears five longitudinal rows of tubercles, the individuals of the middle row being much larger than those in the rows on each side of it. There are at least twelve or thirteen rings in the axis, and a central tubercle on ten of these can be clearly seen; this applies also in the case of each row immediately adjacent to the central one. Axial furrows deep. Side-lobes consist of six (? seven) pairs of segments, the ridges of which are very prominent, and bear several relatively large tubercles and some of smaller size; each of the posterior pair merely consists of a tubercle, and each ridge of the anterior pairs bears several tubercles varying much in size, the larger being

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* Geol. Mag., N.S., Dec. iv., Vol. x., 1903, pp.193-196.

situated near the axial furrows and border; the ribs apparently extend into spines beyond the border, mesial furrows of the ribs deep. Border of moderate width, and apparently only mildly thickened.

This pygidium, though it presents in a general way a strong resemblance to that of *Br. strzeleckii*, exhibits features which help to separate the two forms. The chief differences between their pygidia are—1. The axis of *Br. dunstani* consists of twelve or thirteen rings, as against ten in the other. 2. Five longitudinal rows of tubercles traverse the axis of the former, while seven rows occur on the latter on the same part. 3. A large tubercle is situated centrally on each axial ring of the former, but only on every alternate axial ring in the latter. 4. There is a smaller number of tubercles on each pleural segment of the former than on the similar segments of the latter. The pygidial ornamentation of our species agrees closely with *Br. lodiensis* Meek.

Dedicated to Mr. B. Dunstan, Chief Government Geologist, Brisbane, whose palæontological discoveries have been numerous and important.

Loc. and Hor.—Trilobite Ridge, Mt. Morgan, Queensland, associated with *P. woodwardi.* Lower or Middle Carboniferous. Specimens Nos. F 1031, F 1007, Geological Museum, Dept. of Mines, Brisbane; and No. 712, Queensland Museum, Brisbane.

BRACHYMETOPUS, sp. indet.

In addition to the head and tail, which served for the description of *Br. dunstani*, there occur on specimen No. 712 of the Queensland Museum, Brisbane, no less than three pygidial fragments of Brachymetopi, besides the pygidium which served for the foregoing description of *Br. dunstani.* In the case of two, one is partially superimposed on the other, and the third is almost touching these. On specimen F 1007 is a portion of a right cheek, which presents features evidently unlike either *Br. strzeleckii* or *Br. dunstani.* Two of the fragmentary pygidia also appear to be new, and may be specifically identical with the individual to which the cheek-fragment belonged. The material, however, is too fragmentary to describe and figure. The occurrence of three pygidia in a bunch indicates that they may be plentiful, and careful search may bring better specimens to light.

EXPLANATION OF PLATES XLVI.-LIII.

Plate xlvi.

Phillipsia collinsi Mitchell.

Figs. 1, 2, 3, 4, 5.—Fig. 1 is a photo ($\times 3$) made from the specimen represented in Fig. 2. The glabellar features are plainly visible. Figs. 3, 4, 5 represent pygidia, and show their characteristic features very well. Figs. 4 and 5 $\times \frac{7}{4}$ (about). (Coll. Mitchell).

Phillipsia coulteri Mitchell.

Figs. 6, 7, 8, 9, 10.—Different views of one individual. Fig. 6 $\times \frac{7}{4}$, and Fig. 10 nearly natural size. In Figs. 8 and 9, the mild dorsal serration is visible. In Fig. 10, the hypostome is plainly seen, and the rather large tubercle of the terminal axial ring. (Coll. Mitchell).

Phillipsia breviceps Mitchell.

Figs. 11, 12.—Cephalon and tail. (Coll. Mitchell).

Griffithides convexicaudatus Mitchell.

Fig. 13.—Dorsal view. (Coll. Mitchell).

Phillipsia stroudensis Mitchell.

Fig. 14.—The specific features clearly represented; ($\times \frac{3}{2}$). (Coll. Mitchell).

Phillipsia proxima Mitchell.

Figs. 15, 16.—Two views of a pygidium, the latter about natural size. (Coll. Mitchell).

Plate xlvii.

Phillipsia robusta Mitchell.

Fig. 1.—The pygidium originally described by Mr. R. Etheridge, Junr., as *P. grandis*. It shows the important features rather clearly. (Coll. Geological and Mining Museum, Dept. of Mines, Sydney. No. 1492).

Phillipsia grandis Eth. fil.

Fig. 2.—Photo of the specimen originally described by Mr. R. Etheridge, Junr., and for which the specific name *grandis* was first suggested by him. The figure shows how different in character are the pleural ribs from those of *P. robusta*; the sutures along the articulating ridges, and the crossing of the border by the anterior ribs. (Coll. Geological and Mining Museum, Dept. of Mines, Sydney. No. 1590).

Phillipsia elongata Mitchell.

Figs. 3, 4.—Casts from an almost perfect mould or cover. They exhibit clearly the features of this fine trilobite. [Coll. Geological and Mining Museum, Dept. of Mines, Sydney. No. 1500, (cover)].

Fig.5.—The natural cast. Part of the right side of the cephalon is absent. Shows traces of the left genal spine. (Coll. Geological and Mining Museum, Dept. of Mines, Sydney. Fig.3, F1500, etc.).

Phillipsia dungogensis Mitchell.

Fig.6.—Part of a pygidium, showing the continuous border, and other essential features. (Coll. Geological and Mining Museum, Dept. of Mines, Sydney. No.1494).

Fig.7.—A smaller and nearly perfect pygidium; (× $\frac{3}{2}$). (Coll. Geological and Mining Museum, Dept. of Mines, Sydney. No.1494).

Phillipsia robusta Mitchell.

Fig.8.—Another view of the pygidium, only less enlarged.

Phillipsia woodwardi Eth.fil.

Fig.9.—Medial portion of a cephalon much weathered. (Coll. Geological Museum, Dept. of Mines, Brisbane. No.F.1017).

Plate xlviii.

All figures on this Plate × $\frac{3}{2}$ about.

Griffithides convexicaudatus Mitchell.

Figs.1, 2.—Dorsal and side-view.

Fig.3.—Pygidium and free cheek, with the eye of a young individual; the free cheek partly covering the tail. (Coll. Mitchell).

Phillipsia rouchelensis Mitchell.

Figs. 4, 5, 6, 7.—Four pygidia. They exhibit the specific features. Figs. 5 and 7 are photos of the specimens used by Mr. Etheridge for his figures (Pl. xxi., figs. 6-7, *op. cit.*, *antea*). (Coll. Geological and Mining Museum, Dept. of Mines, Sydney. Nos. E 1495, 3534 (2), F 1595).

Phillipsia collinsi Mitchell.

Figs.8, 9.—Fragmentary head-shield, and faint outline of a poorly preserved but almost complete individual. In Fig.8, all the glabellar features are visible. (Coll. Mitchell).

Phillipsia stanvellensis Mitchell.

Figs.10, 11, 12.—Three different views of a mature individual. The specimen represented by these figures was used by Mr. Etheridge for his Queensland type of *P. dubia* (Pl. viii., fig.5, *op. cit.*). (Coll. Geological Museum, Dept. of Mines, Brisbane. No.F 969).

Fig.13.—On this photo are the middle part of a cephalon and a pygidium of an immature individual. The former shows the normal and dunce's hat-like shape of the glabella, globular basal glabellar lobes, and the relatively strong neck-ring. The pygidium shows the narrow, prominent axis, etc., characteristic of the species. (Coll. Geological Museum, Dept. of Mines, Brisbane. No.F 980).

Phillipsia elongata Mitchell.

Fig. 14.—Portion of a head-shield, thorax, and tail. The markings on the basal glabellar lobes are accidental. The normal glabellar frontal limb and anterior courses of the facial sutures are shown. (Coll. Geological and Mining Museum, Dept. of Mines, Sydney. No. F 1498; Pal. Mem. Pt. 5, No. 2, Pl. xxi., fig. 2).

Phillipsia superba Mitchell.

Fig. 15.—Cephalon minus the right free cheek. (Coll. Geological and Mining Museum, Dept. of Mines, Sydney. No. 24).

Phillipsia waterhousei Mitchell.

Figs. 16, 17, 18.—The first and second of these are from an intaglio, and the other is from a squeeze from it. With the aid of a lens, the features can be made out. (Coll. Geological and Mining Museum, Dept. of Mines, Sydney. Nos. 28 and 30).

Plate xlix.

Phillipsia woodwardi Eth. fil.

Figs 1-6.—Pygidia, all assumed to belong to this species. All show practically the same features. Figs. 3 and 4 are more strongly granulated than the others; but this difference probably arises from degrees of weathering. Fig. 5 was figured by Mr. Etheridge (*op. cit.* Pl. viii., fig. 6) as the normal tail of his *P. dubia.* (Coll. Geological Museum, Dept. of Mines, Brisbane. Nos. F 985, F 1024, F 995, F 1026, F 968, F 993).

Figs. 7-8.—Photos of a fragmentary cephalon, about which I am doubtful that it is rightly placed here. It is one of Mr. Etheridge's types (Geol. and Pal. Queensland and New Guinea, Pl. vii., fig. 13). (Coll. Geological Museum, Dept. of Mines, Brisbane. No. 967).

Phillipsia rockhamptonensis Mitchell.

Figs. 9-10.—Two prints of a nearly complete specimen. Fig. 10 has some of its features intensified. This specimen was figured by Mr. Etheridge, Junr., and determined to belong to his *P. dubia* (*op. cit.*, Pl. xliv., fig. 4). This figure very indifferently represents the original, as will be seen by comparing it with the present photos, which show its chief characteristic features clearly. (Coll. Queensland Museum. No. 716).

Phillipsia morganensis Mitchell.

Figs. 11-12.—Fig. 11 represents portions of a cephalon, thorax, pygidium, and a hypostome. Fig. 12 is a rough sketch of part of a cephalon. (Coll. Geological Museum, Dept. of Mines, Brisbane. No. F 1000).

Phillipsia woodwardi Eth. fil.

Figs. 13-14.—Photos of the type-specimen. Fig. 14 has the outline traced in. (Coll. Geological Museum, Dept. of Mines, Brisbane. No. 966).

Brachymetopus dunstani Mitchell.

Figs. 15-16.—Showing the cephalon and pygidium of the species. (Coll. Geological Museum, Dept. of Mines, Brisbane, No. F 1031; and Queensland Museum, Brisbane, No. 712).

Plate l.

All figures, except 2 and 3, which are about nat. size, $\times \frac{3}{2}$.

Phillipsia grandis Eth. fil.

Figs. 1, 2, 3.—Photos of a pygidium. Figs. 2 and 3 are from casts of No. 1 in Fig. 1. Besides the pygidium, parts of at least three free cheeks, etc., are visible. One cheek shows within it the hypostome. The borders of these cheeks are remarkably large. (Coll. Geological Museum, Dept. of Mines, Brisbane. No. F 927).

Phillipsia elongata Mitchell.

Figs. 4, 5, 6, 7.—Figs. 4 and 7 represent pygidia. Fig. 5 is a side-view of a very fine specimen, and shows, besides other features, the squatness of the eyes. Fig. 6, a pygidium and a portion of a head-shield. (Coll. Geological and Mining Museum, Dept. of Mines, Sydney. Nos. F 1496, 1500, and 1506).

Phillipsia rockhamptonensis Mitchell.

Figs. 8, 9.—Two pygidia. Fig. 8 is a photo of the specimen shown in Geol. and Pal. Queensland and New Guinea, Pl. xliv., fig. 6. Fig. 9 represents a young individual. (Coll. Queensland Museum, Brisbane, No. 833; and Geological Museum, Dept. of Mines, Brisbane, No. F 792).

Phillipsia(?) *woodwardi* Eth. fil.

Fig. 10.—On this specimen are several pygidia and a remarkable hypostome, doubtfully assumed to belong to this species; and, in addition, the greater part of a cheek of a *Brachymetopus;* the position of which is indicated by an arrow. (Coll. Geological Museum, Dept. of Mines, Brisbane. No. 1007).

Fig. 11.—Glabella; one of Mr. Etheridge's types. (Coll. Queensland Museum, Brisbane. No. 707).

Plate li.

If not otherwise indicated, all the figures are $\times \frac{3}{2}$ (about).

Phillipsia morganensis Mitchell.

Fig. 1.—A photo, in two sections, of a specimen on which are parts of at least three individuals, all assumed to belong to this species. The glabellar, pygidial, ocular, and hypostomal features are all discernible, as are also those of the thorax. (Coll. Geological Museum, Dept. of Mines, Brisbane. No. F 1000).

Phillipsia breviceps Mitchell.

Figs.2, 3.—Photo of a specimen showing portions of two cephalic-shields and a very perfect pygidium, whose characteristics are represented. Mark the peculiar contraction near the middle of the tail, which suggests a short tail, and a portion of a thorax. Fig.3, a portion of a cephalon, showing limb, mesial furrow on the right, etc. (Coll. Mitchell).

Phillipsia connollii Mitchell.

Figs.4-7.—A dorsal and side-view of the only pygidium known. The proportionately very wide border, prominent axis, granulation, and other features are fairly well shown. In Fig. 6, the axial and pleural divisions have been intensified slightly. (Coll. Geological and Mining Museum, Dept. of Mines, Sydney. No. F 1497).

Phillipsia stanvellensis Mitchell.

Figs.8-10.—Dorsal and side-view of a very perfect tail, and showing the very prominent, mildly serrated axis clearly. In this specimen, all the axial rings (12, doubtfully 13) are visible, as also are eight pleural segments, and the steep striated border. (Coll. Geological Museum, Dept. of Mines, Brisbane. No.F 977).

Phillipsia stroudensis Mitchell.

Fig.11.—A medium-sized tail, having the dorsal part of the axis damaged; but otherwise exhibiting the normal features. (Coll. Mitchell).

Phillipsia woodwardi Eth. fil.

Figs.12-13.—Portions of cephalons. Fig.12 shows the glabellar furrows, strong neck-ring, and supplementary lobes, etc., very well. Fig.13 exhibits these features less clearly. Fig.12 is from the same specimen as that figured by Mr. Etheridge, Junr., (*op. cit.*, Pl. xliv., fig.5). (Coll. Queensland Museum, Brisbane, No.707; and Geological Museum, Dept. of Mines, Brisbane, No.F 1017).

Phillipsia woodwardi(?) Eth. fil.

Fig.14.—This photo shows the fragments of trilobite-remains, on which Mr. Etheridge chiefly founded his species *G. seminiferus* var. *australasica*. On this specimen also occurs the tail of *Brachymetopus dunstani*. It remains to be proven that they are not portions of the above species. The tails shown on this specimen have the same number of axial and pleural divisions, and kind of granulation as those included with the cephalons of *P. woodwardi*. (Coll. Queensland Museum, Brisbane. No.712).

Plate lii.

Phillipsia woodwardi(?) Eth.fil., and *Brachymetopus dunstani* Mitchell.

Fig.1.—This represents a portion of specimen No.712 of the Queensland Museum, Brisbane. On it is the pygidium assumed to belong to *P. woodwardi*, and a pygidium of *Br. dunstani* in front of the arrow; (×3).

Brachymetopus dunstani Mitchell. etc.

Fig.2.—Enlarged portion of specimen No. F 1017, Geological Museum, Dept. of Mines, Brisbane. On it is the intaglio of *Br. dunstani*, showing, fairly well, the chief specific features. The other pygidial and cephalic imprints are assumed to belong to *P. woodwardi* Eth. fil.; (×3).

Phillipsia superba Mitchell.

Fig.3.—Head-shield (×$\frac{5}{2}$) from the same specimen as Pl. xlviii., fig.15.

Phillipsia collinsi Mitchell.

Fig.4.—A perfect tail of an immature individual; (×$\frac{5}{2}$).

Griffithides convexicaudatus Mitchell.

Figs.5, 6.—Tails about complete. Fig.5 is that of a young individual, but shows all the axial and pleural divisions.

Phillipsia waterhousei Mitchell.

Fig.7.—From a cast; it shows the glabellar furrows plainly; and other features.

Plate liii.

Griffithides(?) *sweeti* Eth.fil.

Figs.1, 2.—Dorsal aspect. Traces of glabellar furrows are visible, especially on the right side generally. The important features are well shown. The photos are from the type-specimen; (×2). (Coll. Sweet).

Brachymetopus strzeleckii McCoy.

Figs.3, 4.—Photos of the enlarged figures of McCoy (*loc. cit.*).

Figs.5, 6.—Photos of Reed's figures of the species (*loc cit.*).

Griffithides dubius Eth. Senr.

Fig.7.—Copy of the figure given by R. Etheridge, Junr., (in Geol. Pal. Queensland and New Guinea, 1892, Pl. vii., fig.12).

Phillipsia woodwardi Eth.fil.

Figs.8, 9.—Copies of Mr. Etheridge's figures (*op. cit.*, Pl. vii., figs.13, 15).

Griffithides(?) *seminiferus* var. *australasica*.

Fig.10.—Copy of Mr. Etheridge's original figure of a free cheek.

ORDINARY MONTHLY MEETING.

September 25th, 1918.

Professor H. G. Chapman, M.D., B.S., President, in the Chair.

The President announced that the Council had come to the conclusion, that the proposed scheme "to create a miniature Australia in its primary conditions," on Pulbah Island in Lake Macquarie, as mentioned at last Meeting, was not a matter in which the Society could move with advantage, at present.

The Donations and Exchanges received since the previous Monthly Meeting (28th August, 1918), amounting to 4 Vols., 38 Parts or Nos., 5 Bulletins, 1 Report, and 2 Pamphlets, received from 30 Societies, etc., were laid upon the table

NOTES AND EXHIBITS.

Dr. J. B Cleland mentioned that, on two consecutive days in August last, he had heard and seen a Little Penguin, *Eudpytula minor*, off Kurraba Point, in Neutral Bay.

Dr. R. J. Tillyard exhibited a slide of some transverse sections of the Saccoid Caudal Gills of the larva of the Dragonfly *Pseudophæa* sp., (Fam. *Calopterygidæ*) from Java, sent by Dr. F. Ris, of Rheinau, Switzerland. In this preparation, the alveoli show some remarkable structures, described originally by Dr. Ris as "moss-like branching tufts of standing fibrils," and considered by him to be special respiratory organs of the gill. From the photographs which Dr. Ris published of these sections, Dr. Tillyard concluded that they were artefacts, a conclusion which Dr. Ris is unwilling to accept. He therefore sent the slide in support of his opinion. The slide shows many alveoli in which the fibril-tufts project considerably beyond the boundary of a single alveolus. They were examined under the microscope by biologists and physiologists present at the Meeting, all of whom agreed that they were artificial products; though it is not possible to say definitely what caused them, in view of the fact that no information is available as to the method of fixation used by the collector who took the larva in Java. (These Proceedings, 1917, xlii., pp.51-54, and Pl. iv., figs.31-33).

Mr. Fletcher exhibited five portions of typical, water-storing Mallee-roots, and one of two bottles of root-water from South Australia, received from Mr. H. S. Crummer, through the kind co-operation of Mr. T. Gill, of Adelaide, and Mr. G. Murray, of Fowler's Bay, S.A.

Dr. R. Greig-Smith offered some observations, based on a preliminary examination of one of the two samples of water obtained from Mallee-roots.

NEW AND RARE FRESHWATER ALGÆ.

By G. I. Playfair, late Science Research Scholar of the University of Sydney.

(Plates liv.-lviii.; and eleven Text-figures.)

In the following notes are embodied observations on a number of new and rare freshwater algæ, that have come under my notice during the last few years. Of those mentioned, a little over two-thirds of the new forms, and about half the others, are from Lismore, the gleanings of 23 gatherings made during the summers of 1916 and 1917: to be precise, from Sept. 16th, 1916, to May 14th, 1917, and from Sept. 21st, 1917, to Feb. 10th, 1918. During the colder months of May, June, July, and August, very little of interest is to be found. The others are from older samples, also locally obtained, or out of still earlier gatherings from Sydney. In all, 66 new forms are described and figured, 28 being admitted to specific rank, 29 classed as variations, and 9 as forms; one new genus is proposed. The figures are, of course, all drawn from Australian specimens.

Habitats.—The districts from which the various forms have been obtained are purely of local interest, but more general value attaches to the character of the habitat. The numbered gatherings, referred to, are accordingly classified as follows. Plankton: 80, 81, 90, 99, 100, 115, 121, 136, 258, 265, 266, 311, 316, 327, 328, 332, 340*a*, 347, 362. Out of weeds (practically plankton): 3, 26, 50, 158, 184, 189, 193, 272, 317. Mucous strata: 306, 323, 326. Ponds, lagoons, and swamps account for the remaining twenty.

One of these last, a swampy pool formed entirely by surface-water, deserves special mention; during the two summers, it was responsible for 30 out of the 64 new forms here described. The samples which refer to it are 284, 286, 298, 302, 308, 311, 312, 316, 317, 327, 337, 340*a*, 345, 347, 352. The pool is the drainage of a considerable area of ground swampy after rain, and is about 2 feet deep in the centre; in droughty weather, it is often entirely dry.*

On account of its unpromising appearance, and to secure everything that might be present, a quantity of water was taken from a spot where there was a growth of coarse weeds, the weeds being well shaken up, and the bottom disturbed also to some extent. This water was strained through a plankton-net of common calico, ground-samples from the swamp being sometimes added. Several gallons would be treated in this way, and the last quart, or so, of water and sediment taken home in a tin and decanted.

During the periods mentioned above, a gathering was taken, on an average, once a month, the main portion of the water being drawn from the same spot. The results show the importance of a regular periodic examination of a pond. The desmids and diatoms were fairly constant, but the *Myxophyceæ*, *Volvocaceæ*, and *Protococcoideæ* presented, from month to month, an apparently endless succession of forms, new, uncommon, or not previously recorded. Rarely could any of these be noted in two successive gatherings, and very often they were never seen again. For instance, of *Chlamydomonas*, 10 different forms, new or rare, were noted; of *Carteria*, 5; of *Phacotus*, 2; of *Volvox*, 2; of *Oocystis*, 7; of *Tetraëdron*, 7; of *Geminella*, 4. Yet, in two summers, the most that could be said was, that a few of them had been recorded a second time.

Of course the swamp, with its ever-changing conditions of life, is the real breeding-ground of all these forms, the pool being only the repository of them, *Chlamydomonas* and *Carteria* are notoriously dependent on rainfall, and are very sensitive to stagnation; but I find that forms of *Oocystis* and *Tetraëdron* are just as irregular in their appearance. Probably, the reason is

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* Swampy pools of this sort are the best places to search for new and rare forms of microscopic life; permanent waters, on the other hand, can generally be relied on to yield a micro-flora and fauna of unvarying character.

to be found in the propagation of all these genera by autospores. To begin with, the autospores differ slightly (and sometimes more than slightly) from the parent-cell, and their subsequent development along diverging lines will, no doubt, result in more or less widely differing forms.

Another interesting point to be noted is, that now and again one or other of these forms would be recorded *at the same time* from some other pool connected with an entirely different watershed, or even in another part of the neighbourhood, but they were just as evanescent.

MYXOPHYCEÆ.

Syn. *Phycochromophyceæ*, *Cyanophyceæ*, *Schizophyceæ*.

Fam. CHROOCOCCACEÆ.

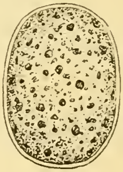
Genus Synechococcus Näg.

Synechococcus grandis, n.sp. (Text-fig.1).

Cellulæ magnæ, crassæ, oblongo-ovales; apicibus late-rotundatis; lateribus arcuatis; cytoplasmate æruginoso, granuloso.

Long. 33, lat. 23μ. Lismore (345).

Of Nägeli's three species (Gatt. einz. Alg., p.56, T. i.E, f.1-3), none are over 20μ long. *S. major* Schröter, the nearest in size, is cylindrical. *See* G. S. West, Br. Frw. Alg., p.347, f.161D, E.



Text-fig. 1.*

Genus Merismopedium Meyen.

Merismopedium punctatum Meyen. (Text-fig.2*a*).

In Wiegm., Archiv, 1839, p.67, *sec.* Rabenhorst, Fl. Eur. Alg., ii., p.57. Syn., *M. Kützingii* Näg., *l.c.*, p.55, T. i.D, f.2. Contents generally pale blue. Usually found in our waters in isolated sets of four cells. As figured, however, out of weeds in the river, the cells were in large sheets but still semi-detached in cœnobia of 4.

Cell. diam. 2μ. Lismore, Richmond R. (272).

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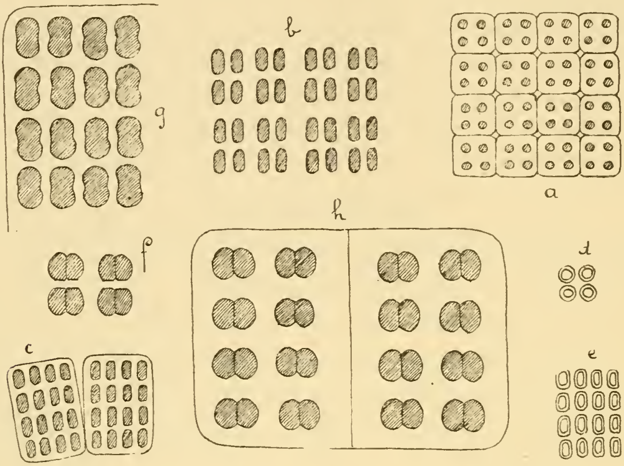
* *Synechococcus grandis*, n.sp., (×660).

Var. OBLONGUM Playf. (Text-fig. 2*b*, *c*).

Biol. Richm. River, p.135. Generally sparsely distributed in isolated sets of 4, or more rarely of 16. The latter were frequent in plankton from the Nymboidia River, near Grafton, where I even noted a large cœnobium (30 × 20μ) of four sets of 16 cells each. The cells are irregularly oblong, the contents pale blue.



Text-fig.2.

(*a*) *Merismopedium punctatum* Meyen, forma, (×500); (*b*, *c*) var. *oblongum* Playf., (*b* ×1000, *c* ×660); (*d*, *e*) var. *vacuolatum*, n.var., (×660); (*f*) *M. cyaneum*, n.sp., (×660); (*g*) *M. elegans* var. *constrictum*, n.var., (×660); (*h*) *M. duplex*, n.sp., (×1330).

Cell. long. 2-3, lat. $1\frac{1}{2}$-2μ (plerumque 3 × 2μ).

Lismore (350); Grafton (265, 266).

Var. VACUOLATUM, n.var. (Text-fig. 2*d*, *e*).

Cellulæ globosæ vel oblongæ; media cellula loco vacuo magno occupata.

Cell. diam. 2μ; vel long. 3, lat. 2μ. Lismore (350).

The cells are irregularly globose or oblong, and the centre is occupied by a large vacuole giving each cell the appearance of a ring. Globose and oblong cells are sometimes mixed in the same cœnobium.

MERISMOPEDIUM CYANEUM, n.sp. (Text-fig.2*f*).

Cellulæ ovales vel oblongæ; cytoplasmate cyaneo.

Cell. long. 5-6, lat 3μ. Potts Hill (121).

Cœnobium of 4 cells measured 12 × 6μ, the cells not quite divided; the colour of the cell-contents a strong bright blue.

MERISMOPEDIUM ELEGANS v. CONSTRICTUM, n.var. (Text.fig.2*g*).

Cœnobium membranaceum, extensum, e cellulis permultis, confertis, compositum; cellulis oblongis medio constrictis; cytoplasmate dilute cæruleo vel dilute viridi.

Cœnob. long. c. 300, lat. c. 200; cell. long. 6-7, lat. 4-5μ.

Lismore, Richmond R. (184, 193).

The cœnobia were wide-spreading, containing 1024 cells (32 × 32) or so. Cells oblong, constricted in the middle, pale blue or pale green. A few cells of the type present, oblong, not constricted, 6 × 4μ.

MERISMOPEDIUM DUPLEX, n.sp. (Text-fig.2*h*).

Cellulæ sphæricæ vel ovales, remotæ; cytoplasmate dilute cæruleo.

Cell. long. 4, lat. 3μ Coogee (4).

Cœnobia small, about 30 × 25μ, consisting of 8-32 cells generally found half-divided, remote. Contents pale blue.

Fam. OSCILLATORIACEÆ.

Genus OSCILLATORIA Vaucher.

OSCILLATORIA FLEXA, n.sp. (Pl. liv., fig.1).

Stratum mucosum, foliaceum, saturate viride; filis arcte intricatis rectis, juxta apices subito deflexis, haud attenuatis, apicibus rotundatis, vaginis tenuissimis; trichomatis dilutissime ærugineis, ad genicula haud constrictis; articulis subquadratis vel cylindraceis; dissepimentis ægre cernendis, haud granulatis; cytoplasmate tenui-granuloso.

Diam. fil. 2½-3, cell. alt. 2-8μ. Lismore (317).

A mucous stratum of dark green flakes in shallow water at the grassy edge of a swampy pool, in quantity. The filaments were very lively under the microscope, as is usual with species of this genus; and the sheath, though very delicate, was quite distinct in broken filaments. I have always found it so, even in the finest species of *Oscillatoria*. The filaments, in general quite straight, were bent suddenly about 10μ from the end, which was not attenuated.

OSCILLATORIA SIMPLICISSIMA V. GRANULATA, n.var. (Pl. liv., f.2).

Forma dissepimentis tenuissime granulatis.

Diam. fil. 8, cell. alt. 4-6 (plerumque 4μ).

Lismore (327).

Filaments free-floating in prodigious quantities, colour pale grey-green, contents finely granular, as also are the dissepiments.

Var. CONSTRICTA, n.var. (Pl. liv., f.3).

Forma trichomatis ad genicula levissime constrictis.

Diam. fil. 13, cell. alt. 4-8μ. Lismore (350).

Filaments free-floating, more than half as broad again as in the type, with the cells slightly constricted, a mere nick at the edge. Colour pale blue, contents homogeneous not granular. Type in Gomont, Monog. d. Oscillariées, p.219, Pl. vii., f.1.

OSCILLATORIA PRINCEPS Vauch. (Pl. liv., f.4).

Diam. fil. 30-57, cell. alt. 4-8μ. Lismore (350, 352).

Colour pale grey-blue or grey-green. I mention this species for the sake of giving a figure of a piece of empty sheath showing fixed dissepiments right across, with incipient intermediate ones. In surface-view, the septa appeared as faint transverse lines, but, in optical section, they showed bulging to one end, as if the cells had been violently forced out.

Genus PHORMIDIUM Kütz.

PHORMIDIUM GRANDE, n.sp. (Pl. liv., f.5).

Stratum papyraceum olivaceum; filis rectis, apicibus rotundatis, calyptra nulla, vaginis plerumque crassis; trichomatis saturate viridibus interdum luteolo-viridibus, ad genicula haud constrictis; articulis brevissimis; dissepimentis latis, haud granulatis; cytoplasmate tenui-granuloso.

Diam. fil. 21-23, trich. 19-20, cell. alt. $1\frac{1}{2}$-$2\frac{1}{2}$ (plerumque 2μ). Lismore (323).

An olive-green papyraceous stratum in great quantities on the surface of a creek-pool, after heavy rain followed by heat. The trichomes under the microscope were of a brilliant green colour (very unusual in this family, but found also in *O. nigro-viridis*) or sometimes yellow-green. The tips of the filaments were sometimes rounded, but generally slightly constricted at the terminal cell so as to be subcapitate.

PHORMIDIUM NUMARIUM, n.sp. (Pl. liv., f.6, 7).

Stratum papyraceum olivaceum; filis angustissimis arcte intricatis, vaginis tenuissimis, apicibus rotundatis; trichomatis dilute cæruleis, ad genicula valde constrictis, articulis brevissimis disjunctis; cytoplasmate homogeneo.

Diam. fil. 2, cell. alt. $\frac{1}{2}$-$1\frac{1}{2}\mu$. Lismore (326).

An olive-green papyraceous stratum on the curb-stone near a down-pipe. The cells of the trichomes are disjoined and are of the palisade-type, reminding one of a *rouleau* of coin, at most quadrate before division, only to be distinctly made out with the $\frac{1}{12}$ obj., the contents homogeneous, pale blue with a darker band at the sides.

Fam. NOSTOCACEÆ.

Genus ANABÆNA Bory.

ANABÆNA AUSTRALICA, n.sp. (Pl. liv., f.8, 9).

Trichomata angusta, recta, libere natantia, ad genicula levissime constricta; cellulis rectangularibus, adpressis, apicibus truncatis; cytoplasmate dilutissime cæruleo pæne hyalino, homogeneo vel minutissime granulato; heterocystidibus angustis cylindraceis, apicibus rotundato-truncatis; gonidiis angustis cylindraceis, apicibus rotundatis, lateribus parallelis, juxta heterocystides ordinatis; cytoplasmate pulchre cyaneo, granulato.

Cell. diam. 3-4, alt. 6-10, plerumque 8; heterocyst. diam. 4-5, alt. $10\frac{1}{2}$-15; gonid. diam. 5-7, alt. 19-32μ.

Lismore (327, 337).

Found free, floating. Trichomes narrow, very pale blue, almost hyaline, with cells so strictly rectangular and so closely adpressed that the trichome has the appearance of an *Oscillatoria*; the slight constriction at the joints, a mere nick at the edge, is discernible only with the $\frac{1}{12}$ obj. (often the dissepiments also): contents homogeneous or finely granular. Heterocysts narrow, strictly cylindrical. Gonidia one or two on either side of a heterocyst, narrow, cylindrical; contents bright blue, granular.

Var. CONSTRICTA, n.var. (Pl. liv., f.10).

Forma gonidiis in medio constrictis. Cell. diam. 3, alt. 8-10; heterocyst. diam. 4, alt. 11; gonid. diam. 4-6, alt. 19-21μ.

Lismore (350).

A form with rather short gonidia somewhat constricted in the middle.

ANABÆNA VARIABILIS var. CYLINDRACEA, n.var. (Pl. liv., f.11-13).

Trichomata flexuosa, dilute cærulea, ad genicula constricta; cellulis stricte rectangularibus, disjunctis, apicibus truncatis; cytoplasmate minute granulato; heterocystidibus oblongis vel oblongo-cylindraceis, apicibus rotundatis; gonidiis doliformibus, quadratis vel oblongis, disjunctis, apicibus truncatis.

Cell. diam. 3, alt. 4-6; heterocyst. diam. 4-5, alt. 7½-10½; gonid. diam. 6, alt. 7-10½μ. Lismore (316).

Easily recognised as *A. variabilis* by its catenate gonidia remote from the heterocysts, differing from the type, however, in its rectangular cells. All parts of the trichome also seem to be slightly more slender than usual. The gonidia were perhaps immature, and would probably become oblong with rounded ends.

ANABÆNA OSCILLARIOIDES var. CRASSA, n.var. (Pl. liv., f.14).

Forma cellulis crassioribus, globosis (e divisione oblongis vel oblongo-constrictis); cytoplasmate æruginoso; heterocystidibus interdum minoribus, sphæricis; gonidiis oblongis, apicibus rotundatis, cytoplasmate æruginoso granulato.

(1). Cell. diam. 6-8; heterocyst. 4; gonid. diam. 9, alt. 22-23μ.
Lismore (298).

(2). Cell. diam. 8-9½; heterocyst. 8; gonid. diam. 12, alt. 25μ.
Lismore (337).

In this form, the cells are broader and the heterocysts sometimes narrower than in the type (cell. diam. 4-6, heterocyst. 6-8, gonid. 8-10μ); *cf.* Bornet et Flahault, Revis. d. Nostoc., p.233; Tilden, Minnesota Algæ, i., p.193, Pl. ix., f.19.

ANABÆNA LAXA var. HORTENSIS, n.var. (Pl. liv., f.15, 16).

Forma heterocystidibus cylindraceis; gonidiis cylindraceis elongatis.

Cell. diam. 6-7, alt. 8-12; heterocyst. 7, alt. 14-16; gonid. 7, alt. 33μ.

Botanic Gardens, Sydney (158).

Cf. *Sphærozyga* (*Anabæna*) *laxa* Rabenhorst, Fl. Eur. Alg., ii., p.193; Tilden, *l.c.*, p.192, Pl. ix., f.18. In the type, the heterocysts are spherical, and the gonidia are shorter. Cell-contents, in our form, pale blue, in the heterocysts and gonidia a deeper blue. Rabenhorst, *l.c.*, gives "*trichomatibus . . . luteo-æruginеis*," and "*sporis . . saturate luteo-viridibus*" for the type.

Genus CYLINDROSPERMUM Kütz.

CYLINDROSPERMUM STAGNALE V. AUSTRALE, n.var. (Pl. liv., f.17-21).

Forma cellulis cylindraceis, disjunctis, apicibus truncatis; heterocystidibus oblongo-cylindraceis vel conicis; gonidiis oblongis vel oblongo-cylindraceis, apicibus rotundatis, cytoplasmate pulchre cyaneo vel dilute viridi.

(1). Cell. diam. 4-5, alt. 5-10 (plerumque 7-8); heterocyst. diam. 4-6, alt. 8-11; gonid. diam. 9-13, alt. 18-30μ. Lismore (302).

(2). Cell. diam. 3, alt. 4-10 (plerumque 4-5); heterocyst. diam. 3-4, alt. 7-14; gonid. diam. $7\frac{1}{2}$-$9\frac{1}{2}$, alt. 11-12μ. Lismore (306).

Cf. G. S. West, Br. Frw. Alg., p.328, f.150; Tilden, Minnesota Algæ, i., p.198, Pl. x., f.2. The type has oblong cells; in this form, they are quadrate or cylindrical. I found it once (sample 306) as a grey-green, foliaceous, mucous stratum at the grassy edge of a swampy pool. Though the cells and heterocysts of the interlaced trichomes were all of the same size and shape, there were intermingled in this one stratum *three distinct types of gonidia*. The most frequent answered exactly to *C. stagnale*; another I have already described as *C. rectangulare*; and the third seems to be a form of *C. Goetzei* Schmidle. I have accorded these forms specific rank, as it is the general practice, and convenient for classification; besides, what should be characteristic of a species in these plants, if not the shape of the gonidia! Nevertheless, their being intermingled in one mucous stratum indicates that they are merely allotropic forms of one plant, brought about by different modes of growth.

Most of the trichomes in the mucus were merely interlaced, but here and there they were closely coiled in a spiral manner (Pl. liv., f.21). This is not uncommon in free-swimming filaments of the plankton, but very unusual in mucous strata.

CYLINDROSPERMUM RECTANGULARE Playf.

(1). Gonidia thin-walled, rectangular; heterocysts oblong or acutely conical.

Cell. diam. 3, alt. 4-10; heterocyst. 3-4, alt. 7-14; gonid. 4, alt. 14μ.

Lismore (306). (Pl. liv., f.22).

(2). Gonidia thick-walled, cylindrical; heterocysts oblong.

Cell. diam. 4, alt. 5-10 (plerumque 7); heterocyst. 4-6, alt. $8\frac{1}{2}$-$10\frac{1}{2}$; gonid. diam. $9\frac{1}{2}$-12, alt. 29-38μ.

Lismore (302). (Pl. liv., f.23).

Cf. Frw. Algæ of the Lismore Distr., these Proceedings, 1915, p.349, f.A.

Var. PARVICELLULA, n.var. (Pl. liv., f.24, 25).

Forma cellulis minimis, plerumque adpressis, quadratis vel diametro brevioribus, cellula apicali acute-conica; heterocystidibus oblongis; gonidiis interdum lateribus paullo arcuatis.

Cell. diam. 2-$2\frac{1}{2}$; heterocyst. $3\frac{1}{2}$, alt. 7; gonid. 10, alt. 24μ.

Woy Woy (270).

In a gathering kindly sent me by Mr. A. H. S. Lucas. The cells are unusually small for plants of this family; it should be noted, too, that the gonidia are not any smaller on that account. The walls of the latter were incrassate, rufescent and scrobiculate; this takes place with age, however, in the gonidia of every species.

CYLINDROSPERMUM GOETZEI Schm., forma. (Pl. liv., f.26, 27).

Trichomata angusta, ad genicula constricta; cellulis quadratis vel cylindraceis, disjunctis; heterocystidibus oblongis vel conicis; gonidiis lanceolatis vel subdoliformibus, apicibus angustis truncatis.

Cell. diam. 3-5, alt. 4-10; heterocyst. 3-6, alt. 6-14; gonid. 7-10, alt. 14-22μ. Lismore (306).

C. rectangulare Playf., *partim*, Frw. Alg. Lismore, p.349, f.A. *Cf.* Schmidle, Schiz. Conj. Chlor. in Engler's Flora von Afrika, H. xxii., p.245, T. iv., f.5. In this, as in all other species of the family, the cells and heterocysts may vary much in shape and size, but the form of the gonidia is characteristic. With the three species of *Cylindrospermum* mentioned above, compare *Anabæna oscillarioides* (type), its var. *stenospora* Born. & Flah., and *A. Volzii* Lemm. These show the same three allotropic forms of gonidia in what is, biologically, one species; they are all found here with the same (quadrate or cylindrical) cells and heterocysts, very often also accompanying one another.

Fam. SCYTONEMACEÆ.

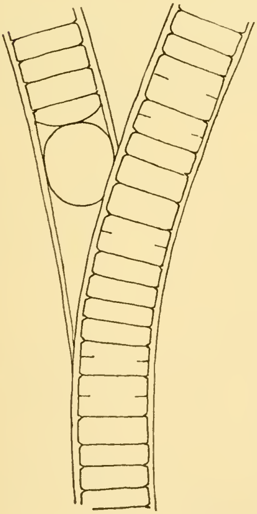
Genus TOLYPOTHRIX Kütz.

TOLYPOTHRIX LANATA (Desv.) Wartmann. (Text-fig.3).

Diam. fil. 15-17, trich. 14; cell. alt. 4-8 (plerumque 4); heterocyst. 15 × 14μ.

Grafton, Nymboidia R. (265).

Our specimens agree in dimensions fairly well with those given by Rabenhorst, Fl. Eur. Alg., ii., p.277 (fil. diam. 14-18½, trich. 11-15μ), but the cells are much shorter (equal to, slightly less than, or half as long as the diameter—Rabh.). Sheath colourless, ½ to 1½μ thick, trichomes constricted at the dissepiments, cytoplasm pale green or pale grey-green, very finely granular.



Text-fig.3.—*Tolypothrix lanata* (Desv.) Wartmann; (× 660.

FLAGELLATÆ.

Fam. HYMENOMONADACEÆ.

Genus SYNURA Ehr.

SYNURA GRANULOSA Playf. (Pl. lvi., f.1-3).

I give another figure of the cells of this species, that in Frw. Alg. Lismore, Pl. xlv., f.3, being shown too finely granulate. The granules are quite coarse, no more than 16 being visible at the edge, round the anterior margin. Some, that I noted lately, had from 1 to 8 minute dark red, or nearly black, irregular granules at the base of the flagella; or, sometimes, one, larger, simulating a stigma, in the gap between the chloroplasts (Pl. lvi., f.2, 3). The chromatophores in this case were a very pale green without any trace of yellowness, and the cœnobia peculiar in being oblong (not globose and stellate), with the cells attached round a central peduncle. The origin of these oblong cœnobia became clear later, when I found a long cylindrical cœnobium (80μ long by 30μ broad, cells long. 12-20, lat. 6-10μ) with a central mucous or membranous peduncle (Pl. lvi., f.1). The latter being gradually drawn apart by the perpetual twisting of the cells, the cœnobium broke up into two oblong colonies. In the same way, these probably break up into smaller groups, which become regularly stellate by cell-division. The formation of the cœnobia in this genus would appear, therefore, to be on somewhat the same lines as in *Anthophysa vegetans*.

Genus TESSELLARIA Playf., *nom. emend.*

Cf. Frw. Alg. Lismore, p.315. I find that "*Tessella*" is preoccupied by Ehrenberg for a genus of diatoms; I have altered the name of my new genus, therefore, to *Tessellaria*.

TESSELLARIA VOLVOCINA Playf.

In Pl. lvi., f.4, I give a figure of a yellow-green flagellate evidently belonging to this family, which I think is very probably a free zooid of this organism. In shape globose, truncate in front, diam. 10μ, with two long flagella, two small yellow-green chromatophores confined to the anterior part of the cell, and a number of relatively large refractive globules scattered round just inside the membrane; membrane very delicate. One c.v. was noted at the side, but perhaps more were present concealed by the globules.

This organism in its early stages seems to be distinctly a plankton-form and to have a fondness for the surface-layer of water. Only later, when the cœnobia have become heavier, do they fall to the bottom and become ground-forms. On the surface of a gathering which was being decanted, I was able to descry, with the help of a Coddington lens and a ray of direct sunlight, quite a miniature world of micro-flora and fauna, among which there turned out to be numbers of *Tessellaria* cœnobia of varying sizes but all small.

Incertæ sedis.

Genus XANTHODISCUS Schew.

XANTHODISCUS LAUTERBACHI Schew. (Pl. lvi., f.5, 6).

Schewiakow, Geogr. Verbreit. d. Süsswasserprotozoen, Mem. Acad. sc. de St. Pétersbourg, Sér. 7, T. xli., 1893. A rare flagellate, about whose position and characteristics there seems to be some uncertainty. Wille, Conj. und Chlorph., p.21 (in Engler & Prantl, Die naturlichen Pflanzenfamilien) has placed it as a doubtful genus of the *Volvocaceæ*, relying, apparently, on a certain similarity to *Chlamydomonas* in the arrangement of the cell-contents (fig.7D, E). I first obtained it in great abundance out of *Myriophyllum* in the Orphan School Creek, near Canley Vale Railway-station (March, 1909), and afterwards from Fairfield; I have noted it also from Gardener's Road, Botany. Unfortunately, the disposition of the contents was vague, and my lenses at that time not good enough to distinguish any details. My recollection is, that the chromatophores were pale yellow-green (not brown-green as described). One point, however, which is quite certain, has not been noted either in the figure or description (*l.c.*), viz., that the cell-wall is in two parts, as in *Phacotus*, merely agglutinated together. The organism appears to be a freshwater survival of a large marine family of flagellates —the *Prorocentraceæ*—distantly related to the *Peridinieæ*.

Stein, in Naturg. d. Flagell., ii., T. i., f.27-33, figures it as *Dinopyxis læris* Stein. He shows a pair of c.v. in front; the large posterior globule, he considers the nucleus; and the smaller central bodies, pyrenoids (two appear in his figures). Lemmermann, however, Reise n.d. Pacific, p.361, mentions *Dinopyxis læris* as a synonym of *Exuriella Lima* (Ehr.) Schütt, (*Cryptomonas Lima* Ehr.), quoting Schütt, Gymnodiniaceæ, p.8, fig.9 (in Engler & Prantl, *l.c.*). Schewiakow's genus and species, therefore, would seem to be invalid. As a freshwater form, it is known only from Australia.

CONJUGATÆ.

Genus SPIROGYRA Link.

SPIROGYRA LISMORENSIS Playf.

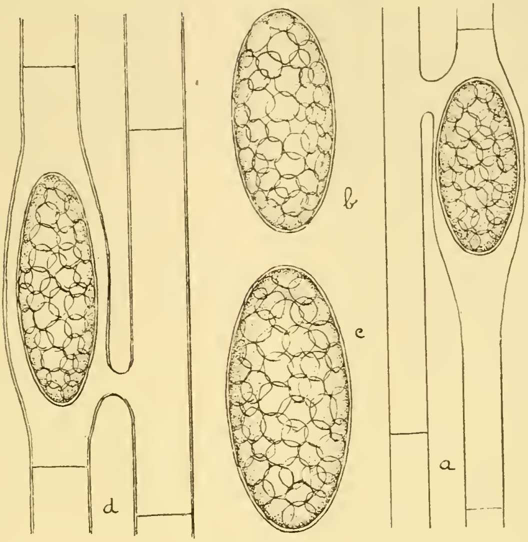
Biol. Richm. River, p.28, Pl. iii., f.1. Noted also from the Nymboidia River (Grafton Water-supply), infertile. It seems, therefore, to be a plankton-form.

SPIROGYRA MIRABILIS (Hass.) Kütz. (Text-fig.4).

Diam. cell. veg. 15-23, alt. 230-245; cell. fruct. max. 25-42, alt. 180-190; zygosp. 21-34, alt. 44-93μ.

Lismore (308).

Cf. Petit, Spir. de Paris, p.14, Pl. iii., f.3, 4; Borge (in Pascher, Süsswasserfl. Deutschl.) *Zygnemales*, p.21, f.17. This seems to be the first record of the conjugation of *Sp. mirabilis*, as Borge, *l.c.*, 1913, says "*Kopulation nicht bekannt.*" The vegetative cells were very long, 10-16 times the diameter; there was one chloroplast making 3½-4 turns. With this species should be compared *Sp. Spreeiana* Rabh. The two are so very much alike, both in characteristics and dimensions, that, in spite of the replicate cell-ends of the latter, I am not convinced that they are distinct species. Moreover, Hirn, Finländischen Zygnemaceen, p.11, f.4, in *Sp. kuusamoënsis* (= a more slender form of *Sp. Spreeiana*) and in *Sp. Spreeiana* itself, *l.c.*, p.12, f.5, shows both simple and replicate septa in the same filament. So also Borge, in *Spirogyra* spp., Sibiriens Chloroph., p. 8, f. 2, 3 (= *Sp. Spreeiana* stouter form. For convenience of comparison, I append a Table of the dimensions of all these forms; in the characters of the cells, chloroplasts, and zygospores they are all one.



Text-fig. 4.

Spirogyra mirabilis (Hass.) Kütz ; (*a*) conjugated cells (× 330); (*b*, *c*) two sizes of zygospore, (*b* × 660, *c* × 500); (*d*) form with broader filaments and larger, more slender zygospore, (× 330),

	Diam.		Zygo.	
	cell. veg.	cell. fruct.	diam.	alt.
Sp. mirabilis ...	18-27	··—42	24-29 aplano.	1½-2 plo.
Ours	15-23	25-42	21-34	44-93 2-3 plo.
Sp. Spreeiana (Borge, *Zygnem.*)	18-24	30-42	30-36	2-3 plo.
Sp. kuusamoënsis...	13-17	25-40	23-33	45-75 2-3 plo.
Spirogyra spp., Borge	26-31	? 40-48	39-46	97-118 2½ plo.

Let *Sp. kuusamoënsis* be united with *Sp. Spreeiana*, and our specimens agree perfectly with them in all points, as well as with *Sp. mirabilis.*

SPIROGYRA NEGLECTA (Hass.) Kütz. (Pl. lviii., f.1 13).

A.—Cell. veg. diam. 46-57, alt. 53-360; cell. fruct. diam. ad dissep. 46-57, ad inflation. 65-68, alt. 42-125μ. Zygosporæ ut sequitur:—

a. Zygo. late ovales, long. 52-66, lat. 42-49μ. (Pl. lviii., f.3).
b. Zygo. longius ovales, long. 64-74, lat. 45-51μ. (Pl. lviii., f.4).
c. Zygo. ellipticæ, long. 78-91, lat. 46-51μ. (Pl. lviii., f.5).
d. Zygo. oblongæ, long. 75-80, lat. 45-51μ. (Pl. lviii., f.6).
Lismore (353).

Cf. Petit, *Spirog.* d. Paris, p.26, Pl. ix., f.1-5; Borge, *Zygnemales*, p.29, f.36. In the very short cells, there are generally 3 chloroplasts making 1 turn; in the long cells, 3-5 chloroplasts making 2-3 turns. Three forms of chloroplast also were noted intermixed; all, however, had the central ridge, which is said to be characteristic of the species:—

(1). As in Petit, *l.c.*, a narrow delicate band with minutely irregular edges, and very small, almost indistinguishable, pyrenoids. Only noted in uncopulated cells of fertile filaments. (Pl. lviii., f.7, 8).

(2). A very delicate band with finely fimbriated edges; also with very minute pyrenoids. (Pl. lviii., f.9, 10).

(3). A more robust band with edges irregularly scalloped, not fimbriated, and with large, distinct pyrenoids. (Pl. lviii., f.11-13).

Four distinct shapes of zygospore were noted in this one sample, and, in such profusion, as to be all present under the cover-glass at one time. Inflated sporangial cells, and uninflated, were noted in the same conjugated filament (Pl. lviii., f.1, 2).

B.—Cellulæ vegetativæ paullo crassiores; zygosporis paullo majoribus; chloroplastidibus tenuibus laciniatis.

Cell. veg. diam. 62-64, alt. 70-120; zygo. long. 94-100, lat. 52-56μ. Lismore (297).

A broader specimen than usual, with slightly larger zygospores. In gatherings of *Sp. neglecta* there may generally be noted a few filaments of *Sp. nitida*, easily distinguished by their greater breadth:—diam. cell. veg. 95-116, alt. 84-360; 3-5 chloroplasts making 2-3 turns, edges scalloped, a central ridge evident here and there, large pyrenoids 6-10 to the half turn. (Lismore, 352, 353, 358). It is not unlikely that they really form one species. *Sp. Fullebornii* Schm., Alg. aus Nyassasee, p.76, T. iii., f.2 (fil. diam. 40-42, zygo. 64-80 × 40μ) seems to me a somewhat narrower form of *Sp. neglecta.*

Var. AMYLACEA, n.var. (Pl. lviii., f.14-16).

Cellulæ vegetativæ chloroplastidibus amylo suffusis, in granula fractis; pyrenoidibus maximis, granulosis.

Cell. veg. diam. 46-54, alt. 60-260; zygo. long. 74-90, lat. 48-50μ. Lismore (271).

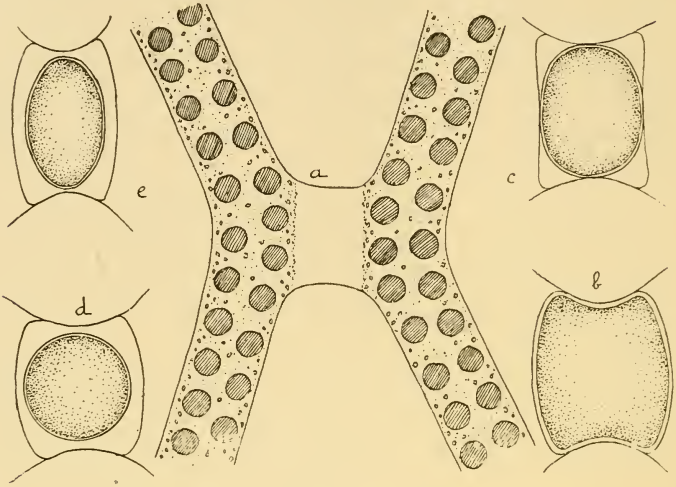
In this form, the chloroplasts have become impregnated with amylum, and have broken up into minute irregular grains. The central ridge, however, is generally still noticeable, and the pyrenoids are very large (up to 10-12μ), and granular as in *Closterium lunula.* The whole of this gathering was of the same character. The zygospores present were long-elliptic with pointed ends, lying diagonally in short oblong cells which were not inflated (as in Pl. lviii., f.1). Probably, however, all the various forms of zygospore detailed above for the type will be found also in this variation. Chloroplasts 2-3, making 1½ to 3½ turns in the cell.

Genus MOUGEOTIA (Ag.) Wittr.

MOUGEOTIA LÆTEVIRENS (A.Br.) Wittr. (Text-fig.5).

Cell. veg. diam. 27-44, alt. 255-408; zygo. long. 61-63, lat. 42-53μ. Botanic Gardens, Sydney (158); Lismore (328, 332).

Cf. Borge, *Zygnemales*, p.40, f.62. In our specimens, the chloroplasts generally have a large number of pyrenoids, either irregularly scattered or arranged in two lines at the edges. This is the only species of *Mougeotia*, as far as I know, in which this occurs. The pyrenoids are sometimes comparatively small (2-4μ) but occasionally very large, diam. 10μ. The contents of the cyst are generally retracted into an oval ($53 \times 32\mu$), oblong ($53 \times 42\mu$) or more rarely globular (diam. 42μ) zygospore.



Text-fig. 5.
Mougeotia lætevirens (A. Br.) Wittr.; (*a*) conjugating filaments with unusually large pyrenoids; (*b*, *c*, *d*, *e*) types of zygospores; (all × 330).

CHLOROPHYCEÆ.

Fam. VOLVOCACEÆ.

Genus CARTERIA Diesing.

CARTERIA RUGULOSA, n.sp. (Pl. lv., f. 1, 2).

Cellulæ reniformes, in fronte acuminatæ, a tergo concavæ, angulis posterioribus rotundatis. A vertice late ellipticæ. Membrana paullo rufescens, jugis granulatis convergentibus 12, longitudinaliter dispositis, ornata. Cytoplasma retracto globoso, stigmate juxta apicem.

Long. 17, lat. 23, crass, 17μ. Lismore (311, 312).

A most curious form, noted in some numbers. The cell-wall is much larger than the mass of cytoplasm, and is reniform or rather broadly obcordate in shape, with 12 coarse longitudinal ridges bearing a series of granules. The ridges converge to a point in front and behind. The cell-wall was rufescent, and the arrangement of the chloroplasts could not be discerned: a distinct stigma near the apex was noted, but no pyrenoid.

Var. ANGULATA, n.var. (Pl. lv., f.3).

Forma ad apicem depressa, in medio depressione papilla instructa; lateribus inferne paullo angulatis; ceteris ut in forma typica.

Long. 17, lat. 23μ. Lismore. Cum priori.

A cup-shaped depression with central papilla replaces the pointed apex of the type. The sides run back to a slight angle in the hinder portion.

Var. INÆQUALIS, n.var. (Pl. lv., f.4).

Forma major, ovata, in fronte acuminata, a tergo late-rotundata. Membrana luteo-fuscescens; ceteris ut in forma typica.

Long. 30, lat. 21-25$\frac{1}{2}\mu$. Lismore. Cum priori.

In all specimens of this form there was a minute projection at one side of the apex. Undoubtedly, I think, this variation is produced by uneven growth, only one lobe of the cell-wall developing; the small subapical projection is the remains of the undeveloped lobe.

CARTERIA MULTIFILIS (Fresen.) Dill. (Pl. lv., f.5, 6).

Cellulæ parvæ sphæricæ; membrana tenuissima vel interdum crassa; papilla nulla nec cytoplasmatis projectione; chloroplastide crasso parietali; pyrenoidi in media cellula.

Diam. cell. 8-11; pyrenoid. 3μ. Lismore (345).

Cf. Fresenius, Beitr. z. Kenntn. mikrosk. Organism., Abh. d. Senckenb. Gesells., 1856, p.235. Goroshankin, Morph. u. System. d. Chlamyd., ii., 1891, p.120, reproduces Fresenius' original description of the type, the chief points of which are:—cell spherical or oval, length 10-16μ, pyrenoid in the centre of the cell, cytoplasm minutely granular, stigma between the apex and the middle, membrane very delicate, close-fitting.

I have not seen Fresenius' figure of the type, but our specimens seem to me in some respects to tally with his description better than other published figures, and specially in this, that they have a massive parietal chloroplast with a central globular locellus in which the pyrenoid (when present) is situated.* Excellent figures are given by Goroshankin, *l.c.*, Pl. ii., f.14, and by G. S. West, Br. Frw. Alg., p.188, f.73A, B, but in each case the pyrenoid is eccentric. Fresenius says "*In der Mitte ein scharf umschriebener Kern.*" Ours, on the other hand, are smaller, (Rabenhorst, however, reports specimens of 6-8μ diam.) quite spherical and without any apical protuberance. The cell-wall, generally very thin, is sometimes stratified. This species, considered the most common in Europe, is very rare here, in my experience. I obtained it (the only time) from two local ponds in October, 1917, after the spring rains, in some quantity. Though I had assiduously worked these pools for five years previously, I had never seen a sign of it before, nor have I noted it since from either.

CARTERIA BULLULINA, nom.nov.

Syn., *Carteria multifilis*, forma, Australian Frw. Phytoplankt., these Proceedings, 1917, p.824, Pl. lvi., f.1-4. The expression "closely fitting membrane" (*dicht anliegenden Haut*) in Fresenius' description of *C. multifilis* rules out this form from any connection with the latter. My description, *l.c.*, applies to the cell-membrane ; the mass of cytoplasm is much smaller and attached at the apex (fig.1). The details of the chloroplast, I have not yet noted.

CARTERIA GRANULOSA, n.sp. (Pl. lv., f.7, 8).

Cellula compressa, fronte visa pæne circulata, superne fissura obliqua instructa; a latere valde compressa, superne in cornua duo divisa, cornibus evolutis. Membrana rufescens, granulosa. Cytoplasma retractum, ad cellulæ apicem affixum, a latere compressum. Pyrenoidis nulla nec stigma (in speciminibus notatis).

Long. 31½, lat. 29½, crass. 10μ. Lismore.

A compressed form, with granulate cell-wall. Above, the cell-wall is divided into two rounded overlapping heads by a deep

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* When the pyrenoid, as in this case and many others that I have noticed, is central, it would seem to enclose the nucleus.

oblique cleft. In sideview, both cell-wall and green cell are seen to be compressed, the cell-wall cleft above and the two heads turned outwards. No pyrenoid in the specimens observed. Nucleus and stigma not visible, the membrane strongly rufescent.

Genus CHLAMYDOMONAS Ehr.

CHLAMYDOMONAS RENIFORMIS, n.sp. (Pl. lv., f. 9, 10).

Cellula compressa; fronte visa reniformis ubique rotundata, pone indentata. A latere compressa, ovalis vel ovata. Membrana tenuissima glabra, cytoplasmati arcte adhærens. Pyrenoidis nulla nec stigma (in specimine notato).

Diam. 10½, alt. 8½μ. Lismore (312).

A very curious form, of which I saw but one specimen. It very much resembles *Carteria rugulosa*, and might possibly be a young form of that species. The flagella (2) were very distinct and unusually thick. On the other hand, the cell-wall is closely adherent to the cytoplasm, perfectly smooth and hyaline.

CHLAMYDOMONAS LISMORENSIS v. GRACILIS, n.var. (Pl. lv., f. 11).

Cellula anguste cylindracea, pone rotundata, fronte conica, lateribus parallelis. Chloroplastis parietalis; pyrenoide nulla visa; stigmate distincto inter apicem et medium posito; granulis paucis juxta apicem.

Long. 9½, lat 2½μ. Lismore (345).

The type (these Proceedings, 1917, p.827, Pl. lvi., f.18) is oblong-cylindrical with rounded ends, and proportionately broader. This form is narrower, and conical in front. Chloroplast bright green, homogeneous, parietal; no pyrenoid seen; stigma wick-shaped, very distinct, halfway between the apex and the middle.

CHLAMYDOMONAS ROTULA, n.sp. (Pl. lv., f. 12).

Cellula oblonga (vel globosa?) ubique rotundata; in media cellula pyrenoide magna; chloroplastide in discos tenues parietales multos diviso, discis singulis ad pyrenoidem tænia chlorophyllacea connectis; stigmate nullo viso.

Long. 19-21, lat. 15; pyrenoid. 6μ. Lismore (345).

Easily recognised by reason of the extraordinary disposition of the endochrome. The chloroplast is broken up into a number of very delicate parietal discs, each connected with the large central pyrenoid by a filament narrowing from without inwards. There are about seven discs visible round the margin in optical section. Cf. *Chl. stellata* Dill, Gatt. *Chlamyd.*, p.17, T. v., f.31-36; Wille, Alg. Notizen ix.-xiv., p.134, T. iv., f.4. The latter, however, has a massive chloroplast, and differs considerably in appearance. *Chl. rotula* also has a papilla or apical protuberance. A *Glœocystis*-stage was noted, eight cells in a mucous sphere; the cells were in every respect the same as the zoospore. I have given this species the name "*rotula*," as I have my suspicions that *Oocystis rotula* Playf., is a young *Glœocystis*-stage of it.

CHLAMYDOMONAS ALPINA (Wille) mihi. (Pl. lv., f.13).

Chloromonas alpina Wille, Alg. Notizen ix.-xiv., p.152, T. iii., f.24-34.

Cell. long. 10½, lat. 7μ. Lismore.

Noted *both with and without a pyrenoid*, the latter situated close to the posterior end of the cell. The chloroplast-discs are about 2-3μ in diameter. Two c.v. observed, and an oval orange-coloured stigma in the middle of the cell (near the apex in the type). In the specimen measured, the flagella were very long, quite twice the length of the cell, but I did not notice if they were so in every instance. Noted in winter, among fungoid growth on a rotten stick in swamp-water.

CHLAMYDOMONAS CAUDATA Wille. (Pl. lv., f.14).

Algologische Notizen ix.-xiv., p.135, T. iii., f.4-11. The only tailed species of *Chlamydomonas*; it is impossible to make any mistake in the identification. Yet there was *not a trace of a pyrenoid*, though the body was very transparent, and the nucleus distinctly visible. Stigma wanting.

Cell. long. 30, lat. 18; corp. long. 20, lat. 12μ. Lismore (344).

CHLAMYDOMONAS MACULATA, n.sp. (Pl. lv., f.15-17).

Cellulæ sphæricæ, papilla nulla nec projectione apicali; membrana crassa interdum lamellosa; vacuolis contractilibus 2; stigmate distincto, hemisphærico, luteo-fusco, paullo supra medium posito; nucleo in media cellula. Chloroplastide valida parietali, maculata (superficie externa scrobiculata); pyrenoide plerumque nulla (in speciminibus notatis).

Diam. 15-25; membr. 2-4; cell. matric. 40, autosp. 11-13μ.

Lismore (345, 350).

Compare *Chl. subcaudata* Wille, Alg. Notizen ix.-xiv., p.118, T. iii., f.12-18; W. & G. S. West, Frw. Alg. Brit. Antarct. Exp., p.274, Pl. xxiv., f.25-29. Generally spherical without apical projection; membrane thick, sometimes lamellar in two layers. It is distinguished from *Chl. globulosa* Perty, by the massive parietal chloroplast evenly distributed round the cell-wall except, of course, at the apex, and particularly by the fact that the outer surface of the chloroplast is pitted, giving it a spotted appearance all over. The central locellus is globular. Nucleus central; stigma orange-coloured, a little above the middle; pyrenoid generally wanting. A mother-cell, however, was noted, containing four autospores, of which one had a distinct pyrenoid; in two others, it was faintly indicated, and, in the fourth, it was entirely absent.

Var. OBLONGA, n.var. (Pl lv., f.18).

Cellulæ oblongæ; ceteris ut in forma typica.

Long 16, lat. 13½μ. Lismore (350).

Var. PLANKTONICA, n.var. (Pl. lv., f.19).

Cellulæ oblongæ, interdum apicem versus modice angustatæ; humili projectione apicali instructæ, membrana tenuissima arcte adhærente; stigmate nullo nec pyrenoidi (in speciminibus notatis); ceteris ut in forma typica.

Long. 20-26, lat. 13-17μ. Lismore (347).

This form has the same parietal chloroplast with scrobiculæ on the outer surface, but the membrane is very thin; there is a slight apical protuberance, and, in specimens observed, the stigma and pyrenoid were absent.

CHLAMYDOMONAS METASTIGMA Stein. (Pl. lv., f.20).

Forma stigmate luteo-fusco, bacillari, subapicali.

Long. 26, lat. 13μ. Lismore (327).

Cf. Stein, Naturg. d. Flagell., i., T. xv., f.46 : Goroshankin, Morph. u. System. d. *Chlamyd.*, ii., p.131, Pl. iii., f.26: Wille, Alg. Notizen ix.-xiv., p.146, T. iv., f.22. Goroshankin's figure (reproduced by Wille) differs from the type in being a short oval; whereas Stein's figure is a long oval, subcylindrical. Our specimens agree with the type in outline and in proportions (Stein's figure works out at 20 × 11μ), but differs in the position of the stigma, which is near the end in the type, but subapical in ours. Goroshankin makes it hemispherical, here it was wick-shaped. The upper pyrenoid was laterally disposed, and perhaps was geminate, or becoming so; Goroshankin notes the occurrence of two pyrenoids in front.

CHLAMYDOMONAS PAUPERCULA, n.sp. (Pl. lv., f.21, 22).

Cellulæ longo-ovatæ, subellipticæ, in medio latissimæ, pone paullo angustatæ, fronte conicæ; apice obtuso paullo producto: membrana tenuissima inconspicua arcte adhærente; chloroplastide crassa parietali, granulis sparsis superficie exteriore vel interiore dispositis; stigmate nullo nec pyrenoidi (in speciminibus notatis).

Long. 14-17, lat. 6-8μ. Lismore.

In shape and size, very like *Chl. alboviridis* Stein, Naturg. d. Flagell., i., T. xiv., Abt. vi., f.1, 2, 21; (figures 1, 2 work out at 26 × 13μ, fig.21 at 17 × 8μ). The cell is elliptic, conical in front, the apex obtuse and slightly produced; membrane very thin. The chloroplast is massive and parietal, with scattered granules sometimes on the outer surface, sometimes on the inner. Though viewed with the $\frac{1}{12}$ obj., the nucleus was not discernible; pyrenoid and stigma absent.

CHLAMYDOMONAS PUSILLA, n.sp. (Pl. lv., f.23).

Cellulæ ovatæ, ubique rotundatæ; apice obtuso haud producto; membrana tenuissima, inconspicua, arcte adhærente; chloroplastide crassa, parietali; intus granulata; nucleo in media cellula; stigmate mediano; pyrenoidi nullo viso.

Long. 30, lat. 20μ. Lismore (350).

Cell broadly ovate, rounded off everywhere, obtuse in front and without projection. Chloroplast massive, parietal, granulate on the inner surface, no pyrenoid in the specimens observed, stigma median. The nearest form seems to be *Chl. media* Klebs, Beding. d. Fortpflanz., p.425, f.12, (Wille, Alg. Notizen ix.-xiv., p.140, T. iv., f.11) which, however, is more pointed in front, and has a subapical stigma and a pyrenoid at the side in the middle.

CHLAMYDOMONAS ANGULOSA V. OBESA, n.var. (Pl. lv., f.24).

Cellulæ præ latitudine breviores, crassæ, subglobosæ; de singulis rebus ut in forma typica.

Long. 16, lat. 14μ. Lismore (350).

Cf. Dill, Gatt. Chlamyd., p.15, T. v., f.21-25; Wille, *l.c.*, p.141, T. iv., f.13. Our form agrees in all details with Dill's type, but in shape it is subglobose, almost subquadrate, instead of oval. Dill's figure works out at 20 × 14μ.

CHLAMYDOMONAS PISIFORMIS V. OCELLATA, n.var. (Pl. lv., f.25).

Cellulæ ambitu formæ typicæ consimiles; chloroplastide autem parietali; in media cellula locello magno pyrenoidem continente: stigmate nullo viso.

Long. 17, lat. $8\frac{1}{2}$; cell. matric. long. 25, lat. 19μ.

Lismore (350).

Cf. Dill, *l.c.*, p.14, T. 5, f.13-19; Wille, *l.c.*, p.138, T. iv., f. 8. Only noted as autospores, 2, 4, 8 to the mother-cell. In shape, they agree exactly with the type, even to the slight curve to one side, and the apical projection, broad from the front and wick-like from the side. The chloroplast, however, is parietal, and the centre of the cell occupied by a large locellus containing a pyrenoid (diam. 5μ). No stigma, and the nucleus not discernible.

Genus CHLOROGONIUM Ehr.

CHLOROGONIUM MINIMUM, n.sp. (Pl. lv., f.26).

Cellulæ minutæ, gracillimæ, fusiformes, pone acutissimæ, fronte rostratæ; membrana tenuissima, arcte adhærente; chloroplastide tenuissima, homogenea, parietali; in media cellula locello hyalino (? nucleum contingente); flagellis 2, ex apice oblique orientibus; stigmate distincto, bacilliformi, subapicali; pyrenoide nulla.

Long. 30, lat. 2-3μ. Auburn; Lismore (350).

A minute and very slender species, rostrate in front and very acute behind; membrane very delicate. Chloroplast also very delicate, homogeneous, parietal, without pyrenoids. A hyaline space, probably containing the nucleus, in the centre of the cell. Stigma very distinct, wick-shaped, some distance down from the apex. Contractile vacuoles not noted. Flagella 2, going off at right angles close to the tip.

Genus PTEROMONAS Seligo.

PTEROMONAS ANGULOSA V. AUSTRALIS Playf.

Syn., *Pt. alata* v. *australis* Playf., Frw. Alg. Lismore, p.335, Pl.42, f.14. *Pt. alata* Seligo, is a synonym, it appears, of *Pt. angulosa* (Carter) Dang., (*Cryptoglena angulosa* Carter, Ann. Nat. Hist., 1859, T.1, f.18*a-c*). The side-view (Pl. lv., f.28) is characteristic of the type and all its forms, *cf.* Chodat, Alg. vertes, p.144, fig.68 E.

Forma. (Pl. lv., f.27, 28).

Membrana a tergo incisa. Long. 22½, lat. 15μ. Lismore(312).

Var. SCUTIFORMIS, n.var. (Pl. lv., f.29).

Cellulæ membrana oblonga, fronte paullo angustata; lateribus inferne rectis, levissime convergentibus, apicem versus incurvis; apice levissime concavo; angulis posterioribus rectis; basi in medio inflata.

Long. 16, lat. 11; corp. lat. 8μ. Lismore (344).

The enveloping membrane is oblong, with straight sides converging slightly, and drawn together in front, the apex a little concave. Lower angles square, and at the base convex. In all these forms observed here, the chloroplasts, though very pale and thin, showed the characteristic cup-shape. No stigma, however, was present, nor pyrenoid.

Var. VEXILLIFORMIS, n.var. (Pl. lv., f.30).

Cellulæ membrana fere quadrata; lateribus rectis, parallelis: apice plano; angulis superioribus oblique truncatis; basi convexa;

angulis inferioribus obtusis. Pyrenoides parvæ 2, paullo supra cellulam mediam ad latera dispositæ.

Long. 20, lat. 16, crass. 8; corp. lat. 11μ. Lismore (344).

The envelope is quadrate with convex base, straight parallel sides, flat apex, and the upper angles obliquely truncate. A specimen was noted with two small pyrenoids, on either side one, a little above the centre of the cell. No stigma present. For another example of a pyrenoid on each side, see *Chl. longistigma* Dill, (Wille, *l.c.*, T. iv., f.21).

Genus PHACOTUS Perty.

PHACOTUS CRASSUS, n.sp. (Pl. lvi., f.7, 8).

Cellulæ fronte visæ fere circulatæ, margine aspera, ad apicem papilla instructæ; a latere paullulo compressæ, oblongæ, lateribus arcuatis, apicibus late-rotundatis, papilla instructis. Membrana crassa, aspera. Cytoplasma in globo retractum, densum, crasse granulosum; vacuolis contractilibus 2; stigmate nullo nec pyrenoidi.

Long. 22, lat. 19, crass. 14μ. Lismore (311).

Nearly circular in face-view, with apical papilla; oblong somewhat compressed from the side, with broadly rounded ends and arched sides. The membrane is thick, and rough with irregular asperities. The cytoplasm is retracted into a globe beneath the apex, contents dense, coarsely granular, two contractile vacuoles noted but no stigma or pyrenoid.

PHACOTUS GLABER, n.sp. (Pl. lvi., f.9, 10).

Cellulæ fronte visæ fere circulatæ, ad apicem concavæ, papilla instructæ; a latere modice ovato-oblongæ, ad apicem truncatæ, a tergo fere hemisphæricæ, lateribus levissime arcuatis. Membrana crassa, glabra, dilute rufescens. Cytoplasma in globulo parvo ad apicem retractum; stigmate nullo nec pyrenoidi.

Long. 22, lat. 21; cytopl. glob. diam. 9½μ. Lismore (312).

In face-view, nearly circular with a slight concavity, and a papilla at the apex; ovate-oblong from the side, sides slightly arched, apex truncate, hemispherical behind. Membrane smooth, thick, slightly coloured. Green cell remarkably small, retracted to the apex: no stigma, no pyrenoid.

Forma. (Pl. lvi., f.11).

Cellulæ fronte visæ haud circulatæ sed modice quadratæ, ubique rotundatæ; ad apicem quam levissime concavæ, papilla nulla; ceteris ut in forma typica.

Long. 21, lat. 19, crass. 14; corp. 13μ. Lismore (312).

Rather rounded-quadrate than circular in face-view, apex very slightly concave, no papilla; other details as in the type.

Forma. (Pl. lvi., f.12).

Cellulæ ad apicem paullo quadratæ, pone circulatæ; membrana crassa, saturate rufescente; cytoplasmate in massa ovata retracto; chloroplastide parietali intus granulis amylaceis magnis ornata; vacuolis contractilibus distinctis 2; stigmate mediano.

Long. 21, lat. 20; corp. long. 12, lat. 10μ. Lismore (345).

In shape, intermediate between the two forms (*supra*), being broad and "shouldered" above, and circular below. Membrane deeply rufescent; cytoplasm retracted into a small ovate mass; chloroplast parietal, granulate on the inner surface with large granules; stigma distinct, median; two contractile vacuoles distinctly visible. These details are very rarely observable in *Phacotus*.

PHACOTUS AUSTRALIS, n.sp. (Pl. lvi., f.13, 14).

Cellulæ fronte visæ fere circulatæ, ad apicem concavæ, papilla instructæ; a latere valde compressæ, ellipticæ, apicibus acute-rotundatis. Membrana tenuis, glabra, dilutissime rufescens. Cytoplasma in massa apicali retractum, a latere visum compressum, ovatum; stigmate nullo nec pyrenoidi.

Long. 20, lat. 21, crass. c. 8μ. Lismore (350).

Almost circular in face-view with a slight apical concavity and papilla: from the side very compressed, elliptic with acutely rounded ends. Membrane thin, smooth, pale biscuit-colour, with a matt surface. Cytoplasm retracted, compressed, ovate, in side-view: no stigma nor pyrenoid.

Genus SPONDYLOMORUM Ehr.

SPONDYLOMORUM QUATERNARIUM Ehr.

Ehrenberg, Beob. zweier generisch. neuer Formen d. Frühlingsgewassers bei Berlin, Monatsber. d. Berl. Acad. d. Wissensch., 1848. *Cf.* Stein, *l.c.*, T. xviii., f.30-34. Syn., *Burkillia cornuta* W. & G. S. West, Frw. Alg. Burma, p.228, Pl. xii., f.19-21: *Uva Casinoënsis* Playf., Biol. Richm. R., p.108, Pl. ii., f.13.

This flagellate seems to be very little known: it is not mentioned either by Chodat in Alg. vertes de la Suisse, 1902; nor by G. S. West in Br. Frw. Algæ, 1904. Lemmermann reports it from a single locality in Sweden, but it is not included in Bachmann's Das Phytoplankton des Süsswassers, 1911. In my former paper, I had not the assistance of Stein's excellent illustrations; also the figure and description of this organism published in the Micrographic Dictionary, p.721, Pl.3, f.23, are entirely incorrect and misleading. The figure here given agrees almost exactly with that by Stein, *l.c.*, f.30, save that the stigma is above, not below, the centre.

The cœnobia are generally oblong, consisting of rings of four cells, arranged one above another. They easily break up either longitudinally or transversely; in the latter case, the resulting cœnobia are often hemispherical or rosette-shaped. The cells, originally globose, very soon become broadly oval or ovate; the membrane is very delicate, and, by reason of their very rapid movement through the water, it is generally drawn out at the back into a short pointed sac, at first very indistinctly outlined. Later, however, it becomes stouter and more evident. The chloroplast is cup-shaped, generally without a pyrenoid; there is a central nucleus, two apical contractile vacuoles, and a stigma, median or a little above or below the midline. The internal details, however, are not easily seen, as the cytoplasm is generally very dense. In a zooid which became detached from a cœnobium, I was able to see distinctly that there are two unusually long apical flagella. Noted from at least four different spots round Lismore.

Cœnob. long. 28-40, lat. 22-27; cell. long. 10-20, lat. 6-12μ.

Merrylands (Sydney); Casino (189): Lismore (237, 246, 307, 344).

Var. ROSTRATUM, n.var. (Pl. lvi., f.16, 17).

Cellulæ plerumque 4-8 in fascina conjunctæ, fronte globosæ, pone in rostrum acutum levissime curvatum productæ. Cum forma typica atque ejusdem dimensionis.

Cœnobia generally small, with a few cells in a bunch or rosette; cells globose in front, and behind drawn out into a sharp-pointed slightly curved beak; cytoplasm and chloroplast filling the whole cell, only the tip hyaline. Generally no pyrenoid or stigma.

Genus VOLVULINA Playf.

VOLVULINA STEINII Playf. (Pl. lvi., f.18).

Cœnob. diam. 70, cell. diam. 15, alt. 12μ. Lismore (350).

In a cœnobium of the type with very transparent pale green cells, a minute central nucleus could be observed. The flagella originated close together, and, *at their base*, two contractile vacuoles, as in Stein, *l.c.* In some cells, a large orange-coloured stigma on the margin in front. The investing membrane of the cœnobium, as usual, very delicate, and the cells, which were nearly spherical, were pressed close against it.

Genus VOLVOX Linn.

VOLVOX AUREUS var. HEMISPHÆRICUS, n.var. (Pl. lvi., f.19, 20).

Cœnobium muco investiente tenui; cellulis vertice visis circulatis, diametro inter se distantibus; a latere plus minusve hemisphæricis, basi plana. Cytoplasma granulis magnis amylaceis singulis instructum, stigmate ad marginem: vacuolis contractilibus 3 circa marginem; pyrenoidi nulla.

Cell. diam. 8-8½μ. Lismore (311, 328).

The investing mucus of the cœnobium very thin, cells quite close to the edge. From above, the latter are circular, about one diameter apart, with a large amylaceous granule towards the centre, stigma at the margin, and three contractile vacuoles at intervals round the circumference. In side-view, the cells are more or less hemispherical, with a flat face closely adpressed to the investing mucus. The connecting filament arises at the angle. In the shape of the cells, this form recalls *Volvulina Steinii*, which also has, sometimes, a series of c.v. round the circumference.

VOLVOX CARTERI Stein. (Pl. lvi., f.21, 22).

Cœnob. diam. ad 900; cell. diam. 4-5, inter se distant. 7-10; zygo. immat. diam. 44-46, matur. ad 60μ.

Lismore (311, 327, 328).

Cf. Carter, Ann. Mag. Nat. Hist., Ser. 2, Vol. iii. I have not access, unfortunately, either to Carter's paper or to that of Stein (the species is not mentioned in his Naturg. d. Flagell.); but Lemmermann, Das Plankton schwedischer Gewässer, p.105, in one of his very useful little reviews of various genera, gives the name, with the remark that the zygotes "are said to possess an undulate membrane." By this character, I was able to recognise the species. The cœnobium is like that of *V. tertius* Meyer, with globular cells which, even under the $\frac{1}{12}$ obj., show no signs of connecting filaments. It is the immature zygote which has an undulate membrane (cell. diam. 31-33, lat. max. 44-46μ); when mature, the undulations have been produced into stout, slightly curved spines (cell. diam. 36-37, lat. max. 53-60μ). Several dozen zygotes in the cœnobium. I have the species from two places at Lismore; it would appear to be the first time that this *Volvox* has been recorded since Carter discovered it in India, fifty years, or so, ago.

Fam. PLEUROCOCCACEÆ.

Genus ELAKATOTHRIX Wille.

ELAKATOTHRIX GELATINOSA Wille. (Pl. lvii., f.1, 2).

Cell. long. 15, lat. 3μ. Sydney Water-supply (100).

Cf. Wille, Conj. u. Chloroph., p.38, fig.18A-E; W. & G. S. West, Phytoplankton Eng. Lake Distr. (Naturalist, 1909), p.291, f.6. A cœnobium of four lately-divided cells (8 × 2μ), and a single full-grown cell (15 × 3μ) noted in the filtrates of the Sydney Water-supply. This organism bears a suspicious resemblance to *Spirotænia acuta* Hilse (*see* W. & G. S. West, Brit. Desm., i., Pl.

iii., f.14, 15). Known hitherto only from Norwegian and English lakes.

Genus DACTYLOTHECE Lagerh.

DACTYLOTHECE ARCUATUM, n.sp. (Pl. lvii., f.3, 4).

Cellulæ sparsæ in muco amorpho involutæ; fronte visæ lineari-ellipticæ, quam levissime arcuatæ, apicibus obtusis; a latere rectæ, lineari-ellipticæ, lateribus quam levissime convexis, apicibus obtusis; membrana tenui; chloroplastide tenuissima, parietali, minute granulosa, interdum in medio divisa; pyrenoidibus nullis.

Cell. long. 14 15, lat. 3-4μ. Lismore (302).

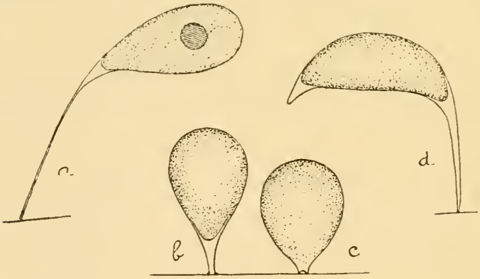
About 30 cells in a clump, irregularly disposed, enveloped in mucus. Cells linear-elliptic, straight in side-view but from the front arcuate, one side slightly concave, almost flat, the other distinctly convex, ends obtuse. Membrane thin; chloroplast delicate, parietal, pale green, minutely granular, sometimes divided in the middle, no pyrenoids.

Fam. PROTOCOCCACEÆ.

Genus CHARACIUM A.Br.

CHARACIUM GUTTULA, n.sp. (Text-fig.6*a*).

Cellulæ corpore ovato levissime curvato, supra rotundato, subter rostrato in petiolum longum tenuissimum protracto; membrana tenui; chloroplastide interdum pyrenoidibus singulis continente.



Text-fig.6.
(*a*) *Characium guttula*, n.sp.; (*b*, *c*) *Ch. cerassiforme* var. *minimum*, n.var.; (*d*) *Ch. ornithocephalum* A.Br.; (all × 1000).

Cell. long. max. 25-40; corp. long. 12-16, lat. 6-8μ.

Lismore (284, 286).

Cells drop-shaped, rounded above, pointed below, and drawn out into a slightly curved hyaline beak, which merges into a long thin hyaline stalk as in *Ch. longipes*. Membrane thin, chloroplasts sometimes containing a pyrenoid. Noted from two spots at Lismore, singly, or several in a clump, on filamentous algæ.

CHARACIUM CERASSIFORME v. MINIMUM, n.var.

Cellulæ minutæ, supra rotundatæ nec deplanatæ; petiolo parvo aut nullo; magnitudine formæ typicæ triens.

Long. 14-18, lat. 10μ. Lismore.

Cf. *Ch. cerassiforme* Eich. & Racib., Nowe gat. zielenic, p.1, T. iii., f.12; also *Ch. pyriforme* A. Braun, Alg. unicell., p.40, T. v.B. About one-third the size of the type, and not flattened above. *Ch. cerassiforme* is more globose in the body of the cell than *Ch. pyriforme*. On *Tribonema*; (Text-fig.6*b*, *c*).

CHARACIUM ORNITHOCEPHALUM A.Br. (Text fig.6*d*).

Long. corp. 23, lat. 7½; petiol. long. 14μ. Lismore.

Fam. HYDROGASTRACEÆ.

Genus URNELLA, gen.nov.

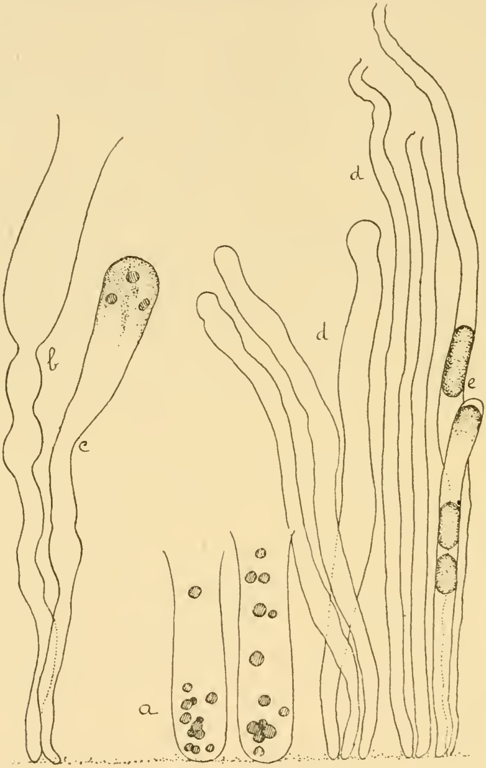
Character idem ac speciei.

URNELLA TERRESTRIS, sp.unica. (Text-fig.7*a-c*).

Cellulæ primum clavatæ, deinde dehiscione anguste-urniformes; lateribus subparallelis; ore everso; basi rotundata; aut humo sedentes aut tubulo inæquali longo erectæ. Membrana tenuis, hyalina. Chloroplastis parietalis in extrema cellula contracta: pyrenoidibus plurimis.

Corp. urniform. long. 60-90, lat. 12-20; tubul. long. ad 150, lat. 7-8μ. Auburn.

Noted in a green growth on a garden-path (clay) in very wet weather. The important part of the plant seems to be the long clavate cell which, at dehiscence, becomes a slender urn-shape, rounded below, with sides almost parallel, and the rim everted. This cell is sometimes seated on the ground, sometimes erected at the end of a fairly long irregular tubule of which it really forms the inflated head. Membrane thin and hyaline, the chloroplasts deep green, parietal, collected at the end of the cell, and containing several pyrenoids. Reproduction apparently by zoogonidia. The plant bears a general resemblance to *Protosiphon* Klebs, but it does not form a series of *gemmæ*, nor does the apical cell multiply by division, but seems to be entirely a gonidangium There is also a great likeness to *Codiolum gregarium* A.Br., but the latter has a thick cell-wall and a laminated *stipes*—"*stipitem elongatum hyalinum solidum* (*gelatina indurata farctum*)"—A. Braun, Alg. unicell., p.20, T. i.



Text-fig. 7.
(*a*) *Urnella terrestris*, gen.nov. et sp., (×500); (*b*, *c*) tubular form (×330); (*d*) var. *abnormis*, n.var., (×500); (*e*) akinetes ?, (×500).

Var. ABNORMIS, n.var. (Text-fig.7*d*).

Cellula tota tubiformis, longe protracta nec corpore urniformi in extremo instructa.

Cell. long. c. 150-200, lat. 7-10μ. Auburn.

In this form, found with the type, the cell, probably by excess of rain, is drawn out into a simple irregular tube, dehiscing at the end. There are none of the inflations in the tube which evidence previous attempts at forming the gonidangium. Reproduction probably by zoogonidia, and perhaps also by akinetes; (Text-fig.7*e*).

Fam. OOCYSTACEÆ.

Genus EREMOSPHÆRA De By.

EREMOSPHÆRA VIRIDIS V. TETRAEDRICA, n.var. (Pl. lvii., f.5).

Forma tetraëdrica, lateribus valde arcuatis, nodibus 4 levissime angulatis.

Cell. diam. 110μ. Lismore (308).

A curious form, in which the cell looks as if it were an inflated tetraëdron. The sides are well arched, and the angles only slightly marked.

The hypnospore of *E. viridis*, which was described and figured by me in *Oocystis* and *Eremosphæra*, p.116, f.6, I have lately noted again in a fresh gathering (316) from Lismore. Outer cell diam. 120, hypnospore 97μ. The scrobiculations are closer even than figured, being only about their diameter apart, and the scrobiculate membrane is backed, apparently, by the thick mucilaginous lining often found in *Eremosphæra*. The contents were green, but the chlorophyll seemed to be diffused in an even parietal layer, no distinct chloroplasts being visible.

Genus OOCYSTIS Näg.

OOCYSTIS ROTULA Playf. (Pl. lvii., f.6, 7).

Cœnob. diam. 50, autosp. diam. 12μ. Lismore.

Cf. Chodat, Entwickl. d. Erem. virid., f. 13, 21; Playfair, *Oocystis* and *Eremosph.*, p.130, Pl. vii., f.31. Cœnobium spherical, thin-walled, containing 8 spherical autospores. The latter are thick-walled, each with a central pyrenoid and cuneate chloroplasts radiating out from it, six visible in optical section. It is very difficult to see how they show at the surface, probably as delicate discs. I had hardly finished congratulating myself on this find, when a *Chlamydomonas* with similar cell-contents turned up (from a different pool, however) and cast great suspicion on its validity as an *Oocystis*; (see *Chl. rotula*).

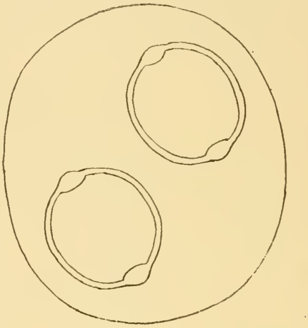
OOCYSTIS NODULOSA V. CRASSA, n.var. (Text-fig.8).

Forma præ longitudine crassior, subglobosa; membrana crassa; apicibus et interiore incrassatis et exteriore tuberculatis ut in forma typica.

Cell. long. 35, lat. $28\frac{1}{2}$-$29\frac{1}{2}$; cell. matric. 84-74μ.

Lismore (308).

Cf. W. West, New Brit. Frw. Alg. (J.R.M.S. 1894), Pl. ii., f. 31. Our specimens are larger than the type, and proportionately $\frac{1}{4}$ broader, which makes them, therefore, subglobose, not oval. W. West gives long. 25-26, lat. 16-17μ as the dimensions.



Text-fig.8.
Oocystis nodulosa var. *crassa* n.var., mother-cell with two autospores; (× 500).

OOCYSTIS LACUSTRIS V. NATANS (Lemm.) Playf. (Pl. lvii., f.8, 9).

Cœnob. long. 57, lat. 38; cell. long. 23, lat $12\frac{1}{2}\mu$.

Lismore (316).

Cf. *Oocystis* and *Eremosph.*, p.125, f.14*b*. Our specimens are the same diameter as the type, but a trifle longer; the chloroplast also is more reticulate. The shape of the mother-cell is characteristic of *O. lacustris*, as also the arrangement of the autospores, *l.c.*, Pl. vii., f.20.

Genus FRANCEIA Lemm.

FRANCEIA OBLONGA, n.sp. (Pl. lvii., f.10).

Cellulæ oblongæ nec ovales; membrana crassa; setis tenuissimis ubique vestitis.

Cell. long. 15, lat. 10; set. long. 15μ. Lismore (332).

Cf. *Franceia ovalis* (Francé) Lemm. in Wille, Conj. u. Chloroph., p.59, f.31, which works out at 25 × 15½μ. Our form, however, is distinctly oblong. The contents are deep green, showing signs of division into four parts.

Genus LAGERHEIMIA Chodat.

LAGERHEIMIA ELLIPTICA, n.sp. (Pl. lvii., f.11).

Cellulæ exacte ellipticæ, graciles, utroque polo setis longis subapicalibus binis instructæ. Cell. long. 12½, lat. 6; set. long. 20μ.

Sydney Water-supply (100).

The nearest form to this, I know of, is *L. genevensis* v. *gracilis* Playf., (*L. ciliata* v. *gracilis*) Plankt. Sydney Water-supply, Pl. liii., f.10-12. The latter, however, is narrowly cylindrical, while this form is a perfect, slender ellipse.

Genus BERNARDIA Playf.

BERNARDIA TETRAEDRICA, n.sp. (Pl. lvii., f.12).

Cellulæ sphæricæ, spinis longis cavis gracillimis 4, tetraëdrice ordinatis instructæ; spinis basi valde inflatis, apice obtusis.

Diam. c. spin. 30; corp. 5μ. Lismore (351).

This species consists of a single spherical cell with (apparently) the membrane drawn out into four long very slender hollow spines, arranged tetraëdrically. The spines are blunt at the extreme tip, not acutely pointed, and at the base are greatly inflated. Chloroplast delicate, pale green, parietal, confined to the central part of the cell. Cf. *Bernardia Chodati* (Bernard) Playf., Austral. Frw. Phytopl., Pl. lix., f.5, 6.

Genus KIRCHNERIELLA Schm.

KIRCHNERIELLA OBESA W. & G. S. West. (Pl. lvii., f 13-16).

Cell. lat. 6-10, alt. 6-8, crass. 3½-5μ. Clyde, Duck Creek (26).

Cf. W. & G. S. West, New Brit. Frw. Alg., p.16. Syn., *Selenastrum obesum* W. West, Alg. Eng. Lake Dist., p.22, Pl. x., f.50-52; *K. subsolitaria* G. S. West, Some Critical Green Algæ, p.285, Pl.20, f.20-30. Dimensions of the type, "diam. max. 6-9μ, crass. cell. 3-4·2μ"; of *K. subsolitaria*, "diam. max. 6-7μ, crass. cell. 2·9-3·2μ." I have found this form only once.

Genus TETRAEDRON Kütz.

TETRAEDRON GRANULOSUM, n.sp. (Pl. lvii., f.17, 18).

Cellulæ planæ, parvæ, triangulares; lateribus rectis in medio levissime convexis; angulis acutis haud inflatis; membrana grosse granulata, granulis in quincuncem ordinatis. A latere visæ, modice compressæ, elliptico-lanceolatæ, angulis acuminatis.

Cell. diam. 21, crass. 11μ. Lismore (302).

The specimens noted were flat, not tetrahedral, triangular with straight sides slightly convex in the centre; angles acute, not inflated; membrane coarsely granulate in quincunx. From the side, elliptic-lanceolate with pointed ends. In the centre of the cell might be discerned a minute nucleus enclosed in a pale brown globule (? pyrenoid). Sometimes the nucleus was entirely hidden by the globule, which then had the appearance of a large brown pyrenoid; cf. *Oocystis* and *Eremosphæra*, p.126, remarks on *O. lacustris* v. *paludensis*; and p.137 on *O. ovalis* v. *cylindracea*, where the same phenomenon occurs.

TETRAEDRON QUADRATUM f. MINOR Reinsch. (Pl. lvii., f.19).

Cellula plana; diam. sine spinis 17μ. Lismore.

Forma EXCAVATA, n.f. (Pl. lvii., f.20).

Forma plana, lateribus alternantibus concavis, alteris levissime convexis; angulis spinis brevibus acutis singulis armatis.

Cell. diam. 19, alt. 15μ, s.sp. Lismore. Cum priori.

Cf. Reinsch, Monog. *Polyedrium*, p.500, T. iv., fig.7*d*. This is a variant of f. *minor* with alternate sides concave, the other sides generally somewhat convex.

TETRAEDRON CAUDATUM v. AUSTRALE, n.var. (Pl. lvii., f.21, 22).

Cellulæ inæqualiter pentaëdricæ; angulis acutis, spinulis minutis singulis armatis; lateribus concavis; utrinque infra marginem angulis mammillatis armatis singulis instructæ. A latere, planæ (ichnographia universa respecta), lanceolato-ellipticæ, apicibus acutis armatis; altero latere convexæ, altero autem angulis mammillatis armatis binis projicientibus, instructæ.

Cell. lat. max. c. spinis 21μ. Lismore. Cum priori.

Cf. *Polyedrium pentagonum* Reinsch, Algenfl. v. Frank., T.iii., fig. ii.*c*(= *Tetr. caudatum* Corda) which is exactly the same shape but without the two mammillate angles which jut out from one side.

TETRAEDRON REGULARE V. OCTAEDRICUM (Rein.) mihi.

Cellulæ angulis senis octonisve præditæ. (Pl. lvii., f.23).

Cell. diam. 17μ. Lismore.

Cf. *Polyedrium octaëdricum* v. *spinosum* Reinsch, Algenfl. v. Frank., p.78, T. v., fig. v., 1867. In this place, Reinsch has united two distinct types under one name* (*P. octaëdricum* Rein., Monog. *Polyedr.*, p.507, 1888). The first of these. T. v., fig. iv., must retain the specific name, while the other, T. v., fig. v., is evidently a form of *Tetr. regulare* Kütz. (= *P. tetraëdricum* Näg.), with from six to eight angles instead of four. Our specimens are the same shape as Reinsch's fig. v.*b*, but very much smaller; he gives lat. 38-47μ.

TETRAEDRON HASTATUM V. ELEGANS Playf.

Cell. diam. c. proc. 30μ. Noted lately at Lismore (362), only known previously from Parramatta. *Cf.* Austral. Frw. Phytopl., p.845, Pl. lviii., f.27.

TETRAEDRON ACUTUM V. RECTILINEARE Playf.

Cell. diam. c. spin. 34-40μ, sp. long. 10μ. Confirmed from Lismore (362), only recorded previously from Enoggera; *ibidem*, p.845, Pl. lviii., f.26.

TETRAEDRON CONICUM, n.sp. (Pl. lvii., f.24).

Cellulæ tetraëdricæ; angulis conicis vix inflatis; apicibus muticis, obtuse-rotundatis; lateribus levissime concavis.

Cell. diam. 19-25μ. Lismore (362).

The cells are tetrahedral, composed of four conical angles meeting in the centre. The angles can hardly be called inflated, the sides of the cones being almost straight. The apices are bluntly rounded, without point or spine.

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* *Polyedrium acuminatum spinosum* at the bottom of Plate v., *l.c.*, is either a slip of the pen or a printer's error.

TETRAEDRON MINIMUM V. RECTILINEARE Playf. (Pl. lvii., f.25).

Cell. long. 11½, lat. 10½μ. Botanic Gardens, Sydney (3).

Cf. Australian Freshwater Phytoplankton, these Proceedings, 1917, p.842, Pl.58, f.16, 17. Known to me previously only from Guildford. A rare form.

TETRAEDRON OBTUSUM, n.sp. (Pl. lvii., f.26).

Cellulæ tetraëdricæ; lateribus rectis; angulis rostratis; rostris crassis quadratis, brevibus; apicibus truncatis.

Cell. diam. 21μ. Lismore (362).

Cell tetrahedral, sides straight, angles produced into a snub-nosed rostrum, the latter broad, quadrate, truncate.

TETRAEDRON TRIGONUM Näg., forma (Pl. lvii., f.27, 28).

Forma lateribus in medio quam levissime retusis; spinis brevissimis oblique recurvis; membrana crassa.

Cell. diam. 36, crass. 20μ. Lismore (345).

Syn., *Polyedrium tetragonum β punctatum* (Kirchn.) Lag., Bidrag till Sveriges Algflora, p.62, T. i., f.28. *P. trigonum* e *punctatum* Kirchn., Alg. v. Schles., p.104 (*sec.* Lagerheim, *l.c.*). The type has sides simply arched, with or without a small straight spine at the angles. In this form, the sides are slightly flattened or retuse in the middle, and the spines are obliquely recurved. Our specimen was not punctate. For the type, *cf.* Nägeli, Gatt. einz Alg., T. iv.B, figs. 1*a* and 3*a*, *b* only.

Fam. HYDRODICTYACEÆ.

Genus PEDIASTRUM Meyen.

PEDIASTRUM SIMPLEX Meyen. (Pl. lvii., f.29, 30).

Cœnob. (cell. 4) c. proc. long. 35-50, lat. 33-48; s. proc. long. 17-24, lat. 16-22; cell. long. 24-34, lat. 12-17μ. Cœnob. (cell. 8) diam. 50-64; cell. long. 18-24, lat. 8-12μ.

Parramatta Park (99, 136).

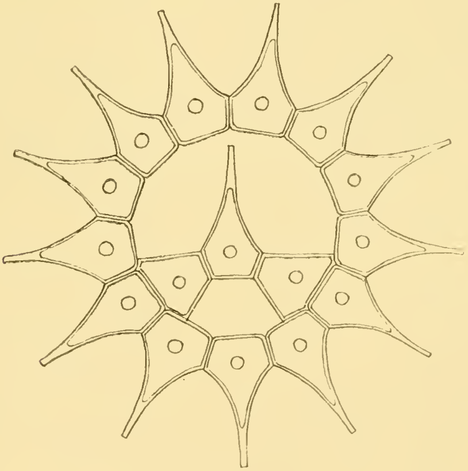
Meyen, Beob. üb einig. nied. Algenf., (1829) T. xliii., f.1. Syn., *P. simplex* var. *radians* Lemm., Zeitschrift f. Fischerei, 1897; *P. simplex β annulatum* Chodat, Alg. vertes, p.225, 1902; *P. simplex* v. *clathratum* f. *radians* (Lemm.) G. S. West, Third Tanganyika Exp., p.134, 1907.

Meyen gives five figures in illustration of his *P. simplex*, and these have since been arranged as three different variations. His fig.1 is var. *radians* Lemm.(1897); figs.2, 5 are f. *ovata* (Ehr.) Racib., (*Asterodiction ovatum* Ehr., 1845); while figs. 3, 4 are f. *clathrata* Schröter (1883). One of his figures, however, must be left to represent the type, and it falls to fig.1 to do this, var. *radians* Lemm., being the last in order of priority. It seems to have been overlooked also, that Meyen himself arranged it so in the text. He says (*l.c.*, p.4) "*die unter Fig.1 möchte als die Norm zu betrachten seyn.*" The 8-celled cœnobium without central cells is, therefore, the type of *P. simplex*, and, incidentally also, of the genus *Pediastrum*.

Forma CLATHRATA (Schröter) Rac. (Text-fig.9).

Cœnob. diam. 60-92; cell. periph. long. 26-28, lat. 12μ.

Parramatta Park (99, 136).



Text-fig.9.

Pediastrum simplex f. *clathrata* (Schröter) Rac.; (× 660).

Schröter, in Jahresbericht d. Schles. Ges. für vaterländ. Cultur, 1883, p.182; Raciborski, Gatunki rodz. *Pediastrum*, 1889, p.8. Syn., *P. enoplon* W. & G. S. West, Frw. Alg. Madag., 1895, p.81, T. 5, f.1, 2; *P. clathratum* (Schröt.) Lemm., Forsch. Biol.

Stat. Plön, vii., 1899, p.20. A name that would take priority of Schröter's is *P. duodenarium* (Bail.) Rabh., Fl. Eur. Alg., iii., p.71, 1864, but, from Raciborski's notes, it would appear to include several different forms, *l.c.*, pp.9, 10.

Forma OVATA (Ehr.) Rac. (Pl. lvii., f.31).

Cœnob. (cell. 4) diam. 53; cell. long. 25, lat. 16μ.

Parramatta Park (136).

Raciborski, Gatunki rodz. *Pediastrum*, 1889, p 8. Syn., *Asterodiction ovatum* Ehr., Ber. üb. d. Verh. d. Akad , 1845, p.71; *P. ovatum* (Ehr.) A.Br., Alg. unicell., 1855, p.81; *P. Sturmii* Reinsch, Algenfl. v. Frank., p.90, T. vii., f.1; *P. Schröteri* Lemm., Forsch. Biol. Stat. Plön, vii., 1899, p.20, T.2, f.33; *P. clathratum* f. *ovatum* (Ehr.) Schm., in Eng. Bot. Jahrb., xxxii., 1902, p.84 T.3, f.18.

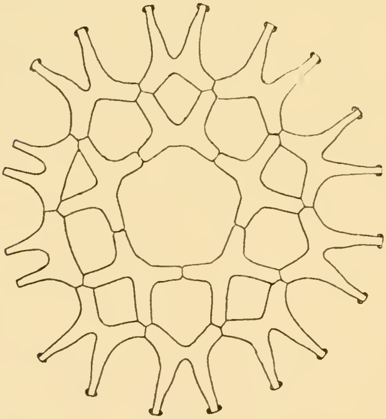
All forms of *P. simplex* are very rare here; I have them from one spot only.

PEDIASTRUM DUPLEX V. RETICULATUM Lag. (Text-fig.10).

Cœnob. (cell. 4) diam. 52; cell. long. 16, lat. 14μ. Cœnob. (cell. permult.) long. 90-130, lat. 90-120; cell. long. 26-30, lat. 15-23μ.

Sydney Water-supply (80, 81, 90, 100, 115); Botany (50).

Lagerheim, Stockholms Pedi., Protococc., o. Palm., p.56, T. ii., f. 1. Syn., *P. duplex* v. *clathratum* Schröter, Schwebefl. uns. Seen, p. 37, f.86. This form is common enough in the Sydney Water-supply, but rare elsewhere here. In the large cœnobium figured, the two dead cells on the left show that the early stage of the plant was more akin to *P. Boryanum*.



Text-fig. 10.
Pediastrum duplex var. *reticulatum* Lagerh.; (× 500).

PEDIASTRUM BORYANUM (Turp.) Menegh. (Pl. lvii., f.32).

Forma; cœnobium e cellulis 4 exstructum. Cœnob. diam. 40μ.

Botany (15).

Var. HAYNALDII (Istv.) mihi. (Pl. lvii., f.33).

Cœnobium long. 180, lat. 155; cell. diam. 32μ.

Botanic Gardens (3).

P. Haynaldii Istvanffi, Jel. Magyar. Alg., 1888, p. 252, T. ii., f. 38. Syn., *P. angulosum* v. *araneosum* Rac., Gatunki rodz. *Pediastrum*, 1889, p.18, T. ii., f.40. This form is characterised by the fine ridging on the cell-wall. There is no difference between Raciborski's form and that of Istvanffi, save that in the latter the lines on the cell are granulate.

Var. AUSTRALE, n.var. (Pl. lvii., f.34).

Cellulæ perimetri cornibus plerumque brevibus; incisuris altis, oblongis, intus rotundatis, lateribus parallelis.

Cœnob. long. 116-150, lat. 100-127; diam. cell. 12-20μ.

Botanic Gardens (3).

A form of *P. Boryanum* common and widespread here, but apparently not so elsewhere. It is characterised by the shape of the marginal incisions, which are in the form of the letter U, oblong with rounded ends and parallel sides. The horns are generally short. The margin between the horns of the two adjacent cells is very slightly concave.

PEDIASTRUM BIRADIATUM var. BRAUNII (Wartm.) Chod.

Cell. long. 24, lat. 12μ. Kyogle (219). (Pl. lvii., f.35).

Cf. Chodat, Alg. vertes, p.230. Syn., *P. Braunii* Wartmann, Schw. Crypt. No.32.* *P. rotula* Ehr., (*non* Nägeli) in A. Braun, Alg. unicell., T. vi., figs.2, 5, 6. The dimensions of the peripheral cells of Braun's fig.5 work out at long. 22, lat. 13μ. *P. biradiatum* Meyen, is extremely rare; I have never come across the type, and only one specimen of the variation. The lobules of the cells are bifid in this form, only incised in the type.

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* Not having seen Wartmann's type, I simply follow Chodat in the synonymy. Lagerheim, however, Veg. süssw. plankt. Bären-Insel, p.10, and Borge, Algenfl. v. Schweden, p.60, identify it with *P. tricornutum* Borge.

Pediastrum tetras var. Crux Michæli (Rein.) Playf.

Cell. diam. 18μ. Botany (109). (Pl. lvii., f.36).

Noted also in the Sydney Water-supply, these Proceedings, 1913, p.518, Pl.56, f.6. In the specimen here figured, the cells were closely appressed, and the slits were observable through which the zoogonidia had escaped.

Fam. CŒLASTRACEÆ.

Genus Tetrastrum Chodat.

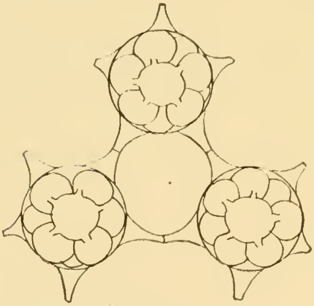
Tetrastrum elegans v. dentatum Playf.

Cœnob. c. spin. diam. 32; corp. 8; sp. long. 12; dent. long. 2-3μ. Lismore (258).

Cf. Austral. Frw. Phytopl., p. 833, Pl. lvii., f. 7. Hitherto known only from Parramatta; this form is now confirmed from Lismore.

Genus Cœlastrum Näg.

Cœlastrum reticulatum (Dang.) Senn. (Text-fig.11).



Text-fig. 11.*

Cellulæ matric. diam. 14μ; cell. cœnob. filial. 6μ.

Parramatta Park (136).

Syn., *Hariotina reticulata* Dangeard, Mem. s. l. algues, ii., 1889. Generally found in plankton-gatherings as broken cœnobia. In this case, six cells were noted, partially united by their processes, each with a perfectly formed autocolony within.

EXPLANATION OF PLATES LIV.-LVIII.

Plate liv.

Fig. 1.—*Oscillatoria flexa*, n.sp.; (× 660).

Fig. 2.—*O. simplicissima* v. *granulata*, n.var.; (× 1000).

Fig. 3.—*O. simplicissima* v. *constricta*, n.var.; (× 660).

Fig. 4.—*O. princeps* Vaucher; portion of an empty filament, showing the thick sheath and permanent dissepiments; (× 330).

Fig. 5.—*Phormidium grande*, n.sp.; (× 500).

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* *Cœlastrum reticulatum* (Dang.) Senn, three isolated cells of a cœnobium, each containing an autocolony; (× 1000).

Figs 6, 7.—*Ph. numarium*, n.sp.; (6) × 1330, (7) × 2000.

Figs.8, 9.—*Anabæna australica*, n.sp.,(× 1000); (8) cells and heterocyst of infertile trichome; (9) part of a fertile trichome; the constrictions of the cells can be discerned only with the $\frac{1}{12}$ in. obj.

Fig.10.—*A. australica* var. *constricta*, n.var.; (× 1330).

Figs.11-13.—*A. variabilis* var. *cylindracea*, n.var. (× 1000); (11) cells and heterocyst; (12) immature catenate gonidia; (13) mature spore.

Fig.14.—*A. oscillarioides* var. *crassa*, n.var.; (× 660).

Figs.15, 16.—*A. laxa* var. *hortensis*, n.var., (× 1000); (15) cells and heterocyst; (16) cells and spore.

Figs.17-21.—*Cylindrospermum stagnale* var. *australe*, n.var.; (17, 18) with conical heterocysts (× 1000); (19, 20) with oblong heterocysts (× 660); (21) coiled trichome.

Figs.22, 23.—*C. rectangulare* Playf.; (22) trichome with thin-walled immature spore (× 1000); (23) with mature thick-walled spore (× 660).

Figs.24, 25.—*C. rectangulare* var. *parvicellula*, n.var. (× 1000); (25) trichome with apical cell.

Figs.26, 27.—*C. Goetzei* Schm., forma; (× 1000).

Plate lv.

Figs.1, 2.—*Carteria rugulosa*, n.sp.; (2) endview; (× 1000).

Fig.3.—*C. rugulosa* var. *angulata*, n.var.; (× 1000).

Fig 4.—*C. rugulosa* var. *inæqualis*, n.var.; (× 1000).

Figs.5, 6.—*C. multifilis* (Fresen.) Dill, formæ; (× 1330).

Figs.7, 8.—*C. granulosa*, n.sp.; (8) sideview; (× 660).

Figs.9, 10.—*Chlamydomonas reniformis*, n.sp.; (10) sideview; (× 1000).

Fig.11.—*Chl. Lismorensis* var. *gracilis*, n.var.; (× 2000).

Fig.12.—*Chl. rotula*, n.sp.; (× 1000).

Fig.13.—*Chl. alpina* Wille; (× 2000).

Fig.14.—*Chl. caudata* Wille; (× 1000).

Figs.15-17.—*Chl. maculata*, n.sp.; (15) × 1330; (16) with stratified cell-wall (× 660); (17) mother-cell (× 660), autospores (× 1000); for convenience, the cœnobium is drawn smaller, and the autospores therefore appear more crowded than natural; the latter are in optical section, the spotted surface of the chloroplast being omitted; the flagella were just as figured.

Fig.18.—*Chl. maculata* var. *oblonga*, n.var.; (× 1330).

Fig.19.—*Chl. maculata* var. *planktonica*, n.var.; (× 1000).

Fig.20.—*Chl. metastigma* Stein; (× 1000).

Figs.21, 22.—*Chl. paupercula*, n.sp.; (21) × 2000; (22) × 1800.

Fig.23.—*Chl. pusilla*, n.sp.; (× 660).

Fig.24.—*Chl. angulosa* var. *obesa*, n.var.; (× 1330).

Fig.25.—*Chl. pisiformis* var. *ocellata*, n.var.; mother-cell and autospores; (× 1000).

Fig. 26.—*Chlorogonium minimum*, n.sp.; (× 1330).

Figs. 27, 28.—*Pteromonas angulosa* var. *australis* Playf., forma; (× 1000).

Fig. 29.—*Pt. angulosa* var. *scutiformis*, n.var.; (× 1330).

Fig. 30.—*Pt. angulosa* var. *vexilliformis*, n.var.; (× 1330).

Plate lvi.

Figs. 1-3.—*Synura granulosa* Playf.; (1) elongate cœnobium with zooids attached to a central mucous peduncle (× 660); (2, 3) individual zooids showing one or more dark red granules near the anterior end (× 1000).

Fig. 4.—*Tessellaria volvocina* Playf., supposed free zooid; (× 1500).

Figs. 5, 6.—*Xanthodiscus Lauterbachi* Schew., (so-called); (5) face-view of a preserved specimen with shrunken contents showing central nucleus, but no chlamydomonadine arrangement of the chromatophore; (6) sideview; (× 1000).

Figs. 7, 8.—*Phacotus crassus*, n.sp., (× 1000); (8) sideview.

Figs. 9, 10.—*Ph. glaber*, n.sp., (× 1000); (10) sideview.

Figs. 11, 12.—*Ph. glaber*, formæ; (× 1000).

Figs. 13, 14.—*Ph. australis*, n.sp., (× 1000); (14) sideview.

Fig. 15.—*Spondylomorum quaternarium* Ehr.; (× 1000).

Figs. 16, 17.—*Sp. quaternarium* var. *rostratum*, n.var., (× 1000); (16) bunched cœnobium; (17) rosette-form.

Fig. 18.—*Volvulina Steinii* Playf., single cell of a cœnobium, in sideview, showing nucleus, contractile vacuoles, and stigma in the usual chlamydomonadine positions.

Figs. 19, 20.—*Volvox aureus* var. *hemisphæricus*, n.var.; (19) cells from above (× 660); (20) three cells in sideview (× 1000).

Figs. 21, 22.—*Volvox Carteri* Stein; (21) immature zygote as described by Carter (× 660); (22) mature zygote (× 500).

Plate lvii.

Fig. 1.—*Elakatothrix gelatinosa* Wille, isolated cell; (× 1330).

Fig. 2.—*E. gelatinosa*, mucous matrix with newly divided cells; (× 1000).

Figs. 3, 4.—*Dactylothece arcuatum*, n.sp., two cells, of many noted, involved in a mucous matrix (× 1330); (3) face-view; (4) sideview.

Fig. 5.—*Eremosphæra viridis* var. *tetraëdrica*, n.var.; (× 270).

Fig. 6.—*Oocystis rotula* Playf., mother-cell with autospores; (× 660).

Fig. 7.—*O. rotula*, autospore; (× 1100).

Fig. 8.—*O. lacustris* var. *natans* (Lemm.) Playf., mother-cell with autospores; (× 660).

Fig. 9.—*O. lacustris* var. *natans*, autospore, showing fragmented, reticulate chloroplast; (× 1000).

Fig. 10.—*Franceia oblonga*, n.sp.; the setæ are, for convenience, figured much shorter than natural; they should be as long as the cell; (× 1330).

Fig. 11.—*Lagerheimia elliptica*, n.sp.; (× 1330).

Fig 12.—*Bernardia tetraëdrica*, n.sp.; (×1000).

Figs. 13-16.—*Kirchneriella obesa* W. & G. S. West; (× 1000).

Figs. 17, 18.—*Tetraëdron granulosum*, n.sp.; (17) face-view; (18) sideview (× 1000).

Fig. 19.—*Tetr. quadratum* f. *minor* Reinsch; (× 800).

Fig. 20.—*Tetr. quadratum* f. *excavata*, n.f.; (× 800).

Figs. 21, 22.—*Tetr. caudatum* var. *australe*, n.var.; (21) face-view; (22) side; (× 1000).

Fig. 23.—*Tetr. regulare* var. *octaëdricum* (Reinsch) mihi; (× 1000).

Fig. 24.—*Tetr. conicum*, n.sp.; (× 1000).

Fig. 25.—*Tetr. minimum* var. *rectilineare* Playf.; (× 1000).

Fig. 26.—*Tetr. obtusum*, n.sp.; (× 1000).

Figs. 27, 28.—*Tetr. trigonum* Näg., forma; (27) face-view; (28) side; (×660).

Figs. 29, 30.—*Pediastrum simplex* Meyen, 4-celled forms; (×660).

Fig. 31.—*Pedi. simplex* f. *ovata* (Ehr.) Racib.; (×660).

Fig. 32.—*Pedi. Boryanum* (Turp.) Menegh., 4-celled form; (×500).

Fig. 33.—*Pedi. Boryanum* var. *Hayaldii* (Istv.) mihi; (×500).

Fig. 34.—*Pedi. Boryanum* var. *australe*, n.var.; (× 660).

Fig. 35.—*Pedi. biradiatum* var. *Braunii* (Wartm.) Chodat; (×660).

Fig. 36.—*Pedi. tetras* var. *Crux Michaeli* (Reinsch) Playf.; (× 1000).

Plate lviii.

Spirogyra neglecta (Hass.) Kütz.

Fig. 1.—Conjugated filaments with elliptic zygospores and non-inflated sporangial cells; (×220).

Fig. 2.—Conjugated filaments with oval zygospores and inflated sporangial cells; (× 220). Figs. 1 and 2 formed part of one and the same scalariform filament.

Figs. 3-6.—Four types of zygospore in the one gathering (× 400); fig. 5 (× 500).

Figs. 7, 8.—Unaltered cells of a conjugated filament, with simple delicate chloroplast; (8) × 330; (7) chloroplast much enlarged.

Figs. 9, 10.—Long cell of a vegetative filament, with delicate, fimbriate chloroplast and minute pyrenoids; (9) chloroplast much enlarged; (10) × 330; the fringed edge of the chloroplast is too delicate to be seen under this low magnification.

Figs. 11-13.—Cells with more robust, scalloped chloroplast; (11) chloroplast much enlarged; (12) short inflated cells probably about to conjugate (× 330); (13) long uninflated cell of vegetative filament (× 330).

Figs. 14-16.—*Spirogyra neglecta* var. *amylacea*, n.var., vegetative filaments and chloroplast; (14) long cell (×330; (15) short cells (× 330); (16) chloroplast enlarged. Conjugating cells and zygospores of this variation as in fig. 1.

THE MOSSES OF NORTH QUEENSLAND.

By Dr. V. F. Brotherus and the Rev. W. Walter Watts.

Foreword.

(By the Rev. W. W. Watts.)

The following paragraph is reprinted from my paper, "Some Notes on the Ferns of North Queensland" (These Proceedings, 1914, Vol. xxxix., Part 4, p.756). "In the winter of 1913 (July-August), I spent a month in the Cairns district in search of Ferns and Mosses. I collected in the rich scrub-lands between Bartle Frere and the Russell River, more especially in the neighbourhood of Josephine Creek; around Babinda also, and up Frenchman's Creek to beyond the Second Falls. Babinda and Frenchman's Creek lie at the base of Bellenden Ker, along the coastal railway. Following, later, the main line, I visited Stoney Creek, Kuranda, Atherton, Malanda, Yungaburra, Lake Barrine, and, last and best of all, Ravenshoe and the Tully Falls."

The mosses of North-east Queensland being essentially Malaysian, rather than Australian, in their affinities, specimens from all my packets were submitted to the distinguished expert, Dr. V F. Brotherus. Despite the war, with its submarine dangers, every parcel reached Helsingfors in safety, and, by the end of 1917, full reports, in return, came to hand. The number of new species is smaller than I anticipated, owing, in part, to the zeal of the late Government Botanist of Queensland, Mr. F. Manson Bailey, C.M.G., F.L.S., but mainly to the aforesaid Malaysian affinities of the flora. The chief feature of the following pages is the large number of new records. No less than seventeen genera new to Australia are listed, and some thirty known species. One new genus, *Pterobryidium*, is described, and there are fourteen new species. In addition, many of the species recorded are new for tropical Queensland, though not new for Australia. The new genus was first found by me, in 1913, at

Ravenshoe, North Queensland; but, curiously enough, was collected, in 1916, by Mr. J. L. Boorman, of the Sydney Botanic Gardens, on Mt. Lindsay on the border between Queensland and New South Wales.

It is interesting to note that a few species, the occurrence of which in Australia was regarded as doubtful by Watts and Whitelegge (Census Muscorum Australiensium) are now definitely recorded, such as *Leucobryum sanctum*, *Arthrocormus Schimperi*, *Leucophanes octoblepharoides*, and *Calymperes moluccense.*

It remains, on behalf of Australian botanists, to express sincere thanks to Dr. Brotherus for his continued and generous assistance; and also to thank the Director of the Sydney Botanic Gardens for the facilities afforded me at the National Herbarium for working up my material.—W.W.W.

Note.—The sign * before a generic or specific name denotes that it is new for Australia; and the sign † that it is new for tropical Queensland.

A. ACROCARPI.

Dicranaceæ.

TREMATODON Michx.

†T. LONGESCENS C.M.

Barron River, n. 386; Frenchman's Creek, n. 419.

[Note.—*Trematodon Baileyi* Broth., belongs also to the Cairns district (Mulgrave River), but appears not to have been collected since Bailey found it in 1889.]

PLEURIDIUM Brid.

PLEURID. sp. ster. incerta.

Track down to Redlynch Railway Station, near Cairns. No Pleuridium previously recorded for Queensland.

*GARCKEA C.M.

*G. PHASCOIDES (Hook.) C.M.

Babinda, n. 326 e.p. Previous record, "Southern Asia."

DITRICHUM Timm.

D. AFFINE C.M.

Ravenshoe, n. 457.

DICRANELLA Schimp.

D. DIETRICHIÆ (C.M.) Jaeg.

Ravenshoe, n. 447-8.

D. PYCNOGLOSSA (Broth.) Par.

Stoney Creek: Babinda; Malanda. Kuranda: Mrs. Brotherton. First found by Mr. F. M. Bailey on the Mulgrave River in 1889.

Var. LONGIFOLIA Broth. et Watts, var.nov.

Street's Gully, Kuranda, n. 265.

HOLOMITRIUM Brid.

H. MUELLERI Hampe.

Ravenshoe, n. 573 e.p. Previous records, Rockingham Bay: Dallachy, 1868; Bellenden Ker: S. Johnson, 1891.

H. PERICHÆTIALE (Hook.) Brid.

Ravenshoe and Malanda (several nos.).

DICRANOLOMA Ren.

D. DICARPUM (Hsch.) Par.

Ravenshoe, several nos.

D. SERRATUM (Broth.) Par.

Malanda, n. 494, 615 e.p. (Previous Queensland record, Mt. Mistake: Bailey, 1885).

D. WATTSII Broth., n.sp.

Dioicum; glauco-viride, nitidiusculum; *caulis* usque ad 5 cm. longus, adscendens, inferne denudatus, dein dense foliosus, simplex vel parce ramosus; *folia* horride patula, stricta, late lanceolata, breviter acuminata, 4-4·5 mm. longa et 2-2·5 mm. lata, marginibus erectis, summo apice conniventibus ibidemque argute serratis, ubique hyalino-limbata, limbo latissimo, apicem versus sensim angustiore, nervo tenui, continuo, dorso superne argute serrato, cellulis chlorophyllosis, elongate et anguste linearibus, apice brevioribus, alaribus numerosis, quadratis, fusco-aureis, sæpe decoloratis: bracteæ perichætii internæ e basi longe vaginante convoluta subito in pilum longiusculum contractæ; setæ binæ ex eodem perichætio, tenues, vix ultra 5 mm. altæ, fuscidulæ; theca oblonga, obliqua, subcernua, collo strumuloso; operculum e basi conica longe et oblique subulatum.

Ravenshoe, n. 534*a* (type).

Species *D. austro-scopario* (C. Muell.) affinis, sed foliis latioribus, brevius acuminatis, setis binis ex eodem perichætio, brevioribus et tenuioribus dignoscenda.

[Note.—*D. austro-scoparium* (C.M.) was collected by Bailey, in 1889, on the summit of Bellenden Ker.]

LEUCOLOMA Brid.

L. SIEBERIANUM (Hornsch.) Par.

Ravenshoe (several nos.).

L. SUBINTEGRUM Broth.

Babinda: Frenchman's Creek; Malanda; Ravenshoe (frequent). [Originally found at Palm Camp, Bellenden Ker, by Bailey (1889)].

[Note.—*L. clarinerve* C.M., is recorded for "Tropical Queensland" in Bailey's Suppl. to his Synopsis, 1888.]

CAMPYLOPUS Brid.

C. (*Rigidi*) WATTSII Broth., n.sp.

Dioicus; robustiusculus, cæspitosus, cæspitibus densis, viridissimis, subopacis; *caulis* adscendens, usque ad 3 cm. longus, fere ad apicem rubro-tomentosus, simplex vel furcatus; *folia* sicca imbricata, humida patentia, canaliculato-concava, lanceolato-subulata, c. 6 mm. longa et c. 0·8 mm. lata, superne margine et dorso serrata, nervo basi dimidiam partem folii latitudinis occupante, dorso lamelloso, lamina usque ad apicem distincta, cellulis minutis, rhombeis, haud incrassatis, basilaribus in seriebus pluribus quadratis, alaribus teneris, fuscis, auriculas distinctissimas efformantibus. Cætera ignota.

Cairns district, Frenchman's Creek, Second Falls, n. 366; Ravenshoe, on rocks above Falls, near Major's, n. 484 e.p.: Watts, 1913.

†C. WOOLLSII (C.M.) Par.

Ravenshoe, n. 452, 459, 532.

EUCAMPTODON Mont.

†E. MUELLERI Hpe. et C.M.

Ravenshoe and Malanda,

Leucobryaceæ.

LEUCOBRYUM Hampe.

†L. BALLINENSE Broth., A.M., vi., 1916, n.199.

Ravenshoe, n.534 *c*, *d*; Malanda, n.550 e.p. Ballina, N.S.W., the only previous record.

L. BRACHYPHYLLUM Hpe.

Babinda; Frenchman's Creek; Ravenshoe.

L. CANDIDUM Brid.

Frenchman's Creek, n.397 e.p.; near Babinda, n.445 e.p. Apparently the first record for N.Q.

L. SANCTUM (Brid.) Hampe.

Kuranda; Bartle Frere; Babinda; Frenchman's Creek: Malanda. Widespread "from Nepal to Malesia" (teste Broth.).

†L. STRICTIFOLIUM Broth.

Ravenshoe, n. 469, 672. Previously limited to N. S. Wales and S. Queensland.

[*L. vesiculosum* C.M., was collected, at Whelanian Pools, Palm Camp and Harvey's Camp, Bellenden Ker, by F. M. Bailey, in 1889; and at Trinity Bay, by Mrs. (or Miss) Gribble, in 1894. *L. viride* Mitt., is recorded, in Herb. Melb., for Daintree River, Q., but information regarding this sp. is needed. *L. Wattsii* Broth., was collected by Dallachy at Rockingham Bay, Q., but named *L. sanctum* var. in Hb. Melb.]

LEUCOPHANES Brid.

L. AUSTRALE Broth.

Kuranda, n.435. Previously recorded for Freshwater Creek, near Cairns, and "Ker Range" (teste C.M.).

L. OCTOBLEPHAROIDES Brid.

Kuranda; Bartle Frere; Frenchman's Creek; Babinda; Malanda. Previously recorded, in Hb. Melb., for Johnstone River (Berthaud), and Daintree River (Pentzske). Distrib. "from Nepal to Pacific Islands."

OCTOBLEPHARUM Hedw.

O. ALBIDUM (L.) Hedw.

Cairns; Kuranda; Malanda; Ravenshoe.

ARTHROCORMUS Doz. et Molk.

A. SCHIMPERI D. et M.

Babinda, n. 422, 438. In the Melb. Herb., there is a doubtful record of "*Leucobryum*" *Schimperi* for the Johnstone River. *A. Schimperi* is found in the Indian Archipelago, the New Hebrides, etc.

*EXODICTYON Card.

*E. SUBSCABRUM (Broth.) Card.

Frenchman's Creek, n. 394*b*. Previous record, Papua.

Fissidentaceæ.

FISSIDENS Hedw.

†F. ARBOREUS Broth.

Stoney Creek; Babinda; Lake Barrine; Ravenshoe.

†F. ASPLENIOIDES (Sw.) Hedw.

Ravenshoe, n. 471, 533 e.p.

F. (*Semilimbidium*) CAIRNENSIS Broth. et Watts, n.sp.

Dioicus(?): gregarie crescens, pallide viridis, opacus; caulis usque ad 5 mm. longus, cum foliis usque ad 1 9 mm. latus, infima basi fusco-radiculosus, dense foliosus, simplex vel furcatus; folia sicca homomallula, humida stricta, erecto-patentia, infima minuta, dein subæqualia, ligulata, breviter acuminata, acuta, c. 1·3 mm. longa et c. 0·38 mm. lata, marginibus superne minutissime serrulatis, lamina vera ad medium folii producta, basi limbo albido, e cellulis angustissimis constructo, lamina dorsali e basi nervi enata, ibidemque rotundata, nervo crassiusculo, lutescente, infra summum apicem folii evanido, cellulis rotundato-hexagonis, 0·007-0·010 mm., pellucidis, papilla media instructis; seta terminalis, solitaria, rarius binæ ex eodem perichætio, usque ad 2 mm. alta, tenuis, rubra, levissima; theca inclinata vel nutans, minuta, ovalis, pallida; operculum e basi conica recte rostratum; calyptra ignota. Planta mascula ignota.

Near Hotel, Babinda, Cairns district, on rotten logs, n. 332*a* (leg. Watts).

Species limbo brevi cellulisque pellucidis, papilla media instructis dignoscenda.

†F. Dietrichiæ C.M.

Ravenshoe, n. 465 e.p., 528 e.p., 529 e.p.

F. kerianus C.M.

Cairns, n. 234*a*, 243; Stoney Creek, n. 252.

F. (*Aloma*) kurandæ Broth. et Watts, n.sp.

Corticola, gregarie crescens, pallide viridis; caulis adscendens, usque ad 8 mm. longus, cum foliis c. 1·5 mm. latus, basi fusco-radiculosus, dense foliosus, simplex; folia usque ad 18-juga, sicca homomalla, humida erecto-patentia, infima minuta, dein subæqualia, ligulata, breviter acuminata, obtusiuscula, apiculata, c. 1 mm. longa et c. 0·25 mm. lata, elimbata, integra, lamina vera ad medium folii producta, lamina dorsali e basi nervi enata, ibidemque rotundata, nervo pallido, in apiculo folii evanido, cellulis valde pellucidis, rotundato-hexagonis, 0·010-0·015 mm., ad basin laminæ veræ paucis, elongatis, limbum inframarginalem valde indistinctum efformantibus. Cætera ignota.

Kuranda, n. 273 (leg. Watts, 1913).

Species habitu *F. Holliano* Doz. et Molk., similis, sed cellulis pellucidis, multo majoribus jam dignoscenda.

†F. pallidus H.f.W.

Ravenshoe, n. 470; Malanda, n. 512.

†F. tenellus H.f.W.

Ravenshoe, n. 500 e.p.

*F. zippelianus Bryol. jav.

Babinda, n. 308 e.p., 343. Previous records, Sumatra, Java, Hongkong.

[*Note.*—The following also is recorded for N.Q.: *F. microlecythis* C.M. (Trinity Bay), but the name alone has been published (C.M., Genera Muscorum, p.59).]

Calymperaceæ.

Syrrhopodon Schwgr.

*S. amœnus Broth.

Frenchman's Creek, n. 368 e.p., 385, 393; Babinda, n. 439. Previous record, Papua.

S (*Cavifolii*) CAIRNENSIS Broth. et Watts, n.sp.

Dioicus; tenellus, cæspitosus, cæspitibus laxiusculis, pallide viridibus; caulis erectus, vix ultra 4 mm. longus, basi fusco-radiculosus, dense foliosus, simplex vel ramosus; folia sicca circinato-incurva, dorso nitidiuscula, humida erecto-patentia, e basi paulum latiore ligulata, obtusa, mucronatula, usque ad 1·7 mm. longa, superne 0·25-0·27 mm. lata, limbata, limbo angustissimo, hyalino, infra apicem minute serrulatam evanido, in parte superiore basis ciliato-serrato, nervo crassiusculo, infra summum apicem folii evanido, inferne levi, dein parce aculeato-papilloso, cellulis laminalibus acute et elevato-papillosis, basilaribus laxis, inanibus, breviter rectangularibus vel subquadratis. Cætera ignota.

Cairns district, Babinda, on tree-trunks, n. 313*a* (leg. Watts, July, 1913).

Species distinctissima, a *S. fimbriatulo* Sauerb., foliis multo brevioribus, nervo inferne levi, superne parce aculeato-papilloso facillime dignoscenda.

*S. CROCEUS Mitt.

Frenchman's Creek, n. 418 e.p. An Indo-Malayan species.

S. FASCICULATUS Hook. et Grev.

Base of Bartle Frere; Babinda; Frenchman's Creek, etc. Previous record, Johnstone River: Berthaud, Dec., 1882. A widespread tropical species.

†S. FIMBRIATULUS Sauerb. *S. fimbriatus* C.M., non Mitt.

Frenchman's Creek, n. 408; Tully Falls, n. 462.

*S. MUELLERI (Doz. et Molk., *Calymperidium*) Lac.

Frenchman's Creek, n. 361, 368 e.p. An Indo-Malayan-Polynesian species.

S. NOVÆ VALESIÆ C.M.

Ravenshoe, n. 461, 468, 531*a*. A forma *microcarpa* was collected at Trinity Bay by Sayer, in 1886; otherwise new for Q.

S. UNDULATULUS Broth.

Babinda, n. 313 e.p.; Frenchman's Creek, n.421 e.p.; Kuranda, n. 427. Previous record, Bellenden Ker: Mrs. Gribble (Herb. Melb.).

*S. UNDULATUS (Doz. et Molk.) Lindb.

Base of Bartle Frere, n. 293; Babinda, n. 310; Frenchman's Creek, n. 405, 412, 414, 420 e.p., 421. Previous record, Sunda Islands.

[Note.—*S.* (Thyridium) *humile* Mitt., is recorded in the Melb. Herb. for Johnstone River (leg. Berthaud).]

CALYMPERES Sw.

†C. MOLUCCENSE Schwgr.

Frenchman's Creek, n. 372. Hampe, in Pl. Preiss, recorded it for West Australia, but this record is not found in Mitten's Catalogue, nor in Jaeger's Adumbratio. It is almost certainly new for Australia. Previous range, the Moluccas.

C. NIGRESCENS Broth. et Geh.

Cairns: Allen, Sept., 1906 (Herb. J. M. Murdoch). Earlier record, Bellenden Ker: Mrs. Gribble (Herb. Melb.).

*C. SERRATUM A.Br.

Malanda, n. 497, 530. Previous records, Java, New Hebrides, etc.

*C. TENERUM C.M.

Fig-tree, Police Paddock, Cairns, n. 226-8, 230, 232; base of Bartle Frere, n. 285. Previous range, Indo-Malaysia.

[Note.—*C. Motleyi* Mitt., is recorded for Cape Yorke (leg. Micholitz, 1897); and *C. Kennedyanum* Hampe, (1876) was found at Rockingham Bay by E. B. Kennedy, and at Goode Island by Powell in 1883.]

Pottiaceæ.

WEISIA Hedw.

W. VIRIDULA (L.) Hedw.

Ravenshoe, n. 475 (f. eperistomata).

HYOPHILA Brid.

*H. MICHOLITZII Broth.

Stoney Creek, n. 237 e.p., 261. Previous record, Papua.

BARBULA Hedw.

B. CALYCINA Schwgr.

Ravenshoe, n. 464 e.p.

Grimmiaceæ.

GLYPHOMITRIUM Brid.

†G. COMMUTATUM (C.M.) Broth.

Ravenshoe, n. 463 e.p., 488, 532 e.p.

Orthotrichaceæ.

MACROMITRIUM Brid.

†M. DAEMELII C.M.

Ravenshoe, n. 490, 536, 616 e.p.

†M DIMORPHUM C.M.

Stoney Creek, n. 258; Ravenshoe, n. 485; Malanda, n. 491; Kuranda, n. 511, 607*b*.

M. HEMITRICHODES Schwgr.

Ravenshoe, several nos.

†M. PUGIONIFOLIUM C.M.

Malanda, n. 493, 495; Ravenshoe, n. 506; Yungaburra, n. 520. Earlier records limited apparently to N.S.W.

†M. SCOTTIÆ C.M.

Ravenshoe, n. 481, 486, 534*b*. Previous record, N.S.W., from Monga and Nowra northwards to the Richmond River.

[Note.—*M. aurescens* Hpe., is recorded from Mt. Archer, near Keppel Bay (leg F.v.M.); *M. microstomum* (Hook. et Grev.), for Rockingham Bay (Dallachy, 1868); *M. pusillum* Mitt., from Tringilburra Creek, Bellenden Ker (F. M. Bailey); *M. Sayeri* Mitt., from the Russell River (W. A. Sayer, 1886, Herb. Melb.), and *M. Whiteleggei* Broth. et Geh., from Bellenden Ker and Bartle Frere (S. Johnson, 1891).]

SCHLOTHEIMIA Brid.

S. BAILEYI Broth.

Ravenshoe, several nos. The original record was Bellenden Ker; the species spreads south well into N.S.W., and probably into Victoria.

Splachnaceæ and **Funariaceæ.**

These two families are quite unrepresented in my N.Q. collection, but the following record may be noted: *Goniomitrium acuminatum* H.f.W., (Clermont, Miss Gore).—W.W.W.

Bryaceæ.

BRACHYMENIUM Schwgr.

B. (*Dicranobryum*) WATTSII Broth., sp.n.

Dioicum; gracilescens, cæspitosum, cæspitibus densis, lutescenti-viridibus, sericeo-nitidis; caulis erectus, vix ultra 1 cm. longus, inferne fusco-radiculosus, dense foliosus, simplex; folia imbricata, ovata, breviter acuminata, aristata, marginibus basi recurvis, integris, nervo lutescente, in aristam denticulatam excedente, cellulis superioribus elongate et anguste rhomboideis, basilaribus et alaribus quadratis. Cætera ignota.

Ravenshoe (Millstream), n. 489 and 527 (leg. Watts, 1913). Species *Br. acuminato* Harv., valde affinis, sed statura paulum robustiore, foliisque brevius acuminatis dignoscenda.

*ANOMOBRYUM Schimp.

*A. CYMBIFOLIUM (Lindb.) Broth.

Ravenshoe, n.464 e.p., 521*b*, 532 e.p. Previous range, India to Java and Amboina.

BRYUM Dill. emend. Schimper.

†B. ARGENTEUM L., var. NIVEUM H.f.W.

Ravenshoe, n. 463 e.p., 521 e.p.

†B. ERYTHROCARPOIDES Hpe. et C.M.

Kuranda, n. 429; Malanda, n. 521 e.p.

B. (*Alpiniformia*) KURANDÆ Broth. et Watts, n.sp.

Dioicum; gracilescens, cæspitosum, cæspitibus densiusculis, pallide lutescenti-viridibus, nitidis; caulis vix ultra 5 mm. longus, basi radiculosus, dense foliosus, innovationibus pluribus erectis, vix ultra 5 mm longis, strictis, julaceis, obtusis; folia caulina erecto-patentia, carinato-concava, oblongo-lanceolata, breviter acuminata, acuta, marginibus anguste recurvis, apice minutissime serrulatis, nervo tenui, brevissime excedente, cellulis elongate et anguste hexagono-rhomboideis, basilaribus laxioribus, alaribus breviter rectangularibus; seta 1-1·5 cm. vel paulum ultra alta, tenuissima, fuscescenti-rubra; theca nutans, minuta, cum collo sporangii longitudinis, pyriformis, c. 2·5 mm. longa et c. 0·95 mm. crassa, sicca deoperculata sub ore haud constricta, macrostoma, fusca; exostomii dentes lineari-lanceolati, subulato-acuminati, rufi, apice hyalini, dense lamellati; endostomium luteum, minutissime papillosum, membrana basilaris ultra medium dentium producta; processus lanceolati late fenestrati; cilia terna bene evoluta, longe appendiculata. Cætera ignota.

Damp wall of creek by Railway line, near Kuranda, n. 498 (leg. Watts, 1913).

Species innovationibus julaceis, theca minuta, macrostoma oculo nudo jam dignoscenda.

†B. PIMPAMÆ C.M.

Wall of creek by railway, near Kuranda, n. 679.

†B. SUBATROPURPUREUM C.M.

Malanda, n. 505; Millstream, Ravenshoe, n. 521*a*.

†B. SUBOLIVACEUM C.M.

Millstream, Ravenshoe, n. 525 e.p ; Kuranda, n. 535.

B. SUBPACHYPOMA Hampe.

Stoney Creek, n. 249, 255, 259 Earlier record, Rockingham Bay (Dallachy, 1869).

[*Note.*—The following records should be noted : *B. Baileyi* Broth., (Freshwater Creek, near Cairns, Bailey, 1889; Bellenden Ker, S. Johnson); *B. leptothrix* C.M., (Trinity Bay, Karsten, 1881).]

RHODOBRYUM (Schimp.) Hampe.

†R. OLIVACEUM Hpe.

Ravenshoe, n. 506.

†R. SUBCRISPATUM (C.M.) Par.

Yungaburra, on hillside, n. 501.

Mniaceæ.

MNIUM (Dill. exp.) L., emend. Schimper.

MN. sp.(?).

Ravenshoe, n. 517 e.p.

MN. sp.(?), probably sp.nov.

(?)Loc., n. 522.

Rhizogoniaceæ.

RHIZOGONIUM Brid.

†RH. GEHEEBII C.M.

Ravenshoe, n. 483, 502.

RH. PARRAMATTENSE C.M.

Ravenshoe, n. 523, 615 e.p.; Malanda, n. 618*c*. A southern species, but already recorded (in Hb. Melb.) for Bellenden Ker.

RH. SPINIFORME (L.) Bruch.

Malanda, Kuranda, and Ravenshoe, including f. minor, n.482, 492 (previously recorded from N.S.W., and S.Q.).

[Note.—*Rh. brevifolium* Broth., was collected on Bellenden Ker by F. M. Bailey (1889), also by S. Johnson, on the same range, and on Bartle Frere in 1891.]

MESOCHÆTE Lindb.

M. UNDULATA Lindb.

Babinda, n. 387. Common in the south, with, also, a record for Port Denison (Birch, 1889).

Bartramiaceæ.

PHILONOTIS Brid.

*PH. LAXISSIMA (C.M.) Bry. jav.

Babinda, n. 334; *forma*, Ravenshoe, n. 517, 524.

†PH. PSEUDOMOLLIS (C.M.) Jaeg.

Ravenshoe, n. 489 e.p., 516; Barron River, n. 496, 534*g*.

Polytrichaceæ.

POLYTRICHUM Dill.

P. JUNIPERINUM Hedw.

Ravenshoe, n. 519.

B. PLEUROCARPI.

Cryphæaceæ.

CRYPHÆA Mohr.

C. TENELLA Hornsch.

Ravenshoe, n. 610 e.p., 616 e.p.

CRYPHIDIUM (Mitt.) Broth.

C MUELLERI (Hampe) Par.

Ravenshoe (Millstream, etc.), several nos.

Cyrtopodaceæ.

BESCHERELLEA Dub.

B. CYRTOPUS F.v.M.; *B. brevifolia* Hpe.

Ravenshoe, several nos.

Ptychomniaceæ.

HAMPEELLA C.M.

H. PALLENS (Lac , *Cladomnion*) Fleisch.; *Lepidopilum australe* Broth.; *Hampeella Kurzii* C.M.

Tully Falls, n.591. [Previously recorded from Harvey's Creek: Bailey, 1889].

Œdicladiaceæ.

*MYURIUM Schimp., Fleischer.

*M. RUFESCENS (Hsch. et Reinw.) Fleisch.

Ravenshoe, n.534*e* (f. depauperata). Range, Indo-Malaysia.

Neckeraceæ.

TRACHYLOMA Brid.

T. PLANIFOLIUM (Hook.) Brid.

Ravenshoe, n. 543; Malanda, n. 650 e.p.

ENDOTRICHELLA C.M.

E. DIETRICHIÆ C.M.

Babinda, n. 440; Ravenshoe, n. 558, 572*b*, 616 e.p.; track to Tully Falls, n. 561.

E. LEPIDA C.M.

Frenchman's Creek, 417 e.p.; Kuranda, 511 e.p., 607*e*; Ravenshoe, 476 e.p., 564 e.p.

GAROVAGLIA Endl.

G. MUELLERI (Hpe.) Mitt.

Kuranda; Babinda; Malanda; Ravenshoe, etc.

MUELLERIOBRYUM Fleisch.

M. WHITELEGGEI (Broth.) Fl.

Stoney Creek; Babinda; Frenchman's Creek; Malanda; Ravenshoe.

*Pterobryopsis Fleisch.

P. filigera Broth. et Watts, n.sp.

Dioica; gracilis, gregarie crescens, læte viridis, nitidiuscula; caules secundarii usque ad 3 cm. longi, inferne simplices, nudi, dein densissime pinnatim ramosi, filis elongatis, sat numerosis, articulatis, papillosis instructi, ramis erecto-patentibus, vix ultra 6 mm. longis, complanatulis, simplicibus, obtusis; folia imbricata, subcymbiformi-concava, dorso lævia, ovato-oblonga, breviter acuminata, acuta, marginibus erectis, ubique serrulatis, nervo tenui, subcontinuo, dorso superne serrato, cellulis angustissimis, apice papillose exstante, basilaribus infimis laxioribus, alaribus sat numerosis quadratis. Cætera ignota.

Malanda, on trunks of trees, n. 549: Ravenshoe, on trunks of trees, n. 605*a*.

Pterobryidium Broth. et Watts, n.gen.

Pt. australe B. et W., n.gen. et sp.

Dioicum; robustiusculum, læte viride, ætate lutescens, nitidum; caulis primarius longe repens, plus minusve fusco-radiculosus: caules secundarii conferti, rigidi, superne sæpe arcuati, usque ad 12 cm. longi, dense foliosi, plerumque obtusi, rarius flagelliformiter attenuati, inferne simplices, dein plus minusve regulariter pinnati, ramis patulis, teretibus arcuatulis, usque ad 2 cm. longis, obtusis vel plus minusve longe, rarius flagelliformiter attenuatis, simplicibus, rarius longioribus, parce ramulosis; folia caulina infima, minuta, dein sensim accrescentia, cochleariformi-concava, sicca imbricata, lævia, late ovalia, apiculo lato, obtuso, recurvulo terminata, nervo simplici basi validiusculo, dein raptim tenuiore, ultra medium folii evanido, cellulis inter se porosis, linearibus, chlorophyllosis, basilaribus infimis fusco-aureis, alaribus numerosis, subquadratis: bracteæ perichætii erectæ, concavæ, internæ oblongæ, raptim breviter acuminatæ, c. 5 mm. longæ et c. 1·5 mm. latæ, integræ, nervo tenui, vix ad medium bracteæ producto, cellulis linearibus, inter se valde porosis, basilaribus laxioribus; seta c. 1 mm. alta, stricta, fusca; theca immersa, breviter ovalis, sicca deoperculata sub ore paulum constricta, c. 2 mm. longa et c. 0·90 mm. crassa, fusca; peristomium duplex, infra orificium oriundum, rufum, læve, cum præperistomio; exostomii dentes anguste lanceolati, linea dorsali recta, articulationibus lamelliformibus: corona basilaris rudimentaria; processus angusti; sublineares. Cætera ignota.

North Queensland : Malanda, n. 619*a*; Ravenshoe in scrub, n.551 e.p., 555, 556, 557 e.p., (Watts, 1913). Queensland-N.S W.: Mt. Lindsay (J. L. Boorman, n.1522 in Herb. Sydn.).

Genus novum insigne, habitu foliorumque structura speciebus nonnullis *Pterobryopsidis* simillimum, sed theca immersa nec non peristomio dignoscendum.

PAPILLARIA (C.M.) C.M.

P. AMBLYACIS (C.M.) Jaeg.

Lake Barrine, n. 636.

P. FLEXICAULIS (Tayl.) Jaeg.

Ravenshoe, n.556 e.p., 610 e.p., 654*a*; Malanda, n.619 e.p., 647.

P. KERMADECENSIS (C.M.) Jaeg.

Babinda; Malanda; Ravenshoe; several nos.

†P. NITIDIUSCULA Broth.

Malanda, n.618 e.p., 619*b*. Previous records, N.S.W.

METEORIUM Doz. et Molk.

M. BAILEYI (Broth., *Papillaria*) Broth., *Bryales*, p.818.

Ravenshoe; Malanda; Yungaburra; several nos.

*M MIQUELIANUM (C.M.) Fleisch.

Malanda; Ravenshoe; several nos.

AEROBRYOPSIS Fleisch.

A. SIGMATOPHYLLA (C.M.).

Base of Bartle Frere; Babinda; Frenchman's Creek; Malanda; Lake Barrine; Ravenshoe: many nos.

*FLORIBUNDARIA C.M.

*FL. FLORIBUNDA (Doz. et Molk., *Meteorium*) Fleisch.

Malanda, n. 494*b*, 619*e*: Yungaburra, n. 668 e.p.: Ravenshoe, n. 579.

*FL. PSEUDOFLORIBUNDA Fleisch.

Malanda, n.651 e.p., 655; Ravenshoe, n.582, 624 e.p., 656.

Fl. robustula Broth. et Watts, n.sp.

Dioica; robustiuscula, pallide lutescenti-viridis, opaca; caulis secundarius breviusculus, dense pinnatim ramosus, ramis patulis, usque ad 2 cm. longis, apicem versus decrescentibus, laxiuscule foliosis, simplicibus, obtusis; folia ramea horride patula, e basi cordato-ovata lanceolato-subulata, comalia in pilum flexuosum, denticulatum attenuata, marginibus basi uno latere inflexis, apice crenulatis, nervo tenui, ultra medium folii evanido, cellulis elongatis, angustis, seriatim papillosis. Cætera ignota.

N. Queensland: Malanda, on tree-trunks, n. 618*a*.

Species statura robustiuscula foliisque horride patulis oculo nudo jam dignoscenda.

Barbella (C.M.) Fleisch.

B. enervis (Thw. et Mitt.) Fl.; *Neckera trichophoroides* Hpe. Ravenshoe, n. 558, 624, 628 e.p.

*Meteoriopsis Fleisch.

*M. reclinata (C.M.) Fl.

Malanda, 604, etc.; Yungaburra, n.626*a*; Ravenshoe, 541, etc.

*Trachypus Reinw. et Hornsch.

*T. Novæ Caledoniæ C.M.

Malanda, n. 633.

Orthorrhynchium Reichdt.

O. cymbifolioides C.M.

Ravenshoe, n. 600, 605 e.p., 611 e.p.

Calyptothecium Mitt.

C. acutum (Mitt.) Broth.

Babinda, n. 317; Ravenshoe, n. 551, etc.

C. humile (Mitt.) Broth.

Ravenshoe, n.557 e.p.; Yungaburra, 612, etc.; Malanda, n.619*g*.

C. recurvulum (C.M., *Trachyloma*) Broth.

Babinda, n. 312 e.p.

Neckeropsis Reichdt., emend. Fleisch.

N. Lepineana (Mont.) Broth.

Malanda; Ravenshoe; Yungaburra: several nos.

*HIMANTOCLADIUM (Mitt., *Neckera*) Fleisch.

*H. LORIFORME (Bryol. jav.) Fl.

Base of Bartle Frere, n. 294; Babinda, n. 437.

*HOMALIODENDRON Fleisch.

*H. EXIGUUM (Bryol jav., *Homalia*) Fl.

Ravenshoe, n. 546, 576*e*.

*H. FLABELLATUM (Dicks, Sm., *Hookeria*) Fl.

Ravenshoe, n. 547-8, 564 e.p., 609.

*PINNATELLA (C.M.) Fleisch.

*P. INTRALIMBATA Fl.

Ravenshoe, n. 600*a*, 611, 632, 667 e.p.

Lembophyllaceæ.

CAMPTOCHÆTE Reichdt.

C. BRISBANICA (C.M.).

Ravenshoe, n 542, 595, 648 e.p.; Lake Barrine, n. 636.

C. VAGA (Hornsch.) Broth.

Babinda; Frenchman's Creek; Malanda : several nos.

Entodontaceæ.

*CAMPYLODONTIUM Doz. et Molk.

*C. FLAVESCENS (Hook., *Pterogonium*) Bryol. jav.

Ravenshoe, n. 538, 581 e.p.

Fabroniaceæ.

*AUSTINIA C.M.

*A. LUZONENSIS Broth.

Ravenshoe, n. 667 e.p.

Hookeriaceæ.

DISTICHOPHYLLUM Doz. et Molk.

D. BAILEYANUM C.M.

Kuranda; Ravenshoe; Yungaburra : several nos.

CYCLODICTYON Mitt.

C. LEPIDUM (Mitt.); *Hookeria karsteniana* Broth. Geh.

Yungaburra, n. 576*a*, 674.

CALLICOSTELLA (C.M.) Jaeg.

*C. KÆRNBACHII Broth.

Kuranda, n. 266, 272; Babinda, 332 *bis*.

CHÆTOMITRIUM Doz. et Molk.

CH. ENTODONTOIDES Broth. et Watts, n.sp.

Dioicum; gracile, cæspitosum, cæspitibus laxis, mollibus, depressis, lutescenti-viridibus, nitidiusculis; caulis repens, fuscoradiculosus, dense et complanate foliosus, dense pinnatim ramosus, ramis vix ultra 1 cm. longis, complanatis, obtusis; folia erectopatentia, concaviuscula, ovato-oblonga, rotundato-obtusa, dorso lævia, marginibus erectis vel basi anguste recurvis, superne argute denticulatis, nervis binis, brevibus, indistinctis, cellulis angustissimis, linearibus, infima basi brevioribus et latioribus, aureis, omnibus lævissimis. Cætera ignota.

North Queensland: Frenchman's Creek, Cairns District, n.352.

Species distinctissima, habitu entodontoideo foliorumque forma facillime dignoscenda.

CH. GEHEEBII Broth.

Babinda, n. 336*a*.

CH. NEMATOSUM Broth.

Babinda; Frenchman's Creek; Ravenshoe: several nos.

Lepidopilum australe. See *Hampeella pallens*.

Hypopterygiaceæ.

HYPOPTERYGIUM Brid.

H. MUELLERI Hpe. et C.M.

Lake Barrine, n. 643.

Helicophyllaceæ.

POWELLIA Mitt.

P. AUSTRALIS (Hpe., *Helicophyllum*) Broth.

Frenchman's Creek, n. 401. Found earlier by Dallachy at Rockingham Bay.

Rhacopilaceæ.

RHACOPILUM Palis.

RH. CONVOLUTACEUM C.M.

Babinda; Frenchman's Creek; Malanda; Ravenshoe.

Leskeaceæ.

*Herpetineuron (C.M.) Cardot.

*H. Toccoæ (Sull. et Lesq., *Anomodon*) Card.

Ravenshoe, n. 598 e.p.

Thuidium Bryol. eur.

†Th. lilliputanum Broth.

Ravenshoe, n. 648, 665.

Th. plumulosiforme (Hpe.) Jaeg.

Stoney Creek; Frenchman's Creek; Kuranda; Ravenshoe.

†Th. suberectum (Hpe.) Jaeg.

Stoney Creek; Malanda; Ravenshoe.

[*Note.*—The following species have also been recorded for N.Q.: *Th. ramentosum* Mitt , (Bellenden Ker: Karsten); *Th. sparsum* (Bellenden Ker : Karsten), and perhaps others.—W.W.W.]

Hypnaceæ.

Stereodonteæ.

Ectropothecium Mitt.

E. serrifolium Broth. et Watts, n.sp.

Dioicum (?) : gracile, cæspitosum, cæspitibus densiusculis, rigidis, depressis, læte viridibus, nitidiusculis; caulis elongatus, repens, fusco-radiculosus, dense subpinnatim ramosus, ramis vix ultra 5 mm. longis, strictis, dense et complanate foliosis, simplicibus, obtusis; folia erecto-patentia, caulina superiora plus minusve distincte homomalla, concava, caulina ovato-lanceolata, plus minusve longe acuminata, marginibus inferne indistincte recurvis, superne erectis, argute serratis, nervis binis, brevibus, cellulis anguste linearibus, apice distinctissime papillose exstante, marginalibus in serie unica brevioribus, ramea breviter et late acuminata. Cætera ignota.

Cairns District : Millstream Falls, Ravenshoe, n. 528 (leg. Dr. Joynt).

Species *E. Zollingeri* (C.M.) Jaeg., affinis, sed foliis argute serratis jam dignoscenda.

E. umbiculatum (C.M., *Hypnum*) Par.

Stoney Creek; Kuranda; Babinda; Ravenshoe, etc.

*E. verrucosum (Hpe.) Jaeg.

Ravenshoe, n. 539 e.p., 606, 653 e.p., 661.

Stereodon Mitt.

S. mossmannianus (C.M., *Hypnum*) Broth.

Millstream, Ravenshoe, n. 521 e.p.

†S. subchrysogaster Broth.

Rocky Hill, Kuranda, n. 680 e.p. Previous loc., Blackall Range: leg. Whitteron.

Acanthocladium Mitt.

A. extenuatum (Brid.) Mitt.

Frenchman's Creek; Malanda; Ravenshoe; Tully Falls.

A. sp.?

Ravenshoe, n. 605 e.p.

Plagiothecieæ.

Isopterygium Mitt.

I. austro-pusillum (C.M.) Jaeg.

Stoney Creek; Kuranda; base of Bartle Frere; Babinda.

I. candidum (C.M.) Jaeg,

Kuranda; Malanda.

I. sublatifolium Broth.

Base of Bartle Frere, n. 299 e.p., 305.

Taxithelium Spruc.

T. kerianum (Broth., *Trichosteleum*) Broth., Bryales.

Base of Bartle Frere, n. 285 e.p., 298; Babinda, n. 320 e.p.; Tully Falls, n. 591 e.p., 597.

†T. Novæ Valesiæ (Broth., *Isopterygium*) Broth.

Babinda; base of Bartle Frere; Malanda; Yungaburra; Tully Falls, etc.

*T. papillatum (Harv.) Broth., Bryales.

Babinda, n. 424; Frenchman's Creek, n. 362*a*.

T. (*Polystigma*) WATTSII Broth., n.sp.

Dioicum; robustiusculum, cæspitosum, cæspitibus densis, depressis, viridibus, nitidis; caulis elongatus, repens, per totam longitudinem fusco-radiculosus, dense pinnatim ramosus, ramis patulis, valde complanatis, dense foliosis, obtusis, rarius flagellis microphyllinis instructis, cum foliis c. 1·7 mm. latis, vix ultra 5 mm. longis, simplicibus vel longioribus, pinnatim ramulosis; folia ramea lateralia patentia, valde concava, e basi paulum angustiore oblonga, sensim lanceolato-acuminata, marginibus erectis, apice minute serrulatis, nervis binis brevibus vel nullis, cellulis angustissimis, seriatim minutissime papillosis, basilaribus infimis vesiculosis, hyalinis. Cætera ignota.

Babinda, North Queensland, on living tree-trunks, n. 441.

Species valde peculiaris, cum nulla alia commutanda.

VESICULARIA (C.M.) C.M.

†V. RIVALIS Broth.

Stoney Creek, n. 256 e.p. A second locality. The type was collected by Watts on the Richmond River (Whian Creek).

Sematophyllaceæ.

MEIOTHECIUM Mitt.

M. BROTHERI Watts; *M. tenerum* B.P., non Mitt.

Cairns (Police paddock, on fig-tree), n. 227, 228, 230; Street's Gully, Kuranda, n. 270*a*, 607.

†M. WATTSII (Broth., *Pterogoniella*) Broth., Bryales.

Kuranda, n. 607*c*, 642.

RHAPHIDOSTEGIUM Schimp.

RH. ACICULUM (C.M.).

Stoney Creek; Kuranda; Ravenshoe, etc.

RH. OVALE Broth.

Babinda; Frenchman's Creek; Ravenshoe.

RH. PSEUDO-HOMOMALLUM (C.M.).

Kuranda; base of Bartle Frere; Babinda; Frenchman's Creek; Ravenshoe.

*RH. SAPROXYLOPHILUM (C.M.) Jaeg.

Frenchman's Creek, n. 362; *f. robusta* (n. 415).

SEMATOPHYLLUM (Mitt.) Jaeg.

S. ERYTHROPODIUM (Hpe.) Jaeg.

Malanda, n. 625 e.p. Previous record, Rockingham Bay: Dallachy.

S. sp.? (ster.): Ravenshoe, n. 588.

S. sp.? (ster.): Tully Falls, n. 591 e.p.

*TRICHOSTELEUM (Mitt.) Jaeg,

T. (*Papillidium*) ELEGANTULUM Broth. et Watts, n.sp.

Autoicum; tenellum, cæspitosum, cæspitibus densis, pallide viridibus, ætate lutescenti—vel fuscescenti—viridibus, nitidiusculis; caulis breviusculus, per totam longitudinem fusco-radiculosus, dense ramosus, ramis adscendentibus, complanatis, brevibus, simplicibus vel longioribus plus minusve ramulosis; folia erecto-patentia, concava, e basi anguste oblongo-elliptica sensim lanceolata vel lanceolato-subulata, marginibus late recurvis, superne argute serratis, enervia, cellulis anguste ellipticis, superioribus papilla media altiuscula instructis, infimis aureis, alaribus magnis vesiculosis, hyalinis vel aureis; bracteæ perichætii internæ erectæ, e basi vaginante in acumen loriforme, argute serratum sensim attenuatæ; seta vix ultra 8 mm. alta, tenuis, rubra, ubique mammillis humilibus latis, luteis obtecta; theca suberecta, majuscula, ovalis, fusco-rubra, lævis; operculum ignotum.

Cairns District (Frenchman's Creek), n. 382.

Species distinctissima, foliis angustis, nec non theca majuscula oculo nudo jam dignoscenda.

T. HAMATUM (Doz. et Molk.) Jaeg.

*Var. SEMIMAMMILLOSUM (C.M.) Par.

Babinda, n. 319 e.p., 337*a*; Frenchman's Creek, n. 362*b*, 383. The var. previously recorded for Papua and the New Hebrides.

Rhegmatodontaceæ.

*MACROHYMENIUM C.M.

*M RUFUM (Reinw. et Hornsch.) C.M.

Malanda, n. 623; Ravenshoe, n. 657, 660, 662.

Brachytheciaceæ.

RHYNCHOSTEGIELLA (Bryol. eur.) Limpr.

RH. CONVOLUTIFOLIA (Hpe.) Broth.

Base of Bartle Frere, n. 297 e.p.

RHYNCHOSTEGIUM Bryol. eur.

RH. NANO-PENNATUM (Broth.) Par.

Base of Bartle Frere, n. 285 e.p., 296-7; Babinda, n. 320 (*bis*); Frenchman's Creek, n. 416.

RH. TENUIFOLIUM (Hedw.) Jaeg.

Ravenshoe, n. 425 e.p., 476 e.p.; Yungaburra, n. 601.

Hypnodendraceæ.

HYPNODENDRON (C.M.) Lindb.

H. SPININERVIUM (Hook.) Jaeg.

Kuranda; Babinda; Yungaburra; Ravenshoe.

MNIODENDRON Lindb.

MN. COMATULUM Geh. in Herb. Broth.

Dioicum; gracilescens, viride, ætate fuscescens, nitidiusculum; caules secundarii approximati, usque ad 4 cm. longi, a foliis squamæformibus, remotis, patentissimis, reflexis, tomento densissimo fusco-purpureo occultis obtecti, superne verticillatim ramosi, ramis 1-1·5 cm. longis, gracilibus, arcuatulis, undique dense foliosis, simplicibus: folia caulina e basi late cordata, triangularia, longe aristata, marginibus erectis, basi minute denticulatis, superne argute et inæqualiter serratis, nervo longe excedente, cellulis angustissimis, alaribus sat numerosis, ovalihexagonis, fusco-aureis; folia ramea patentia, ovato-lanceolata, breviter acuminata, marginibus basi integris, superne argute et inæqualiter serratis, nervo apice evanido, superne dorso serrato; seta usque ad 2 cm. alta, flexuosula, tenuis, fuscidula; theca horizontalis, oblongo-cylindrica, c. 3 mm. longa; operculum e basi convexo-conica longe rostratum.

Charmellan's Creek, on Gordon's track from Ravenshoe to Tully Falls, n. 676. Mt Armit: Pentzke in Herb. Melb.(type).

MESOZOIC INSECTS OF QUEENSLAND.

No.4. Hemiptera Heteroptera: The Family *Dunstaniidæ*. With a Note on the Origin of the Heteroptera.

By R. J. Tillyard, M.A., D.Sc., F.L.S., F.E.S., Linnean Macleay Fellow of the Society in Zoology.

(Plate lix.; and Text-figures 17-22).

In 1916, I described(3) the beautifully preserved wing of *Dunstania pulchra* Till., from the Upper Trias of Ipswich, Queensland, and placed it as the sole representative of a new family *Dunstaniidæ* within the Order Lepidoptera. This decision had the concurrence of Dr. A. Jefferis Turner, of Brisbane, and was based mainly upon the presence of eight longitudinal veins in the fossil, this being the number found in the hindwings of Frenate Lepidoptera.

While the description of this fossil was going to press, I happened to be on a visit to Brisbane. A day or two before I left, Mr. Dunstan showed me four other specimens bearing the label "*Dunstania*" in pencil; these had just been discovered at Ipswich. Two of them were broad wings resembling the type, and two were much longer and narrower wings. Thinking that these latter must be the forewings of the same insect as that whose hindwing I had assumed the type to be, I added the note on p.32 of the paper quoted above. However, when I received from Mr. Dunstan, later on, the complete collection of Ipswich Insects of which these wings formed a part, and had time to work at them in detail, I soon found that the two narrow wings did not belong to *Dunstania* at all; so that there remained only the two broad wings for study in connection with the original type. Neither of these is in anything like as good a state of preservation as the type is, and one of them is very poorly preserved indeed.

Meanwhile the publication of the original description had created considerable interest amongst entomologists, and discussion soon became rife as to its true affinities. In August, 1916, Mr. E. Meyrick, F.R.S., contributed a paper on the subject*(**2**), in which he argued strongly against the admission of *Dunstania* to the Order Lepidoptera, and suggested that its affinities might rather be with the Homoptera. He reasoned as follows:—"In order to appreciate the position, I looked up the record of *Palæontina oolitica* Butl., from the Jurassic, hitherto the oldest known Lepidopteron, ... ; I must express my opinion that there is little doubt it belongs to the *Hepialidæ*. . . . . . Now it is clearly proved on structural grounds that the *Micropterygina* (the small group to which the *Hepialidæ* belong, otherwise termed Jugatæ) were the primitive form of the Lepidoptera, and the nature of *Palæontina* is in accord with this conclusion and confirmatory of it. Parenthetically, I take occasion to notice that Goss, Tillyard, and others are troubled as to what the early Lepidoptera can have fed upon, when flowering plants were not yet in existence, and honey was not available; it is a problem easy of solution, since the more primitive forms (including the *Hepialidæ*) have in general no proboscis or feeding apparatus, and, therefore, fed on nothing in the perfect state."

"With the evidence recounted above, *Dunstania*, if regarded as Lepidopterous, is violently discordant. As the hindwing possesses neither frenulum nor prominent basal angle of costa, it must be assumed that the forewing was furnished with a jugum; all existing Lepidoptera exhibit one or other of these structures. But all jugate Lepidoptera have the hindwing similar in neuration to the forewing, with at least 11 veins, whereas this wing seems to be of the modern 8-veined type, though conspicuously different from any known form, and in fact quite as highly specialised as any now existing. Finally, there is the apparently corneous margin round the costa and termen, which is altogether abnormal, no other Lepidoptera showing a

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* See also "Nature," No. 2488, Vol. 99, Sept. 28th, 1916, p.75, where this paper is reviewed.

trace of it, and in my estimation a far more important systematic character than the two which the author lays stress on."

"It appears to me, then, that this specimen can only be regarded as Lepidopterous on the theory that it is a member of an entirely unknown line of development of that Order, which had attained a high degree of specialisation at a period far anterior to the earliest certainly Lepidopterous insect known, itself a lowly organised form; this cannot be termed impossible, but it involves a very great improbability. The alternative view that the resemblances are accidental and the insect not Lepidopterous seems to me, on the whole, less improbable."

"I cannot venture to express any positive opinion on its possible relation to other Orders, but I suggest that there are some points of resemblance to the Hemiptera-Homoptera, some species of which have a semi-Lepidopterous facies. The corneous margin of the wing, the central cell (usually, it is true, much larger), and approximate number of veins rising from it, and even the curious dark banding of the membrane alongside the veins, can all be paralleled in this group, which, moreover, is already known to have been in existence since the Carboniferous period."*

Mr. Meyrick's criticism led me to study intensely the various types of Lepidopterous wing-venation extant, about which I knew very little at the time that I first described the fossil. I very soon became convinced that *Dunstania* was not a Lepidopteron; but that conviction was not based, for the most part, on the argument set forth by Mr. Meyrick, which I regard as unsound in several important particulars.

Firstly, as regards *Palæontina.* The latest authority on the family to which this fossil belongs is Handlirsch (1), who gives a masterly treatment of this and allied fossils, with photographs and restorations of a number of types, in some of which the hindwing is complete enough to allow of definite proof that the *Palæontinidæ* were most certainly not *Hepialidæ*, as Meyrick avers, nor even Jugatæ of any kind, but definitely Frenatæ allied

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* This is surely an error. No true Homoptera were known below the Lias, until I described *Mesojassus* from the Ipswich Trias, and, later on, two new genera from the Permian of Newcastle, N.S.W.

to the *Limacodidæ*. If Mr. Meyrick "turned up the record of *Palæontina oolitica*," how is it that he ignored Handlirsch's epochal work, which does not fit in with his own opinions?

I accept without any doubt whatever Handlirsch's proof that the *Palæontinidæ* were Frenate moths, though I take leave to doubt that they were as closely allied to the *Limacodidæ* as he imagined. The evidence of the hindwings, which are small, with only eight or nine veins, is conclusive on the point. Consequently, there is no absurdity in supposing that Frenate types might have existed also in the Lias, or in the Upper Trias of Australia. That being so, all this part of Mr. Meyrick's argument rests upon an unsound basis.

There is, therefore, no *a priori* reason why a Frenate moth, of a type *far removed* from those we know at the present day, might not also have been in existence in the Upper Trias at Ipswich, though I am quite willing to admit that it might not be a very probable supposition.

Secondly, as regards the "apparently corneous margin" round the costa and termen. In my description, I simply called this "a wide margin without pits," and added that "the external border, or *termen*, shows signs of a delicate transverse ribbing" which "extends also somewhat indistinctly round the apex on to the costa." I purposely refrained from suggesting that it was a corneous margin, as it seemed to me to be equally likely that it had been formed by the crushing down of the deep bases of insertion of a series of stiff and closely packed marginal hairs or bristles, such as one sees in many Diptera, for instance. There was no inherent improbability that such a margin might not be found on a strongly-built and hairy-winged, primitive Lepidopteron.

If, however, the margin be really corneous, then I admit that the character is of great importance, and definitely rules *Dunstania* out of the Lepidoptera. In the actual fossil, the appearance of this margin is certainly not such as to suggest a positive solution to this question, one way or another; but Mr. Meyrick, of course, had only my drawing to go upon.

Thirdly, I should like to reply to Mr. Meyrick's parenthetical statement that the early ancestors of the Lepidoptera took no food in the imaginal condition. This argument defeats itself. For, if these insects took no food as imagines, then surely their descendants must have even more aborted mouth-parts than their ancestors, and thus they should all be either *Hepialidæ* or *Saturniidæ* ! Surely the ancestors of those Lepidoptera that are, to-day, of the haustellate type were originally of the weak mandibulate type still preserved in *Micropteryx* and allies, and were, therefore, pollen-feeders and lappers-up of dew and rain-drops, as the great majority of the Planipennia, Mecoptera, Trichoptera and Diptera are to-day!

To my mind, the great argument against *Dunstania* being a Lepidopteron is simply this, that the venation, quite apart from the mere number of the veins, does not show any of the typical arrangements of that Order, whether Frenatæ or Jugatæ. As soon as I had sufficiently mastered the wing-venation of the Order, I became convinced of this, and definitely rejected my original placing of the fossil. It is part of the object of this paper to relate how the opinions of different entomologists, looking at the problem from different points of view, favoured the claims of various Orders to receive this fossil; but none, including myself, who had the type-specimen itself to study, succeeded in finding the true solution, which was at last given by the study of the new material.

Starting from Mr. Meyrick's suggestion that *Dunstania* might be Homopterous, I find that a number of correspondents entertained this idea, the strength of which lies, of course, in the interpretation of the margin of the wing as corneous. However, Mr. J. Edwards, of Cheltenham, England, an acknowledged expert upon this Order, wrote to Mr. Meyrick, and also to me, strongly opposing the idea, on the ground that he could see nothing in the fossil to indicate such a relationship. As the Homoptera are well represented in the Ipswich Trias by forms differing entirely from *Dunstania*, and as I was unable to establish a single venational character common to the two types, I soon abandoned any idea of relationships in this direction.

In correspondence, other entomologists discussed with me the probable affinities of *Dunstania*, but their opinions were not published. In particular, I desire to mention Mr. Herbert Campion's share in the clearing up of the mystery. It was through his unfailing courtesy that I was kept in touch with the trend of opinion in England on the fossil, and from him I obtained valuable suggestions as to clues that were worth following out. One of the most interesting of these, originating with Mr. Durrant of the British Museum, and stated in publication by Dr. Bather, F.R.S., in the course of a short review of my paper in "Nature,"* was, that the venation of *Dunstania* might be compared with that of certain groups of Diptera, such as the *Psychodidæ.* At about the same time, Dr. C. J. Gahan, of the British Museum, had before him a small collection of insects from New Zealand, and suggested to Mr. Campion that the fossil should be compared with the Anthomyiid *Exsul singularis* Hutton, which it closely resembles in the shape and general appearance of the wing.

Acting on these suggestions, I put myself into communication with several New Zealand entomologists, in the endeavour to obtain material of *Exsul.* This, however, was not easy to get, as the fly is exceedingly rare, and regarded as a great prize. After a considerable time, I obtained two specimens, one from Mr. David Miller, Government Entomologist of New Zealand, and an expert Dipterologist, and another from Mr. G. V. Hudson, of Wellington. To both of these gentlemen I offer my cordial thanks for their generosity in sending me such valuable material.

While I could not admit any affinity between *Dunstania* and the *Psychodidæ*, I was impelled to study more closely its possible affinity with *Exsul*, in spite of some cardinal differences in the venational scheme, which would be hard to explain on any hypothesis. Believing that I had here, at last, a good solution of the problem, and wishing to give due credit to those to whom the suggestion was originally due, I wrote to "Nature,"† stating my adherence to the probable Dipterous nature of *Dunstania.* However, it was necessary to carry out a very detailed study of

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* "Nature," No. 2441, Vol. 97, Aug. 10th, 1916, p.489.

† "Nature," No. 2488, Vol. 99, July 8th, 1917, p.373.

the fossil before anything could be published. Here I was helped and guided by a regular correspondence with Mr. Miller. He, like other entomologists, found in the supposed corneous border of the wing a stumbling-block to the acceptance of any theory of Dipterous affinity for the fossil. He also pointed out the remarkable difference between the structure of the costal vein in *Dunstania* and in *Exsul*, and finally declared his belief in the Homopterous nature of the fossil.

The only other possibility that occurred to me was, that *Dunstania* might be the wing of a large Oligoneurous Mayfly. The shape and venation of the wing made this likely; but I was unable to follow this line of research far, as I soon became convinced that the evident toughness and strength of build of the *Dunstania* wing could not possibly have belonged to the wings of any representative of the Order Plectoptera.

Here, then, after having reviewed possible affinities with four Orders, Lepidoptera, Diptera, Homoptera and Plectoptera, I abandoned the study of this puzzling fossil for a time, in the hope that a respite from the work might rid my mind of any preconceived notions, that were bound by now to be present, after so long a time spent in thinking over the problem, and might allow some new light to come in.

In the meanwhile, I had received from Mr. Dunstan the complete series of fossils found at Ipswich since my first paper had been published, and had been arranging these for study. For some months, I had put the new material of *Dunstania* by, as it was evidently in very poor preservation compared with the type, and I did not expect to get any new evidence from it. It was, however, from this new material that the solution of the problem came; and that solution was of such a nature that it could have scarcely been suggested as a possibility, on the evidence of the type alone.

The number of the type-specimen was 2*a*; the two wings of *Dunstania* received after the type had been described were numbered 107*a* and 147 respectively. In the present paper, I propose to give a complete description of the new material, together with a re-examination of the type in the light of the new evidence, and an attempt at a complete restoration of the wing.

Specimen No.147 is in a very poor state of preservation, and represents practically the same area of the wing as is found in the type. It clearly belongs to a somewhat larger insect than the type; and, as the venation differs from that of the latter in some important respects, it will form the type of a new genus within the family *Dunstaniidæ*.

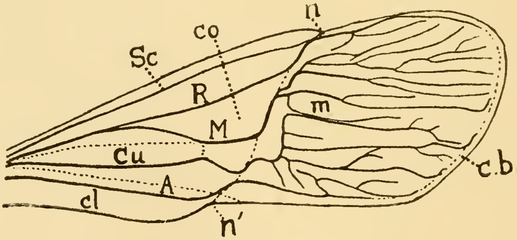
Specimen No.107*a* is in much better preservation than No. 147, but it is not so well preserved as the type. The apical part of the wing is missing, but the whole of what was taken to be the basal part in the type is fairly well preserved. On the other side of this there is preserved a large flattened area, with only traces of disconnected venation. On making a careful drawing of this, and trying to establish its connection with the rest of the wing, on which the venation is well preserved, it became at once apparent that this new fossil represented almost the whole (excluding the base and apex only) of a huge Heteropterous hemelytron, and that the supposed almost complete wings preserved in the type-specimen and in No.147 were, in reality, nothing more than the distal membranous half of the hemelytron, which is separated anteriorly from the basal half, or *corium*, by a strongly developed *node* upon the costa.

With this new and unexpected light upon the problem that had been exercising me for so long, the mystery of the affinities of *Dunstania* became cleared up in a moment. There cannot now be any doubt that these fossils are Heteropterous; the only question that remains for discussion is as to what, if any, recent or fossil families of Heteroptera show any affinity with them.

Before the fossils, including the type, can be correctly described in terms suitable to their new position, it will be necessary to examine them very carefully, with a view to trying to establish the homologies of their unique venation upon the Comstock-Needham system. This is a difficult task. I propose, therefore, to use the new names under which I shall describe the two new fossils at the end of this paper, in order to facilitate the discussion that must take place before those descriptions can be properly given.

Specimen No.107*a* is to be made the type of a new genus and species, *Dunstaniopsis triassica*, n.g. et sp., while specimen No. 147 will also be the type of a new genus and species, *Paradunstania affinis*, n.g. et sp. All these are evidently members of the same family, *Dunstaniidæ*, the venational differences being, at the most, only of generic value.

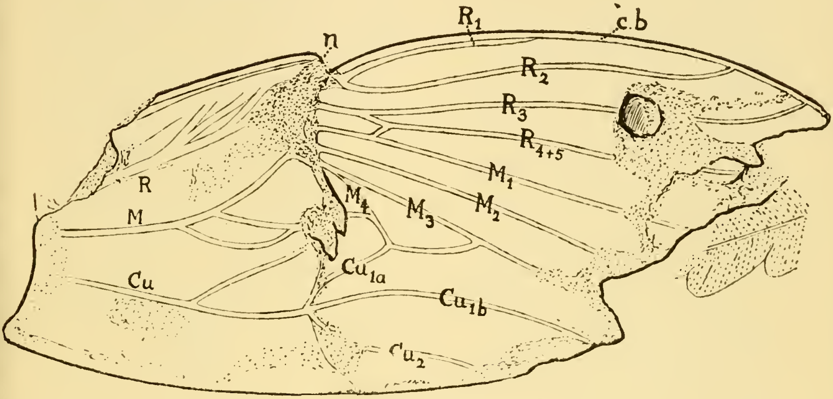
In discussing the venation of the *Dunstaniidæ*, we shall make use of the most complete specimen, *Dunstaniopsis triassica*, n.g. et sp., supplemented by the type of the family, *Dunstania pulchra* Till. It will be necessary to compare the venation on the corium of the former with the tracheation to be found on the same area of the hemelytra of recent Heteroptera. Unfortunately, few reliable figures of the latter are available. I have selected as the most suitable for our purpose the excellent figure of the tracheation of the nymphal forewing of *Syromastes* (family *Coreidæ*) given by Handlirsch (1, Atlas, Pl. vii., fig.3). It is not necessary to figure the corresponding venation in the imago, as it only differs from that of the nymph in the greater differentiation between corium and membrane, the dividing line becoming a complete whole, and effectually concealing the connections between the veins on the corium and those on the membrane. Consequently, such an archaic type as *Dunstaniopsis* is more closely comparable with the tracheation of the nymphal wing of *Syromastes* than with the venation of the imaginal wing.



Text-fig.17.

Tracheation of forewing of nymph of *Syromastes* sp.; (× 8). After Handlirsch. For lettering, see p.592.

Text-fig.17 shows the tracheation of the nymphal wing in *Syromastes*. The wing consists of a hard coriaceous basal half, called the *corium* (*co*), and a softer membranous distal half, called the *membrane* (*m*). These are separated by the *dividing line*, running somewhat obliquely across the wing from the *node* (*n*) on the costa to the *antinode* (*n′*) on the dorsum. Posterior to the corium is a narrow projecting anal area, known as the *clavus* (*cl*). Around the membrane is a complete *coriaceous border* (*c.b.*), such as we have already noticed very prominently in the type-specimen of *Dunstania*.



Text-fig.18.

Hemelytron of *Dunstaniopsis triassica*, n.g. et sp.; (×2·8). Upper Triassic, Ipswich, Q. For lettering, see p.592.

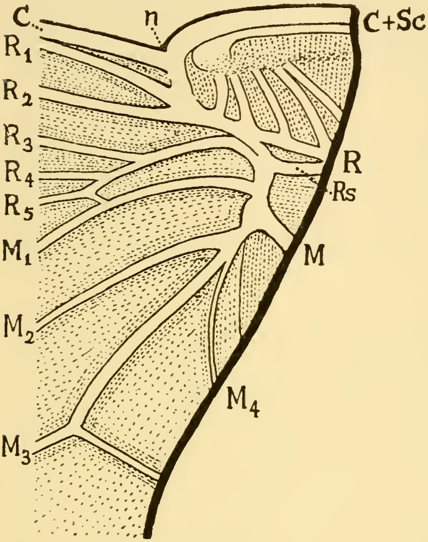
Turning next to *Dunstaniopsis* (Text-fig.18) we see that the node is more prominent, but that the dividing line is, on the whole, not so clearly marked, and its course is far more irregular. This line also runs more transversely across the wing in *Dunstaniopsis* than in *Syromastes*; but, in many recent Heteroptera, especially in the family *Pentatomidæ*, it takes a similar transverse course, though much straighter than in *Dunstaniopsis*. A further point of difference is that no true claval area can be seen in *Dunstaniopsis*. But, as the extreme base of the wing is not preserved, there may well have been a short clavus present on the lost part.

Turning next to the venation, we notice that, in *Syromastes*, the corium is crossed by four longitudinal veins, not counting the analis, which borders the clavus anteriorly. By reference to the precedent tracheation, these veins are shown to be the subcosta, radius, media, and cubitus respectively. As in most Heteroptera, the subcostal trachea lies close up to the costal border; in the imago, the subcostal vein becomes more or less fused with this border. The radius and media are fused for some distance from their bases, and then diverge gradually at an acute angle. The cubitus is a separate vein, lying about half-way between the media and analis.

Having made the above comparison with *Syromastes*, it now becomes an easy task to name the radius, media, and cubitus in the corium of *Dunstaniopsis*. This is shown in Text-fig. 18. Owing, however, to the bad state of preservation, in this fossil, of the dividing line between corium and membrane, we cannot proceed to name the numerous veins in the latter area with any certainty. Here, however, we may fall back upon the type-specimen of *Dunstania*, in which there is just enough of the corium preserved to enable us to make the necessary connections.

In my original description of *Dunstania*, I paid little attention to this part of the wing, believing it to represent only a small flattened-out portion of the thorax of the insect. I now give, in Text-fig. 19, a careful drawing of the region of the node and dividing line in this fossil. From the figure of *Dunstaniopsis*, it will be seen that R and M, after diverging from one another in the middle of the corium, again begin to converge, and are then unfortunately lost in a break in the rock-surface. In *Dunstania*, however, we are able to pick up these two veins as they approach the dividing line. R is seen to be just dividing into R_1 and Rs, while M converges towards the latter as a stout vein from below. Sc is fused with the costa, as in *Dunstaniopsis*. Between Sc and R there are a number of oblique ribs, half fused into the corium; these can also be seen in *Dunstaniopsis*, further basad along the same area.

Just before the level of the node, Rs turns upwards, and partially fuses with R_1. From the combined stem thus formed, three branches pass out into the membrane, viz., R_1, R_2, and $R_{3.5}$. Of these, R_1 is a short vein lying close alongside the costal margin, and supporting it from below; it ends up at about one-third of the length of the membrane, upon the costal margin. The second branch, R_2, is a longer, gracefully curved vein, running below R_1 and parallel to the costal margin for most of its length, and finally curving up to meet the margin at about two-thirds of the length of the membrane. The last branch, R_{3-5}, gives off R_3, close to its base, and immediately after divides into R_4 and R_5. R_3 passes in a gentle curve beneath R_2, and ends up just above the apex of the wing. R_4 and R_5 meet again (in *Dunstania* only) beyond the middle of the membrane, and from there on continue straight to the termen as a single vein R_{4+5}. In *Dunstaniopsis*, R_{4+5} is a single unbroken vein from its origin to its termination.



Text-fig.19.*

Returning to the corium of *Dunstania* (Text-fig.19 and Plate lix., fig.15), we can pick up M converging towards R as it approaches the membrane. On the dividing line, it is connected with R by a short, stout cross-vein, forming portion of the dividing line itself. From the swollen root of M upon the dividing line, two branches pass out into the membrane. Of these, the upper, M_1, arches gently upwards, so as to approach close to R_{3-5}, and is connected with R_5, just distad from its origin, by a short cross-vein. Thence onward, M_1 runs with a slight double-curving to the termen. The lower branch, M_{2+3}, almost

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* Region of node and dividing line in hemelytron of *Dunstania pulchra* Till., showing the small anterior portion of the corium preserved in the fossil; (× 7·5). Upper Triassic, Ipswich, Q.

immediately divides into two; of these, the upper, M_2, runs to the termen on a similar course to that of M_1, but well below it; while the lower branch, M_3, diverges from M_2 for some distance, until it gives off a backwardly descending vein, whose destination cannot be followed out in *Dunstania*; at this point, M_3 is bent at a very oblique angle, and passes on probably to near the tornus of the wing.

From the base of M_3, in *Dunstania*, a very weakly indicated vein, M_4, can be made out, passing downwards, about midway between M_3 and the dividing line; it can be seen to be converging towards the cross-vein mentioned in the preceding paragraph; but the fracture of the rock hides its further course from our view.

In order to follow out the further structure of the wing, posteriad to the region of M, we must now turn again to *Dunstaniopsis* (Text-fig.18), in which most of this part of the wing is fairly well preserved. In this genus, we can easily pick up the cubitus, running with a gentle curve upon the corium, well below M. In *Syromastes*, we see that M and Cu are connected by a short cross-vein, not far from the dividing line. In *Dunstaniopsis*, Cu gives off an oblique anterior branch, which approaches closely to two oblique posterior branches given off by M at about the same level; these two branches of M unite close to the dividing line, at a point where the branch from Cu lies very close below them. Here there is a break in the rock-surface; but we can pick up, on the other side of the break, a single weak vein curving into M_4. This is evidently the prolongation of the united branches from M and Cu.

Turning now to the main stem of Cu, we can follow it, in *Dunstaniopsis*, up to the dividing line between corium and membrane, where it gives off an oblique anterior branch, Cu_{1a}; this branch meets M_4, the weak vein already mentioned as descending from the base of M_3. At the angle formed by these two, which is almost a right angle in *Dunstaniopsis*, a third vein comes in from the membrane; following this distad, we see that it arises from M_3, which, in this genus, is a straight vein running to near the tornus of the wing.

We can now complete this part of the wing in *Dunstania*. The descending vein from M_3 must be the homologue of the corresponding vein in *Dunstaniopsis*; the only difference is in the angle of departure from M_3. On this difference, as well as upon its more numerous and slightly more divergent veins, we see at once that *Dunstania* had a broader and shorter membrane than *Dunstaniopsis*.

Following the main stem of Cu, which I call Cu_{1b}, across the dividing line in *Dunstaniopsis*, we see that it continues in a gentle curve, until it ends up on the dorsum of the wing, not far from the tornus. Below Cu_{1b}, another branch of Cu, Cu_2, arises on the dividing line, and passes into the membrane as a curved vein running to the dorsum below Cu_1.

The dividing line hereabouts is not well preserved, but its ending up on the dorsum can be just made out. The division between corium and membrane is clearly noticeable in the fossil on account of the difference between the colour of the rock and the fossil itself. The former is a dark grey; the latter a pale brown. The whole of the corium is coloured pale brown, and is flat and smooth. The membrane, on the other hand, is varicoloured, showing pale veins bordered by narrow bands of dark brown pigment, and, between these, areas of the darker rock-colour on those parts where no veins are present. Also, the membrane is lightly pitted all over, whereas the corium is quite smooth in this genus.

Sufficient will now have been said to make it abundantly clear that we have, in *Dunstania* and its allied genera, a primitive type of Heteropteron, of large size, and very probably of amphibiotic habits. From recent Heteroptera, such as the *Lygæidæ* and *Pyrrhocoridæ*, in which some of the venation is still preserved upon the corium, the *Dunstaniidæ* differ in the incompleteness and tortuosity of the dividing line between corium and membrane; and they show us how the anterior portion of this dividing line has been evolved, apparently in a most complicated manner, from a series of cross-veins and branches of main-veins linking up at different angles. The process by which the straight division between corium and membrane, found in most recent

Heteroptera, has been evolved from the stage seen in the *Dunstaniidæ*, is simply one of reduction and alignment of parts. When it is completed, as in recent *Pentatomidæ*, the clue to the venation of the membrane would be quite lost, were it not for the preservation of the tracheæ in the nymphal wing. I have not been able to find a single existing type of Heteropteron in which this venation is at all closely comparable with that of *Dunstania*. In the aquatic forms, especially, there does not seem to be any clue at all. Judging chiefly by the shape of the wing, and the condition of the venation of the corium, I am inclined to regard the *Coreidæ*, *Lygæidæ*, and *Pyrrhocoridæ* as the nearest relatives of the *Dunstaniidæ* at the present day. These three families, and no doubt also the *Pentatomidæ*, may well lie almost in a direct line of descent from the *Dunstaniidæ*. We should have to suppose, in restoring the latter, that the development of the scutellum had advanced very little beyond a normal size; and consequently, that the clavus, which, in the position of rest, borders the scutellum, was also very short. As no anal vein or clavus can be seen in the preserved portion of the hemelytron of *Dunstaniopsis*, this was almost certainly the case.

In Plate lix., fig.15, I offer a restoration of the complete hemelytron of *Dunstania pulchra* Till., based upon the preserved portions of the type and of *Dunstaniopsis triassica*. The poorly preserved *Paradunstania affinis* has not been brought into the discussion at all, and its only use in the restoration is to indicate the course of the wing-border below the tornus.

It now remains for me to revise my original definition of the family *Dunstaniidæ* in the light of our new knowledge, and to give definitions of the type-genus, and of the two new genera here proposed, and descriptions of the new species.

Order **HEMIPTERA.**

Suborder **Heteroptera.**

Family DUNSTANIIDÆ.

Large bugs, with hemelytra more than 30 mm. long. Hemelytron suboval, about half as wide as long, the corium either smooth or lightly pitted (hairy), the membrane pitted (hairy).

Veins present on the corium are R, M, and Cu; no clavus visible in the preserved portion, but the base of the wing is incomplete posteriorly in all known specimens. Sc fused with costal margin. Costa broken between corium and membrane by a strongly developed node. Dividing line between corium and membrane crosses the wing from node to antinode in a very irregular manner, being formed anteriorly by short cross-veins and portions of main veins, posteriorly by a sinuous line not made up of veins. On the membrane there are either eight or nine longitudinal veins, of which either three or four arise from R, three from M, and two from Cu; these veins runs distad in a slightly diverging manner, R_3 ending up at or near the apex, and Cu_1 at or near the tornus. From M_3 a downward and backwardly running branch passes to the dividing line, where it meets the intersection of M_4 and Cu_{1a}. Few cross-veins present on membrane. Veins of the membrane pale, generally bordered on either side by a band of dark brown pigment. A fairly broad border without pits, and probably coriaceous, runs completely round the membrane.

Horizon, Upper Trias of Ipswich, Queensland.

The genera comprised in this family are *Dunstania* Till., *Dunstaniopsis*, n.g., and *Paradunstania*, n.g.

Key to the known genera of *Dunstaniidæ*.

M_1 connected with the lowest branch of R by a short cross-vein, not far distad from the dividing line .... 1.
No cross-vein present at this level between M_1 and lowest branch of R .... *Paradunstania*, n.g.

Four branches of R crossing the membrane, viz., R_2 to R_5; R_4 and R_5 unite a little beyond half-way, forming a closed cell .... *Dunstania* Till.
1. Three branches of R crossing the membrane, viz, R_2, R_3, and R_{4+5}; the last a single straight vein connected with M_1 near its origin.. ... *Dunstaniopsis*, n.g.

Genus DUNSTANIA Tillyard.

(Plate lix., fig.15, and Text-fig.19).

Membrane and a very small portion only of the corium preserved. Preserved portion of corium distinctly pitted all over. Membrane about as broad as long, the apex prominent but gracefully rounded. Node exceedingly prominent. R_1 a weak vein fused with costal margin from below node up to about one-third the length of the membrane. R_2 ending well before the apex, R_3 at the apex itself. Between R and M, at the base of the membrane, a closed cell is formed, bounded by the dividing line basally, by R_{3-5} anteriorly, by M_1 posteriorly, and by a short cross-vein connecting these two veins distally. Distally from this cell a second closed cell is formed between R_4 and R_5, these two veins at first diverging, and then converging to meet again at a point beyond the middle of the membrane. M_2 and M_3 united distally for a short distance upon the membrane. The backwardly projecting branch from M_3 comes off almost at right angles from the main stem. (Rest of hemelytron missing).

Genotype, *Dunstania pulchra* Till., (**3**, p.32, and Plate iii., fig.6).

Genus Dunstaniopsis, n.g. (Text-fig.18).

Hemelytron completely preserved except for the extreme base of the corium (including the clavus, if present) and the apical portion of the membrane. A longer wing than that of *Dunstania*, and narrower in proportion. Differs from *Dunstania* as follows:—Corium smooth, membrane lightly pitted all over. Coriaceous border narrower and less defined; node somewhat less prominent. R_{4+5} a single straight vein, and hence no closed cell formed between R_4 and R_5. The basal cell completed by the presence of the short cross vein between M_1 and lowest branch of R is present, but is much shorter than in *Dunstania*. The backwardly projecting branch from M_3 to the junction of M_4 and Cu_{1a} comes off from the main stem at an angle of about 30°, and runs almost parallel to the posterior border below it. On the corium, M curves upward distally, converging towards R, and giving off posteriorly two branches which unite further distad and then meet an anterior branch given off from Cu; this latter vein divides at the dividing line into three branches, Cu_{1a}, Cu_{1b}, and Cu_2, of which the first runs to the intersection of M_4 and the backward branch from M_3. Cu_{1b} ends up at or near the tornus.

Genotype, *Dunstaniopsis triassica*, n.sp.

DUNSTANIOPSIS TRIASSICA, n.sp. (Text-fig.18).

Greatest length of fragment, 31·5 mm.; breadth across the dividing line, 15·5 mm Estimated total length of hemelytron, 40 mm.

The specimen is only moderately preserved, and would appear to have been much torn distally before it became fossilised, since a part of a frond of *Thinnfeldia*, lying upon the same rock-surface, projects well into the gap where the missing distal portion ought to be, and is embraced on one side by the projecting torn costa, without appearing to overlie the wing in any way. Also the beautiful pattern of brown pigmentation bordering the veins of the membrane, though it can be seen to be present, is not by any means so well preserved as in *Dunstania*. The corium appears to have been hard, and is fairly well preserved; the veins lying upon it are not so distinct as those upon the membrane.

The venational characters being considered as of either family or generic importance, they will be found in full in the definitions given above.

Type, Specimen No. 107*a*, in the Queensland Geological Survey Collection.

Genus PARADUNSTANIA, n.g. (Text-fig.20).

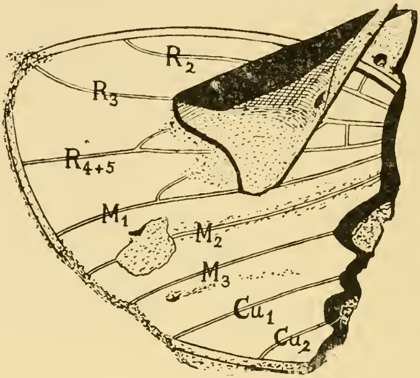
Portion of membrane only preserved, and in very poor condition. Apparently a hemelytron of somewhat larger size than that of *Dunstania*. No cross-veins basally between M_1 and lowest branch of R. Cross-veins developed not far from dividing line between R_1 and R_2, and also between R_3 and R_{4+5}. This last vein receives a curved branch-vein from above, at about the same point as where, in *Dunstania*, R_4 and R_5 unite distally; but a break in the rock-surface prevents us from determining whether this branch is really R_4 or not. At about the same level, M_1 receives a curving branch from above; this branch appears to come from R_{4+5}, but its origin is not determinable with certainty. Rest of venation similar to that of *Dunstania*.

Genotype, *Paradunstania affinis*, n.sp.

PARADUNSTANIA AFFINIS, n.sp. (Text-fig.20).

Greatest length of fragment, 17 mm.; greatest breadth, 14·5 mm. A very poorly preserved specimen, with very little trace of the brown pigmentation bordering the veins. A large and deep triangular break has cut out a considerable portion of the courses of all the branches of R; the rest of the veins present can be traced out by the use of careful lighting.

This specimen appears to represent a hemelytron intermediate in size between that of *Dunstania pulchra* Till., and the much larger hemelytron of *Dunstaniopsis triassica*, n.g. et sp. In shape, also, it was probably intermediate between these two.



Text-fig.20.*

Type, Specimen No.147, in the Queensland Geological Survey Collection.

Note on the Origin of the Heteroptera.

In dealing with the phylogeny of the Order Hemiptera, Handlirsch (**1**, pp.1244-1249) rightly insists upon the clear-cut dichotomy between the two Suborders Heteroptera and Homoptera. Neither of these two Suborders can be derived from the other; for, on the one hand, the Homoptera have preserved the more primitive wing-form and venation, while, on the other, the Heteroptera have preserved the more archaic form of the head and antennæ. As the direct ancestors of both these recent Suborders, Handlirsch indicates some known Hemipterous fossils of the Upper Permian and Lias of the Northern Hemisphere, which he places in a distinct Order, Palæohemiptera, on the ground that it is not possible to demonstrate that they are definitely either Heteropterous or Homopterous. The Palæohemiptera he

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* *Paradunstania affinis*, n.g. et sp.; (×2·8). Upper Triassic, Ipswich, Q.

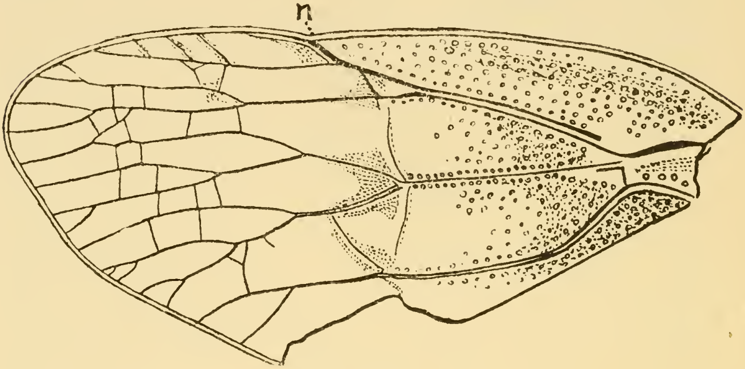
would, in turn, derive from the Lower Permian fossil genus *Eugereon*, which he places in a third Order, Protohemiptera.

Had it not been for the preservation of its mouth-parts, which form a primitive elongated sucking beak, *Eugereon* would never have been considered to have any relationship whatever with the Hemiptera. It was a huge insect, with primitive densely veined wings that were held out away from the body; the prothorax had lateral expansions suggestive of rudimentary wings, as in the case of some of the Carboniferous fossils. Apart from the dense venation, it is not possible to establish any close relationship between the venational plan of *Eugereon* and that of primitive Hemiptera; although it might be admitted that such a connection may possibly have actually taken place in the course of evolution, between *Eugereon* and the most densely veined types of *Fulgoridæ*, if the venation of the former had undergone a great deal of reduction and fusion of parts. That being so, it seems to me that the Protohemiptera are best regarded as a separate Order lying right off the main line of descent of the Hemiptera proper; the connection between the two being only establishable through a lost Carboniferous ancestor common to both.

The Palæohemiptera, on the other hand, are so obviously Hemiptera, that there seems to be no point at all in erecting a separate Order to contain them. Most of the Liassic fossils known are, in fact, definitely placed within the Homoptera by Handlirsch; and it is quite evident that they rightly belong there. Only the genus *Dysmorphoptila* Brodie, is retained within the Palæohemiptera; and, as this is probably a fragment, we may disregard it. Turning to the Permian fossils, we find two beautifully preserved wings, *Scytinoptera kokeni* Handl., and *Prosbole hirsuta* Koken, which are placed together in the Order Palæohemiptera. The former, I would regard definitely as an Homopteron; the latter most certainly combines the wing-characters of both Heteroptera and Homoptera, and could not well be placed in either Suborder without disregarding its evident affinity to the other. I propose, therefore, to sink Handlirsch's Order Palæohemiptera to the status of a Suborder within the

Order Hemiptera, this Suborder representing the original main stem of the Order, while the Heteroptera and Homoptera represent two distinct branches evolved from it.

Let us now compare *Prosbole* (Text-fig.21) with the restored wing of *Dunstania*, with a view to the establishment of a more complete phylogeny of the Heteroptera.



Text-fig.21.
Prosbole hirsuta Koken, hemelytron, after Handlirsch; (×2·1).
Upper Permian, Kama River, Russia; *n*, node.

We notice, at once, that *Dunstania* is much more definitely Heteropterous, in that it shows the distinction between corium and membrane much more plainly than *Prosbole* does. Moreover, the corium of *Prosbole* is strongly pitted, while the membrane is smooth. In *Dunstania*, both are strongly pitted, while, in *Dunstaniopsis*, the corium is smooth and the membrane pitted. If, then, these genera had a common ancestor, it must have had a wing pitted all over, such as we find still preserved in many Homoptera. In most recent forms, the pits are swollen into tubercles, and no longer carry hairs; but there can be little doubt, from the nature of the pits in *Dunstania*, that, originally at any rate, they were the bases of insertion of macrotrichia. As we have already seen in the Protomecoptera, the macrotrichia were originally carried upon a dense meshwork of veinlets all over the wing. If, then, the wings of the Protohemiptera were also hairy, we are led to suggest that the true Hemiptera diverged from them by a reduction of the original meshwork, in the course of which the pits, or bases of insertion for the macrotrichia, became seated upon the membrane of the wing; just as, in the Lepidoptera, the scales have appeared in a similar manner.

The original pitted wing of the true Hemiptera may be considered to have given origin directly to the various wing-types still extant amongst the older families of recent Homoptera: the main developments in this latter Suborder are not to be found in the wing at all, but in the specialisation of the head and antennæ, and in the development of the power of leaping. In this connection, we should bear in mind that a number of Homoptera, especially in the *Cicadidæ*, still show the dividing line between corium and membrane.

We have now to consider the origin of the Heteroptera. For this, we cannot take *Prosbole* itself as a starting point; but we must go back a little way beyond this type, and assume a closely similar ancestral form with a wing pitted all over. Keeping the *main scheme* of venation unaltered, we may now see the origin of the Heteroptera in a form in which the tendency of evolution in the basal half of the wing was towards *suppression* of the venation and hardening of the wing-membrane (with or without loss of the pits); while, in the distal half of the wing, the cross-veins of dense Fulgorid-like venation still preserved in *Prosbole* become obsolete, and the remaining venation becomes greatly altered, in correlation with the differentiation of the dividing line between corium and membrane.

I think that a very little consideration, aided by a comparison of the figures of *Prosbole* and *Dunstania* here given, must convince us that *Dunstania* represents a very typical immediate derivative from the hypothetical ancestor of *Prosbole*, from which we started in the preceding paragraph, along the lines there indicated as leading directly to the Heteropterous type. That is to say, *Dunstania*, though not directly derivable from *Prosbole*, is nevertheless closely related to it; but, while *Prosbole* itself cannot be accepted as having advanced along the line of the true Heteroptera, and must, therefore, be kept in a separate Suborder Palæohemiptera, *Dunstania*, on the other hand, has advanced far enough to be considered a definite Heteropteron of a primitive type.

Let us now consider the very interesting question of the evolution of the dividing line between corium and membrane in the Suborder Heteroptera. *Dunstania* shows us this line in an exceedingly primitive condition. From it, we see that its anterior portion was originally composed of either branches of main veins, or cross-veins. But, as the main veins are all proceeding more or less distad, it is, therefore, inevitable that these various parts should meet at different angles, as we see so definitely shown in *Dunstania*.

The parts of the dividing line may be shown as follows, starting from the node or costal end (see Plate lix., fig.15, and Text-figs.18-19):—

A. Anterior Division, formed from cross-veins and branches of main veins:

1. The *node*, formed from the fused C and Sc.
2. Radial portion, formed from short parts of R_1 and R_2, partially fused together.
3. A short cross-vein connecting the radial portion with the median portion.
4. Median portion, consisting of a swollen root on M, from which the three branches of M are given off.

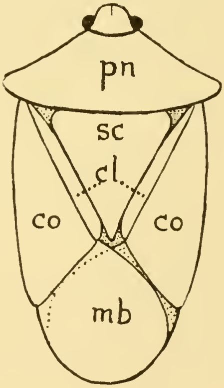
B. Posterior Division, consisting of a sinuous line crossing the wing more or less transversely, and not carrying either cross-veins or parts of main veins:

5. Medio-cubital portion, from the swollen root of M to Cu; the curvature of this part is concave to the corium.
6. Cubito-anal portion, from Cu to the antinode; the curvature of this part is slightly convex to the corium.

In the evolution of such a type as a recent Lygæid or Pentatomid Bug, all these diverse parts have to become aligned and fused into one harmonious whole. Probably a careful study of existing types amongst the Heteroptera would reveal many traces of the method by which this change has been brought about.

The other point of outstanding interest in the evolution of the Heteropterous hemelytron is the development of the clavus, which is correlated with the growth of the scutellum. We are bound to assume that, in the original Hemiptera, the scutellum was of more normal size than it now is; and, consequently, the wings were not so completely folded over one another distally as they now are. In fact, we have to start from the normal type of scutellum and the roof-like position of holding the wings, still to be found in many Homoptera of the present day. From this, a gradual enlargement of the scutellum, together with a close folding-down of the wings upon one another, leads us to the condition found in recent Heteroptera. Here the dividing line marks the limit of the portions of the wing that are folded upon one another; while the anal area, or clavus, borders the two posterior sides of the large triangular scutellum. Thus we have to correlate the length of the clavus with the size of the scutellum, the tendency being towards enlargement as evolution progresses. Since, in *Dunstaniopsis*, there is no trace of a clavus in the preserved part of the wing, and the same is true of *Prosbole*, we have to conclude that both these forms had only a small or moderate-sized scutellum, bordered by a correspondingly short clavus, or even, perhaps, by scarcely any claval area at all.

As soon as the overlapping of the two distal parts of the wing, or membranes, has been brought about, it will be clear that these two parts will in future act (while the insect is at rest) as one only; whereas the coria of the two wings remain separate. There will, therefore, be little tendency towards the thickening of the membrane at all, and the "heteroptery" might be expected to advance more quickly than ever. The line of evolution would then culminate in forms having a thick corium, from which all traces



Text-fig. 22.*

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* Diagram of a Shield-bug, family *Pentatomidæ*, to show the five parts of the shield, viz., 1, the pronotum, *pn*; 2, the scutellum, *sc*; 3 and 4, the right and left coria, *co*; and 5, the two completely overlapping membranes, *mb*. The clavus, *cl*, borders the scutellum on either side.

of venation had been eliminated, and a thin membrane, in which the veins were arranged more or less parallel to one another and to the wing-border. Probably the highest point reached by this line of evolution to-day is to be seen in the dominant family *Pentatomidæ*, in which the shield-shaped or "cut-into-five" appearance of the insect becomes perfected, and is often enhanced by bizarre sculpture and brilliant colouration. Text-fig. 22 shows the outline of such an insect, with the five separate areas of the shield-design named.

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EXPLANATION OF PLATE LIX.

Fig. 15.—Restoration of right hemelytron (forewing) of *Dunstania pulchra* Till., based upon the preserved portions of this fossil and of the allied *Dunstaniopsis triassica*, n.g. et sp.; (× 5).

Lettering of Text-figures.

A, analis—C, costa—*c.b.*, coriaceous border—*cl*, clavus—*co*, corium—Cu, cubitus; Cu_{1a}, Cu_{1b}, Cu_2, its branches on the membrane—*m* or *mb*, membrane—M, media; M_1 to M_4, its branches on the membrane—*n*, node—*n'*, antinode—*pn*, pronotum—R, radius; R_1 to R_5, its branches on the membrane—Rs, radial sector—*sc*, scutellum—Sc, subcosta.

THE GEOLOGY AND PETROLOGY OF THE GREAT SERPENTINE BELT OF NEW SOUTH WALES.

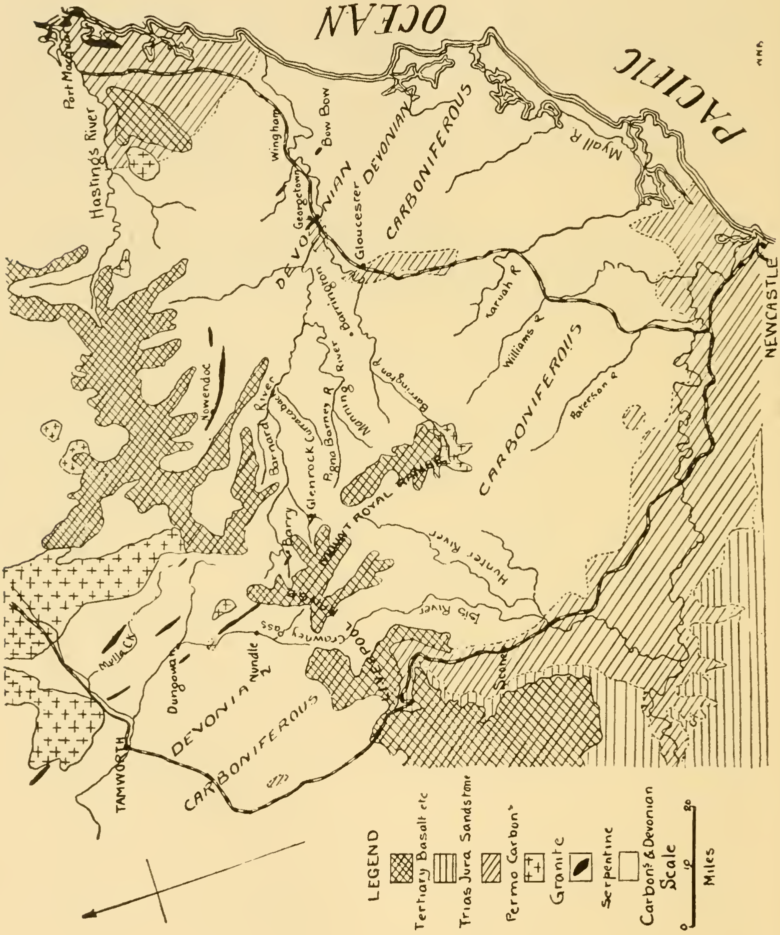
Part viii. The Extension of the Great Serpentine Belt from the Nundle District to the Coast.

By W. N. Benson, B.A., D.Sc., F.G.S., Professor of Geology and Mineralogy in the University of Otago, N.Z., late Linnean Macleay Fellow of the Society in Geology.

(With one Text-figure).

The previous parts published have described, in greater or less detail, the whole of the country along the Serpentine Belt, extending from Warialda to Hanging Rock, a distance of nearly 150 miles. Some facts, however, have been collected with regard to the further extension of the Belt, which may be worthy of record before this series of papers is concluded.

Somewhat to the west of the Serpentine-line, and about twelve miles south of Nundle, commences, on Wombramurra Creek, one of the largest masses of limestone in the State, which mass continues for some miles across the Main Divide, at Crawney Pass, into the head of the Isis River. This has, as yet, been little studied. It was briefly described by Phillips, in 1875(**1**). Mr. Etheridge described a new coral therefrom, in 1898(**2**); and Mr. Dun, two years later, determined a large collection of fossils obtained by Mr. Cullen(**3**). It was visited by the writer in 1910, and has recently been studied by Mr. Carne, and is to be described in his forthcoming account of the limestones of New South Wales(**4**). Very little is known of its stratigraphical relationships to the other Devonian rocks; it seems to occur among a series of banded claystones like those of the upper portion of the Tamworth Series, or even of the Barraba Series, though, as pointed out in previous papers, the lithology of the Tamworth Series is not very constant, and the cherty facies is more marked



in the Tamworth-Nundle region than elsewhere. The following fossils were found to be present in this limestone, the letters M., L., and N. indicating whether the forms are also present in the

Moore Creek, Loomberah, or Nemingha horizons respectively.

Favosites gothlandica	M., N.
F. basaltica var. *moonbiensis*	N.
F. salebrosa	M., N.
F. multitabulata	M?, L., N.
A Stromatoporoid	M., L., N.
Diphyphyllum porteri	M., L., N.
D. sp.nov.	
**Sanidophyllum davidis*	M., N. (rare).
Tryplasma, sp.nov.	M.?, L.?, N.?
**Spongophyllum giganteum*	M.
**Actinocystis cornu-bovis*	M.
Cyathophyllum sp.	L.?
Cystiphyllum australasicum	L.?
**Microplasma parallelum*	M.
Heliolites porosa	M., L., N. (rare).
**Syringopora auloporoides*	M.
Litophyllum konincki	M., L., N.
Alveolites sp.	M.?, N.?
Endophyllum schlueteri.	
Atrypa sp.	M.?, N.?
Euomphalus sp.	M.?

The association of the species marked with an asterisk, and the abundance of *Heliolites* are features very characteristic of the Moore Creek limestone, with which the great development of pure grey or white limestone also accords. The absence of the great abundance of Stromatoporoids, or Pentameroid shells, or of the signs of shallow water, distinguishes this from the Loomberah Limestone; and the want of association with fragmental igneous rocks, or with banded cherts, separates it from the Nemingha Limestone. It seems permissible, therefore, to correlate it with the Moore Creek Limestone.

East from here, across the Main Divide, the Serpentine Belt extends across the headwaters of the Manning River, through extremely rugged and broken country. It is the deeply dissected remnant of a plateau, over which extends a widespread series of more or less alkaline basic rocks, which were described by Mr.

Andrews, at the head of the Hunter and Manning Rivers, as being of two types, "one, a holocrystalline rock with large augite crystals so abundantly scattered throughout its mass as to obtain for it locally the name of 'plum-pudding stone.' Other types found there are dense, fine-grained, vesicular olivine-basalts"(**5**). The writer has shown that, among these, are to be found various types of basalt, basanite, dolerite, essexite, teschenite, and theralite, with sometimes an abundance of nepheline (**6**, **7**). Indeed, there is an assemblage of basic rocks quite analogous to those of the Bohemian Mittelgebirge, which Becke described as a typical instance of an assemblage of Atlantic rocks. The shapely cone of Wombramurra Peak, a few miles east of the Pass, was not visited by the writer, but is very analogous to the conical Gragin Peak near Delungra, Warialda, which Mr. Carne believes to be a centre of intrusion, and in which Mr. Card found olivine-dolerite. Mount Jellore, near Mittagong, 80 miles S.W. of Sydney, may possibly be of a like nature.

Serpentine occurs on this line at the Barry, at the head of the Barnard River, twelve miles distant from Nundle, and was here observed by Mr. Andrews, who remarked on the association with it of "diorites and basic rock-types," probably dolerites, and spilites (**8**). Mr. Longrigan, of the Barry, informed the writer of the occurrence of limestone east(?) of the serpentine on his property; and Mr. Stonier records the finding of *Favosites* in limestone on the Pigna Barney River, two miles above its junction with the Manning (**9**). Serpentine occurs again at Glenrock, some twenty-five miles south-east of Nundle (**8**), and local prospectors say that it is also present at the old " Polly Fogal " Diggings, which are not marked on any map, but are stated to be sixty miles east from Scone, and forty south-east of Nundle. An analysis of chromite obtained from here has been recorded (**10**). This must be near the Curracaback River, which is crossed by the serpentine (**8**).

North-east from this line, serpentine has been recorded from Nowendoc (**8**), doubtless among rocks of the Eastern Series, and will thus probably be on or near a line extending from the belt of serpentine recorded by Stonier (**11**), which extends from near

Dungowan Creek, at a point about six miles south-east of Dungowan township, across to the Mulla Creek, east of Moonbi. At the south end of this, the writer found antigoritic serpentine, and various intrusive doleritic rocks. A further northern continuation of this beyond the Moonbi granite is, perhaps, to be seen in the serpentine which occurs (*fide* D. A. Porter) near the head of Moore Creek, from which a nickeliferous opal was obtained(**12**).

Further to the south-east, Mr. Süssmilch and the writer(**13**) have observed the occurrence of serpentine at Mt. George, on the Manning River, and have remarked on the presence of the same rock at Glen Lewis, five miles to the north of this spot, and at Bow Bow near Tinonee, south of the Manning River, twelve miles to the south-east of the last-mentioned occurrence. This last record, we owe to Mr. Card, who received specimens therefrom. Between this group of intrusions of serpentine and Gloucester, to the south-west, there is a great development of Middle and Upper Devonian and Lower Carboniferous rocks, extremely like those in the areas to the north, described in the preceding parts of this series. The strike is generally N.W.-S.E., with a S.W. dip. In the Middle Devonian beds there is an immense development of spilite with pillow-structure, rising to form Kangat Mountain. The geology is further complicated by the presence of an infaulted outlier of Permo-Carboniferous rocks, perhaps analogous to that recorded from the Nundle district(**14**). What exactly is the relationship of this district to those further to the north, has yet to be discovered. It lies rather too far to the east to be in the direct continuation of the main Serpentine-line, unless (as is quite possible) the direction of that line has been bent to the E.S.E. in the Manning River valley. In the absence of such a deflection, it may be suggested that the George Town serpentine is a continuation of the Mulla-Nowendoc line of intrusions, and that the southerly continuation of the main Serpentine-line is indicated by the serpentine and chromite, which occurs near Barrington(**15**), and the serpentine recorded by Mr. Andrews, on the Myall River(**8**). If this be so, however, the Carboniferous and

Devonian rocks of this region are so remarkably little altered, for rocks east of the main Serpentine-line, as to indicate somewhat different conditions from those which have prevailed in the districts north of Nundle. In either case, it is probable that the Serpentine-line will eventually be traced from Nundle down to the coast, thus adding another hundred miles to the hundred and fifty already mapped, and thus forming one of the most continuous structural lines in the State.

A few words may be given with respect to the serpentines of Port Macquarie, which were described by Mr. Carne(**16**). In this region, the predominant strike is to the N.N.E. It has been suggested that the serpentines here lie on the same line as those of the Great Serpentine Belt, which has swung round from the S.S.E. to the S.E., and eventually into the N.N.E direction, and thence swings further round to include the serpentines of the Clarence River, recorded by Professor David and others(**17**). The Serpentine-line, on this hypothesis, forms a discontinuous ring about the strongly compressed Permo-Carboniferous rocks and the great granitic masses of north-eastern New South Wales(**18**). The writer has pointed out, however, that the presence of a N.W. to N.N.W. strike so close to the coast as the Gloucester District renders this suggestion improbable, and indicates rather that the Port Macquarie N.N.E. line of strike is more likely to be on a virgation passing off from the main N.N.W. direction. Several such virgations have been noted between Bingara and Nundle, notably at Mundowey on the Namoi River(**19**), though they have not been traced into a greater divergence from the main direction than a N.-S. line of strike. Such an hypothesis, however, involves a much simpler distribution of folding forces than that necessary to explain the discontinuous ring of intrusions, though the latter would not be entirely without analogies. A comparison, though an extremely strained one, might be made with the discontinuous line of serpentine-intrusions around the Central Granite of the Austrian Tyrol, but it is very doubtful whether such a comparison would indicate any real analogy, so diverse are the other features in the two areas (see **20**).

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THE STEMS OF CLIMBING PLANTS.

By John Shirley, D Sc., and C. A. Lambert.

(Plates lx.-lxvi.).

In botanical excursions with the Field Naturalists' Club or Royal Society, it has been a constant source of interest that climbing plants of the Orders Bignoniaceæ and Menispermaceæ could be partly determined by studying the cut ends of their stems. This determination extended only to the Order, and not to the genus or species. In Bignoniaceæ, the determining factor was the arrangement of the bast in four masses, or in multiples of four, each mass usually presenting rectangular outlines in transverse section. In Menispermaceæ, the rays of wood and bast have usually a stellate arrangement, the vascular bundles being separated by broad, multiseriate medullary rays, which, in transverse sections of the stem, appear club-shaped from dilation of the last-formed cells.

To test whether similar peculiarities marked the structure of climbing plants of other Orders, some fifty-three stems were sectioned, and their slides photographed by my colleague, Mr. C. A. Lambert.

List of Species examined.

Acanthaceæ.—*Thunbergia grandiflora* Roxb., *T. laurifolia* Lindl.

Ampelideæ.—*Vitis hypoglauca* F.v.M., *V. opaca* F.v.M., *V. sterculifolia* F.v.M.

Apocynaceæ.—*Beaumontia grandiflora* Wall., *Melodinus acutiflorus* F.v.M., *Trachelospermum jasminoides* Lindl.

Asclepediaceæ.—*Cryptostegia grandiflora* R.Br.

Bignoniaceæ.—*Adenocalymma nitidum* Mart., *Bignonia floribunda* H.B.& K., *B picta* Lindl., *B. Tweediana* Lindl., *B. venusta* Ker, *Tecoma Hillii* F.v.M., *T. jasminoides* Lindl.

Combretaceæ.—*Quisqualis indica* Roxb.

Compositæ.—*Senecio tamoides* DC.

Convolvulaceæ.—*Ipomœa Horsfalliæ* Hook.

Cucurbitaceæ.—*Bryonia laciniosa* Linn.

Leguminosæ.—*Abrus precatorius* Linn., *Bauhinia scandens* Burm.,(= *B. corymbosa* Roxb.), *Derris scandens* Benth., *Lathyrus odoratus* Linn., *Milletia australis* F.v.M., *M. megasperma* F.v.M., *Wistaria chinensis* DC.

Loganiaceæ.—*Buddleia madagascariensis* Vahl.

Malpighiaceæ.—*Banisteria chrysophylla* Linn., *Hiptage Madablota* Gærtn., *Stigmaphyllon jatrophæfolium* Juss.

Menispermaceæ.—*Carronia multisepalea* F.v.M., *Legnephora Moorii* Miers, *Stephania hernandiæfolia* Walp.

Nyctagineæ.—*Bougainvillea lateritia* Hort., *B. Sanderiana* v. *variegata* Hort., *B. spectabilis* Juss.

Passifloreæ.—*Passiflora suberosa* Linn.

Piperaceæ.—*Piper nigrum* Linn.

Polygonaceæ.—*Antigonon leptopus* Hook.

Rubiaceæ.—*Cœlospermum paniculatum* F.v.M.

Solanaceæ.—*Solanum Wendlandii* Hook. f.

Urticaceæ.—*Ficus pumila* Linn.

Verbenaceæ.—*Faradaya splendida* F.v.M., *Petræa volubilis* Linn.

Aroideæ.—*Monstera acuminata* C. Koch, *Pothos aureus* Linden.

Flagellarieæ.—*Flagellaria indica* Linn.

Liliaceæ.—*Asparagus racemosus* Willd., *Geitonoplesium cymosum* A. Cunn., *Rhipogonum album* R.Br., *Smilax australis* R.Br.

Orchidaceæ.—*Galeola cassythoides* Reichb.

The study had not proceeded far, when it was seen that any grouping in Natural Orders was impossible, as similar characteristics were common to plants of many different families, especially among Dicotyledons. It was necessary, therefore, to create classes, among which the stems could be distributed, and the following are submitted.

Subclass i. DICOTYLEDONES.

1. **Normales.**—The stem shows a single cambium-ring, with the wood and bast of each bundle lying along the same radius, the exterior outlime of the bast approximating to a circle. Type, *Cœlospermum paniculatum* F.v.M.

2. **Chiastoxylon.**—A single zone of cambium, with anomalous distribution of tissues in young stems into four rays, each of alternating wood and bast, the bast reaching (*a*) partly to the pith, or (*b*) stopping short of it. Type 2 (*a*), *Bignonia Tweediana* Lindl., 2 (*b*), *B. picta* Lindl.

3. **Astroxylon.**—Normal cambium, with definite and continuous separation of fibro-vascular bundles by means of pluriseriate medullary rays, that present, in transverse section, a stellate arrangement. Type, *Carronia multisepalea* F.v.M.

4. **Endophloia.**—Besides the normal bast, a second development of bast occurs at the inner margin of the ring of wood, forming bicollateral bundles. Type, *Bryonia laciniosa* Linn.

5. **Exocycla.**—Besides the normal cambium-ring, new cambium-zones appear successively in centrifugal order. Type, *Wistaria chinensis* DC.

6. **Phloiocycla.**—New zones of bast produced in each period of vegetation in centripetal order. Type, *Vitis sterculifolia* F.v.M.

7. **Polycycla.**—The oldest vascular bundles lie in the pith; outside the pith, a normal zone of wood and bast is formed, or alternating rings of wood and bast may be formed. Type, *Bougainvillea spectabilis* Hort.

Subclass ii. MONOCOTYLEDONES.

1. **Vulgares.**—Possessing the usual rind, hard ground-parenchyma, and scattered, closed bundles of the ordinary monocotyledon.

2. **Abnormales.**—Differing from the typical monocotyledonous stem in one or other of the above peculiarities.

Subclass i. DICOTYLEDONES.

1. **Normales.**—To this section belong *Banisteria chrysophylla* L., *Cœlospermum paniculatum* F.v.M., *Cryptostegia grandiflora* R.Br., *Faradaya splendida* F.v.M., *Hiptage Madablota* Gærtn.,

Milletia australis F.v.M., *M. megasperma* F.v.M., *Senecio tamoides* DC., *Solanum Wendlandii* Hook. f., and *Tecoma jasminoides* Lindl , etc., etc.

(*a.*) CŒLOSPERMUM PANICULATUM F.v.M. (Plate lx., fig.1).—Although this stem is normal in having a single ring of cambium, and in regard to the formation of secondary wood, the pith presents peculiarities. It is made up of two elements; one, the ordinary pith-cell, containing starch; and the other, found mainly in the centre of the pith, a thick-walled, sclerotic cell. The latter form strands which do not extend to the circumference of the pith. They are akin to the gum-resin sacs, described by Karsten,* in the allied genera, *Cinchona* and *Ladenbergia.*

(*b.*) MILLETIA AUSTRALIS F.v.M. (Plate lx., fig.2).—Although normal in the development of its cambium-ring, this stem shows some special features. The pith is of very large cells, and, in transverse section, these seem to be radially arranged, forming conical masses. In the rays, the cells are elongated, and have not the usual hexagonal outline. The cambium-ring is very well defined, and, outside the bast, is a sclerenchymatous ring, 6 to 8 cells in depth, with intervals in which are inserted a few, much larger, thinner-walled cells, evidently a transfusion-tissue. Sacs containing single crystals abound in the cortex, and others with much larger single crystals are scattered through the pith.

MILLETIA MEGASPERMA F.v.M.—The arrangement of the pith is normal. The wood-vessels form radial rows, with large masses of murally arranged wood-fibres between them. There is a thick sclerenchymatous ring outside the bast, with transfusion-tissue at intervals; but, in this species, the thin-walled cells are oval, and elongated along radii passing through the transfusion-tissue. A second, much narrower, sclerenchymatous ring separates the periderm from the cork. The medullary rays differ little, in a transverse section from the wood-parenchyma.

(*c.*) SOLANUM WENDLANDII Hook. f., (Plate lxi., fig.3).—The central pith is of large cells. The ring of wood is very regular, the wood-fibres showing very even ranks, the cells increasing in size towards their inner boundary, and gradually merging in

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* Karsten, Die medic. China-rinden Neu-Grenadas, Ges. Beitr., p.382.

those of the pith. Outside the bast is a ring of sclerenchymatous cells, that apparently acts as an endodermis also. The bark shows all the usual tissues excellently—phelloderm, phellogen, cork, and epidermis with cutin. Scattered, sclerenchymatous elements are found also in the circumferential parts of the pith.

2. Chiastoxylon.

(*a*.) Bignonia Tweediana Lindl., (Plate lxi., fig 4).—In transverse section, the pith is roughly square in outline, and a rectangular ray of bast strikes the centre of each side of the square at right angles or nearly so. From the inner end of each bast ray, a small cone of wood (protoxylem) penetrates the pith to about one-sixth of its diameter. The pith-cells are filled with starch-grains. The wood is continuous round the pith, but forms a very narrow connecting band at the base of each bast-ray, near the protoxylem-masses already mentioned. The vessels occur in V-shaped bands, which are most definite near the bast. The wood-parenchyma forms irregular, radiate rows. The bast-rays project into the cortex at their circumferential limit, and preserve their shape as rectangular masses. Their bast consists of alternating strips of hard and soft bast, the latter of more rows of elements. The bast-rays are connected by a bast-ring surrounding the four masses of wood, and showing alternate strips of hard and soft bast, as in the rays. There is an incomplete circle of sclerenchyma within the phellogen, beyond which are 6-7 tiers of cork-cells bounded by dead bark.

(*b*.) Bignonia picta Lindl., (Plate lxii., fig.5).—The bast forms four square masses of five thin layers of hard bast, alternating with five broader layers of soft bast. Where these masses occur, the wood-tissues have about half their usual depth, and press on the central pith, giving it almost a square outline. The cambium is thick and definite. It is depressed at each of the bast-patches, so that the cambium-ring has a crenulated outline. On a circle outside the bast are a number of roughly elliptical masses of thick-walled sclerenchyma. A second narrow and almost complete ring of sclerenchyma, bounding the cork-cambium, is constructed of brick-shaped cells, whose cavities are almost obliterated.

3. **Astroxylon.**—Type, CARRONIA MULTISEPALEA F.v.M., (Plate lxii., fig.6).—The stele consists of a central pith, composed of very fine polygonal cells in which a few thick-walled ducts are inserted at irregular intervals. Of wood and bast, there are about thirty fibro-vascular bundles, each showing six to eight large vessels, increasing in size, as usual, from the centre outwards. Bordering the pith in each, is a cluster of mainly spiral vessels. Each medullary ray is well defined, and shows five to eight rows of brick-shaped cells, parting at the circumferential end to send, right and left, divisions round the separated bundles. The bast-masses are oval and well defined. They are flanked outwardly by older bast-tissues, now changed into sclerenchyma, to be finally cast off with the outer bark. The different layers of the bark are well defined, and the phelloderm assumes a wavy outline, parallel to the outward curves of the various bundles.

Lighter in colour than the rest of the stele, the medullary rays present a stellate pattern on a freshly cut, transverse section of the stem.

4. **Endophloia.**—BRYONIA LACINIOSA Linn.,(Plate lxiii.,fig.7).—The development of the stem is apparently normal, but the vascular bundles are bicollateral, having bast on both inner and outer faces. The vessels of the xylem are unusually large for a young stem in its second year of development. A large pad of cork is seen on the side of the stem that has flattened by pressure against the supporting plant. Very little pith is to be noted, and the cells of the medullary rays are peculiarly large and broad. There are signs of the production of interfascicular bast from the sides of vascular bundles.

5. **Exocycla.**—WISTARIA CHINENSIS DC., (Plate lxiii., fig.8).—The medullary rays are exceedingly well defined, usually of 2-6 rows of radially elongated cells. At their outer extremities, the cells, lying in the bast, are of larger size. The cambium-ring is also clearly defined, and outside it are 6-8 ranks of thin-walled bast-cells. The older bast-cells, pushed out towards the circumference, have most of their cavities obliterated by internal thickenings. The phellogen-ring is also well marked, and 3-5 layers of dead cells lie outside the cork. Cortex and pith show sacs

containing single, lozenge-shaped, octahedral crystals. The remains of a former cambium-ring are seen in the wood about one-third of the distance from pith to cortex. A third cambium-ring is seen forming in the bast, from which additional rings of xylem and phloëm will be created.

6. **Phloiocycla.**—VITIS STERCULIFOLIA F.v.M., (Plate lxiv., fig. 9).—The pith appears homogeneous. The medullary rays, 2-8 rows of radially arranged, brick-like cells, contrast clearly with the murally arranged wood-fibres. The vessels are large, and evidently capable of division. The medullary rays are as well defined between the bast-masses as between the wedges of wood. They increase in size towards the circumference of the transverse section, and take a clavate outline. The bast is composed of 8-10 rows of thin-walled cells, with a terminal, almost circular mass of sieve-tubes. Outside the stele, the remains of former bast-masses, now sclerotic, form a strengthening layer in the cortex. A few sacs containing raphides may be noted here and there; others contain single, larger, flattened crystals, and others, again, store starch-grains.

7. Polycycla.

(*a.*) BOUGAINVILLEA SPECTABILIS Juss., (Pl. lxiv., fig.10).—The centre of the transverse section of the stem contains the largest vascular bundles, scattered through the pith. The xylem and phloëm portions of each bundle are clearly defined, but the cambium is usually marked by a scar, where it has torn under the knife of the microtome. Outside these older and scattered bundles, is a clearly defined ring of two years' growth of younger bundles, normally dicotyledonous in general appearance, but having alternate circles of wood, bast, wood, bast. Between any two bundles of the outer ring are well defined medullary rays; but, at the interior end of each ray, the cells composing it become roughly polygonal, and merge into the pith-cells. When a new cambium appears, outside the last ring of bundles, the cells of the outer ends of the rays unite round the outer extremity of each bundle, so as to isolate the ring previously formed by a definite wavy circle of parenchymatous tissue. The bast arising from this latest-formed cambium consists of 6-8 rows of brick-like, thin-walled cells, outside of which is a single-rowed circle of sclerenchyma.

(*b.*) BOUGAINVILLEA LATERITIA Hort., (Plate lxv., fig.11), differs little from *B. spectabilis* and *B. Sanderiana*, except that numerous sacs containing clinorhombic crystals—raphides—are found in the periderm and pith. Where a bud is formed on the stem, the tissues entering the bud from the stele are full of these needle-crystal sacs.

(*c.*) BOUGAINVILLEA SANDERIANA Hort., (Plate lxv., fig.12).—This section (× 90) shows the central and first-formed vascular bundles isolated in the pith, as in the case of its allies; and four annual zones of alternating wood, bast, and encircling medullary ray-tissue. This last might be taken for cambium, but is quite distinct in the character of the cells composing it, from that of the last-formed cambium-ring. Periderm, cork, and the dead cells of the outer bark are well shown.

(*d.*) PIPER NIGRUM Linn., (Pl. lxvi., fig.13).—The general structure of this stem is similar to that of Bougainvillea. The first-formed set of bundles, seven in number, develops cambium within each bundle, but not between them. These bundles are further isolated by the growth of the pith. Circumferentially, other cambium-tissues form, making a complete wavy ring, and give rise to a normally developed set of vascular bundles of the usual dicotyledonous arrangement. Lying in the pith, outside each of the original isolated bundles, is a resin-duct; and a larger one occupies the centre of the stem. Bounding the outer, normal ring of vascular bundles on the inner side, is a complete wavy ring of sclerenchyma, of about six irregular rows of thickly strengthened, polygonal cells. An indefinite ring of sclerenchyma, its cells elongated circumferentially, surrounds the outer ring of wood and bast.

STEPHANIA HERNANDIÆFOLIA Walp.—In a first year's shoot, there is a remarkable similarity between the cells of the pith, medullary rays, and periderm. As in *Piper nigrum*, the stele is bounded by a scolloped line, outside of which new cambiums arise, and new rings of wood and bast are developed.

ii. MONOCOTYLEDONES.

1. **Vulgares.**—To this section belong *Asparagus racemosus* Willd., *Flagellaria indica* Linn., *Geitonoplesium cymosum* A. Cunn., *Rhipogonum album* R.Br., and *Smilax australis* R.Br., &c.

2. **Abnormales.**—GALEOLA CASSYTHOIDES Reichb. f., (Pl. lxvi., fig.14).—In this leafless, climbing orchid, the bundles are numerous, and contain six large vessels, with a few smaller marking the protoxylem. In each vascular bundle there is a limited quantity of soft bast, and a few sieve-tubes. The ground-parenchyma is formed of larger cells than usual, and these are massed round the bundles, forming bundle-sheaths. In transverse sections of the stem, a roughly radiate arrangement of the cells of the ground-parenchyma is evident, in some sections showing four rays, in others with more and irregular rays. Numerous sacs containing raphides are seen in the ground-tissue. The contents of cells lying immediately within the bark show a brown discoloration; these are evidently attacked by a parasitic fungus, whose hyphæ can be seen within the brown cells.

Conclusion.—The whole of the abnormal stem-structures in climbing plants have, for their object, the free flow of elaborated sap in the bast-tissues. In Chiastoxylon, the stem so presses on the support as not to put pressure on the bast-masses; in Astroxylon, the broad medullary rays ensure the nutrition of the stele; in Hiptage, Bryonia, and *Solanum Wendlandii*, a thick pad of elastic cork is developed on that side of the stem subject to pressure, and so on.

Reference letters.—*b.*, Bast—*c.*, Cambium—*c.c.*, Cork-cambium—*ck.*, Cork—*cr.*, A crystal—*ev.*, Protoxylem—*fb.*, Fibro-vascular bundle—*h.*, Hair—*m.r.*, Medullary ray—*p.*, Pith—*ph.*, Phelloderm—*r.d.*, Resin-duct—*ry.*, (Fig.14), Three of the four rays traversing the ground-parenchyma—*s.*, Sclerotic cells—*sc.*, Sclerenchyma—*s.v.b.* (Fig.14), Secondary vascular bundles—*t.t.*, Transfusion-tissue—*v.*, Vessels of wood—*v.b.* (Fig.14), Vascular bundle with apparent bundle-sheath—*w.*, Wood—× (Fig.14), Traces of fungal hyphæ.

EXPLANATION OF PLATES LX.-LXVI.

Plate lx.

Fig.1.—T.S. *Cœlospermum paniculatum* F.v.M.; (×24). (1.**Normales**].
Fig.2.—T.S. *Milletia australis* F.v.M.; (×17). [1.**Normales**].

Plate lxi.

Fig.3.—T.S. *Solanum Wendlandii* Hook. f.; (×90). [1.**Normales**].
Fig.4.—T.S. *Bignonia Tweediana* Lindl.; (×17). [2 **Chiastoxylon**].

Plate lxii.

Fig.5.—T.S. *Bignonia picta* Lindl.; (×23). [2.**Chiastoxylon**].
Fig.6.—T.S. *Carronia multisepalea* F.v.M.; (×13). [3.**Astroxylon**].

Plate lxiii.

Fig.7.—T.S. *Bryonia laciniosa* Linn.; *ck.*, cork-layers on side facing support; (×23). [4. **Endophloia**].
Fig.8.—T.S. *Wistaria chinensis* DC.; (×40). [5.**Exocycla**].

Plate lxiv.

Fig.9.—T.S. *Vitis sterculifolia* F.v.M.; (×40). [6. **Phloiocycla**].
Fig.10.—T.S. *Bougainvillea spectabilis* Juss.; *ck.*, pad of cork opposite supporting branch; (×23). [7. **Polycycla**].

Plate lxv.

Fig.11.—T.S. *Bougainvillea lateritia* Hort.; (×90). [7. **Polycycla**].
Fig.12.—T.S. *B. Sanderiana* v. *variegata* Hort.; (×90). [7. **Polycycla**].

Plate lxvi.

Fig.13.—T.S. *Piper nigrum* Linn.; (×40). [7. **Polycycla**].
Fig.14.—T-S. *Galeola cassythoides* Reichb.; (×19). [MONOCOTYLEDON: 2. **Abnormales**].

ORDINARY MONTHLY MEETING.

October 30th, 1918.

Professor H. G. Chapman, M.D., B.S., President, in the Chair.

The President announced that the Council was prepared to receive applications for four Linnean Macleay Fellowships, tenable for one year from April 1st, 1819, from qualified Candidates. Applications should be lodged with the Secretary, who would afford all necessary information to intending Candidates, not later than 30th November, 1918.

The Donations and Exchanges received since the previous Monthly Meeting (25th September, 1918), amounting to 3 Vols., 50 Parts or Nos., 11 Bulletins, 1 Report, 5 Pamphlets, and 1 Map, received from 43 Societies, etc., were laid upon the table

NOTES AND EXHIBITS.

Mr. Fred Turner exhibited a specimen of a very rare plant, *Trichinium corymbosum* Gaud., var. *parviflora* Benth., from near Barringun, the only specimen he had seen in New South Wales.

Mr. Froggatt showed specimens of an Indian wood-borer (*Bostrychus æqualis* Jud.) introduced in the wood of boxes containing helmets; and likely to cause trouble unless looked after.

Mr. E. Cheel exhibited specimens of two distinct forms of plants commonly known as "Cobblers' Pegs" (*Erigeron linifolius* Willd.) showing the following characters:—(*a*) Plants with lacinated, basal leaves, and narrow, linear, upper leaves; and with comparatively small flowers; the commonest form. (*b*) Plants with very large, basal leaves, more or less serrated or toothed; and with much larger flower-heads than in (*a*). The two forms had been noted for the past five years in gardens, and on vacant land at Wynyard Square and other places in the city and suburban districts. He suggested that they were two distinct species, or it may be that one or other of the forms is heterozygous. Both are easily distinguished from the "Canadian Fleabane" (*E. canadensis* Linn.) found at Cronulla, but comparatively rare in this State; as well as from *E. bonariensis*, recently brought under notice by Mr. A. A. Hamilton, which is fairly common in New South Wales.—Also a series of seeds of "Soy Beans" (*Glycine hispida*), which originated from a form known in the trade as "Ebony Soy." The mother-plant "Ebony Soy," is a black-seeded form, which had been cultivated for four years, and had bred true. In the fifth year, one of the plants gave seeds of a greenish-yellow colour and distinctly green seeds in the same pods. This was distinguished under the name "Australia." When seeds of "Australia" were sown, the resultant F_1 plants gave seeds of the following colours:—(1) Plants with light brown pods, and seeds similar to those of the parent. (2) Plants with dark brown pods, and seeds similar to those of the parent. (3) Plants with dark pods, and black seeds. (4) Plants with ginger-coloured pods, and brown seeds. (5) Plants with brown pods, and dark brown seeds. When samples of the above were sown, the resultant plants (F_2) gave the following results. No.1 gave plants yielding greenish-yellow, black, brown, and green seeds similar to those of "Australia." The seeds of No.2 were similar to those of No.1. No.3 produced plants yielding some brown seeds, and others with black seeds, the pods and seeds in both instances varying in colour and in the shape of the seeds of different plants. No.4 gave plants yielding all brown seeds. No.5 produced results similar to No.4. Some distinctly green seeds were separated from No.1, and sown separately, and these yielded distinctly green-coloured seeds. The behaviour of these plants is very similar to that noted in certain "French Beans" (*Phaseolus vulgaris*), recorded in these Proceedings 1914, xxxix., p.160; and 1916, xli., p.192.

Dr. A. J. Turner exhibited a collection of Lepidoptera made on the journey across Canada, on his way back to Australia from England.

Dr. Tillyard showed a collection of Canadian Lacewings and Caddisflies, presented to him by Dr. A. J. Turner. Also a large Dragonfly (*Petalura gigantea* Leach), picked up on the pavement outside the Society's gate on the 25th inst., in an exhausted, but otherwise uninjured condition—a stray from the Blue Mountains under the influence of westerly winds.

Professor H. G. Chapman, on behalf of Miss M. Lilley and himself, exhibited some samples of yeast, on which observations had been made on the rate of multiplication of the yeast-cells, on the amount of sugar present, and on the production of alcohol and carbon dioxide. The figures obtained showed that most of the growth of the yeast occurred before the decomposition of glucose into alcohol and carbonic acid gas.

THE RELATION BETWEEN THE FAT-CONTENT AND THE ELECTRICAL CONDUCTIVITY OF MILK.

By H. S. Halcro Wardlaw, D.Sc., Linnean Macleay Fellow of the Society in Physiology.

(From the Physiological Laboratory of the University of Sydney.)

Milk consists of water containing substances in solution, in the colloidal state, and in suspension. The electrical conductivity of milk is due to the presence of ionised salts among the substances in solution. The colloidal and the suspended matter, the protein and the fat, do not contribute appreciably to the transport of electricity. These substances, in fact, depress the conductivity, for they displace a certain amount of conducting material.

The effect of protein on the conductivity of milk has been studied by Jackson and Rothera (1913). They removed the proteins from separated milk by dialysis, and found that each gram of protein in 100 cc. of the separated milk depressed the electrical conductivity by 2·76%.

The effect of fat on the conductivity is shown by the figures given by Taylor (1913). He found, as an average of five experiments, that the removal of 5% of fat from milk caused an increase of electrical conductivity of 11·4%. This increase of conductivity is more than twice as great as that which would be accounted for by the increased concentration of electrolyte due to the removal of the fat. The excess is ascribed by Taylor to the removal of the mechanical obstruction which the fat-globules may offer to the movement of the ions.

The object of the present work was to investigate more closely the relation between the fat-content of cows' milk and its electrical conductivity.

It has been found that, in a given sample of milk, the depression of conductivity is directly proportional to the fat-content; but that, in different samples of milk, the removal of equal amounts of fat does not lead to equal increments of conductivity. Various other properties of the milk have been examined in the endeavour to account for this difference between samples, but no definite correlation has been found.

1. *Relation between the fat-content of a sample of milk and its electrical conductivity.*—Mixtures of the same sample of milk with different percentages of fat were prepared by spinning the samples in a centrifuge to remove as much of the fat as possible, and mixing various proportions of the spun and the whole milk. The conductivities of these mixtures of known fat-content were determined.

The percentages of fat in the spun and whole milk were determined by the Röse-Gottlieb method; the percentages of fat in the various mixtures were obtained by calculation. The results have errors of not more than 2%.

The electrical conductivities were determined at 25°C., by the Kohlrausch method; a Wolff's Wheatstone-bridge was used, with a telephone as a null instrument The determinations were made in a conductivity-vessel provided with vertical electrodes. The measurements obtained were concordant to 0·5%. The details of these methods are given in a previous paper (Wardlaw, 1917).

As the effect of the fat on the conductivity is probably related more closely to the volume occupied than to the weight in a given quantity of milk, some preliminary determinations were made of the density of the fat in the samples examined; from these figures, the volumes can be calculated.

The density of the milk-fat was calculated from the densities of the spun and the whole milk. The figures obtained are given in the accompanying Table.

TABLE i.

Density of fat removed from cows' milk by spinning.

Sample.	Density of milk.		Percentage of fat.		Density of fat.
	Spun.	Whole.	Spun.	Whole.	
5	1·0312	1·0349	3·51	0·19	0·933
7	1·0307	1·0347	3·98	0·16	0·938
8	1·0308	1·0352	3·78	0·17	0·923
9	1·0306	1·0349	4·03	0·15	0·933
10	1·0312	1·0354	3·80	0·18	0·929
11	1·0310	1·0351	3·73	0·17	0·927
12	1·0303	1·0347	4·05	0·17	0·922
13	1·0308	1·0352	3·70	0·16	0·921
21	1·0317	1·0351	3·51	0·13	0·934
Mean					0·929

The determinations of density were made as described in a previous paper (Wardlaw, *loc. cit.*), water at 25°C. being taken as standard. The results have an error of about 1 in 10,000.

If the two errors are maximal and fall in opposite directions, the calculated density of the fat will have a possible error of about 2% The actual values obtained, as shown above, have an extreme range of rather less than this, from 0·921 to 0·938, and the variation from the mean is less than 1%.

The above results show that the densities of the fat removed by spinning from the samples of milk examined varied between 0·921 and 0·938; 0·93 has been taken as the mean value in the subsequent calculations. This value agrees well with that obtained by previous investigators (Fleischmann, 1885).

The following Table shows the percentages of fat and electrical conductivities (K) of various mixtures in whole and spun milk in the case of different samples, and the ratios of the decrements of conductivity to the corresponding increments of fat-content.

If the decrement of conductivity is directly proportional to the increment of fat, these ratios will be constant for each sample of milk.

TABLE ii.

Relation between electrical conductivity and fat-content of individual samples of cows' milk.

Sample.	Percent. of fat by vol.	Increment of fat.	$K \times 10^{-3}$.	Decrement of $K \times 10^{-2}$	$\frac{D.K \times 10^{-2}}{D.Fat.}$
1	3·75	2·60	4·72	2·9	1·1
	3·42	2·27	4·76	2·5	1·1
	3·12	1·97	4·79	2·2	1·1
	2·85	1·70	4·83	1·8	1·15
	2·60	1·45	4·85	1·6	1·1
	2·38	1·24	4·87	1·4	1·1
	2·19	1·04	4·88	1·3	1·25
	1·15	0	5·01	0	
2	0·29	0	5·43	0	
	1·57	1·28	5·30	1·3	1·0
	2·05	1·76	5·25	1·8	1·0
	2·45	2·16	5·23	2·0	0·95
	2·76	2·47	5·19	2·4	1·05
	2·98	2·69	5·18	2·5	1·0
	3·59	3·30	5·15	2·8	0·85
	4·01	3·72	5·06	3·7	1·05
6	0·23	0	5·38	0	
	1·78	1·55	5·26	1·2	0·8
	2·42	2·19	5·20	1·8	0·85
	2·80	2·57	5·18	2·0	0·8
	3·38	3·15	5·15	2·3	0·75
7	0·17	0	5·40	0	
	1·65	1·48	5·28	1·2	0·8
	2·18	2·01	5·26	1·4	0·7
	3·02	2·85	5·20	2·0	0·7
	3·53	3·35	5·18	2·2	0·65
	4·28	4·11	5·10	3·0	0·7

The values of K in this Table have a possible error 20 to 50 times that of the corresponding measurements of conductivity. The above figures show that the ratio of decrement of conductivity to increment of fat is constant to within the limit of error of the determinations for the samples of milk examined.

From these results, it will be seen that, for a given sample of milk, the depression of conductivity is directly proportional to the percentage of fat.

2. *Relation between fat-content and conductivity of different samples.*—The above figures also indicate, however, that the depression of conductivity due to a given increase of fat-content is not the same for different specimens of milk. To confirm this observation, a number of determinations have been made of the percentage-decrease of conductivity of spun milk due to the addition of 1% of fat. These figures are given in the last column of the following Table.

TABLE iii.

Percentage-depression of electrical conductivity due to the addition of 1 c.c. of fat to different samples of cows' milk.

Sample	Percent. of fat by vol.	D. Fat.	D. K $\times 10^{-3}$.	DK $\times 10^{-2}$.	DK% for 1 c.c. fat.
1	3·75		4·72		
	1·15	2·60	5·01	2·9	2·25
2	4·01		5·06		
	0·29	3·72	5·43	3·7	1·8
3	3·87		4·84		
	0·19	3·68	5·10	2·6	1·3
4	4·15		5·07		
	0·18	3·97	5·37	3·0	1·4
5	3·78		5·10		
	0·23	3·55	5·41	3·1	1·65
6	3·38		5·15		
	0·23	3·15	5·38	2·3	1·35
7	4·28		5·10		
	0·17	4·11	5·40	3·0	1·35
8	4·06		5·11		
	0·18	3·88	5·42	3·1	1·5
9	4·33		5·07		
	0·16	4·17	5·37	3·0	1·35
10	4·09		5·08		
	0·19	3·89	5·44	3·6	1·7
11	4·01		5·09		
	0·18	3·83	5·37	2·8	1·35
12	4·36		5·05		
	0·18	4·17	5·36	3·1	1·4
13	3·98		5·07		
	0·17	3·81	5·39	3·2	1·55
14	3·92		5·08		
	0·20	3·72	5·41	3·3	1·65
15	3·84		4·99		
	0·16	3·68	5·35	3·6	1·8

TABLE iii.—(*continued*).

Sample.	Percent. of fat. by vol.	D. Fat.	D.K × 10^{-3}.	D.K × 10^{-2}.	D.K % for 1 c.c. fat.
16	3·98		5·05		
	0·14	3·84	5·33	2·8	1·35
17	4·39		5·02		
	0·17	4·11	5·32	3·0	1·4
18	3·70		5·01		
	0·17	3·53	5·42	4·1	2·15
19	3·96		5·21		
	0·15	3·81	4·93	2·8	1·4
20	3·97		5·81		
	0·12	3·85	5·47	3·4	1·5
21	3·65		5·37		
	0·14	3·51	5·71	3·4	1·7
22	3·59		5·43		
	0·18	3·41	5·72	2·9	1·5
23	3·86		5·49		
	0·15	3·71	5·83	3·4	1·6
24	3·70		5·46		
	0·14	3·56	5·83	3·7	1·8
25	3·80		5·48		
	0·15	3·65	5·85	3·7	1·75
26	4·10		5·51		
	0·13	3·97	5·89	3·8	1·65
27	3·45		5·88		
	0·16	3·29	6·21	3·3	1·6
28	3·96		5·34		
	0·15	3·81	5·67	3·3	1·55
29	3·75		5·50		
	0·17	3·58	5·81	3·1	1·5
30	3·72		5·48		
	0·16	3·56	5·78	3·0	1·45
31	3·55		5·55		
	0·16	3·37	5·89	3·4	1·7
32	3·67		4·47		
	0·16	3·51	5·81	3·4	1·65
Mean					1·58

The figures in the above Table show that 1 c.c. of fat in 100 c.c. of milk depresses the conductivity 2·3 to 1·3% of the value for spun milk in the samples examined, the mean depression being 1·58%. The effect of fat on the conductivity in these cases is thus 30 to 120% greater than can be accounted for by the amount of conducting material displaced.

It was thought that this variable effect upon the conductivity might be due in some way to the method of removal of the fat from the milk. The milk might be concentrated slightly by evaporation during the process of spinning in the centrifuge. The conductivity of the spun milk would then be greater than could be accounted for by the removal of the fat. Or, substances other than fat might be removed by spinning. In this way also the electrolytes of the spun milk might become more concentrated, and the effect of the removal of the fat would be exaggerated.

To test the first of the above suppositions, the conductivity of samples of milk which had been spun covered to prevent evaporation was compared with the conductivity of samples spun uncovered in the ordinary way. The results obtained are given below.

Electrical conductivity of milk after spinning in covered and uncovered tubes.

Sample.	Conductivity.	
	Covered.	Uncovered.
3	5·08	5·08
4	5·37	5·35
5	5·39	5·40

These results show that there is no appreciable increase of conductivity due to the concentration of the milk by evaporation during spinning.

To test the second hypothesis, the amounts of total solid matter as well as of fat in the milk were determined. The following Table gives the weights of fat and of total solids in 100 c.c. of milk before spinning, and in the volume obtained after spinning (100 c.c. less volume of fat).

TABLE IV.

Weights of fat and of total solid matter removed from 100 c.c. of milk by spinning in a centrifuge.

Sample.	Fat in 100 c.c.		Solids in 100 c.c.		Wt. from 100 c.c.		Solids.
	Whole.	Spun.	Whole.	Spun.	Fat.	Solids.	Fat.
8	3·78	0·17	12·70	8·91	3·61	3·79	1·05
9	4·03	0·15	12·76	8·54	3·88	4·22	1·09
10	3·80	0·18	12·72	9·07	3·62	3·65	1·01
11	3·73	0·17	12·66	8·94	3·56	3·72	1·05
12	4·05	0·17	12·95	8·82	3·88	4·13	1·06
13	3·70	0·16	12·60	8·95	3·54	3·65	1·03
14	3·65	0·19	12·58	8·92	3·46	3·66	1·06
15	3·57	0·15	12·88	8·95	3·42	3·83	1·12
16	3·70	0·13	12·72	8·92	3·57	3·80	1·06
17	4·08	0·16	13·00	8·96	3·82	4·04	1·06
18	3·44	0·16	12·39	8·99	3·28	3·40	1·04
20	3·80	0·11	12·85	9·00	3·69	3·85	1·04
21	3·39	0·13	12·40	9·01	3·26	3·39	1·04
22	3·44	0·17	12·45	9·09	3·27	3·36	1·03
23	3·70	0·14	12·72	8·97	3·56	3·75	1·05
24	3·54	0·13	12·56	9·00	3·41	3·56	1·04
25	3·64	0·14	12·57	9·05	3·50	3·52	1·01
26	3·92	0·12	12·99	9·00	3·80	3·99	1·05
27	3·31	0·15	12·01	8·85	3·16	3·16	1·00
28	3·79	0·14	12·80	8·86	3·65	3·94	1·08
29	3·59	0·16	12·59	9·08	3·43	3·51	1·02
30	3·55	0·15	12·51	9·00	3·40	3·51	1·03
31	3·40	0·15	12·35	8·96	3·25	3·39	1·04
32	3·51	0·15	12·57	9·06	3·36	3·51	1·05

The above figures show that a certain amount of material other than fat is removed from milk by spinning. This is the material adsorbed by, and adherent to, the fat-globules, and as would be expected from the rather indefinite nature of its association with the fat, its amount is rather variable, ranging from 12% to 1% of the weight of fat removed. If this material be assumed to have the average density of the solids other than fat of milk, 1·6, then the volume occupied by it will be only 0·6 to 7% of the total volume removed. This increase of volume is quite insufficient to account for the excess of the effect of the fat on the conductivity over the volume-effect (30-120%).

3. *Effect of degree of subdivision of fat.*—It was thought that some light might be thrown on the variable effect of fat on the

conductivity of milk by examining the relation between this effect and the number of fat-globules in a given volume of fat.

The effect of non-conducting suspended matter on the conductivity of electrolytes has been studied by Oker-Blom (1900). He determined the conductivity of suspensions of sand in jellies made up with salt solutions, and came to the conclusion that the size of the particles (between 2 and under 0·5 mm.) made no difference to their effect on the conductivity, but that the sand depressed the conductivity less when uniformly distributed through the jelly than when collected into one layer. These conclusions are to a certain extent contradictory, however, as the difference between the first and second cases is mainly one of aggregation. Further, the range of size of particles examined in the first case was not very great.

The sizes of the fat-particles even in one sample of milk vary enormously. But each sample contains a certain average size and number of particles in a given volume, and well-defined differences exist between the sizes and numbers for samples of different origin. Strippings, for instance, contain larger fat-globules than first milk, and the milk of Jersey cows contains larger particles than the poorer milk of Shorthorn cows.

The number of fat-globules in the milk was counted by the method of Babcock (1886) as modified by Shaw and Eckles (1909). One volume of milk is diluted to 50 with water. The mixture is drawn up into capillary tubes, the internal diameters of the tubes are measured, and the numbers of globules in a known length are counted. From the figures obtained, the numbers of globules in a known volume of the undiluted milk may be calculated. The measurements are made with an ocular micrometer. The workers quoted made the optic measurements with the capillaries immersed in glycerine. It was found in the present work, however, that owing to the differences between the refractive index of glycerine and that of glass, the values of the diameter of the capillaries measured in this way were too high. The present measurements, therefore, were made with the tubes immersed in a solution of chloral hydrate in glycerine (7 : 1). This solution has a refractive index of 1·508, which is very close to that of the glass used. The measurements were checked by weighing the amount of mercury contained in a known length of the tube. The accompanying figures show that the optical measurements of diameter agree well with those calculated from the weights.

Tube.	Weight of Hg.	Length.	Diameter from weight.	Diameter optically.
1	1·35 mg.	13·57 mm.	0·097 mm.	0·096 mm.
2	1·075 ,,	17·35 ,,	0·0745 ,,	0·0735 ,,
3	0·955 ,,	16·15 ,,	0·74 ,,	0·072 ,,
4	1·22 ,,	22·2 ,,	0·071 ,,	0·072 ,,

These figures show that the results obtained by the two methods are concordant to within their limits of error.

In the following Table are shown the ratios of percentage of fat to the percentage-decrease of conductivity, and the numbers of fat-globules in 1 cu.mm for different samples of cows' milk.

TABLE V.

Degree of subdivision of milk-fat and its effect on the electrical conductivity.

Sample.	Fat in 100 c.c. D.K% for 1% fat.	Globules per cu.mm, milk $\times 10^{-6}$	Globules per cu.mm. fat $\times 10^{-4}$.
19	1·36	1·92	4·85
20	1·36	1·94	4·86
21	1·71	1·96	5·40
22	1·44	1·72	4·65
23	1·53	1·79	4·51
24	1·73	1·98	5·20
25	1·69	2·02	5·17
26	1·58	1·89	4·47
27	1·57	2·27	6·38
28	1·49	2·10	5·15
29	1·45	2·02	5·22
30	1·42	1·95	5·09
31	1·65	1·77	4·84
32	1·62	2·12	5·61

As will be seen from the above figures, no simple relation appears to exist between the depression of conductivity due to 1 c.c. of fat in 100 c.c. of milk and the average number of globules into which this amount of fat is divided, or the average size of the globules. The degree of subdivision of the fat thus does not seem to influence its effect on the conductivity in excess of the effect due to the volume displaced.

4. *The relation between the increase of viscosity due to the fat of milk and its effect on the electrical conductivity.*—The electrical conductivity of a solution of electrolytes depends on the velocity and concentration of its ions. One factor which determines the velocity of the ions is the resistance which the liquid of the solution opposes to their movement. In the case of aqueous solutions of salts only, this resistance is measured by the viscosity. In the case of systems which are not homogeneous, however, the viscosity of the system as a whole is not a measure of the resistance offered to the passage of ions. The addition of gelatine to a salt solution, for example, may increase the viscosity enormously, while the resistance to the movement of ions, as measured by the conductivity, is hardly affected. The system is no longer homogeneous, but consists of two phases.

Milk is such a heterogeneous system, and contains at least three phases. No simple relation is to be expected, therefore, between the viscosity of milk as a whole and its electrical conductivity. It was thought, however, that these two properties might be connected in some regular manner which would explain the disparity between the volume occupied by the fat of milk and its effect on the conductivity.

In the following Table are shown the effect of the removal of measured amounts of fat on the conductivity and viscosity of milk. The viscosities were measured in an Ostwald viscosimeter at 25°C. The values given are those compared with water as unity. The results have a maximum relative error of 1%.

Table vi.

Effect of fat on conductivity and viscosity of milk.

Sample.	Decrement of fat.	Increment of K.	Viscosity.		$\frac{DK\%}{DFat\%}$	$\frac{DV\%}{DFat\%}$
			Whole.	Spun.		
28	3·92	3·3	1·96	1·55	1·38	1·07
29	3·69	3·1	1·74	1·59	1·35	1·03
30	3·83	3·0	1·84	1·64	1·32	1·03
31	3·49	3·4	1·86	1·59	1·53	1·05
32	3·61	3·4	1·81	1·61	1·51	1·03

The above figures show that in these samples of milk a decrease of 1 gm. of fat in 100 c.c. diminished the viscosity from 3 to 7%. The corresponding increases of conductivity, however, are from 30 to 50% above the values due to the volume occupied by the fat. The diminution of viscosity is thus quite insufficient to account for the discrepancy between the volume occupied by the fat and its effect on the conductivity. It will be seen, too, that the increase of conductivity is not proportional to the decrease of viscosity.

These results also indicate that, in the samples of milk examined, the effect exerted on the conductivity by 1% of fat by volume is as variable as the effect exerted on the conductivity, and does not show that constancy which Taylor (*loc. cit.*) found in the samples examined by him.

5. *The behaviour of fat-globules in an electric field.*—If the fat-globules of milk carry an electric charge, they may retard the movement of ions in their vicinity, and in this way be responsible for the variable effect that fat exerts on the conductivity in addition to the effect due to the volume displaced. The attempt was made to observe whether the fat-globules were charged by placing milk in a shallow cell less than 1 mm. deep, provided with platinum electrodes (Chick and Martin, 1912). A current was passed between the electrodes, and the fat-globules were watched under the microscope. No movement was observed with a fall of potential below about 3 volts per cm. With higher voltages, bubbles of gas were formed at the electrodes, and caused movement of the globules mechanically. These experiments do not show conclusively that the fat-globules of milk

are not charged electrically. They indicate, however, that any charge carried must be small; much smaller, for example, than that carried by the particles of a suspension of coagulated protein, which show very evident movement in an electric field under conditions similar to those described.

SUMMARY.

(1). Removal of fat from milk increases the electrical conductivity.

(2). In a given sample of milk, the increase of conductivity is directly proportional to the volume of fat removed.

(3). The increase of conductivity due to the removal of a given amount of fat is not the same, however, in different samples of milk. The average increase of conductivity due to the removal of 1% by volume of fat is 1·5%.

In conclusion, I wish to express my indebtedness to Sir Thomas Anderson Stuart, in whose laboratory this work was done.

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THE PANORPOID COMPLEX.

PART 2. THE WING-TRICHIATION AND ITS RELATIONSHIP TO THE GENERAL SCHEME OF VENATION.

BY R. J. TILLYARD, M.A., D.SC., F.L.S., F.E.S., LINNEAN MACLEAY FELLOW OF THE SOCIETY IN ZOOLOGY.

(Plates lxvii.-lxix., and Text-figures 17-34).

If we cut off a small portion of the wing of any archaic Holometabolous Insect, such as, for instance, *Archichauliodes guttiferus* Walk., (Text-fig.22) of the Order Megaloptera, and make a cleared mount of it, we shall find that, when it is examined under a high power, both veins and membrane of the wing are covered with hairs. These hairs will be seen to be developed equally abundantly upon the upper and under sides of the wing.

This covering of hairs may be spoken of collectively as the *Wing-trichiation.* Though it is to be found in all Orders of the Holometabola, it does not occur in all Orders of Insects. It is, for instance, entirely absent from the wings of the Odonata.

Generally speaking, there may be found upon the wing of any Holometabolous Insect two types of hairs, which I have already named microtrichia and macrotrichia respectively **(5)**. These may be defined as follows:—

Microtrichia (Gr. μικρός, small; and θρίξ, τριχός, a hair) are minute hairs, generally much curved or hooked, which are developed in connection with every unspecialised hypoderm-cell of both upper and under surface of the wing. Hence they occur indiscriminately and exceedingly abundantly upon veins and membrane alike. Their bases of insertion appear as simple circular pits, in which, under a very high power, a central perforation leading into a very small lumen in the interior of the hair can be made out. They vary in length from under 1μ to about 30μ, but in most cases lie between 10μ and 20μ. Similar hairs are frequently present upon the softer parts of the body, as, for instance, on the abdominal sutures and pleuræ. (Text-fig. 17, *a*, *d*).

Macrotrichia (Gr. μακρός, large; and θρίξ) are much larger and stronger hairs, much less abundant, and only developed from large specialised hypoderm-cells (trichogen cells) in connection with special nerve-endings. They are thus of the nature of *sensillæ*, and homologous with similar hairs on other parts of the body. Their bases of insertion are in the form of raised circular rings, enclosing an opening in the cuticle, which is continued as a very definite lumen within the hair, almost to its very tip. These hairs are almost universally present upon the main veins and their branches, less frequently upon the membrane of the wing, and only in very special cases upon the true cross-veins. In several Orders they become evolved, in certain cases, by a process of flattening, into *scales*; but this development is only spasmodic except in the Order Lepidoptera, where scales are found universally. (Text-fig. 17, *b*, *c*, *e*, *f*).

Text-fig. 17.*

Those macrotrichia found upon the veins are usually somewhat larger and stronger than those found upon the membrane, and both series may vary considerably in size upon the same wing. In different insects, the limits of variation of these hairs may be placed at from 40μ to over 200μ. Text-fig. 17 shows two sets of fairly normal hairs, one from *Panorpa*, and one from *Rhyphus*.

It is the purpose of this Part to study the evolution of the Wing-Trichiation in the various Orders of the Panorpoid Complex. As this is partly dependent upon the state of evolution of

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* Hairs from the wings of *Panorpa confusa* Westw., (*a*-*c*), and *Rhyphus brevis* Walk., (*d*-*f*); *a*, *d*, microtrichia; *b*, *e*, macrotrichia from wing-membrane; *c*, *f*, ditto, from main veins; (×375).

the general plan of the wing-venation, it will be necessary, first of all, to define the composition of this venation somewhat more strictly than is usual.

According to the well-known, and by now generally accepted, theory of Comstock and Needham (**14**), the venation of an insect's wing has been originally determined by the courses of the precedent tracheæ, which supply the growing wing-rudiment of the larva or nymph. From the six main tracheæ that enter the growing wing, there are thus developed six *main veins*, known as the *costa*, *subcosta*, *radius*, *media*, *cubitus* and *analis*, respectively. Some of these main veins may be branched; such primary branches are termed *sectors*.

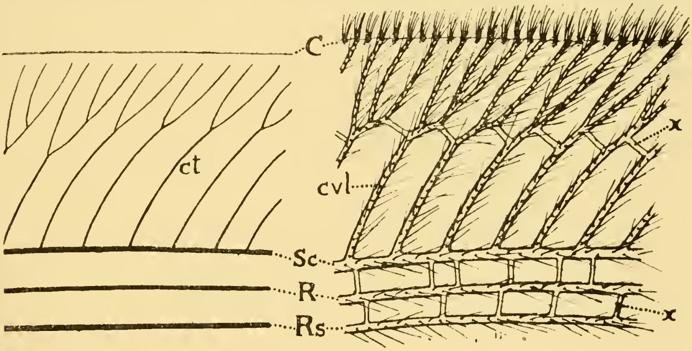
In the case of a main vein which branches and rebranches several times, it is clear that the final branchlets may be both very small and very numerous. I propose to term such branchlets *veinlets*. They are to be distinguished from cross-veins (see below) by the fact that they are always preceded by definite tracheæ.

In contradistinction to a veinlet, I propose to restrict the term *cross-vein* to a short connecting vein which does not form part of the branching system of any main vein, and is developed independently of the precedent tracheation.

It should be clearly understood that there is no reason why such true cross-veins should not be developed upon any portion of a wing, and *at any time*, provided the need for them arises. There is thus, in reality, no difference between true cross-veins and the so-called *false cross-veins*, which appear occasionally in newly-expanded areas of the wings of highly specialised genera; as, for instance, in the enlarged humeral area of the hindwing of *Lasiocampa*. The only difference between these newly formed cross-veins and those found in older wings is one of *time*; where the geological record is available to us, as in the case of the *Psychopsidæ*, the rise of the true cross-veins from a similar origin is clearly indicated.

In order to appreciate the difference between veinlets and cross-veins more clearly, I have figured the tracheation and corresponding venation of a portion of the costal area of the forewing of *Psychopsis elegans* Guérin, (Text-fig.18), in which this difference is very clearly shown. It will be seen that the branches passing into the costal area from the main subcostal vein (Sc) are all of the nature of *veinlets* (*cvl*), since they are all preceded by tracheæ. These veinlets are, however, supported by true *cross-veins* (*x*), which have arisen independently of the tracheation. Also, the narrow areas between Sc, R, and Rs are strengthened by true *cross-veins* (*x*).

In the known fossils of the *Psychopsidæ* and allies, we find the costal veinlets present as in recent forms. But there are no connecting cross-veins. Hence it is evident that these latter are a later development, called into existence by the need for strengthening the enlarged costal area of the wing.

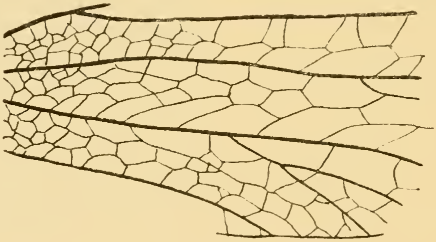


Text-fig.18.

Portion of enlarged costal area of forewing of *Psychopsis elegans* Guér., (×27), with the corresponding tracheation (to the left) of the pupal wing, (×60). C, costa; *ct*, tracheæ preceding the costal veinlets; *cvl*, costal veinlets; R, radius; Rs, radial sector; Sc, subcosta.

Referring again to Text-fig.18, we notice a further difference between the veinlets and the cross-veins. The former, like the main veins of which they are branchlets, carry a regular series of macrotrichia, whereas the latter have no macrotrichia at all. This distinction holds throughout the whole of the Holometabola, with only two exceptions, viz., the Raphidioidea and the higher families of the Planipennia, in which the macrotrichia appear upon the cross-veins as well as on the veinlets.

Having now clearly explained the difference between veinlets and cross-veins, let us now go back to the most primitive fossil insects, and study the venational scheme that they present to us. In the oldest known Orders, the Palæodictyoptera and their allies of the Upper Carboniferous, we find the same scheme of main veins as in recent insects. The spaces between these main veins and their branches are, however, filled up with an irregular meshwork of cellules, quite unlike anything to be seen in the Holometabola of to-day, though very probably homologous with the still-existing dense meshwork of cellules to be found in certain Orders of Hemimetabola, such as the Odonata. To this *original meshwork of cellules*, as developed in the Palæodictyoptera and their allies, I propose to give the name *archedictyon*. A portion of a typical archedictyon is shown in Text-fig. 19.



Text-fig. 19.

Portion of wing of the fossil *Hypermegethes shuckerti* Handl., (Order Palæodictyoptera), to show the archedictyon; (nat. size).

It is here necessary to disabuse our minds at once of the idea, if it exists, that the dense venation found in certain Planipennia is an archedictyon. Practically all known fossils of this Order (Triassic, Liassic, and Jurassic) have either no or few cross-veins, and the spaces between their numerous main veins and branches are devoid of any meshwork. Further, the oldest types still extant, such as the *Psychopsidæ*, *Ithonidæ*, etc., have no meshwork present; and it is demonstrable that the apparent meshwork present in the newer families, such as the *Myrmeleontidæ* and *Ascalaphidæ*, is to be traced back to a simpler arrangement of numerous parallel sectors supported by cross-veins at intervals. It is by the zigzagging of these sectors, and the consequent production of numerous polygonal cellules, that a meshwork appearance has been produced.

The essential characters of the original archedictyon, as we find it preserved in the Palæodictyoptera, are its irregularity, and the delicacy of the *venules* (I use this term as distinct from veinlets or cross-veins) that form it. Whether these first arose in connection with precedent fine tracheæ in the wing-rudiment, or entirely independently of them, or perhaps partly in one way and partly in the other, we have now no sure means of proving. We can only say that the irregularity of their courses, and the fact that, in one fossil at least, macrotrichia have been found to exist upon them, strongly suggest a tracheal basis.

It is now necessary to show the inter-relationship between the archedictyon proper, the veinlets and cross-veins of the wing, and the trichiation. Fortunately all these are preserved together in the fossil Order Protomecoptera, from the Trias of Ipswich, Queensland.

Plate lxvii., figs.9-10, show portions of the wing of *Archipanorpa magnifica* Till., the only known representative of this Order. Here we may see the archedictyon still complete, but evidently in a stage preparatory to becoming completely merged into the wing-membrane. The venules of the archedictyon are not definitely marked out, as in such fossils as *Hypermegethes* (Text-fig. 19), but appear rather as simple ridges of the cuticle, not showing any definite venular structure. In many places, but chiefly close to the main veins, and at the angles of the meshwork, there can be seen rounded or slightly oval tubercles, of a diameter considerably smaller than those seen upon the veins themselves, and, with few exceptions, less clearly preserved. These are evidently the bases of insertion of macrotrichia; but, partly owing to the weak development of the meshwork that carries them, and partly because they apparently lay more flatly along the wing-surface, their bases are not preserved as well as those on the veins, and very rarely show the two concentric circles which characterise the base of a stiff and more upright bristle. In my original description (**5**. Pl. viii., fig.6), I gave a diagrammatic figure of a small portion of the archedictyon of this fossil, much enlarged. I now consider this figure to be somewhat misleading, in that it made the macrotrichia of the meshwork appear as large and as clearly marked as those of the veins, whereas they are always smaller, and in most parts of the wing more difficult to make out. It will be readily seen from the photomicrographs that it is not an easy matter to give a correct drawing of this meshwork, and I think it better simply to give the photographs in this paper.

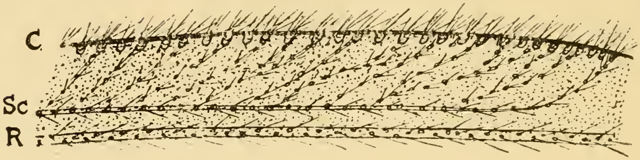
So well is this fossil preserved, that I have been able to find, in several parts of the wing, by the use of careful lighting, definite indications of the fine pitting due to the presence of microtrichia. Their bases of insertion are of about the same diameter as that of the average particle in the grain of the rock, viz., from 2 to 3μ. From a comparison with the microtrichia of *Panorpa*, we may therefore conclude that the length of these microtrichia was 40μ or more; *i.e.*, considerably larger than any to be seen in existing Holometabola.

Measurements of the beautifully preserved bases of insertion of the macrotrichia upon the main veins of this fossil show that the outer diameter of most of them lies between 30 and 40μ. This is much in excess of the size to be found in the wings of existing Orders, which seldom exceeds 10μ. Allowing some expansion due to the pressure upon the wing during fossilisation, it would still appear that this insect possessed macrotrichia very much stouter and longer than any now known to exist; their probable length was between 300 and 400μ. The macrotrichia upon the archedictyon were evidently smaller, and probably did not exceed 200μ, their bases of insertion averaging only 20μ.

The cross-veins in the fossil are clearly seen to be developed as strong struts between the main veins, and are quite independent of the archedictyon. With the exception of one or two macrotrichia that appear to have strayed on to them from the latter, they are found to be quite free from these hairs. Hence they show no evidence whatever of having been developed by straightening out of any portion of the archedictyon. If they had been so developed, it is clear that they must have carried macrotrichia, which they would receive from the archedictyon itself.

It will be seen, from the fossil *Archipanorpa*, that the macrotrichia occurred originally only upon the main veins and their branches, including the true veinlets, and upon the archedictyon. Cross-veins and membrane of the wing are alike free from them. When, however, the archedictyon is absorbed into the membrane (as it is on the point of being, in this fossil), it is evident that the macrotrichia that originally occurred upon the archedictyon must then become seated upon the membrane. This will explain their appearance upon the membrane in many Orders of Holometabola. But, if this explanation be correct, then the arrangement of the macrotrichia might be expected to show some signs of the original design of the archedictyon. If we draw the positions of a number of macrotrichia in any of the older Holometabola, we shall see that this is the case. For this, it will only be necessary to refer again to Text-fig.22, in which it will be seen that the macrotrichia below the main vein there figured tend to lie along oblique lines similar to the courses of the venules running out from the main veins in the fossil wing shown in Text-fig.19; and, like them, are connected by shorter cross-branches, indicated by the presence of macrotrichia lying in intermediate positions. (See also Text-figs. 21, 26, 30, 34).

Further evidence as to how the macrotrichia first appeared upon the membrane of the wing may be obtained by a careful study of the pterostigmatic region in the Planipennia. Text-fig. 20 shows this region in *Micromus tasmaniæ* Walk. The series of costal veinlets, that fills the costal space in all Planipennia, originally extended into the pterostigmatic region. Here there is a gradual thickening of the membrane taking place, with a correspondingly gradual absorption of the veinlets; all stages of this process can still be seen going on by studying various species in the families *Hemerobiidæ*, *Chrysopidæ*, and *Mantispidæ*. As these veinlets carry macrotrichia, it will be obvious that, as they disappear, the macrotrichia will become seated upon the membrane.



Text-fig. 20.

Pterostigmatic area of forewing of *Micromus tasmaniæ* Walk., showing aphantoneuric condition of the veinlets; (× 15). C, costa; R, radius; Sc., subcosta.

Thus we see that the evidence both of the fossil Order Protomecoptera and of the recent Planipennia agrees in pointing to the same conclusion:—*Macrotrichia were originally carried only upon the main veins and their branches, and upon the archedictyon; they appear upon the membrane by absorption of the veinlets or venules, carrying them, into the membrane of the wing.*

From this we come to the further conclusion that:—*The presence of macrotrichia upon the membrane of wings of an open-veined type (*i.e., *one which has no close meshwork of numerous veins) is to be regarded as evidence of the descent of such forms from more densely veined forms.*

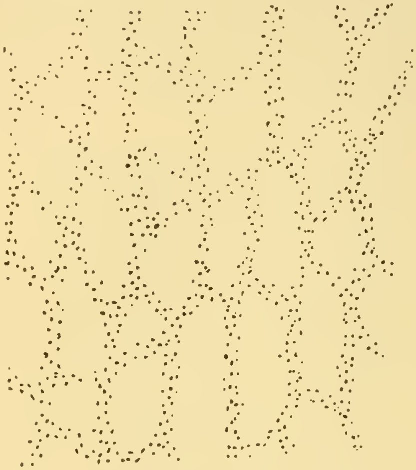
The process by which the archedictyon, or any series of veinlets, becomes merged into the membrane, may be termed *aphantoneurism*, and veins which are in process of disappearing in this manner may be called *aphantoneuric.* It is often possible to reconstruct the aphantoneuric meshwork, merely by plotting the positions of the macrotrichia upon the membrane, and joining them up into a polygonal meshwork. Text-fig. 21 shows a reconstruction of a small portion of the aphantoneuric meshwork of the Hawk-moth *Cœquosa triangularis* Don.

Having now explained how the Wing-trichiation is connected with the venation in general, we may proceed to trace out the various lines of evolution within the Orders of the Panorpoid Complex.

Order PROTOMECOPTERA. (Plate lxvii., figs.9-10).

We have already described above the condition of the trichiation in the wing of the Triassic fossil *Archipanorpa*, the only known representative of this Order.

It will be seen that this wing differs from all known Holometabola at present existing in having the archedictyon still present, upon all parts of the wing-membrane, in an aphantoneuric condition, and carrying macrotrichia upon it, mostly at the junctions of two or more venules.



Text-fig.21.*

Further, it should be noted that both macrotrichia and microtrichia are considerably larger in this fossil than in other Holometabola. The tendency towards reduction in size can be seen to be operating independently in all Orders; it culminates, in the case of the microtrichia, in their complete elimination from the wings of the higher families of the Planipennia and Lepidoptera; and, in the case of the macrotrichia, in a great reduction in their number and shortening in their length, in the case of the Diptera and certain Mecoptera.

Order MEGALOPTERA. (Text-fig.22).

The most archaic members of this family exhibit a near approach, in arrangement of the trichiation, to that seen in the Protomecoptera. We have selected the genus *Archichauliodes* as

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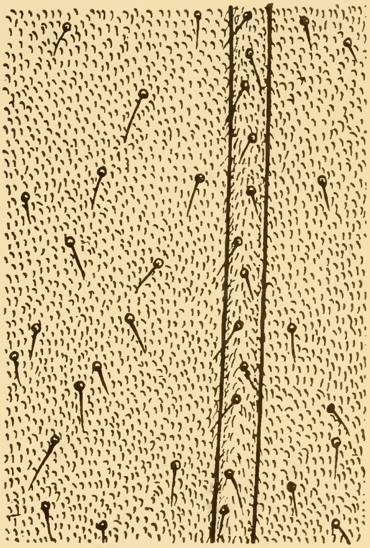
* Arrangement of the bases of insertion of the scales on a small portion of the wing of the Hawk-Moth *Cœquosa triangularis* Don., to show the pattern of the lost archedictyon; (× 50).

an illustration (Text-fig. 22); it belongs to the most archaic family *Corydalidæ*, of the Suborder Sialoidea.

The arrangement of the trichiation differs from that of *Archipanorpa* only in the complete loss of the archedictyon, and in the smaller size of both macrotrichia and microtrichia. As has been already pointed out, if the macrotrichia on any area of this wing be plotted out, they will still show, by their positions on the membrane, the pattern of the lost archedictyon. There is a well developed series of strong cross-veins supporting the main veins at wide intervals. None of these cross-veins carry macrotrichia. But the veinlets of the costal area and round the margin of the wing all show macrotrichia well developed.



Text-fig. 22.*

When we turn to the more specialised genera, we find a great advance over the condition seen in *Archichauliodes*. Take, for instance, the genus *Sialis*, of the family *Sialidæ*, Suborder Sialoidea. Here, although the microtrichia are still present abundantly all over the wing, yet the macrotrichia have quite disappeared, except round the fringe of the wing, and on the pterostigmatic area.

An advance in a different direction is to be seen in the Suborder Raphidioidea, of which the genus *Raphidia* will serve as an example. Here the microtrichia have completely disappeared, but the irregular thickening of the wing-membrane remains as

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* Portion of a main vein and surrounding membrane from the wing of *Archichauliodes guttiferus* Walk., to show the trichiation; (× 100).

an indication of that disappearance. The macrotrichia have also disappeared from the membrane, but are still present on the veins. As a high specialisation, only to be paralleled in the highest families of the Planipennia, we note also that the macrotrichia appear for the first time upon the true cross-veins, thus rendering them indistinguishable from veinlets except by the fact that they are not preceded by tracheæ in the pupal wing.

We may sum up the tendency of evolution of the trichiation in this Order by saying that both macrotrichia and microtrichia appear to have been, from the very first, of small size; and that, although the most archaic genera still show the original arrangement of the trichiation, preserved almost in full, yet reduction set in very early, leading to the loss of one or other series of hairs in all the higher types of the Order.

The wing-trichiation of the Archetype of this Order will be taken to be similar to that of the archaic genus *Archichauliodes*, but with hairs of somewhat larger size.

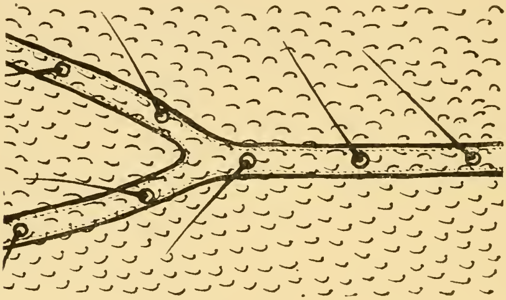
Order PLANIPENNIA. (Text-figs. 20, 23, 24).

The oldest known types of this Order show a wing-trichiation already specialised in certain directions. No traces of the archedictyon are to be found, and macrotrichia have, in every case, been eliminated from the membrane of the wing (Text-fig.23). This is easily understood, when we remember that the wing-venation of the Order early underwent a unique specialisation, in the form of a rapid proliferation of sectors of the main veins, and especially of the branches of the radial sector. This produced the "Prohemerobiid" type (still to be seen in recent *Psychopsidæ*) in which the whole of the wing is covered with numerous parallel longitudinal veins, with few or no cross-veins supporting them. In the very narrow spaces between these veins, it was clearly impossible for the archedictyon to exist, and the macrotrichia upon it probably disappeared with it.

Starting, then, from a type having no macrotrichia upon the membrane of the wing, we find a further specialisation, in the higher families of this Order, in the complete elimination of the microtrichia. Thus we may divide the Order into two groups, as follows:—

(1). The more archaic families, with microtrichia still present. These are the *Ithonidæ*, *Hemerobiidæ*, *Dilaridæ*, *Sisyridæ*, *Coniopterygidæ*, *Psychopsidæ*, *Polystœchetidæ*, and *Osmylidæ*.

(2). The more specialised families, with microtrichia absent. These are the *Trichomatidæ*, *Berothidæ*, *Chrysopidæ*, *Apochrysidæ*, *Mantispidæ*, *Nymphidæ*, *Nemopteridæ*, *Myrmeleontidæ*, and *Ascalaphidæ*.



Text-fig.23.

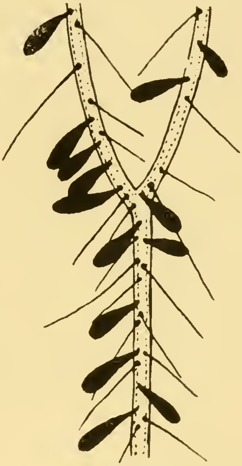
Portion of a main vein and surrounding membrane from the wing of *Micromus tasmaniæ* Walk., to show the trichiation: (×200).

In the first group, macrotrichia are never found upon the true cross-veins. In the second, we find in the *Trichomatidæ* and *Berothidæ* forms showing the passage of the macrotrichia from the main veins on to the cross-veins. For instance, in the genus *Stenobiella*, the cross veins remain without macrotrichia, as in the first group. In *Spermophorella*, one or two isolated macrotrichia may be found upon most of the cross-veins. In *Trichoma*, there is an intense proliferation of macrotrichia upon the main veins; and they overflow, not only on to the cross-veins, but also, in some places, even on to the membrane itself. As this genus is evidently specialised in its excessive hairiness, there can be little doubt that this latter occurrence is in the nature of a cænogenetic development, and is not to be considered as an archaic survival of macrotrichia from an original archedictyon.

Apart from the two families dealt with in the preceding paragraph, all those listed in the second group have the macrotrichia well developed upon the cross-veins.

Another interesting specialisation in this Order is the development of *scales*, which occur in the family *Berothidæ*. They occur upon a more or less restricted area of the hindwing, in the females only, of the genus *Spermophorella* (Text-fig.24), and upon the fringe of the wing in the genus *Isoscelipteron*. They are clearly only modified macrotrichia.

The Archetype of this Order, then, may be defined as having had the archedictyon and its macrotrichia completely eliminated, owing to the unique specialisation of the venation: the macrotrichia, consequently, only occurring on the main veins and their branches, but well developed: and the microtrichia also present and of normal size. From this original type, the line of evolution runs forward in the direction of complete elimination of the microtrichia, with subsequent invasion of the cross-veins by the macrotrichia, and with the occasional formation of scales (in two cases only).



Text-fig.24.*

Order MECOPTERA. (Text-fig.25).

In this Order, microtrichia are always exceedingly well developed all over the wing. Macrotrichia are found upon the main veins and their branches, but never upon the true cross-veins. The archedictyon has been completely eliminated, but its macrotrichia still persist upon the wing-membrane. (Text-fig.25). Owing, however, to the small number of macrotrichia that can

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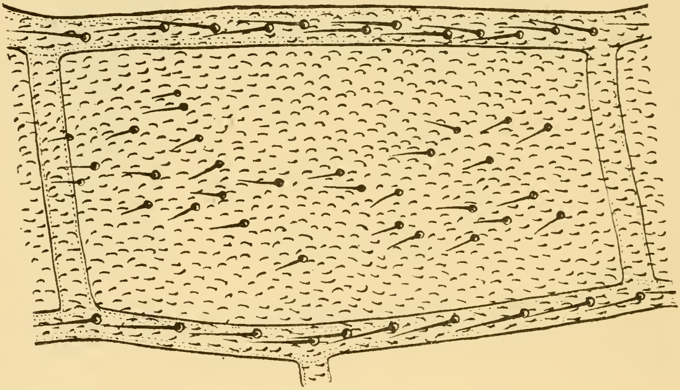
* Portion of a main vein from middle of hindwing of *Spermophorella disseminata* Till., ♀, showing normal macrotrichia interspersed with seed-like scales; (× 90).

be accommodated in the somewhat narrow spaces between the main veins, the original pattern of the archedictyon tends to become lost, and the macrotrichia of the membrane tend to become arranged in regular sets occupying the central part of any closed area of the wing.

The line of evolution in this Order is towards a gradual elimination of the macrotrichia from the membrane of the wing, and a reduction in their size elsewhere. In the most archaic families, such as *Meropidæ* (Text-fig. 25) and *Choristidæ* (Plate lxix., fig. 13), these hairs are still to be found upon the membrane, in almost every part of the wing. In the *Panorpidæ*, we may see the stages of gradual elimination from the basal areas of the wing, while those left in the more distal areas become, for the most part, very regularly arranged in rows parallel to the main veins. In the *Nannochoristidæ*, we see a further stage of reduction reached, the macrotrichia being here entirely absent from the membrane of the hindwing; while, in the forewing, they only remain upon the anterior portion of the pterostigma. Finally, in the highly specialised *Bittacidæ*, all the macrotrichia have



Text-fig. 25.

A single areole from the wing of *Merope tuber* Newm., to show the trichiation; (× 100). Note the absence of macrotrichia from the two cross-veins bounding the areole.

disappeared from the membrane, while those left upon the main veins have become short, stout spines, resembling those found in many Diptera.

As the true cross-veins are always weakly chitinised, and entirely free from macrotrichia in this Order, we have, in the macrotrichia, a valuable aid in the tracing out of the courses of the main veins. In many genera, the extreme base of Cu_1 is sharply bent up to join M not far from its origin, and so takes on the appearance of a cross-vein. But the true nature of this vein is still proclaimed by the presence of well-developed macrotrichia upon it.

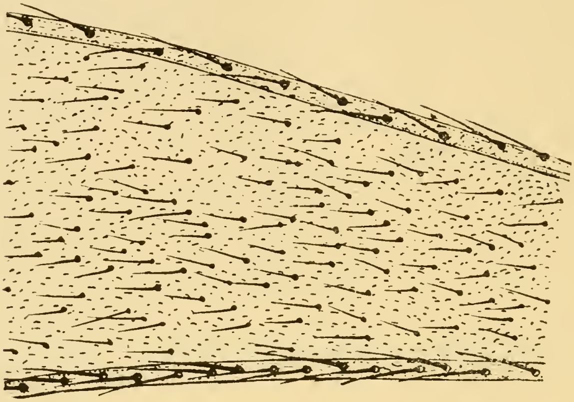
To sum up, then, we may characterise the Archetype of this Order as differing from that of the Protomecoptera only in the complete loss of the archedictyon. While the microtrichia remain constant throughout the course of evolution, the macrotrichia undergo a gradual reduction in size and number.

Order DIPTERA.

(Plate lxviii., fig.12; Plate lxix., fig.14, and Text-figs.26-29).

We take this Order next, since it appears to be, on the evidence of the wing-trichiation, a direct evolutionary derivative from the base of the Order Mecoptera.

Throughout the Order, microtrichia are present upon the wing. Macrotrichia are to be found upon the main veins and their branches; they tend to become reduced both in size and number. In only one family that I have examined are macrotrichia to be found upon the membrane, viz., in the *Rhyphidæ* (Plate lxviii., fig.12, and Text-fig.26). In this family, the structure and size of the macrotrichia are closely similar to those of the older Mecoptera. The arrangement of the macrotrichia upon the wing-membrane, however, shows the pattern of the archedictyon much more definitely than in any existing Mecopteron; so that, on this character, the *Rhyphidæ* can only be derived from a very early form of Mecopteron, if they are to be derived from that Order at all. In this connection, it is interesting to note that the family *Rhyphidæ* combines within itself characters of both the Nemocera and Brachycera. This accords well with the condition of the wing-trichiation; and the two characters taken together suggest that this family represents one of the most archaic types of Dipteron still existing.*



Text-fig.26.

Portion of two main veins and the included membrane from the wing of *Rhyphus brevis* Walk., to show the trichiation; (× 130). (See also Plate lxviii., fig.12).

From the type of trichiation still existing in the *Rhyphidæ*, all other types to be found within the Order are derivable, by elimination of the macrotrichia from the wing-membrane. There are, however, two distinct lines of evolution to be traced, in one of which the macrotrichia tend to become slender and elongated, and finally develop into scales; while, in the other, they tend to become short and stout spines, and also become gradually eliminated from all except the anterior veins and costal border of the wing.

As conspicuous examples of the first line of evolution, we may take the Moth Midges or *Psychodidæ* (Text-fig.27). Here we see the macrotrichia as slender hairs abundantly present upon

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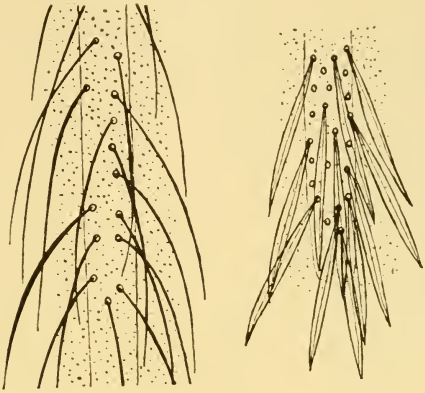
* In this connection, it should be noted that the short vein usually considered as a cross-vein connecting Cu_1 with M_3 in *Rhyphus* is really the basal piece of M_4, since it carries macrotrichia. On the other hand, the vein below it, usually considered to be the basal portion of Cu_1, is a true cross-vein and carries no macrotrichia.

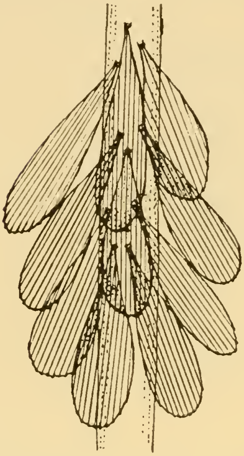
all the main veins and their branches. Here and there these hairs are seen to be slightly flattened out, forming delicate and narrowly lanceolate scales. The culmination of this same line of evolution is to be found in the *Culicidæ* (Text-fig.28), in which all the macrotrichia, even those along the wing-border, have become scales; and these scales, in most cases, are of broad form and specialised sculpture.



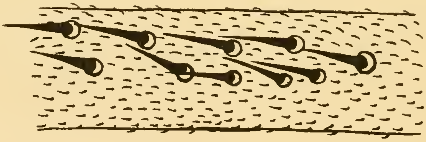
Text-fig.27.

Two portions of a single main vein from the wing of *Psychoda* sp., (Hornsby, N.S.W.), to show the trichiation. On the left, normal macrotrichia, one or two slightly flattened; on the right (distal end of vein), narrow lanceolate scales; (×375).

Along the second line of evolution, which has been followed by many families of Nemocera, and also by the whole series of the Brachycera and Cyclorrhapha, we can follow out the gradual elimination of the macrotrichia, through such forms as the *Tabanidæ*, where they are still present in large numbers on the more anterior veins of the wing, to the higher Cyclorrhapha, where they finally cease to exist anywhere except upon the costal border of the wing. Text-fig.29 shows the type of short, stiff seta into which the macrotrichia develop in this line of evolution. It should be noticed, also, that, concurrently with the broadening and strengthening of certain veins, the macrotrichia upon them become arranged two, three, or even four rows deep, so that the whole vein takes on a spiny appearance. Concurrently with this change in the macrotrichia, we find two lines of evolution of the microtrichia. They either undergo gradual reduction also, until they become partly or entirely eliminated, as in the family *Syrphidæ*; or they may remain well developed, with a differentiation setting in in the size of the two series on the upper and lower surfaces of the wing. In this latter case, the microtrichia on the *upper* surface increase considerably in size, while those of the lower surface remain fairly constant. This development takes place in the Myiodaria, and is especially well shown in the *Muscidæ*. In the Blowfly, for instance, the microtrichia of the upper surface of the wing are quite 30μ in length, and are set in large, swollen bases, while those of the lower surface are only about half as long, and have the usual small bases of insertion. (Plate lxix., fig.14).



Text-fig.28.*



Text-fig.29.
Small portion of a main vein from the wing of *Tabanus* sp., (Hornsby, N.S.W.), to show the trichiation; (× 200).

While, therefore, the main mass of the Diptera shows considerable specialisation in its wing-trichiation, we have to postulate

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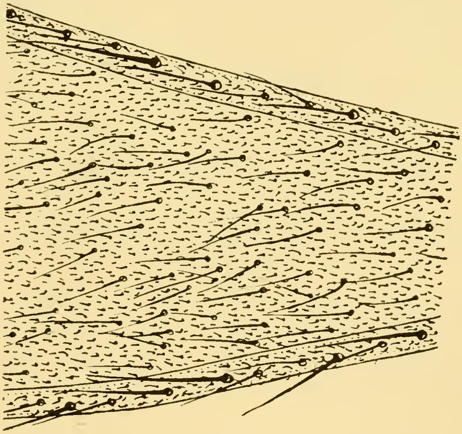
* Small portion of a main vein from the wing of a Mosquito, *Mucidus alternans* Westw., ♀, to show scales; (× 200).

for this Order, on account of the existence of the archaic *Rhyphidæ*, an Archetype similar to that of the Mecoptera, but with the microtrichia somewhat smaller than in that Order.

Order TRICHOPTERA. (Text-figs.30, 31).

In this Order, the most archaic types, such as the *Rhyacophilidæ*, already show considerable specialisation in their wing-trichiation. The archedictyon is always absent, but its macrotrichia are present upon the wing-membrane, and remain there, on the whole with ever increasing abundance, as we pass to the highest types within the Order. Microtrichia are present throughout the Order, but are always small, averaging about 5μ in length. Macrotrichia are present upon the main veins and their branches, but never upon the few and weakly developed cross-veins, except in the cases where the proliferation of these hairs upon the membrane leads to a secondary invasion of all parts of the wing.



Text-fig.30.

Portion of two main veins and the included membrane from the wing of *Rhyacophila dorsalis* Curtis, to show the trichiation: (× 105). (Microtrichia are slightly exaggerated in this figure).

In describing the macrotrichia of the Protomecoptera, we have already mentioned that those found upon the archedictyon were somewhat smaller in size than those upon the veins. This difference is also to be seen, somewhat more intensified, in the older types of Trichoptera, as may be seen in the figure taken from *Rhyacophila dorsalis* (Text fig.30). Not only are the macrotrichia of the veins larger, but they remain for the most part straight and stiff, whereas those of the membrane (derived originally from the archedictyon), are slenderer, and inclined to be slightly curved.

A single line of evolution may be said to characterise the whole Order. It consists in the gradual greater and greater proliferation of the macrotrichia of the membrane, together with various specialisations of the macrotrichia upon the veins. Thus there is produced that excessively hairy type of wing that is especially associated with this Order. In many genera, the stiff bristles of the veins become reduced, either in part, or altogether, to the same type of slender flexible hairs that we find upon the membrane; in others, certain sets of hairs, especially at the base of the cubitus, become erect and bristly. In the *Hydroptilidæ*, all the macrotrichia of the forewings become erect and thickened, while the hindwing develops an exceedingly long fringe.

Text-fig.31.

Forms of scales found in Trichoptera : *a*, a narrow, lanceolate scale, with single longitudinal stria, from wing of an unnamed Leptocerid (Broken Hill, N.S.W.); (×350): *b*, a lanceolate scale with three longitudinal striæ from wing of *Plectrotarsus gravenhorsti* Kol.; (×400).

The slender, flexible macrotrichia of the membrane found in the wings of Trichoptera are exactly comparable with those of the *Psychodidæ* in the Order Diptera (Text-fig.27). Like them, they are easily converted into elongated lanceolate scales. The simplest type of such a scale is one in which the flattening produces only sufficient width to allow of the development of a single longitudinal stria (Text-fig.31,*a*). Such scales may be found in quite a number of isolated genera within the Order. Further broadening leads to the addition of a second, third, or even a fourth parallel stria. The best developed scales known to me in this Order are those of the peculiar genus *Plectrotarsus* (Text-fig. 31,*b*), which always show three or four striæ.

Certain groups of genera show a tendency to the reduction of the hairiness of the wings, which is evidently of a secondary nature. In the subfamily *Macronematinæ*, this culminates in the evolution of a number of forms with the wings almost devoid of macrotrichia.

In conclusion, the Archetype of this Order must evidently have had a wing-trichiation closely resembling that of *Rhyacophila*, *i.e.*, with the archedictyon absent, its macrotrichia present upon the membrane, and already differing considerably, in their smaller size, and slighter, more flexible build, from the larger and more bristle-like macrotrichia of the veins. Macrotrichia were absent from the cross-veins, and the microtrichia were already reduced to a small size.

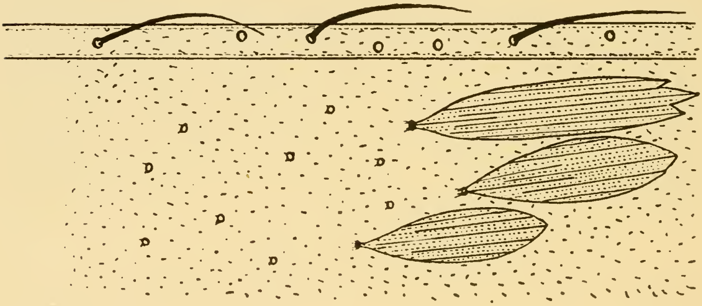
Order LEPIDOPTERA.

(Plate lxviii., fig.11, and Text-figs. 21, 32-34).

In this large Order, it will only be necessary to study fully the most archaic types; in the higher families, only the general trend of the evolutionary effort need be considered.

We take, then, first of all, the three families of the Suborder Homoneura, viz., the *Micropterygidæ*, *Prototheoridæ*, and *Hepialidæ*. In all of these, microtrichia are present, but exceedingly minute, never exceeding 2μ in length. They have been called *aculeæ* in this Order, and an attempt has been made to class together all those families, in which they occur, as the "Aculeate" Lepidoptera. They occur in a number of the older families of the Heteroneura, as well as in the Homoneura. Hence it will be seen that this method of classification is faulty, and should not be persisted in. In all the higher families, microtrichia are no longer present; but it is evident that their loss has been effected along many lines of advance; and that an association of all "non-aculeate" forms into one Suborder would be as unnatural a grouping as it would also be in the Order Planipennia.

The most striking character of the Order Lepidoptera is the specialisation of the macrotrichia as *scales*, throughout the whole Order, from the lowest to the highest forms. Although, as we have already seen, scales are to be found on the wings of other Orders of Holometabola (Planipennia, Diptera and Trichoptera), yet in each case they only occur spasmodically, as cases of high specialisation in one or more isolated groups. But, in the Lepidoptera, the scale-bearing habit is an ordinal character, the only exceptions to which can be traced definitely to retrogression (*e.g.*, in the *Psychidæ*).



Text-fig.32.

Small portion of a main vein and adjacent membrane from the forewing of *Prototheora petrosema* Meyr., (S. Africa), to show the trichiation; (× 200). (From a partially descaled specimen).

In order to establish the proof that these scales are modified macrotrichia, it is only necessary for us to study such an archaic type as *Prototheora** (Text-fig.32), in which the macrotrichia upon the veins remain in their original state of somewhat flexible hairs, while the arrangement of the bases of insertion of the scales upon the membrane can be seen to correspond with the pattern of an original archedictyon. It will also be noticed that

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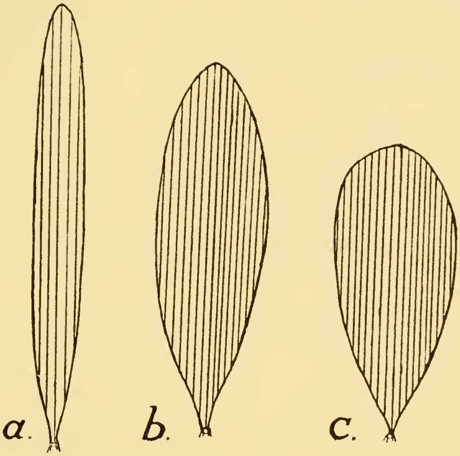
* For the supply of material of this rare genus, I have to thank Dr. Péringuey, Director of the South African Museum, Capetown.

the scales that lie closest to the veins are elongate and narrow; and that, the further we go away from a vein, the broader and shorter the scales become. Thus we can find, in this one insect, all stages in the evolution of a scale from a macrotrichion present upon different parts of the wing.

Similar variations in the form of the scales, connected with their positions in relation to the veins, are to be found in the *Micropterygidæ* (Text-fig.33); but, in this family, the broader scales are much more abundant, and may frequently be seen quite close up to the veins.



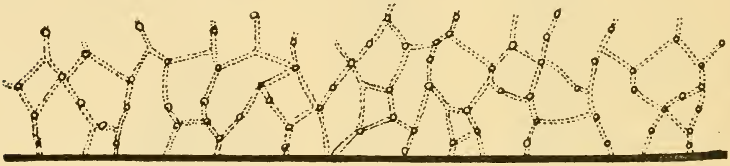
Text-fig.33.

Three types of scales found in the family *Micropterygidæ*; (×400): *a*, from *Eriocrania semipurpurella* Steph.; *b*, from *Mnemonica subpurpurella* Haw.; *c*, from *Sabatinca incongruella* Walk. (All three types may be found upon any one genus).

In the *Hepialidæ*, both narrow, lanceolate scales and moderately broad, oval ones are scattered all over both membrane and veins, interspersed with fairly numerous, slender, flexible hairs, or macrotrichia which have remained unaltered in form.

It will not be necessary, for the purposes of this paper, to follow out the many specialisations to be found in the scales of the Heteroneura. These have already been very fully dealt with by many authors.

Returning to the *Prototheoridæ*, it is of the very greatest interest to note that traces of the original archedictyon are still to be found in this archaic family. In Text-fig.34, and Plate lxviii., fig.11, I show the very definite archedictyon that is to be seen above the radius. Here, not only do the macrotrichia (which, in this region of the wing, are all scales, not hairs) show very clearly the original arrangement of the meshwork, but there is actually a slight thickening and darkening of the membrane forming the archedictyon itself. Allowing for the difference in the sizes of the two wings, this condition in *Prototheora* is closely similar to that preserved in *Archipanorpa*. Though I have not been able to find so good an example of an aphantoneuric archedictyon as this, anywhere else within the Order, yet there are numerous cases in which what appears to be the last remnant of the archedictyon can be seen in proximity to the veins, usually in the form of a series of slightly darkened and thickened spurs projecting almost at right angles to the main vein upon which they abut.



Text-fig.34.

Portion of the aphantoneuric archedictyon preserved above the radius of the forewing in *Prototheora petrosema* Meyr.; (× 130). (See also Plate lxviii., fig.11).

Reviewing the above evidence, it would seem that, in the Lepidoptera, the formation of scales must have begun before the complete disappearance of the archedictyon. This suggests that the scales in this Order must be an exceedingly archaic character, originating in a specialisation of some type belonging to an ancestral Order in which the archedictyon still persisted.

Hence we conclude that the Archetype of this interesting Order must have possessed at least some portions of the aphantoneuric archedictyon; that it also possessed microtrichia of small size; and that the macrotrichia, though remaining as slender, flexible hairs upon the veins, were largely interspersed with true scales upon the wing-membrane, such scales being of elongate, lanceolate form, with few striæ.

We have now to review the above evidence, in order to discover what light it throws upon the Phylogeny of the Orders included in the Panorpoid Complex.

First of all, it must be evident that, as far as the Wing-trichiation is concerned, all six Orders may well have been derived from a single ancestral Order characterised by the following points: presence of an aphantoneuric archedictyon, presence of microtrichia all over the wing, and presence of well-developed macrotrichia upon the main veins and their branches, and upon the archedictyon, but *not* upon the true cross-veins.

Such a type is preserved in the fossil *Archipanorpa* from the Trias of Ipswich, Queensland. This fossil itself, however, cannot have been the ancestral form, since the Mecoptera, Trichoptera, and Planipennia, at any rate, are contemporaneous with it, while the first of these three Orders goes back also into the Permian. For the actual ancestor we must postulate some unknown type of the Lower Permian, or possibly even of the Upper Carboniferous; and whether this ancestor is to be considered as belonging to the Protomecoptera or not, will have to depend upon other characters not dealt with in this Part.

Let us now follow the evolutionary changes of the various structures of the wing separately.

The Archedictyon:—This undergoes complete suppression in all recent Orders, except only in a few Lepidoptera, where distinct traces of the meshwork in an aphantoneuric condition (but not so well marked as in *Archipanorpa*) are still to be found. This is well shown above the radius in the forewing of *Prototheora petrosema* Meyr. (Text-fig.34, and Plate lxviii., fig.11).

After the elimination of the archedictyon, the bases of insertion of the macrotrichia left upon the membrane of the wing still show, fairly plainly, the original pattern of the lost meshwork. A study of the meshwork in the figures of *Prototheora* already referred to will soon convince us that it is possible to reconstruct the course of the meshwork with *fair* accuracy, by joining up the bases of the macrotrichia along the lines which they still indicate. The resulting figure will not be correct in all particulars, since some of the cross-venules of the mesh do not carry any macrotrichia at all, and would therefore be omitted in the reconstruction; while, in a few cases, the positions of the macrotrichia are more or less misleading.

In specialised cases where the macrotrichia proliferate freely on the veins and membrane, as in the case of the higher Heteroneurous Lepidoptera, there are always more than sufficient macrotrichia to ensure an accurate tracing of the original pattern of the archedictyon. This is well shown in the figures of the Hawk-Moth *Cœquosa triangularis* Don., (Text-fig.21). Here it will be seen that the meshwork, probably while it was still aphantoneuric, tended to become arranged into almost parallel lines connected by irregular cross-pieces. It is this tendency, carried to its highest development, that gives the very regular arrangement of the scales seen in the Butterflies. But in all cases, by careful study, it can be seen that the arrangement is a modification of an original meshwork, and not a series of unconnected straight lines.

The evidence afforded by the archaic *Rhyphus* in the Diptera, and by both the Homoneura and the older types of the Heteroneura in the Lepidoptera, points definitely to the conclusion that these two Orders, like the less highly specialised Orders of the Panorpoid Complex, had their macrotrichia arranged upon the membrane in the original positions which they occupied upon the aphantoneuric archedictyon.

The Microtrichia:—Though absent in the higher types of some Orders, *e.g.*, Megaloptera, Planipennia, Diptera (a few), and Lepidoptera (the great majority), yet they are found to be present upon the wings of archaic types of all the Orders of the Panorpoid Complex. The line of evolution is towards reduction in size in all the Orders, with the single exception of the Myiodaria in the Diptera, where there is an increase in size of the microtrichia upon the *upper* surface of the wing only, resulting in the interesting condition found in the Blowfly and allies (Plate lxix., fig. 14).

The Macrotrichia:—A study of archaic types, including the fossil *Archipanorpa*, shows us that these were originally present upon both archedictyon and main veins, but not upon cross-veins. Moreover, probably because of the comparative weakness of the venules of the archedictyon, there was, from the very first, a considerable difference in size between the macrotrichia of the veins and those of the meshwork. The macrotrichia of the veins also tended to be more erect than those of the membrane; so that, in the fossil *Archipanorpa*, their bases of insertion show the two concentric circles of the raised disc very clearly, while those of the meshwork rarely do so.

We are thus led to expect the following lines of evolution, which do, in fact, actually take place in the various Orders of the Complex:—

(1) If the direction of the evolutionary effort be towards reduction, then the macrotrichia on the meshwork should be affected first, since they are smaller in size from the first, and inserted in less strongly built bases.

As a matter of fact, it will be seen that the tendency towards reduction in the smaller macrotrichia becomes accelerated in the course of evolution; so that, in many cases, they become quite eliminated, while the macrotrichia upon the veins may even proliferate, though usually undergoing some reduction in size as well, as in the higher Diptera.

(2) If the direction of the evolutionary effort be towards the formation of scales, then the macrotrichia of the meshwork should be affected first, since they are in a more favourable condition, both as regards their delicacy of structure and the condition of their bases of insertion, to undergo this change.

The formation of scales in the Lepidoptera and Trichoptera agrees with this; since, in archaic families of the former Order, and in all scale-bearing genera of the second, we can still find some at least of the macrotrichia on the main veins remaining in the form of hairs. Judging also from the tendency, in the Lepidoptera, for the broadest (most highly evolved) scales to appear furthest from the veins, while narrow lanceolate scales are found nearest to the veins, we are led to the same conclusion. Actually, the covering of scales is not needed so much upon the veins as upon the membrane, and the original condition of the macrotrichia is such that the need of the insect is to be met along the easiest line of specialisation; *i.e.*, those macrotrichia whose alteration into scales would most benefit the insect also happen to be those in the best condition to undergo the change.

In the other Orders in which scales appear (Diptera, Planipennia) it should be noticed that they are a comparatively late effort, which takes place after the macrotrichia have been completely eliminated from the membrane of the wing. The scales, in these cases, are formed from the macrotrichia left on the veins. If these are still somewhat bristly, as in the Planipennia, a hard, seed-like scale is produced (Text-fig. 24); if, however, they have become slender and delicate, as in the *Psychodidæ* and *Culicidæ*, then the resulting scales will resemble very closely those of the Lepidoptera and Trichoptera.

The changes in position of the macrotrichia, in connection with the disappearance of the archedictyon, have been already dealt with above.

Taking all the above evidence into account, we may reasonably come to the following conclusions, as far as the limitations of this Part of our study permit:—

(1) The fossil Order Protomecoptera is undoubtedly the most archaic type known within the Panorpoid Complex, as regards the characters of its Wing-trichiation.

(2) A single line of descent from the Protomecoptera to the Mecoptera, and from the very base of this latter Order to the Diptera, is strongly indicated by the uniform type of trichiation

found in these three Orders, together with the very definite evolutionary trend towards reduction.

(3) A second line of descent is less definitely indicated, comprising the Megaloptera and Planipennia, in which the evolutionary tendency runs towards early complete suppression of the macrotrichia upon the membrane of the wing, and a later invasion of the macrotrichia from the main veins on to the cross-veins, culminating in the Raphidioidea on the one hand, and in the higher Planipennia on the other. Both Orders may well have been derived from an early type of Protomecopteron, but neither of them can be derived from the other. For the oldest Planipennia have the largest microtrichia, while the oldest Megaloptera still retain the macrotrichia upon the membrane, a condition which is not to be found within the Planipennia.

(4) As the Trichoptera show a more archaic condition of the macrotrichia upon the membrane than do most of the Mecoptera, they can only be derived either from the very base of this latter Order, or from the preceding Protomecopterous type.

(5) In the Lepidoptera there exist certain types that show portion of the archedictyon still present in an aphantoneuric condition; while, in many others, the pattern of the archedictyon is well preserved. Both the oldest Trichoptera and the oldest Mecoptera are in advance of these types. Hence we can only trace back the Lepidoptera to the Protomecopterous or some similar, extinct type, and may not derive them either from the Mecoptera or from the Trichoptera.

Though the conclusions to be drawn from the structures studied in this Part are somewhat indefinite in themselves, they will be found to be of considerable value when taken in conjunction with the rest of the evidence. Also, in the study of the Phylogenies of the families of each separate Order, (which lies outside the actual scope of this paper), a great deal of very valuable evidence may be gathered from the Wing-trichiation.

We may conclude this Part by giving, in tabular form, the principal characters of the Wing-trichiation for the different Orders—

TABLE OF THE CONDITION OF THE WING-TRICHIATION IN THE ORDERS OF THE PANORPOID COMPLEX.

* indicates well-developed, × present in reduced form, – absent.

Orders and Groups.	Micro-trichia.	Macrotrichia.			Arche-dictyon.
		On main veins and branches.	On cross-veins.	On arche-dictyon or membrane.	
PROTOMECOPTERA ...	*	*	–	*	present, aphanto-neuric.
MEGALOPTERA:—					
Archetype	*	*	–	*	–
Corydalidæ	*	*	–	*	–
Sialidæ	*	–	–	(A)	–
Raphidiidæ	–	*	*	–	–
PLANIPENNIA:—					
Archetype	*	*	–	–	–
Archaic types ...	* or ×	*	–	–	–
Higher types ...	–	(B)	*	–	–
MECOPTERA:—					
Archetype	*	*	–	*	–
Archaic types ...	*	*	–	* or ×	–
Nannochoristidæ and *Bittacidæ*	*	*	–	(C)	–
DIPTERA:—					
Archetype	*	*	–	*	–
Rhyphidæ	*	*	–	*	–
Psychodidæ	×	some scales	–	–	–
Culicidæ	×	all scales	–	–	–
Other types... ...	*, × or –, (D)	* or ×	–	–	–
TRICHOPTERA:—					
Archetype	×	*	–	*	–
Recent families ...	×	*	(E)	very abundant, some-times scales. (F)	–
LEPIDOPTERA:—					
Archetype	×	*	–	hairs and scales	at least partially present, aphanto-neuric.
Prototheoridæ ...	×	* (hairs and scales)	–	scales	partially present, aphanto-neuric.
Other Homoneura ...	×	,,	–	hairs and scales	–
Archaic Heteroneura	×	,,	–	,,	–
Higher Heteroneura	–	scales	–	scales	–

Special References:—(A) Only present on fringe and pterostigma—(B) Some scales developed on hindwing of *Spermophorella* ♀♀ and fringe of *Isoscelipteron*—(C) A few present on pterostigma of forewing in *Nannochoristidæ*—(D) Absent in some *Syrphidæ*; enlarged on upper surface of wing in Myiodaria—(E) Absent except as a late invasion from the membrane—(F) Sparse or absent in *Macronematinæ* and some other forms.

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EXPLANATION OF PLATES LXVII.-LXIX.

Plate lxvii.

Fig. 9.—Portion of forewing of the fossil *Archipanorpa magnifica* Till., showing the aphantoneuric archedictyon with tubercles representing the bases of insertion of the macrotrichia; also showing portion of the main veins R_3 and R_4, with clearly marked bases of insertion of larger macrotrichia, and cross-veins without the same; (× 27).

Fig. 10.—Part of Fig. 9, further enlarged; (× 43).

Plate lxviii.

Fig. 11.—Portion of forewing of *Prototheora petrosema* Meyr., (Lepidoptera; S. Africa), showing the radius, with the aphantoneuric archedictyon above it, carrying scales (macrotrichia); from a cleared mount of a partially de-scaled specimen; (× 50).

Fig. 12.—Portion of forewing of *Rhyphus brevis* Walker (Diptera), showing distribution of microtrichia and macrotrichia; most of the latter have become detached from their bases of insertion; (× 400).

Plate lxix.

Fig. 13.—Apical portion of forewing of *Chorista australis* Klug, (Mecoptera), showing distribution of microtrichia and macrotrichia; notice the absence of the latter from the cross-veins; (× 200).

Fig. 14.—Portion of forewing of Blowfly (*Calliphora villosa* Desv.; Diptera), showing the two types of microtrichia; the larger ones are on the upper, the smaller on the undersurface of the wing; (× 60).

(All figures are from photomicrographs, Figs. 9-10 from the actual fossil, Figs. 11-14 from cleared mounts of wings).

A STUDY OF THE EXTERNAL BREATHING-APPARATUS OF THE LARVÆ OF SOME MUSCOID FLIES.

By John L. Froggatt, B.Sc.

(Plate lxx.)

Heretofore, in the identification of different species of flies from maggots collected, the perfect flies have had to be bred-out. But, in the course of the work of the Government Sheep-Fly Experiment Station, this method was often impossible, when packets of maggots were received dead or rotten. By means of the microscope, I have found that an examination of the spiracles, in particular the posterior spiracles, gives a sure and certain means of identifying the different species here dealt with. As their description has not been published heretofore, the results are here recorded. In every case, the types were procured from eggs deposited by each species of fly, on meat in the field-laboratory.

The species dealt with in this paper are:—

Anastellorhina augur (*Calliphora oceaniæ*).
Pollenia stygia (*Calliphora villosa*).
Pycnosoma rufifacies (*Calliphora rufifacies*).
Pycnosoma varipes (*Calliphora varipes*).
Lucilia sericata.
Ophyra nigra.

The spiracles, in all probability, exercise a most important function in the destruction of maggots by poison. Careful examination of the skin does not reveal the presence of any pores; the organs of the maggot may be looked upon as being enclosed in an india-rubber-bag, the only openings into which are the gullet and anus—the extremities of the alimentary tract—and the anterior and posterior spiracles—the extremities of the respiratory system. These anterior and posterior spiracles are connected by two main tracheæ, from which branches ramify throughout the body. Absorption will, in all probability, take place slowly through the skin; but the action of some liquids is far too rapid to admit of this happening, so that, in these cases, attention must be paid to the openings into the body. I am not at present in a position to point out more than the possibilities of this point, but it is receiving further attention.

The absence of pores in the skin of the maggots of these species is extremely interesting as well as curious, because the larvæ of most other insects, and even diptera, show definite, well-marked pores.

The anterior and posterior spiracles are totally different from one another, the most marked specific differences being given by the latter.

The anterior spiracles are situated one on either side of the body, on the first thoracic segment. In shape, they resemble a cap with a sharp upper edge, and a row of tassels along this edge. The caps are chitinised projections of the two main tracheæ on which they fit by a thickened ring; and it is from this demarcation-line that all measurements are taken. In some species, the cap is differentiated into a thicker lower part, and a thinner upper part. The tassels or tubules are hollow, the open ends having a much-strengthened chitinous rim to keep the apertures open. The number of tubules varies in different species, and within certain limits in the same species, and even between the right and left anterior spiracles in the same maggot.

The tracheæ terminate posteriorly on the anal segment in two spiracular plates or stigmata, the posterior spiracles. These are slightly raised above the surface of the truncated end of the maggot. The position of these plates on the body is such that the bases of the plate, *i.e.*, the spaces in the band, point obliquely towards the median perpendicular plane of the body, and with the median horizontal plane of the body passing through the lower portion of the plates.

As both spiracular plates are alike for each species, a general description of the characters of one will serve equally for the other.

The plate is surrounded by a strong band of chitin, varying in thickness and in outline in different species. At the base is a space or opening in the band; in *Ophyra nigra*, however, this is closed up; and, in *Pycnosoma rufifacies* and *P. varipes*, it is open, forming a break in the band. This space appears to carry some soft structure in life, but which is destroyed in preparation. Within this band are three structures radiating slightly from the base; on subjection to strain, it is seen that these are slits, the openings being crossed by bands of chitin, either straight or anastomosing. The side-walls of the slits are very much strengthened with chitinous blocks, and the ends are always rounded. They are also concave from side to side.

In some species here dealt with, there is an intermediate structure lying between the middle and inner slits—"inner" referring to the side nearest the median line of the body. This is a shallow groove, somewhat V-shaped, coming to a more or less definite point towards the bottom, and rounded at the top. The rounded end encloses a clear space, the margin of which shows, under a low magnification, a "sun-ray" effect. This is due to fine bands of chitin radiating outwardly to the band. The inner ends of these chitinous bands project over the rim of the clear space, and would seem to support some soft structure in life, but which is destroyed by the preparation. In some species, also, a space resembling a blister occurs on the side of the slits; when present, it is always on the outer side of the outer and middle slits, and on the inner side of the inner slit. This "blister-structure" also shows the "sun-ray" effect referred to in the "intermediate-structure."

The length and breadth of all the spiracular plates include the width of the band.

I am indebted to Professor Wheeler, of Harvard University, U.S.A., for the method of preliminary preparation of the maggots. Full-grown maggots are dropped into water heated to 80°C. A few seconds in water at this temperature is sufficient to kill them, and has the great advantage of stretching the maggots to their full length; by killing in alcohol, the maggots generally contract, and often curve the body. The maggots are then placed in 35% alcohol, and, after about 14 hours, they are transferred to 75% alcohol, in which they can be preserved. As a general rule, the maggots are left perfectly white by this preparation, excepting occasionally when they have been feeding on material rich in blood. When ready for preparation as microscopic specimens, the body of the maggot is slit along the median basal line, and boiled in 10% KOH until only the integument remains. This is then put through the usual process for such preparations, and mounted in Canada Balsam. All measurements are in fractions of a millimètre.

The bibliography on the spiracles of dipterous larvæ is, so far as I have been enabled to trace it, very scanty. Figures of the spiracles of different species have been given on a number of occasions; but when a description is given, it is brief and without detail.

Nielsen(**1**) figures the spiracles of certain species of *Tabanidæ*, but goes no further.

Froggatt(**2**) figures the spiracle of a dipterous larva found parasitic in locusts at Minimbah Station, near Singleton, N.S.W. A curious feature in this species was an elongated, cone-shaped tail fitting over the anal portion of the abdomen. This was doubtless to protect the spiracles, and prevent the maggot from being smothered when the legs and wings were folded. The perfect fly was never bred out, so that it could not be identified.

Gurney(**3**) figures the spiracles of three species of fruit-flies, and states that the identification of the different species can be thus determined, but gives no description.

Banks(**4**) gives a slightly more extended account of the spiracles of the different species he deals with, but gives very little detail. He refers to what I am calling the space in the band of the anal spiracular plate, as a "button"; in which I do not agree with him. He does not say how the spiracles were examined.

As extreme forms of spiracles, the following may be given. *Eristalis tenax*, "The Common Drone-Fly," an introduced species common in gardens, is the parent of curious rat-tailed larvæ which can live not only in putrid but even in salt water. The posterior spiracles are projected into a long tail in order to enable it to breathe while completely submerged.

The larvæ of *Stratiomya chamæleo*, another European fly which swarms in water, have a similar, elongated, tail-like projection of the spiracles. The larvæ of a Tachinid fly (*Gymnosoma rotundatum*) live in and feed on the body of a Shield-Bug, and, in order to breathe, have an elongated, hook-like projection of the spiracles, which is pushed through one of the spiracles in the side of the body of the bug.

ANASTELLORHINA AUGUR. (Plate lxx., figs.4, 4*a*).

Anterior Spiracles.—Cap differentiated into two parts. Tubules very strong.

Posterior Spiracles.—The band strong, complete, not markedly thick, showing no differentiation into two parts as in *P. rufifacies* and *P varipes.* The band is thickened round the space which projects the contour outwards at this point. The band is drawn in slightly between the slits, giving the contour a slightly scalloped appearance. The inner margin of the band projects very slightly between the outer and middle slits, and less markedly between the middle and inner slits. The slits are fairly close together at the base, but are well separated otherwise, and do not run quite the full length of the plate. The outer and inner slits are fairly straight throughout their whole lengths. The middle slit is straight for about two-thirds of its length, and then inclines inwards. "Intermediate structure" always present between the middle and inner slits. "Blister-structure" well marked on all three slits.

POLLENIA STYGIA. (Plate lxx., figs.6, 6*a*).

Anterior Spiracles.—Cap differentiated into two parts. Tubules broad compared with their length, and strong.

Posterior Spiracles.—Band strong and complete. Space at base completely enclosed in the band, which is not projected outward to such an extent as in *A. augur.* The band is only slightly drawn inwards between the slits. The inner margin of the band projects strongly downwards between the middle and outer slits, and somewhat less strongly between the middle and inner slits; in the latter case, this projection usually forms a hollow above the space in the upper end of the "intermediate structure." Slits fairly close together, and running practically the whole length of the plate. Outer and inner slits fairly straight throughout their whole lengths. The lower half of the middle slit is fairly straight, from which point it bends slightly inwards. "Blister-structure" usually situated just above the point of curvature. "Intermediate structure" always present between the middle and inner slits, and well developed. In a few cases, a similar structure has been noticed between the outer and middle slits, but then the "blister-structure" on the middle slit is absent. "Blister-structure" well developed on the slits. The "sun-ray" effect is particularly well marked on the "blister-structures" and on the space in the top of the "intermediate structure."

PYCNOSOMA RUFIFACIES. (Plate lxx., figs.5, 5*a*).

Anterior Spiracles.—Cap differentiated into two parts. Tubules long.

Posterior Spiracles.—Band very strong, often differentiated into two parts, the chitinous material being thinner on the outer portion. It would seem that, when the maggots are young, the differentiation in the band is most marked, but as development is carried on, this differentiation decreases until the two parts become either fused or the outer becomes the thicker and stronger. There is, of course, no space between these two parts in the band. The band is broken at the base, leaving the space open and incompletely surrounded. The band is always much thicker at the base. The inner edge of the band projects downwards slightly between the middle and inner slits, and less markedly between the middle and outer slits. The outer margin of the band is regular in outline. The slits run the full length of the plate, abutting on the inner edge of the band at the top and bottom of the spiracular plate. The outer slit, in shape, is fairly straight on the inner side, the outer side being slightly convex, following the outline of the inner margin of the band. The lower part of the middle slit is fairly straight, and close against the base of the outer slit. About the middle of its length, it bends inwards slightly. "Blister-structure," when present, generally situated about the point where the inward bend takes place. The outer edge of the inner slit is fairly straight; the inner edge follows more the contour of the inner margin of the band. It is slightly convex. "Blister-structure" at approximately the maximum point of curvature. The "intermediate structure" occurs between the middle and inner slits, but, in many cases, it is but slightly developed. The "blister-structure" is generally present on the inner side of the inner slit, and absent on the other two slits. It may, however, be seen on all three slits.

PYCNOSOMA VARIPES. (Plate lxx., figs.3, 3*a*).

Anterior Spiracles. Cap differentiated into two parts. Tubules much shorter than in *P. rufifacies.*

Posterior Spiracles.—Band extremely thick and strong, and showing the same differentiation into two parts as in *P. rufifacies;* the same remarks apply equally in this case as in the previous one. The inner margin of the band projects slightly downwards between the outer and middle slits. The band is broken at the base, leaving the space open and incompletely surrounded. On the inner side of the spiracular plate, the band shows a development of chitin like a square flag—the minimum distance between the plates has been taken from the edges of these flags. The slits run the whole length of the plate. The outer slit is fairly straight and regular throughout its whole length, although the outer margin conforms more or less to the contour of the inner margin of the band. The "intermediate structure" is only very slightly developed between the middle and inner slits, and is apparently only noticeable in the later stages of the growth of the maggot. The "blister-structure" on the slits is absent.

LUCILIA SERICATA. (Plate lxx., figs.2, 2*a*).

Anterior Spiracles.—Cap not differentiated into two parts. Tubules short and slender.

Posterior Spiracles.—Band fairly thin and entire, pinched in between the slits as in *A. augur.* The space in the band is completely enclosed by the band, which is thickened at this spot;

the space generally tends to project the inner side of the band inwards. There is no projection of the inner margin of the band between the slits. The slits radiate out from the base, and fill the greater part of the spiracular plate, but do not run the full length of it. In shape, the slits are all very similar, being, as a rule, fairly straight and regular. The "intermediate structure" is well developed, and always present between the middle and inner slits. The "blister-structure" is always present on the slits, and well developed. The blister seems, more noticeably in this species, to be contained in a sheath which generally runs a long way along the slit on either side of the blister; this is generally more pronounced on the middle slit.

OPHYRA NIGRA. (Plate lxx., figs.1, 1*a*).

Anterior Spiracles.—Cap not divided into two parts. Tubules long and slender.

Posterior Spiracles.—Band complete, and comparatively thick and strong. It is differentiated, in the earlier stages of the development of the maggot, into two parts, the inner part being the broader and stronger. It is regular in outline. The space is not in the band, but is surrounded by a development of chitin at the base of the plate, resting against the band. The space is almost completely filled by a development of chitin. The bases of the inner and outer slits rest against this ingrowth of chitin. Compared with the size of the spiracular plate, the slits are small, and appear to be well separated from one another. This is due to each slit being surrounded by an envelope of hyaline material, which envelopes are, however, lying up against one another. The inner margin of the band does not, as a rule, project downwards at all between the slits The outer and inner slits are usually fairly straight and regular to almost the upper end, where they bend over slightly outwards and inwards respectively. They may, however, present a slightly wavy appearance. The middle slit is always wavy in outline, with the tip of the upper end bending slightly over. "Intermediate" and "blister-structures" are absent.

			O. nigra.	*L. sericata.*	*P. raripes.*	*P. rufifacies.*	*Pol. stygia.*	*A. augur.*
			mm.	mm.	mm.	mm.	mm.	mm.
Anterior Spiracles	Cap ...	Total length	0·1640	0·1312	0·1192	0·1558	0·1517	0·1394
		Length of upper part ...	—	—	0·0441	0·0820	0·0502	0·0583
		Length of lower part ...	—	—	0·0747	0·0738	0·1015	0·0811
		Breadth of upper part ...	0·1550	0·1230	0·1107	0·1292	0·2306	0·1609
		Breadth of lower part ...	0·1343	—	0·1025	0·1640	0·2152	0·1785
	Tubules ...	Number	7 to 9	8 to 9	9 to 10	10 to 11	10 to 13	9 to 11
		Length	0·0410	0·0246	0·0287	0·0492	0·0328	0·0328
		Breadth	0·0082	0·0082	0·0139	0·0164	0·0164	0·0164
Posterior Spiracles.	Min. distance between spiracular plates		0·1099	0·1743	0·0656	0·1640	0·1991	0·2583
	Length of spiracular plate		0·1740	0·2109	0·2403	0·3835	0·4152	0·2821
	Breadth of spiracular plate		0·1831	0·2738	0·2433	0·3617	0·4177	0·2852
	Length of intermediate structure ...		—	0·0820	—	0·1722	0·2112	0·1140
	Max. dist. between outer & middle slits		—	0·0389	0·0164	0·0338	0·0864	0·0629
	Min. dist. between outer & middle slits		—	0·0082	Rt. together	0·0072	0·0126	0·0082
	Max. dist. between middle & inner slits		—	0·0375	0·0246	0·0370	0·0840	0·0528
	Min. dist. between middle & inner slits		—	0·0164	Rt. together	0·0154	0·0240	0·0284
	Length of outer slit		0·0767	0·1312	0·1312	0·2378	0·2964	0·1817
	Breadth of outer slit...		0·0246	0·0410	0·0401	0·0681	0·0678	0·0410
	Dist. from base of "blister-structure"...		—	0·0292	—	0·0793	0·1135	0·0656
	Length of "blister-structure" ...		—	0·0574	—	0·0793	0·0880	0·0574
	Length of middle slit		0·0845	0·1394	0·1509	0·2533	0·3216	0·1948
	Breadth of middle slit		0·0246	0·0400	0·1410	0·0647	0·0691	0·0410
	Dist. from base of "blister-structure"...		—	0·0656	—	0·1585	0·1838	0·1239
	Length of "blister structure" ...		—	0·0445	—	0·0519	0·0689	0·0389
	Length of inner slit		0·0877	0·1343	0·1369	0·2232	0·2941	0·1886
	Breadth of inner slit...		0·0246	0·0410	0·3936	0·0665	0·0715	0·0410
	Dist. from base of "blister-structure"...		—	0·0293	—	0·0902	0·1335	0·0948
	Length of "blister-structure" ...		—	0·0691	—	0·0683	0·0770	0·0328

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EXPLANATION OF PLATE LXX.

Anterior and posterior spiracles of *Ophyra nigra* (Figs. 1, 1*a*)—*Lucilia sericata* (Figs. 2, 2*a*)—*Pycnosoma varipes* (Figs. 3, 3*a*)—*Anastellorhina augur* (Figs. 4, 4*a*)—*Pycnosoma rufifacies* (Figs. 5, 5*a*)—*Pollenia stygia* (Figs. 6, 6*a*).

NOTES ON AUSTRALIAN SAWFLIES (*TENTHREDINIDÆ*).

By Walter W. Froggatt, F.L.S., Government Entomologist.

The Sawflies are well represented in Australia by a number of handsome insects belonging to very distinctive genera peculiar to our insect-fauna.

While enormous numbers of the gregarious larvæ of several species of the genus *Perga* are common at certain seasons (March and April in particular), feeding upon the foliage of young gum-trees (*Eucalyptus*) wherever there is plenty of young growth, the perfect insects are comparatively rare. In breeding-out specimens from the pupæ, one finds that a large percentage of them never reach maturity, because they are attacked in the larval stage by many dipterous and hymenopterous parasites which develop after the sawflies have pupated. A great number also fall victims to a mould-fungus, which destroys them in the cocoons.

Perga dorsalis Leach : The Steel-Blue Sawfly.

Zoological Miscellany, iii., p.117, t.148, fig.1, 1817.

This handsome sawfly, one of the largest and best known species of the typical Australian genus *Perga*, has an extended range round the coast, and is common in Victoria and New South Wales.

The gregarious larvæ feed at night, and rest during the day, clustered together in an oval mass, on the stem of the gum-tree upon which they are feeding. When disturbed, they exude a sticky yellow substance from the mouth, at the same time raising the tip of the body, and tapping it down on the foliage. The leaves are devoured from the top of the young gum-trees; and, when the larvæ are full fed, they crawl down the stem to pupate. I have found them fully developed in the middle of April; but, when they descend from their resting-place, they wander about over the grass for several days before they finally select a place in which to pupate, generally the softer soil against a tree-trunk. Into this they burrow to a depth of three or four inches, massing their large, oval cocoons in rows, one against the other I watched several large swarms feeding upon the Peppermint-gums (*Eucalyptus novæ-angliæ*) at our Experiment Station at Uralla, and afterwards in their erratic wanderings over the grass; and marked down their final resting place and dug up the cocoons. At Binalong, in April, I observed two large swarms marching in massed formation: the heads of the hind rows always rested upon those in front as they moved along steadily together. Every now and then, the front rank came to a dead stop, when they all rested for three or four minutes; then a number began raising up and tapping down the tip of the abdomen, whereupon the whole band took up the motion: the leading ranks made a fresh start, and all moved along again. In the largest band, I counted two hundred and fifty caterpillars.

Larvæ that pupated in the soil in the middle of April, produced the perfect sawflies in the Insectarium in the early part of October.

The pupation of this sawfly is very remarkable. Under natural conditions, the long, oval cocoons are formed one above the other into a solid mass like honeycomb. When the full-fed larvæ are placed in a jar of sawdust, each forms a separate oval cocoon up to 1½ inches in length and ½ inch in diameter. The walls are very thin, composed of a tough, sticky, papier-maché-like material, the inner surface smooth and black, with the anterior end rounded, and the apical cut off from a false end (containing the cast larval skin loosely attached to the true cocoon) by a slightly convex partition or cap of a greyish-brown colour, except for the black centre just behind the head of the semipupa; the outer side of this cap is flat, black, and thickly impressed like the surface of a thimble.

The first moult leaves a very wrinkled, pink and yellow, naked pupa, with all the outlines of the larva, and the abdominal segments curled in underneath the hindlegs. This stage may remain from two to three months, when the pupa undergoes a second transformation. A fine, almost black, soft but closely felted, fibrous, inner cocoon is spun, within which the pupa, now an elongate, very wrinkled, white creature, without any outlines of head or appendages, is enclosed. There must be a third change, when the typical, true pupa develops, but this has not yet been worked out. Probably, like some moths, this will not take place until a month or two before the emergence of the perfect sawfly.

PTERYGOPHORUS BIFASCIATUS Brullé.

Hist. Nat. Insect., Hymen., Vol.iv., p.660, Pl.46, fig.1, ♀, 1846.

This handsome species is easily distinguished from all the other species by the dark marking on the forewings. The type, a female, was described from Tasmania. Mr. Rowland Turner informs me that it was unique; he had never seen this insect until I sent specimens to the British Museum. My specimens were collected in the pupal state; a colony, containing about twenty cocoons imbedded in soft wood from the stem of an undetermined tree, was sent by Mr. Harold Brooks, from Dungay, Tweed River, N.S.W. The larvæ, when received in the cocoons, were in a semi-pupal state, but showed that they were typical of the genus *Pterygophorus*. The perfect sawflies emerged from the cocoons early in September.

♂. Shining blue-black, variegated with dull yellow. Length, $\frac{1}{3}$; exp. wings, $\frac{3}{4}$ inch. Head and thorax, with the exception of a yellow blotch on the sides of the latter, shining dark blue. Legs black, variegated on the tarsi. Basal half of the dorsal surface of the abdominal segments black, with the whole of the ventral surface and apical portion of the dorsal surface yellow. Forewings hyaline, richly variegated with chocolate-brown, forming a clouded costal nervure; hind and marginal band, and an outer transverse band crossing the centre of the wing, so that there are three semiopaque areas on the basal half of the wing enclosed in clouded bands. Hindwings slightly fuscous.

♀. Larger than ♂; of the same shining blue-black colour, but having the face, a large blotch on the shoulders, scutellum, post-scutellum, and the whole of the abdomen dull yellow. Antennæ composed of eleven joints; 1st and 2nd small, 3rd-10th rounded, bead-shaped. Eyes large, projecting. Centre of the median lobe of the mesothorax with a lateral depression. Scutellum large, rounded. Length, ½; expanse wings, ½ inch.

PHILOMASTIX MACLEAII Westwood.

Perga macleaii Westwood, Proc. Zool. Soc., 1880, p. 372, Pl. xxxv., f.2, ♂. *Philomastix glaber* Froggatt, Proc. Linn. Soc. N. S. Wales, (2), Vol. v., p.489, 1890.

The type was described from a male specimen whose antennæ were wanting, and thus Westwood made the mistake of placing it in the genus *Perga*.

I have collected a large series of both sexes, with the curious double-tailed green larvæ, upon the wild raspberry-plants on the Tweed River, N.S.W. When visiting the British Museum in 1908, I went through the cabinets of sawflies, and recognised my species under the name of *Perga macleaii*.

PTERYGOPHORUS ANALIS G. Costa.

Ann. Mus. Zool. Napoli, Vol. ii., p.66, 1864.

A number of cases have been recorded from the Roma and Mitchell districts, Southern Queensland, of the death of cattle that have acquired the abnormal habit of eating the larvæ of these sawflies. The sawflies appear in the early summer in the open forest-country in enormous numbers, and deposit their eggs on the foliage of the ironbark-trees. The resultant, long-tailed, slender, green larvæ are so numerous, that they completely strip all the foliage off the trees over a large extent of the ironbark forests. When fully fed, they crawl or fall to the ground, and congregate at the base of the tree-trunks in regular heaps.

The cattle running in infested country have acquired the habit of licking up these moribund larvæ; and quite a number of the young stock, in these particular areas, have died from their partiality to this change of diet.

Mr. Moore, the owner of "The Peaks," Marbango, Southern Queensland, has sent me the following notes. "These caterpillars mature on the leaves of the Ironbark-trees, and, when numerous, as they were last season (1917), do not leave a leaf on the trees. When fully matured, they come down and die all round the trunks of the trees; and it is at this stage that cattle lick them up; an overdose is fatal, particularly to young stock, such as weaners, nine to twelve months old, and calves. I fancy that acute inflammation of the bowels causes death: and the beast appears to be in terrible pain towards the end. I am inclined to think that a good deal of sand is licked up with the caterpillars, and this may add to the irritation."

"The adult sawflies emerge and are active all through April, the caterpillars feeding upon the foliage through the winter. In August, the full-grown caterpillars come down the trunks of the trees, and die in heaps; and, for about three weeks, are a danger to the young cattle in the paddocks. I think it must be a craving for salt that attracts them, and we have laid rock-salt round the trees, but once they have acquired a taste for the caterpillars they will rush round the Ironbarks to lick them up."

"I have had to remove all my cattle into the open country away from the ironbark-forest, or my losses would have been very heavy. As it was, I lost eighty head out of a mob of four hundred, sixty weaners and twenty cows. Twenty per cent. is very heavy in a week, and all the beasts that died were in splendid condition; in fact the fattest seemed to suffer most."

In my opinion, this caterpillar-pest is going to prove a very serious matter; and the only remedy will be to ringbark the ironbark-trees in some of the paddocks, so that the cattle can be kept away from the infested areas.

[Printed off, December 14th, 1918.]

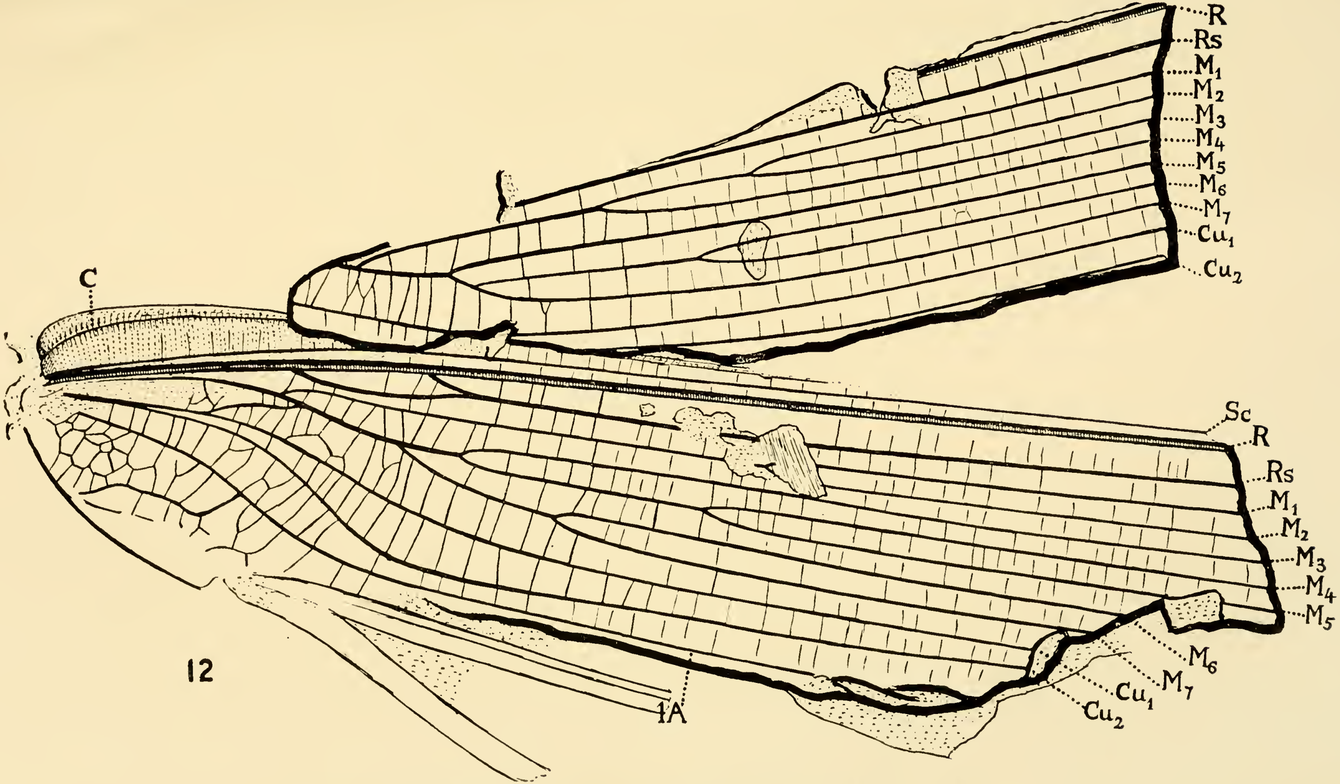
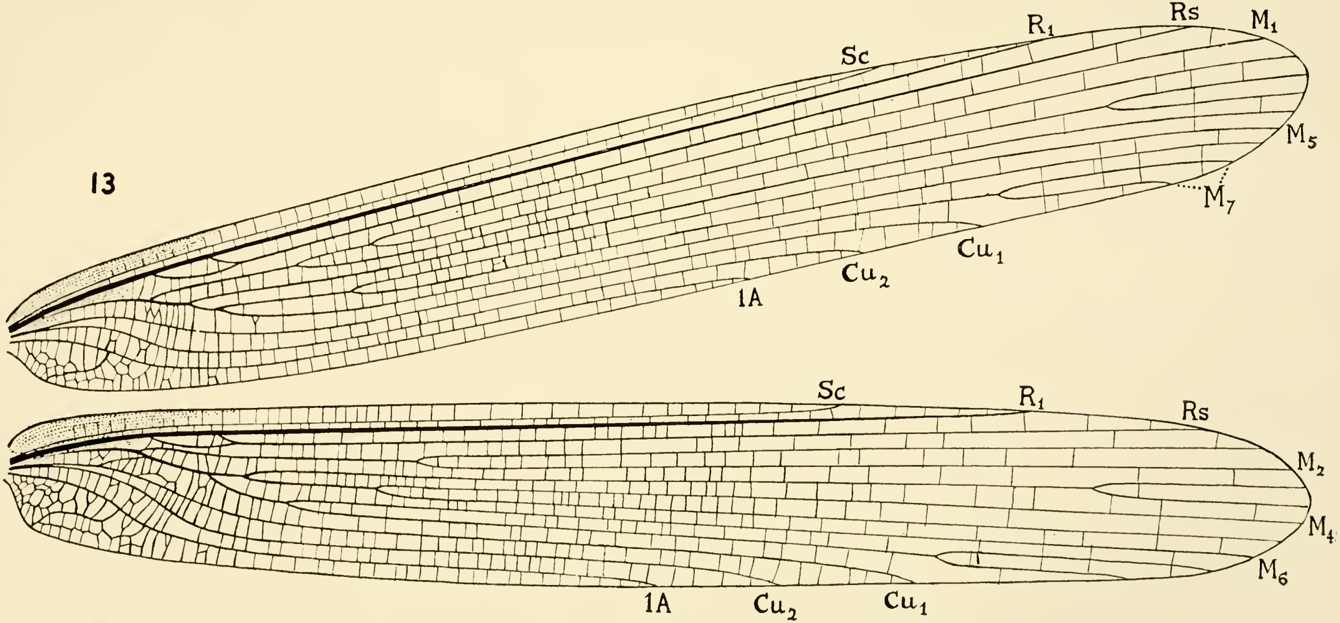
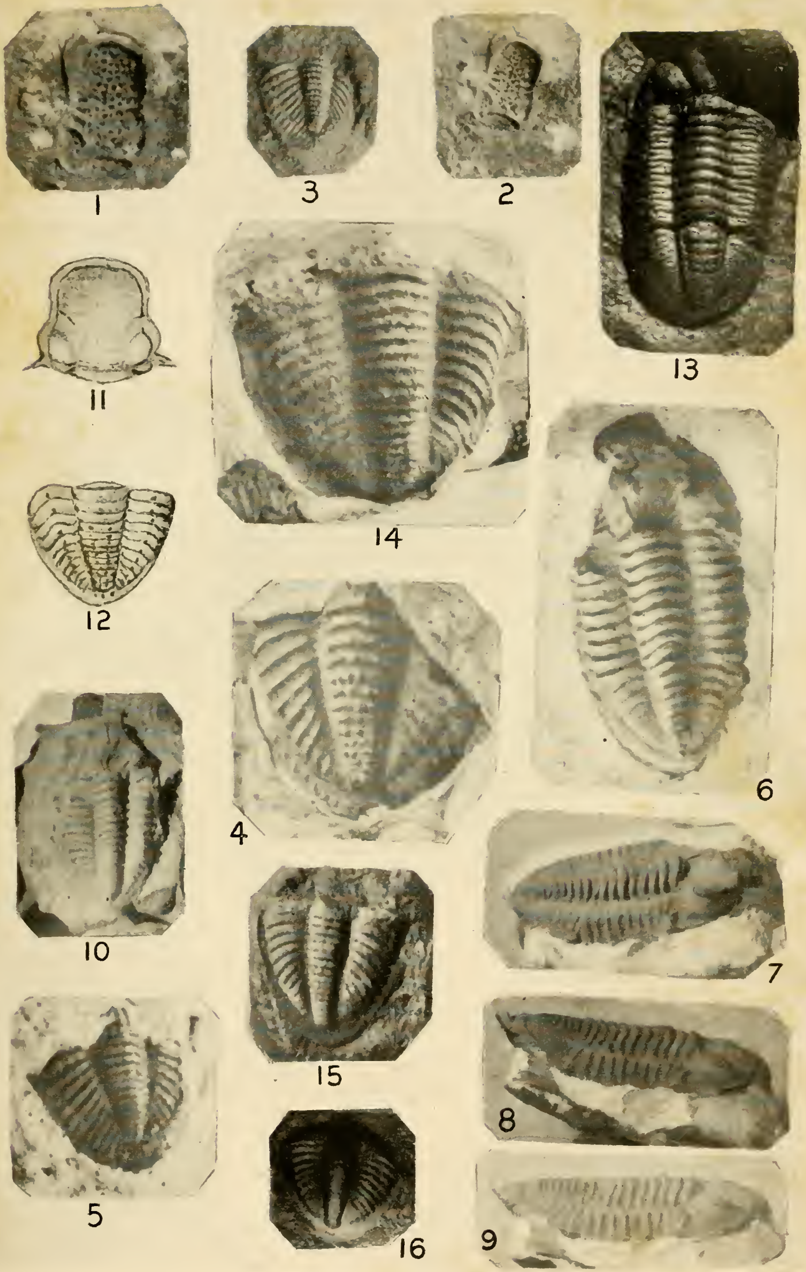


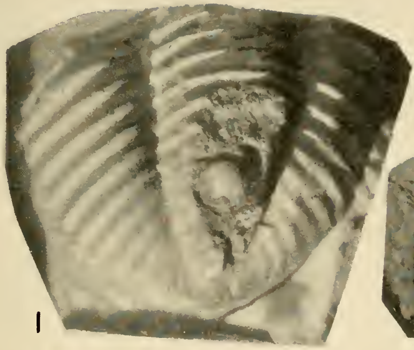
Fig. 12. *Aëroplana mirabilis*, n.g. et sp. Principal preserved portions of the wings; (× 7).



Figs. 13-14. *Aëroplana mirabilis*, n.g. et sp. Restoration of fore- and hindwings; (× 4).



Carboniferous Trilobites of Australia (*Phillipsia, Griffithides*).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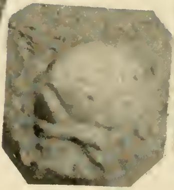
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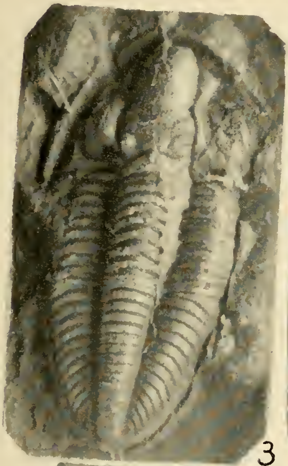
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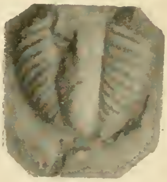
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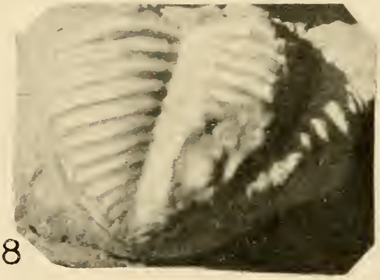
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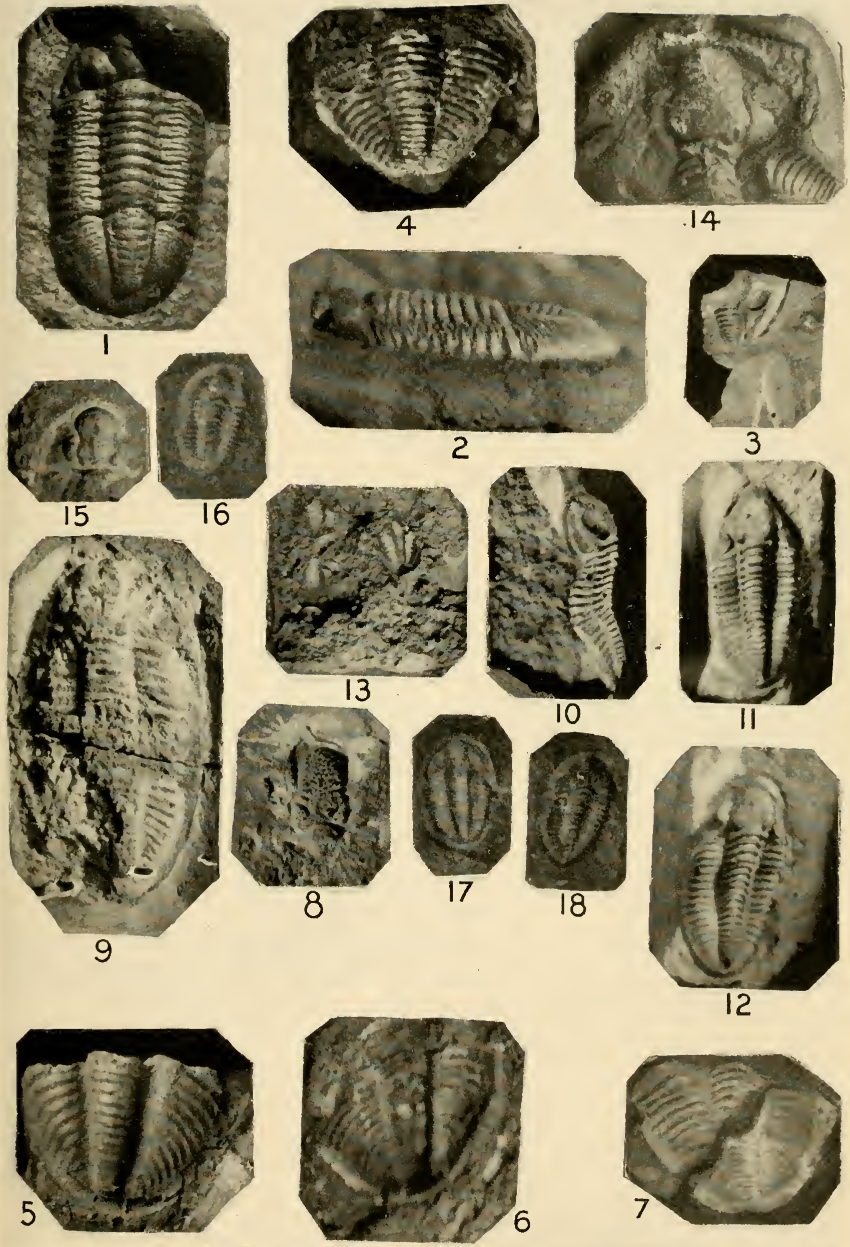
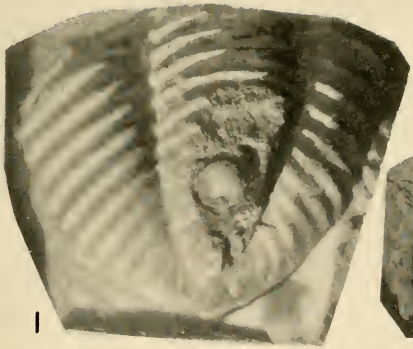
Carboniferous Trilobites of Australia (*Phillipsia*).



Carboniferous Trilobites of Australia (*Griffithides, Phillipsia*).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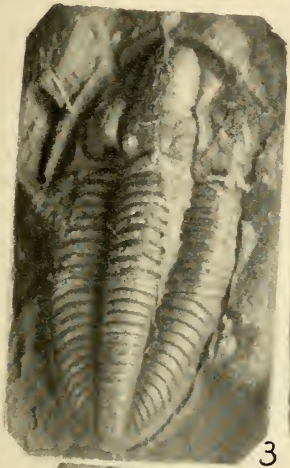
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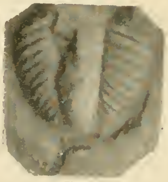
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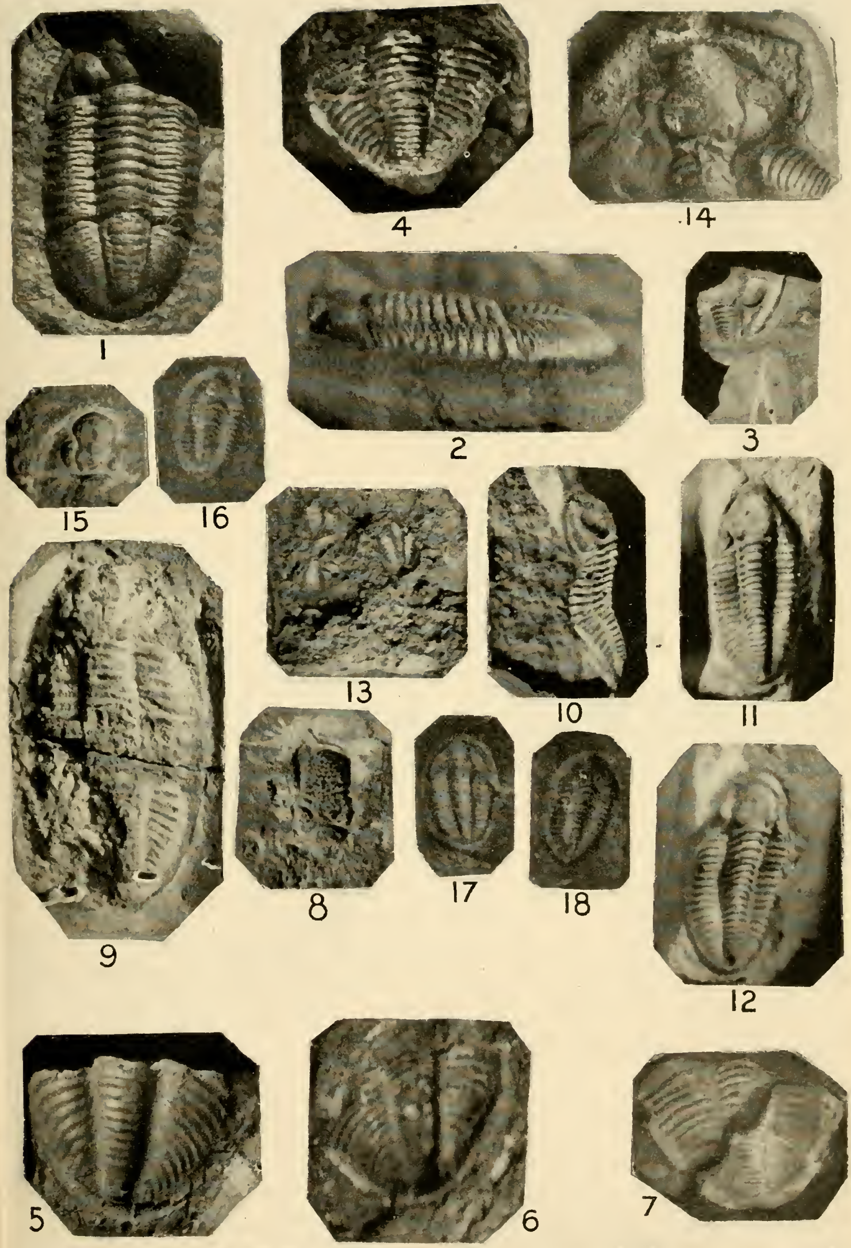
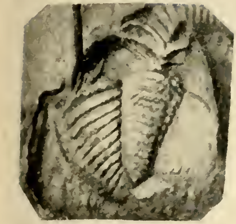
Carboniferous Trilobites of Australia (*Phillipsia*).



Carboniferous Trilobites of Australia (*Griffithides*, *Phillipsia*).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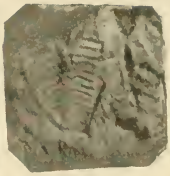
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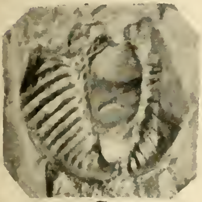
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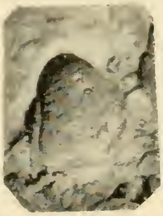
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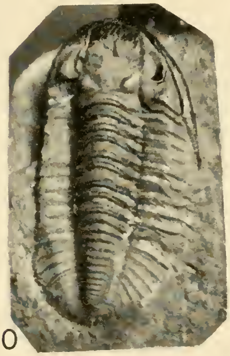
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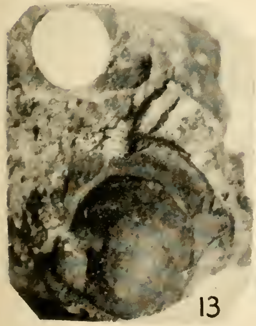
16 (×6)


12 (×2)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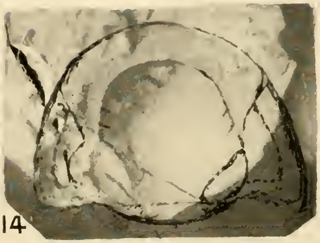
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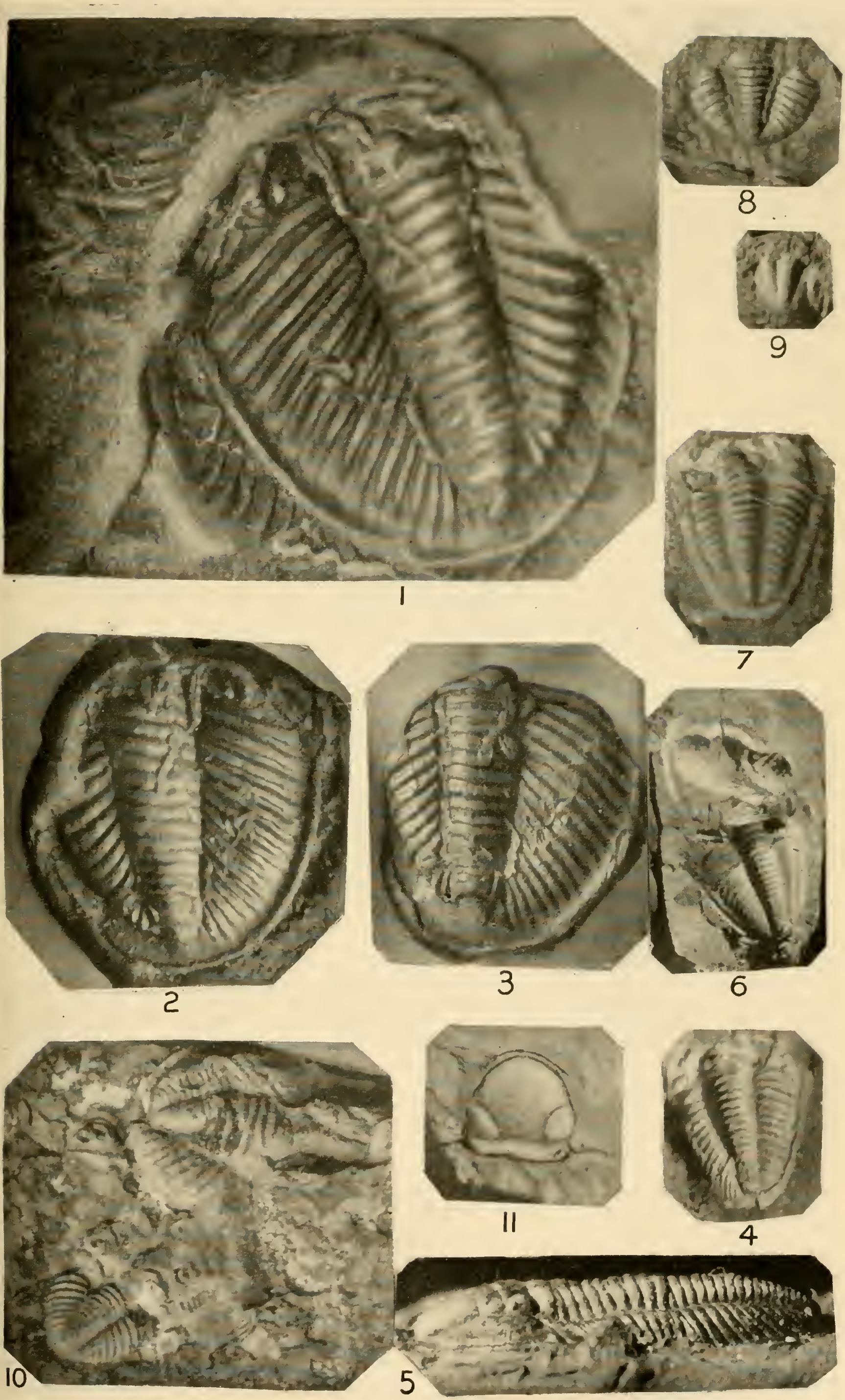
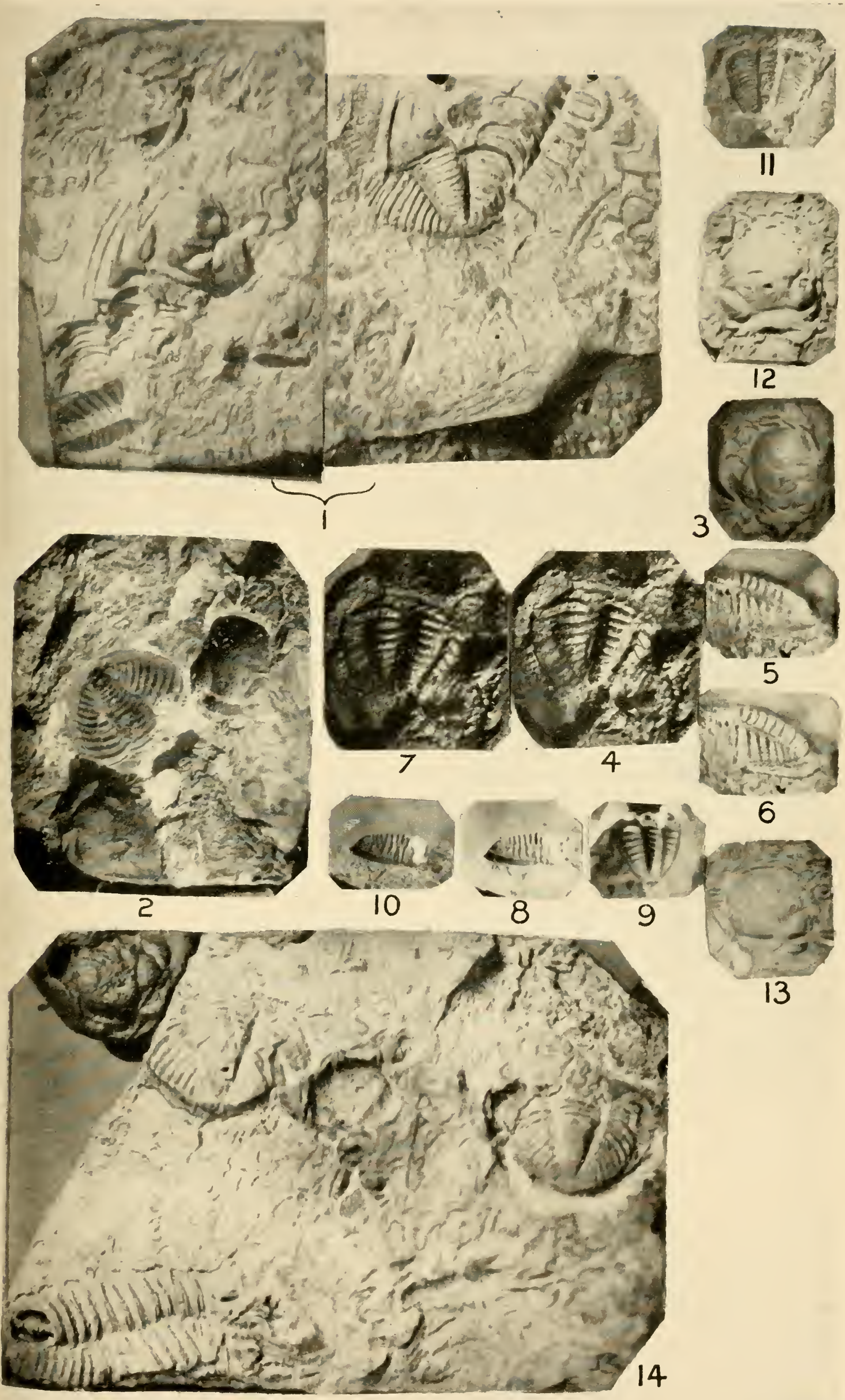
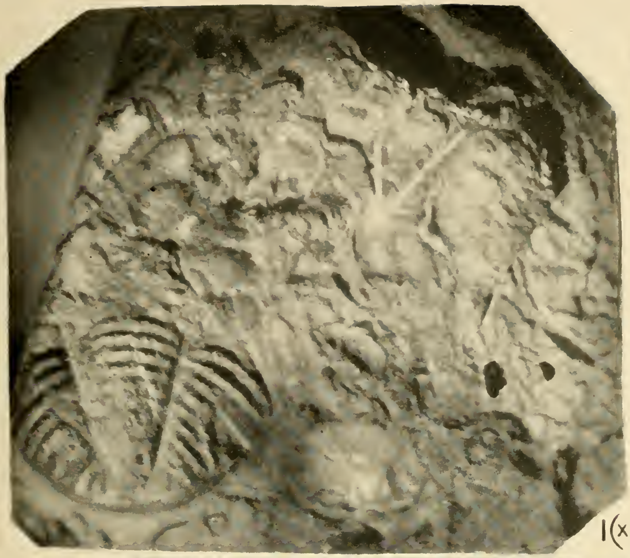
Carboniferous Trilobites of Australia (*Phillipsia, Brachymetopus*).



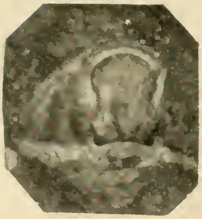
Carboniferous Trilobites of Australia (*Phillipsia*, ? *Brachymetopus*).



Carboniferous Trilobites of Australia (*Phillipsia, Brachymetopus*).



1 $(\times \frac{5}{2})$



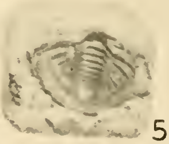
3 $(\times \frac{5}{2})$

7 $(\times \frac{5}{2})$

2 $(\times \frac{5}{2})$

4 $(\times \frac{5}{2})$

6 $(\times \frac{5}{2})$



5 $(\times \frac{5}{2})$

Carboniferous Trilobites of Australia (*Phillipsia*, *Brachymetopus*, *Griffithides*).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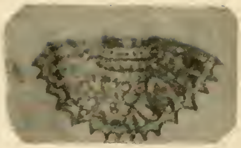
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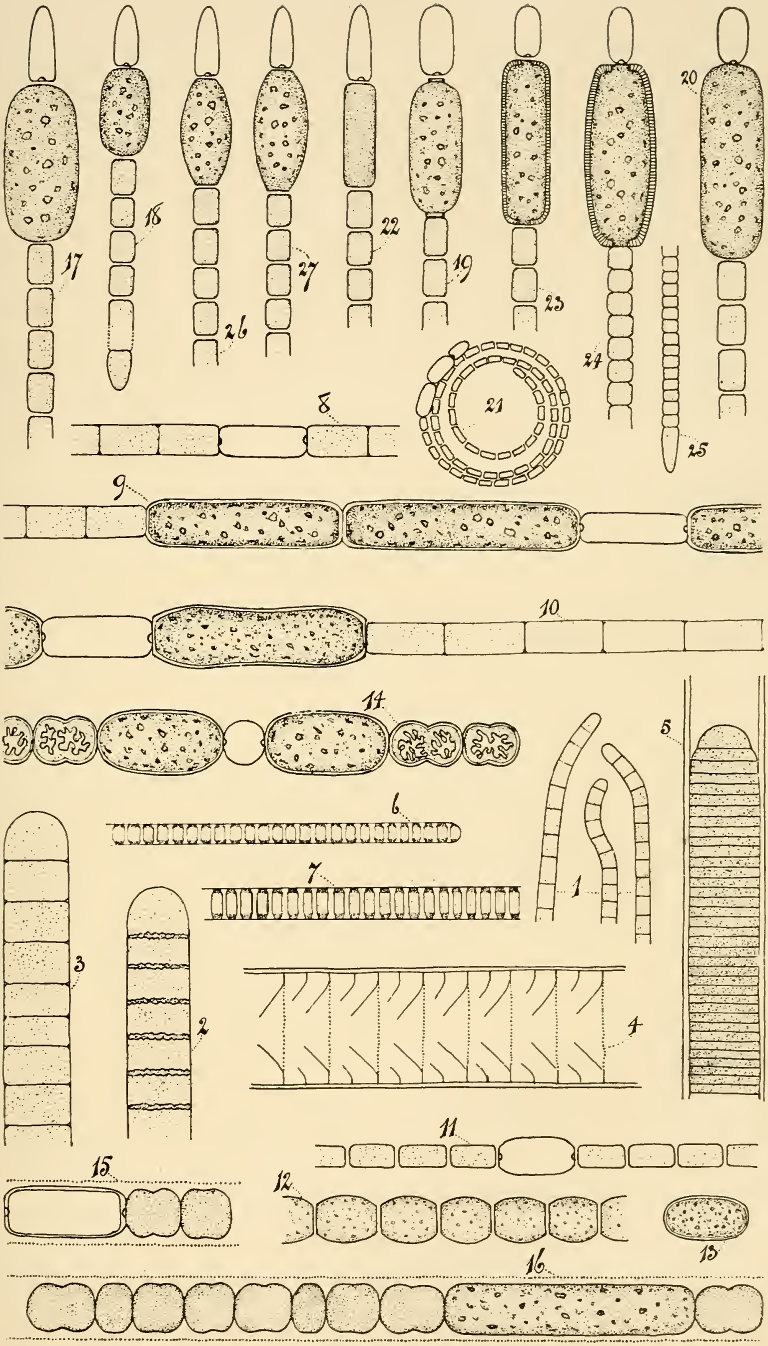
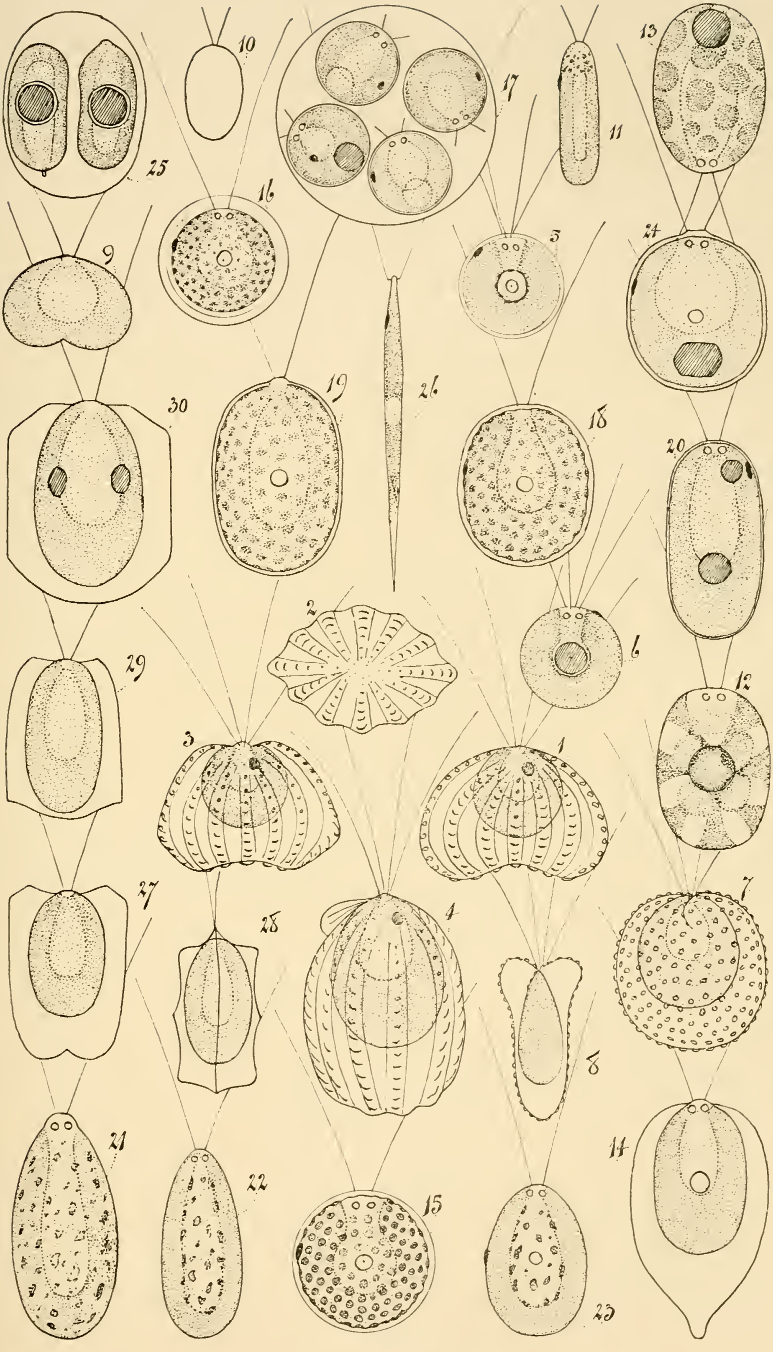
Carboniferous Trilobites of Australia (*Griffithides, Brachymetopus, Phillipsia*).



Myxophyceæ.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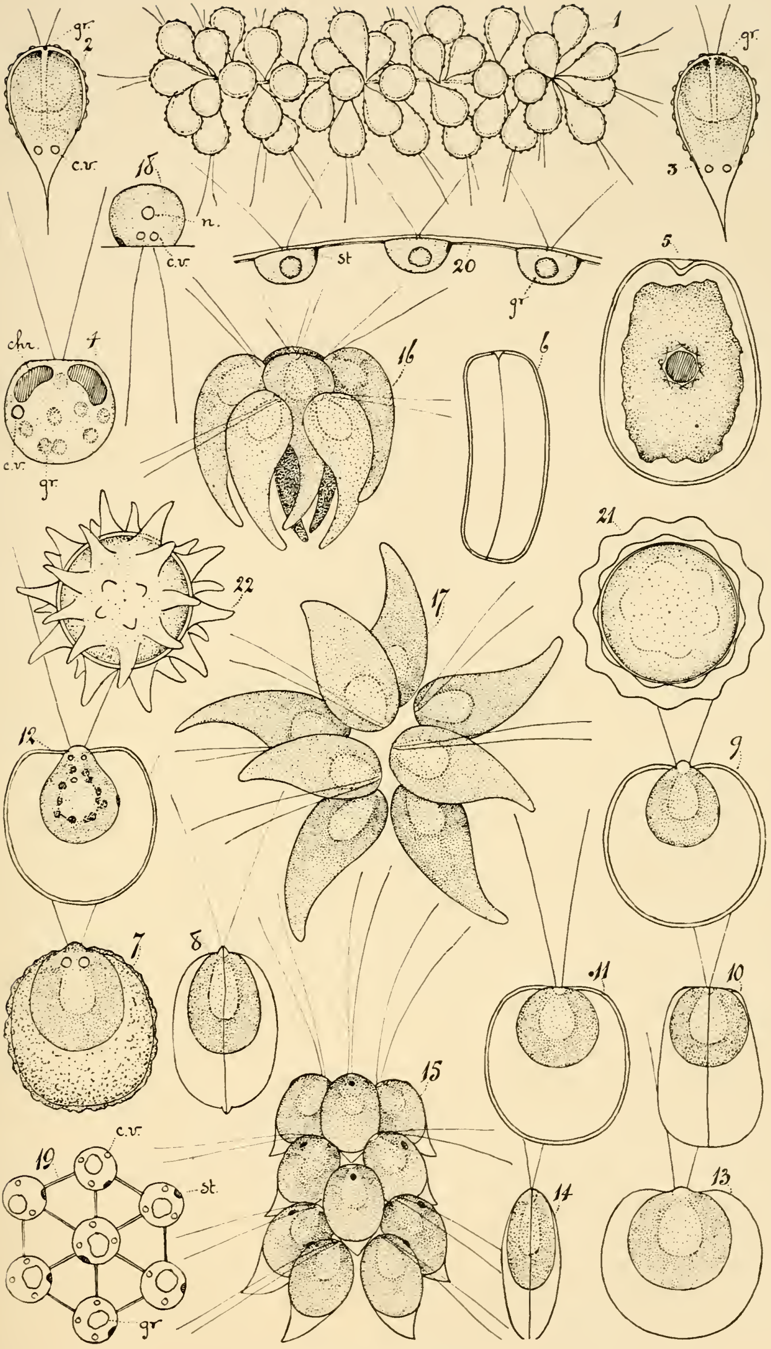
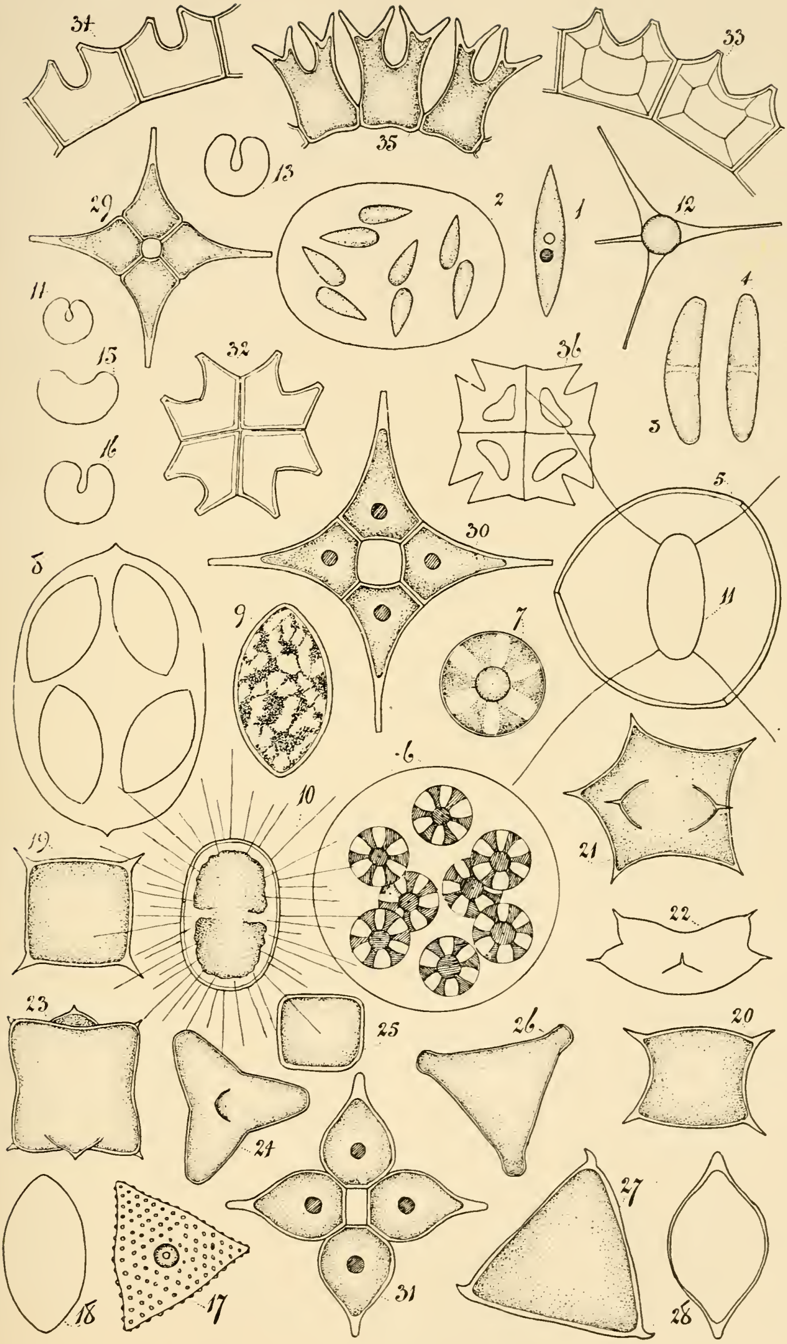
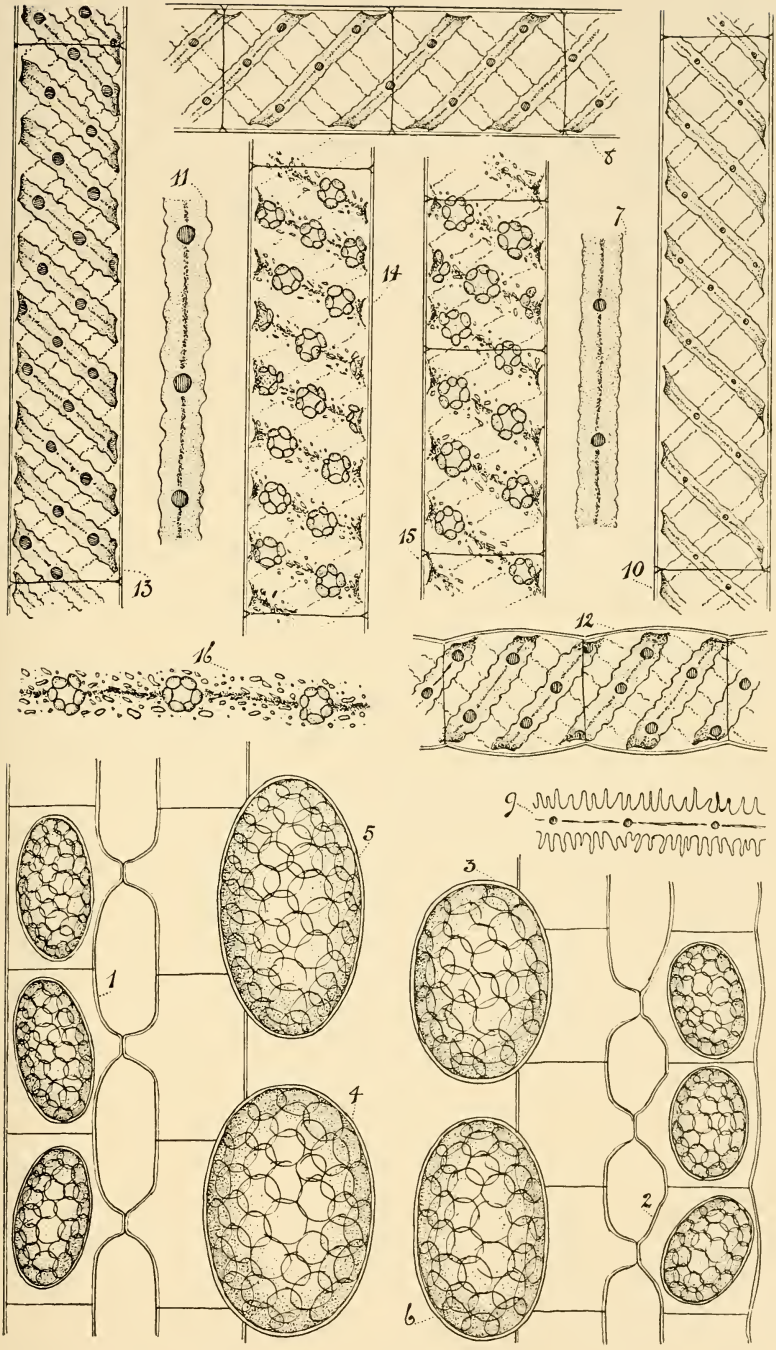
Volvocaceæ.



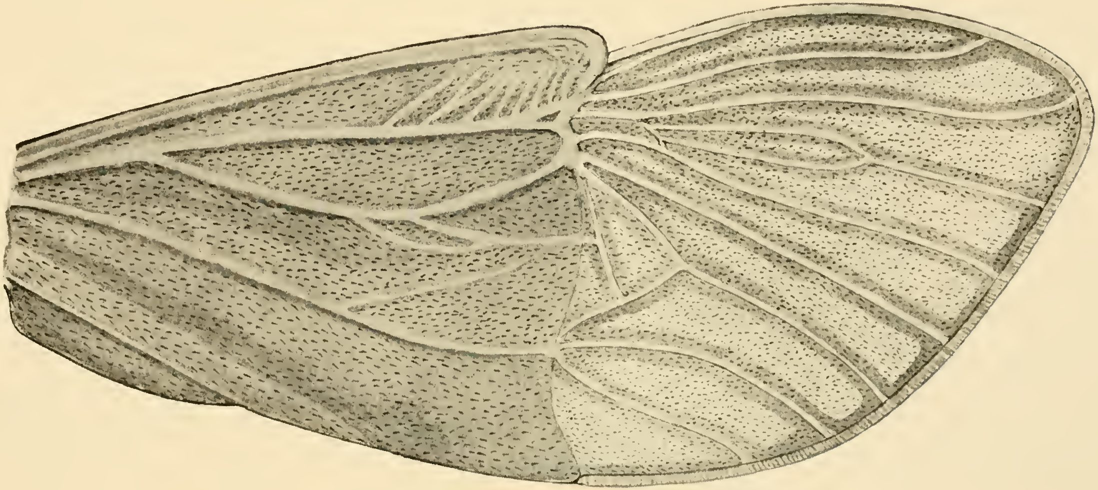
Volvocaceæ and Flagellatæ.



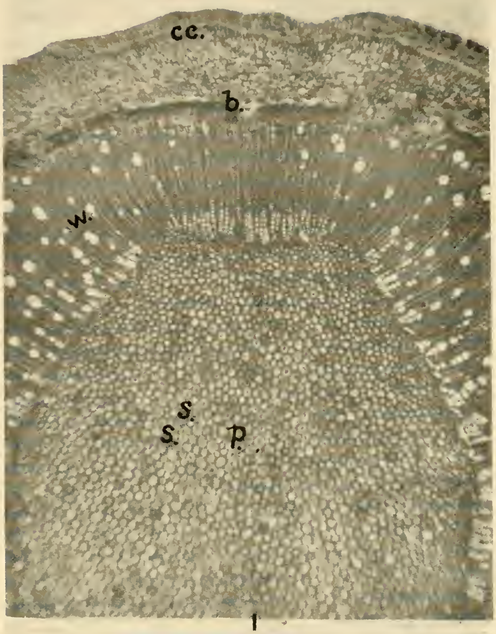
Protococcoideæ.



Spirogyra neglecta : a study in variation.



Restoration of right hemelytron (forewing) of *Dunstania pulchra* Till.



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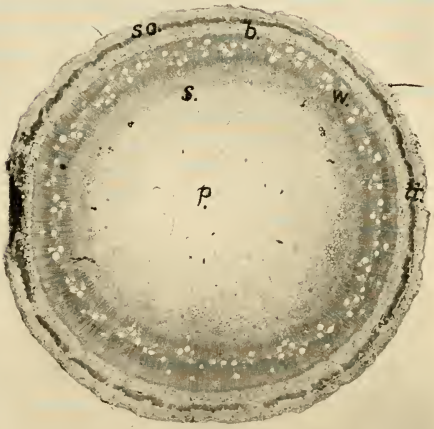

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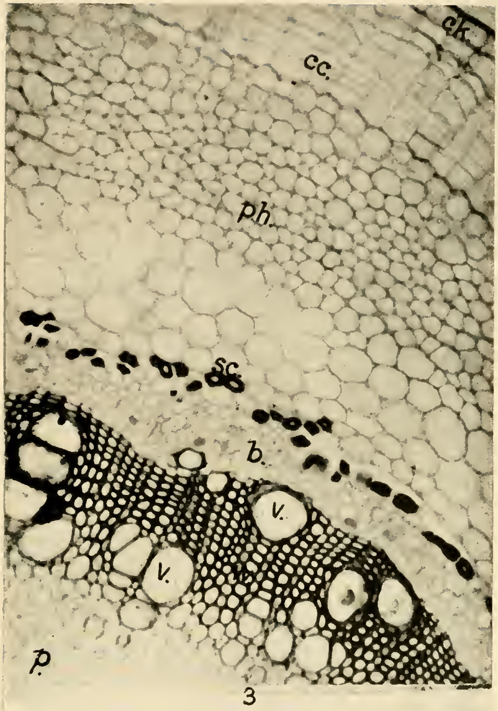
1. *Cœlospermum paniculatum* F.v.M.; (×24). 2. *Milletia australis* F.v M.; (×17).



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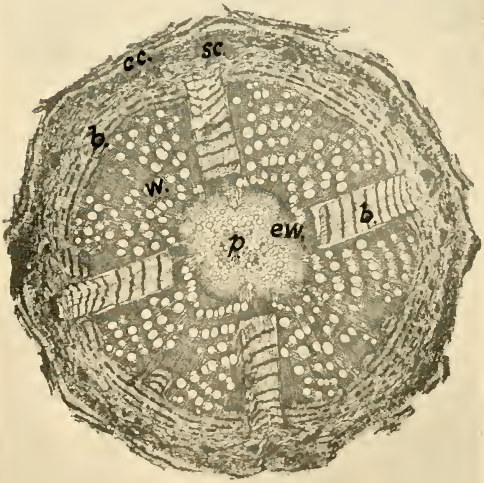

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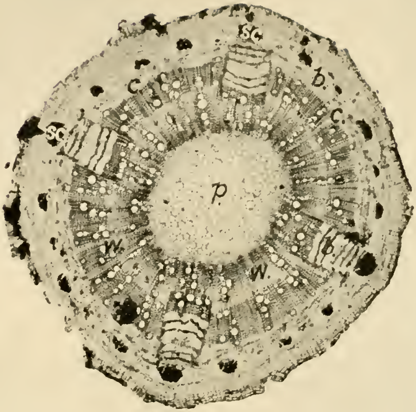
3. *Solanum Wendlandii* Hook. f.; (×90). 4. *Bignonia Tweediana* Lindl.; (×17).



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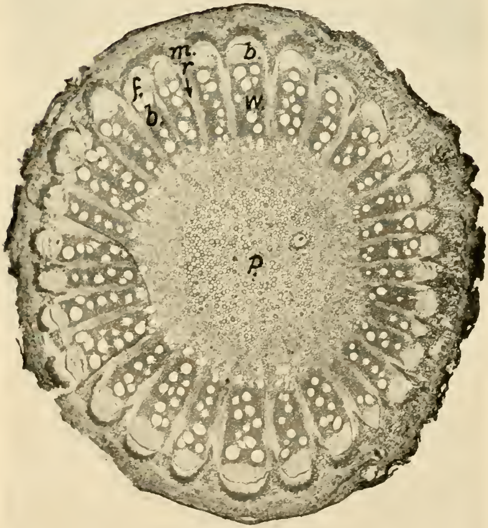

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5. *Bignonia picta* Lindl.; (×23). 6. *Carronia multisepalea* Lindl.; (×13).

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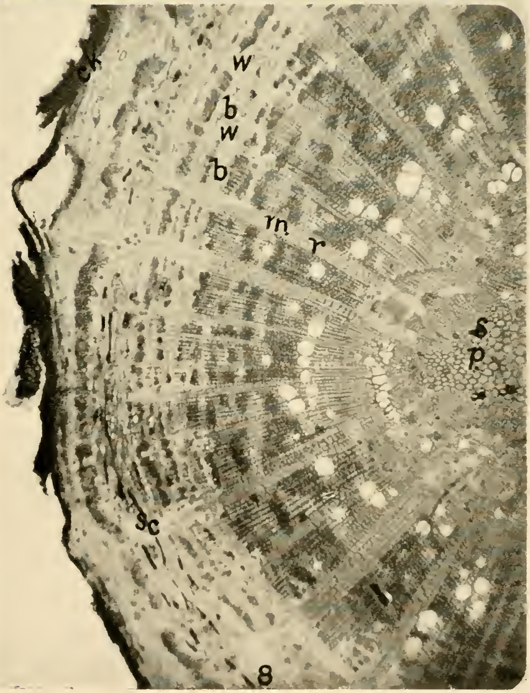

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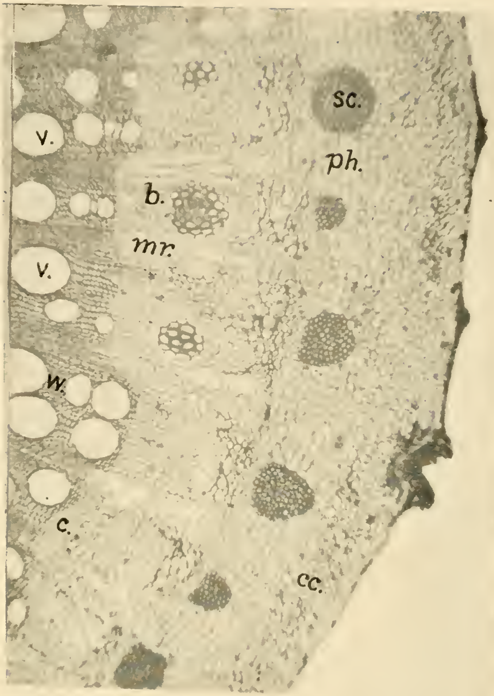
7. *Bryonia laciniosa* Linn.; (×23). 8. *Wistaria chinensis* DC.; (×40).



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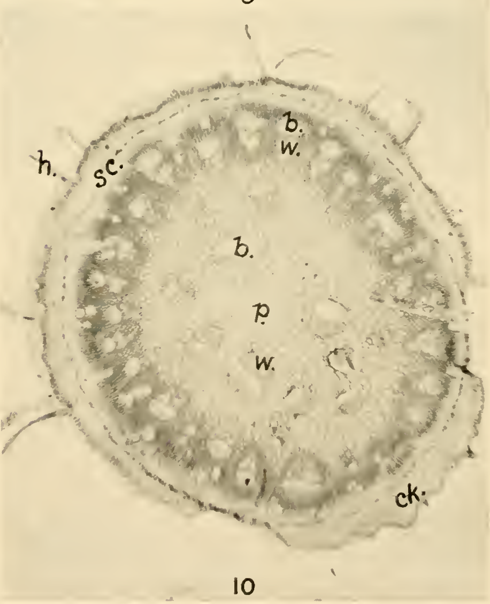

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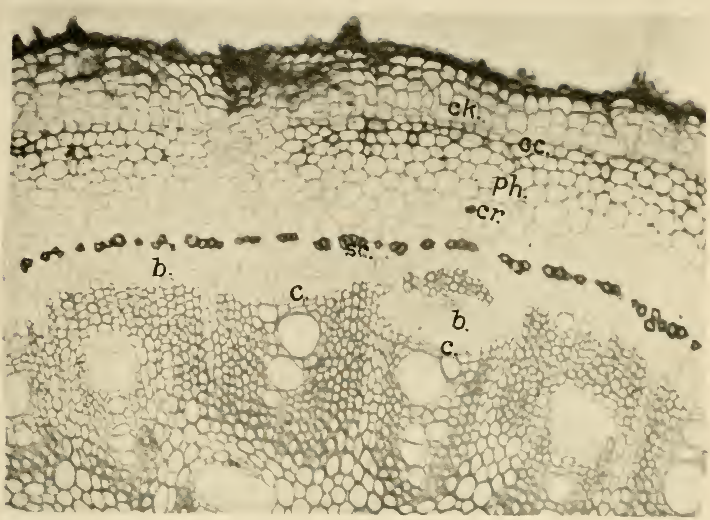
9. *Vitis sterculifolia* F.v.M.; (×40). 10. *Bougainvillea spectabilis* Juss.; (×23).



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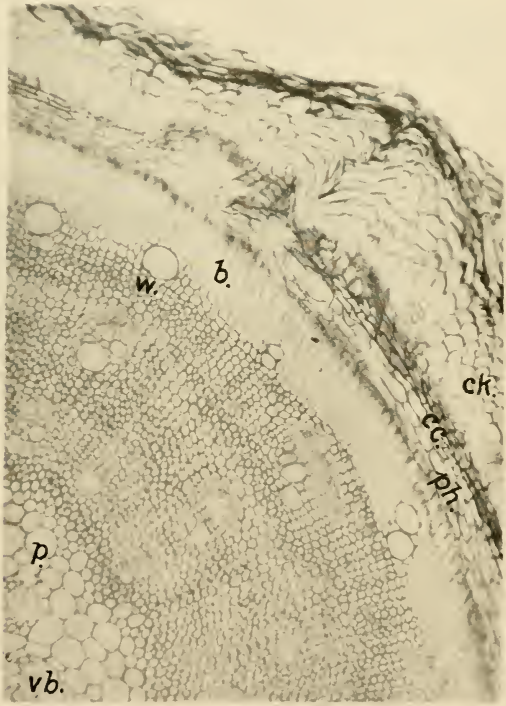

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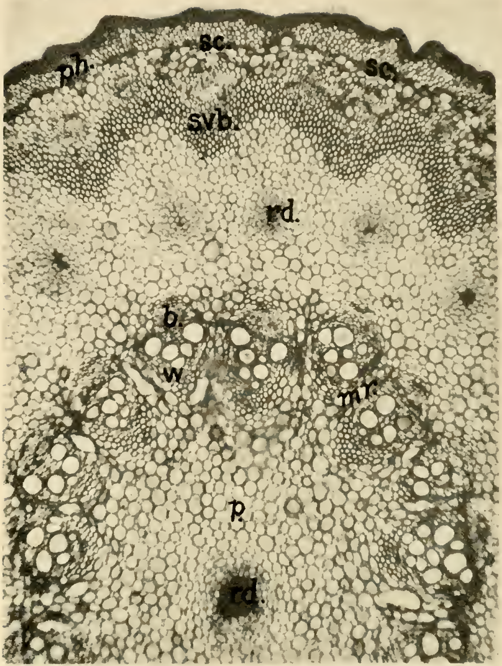
11. *Bougainvillea lateritia* Hort.; (×90).   12. *B. Sanderiana* v. *variegata* Hort.; (×90).



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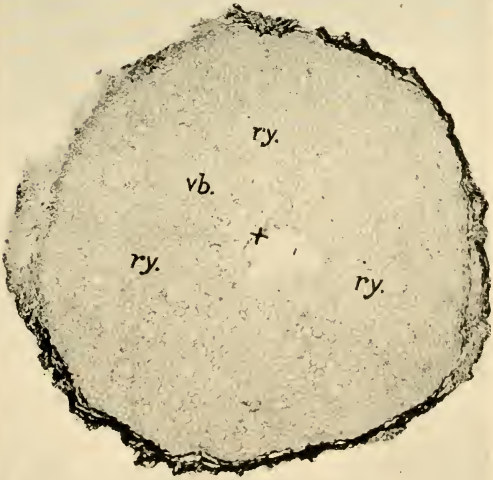

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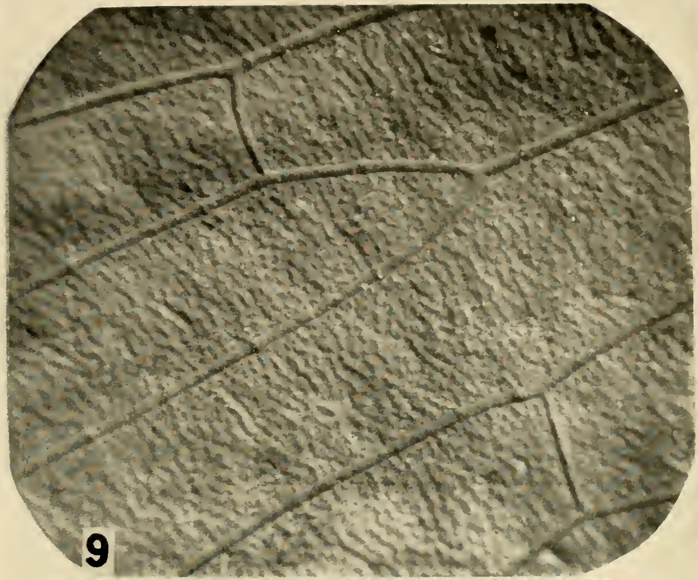
13. *Piper nigrum* Linn.; (×40). 14. *Galeola cassythoides* Reichb.; (×19)



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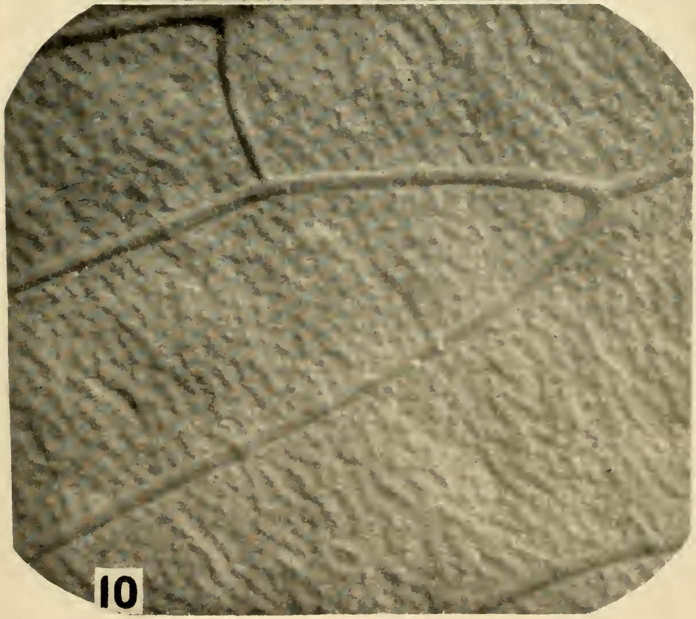

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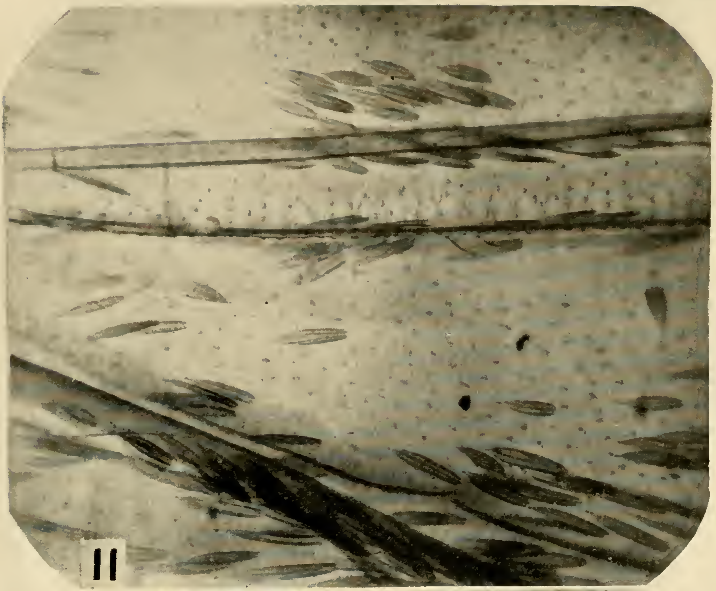
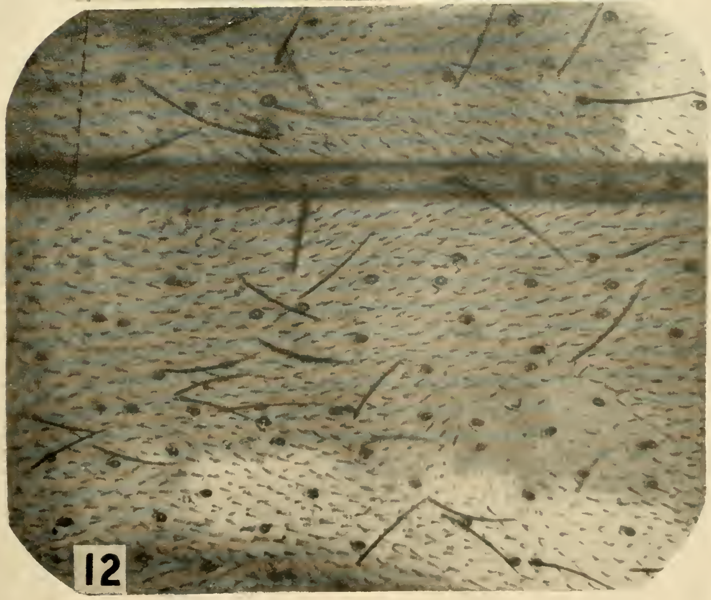
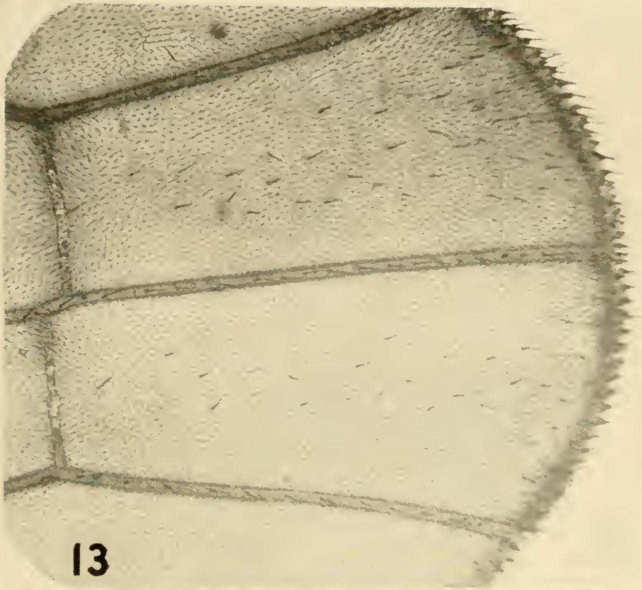
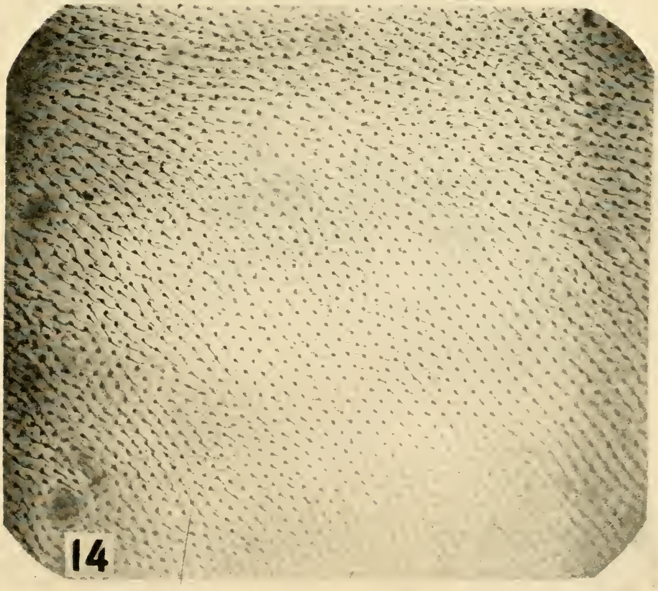
9.-10. *Archipanorpa magnifica* Till.



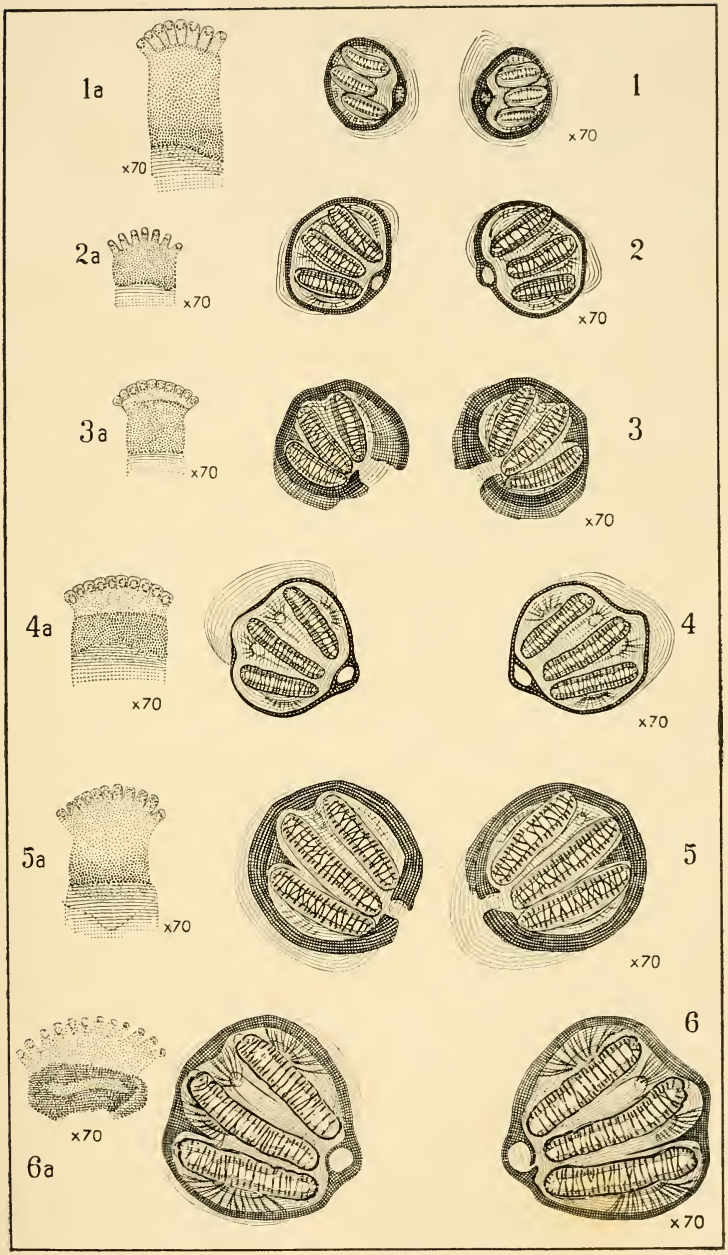


11. *Prototheora petrosema* Meyr., (Lepidoptera). 12. *Rhyphus brevis* Walk., (Diptera).





13. *Chorista australis* Klug, (Mecoptera). 14. *Calliphora villosa* Desv., (Diptera).



E. H. Zeck, del.

Spiracles of larvæ of Muscoid Flies.

NOTES ON THE NATIVE FLORA OF NEW SOUTH WALES.

Part x. The Federal Capital Territory.

By R. H. Cambage, F.L.S.

(Plates lxxi.-lxxiv.)

(Continued from These Proceedings, 1912, p.651.)

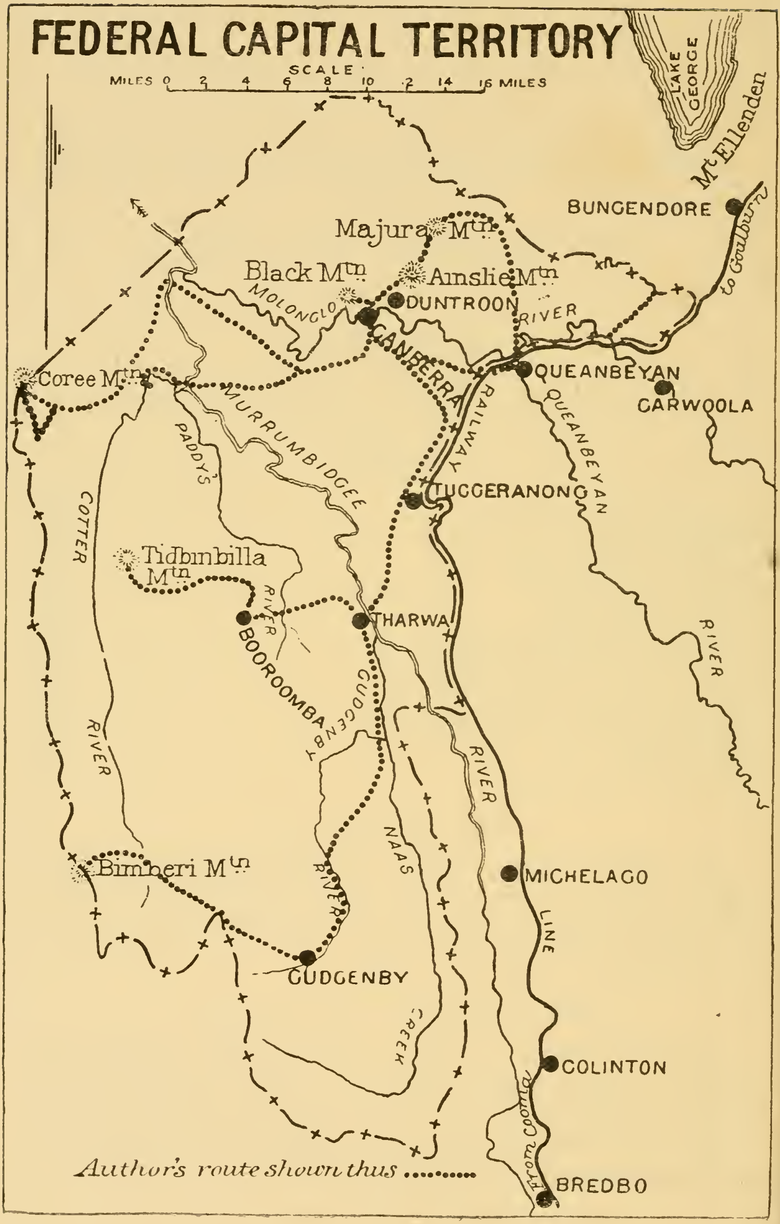
Synopsis.

Area and Situation.

The Federal Capital Territory contains an area of about 900 square miles, and is situated between latitude 35° and 36° south. Its greatest length north and south is upwards of 50 miles, while its average width is under 20 miles.

Early Explorers in the Locality.

The first explorer to reach the Federal Capital Territory was Charles Throsby, of Bong Bong and Glenfield, and he was probably accompanied by Joseph Wild, a constable of the district of Argyle, and a notable bushman, who discovered Lake George, not many miles distant, on 19th August, 1820.


FEDERAL CAPITAL TERRITORY
SCALE
MILES 0 2 4 6 8 10 12 14 16 MILES
LAKE GEORGE
Mt Ellenden
BUNGENDORE
to Goulburn
Majura Mtn
Black Mtn
Ainslie Mtn
MOLONGLO
DUNTROON
RIVER
CANBERRA
QUEANBEYAN
CARWOOLA
Coree Mtn
MURRUMBIDGEE
PADDYS
QUEANBEYAN
RAILWAY
TUGGERANONG
COTTER
Tidbinbilla Mtn
RIVER
THARWA
BOOROOMBA
GUDGENBY
RIVER
RIVER
RIVER
Bimberi Mtn
NAAS
RIVER
MICHELAGO
LINE
GUDGENBY
CREEK
COLINTON
From Cooma
BREDBO
Author's route shown thus ....

In October, 1820, Lake George was visited by Governor Macquarie, who then named it after His Majesty George IV. He also named Goulburn Plains during the same visit. The Governor arrived at Lake Bathurst, from Parramatta, with Deputy Surveyor-General James Meehan, Charles Throsby, Joseph Wild and others, and was there joined by Commissioner Bigge, Surveyor-General John Oxley, and Charles Fraser (Colonial Botanist), who had journeyed from Bathurst up Campbell's River and across the Abercrombie River.* The party travelled to Lake George from Lake Bathurst, which latter was discovered by James Meehan and Hamilton Hume on 3rd April, 1818 (Field Book 143, Lands Department).

On 28th October, 1820, the Governor and party ascended a high hill to the eastward of Lake George, evidently Ellenden, and viewed the high land in the southern portion of the Capital Territory, though, owing to an intervening range, they would not have been able to see the plains at the northern end. That they were not impressed with the potentialities of the future Federal Territory is evident from the following entry made by Oxley :—"The whole extent between the S.E. and West may be properly described as rocky, broken, and mountainous, and no feature or object in the prospect offered any reasonable expectation that a good or even tolerable country could have existence in those quarters." How little could they foresee that they were gazing over what was to become, not only the spot where William James Farrer was to carry out his great wheat-growing experiments, which would do so much towards producing drought-resisting wheats, and revolutionise wheat-production in a dry climate, but that they were also viewing portion of the site of the future capital of all Australia.

Macquarie refers to "a new-discovered river," and mentions that "Mr. Throsby tried to get hold of some of the natives of this part of the country to serve as guides to conduct them to the new River Murrumbidgee," but the Governor's party could

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* See Governor Macquarie's Journal—Report by Commissioner of Inquiry Bigge (Mitchell Library). Oxley's Field Book No. 172, Lands Department.

not find time to visit it, though Throsby did. They were under the impression that the new river flowed towards the south-east into the ocean, which suggests that, although they were aware of the presence of the river, no white man had actually visited it.

It was in April, 1821, that Throsby visited the locality of the present Federal Territory, and, after going southerly from Lake George, he wrote :—" I passed over two rivers, exclusive of the one I discovered and on the banks of which I passed a night at the time the Governor was at Lake George."

The two rivers referred to would be the Molonglo and Queanbeyan, and the one he discovered previously, the Murrumbidgee. He met with vast quantities of limestone, and a good quantity of open forest and plains.*

On the 31st May, 1823, Captain Mark John Currie, Brigade-Major Ovens, and Joseph Wild reached the vicinity of what is now known as Queanbeyan, and, Currie writes, "encamped by the side of the South Fish River (as called by our attendant, Joseph Wild), on the edge of Lime-stone Plains." They travelled thence south-westerly towards the Morumbidgee (as it was usually spelt in those days), and named the Isabella Plain after Governor Brisbane's daughter. This plain is largely included within Portions 190 and 203, Parish of Tuggeranong. They followed up the right bank of the Morumbidgee, finally crossing the Umaralla, thinking it was the Morumbidgee, and discovering the Monaro Plains or Downs. On the way up, they mention having seen pine-trees of about 2 feet in diameter. These would be the species now known as *Callitris calcarata*, Black or Mountain-Pine.

In returning, the party for some distance kept to the eastward of the Federal Territory, and, on the 8th June, 1823, "met with large rocks of limestone," discovering what is now known as London Bridge, "a natural bridge of one perfect Saxon arch, under which the water passed."

Settlement followed this visit within the next few months, for among the records of the Chief Secretary's Department is a letter

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* The Australian Magazine, 1821, Vol. i. (Public Library).

from Joshua John Moore, a retired Lieutenant, dated 16th December, 1826, in which he expresses his desire to proceed with the purchase of 1000 acres, "situated at Canberry, on the east bank of the river, which waters Limestone Plains, above its junction with the Murrumbeeja." He mentions that he had been in possession of the land for upwards of three years. This appears to be the first reference, in an official document, to the name, which, with a slight alteration, was to be selected for the capital city of Australia.

In a letter dated 14th September, 1831, Moore says:—"It is called and known by the name of Canburry, and is bounded on the south by the Molongoo River, and on the west by Canburry Creek."

This area is now Portion 52, Parish Canberra, County Murray, and permission to purchase was granted by Sir Thomas Brisbane on 3rd May, 1825. There seems no doubt that the original was a native name, but its meaning is unknown.

What is now Portion 58, of 4000 acres, Parish Canberra, and known as Duntroon, was promised by Sir Thomas Brisbane on the 18th May, 1825, and Portion 181, of 1000 acres, by Lieutenant General Darling on the 22nd March, 1830, to Robert Campbell, pursuant to instructions from the Right Honorable Secretary of State for the Colonies, in part compensation for the loss of a certain ship called "The Sydney" while employed by the Government of the said territory in the year 1806.

Portion 51, of 640 acres, Parish Canberra, was promised to John McPherson on or before the 10th September, 1831, as a Primary Grant. The name of the farm was Spring Bank, and it was stated to be at Canbury, Limestone Plains.

An area of 2560 acres, said to be at Yarralumla, now Portion 4, Parish Narrabundah, was promised by Governor Darling to Edward Weston, of Horsely, Liverpool, on or before the 5th September, 1831.

An area of 2560 acres, said to be at Yarralumla, now Portion 5, Parish Narrabundah, was promised to Henry Donnison on or before the 15th August, 1828, by Governor Darling, but finally granted to Terence Aubrey Murray and Thomas Walker.

Portion 203, of 2000 acres, Parish Tuggeranong, at Isabella Plain, was promised to Peter Murdock on or before the 14th February, 1827; and Portion 190, of 2560 acres, adjoining, to John McLaren, on or before the 21st February, 1829.

In May, 1829, Surveyor Robert Dixon traversed the Molonglo River from near Queanbeyan, across the "Limestone Plains to the Morumbidgee River." (Field-Book 317, Lands Department).

The position of the junction of the Queanbeyan and Molonglo Rivers is shown, and on one side of the former is written "Medora Creek," and on the other "Quinbean."

The position of "Tim Beards' Station" is shown on the south side of Molonglo River near "commencement of plains."

To the west of where Canberra Church now stands, Dixon shows the position of a fence, and the initials J.J.M., which latter evidently refer to Joshua John Moore, the first owner of of Portion 52, Parish of Canberra.

The entry, "Taylor's Hut," appears near the junction of Yarrolumla Creek and Molonglo River.

On the 15th May, 1832, Surveyor Robert Hoddle commenced a survey at "Malonglo River for the purpose of measuring land at Limestone Plains." (Field Book, No.375). Portions were measured for Robert Campbell, George Thomas Palmer, Joshua John Moore, John McPherson, John Stephen, and Edward Weston.

He refers to Majoura, Ainslie's Hill, Black Mountain, Queenbeeann, Pialligo, and R. Campbell's Cattle Station on Portion 181.

On the 16th May, 1832, when measuring J. J. Moore's Portion 52, of 1000 acres, Hoddle noted, on page 50, the position of several "huts" and some "limestone rocks" at a bend in the river at the spot since named Acton,* and, near them, entered the name Canburry, which he afterwards altered to Canberry, the latter name appearing on his plan. The site near the huts is now occupied by an old stone cottage, built in the early days

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* These identical limestone rocks are shown on the extreme left in photograph No.1, in the "Report on a Geological Reconnaissance of the Federal Territory" by D. J. Mahony, M.Sc., &c., and T. Griffith Taylor, B.Sc., &c. (1913).

of settlement. On the same day, he traversed the creek which flows south-westerly past the eastern slopes of Black Mountain, and, on pages 52 and 53 of his field-book, entered the name as Canbury Creek.*

Elevation and Topography.†

The elevation of the Federal Capital Territory above sea-level ranges from something under 2,000 feet along the valleys in the northern portion, including part of the proposed Federal City of Canberra, to upwards of 6,000 feet in the south-western portion, the highest point being Mount Bimberi, which reaches an elevation of 6,264 feet, giving the Territory a range of elevation exceeding 4,000 feet.

The western boundary follows a range northerly from Mount Bimberi to Mount Coree or Pabral, the elevation of the latter being 4,657 feet Dividing the Cotter from the Murrumbidgee River is another range running north and south, one of the highest points of which is Tidbinbilla, said to be a slightly altered native name which signified a snow-capped mountain, and which reaches an elevation of 5,115 feet. These high points are all visible from many spots on the north side of the Molonglo River.

The area east of the Murrumbidgee, which is regarded as a fault-block, is generally lower than that on the western side, and ranges between about 2,000 and 2,800 feet above sea-level, the vegetation being of an open forest character. Around the Federal City site and Duntroon are the Canberra Plains, formerly known as the Limestone Plains, naturally almost treeless, and through which the small Molonglo River flows.

The southern portion of the Territory is largely composed of a network of broken mountains, though, in a few places, as near

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* In 1837, Surveyor Hoddle had charge of the laying-out of the City of Melbourne, and in 1851 became the first Surveyor-General of Victoria.

† See "Notes on the Physiography of the Southern Tableland of New South Wales," by C A. Süssmilch, F.G.S., Journ. Proc. Roy. Soc. N. S. Wales, Vol. xliii., p.331 (1909). Also "The Physiography of the Proposed Federal Territory at Canberra," Commonwealth Bureau of Meteorology, Melbourne, by Griffith Taylor, B.Sc. (1910).

Gudgenby, there are fairly level interspaces showing little or no dissection, and in some cases containing swampy areas.

If we block out a model in the form of a great irregular wedge, and consider the Molonglo River as the northern edge of the wedge, a horizontal section the full width of the Territory and extending south to the southern boundary would give us the length of the wedge, the length of the base would be the width of the Territory in the south, while the width (depth in this case) of the base would vary from perhaps 3,000 to about 4,300 feet in the south-west corner. In viewing this great irregular so-called wedge, which is higher along the western side, we find it is scored longitudinally into more or less deep ravines, along which flow the Cotter, Paddy's, Gudgenby, and Murrumbidgee Rivers. The deepest of these gorges is occupied by the Cotter River, which at Thomas Oldfield's (Portion 2, Parish Fergus, County Cowley) is roughly 3,600 feet above sea-level, so that the river has here, under Mount Bimberi, entrenched itself to a depth of nearly 2,700 feet. The Murrumbidgee occupies the shallowest of these channels, and, in parts of its upper portion, around Tharwa, flows at the eastern foot of the mountains through an almost mature valley, so far as the eastern side is concerned, while it has cut gorges of varying depths down stream.

GEOLOGICAL FORMATIONS.*

Quoting from Mr. Pittman's map, it may be said that the rocks within the Federal City Site consist of Upper Silurian sandstones, quartzites, shales, tuffs, clay-slates, and several outcrops of limestone, while the igneous rocks are crystalline tuffs and lavas, quartz-porphyries, and quartz-felsites.

In the western and southern portions of the Federal Territory, a considerable area is composed of granite of a fairly siliceous character. Granite rocks are common around Tharwa, Boo-

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* See a detailed "Geological Survey of the Site of the Federal Capital of Australia," by Edward F. Pittman, A.R.S.M. (1910). Also, a "Report on a Geological Reconnaissance of the Federal Territory," by D. J. Mahony, M.Sc., &c., and T. Griffith Taylor, B.Sc., &c. (1913).

roomba, the Gudgenby River, in places alternating with slate, on the range separating the Upper Gudgenby waters from those of the Cotter, and on the summit of Bimberi Peak or Mountain.

No evidence of glaciation was noticed on Bimberi, but it was not specially searched for. The absence of a suitable gathering ground, however, would alone probably be sufficient to account for its absence.

The valley of the Cotter, in the vicinity of Bimberi, and the side of Bimberi, up to at least the 5,000 feet level, are of slate formation, probably Upper Silurian, and this accounts for the great denudation which has been effected by the Cotter River operating on the softer rocks, for it was noticed that the highest hills in the locality are granite.

The summit of Tidbinbilla was found to consist of quartzite and slate, the former supplying the resisting qualities.

The central-eastern portion of the Territory consists largely of quartz-porphyries, and produces an open forest vegetation.

Mount Coree is composed of igneous rocks, a specimen from the summit being considered by Mr. G. W. Card, A.R.S.M., without critical examination, as of the rhyolite or rhyolite-tuff class. This rock splinters in a remarkable manner, and under the bluff at the south-west end, narrow strips may be seen up to 10 feet long.

A few miles south of Coree, and also where the main road crosses Coree Creek, the formation is slate.

A good example of the effect of geological formations on the vegetation may be seen from the City site. To the north east are the slopes of Mount Ainslie (2,762 feet), composed largely of volcanic tuffs, and clothed with open forest, while to the north-west is the coarse sandstone-hill known as Black Mountain (2,658 feet). The name of the latter was suggested by the dark appearance of the more dense foliage of this hill as compared with that on the surrounding elevations, but this mass of vegetation is a direct response to the more siliceous sandstones of which the eminence is composed.

Climate and Rainfall.*

If the flora of the area be classified under the heading of either a warm- or a cool-country flora, its proper place is certainly under the latter. There are a few western or warmth-loving plants found there, one in particular (*Casuarina Luehmanni*) raising an interesting point in the study of distribution, but the great bulk of them are such as may be expected in our cool mountain-areas. Judging from the native vegetation, therefore, the climate of the Federal Capital Territory may be designated as cool.

According to the Commonwealth Bulletin No.7, and further information kindly supplied by Mr. H. A. Hunt, Commonwealth Meteorologist, and Mr. D. J. Mares, Divisional Officer, Sydney, the following are the mean temperatures at a few stations, and the average annual rainfalls at some localities in and around the Federal Territory, including, for comparison, Cootamundra towards the foot of the western slopes, and Milton to the east on the coast.

	Wettest month.	Driest month.	Years.	Rainfall in inches.	Years.	Mean temp.
Braidwood	January	September	39	27·3	—	55·4
Bungendore	January	May	27	23·0	—	—
Carwoola	June	February	27	24·9	—	—
Collector	—	—	17	26·4	—	—
Cooma	February	August	52	19·1	44	54·2
Cootamundra	June	February	28	22·9	16	59·6
Duntroon	June	February	19	20·1	4	56·6
Goulburn	January	April	52	25·0	46	56·1
Gudgenby	January	February	27	31·8	—	—
Gundaroo	June	February	40	24·2	—	—
Kiandra	June	February	42	63·8	—	44·4
Lake George	June	February	33	26·4	19	58·1
Majura	January	February	30	24·1	—	—
Milton	—	—	25	44·2	—	—
Queanbeyan	January	August	46	22·3	—	56·1
Uriarra	—	—	15	32·9	—	—

From the above, it may be seen that January and June are

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* See Bulletin No.7, "On the Climate of the Yass-Canberra District," by H. A. Hunt, Commonwealth Meteorologist. (1910).

the wettest months, while February is usually the driest. The annual rainfall at the Capital City site may be estimated at somewhere about 21 or 22 inches.

The effect of climate upon the native vegetation is largely regulated by the question of aspect. Broadly speaking, Eastern New South Wales has two dominating aspects, the eastern or moist, and the western or dry.

The rain comes chiefly from the eastern or ocean-side, and is precipitated by the cooling or ascending clouds on the mountain-sides and summits; when the clouds pass beyond the summits and commence to descend, the precipitation is reduced. This applies also to clouds coming from the west. The result of this natural law may be seen in the Braidwood district, about 40 miles nearer the coast than Canberra, and at a distance of only 35 miles from the ocean, for Braidwood is largely shut off from full coastal influence by a mountain-range a dozen miles away and known as Budawang, to the east of which the rainfall is quite 40 inches, while at Braidwood it is only about 27 inches. Similar conditions are found at many places towards the eastern edge of the plateau in this State.

A great portion of the Capital Territory, especially along the depressed Murrumbidgee valley, is sheltered by north and south ranges on either side, as well as for the most part on the south, the result being that, to a large extent, it is the descending clouds from east, west, and south which pass over this area, and the rainfall in the valley is, in consequence, less than on the hill-sides. Evidence of this may be seen in the resultant flora. Moreover, the clouds from the coast, after passing over the Territory, encounter the high range known in part as Brindabella Mountain, forming the western boundary extending from Bimberi to Coree, and on its slopes deposit much of their load. As a result, this is the area in which is found the most robust and comparatively luxuriant vegetation in the Capital Territory, including splendid examples of tree-ferns (*Dicksonia antarctica*), ten feet high, which, at about 3,000 feet above sea-level, are nestling under the shelter of Mount Coree, and facing the eastern or moist aspect.

My view is that the luxuriant forests on the mountain-side are the result of a high rainfall induced chiefly by the position of such mountains, rather than that the rainfall is a consequence of the presence of the forest. Judging by the vegetation on the higher land towards Bimberi and Coree, it is probable the annual rainfall there reaches 40 inches, and on Bimberi itself, which intercepts clouds from every direction, it possibly amounts to quite 50 inches

Absence of Trees from Canberra Plains.

The reason why many thousands of acres of almost level or slightly undulating land should be naturally destitute of trees is difficult to explain. The question is a universal one, and Australian examples have been much discussed between botanists. The instances are many, and include those from the extensive plains of the interior with a meagre rainfall, where treeless stretches of upwards of fifty miles are not uncommon, to those on the highlands with a rainfall, in exposed situations, as around Kiandra, of sixty inches per annum, and also such spots as those on the upper Dorrigo, where the brush or jungle in places ceases abruptly and forms a fringe on the edge of an open plain.

My own observations lead me to suggest that the explanation will yet be found in many cases by an examination of the soil, or, in other words, that it is from this source that we shall obtain our best knowledge of the subject, studied in relation to topography, rainfall, and aspect. Whether the feature is chiefly regulated by the chemical constituents or the physical properties of the soil is difficult to decide, but it is probably in some degree the result of both factors.

In These Proceedings (1909, p.310), I discussed the question of the absence of trees from the Monaro Tableland, and pointed out that, where the hills were composed of siliceous formations, they were more or less tree-clad, while those made up of basic soils were bare, except for some scattered trees of *Eucalyptus coriacea* and *Acacia melanoxylon* on a few basalt-summits.

I am indebted to Mr. J. C. H. Mingaye, F.C.S, for the following analyses of soils and quartz-porphyry from the Canberra Plains.

A. From crest of low, treeless elevation at 6¼ miles from Queanbeyan.

Mechanical Analysis.

Coarse particles of stone	19·58	per cent.
Stone left on 20-mesh sieve	9·87	,,
Stone left on 30-mesh sieve	3·92	,,
Stone left on 60-mesh sieve	7·83	,,
Root-fibre	0·59	,,

Chemical composition of soil passing through 60-mesh sieve soluble in warm hydrochloric acid :—

Insoluble in acid	82·04%*
†Ferric oxide alumina	10·56%
Lime (CaO)	0·06%
Silica (SiO_2)	0·25%
Magnesia (MgO)	0·16%
Potash (K_2O)	0·34%
Soda (Na_2O)	0·13%
Phosphoric anhydride (P_2O_5)	0·095%
Manganous oxide (MnO)	trace
Water	5·70%
Organic matter	0·81%
	100·145

* Containing silica 78·21%.

† Including a small amount of Titanium dioxide (T_2O_2).

B. From shallow valley at 5 miles from Queanbeyan.

Mechanical Analysis.

Coarse particles of stone	0·11	per cent.
Stone left on 20-mesh sieve	3·07	,,
Stone left on 30-mesh sieve	nil	
Stone left on 60-mesh sieve	9·38	,,

Chemical composition of soil passing through 60-mesh sieve soluble in warm hydrochloric acid :—

Insoluble in acid	89·11%*
†Ferric oxide alumina	5·13%
Silica (SiO_2)	0·12%
Lime (CaO)	0·61%
Magnesia (MgO)	0·29%
Potash (K_2O)	0·88%
Soda (Na_2O)	0·13%
Phosphoric anhydride (P_2O_5)... ...	0·07%
Manganous oxide (MnO)	trace
Water	3·38%
Organic matter	0·51%
	100·23

* Containing silica 76·62%.

† Including a small amount of titanium dioxide (T_2O_2).

The major portion of the soil which passed through a 60-mesh sieve, and used for the analysis, consists of fine particles of broken-up stone

No.2124/18. Quartz-porphyry, Canberra Road, on treeless plain 2½ miles from Queanbeyan.

Chemical Composition.

Moisture at 100°C	0·52	Soda (Na_2O)	1·37
Water above 100°C ...	2·66	Potash (K_2O)	2·76
Silica (SiO_2)	64·64	Lithia (L_2O)	absent
Alumina (Al_2O_3)	14·49	Titanium dioxide (TiO_2) ...	0·65
Ferric Oxide (Fe_2O_3) ...	2·30	Zirconium dioxide (ZrO_2)...	absent
Ferrous oxide (FeO) ...	3·69	Iron sulphide (FeS_2) ...	absent
Manganous oxide (MnO) ...	0·12	Sulphur trioxide (SO_3) ...	0·08
Nickel and cobalt oxides (NiO-CoO)	0·01	Phosphoric anhydride (P_2O_5)	0·11
		Vanadic oxide (V_2O_3)	minute trace
Calcium oxide (CaO) ...	3·42	Chromium sesquioxide (Cr_2O_3)	ditto
Magnesium oxide (MgO) ...	2·93	Chlorine (Cl)	absent
Barium oxide (BaO) ...	0·06		
Strontium oxide (SrO) ...	present*		99·81

* Spectroscopic reaction only. Specific gravity of rock = 2·735.

The soils of these plains around the Federal Capital are siliceous rather than basic, and the feature which is noticeable at Canberra, and other similar plains, is, that if there are any considerable elevations, of say, 200 feet or upwards, rising above the plain, then such elevations produce trees. The inference is, therefore, that there is some difference, either chemical or physical, between the soils on the well drained hills, and the soils of the lowland; and it may be that, even though the geological formation is the same from which the soils of hill and valley are originally produced, certain salts are leached out from the high land and carried down to the lower, thus differentiating the characters of the two soils.

Text-fig.2.
Buds of *Eucalyptus dealbata* enlarged by dipterous larvæ.

It is usual, of course, for both valley and height to produce trees, the differences in soil accounting perhaps for different local species, but this does not apply to the Canberra Plains, which, for some unexplained reason, are for the most part treeless, though all the considerable elevations around are clad with forest-growths.

INSECT ACTION ON TWIGS AND BUDS.

Some gouty swellings were found at the Cotter River on fruiting twigs of *Eucalyptus hæmastoma* (Brittle Gum), which, Mr. W. W. Froggatt, F.L.S., informs me are caused by the attack of small chalcid wasps (Chalcididæ), some of which are plant-feeders and deposit their eggs just under the bark. The effect on these twigs was such that, in some cases, for a length of 15·3 cm. (about 6¾ inches), they had been increased in diameter from 2·5 mm. to 1·6 cm., or about 6½ times their original diameter.

In November, 1911, great numbers of very interesting insect-galls were found within the City site on many trees of *Eucalyptus dealbata* (Red Gum). The flower buds were aborted by a dipterous larva which Mr. Froggatt has kindly identified as belonging to the family Agromyzidæ. By the action of these larvæ, the buds had been increased in diameter from 2 mm. to as much as 1·2 cm., or six times their original size (Text-fig.2). In some cases, five out of six buds in the umbel were affected. The effect of this swelling of the buds so greatly increased their weight, that broken branches were to be seen in many directions, reminding one of the result of a snow-storm.

PLANTS ABSENT FROM THE FEDERAL TERRITORY.

Owing largely to climatic reasons, several groups of plants are absent from this district, the locality being too cold for them, though, in more northern latitudes, they may ascend to greater elevations than 2,000 feet. No species of Angophora, the coastal Apple-Tree, was seen, and its absence from the south-western district was commented upon by Hume and Hovell, in their overland-journey in 1824 (*ibid.*, p.87).* No representative

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* For previous remarks in regard to distribution of this species, see these Proceedings, 1905, xxx., p.207.

was seen of that large genus Melaleuca, which generally prefers a warmer climate. The whole of the Ironbark-trees are absent, these forming a group which avoid the cold, no species of true Ironbark occurring in Tasmania. No species of White Box was noticed, not even *Eucalyptus albens*, which creeps up the western slopes wherever it can find sufficient warmth, and may be found in isolated cases near Yass. The absence of *E rostrata*, the Murray or River Red Gum, was noticed, but I was informed that it ascends the Murrumbidgee to Umburra, some few miles below the Federal Territory, though it is unable to face the cold within the Territory itself. *E. globulus*, the Tasmanian Blue Gum, was not seen, although the climatic conditions are suitable, and it occurs lower down the Murrumbidgee, at Burrinjuck, and may possibly yet be found in the valley of the Cotter.

General Remarks on various Species.

The notes for this paper were obtained during short visits to the locality in November and December, 1911, and January, 1912. In addition to the area immediately surrounding the City site, the routes examined were the following:—Canberra to Queanbeyan and along the Bungendore Road; the Gundaroo Road; Canberra to the junction of the Cotter and Murrumbidgee Rivers, and up the Cotter just above the dam; Canberra to the summit of Mount Coree; to Tharwa, Booroomba, and the summit of Mount Tidbinbilla; Tharwa to Gudgenby, thence up Middle Creek across to the Upper Cotter, and to the summit of Bimberi Peak. It will be seen that there were many spots not visited, so that the list of plants must be regarded as incomplete.

Mount Tidbinbilla.—Within a radius of 20 yards around the actual summit of Tidbinbilla (5,115 feet), the following plants were noticed :—

Gramineæ : *Poa cæspitosa* (Snow-Tussock or Snow-Grass).
Juncaceæ : *Luzula campestris.*
Liliaceæ : *Bulbine bulbosa, Dianella tasmanica.*
Orchidaceæ : *Caladenia dimorpha.*
Caryophyllaceæ : *Stellaria pungens, Scleranthus biflorus.*

LEGUMINOSÆ: *Acacia penninervis* (Mountain Hickory), *Oxylobium procumbens*(?), *Daviesia ulicina*, *Hovea linearis*.

RUTACEÆ: *Eriostemon myoporoides*.

VIOLACEÆ: *Viola betonicæfolia* (Native Violet).

THYMELÆACEÆ: *Pimelea* sp.

MYRTACEÆ: *Eucalyptus coriacea* (Snow-Gum), *Kunzea peduncularis*, *Callistemon lophanthus*, *Bæckea Gunniana*.

EPACRIDACEÆ: *Leucopogon biflorus*, *L. Fraseri* (prostrate), *Acrotriche aggregata*.

SCROPHULARIACEÆ: *Veronica perfoliata*.

GOODENIACEÆ: *Goodenia hederacea*.

CANDOLLEACEÆ: *Candollea serrulata* (Trigger-Flower).

COMPOSITÆ: *Brachycome* sp., *Helipterum incanum*, *Microseris Forsteri*.

Bimberi Peak.—Writing from memory, the summit of this granite-mountain is approximately a quarter of a mile long, by about 200 or 300 yards wide, the highest point being 6,264 feet above sea-level.

On viewing the flora of this elevated spot on the 15th January, 1912, the feature which impressed me most was the high colouring of the flowers and their great numbers. Masses were to be seen of flowering examples of *Brachycome scapigera* (a Yellow Daisy), and these were blended with others of Senecio, Podolepis, and Helichrysum, the hill being charmingly crested and brightened with a profusion of yellow and white, distributed amongst a groundwork of countless, graceful, grey flowers of the Snow Grass.

The only species of Eucalyptus found on the summit was *E. coriacea* (No.3470), occurring as spreading, dwarfed trees of from 10 to 20 feet high, and flowering, the branches being intensely glaucous. This species grows at a slightly higher level on Kosciusko, but it is doubtful if any other Eucalypt grows at an elevation exceeding that of Mount Bimberi. This was also the only Eucalyptus found on the summits of Tidbinbilla and Coree. *Helichrysum ledifolium* was seen only on the summit, and this species, which occurs in Tasmania, had not been previously recorded for New South Wales.

The following is a list of plants noticed on Bimberi, and in most cases also collected, above the 6,100 feet level, though doubtless several species were overlooked :—

POLYPODIACEÆ : *Polystichum aculeatum* (a common fern in the cold areas of Southern New South Wales).

GRAMINEÆ : *Poa cæspitosa* (Snow-Tussock, or Snow-Grass, in flower all over the summit).

RESTIONACEÆ : *Festuca Hookeriana*, *Hypolæna lateriflora* (a weak, straggling, wiry plant of a few feet high, growing in masses in damp or swampy places, and slightly resembling *Caustis flexuosa*, a common Sydney plant).

ORCHIDACEÆ : *Thelymitra venosa* (a blue Orchid).

PROTEACEÆ : *Orites lancifolia*, *Grevillea australis* (a very narrow-leaved form. This is the only Grevillea which occurs in Tasmania, the genus being one which favours a warm climate).

PITTOSPORACEÆ : *Marianthus procumbens.*

POLYGALACEÆ : *Comesperma retusum.*

THYMELÆACEÆ : *Pimelea ligustrina.*

MYRTACEÆ : *Eucalyptus coriacea* (Snow-Gum), *Callistemon Sieberi* (the flowering was just over), *Bæckea Gunniana.*

UMBELLIFERÆ : *Aciphylla simplicifolia.*

EPACRIDACEÆ : *Epacris paludosa*, *E. microphylla*, *Richea Gunnii.*

LABIATÆ : *Prostanthera cuneata* (with whitish flowers).

RUBIACEÆ : *Asperula oligantha.*

COMPOSITÆ : *Olearia stellulata*, *Celmisia longifolia* (Silver Daisy), *Brachycome scapigera*, *B. discolor*, *Podolepis longipedata*, *Leptorrhynchos squamatus*, *Helichrysum scorpioides*, *H. ledifolium*, *Erechtites quadridentata* (a broad-leaved form), *Senecio pectinatus*, *Microseris Forsteri.*

Thirteen species of ferns were found within the Territory, the most of them being in sheltered portions of the mountain-slopes.

Of the Gramineæ or grasses, twenty-one species were noticed, four of which were naturalised. Probably several native species escaped notice during my hurried visits. *Poa cæspitosa*, the Snow-Grass or Snow-Tussock, is an interesting plant in view of its very wide range in Australia and New Zealand, and its adaptability to environment. Along the coast it is often known as "White Tussock," because of its pale grey colour, and is regarded as an indication of good forest-land; it may occur within a short distance of the ocean, and sometimes, in favoured situations, grows into robust plants of three to four feet high. It shows its disregard for climatic effect by climbing from sea-level to upwards of 6,000 feet, where, owing to the influence of more rigid conditions, it becomes matted and dwarfed, losing much of the tussocky form, and in summer is most useful as sheep-fodder.

Among the Liliaceæ, the somewhat succulent little plant, *Bulbine bulbosa*, was found in various places, including the summit of Tidbinbilla. This species has an extended range in Eastern Australia and Tasmania, and in addition to being found at elevations of 5,100 feet, as in this case, its yellow flowers are conspicuous every spring in the much drier interior at such places as the Macquarie and Lachlan Rivers.

The little terrestrial orchid, *Caladenia dimorpha*, was only noticed within a few yards of the actual summit of Tidbinbilla, while *C. alba* was seen a few hundred feet lower.

Casuarina stricta (She-Oak) was found on various hills, including Ainslie, Majura, Stromla (2,560 feet), and Mugga Mugga (2,662 feet), near Tharwa, and also to the west of the Naas River on the ascent to Gudgenby, where it was growing on the northern or warm side of granite-hills at elevations up to 3,000 feet. I have not found it at an altitude exceeding this.*

Casuarina Cunninghamiana (River-Oak) occurs along the banks of the Murrumbidgee up to within about four miles of Tharwa; above this point, the country is evidently too cold for it. This is an attractive-looking tree and always grows within reach of fresh water, but is restricted in the extent of river it will follow, by the degree of cold in the highland and warmth in the lowland. This Oak-tree may be found on the rivers from Tropical Queensland southerly to the Murrumbidgee and its

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* For previous remarks, see These Proceedings, 1909, Vol. xxxiv., p.326.

tributaries, but is not recorded from Victoria. The first reference to its absence from the Murray or Hume River is that by Hovell and Hume in the report of their exploration from Goulburn to Port Phillip.* When referring to the river, their note reads : " but there was no swamp-oak, the tree so universal on the rivers to the northward and eastward " (p.44).†

A small clump of *Casuarina Luehmanni*, the Bull Oak of the interior, was found near where the Gundaroo Road, at about 2¼ miles from Queanbeyan, passes the Molonglo River. The trees were confined to a high, steeply sloping, volcanic tuff bank of from 40 to 70 feet deep, on the southern side of the River, and, while facing a northern aspect, were well sheltered from the cold southerly influence (Plate lxxi.). Although the branches and stems of some of the Oak-trees reached above the bank, it was noticed that their bases were all below the summit, which signifies that, in the early seedling-stage, the plants require shelter to allow them to become established. The finding of these trees in the Territory was a matter of great surprise, for the nearest locality where they are known to me is between Cootamundra and Temora, a distance of about 80 miles in a direct line, though some may possibly have occurred at intervening spots along the valley of the Murrumbidgee. The species is one having a very wide distribution, extending from the south-eastern portion of South Australia, across part of Victoria and the whole of Central and part of Western New South Wales, continuing along the eastern portion of Queensland at least as far as Biboohra, west of Cairns, in latitude 17°; and, in places, pushing through low gaps in the mountains, towards the east coast, but usually selecting a warm climate. It comes through the Cassilis Geocol and down the Hunter Valley to near Ravensworth and Pokolbin, where it overlaps the coastal salt or brackish-water Swamp-Oak (*C. glauca*), and it may be seen from the train between Bundaberg and Gladstone in Queensland. In 1899, a few trees of

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* Journey of Discovery to Port Phillip, N. S. Wales, in 1824 and 1825, by W. H. Hovell and H. Hume.

† For some previous remarks, see Journ. Proc. Roy. Soc. N. S. Wales, Vol. xlix., p.399(1915). Also, These Proceedings, 1901, Vol. xxvi., p.685.

dwarfed Bull-oak were seen on the southern bank of the Fish River, near O'Connell, in the Bathurst district, and these were growing under somewhat similar conditions, and at approximately the same elevation, about 2,100 feet, as those under discussion on the Molonglo River, which are also rather diminutive specimens, ranging from 12 to 20 feet high, with a stem-diameter up to 9 or 10 inches in a few cases.

The question that naturally arises is, how did these trees find their way to this spot so far from their congeners? Dispersal of seeds by wind can probably be ignored in this case, and dispersal by birds, though much more likely, can scarcely be shown to account for it, although this possibility calls for consideration. There are very few spots within the Federal Territory where seedlings of this species would survive without special care, owing to the coldness of the winter climate. The birds which chiefly feed on Casuarina seeds by tearing open the small cones are of the cockatoo-family, *Calyptorhynchus viridis*, the Glossy Cockatoo or so-called Macaw, and there would be nothing remarkable in finding that one of these birds had visited both the Cootamundra and Queanbeyan districts within a few days. At the same time, there is the coincidence to be accounted for that a seed should be deposited in one of the few spots which would result in the production of a mature tree. It must also be borne in mind that this is a diœcious species, the male and female flowers occurring on separate trees, so that it would be necessary that seeds, producing a pair of trees, should reach the same locality before the species could become established.

It may be considered possible that the seeds were conveyed by natives, but the seeds ripen in midsummer and fall out of the cones within a few days (usually two), after being gathered, and the natives would, therefore, have required closely woven bags to retain them.

The genus is known to be an ancient one, having been identified in fossil form in the Tertiary flora.* This particular species

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* Ettingshausen, "Contributions to the Tertiary Flora of Australia," p.107.

is probably old, considering its wide distribution, and if representatives had been growing in this vicinity, at the time of the Eastern Australian uplift in late Tertiary time,* which seems quite possible, some plants may have survived, during the gradual upheaval, and their descendants, on finding the new conditions too cold, would gradually have become restricted to the warmer and more sheltered nooks where the geological formation was favourable to their growth, and would, thereby, come under the heading of relics or stranded plants. A difficulty about accepting this explanation is that this Oak is a warmth-loving species, and, at an elevation of 2,000 feet, would have found it difficult to survive the Pleistocene glacial period which is generally regarded as of subsequent date to the uplift that formed the present mountains. The fact is clear, however, that these particular Oak trees are now growing near the Molonglo River, and although they certainly appear to be stranded plants, the process by which they reached this spot must remain unsolved, at least for the present.

Grevillea juniperina is one of the most attractive shrubs within the Federal Territory, chiefly because of its beautiful, red, spider-like flowers. It was noticed on the right bank of the Murrumbidgee near its junction with the Cotter, growing as thick spreading bushes up to 10 feet high (Plate lxxii.). It was flowering in November, and among the birds, which were evidently after its honey, were the Leatherheads (*Tropidorhynchus corniculatus*). At Mongarlowe, near Braidwood, this species was seen in November, 1908, with yellow, as well as red flowers, and in several cases both colours were noticed on the same plant. The feature has been observed by others.

Banksia marginata (Honeysuckle) was seen in many portions of the Capital Territory, ascending to an elevation of 4,000 feet, and occurring chiefly in the granite or somewhat siliceous areas. The trees appear toreach greater dimensions than do those of this species in the Sydney district, and examples were seen with

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* "Geographical Unity of Eastern Australia," by E. C. Andrews, B.A., Journ. Proc. Roy. Soc. N. S. Wales, Vol. xliv., p.420(1910).—Presidential Address by C. Hedley, F.L.S., These Proceedings, 1911, Vol. xxxvi., p.13.

trunks up to two feet in diameter and a height of twenty feet. Some of the finest are growing in granite-formation around Booroomba (Plate lxxiii.). Although this Honeysuckle always avoids soils derived from basic rocks, it has a wide range, and is doubtless the species referred to by Hume and Hovell as occurring on the Yass Plains in 1824.

The genus Loranthus (Mistletoes) appears to be only sparsely represented in the Territory, and is practically confined to the levels below about 3,000 feet. The Loranthus is not a lover of extreme cold, and its general absence from part of the southern highlands was noticed some years ago,* while there is no record of the genus occurring at all in Tasmania.

Two species of Drosera (Sundews) were collected, and from the paper in which they were pressed, it has since been noticed that when drying, specimens of *D. peltata* from Gudgenby at 4,500 feet, dyed the paper pink leaving the impression of stems and flowers.

Of the family Leguminosæ, fifteen species of Acacia (Wattles) were seen, and next after the Eucalypts this was the greatest number of species found of any genus.

The plants identified as *A. obtusata*, from Black Mountain, sometimes reach 7 or 8 feet high. Around Mount Coree, they are locally known as Blue Wattle, from the slight colouring sometimes appearing on the leaves and stems, though on many plants the bark is reddish-brown.

Acacia pravissima grows to a height of from 6 to 10 feet, with somewhat pendulous branches. The pods ripen during the latter part of December.

Oxylobium alpestre was seen as spreading shrubs, semi-prostrate, above the 5,500 feet level on Bimberi, and it was noticed that the wombats (*Phascolomys mitchelli*), which are fairly plentiful at many places on these highlands, had undermined many of these plants, upon the roots or possibly root-nodules of which they evidently feed.

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* "Eastern Monaro," by R. H. Cambage. These Proceedings, 1909, Vol. xxxiv., p.331.

Tetratheca ericifolia was found near Coree and Booroomba. It has been noticed, over many years of collecting, that flowers of this species and its variety *thymifolia* keep their pinkish colour for years, or very much longer than those of the majority of Australian plants, and it seems evident that these flowers contain some dye of a fixed nature which is probably worth investigating.

Five species of Pomaderris were seen, distributed over various portions of the Territory. Unless some disinfectant is used in herbaria, the flowers of most plants are attacked by insects, orchids, for instance, being devoured in a very short time; but plants of the genus Pomaderris seem to possess some resisting qualities, as its flowers may remain intact for several years without any special care.

Brachychiton populneus (Kurrajong) is not common within the Capital Territory, the locality being rather cold for it. There is one fairly large tree, however, on the summit of a quartzite hill within the Capital City site, and from which the hill has taken its name. This species is a lover of limestone-formation, and in places on the Western Slopes may occupy almost exclusively certain areas where there is a considerable outcrop of limestone. It is remarkable, therefore, that it should flourish on this quartzite-hill, the rocks of which contain only a trace of lime, according to Mr. J. C. H. Mingaye, but have a high percentage of silica, a constituent which this plant does not favour when present in large quantities. A few Kurrajongs were noticed at other spots, notably between the Naas River and Gudgenby, in which locality they were chiefly on the north or warm sides of the hills, and by this means were able to grow at higher altitudes than usual in this latitude, one tree being seen at an elevation of about 2,600 feet above sea-level.

Viola betonicæfolia and *V. hederacea*, commonly known as Wild Violets, were seen in many shady nooks throughout the Territory, and the beautiful dark blue flowers of the former were noticed as far up as between the 5,500 and 6,000 feet levels on Bimberi Peak.

Of the Eucalypts seen within the Federal Territory, none has so great a vertical range as *E. coriacea*, which extends from the City site at about 2,000 feet, to the summit of Bimberi at 6,264 feet. On the lower land, it is often known as Scribbly Gum from the insect-markings which appear like scribbles on the bark, a feature not confined to this species, but on the high mountains, where it is dwarfed and grows as a spreading plant with several stems, it is usually known as Snow-Gum.

The largest trees within the Federal Territory are *E. gigantea* and *E fastigata*, and both are common on Brindabella Mountain near Coree, the former being known as White, and the latter as Black Mountain Ash.

E. gigantea was described by Hooker,* but there seems no doubt that, when doing so, he had in his mind the present tree, and also a previously described Stringybark, *E. obliqua* L'Hérit., both occurring in Tasmania, the latter being the more common of the two. When the identity of *E. obliqua* was afterwards placed beyond doubt, *E. gigantea* was accepted as a synonym. In 1900, Mr. R. T. Baker, F.L.S , described this tree under the name of *E. Delegatensis*, from Southern New South Wales,† and pointed out its specific characters. In 1913, Mr. Maiden reproduced Hooker's figure of *E. gigantea* as given in the Flora of Tasmania (Vol. i., p.136), and showed how the confusion between *E. obliqua* and *E. gigantea* had arisen.‡ In Hooker's figure, the fruits depicted appear to be those of the Mountain Ash, and not those of *E. obliqua*.

The bark of this Ash for about half-way up the trunk is fibrous, while the upper portion and the branches are smooth and white, hence the prefix, white, before the name of Ash or Mountain Ash. The timber of this species, though very valuable, is known to be light and fissile, and, on examining seedlings of 4-5 feet high, on Brindabella Mountain, it was noticed that the wood was exceptionally soft and would snap with only a

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* Lond. Journ. Bot., vi., 479 (1847).

† These Proceedings, 1900, Vol. xxv., p.305.

‡ "Forest Flora of New South Wales," Part li.

gentle pressure. So far as I know, the most northern tree of this species is about three miles north of Mount Coree.*

Eucalyptus fastigata is very plentiful along the mountain-sides under Coree and Tidbinbilla, and as its trunk and large branches are covered with fibrous, brown bark, it is, in contradistinction to the White Ash, called Black Mountain Ash. Its great affinity with the giant gumtree of Victoria, *E. regnans* F.v.M., is well known, and since *E. fastigata* was described by Deane & Maiden, the latter has expressed the view that it is only a form of the former.† At the same time, it appears as a distinct tree when seen in the forest, for while the Victorian and Tasmanian representatives of *E. regnans* are tall gumtrees with fibrous bark for only 10 or 20 feet at the base, *E. fastigata*, wherever it has been seen over its wide range in this State, has fibrous bark on its trunk and large branches.

E. dives and *E. maculosa* are often found in association, and both will thrive in soils heavily charged with iron.

E. macrorrhyncha (Red Stringybark) is not uncommon, and, with *E. hæmastoma* (Brittle Gum), and a few trees of *Exocarpus cupressiformis* (Wild Cherry), takes possession of the higher portions of the Black Mountain, all three being lovers of a siliceous formation.

Eucalyptus polyanthemos (Red Box) is fairly common throughout the lower levels, and is the form (*E. ovalifolia* R. T. Baker) with smooth gum-tree bark, except that, in many cases, the bark is flaky for a few feet at the base, and as forest-trees are dissimilar to the rough-barked Red Box of Victoria and around Albury. The great lasting qualities of Red Box posts are well known throughout the Federal Territory.

E. elæophora (*E. Cambagei*, Mountain-Apple, No.3000) occurs at various points, and around Tharwa and Booroomba appeared almost white in November, with its intensely glaucous fruits and branchlets.

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* For previous remarks on this species under the name of *E. delegatensis*, occurring near Tumbarumba, see These Proceedings, 1904, Vol. xxix., p.690.

† See "A Critical Revision of the Genus Eucalyptus," by J. H. Maiden, Part vii. (1905).

E. camphora (Swamp Gum, No.3342) was seen only on Coree Creek, near S. A. Shannon's, though it has a considerable range on the highlands of New South Wales, southwards from the Rylstone district. In January, 1913, it was found at various points on the Omeo-Mount Hotham Road, in Victoria, between the 3,000 and 4,000 feet levels (No.3682).

The plants identified as *Leptospermum attenuatum* were seen up to 12 feet high, chiefly on the banks of streams, and have hard, firm, grey bark, and not scaly or flaky bark such as is found on plants recognised as of this species occurring around Sydney and on the Blue Mountains.

Kunzea Muelleri was observed in the drier portions of swampy areas on the highlands around the Upper Cotter, growing in small masses of about a foot high, and having whitish flowers. These plants are associated with *Aciphylla simplicifolia*, *Epacris paludosa*, *Juncus falcatus*, and perhaps *Celmisia longifolia* (Plate lxxiv.).

Kunzea peduncularis was seen up to 15 feet high, with somewhat flaky bark, on the river-banks, and it occurs on some of the mountain-summits as a tough, stunted plant of a few feet. Mr. John Blundell, of Coree, informed me that the blacks formerly split pieces of the wood of this highland form, which they called Budawang, and, after hardening it by fire, used it as needles to pierce holes in the skins of various animals so that such skins might be sewed together for use as rugs.

Richea Gunnii was found only on the summit of Bimberi Peak, and is an alpine plant with very beautiful clusters of flowers somewhat resembling those of *Dracophyllum secundum*, which grows along the coastal districts.

Pomax umbellata is growing on the northern slopes of Black Mountain, selecting a similar highly siliceous formation to that which it favours around Sydney and on the Blue Mountains.

Wahlenbergia gracilis (Blue Bell) and *Candollea serrulata* (Trigger-Flower) were seen at their best at elevations between (4,000 and 5,000 feet. Their colours were deeper than usual, a common feature with plants at high altitudes, and the two species formed separate masses of most charming deep blue and red, the distant blending of which gave a brightness to the open forest, and formed a beautiful setting, in one of Nature's many artistic designs.

Olearia argophylla (Musk-Tree), which grows to a height of over 20 feet, and is regarded as the largest Composite in the world, is growing in the sheltered portions of Mount Coree, associated with *Dicksonia antarctica* and *Bedfordia salicina*, thus showing that the locality is not exposed to the western or dry atmosphere, but is in a zone of moisture resulting from a good rainfall on the mountain-side. In this, and similar sheltered situations within the Federal Territory, the Lyre Bird, *Menura superba*, has its home.

List of Plants.

The following is a list of plants seen within the Federal Capital Territory :—

Hepaticeæ : *Marchantia polymorpha* L., (a cosmopolitan species).

Cyatheaceæ : *Dicksonia antarctica* Labill., (Tree-ferns on Mount Coree).

Polypodiaceæ : *Dryopteris punctata* (Thunb.) C. Chr., (*Polypodium punctatum* Thunb.), *Polystichum aculeatum* (L.) Schott, (*Aspidium aculeatum* Swartz), *Asplenium flabellifolium* Cav., *Pleurosorus rutifolius* (R.Br.), *Blechnum cartilagineum* Sw., *B. discolor* (Forst.) Keys., (*Lomaria discolor* Willd.), *B. pennamarina* (Poir.) Kuhn, (*Lomaria alpina* Spreng.), *B. capense* (L.) Schlecht., (*L. capensis* Willd.), *Cheilanthes tenuifolia* Sw., (plants up to 1 foot 9 inches on Black Mountain), *Adiantum æthiopicum* L., (Maiden-Hair Fern), *Pteridium aquilinum* L. Kuhn., (*Pteris aquilina* L., Bracken), *Polypodium diversifolium* Willd., (*P. scandens* Labill).

Pinaceæ : *Callitris calcarata* R.Br., (Black or Mountain Pine).

Typhaceæ : *Typha angustifolia* L., (Bullrush, in Canbury Creek and other streams).

Potamogetonaceæ : *Potamogeton tricarinatus* F.v.M. & A. Benn., (*P. natans* Benth., non L.), *P. perfoliatus* L.

Juncaginaceæ : *Triglochin procera* R.Br.

ALISMATACEÆ: *Alisma plantago* L., (along the banks of the Molonglo River, and flowering in December).

GRAMINEÆ: *Andropogon affinis* R.Br., *A. refractus* R.Br., *Themeda Forskalii* Hack., (*Anthistiria ciliata* Benth., Kangaroo Grass), *Panicum effusum* R.Br., *Stipa scabra* Lindl., (Silver Grass), *Echinopogon ovatus* Beauv., (Saw Grass), *Calamagrostis æmula* Steud., (*Deyeuxia Forsteri* Kunth), *Holcus lanatus* L., (naturalised), *Aira caryophyllea* L., (Fairy Grass), *Danthonia carphoides* F.v.M., *D. penicillata* F.v.M., var. *semiannularis* F.v.M., *Cynodon dactylon* Rich., (Couch Grass, common in hot and some temperate countries), *Chloris truncata* R.Br., (Umbrella Grass), *Pappophorum commune* F.v.M., *Phragmites communis* Trin., (*Arundo Phragmites* L.), *Kœleria phleoides* Pers., (naturalised), *Poa cæspitosa* G. Forst., (White or Snow Tussocks), *Festuca Hookeriana* F.v.M., (*Schedonorus Hookeriana* Benth.), *F. bromoides* L., (naturalised), *Bromus maximus* Desf., (naturalised), *Hordeum murinum* L., (Barley Grass; naturalised).

CYPERACEÆ: *Kyllingia intermedia* R.Br., (*K. brevifolia* Rottb.), *Cyperus sanguineo-fuscus* Nees, *C. Gunnii* Hook., (*C. lucidus* R.Br.), *Eleocharis acuta* R.Br., *E. cylindrostachys* Boeck., *Scirpus cernuus* Vahl, (*A. riparius* Benth.), *S. inundatus* Poir., *S. stellatus* C. B. Clarke, (*S. cartilagineus* Benth.), *S. lacustris* L., *S. polystachyus* F.v.M., *Carex tereticaulis* F.v.M., *C. appressa* R.Br., *C. Gaudichaudiana* Kunth, *C. pseudo-cyperus* L.

RESTIONACEÆ: *Restio australis* R.Br., (at Gudgenby), *Hypolæna lateriflora* Benth.

JUNCACEÆ: *Luzula campestris* DC., *Juncus bufonius* L., *J. plebeius* R.Br., (*J. homalocaulis* F.v.M.), *J. pallidus* R.Br., *J. radula* Buch., *J. vaginatus* R.Br., *J. polyanthemos* Buch., *J. prismatocarpus* R.Br., *J. Fockei* Buch., *J. lamprocarpus* Ehr., *J. falcatus* E. Mey.

LILIACEÆ: *Anguillaria dioica* R.Br., (*Wurmbea dioica* F.v.M.), *Bulbine bulbosa* Haw., *Thysanotus tuberosus* R.Br., (Fringed Violet), *Arthropodium paniculatum* R.Br., *Tricoryne elatior* R.Br., *Stypandra glauca* R.Br., *Dianella tasmanica* Hook., *D. revoluta* R.Br., *Xerotes longifolia* R.Br., *X. multiflora* R.Br., *X. filiformis* R.Br., *X. glauca* R.Br., *Xanthorrhœa* sp. (Grass-Tree, at Lower Cotter and Booroomba).

AMARYLLIDACEÆ : *Hypoxis hygrometrica* Labill.

ORCHIDACEÆ : *Gastrodia sesamoides* R.Br., *Thelymitra venosa* R.Br., *Diuris maculata* Sm., (Spotted Orchid), *D. sulphurea* R.Br., *Prasophyllum fuscum* R.Br., (?)*Pterostylis curta* R.Br., (?)*P. obtusa* R.Br., (near Gudgenby, at 4,700 feet), *P. rufa* R.Br., (at Booroomba, a form with very short points to the sepals and petals), *Caladenia testacea* R.Br., *C. alba* R.Br., (on side of Tidbinbilla), *C. dimorpha* Fitzg., (on summit of Tidbinbilla).

CASUARINEÆ : *Casuarina stricta* Ait., (She-oak, *C. quadrivalvis*), *C. Luehmanni* R. T. Baker, (Bull-Oak), *C. Cunninghamiana* Miq., (River-Oak).

URTICACEÆ : *Urtica incisa* Poir., (Nettle), *Australina pusilla* Gaud.

PROTEACEÆ : *Persoonia chamæpeuce* Lhotsky, (Prostrate Geebung, at Gudgenby), *Orites lancifolia* F.v.M., (on Mount Bimberi), *Grevillea lanigera* A. Cunn., *G. juniperina* R.Br., (at junction of Murrumbidgee and Cotter Rivers), *G. australis* R.Br., (a very narrow-leaved form), *Hakea sericea* Schrad., (*H. acicularis* R.Br.), *H. microcarpa* R.Br., *Lomatia longifolia* R.Br., *Banksia marginata* Cav., (Honeysuckle).

SANTALACEÆ : *Exocarpus cupressiformis* Labill., (Native Cherry), *E. stricta* R.Br., *Choretrum spicatum* F.v.M., *Omphacomeria acerba* A. DC.

LORANTHACEÆ : *Loranthus pendulus* Sieb., (Mistletoe, with *Eucalyptus dives* as host).

POLYGONACEÆ : *Rumex Brownii* Campd., *R. acetosella* L., (Sorrel; naturalised), *Polygonum prostratum* R.Br., *P. minus* Huds., (Smart-Eye, in bed of Murrumbidgee and other streams).

CHENOPODIACEÆ : *Chenopodium triangulare* R.Br.

CARYOPHYLLACEÆ : *Silene gallica* L., (naturalised), *Cerastium vulgatum* L., (Mouse-ear Chick-weed, naturalised), *Stellaria pungens* Brong., *Spergularia rubra* Camb., *Tunica prolifera* Scop., (Dianthus, naturalised), *Scleranthus biflorus* Hook., (Cushion-Plants forming green compact mats).

RANUNCULACEÆ: *Clematis aristata* R.Br., *C. microphylla* DC., *Ranunculus aquatilis* L.(?), *R. lappaceus* Sm., (Buttercup), *R.*

hirtus Banks and Sol , (*R. plebeius* R.Br.), *R. rivularis* Banks and Sol., *R. parviflorus* L.

MAGNOLIACEÆ: *Drimys aromatica* F.v.M., (Peppercorn).

MONIMIACEÆ: *Hedycarya angustifolia* A. Cunn., (*H. Cunninghamii* Tul , Native Mulberry).

LAURACEÆ: *Cassytha phæolasia* F.v.M., (Dodder), *C. melantha* R.Br.

CRUCIFERÆ: *Cardamine hirsuta* L., var. *tenuifolia* F.v.M., (*C. tenuifolia* Hook.).

DROSERACEÆ: *Drosera peltata* Sm., (Sundew or Fly-catcher), *D. auriculata* Backh

CRASSULACEÆ: *Tillæa verticillaris* DC.

PITTOSPORACEÆ: *Marianthus procumbens* Benth., *Bursaria spinosa* Cav., (Whitethorn), *Billardiera scandens* Sm., (Roly-Poly Vine).

ROSACEÆ: *Rubus parvifolius* L., (Redberry), *Acæna ovina* A. Cunn., *A. sanguisorbæ* Vahl, (Burr).

LEGUMINOSÆ: Sub-family Mimosoideæ:—*Acacia lanigera* A. Cunn., var. *venulosa*, (*A. venulosa* Benth., on Black Mountain), *A. siculiformis* A. Cunn., (at Tidbinbilla and Gudgenby), *A. diffusa* Edw., (Prickly Wattle), *A. armata* R.Br., (Kangaroo-Thorn, on Mount Ainslie), *A. verniciflua* A. Cunn., *A. penninervis* Sieb., (Mountain-Hickory), *A. obtusata* Sieb., (on Black Mountain and Coree), *A. rubida* A. Cunn., (Red-leaved Wattle), *A. buxifolia* A. Cunn., *A. pravissima* F.v.M., (Cotter River near the dam, and on the divide between the Gudgenby and Cotter waters, at 4,500 feet), *A. Dawsoni* R. T. Baker, (near Gundaroo Road from Queanbeyan), *A. melanoxylon* R.Br., (Hickory or Tasmanian Blackwood), *A. implexa* Benth., *A. decurrens* Willd., var. *mollis*, (Green Wattle, seen only in the northern or lower portion of the Territory), *A. dealbata* Link, (Silver Wattle). Sub-family Papilionatæ:—*Trifolium arvense* L., (Hare's-foot Trefoil, naturalised), *Oxylobium ellipticum* R.Br., var. *alpinum*, (on Tidbinbilla at 4,500 feet, and on Bimberi at 5,300 feet), *O. alpestre* F.v.M., *O. Pulteneæ* DC., *O. procumbens* F.v.M.(?), *Mirbelia oxylobioides* F.v.M., *Gompholobium Huegelii* Benth., *G. grandiflorum* Sm.(?), *G. uncinatum* A. Cunn., *Daviesia corym-*

bosa Sm., *D. ulicina* Sm., *Pultenæa Muelleri* Benth.(?), (on Brindabella Mountain), *P. procumbens* A. Cunn., (at Booroomba, on granite at 3,700 feet), *P. fasciculata* Benth., (at 4,500 feet, Gudgenby to Cotter River, rare in New South Wales), *Dillwynia ericifolia* Sm., var. *phylicoides*, *Platylobium formosum* Sm., (around Coree), *Bossiæa buxifolia* A. Cunn., (at Booroomba), *B. Walkeri* F.v.M., (5 feet high, with a cluster of from 30 to 40 stems; at junction of Murrumbidgee and Cotter), *Hovea linearis* R.Br., *Lotus corniculatus* L., (Upper Cotter), *L. australis* Andr., (Upper Cotter, flowers purple to pink), *Indigofera australis* Willd., (Indigo), *Psoralea adscendens* F.v.M., *Swainsona tephrotricha* F.v.M., *Zornia diphylla* Pers., *Desmodium varians* Endl., *Glycine clandestina* Wendl., *G. Latrobeana* Benth., (with blue flowers among the grass, on the City site), *Hardenbergia monophylla* Benth., (False Sarsaparilla).

GERANIACEÆ: *Geranium dissectum* L., *Erodium cygnorum* Nees, *E. cicutarium* Willd., (naturalised), *Pelargonium australe* Willd.

OXALIDACEÆ: *Oxalis corniculata* L., (Sour Grass).

RUTACEÆ: *Boronia polygalifolia* Sm., *Eriostemon myoporoides* DC., *Phebalium squamulosum* Vent., var. *alpinum*, (at 4,500 feet on Coree), *Correa speciosa* Andr.

TREMANDRACEÆ: *Tetratheca ericifolia* Sm.

POLYGALACEÆ: *Comesperma retusum* Labill.

EUPHORBIACEÆ: *Phyllanthus thymoides* Sieb., *Euphorbia Drummondii* Boiss., *E. Lathyrus* L., (naturalised), *Poranthera microphylla* Brongn., *Bertya oleæfolia* Planch., (near Murrumbidgee and Cotter junction).

STACKHOUSIACEÆ: *Stackhousia linariifolia* A. Cunn., (*S. monogyna* Labill.), *S. viminea* Sm.

SAPINDACEÆ: *Dodonæa viscosa* L., *D. attenuata* A. Cunn.

RHAMNACEÆ: *Pomaderris elliptica* Labill., (on Black Mountain), *P. apetala* Labill., *P. prunifolia* A. Cunn., *P. racemosa* Hook., *P. phylicifolia* Lodd., *Cryptandra spinescens* Sieb., *Discaria australis* Hook., (low prickly bushes, with sickly-sweet flowers).

MALVACEÆ: *Plagianthus pulchellus* A. Gray, also var.

tomentosus Hook., *Malva rotundifolia* L., (naturalised), *Modiola multifida* Mœnch., (naturalised).

STERCULIACEÆ: *Brachychiton populneus* R.Br., (*Sterculia diversifolia* G. Don, Kurrajong).

DILLENIACEÆ: *Hibbertia stricta* R.Br., *H. serpyllifolia* R.Br., *H. linearis* R.Br., var. *obtusifolia.*

GUTTIFERÆ: *Hypericum japonicum* Thunb., also var. *gramineum* F.v.M.

VIOLACEÆ: *Viola betonicæfolia* Sm., (Native Violet), *V. hederacea* Labill.

THYMELÆACEÆ: *Pimelea glauca* R.Br., a form with very narrow and acute involucral bracts, *P. colorans* A. Cunn., *P. linifolia* Sm., *P. ligustrina* Labill., also var. *hypericina* Benth., *P. pauciflora* R.Br., *P. curviflora* R.Br., (No. 3473, three feet high, near Gudgenby).

LYTHRACEÆ: *Lythrum salicaria* L., (a swamp-plant), *L. hyssopifolia* L.

MYRTACEÆ: *Eucalyptus stellulata* Sieb., (Sally), *E coriacea* A. Cunn., (Snow-Gum), *E. amygdalina* Labill., (Peppermint or Messmate), *E. fastigata* Deane and Maiden, (Black Mountain Ash; around Mounts Coree and Tidbinbilla), *E. dives* Schauer, (Peppermint), *E. gigantea* Hook., (*E. Delegatensis* R. T. Baker, White Mountain Ash), *E. macrorrhyncha* F.v.M., (Red Stringybark), *E. hæmastoma* Sm., (Brittle Gum), *E melliodora* A. Cunn., (Yellow Box), *E. polyanthemos* Schauer, (Red Box), *E. rubida* Deane and Maiden, (a White Gum, with orbicular reversion-foliage), *E. maculosa* R. T. Baker, (a gum-tree, slightly spotted, but distinct from the Spotted Gum of the coast), *E. camphora* R. T. Baker, (on Condore Creek near Mount Coree), *E. aggregata* Deane and Maiden, (a few trees seen on a flat on western side of Bungendore Road, between the 48 and 49 mile posts from Goulburn), *E. elæophora* F.v.M., (*E. Cambagei* Deane and Maiden, Mountain Apple), *E. Bridgesiana* R. T. Baker, (Apple-Tree or Woollybutt; recognised by Mr. Maiden as *E. Stuartiana* F.v.M.), *E. viminalis* Labill., (White or Manna Gum), *E. Blakelyi* Maiden, (Forest Red Gum), *E. dealbata* A. Cunn., *Leptospermum flavescens* Sm., var. *obovatum* F.v.M., (near summit of Mount Coree), *L. scoparium* Forst., (Tea-tree, the narrow-leaved form), *L. lanigerum* Sm., (along the banks of creeks; trees 30 feet high along the damp gullies on the slopes of Bimberi, just above the 5,000 feet level), *L. stellatum* Cav., *L. attenuatum* Sm., *L. myrtifolium* Sieb., *L. triloculare* Vent., (with silky-hairy calyx-tubes and leaves, on Black Mountain), *Kunzea Muelleri* Benth., (at 4,500 feet, on divide between Gudgenby and Cotter Rivers), *K. parvifolia* Schauer, (between the 7 and 8 mile posts, Queanbeyan to Tharwa Road), *K. peduncularis* F.v.M., (on banks of Murrumbidgee and other streams, also near the summits of Coree and Tidbinbilla; in full flower early in December), *Callistemon paludosus* F.v.M., in bed of Molonglo, Murrumbidgee, Paddy's and Cotter Rivers, flowering early in December, flowers creamy-purple), *C. lophanthus* Sweet, (near the summit of Mount Tidbinbilla), *C. Sieberi* DC., near the summit of Mount Bimberi), *Bæckea Gunniana* Schauer, *Calycothrix* (*Calythrix*) *tetragona* Labill.

Oenotheraceæ: *Epilobium glabellum* G. Forst., *Oenothera biennis* L., (Primrose, naturalised).

Halorrhagaceæ: *Halorrhagis tetragyna* (Labill.) Hook., *H. micrantha* (Thunb.) R.Br., *Myriophyllum propinquum* A. Cunn.

Araliaceæ: *Tieghemopanax sambucifolius* H. Viguier, (*Panax sambucifolius* Sieb.), *Astrotricha ledifolia* DC., (on Black Mountain and Coree).

Umbelliferæ: *Hydrocotyle laxiflora* DC., (*H. Candollei* F.v.M.), *Didiscus humilis* Hook., (*Trachymene humilis* Benth.), *Trachymene Billardieri* F.v.M., (*Siebera Billardieri* Benth., on Tidbinbilla), *Oreomyrrhis andicola* Endl., (Native Carraway-seed), *Aciphylla simplicifolia* F.v.M., (in damp spots on the highlands around Gudgenby and Bimberi), *Daucus brachiatus* Sieb.

Epacridaceæ: *Styphelia triflora* Andr., *Melichrus urceolatus* R.Br., *Lissanthe strigosa* Sm., *Leucopogon lanceolatus* R.Br., *L. virgatus* R.Br., *L. Hookeri* Sond., *L. biflorus* R.Br., *L. Fraseri* A. Cunn., *Monotoca scoparia* R.Br., *Acrotriche aggregata* R.Br., *A. serrulata* R.Br., *Brachyloma daphnoides* Benth., *Epacris paludosa* R.Br., *E. brevifolia* Stapf, (at 3,000 feet on Mount Coree), *E. serpyllifolia* R.Br., *E. microphylla* R.Br., *Richea Gunnii* Hook.

Primulaceæ: *Anagallis arvensis* L., (Pimpernel, naturalised).

Gentianaceæ: *Erythræa australis* R.Br., *Limnanthemum crenatum* F.v.M., (an aquatic plant, with beautiful yellow, large, fringed flowers; in Molonglo River).

Convolvulaceæ: *Convolvulus erubescens* Sims.

Borraginaceæ: *Cynoglossum australe* R.Br.

Labiatæ: *Mentha laxiflora* Benth., *M. australis* R.Br., (Penny Royal), *M. saturejoides* R.Br., *Salvia verbenacea* L., (naturalised), *Brunella* (*Prunella*) *vulgaris* DC., *Scutellaria humilis* R.Br., *Prostanthera lasianthos* Labill., (Native Lilac, called Turpentine-Bush at Coree), *P. cuneata* Benth., *Westringia eremicola* A. Cunn., (white flowers; opposite junction of Murrumbidgee and Cotter), *Ajuga australis* R.Br.

Solanaceæ: *Solanum nigrum* L., *S. simile* F.v.M., *S. opacum* A.Br., (naturalised), *Datura stramonium* L., (naturalised).

Scrophulariaceæ: *Mimulus moschatus* Dougl., (naturalised), *Gratiola Peruviana* L., (Brook-Lime), *G. nana* Benth., *Veronica perfoliata* R.Br., (on the highlands, with beautiful blue flowers), *V. Derwentia* Littlej., *V. gracilis* R.Br., *V. calycina* R.Br., *Euphrasia Brownii* F.v.M., (on Coree, and at 4,500 feet on Tidbinbilla), *Verbascum blattaria* L., (naturalised).

Lentibulariaceæ: *Utricularia dichotoma* Labill., var. *uniflora* Benth.

Plantaginaceæ: *Plantago varia* R.Br.

Rubiaceæ: *Coprosma hirtella* Labill., (at 4,000 feet, on granite, at Booroomba, also towards the summit of Tidbinbilla), *Pomax umbellata* Sol., *Asperula oligantha* F.v.M., also var. *scoparia* F.v.M., *Galium umbrosum* Sol.

Caprifoliaceæ: *Sambucus Gaudichaudiana* DC.

Cucurbitaceæ: *Cucumis myriocarpus* Naud., (small melons, naturalised).

Campanulaceæ: *Lobelia dentata* Cav., *L. pedunculata* R.Br., *Isotoma fluviatilis* F.v.M., *Wahlenbergia gracilis* DC.

Goodeniaceæ: *Velleia paradoxa* R.Br., *Goodenia hederacea* Sm., *G. pinnatifida* Schlecht.

Candolleaceæ (Stylidiaceæ): *Candollea serrulata* Labill., (*Stylidium graminifolium* Sw., Trigger-Flower).

Compositæ: *Olearia megalophylla* F.v.M., (around Coree and Tidbinbilla), *O. chrysophylla* Benth., *O. argophylla* Labill., (Musk-Tree), *O. stellulata* DC., *Celmisia longifolia* Cass., (*Aster celmisia* F.v.M., Silver Daisy), *Vittadinia australis* A. Rich., *Calotis scabiosifolia* Sond. and F.v.M., var. *integrifolia*, *Lagenophora Billardieri* Cass., *Brachycome scapigera* DC., *B. scapiformis* DC., (on Coree and near Gudgenby at 4,500 feet), *B. Sieberi* DC.(?), *B. discolor* C. Stuart, *Cotula filicula* Hook., *Centipeda Cunninghamii* F.v.M., *Craspedia Richea* Cass., (Bachelors' Buttons), *Cassinia aculeata* R.Br., (at Booroomba and Coree), *C. longifolia* R.Br., (at Gudgenby), *C. quinquefaria* R.Br., *Podolepis longipedata* A. Cunn., also var. *robusta* Maiden and Betche, *P. canescens* A. Cunn. *Leptorrhynchos squamatus* Less., *Helichrysum scorpioides* Labill., *H. lucidum* Henck., and var. *viscosum*, (*H. bracteatum* Willd., "Everlasting Flower"), *H. apiculatum* DC., *H. semipapposum* DC., *H. ledifolium* Benth., *H. rosmarinifolium* Less., var. *thyrsoideum* Benth., (at 5,000 feet on Bimberi), *H. Stirlingii* F.v.M., (at 4,000 feet on Bimberi), *H. baccharoides* F.v.M., *Helipterum anthemoides* DC., *H. incanum* DC., *H. dimorpholepis* Benth., *Gnaphalium japonicum* Thunb., *G. purpureum* L., *Stuartiana Muelleri* Sond., *Erechtites mixta* DC., *E. quadridentata* DC., *Senecio pectinatus* DC., *S. dryadeus* Sieb., (*S. australis* A. Rich.), *Bedfordia salicina* DC., (near Mount Coree, and locally called Adam's Flannel from its tomentose, flannel-like leaves), *Cymbonotus Lawsonianus* Gaud., *Centaurea calcitrapa* L., (Star-Thistle, naturalised), *C. solstitialis* L., (naturalised), *Microseris Forsteri* Hook., (a yam, with yellow flowers), *Hypochæris radiata* L., (Dandelion, naturalised), *Picris hieracioides* L., (naturalised), *Carduus pycnocephalus* L., (naturalised).

Comparison with Tasmania.

Although the plant-associations found on the high points appear to disclose certain facts, it has to be remembered that an assemblage of plants is not only regulated by climate, but by geological formations as well. In discussing those plants noticed on Tidbinbilla at 5,100 feet and on Bimberi at 6,200 feet, some interesting features are brought out. On Tidbinbilla, the Families with most representatives were Myrtaceæ and Leguminosæ, with four species each, while Compositæ had three species. Curiously no species whatever of Leguminosæ was noticed on the summit of Bimberi, while Myrtaceæ had three, but Compositæ had eleven.

Before conclusive deductions could be drawn from a record such as this, it would be desirable to have a more systematic examination carried out than time permitted me to make, and over a greater number of levels. It is not remarkable, however, that this limited record shows that the Compositæ, which are considered to be the largest Family among flowering plants, should be the most numerous at the higher levels, for they are known to be able to resist the cold. On the other hand, masses of a few species of Compositæ may be seen on the hot western plains of this State, in places forming the dominant vegetation.

In connection with distribution, it is of interest to make a comparison with Tasmania. There the Family Compositæ predominates, and contains more species than Leguminosæ and Myrtaceæ combined, the figures being approximately—Compositæ 110, Leguminosæ 60, and Myrtaceæ 40.*

From the list of plants collected by me within the Federal Capital Territory, the Families, according to numbers of species, are arranged in the following sequence—Leguminosæ 43 species, Compositæ 42, and Myrtaceæ 34. These figures may be modified by further discoveries, and the first two Families may even change places.

The genera are represented in the following order: Eucalyptus (Myrtaceæ) 19 species, Acacia (Leguminosæ) 15, Juncus (Juncaceæ) 10, and Helichrysum (Compositæ) 8.

Out of 27 species noticed on the summit of Tidbinbilla, at 5,100 feet, 15 of these, or 55%, occur in Tasmania; while on Bimberi, at 6,200 feet, 22 out of 30 species, or 73%, are found in Tasmania.

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* "The Tasmanian Flora," by Leonard Rodway, C.M.G., (1903).

As an evidence of considerable similarity in climate, it is pointed out that, in the whole of the Federal Capital Territory, 361 native species were noticed, of which 233, or 65%, are also indigenous in Tasmania.

I wish to express my indebtedness to Mr. J. H. Maiden, F.R.S., the late Mr. E. Betche, and Mr. E. Cheel for assistance and corroboration in the identification of plants. To Mr. C. R. Scrivener, I.S.O., Director of Commonwealth Lands and Surveys, I am grateful for having afforded me the opportunity and facilities for visiting the various points within the Federal Territory; while to Messrs. Charles H. McKeachnie, of Booroomba, and Marmaduke W. Lee, of Gudgenby, my thanks are due for hospitality and personal guidance to the summit of Tidbinbilla, and the head of the Cotter River respectively; also to Mr. John Blundell for his escort to the summit of Mount Coree. I have also to thank Mr. A. J. Hare, Under Secretary for Lands, and Mr. E. B. Harkness, Under Secretary, Chief Secretary's Department, for information concerning the early records of settlement in the locality.

EXPLANATION OF PLATES LXXI.-LXXIV.

Plate lxxi.

Casuarina Luehmanni R. T. Baker; growing under shelter of bank on Molonglo River.

Plate lxxii.

Grevillea juniperina R.Br.; near Cotter and Murrumbidgee Rivers.

Plate lxxiii.

Banksia marginata Cav.; in open forest granite-country at Booroomba.

Plate lxxiv.

Swampy plain, with *Kunzea Muelleri*, *Aciphylla simplicifolia*, *Epacris paludosa*, *Juncus falcatus*, and *Eucalyptus coriacea*; between Gudgenby and Cotter River, at about 4,500 feet level.

ORDINARY MONTHLY MEETING.

November 27th, 1918.

Professor H. G. Chapman, M.D., B.S., President, in the Chair.

Before proceeding with the formal business of the Meeting, the President reminded Members of the supremely important events that had transpired in the interval since the last Meeting —the signing of the Armistice presaging a victorious peace, and the vindication of the strenuous efforts of the Allied Nations to re-establish Right and Justice, as opposed to Might and Cunning, as the basic principle of International relations.

The President moved the following resolution, which was carried by acclamation, the audience rising:—"That the Members present at this Meeting desire to affirm their loyalty to the King —to record their thankfulness for the cessation of hostilities, as the prelude to a triumphant peace: their gratitude for, and appreciation of, the services rendered to the cause of humanity by the Allied Armies and Navies (including those who have so worthily represented the Commonwealth), and by those, both women and men, who have co-operated with them: and their sympathy with the bereaved."

The National Anthem was sung, and cheers given for the King.

A letter from Lieutenant G. Goldfinch (written from Havre, 18th September, 1918) returning thanks to Members for greetings and a friendly message of sympathy when he was in hospital in England, in the early part of the year, was communicated to the Meeting.

The list of the names of Members on the Honour Roll—only three of whom had yet returned—was read by the Secretary, the audience standing. Mr. F. Turner and Dr. C. Hall expressed the hope that the Honour Roll would take a permanent form—

a matter that has not been overlooked, but, at present, the records available are incomplete.

Mr. J. H. Campbell, Hon. Treasurer, said that, as the only way open to the Society in its corporate capacity, to help the cause of the Allies, it had subscribed to all the War Loans, the total amount being £37,000.

The President reminded Candidates for four Linnean Macleay Fellowships, 1919-20, that the 30th inst. was the last day on which applications would be received.

The Donations and Exchanges received since the previous Monthly Meeting (October 30th, 1918), amounting to 3 Vols., 38 Parts or Nos., 7 Bulletins, 1 Report, and 4 Pamphlets, received from 33 Societies, etc., and one private donor, were laid upon the table.

NOTES AMD EXHIBITS.

Mr. Fred Turner exhibited a teratological specimen of the European *Plantago lanceolata* Linn., from Chatswood, in which all the spikes or heads had developed a number of secondary spikes, in a way that he had not previously observed in this species in Australia.

Mr. E. Cheel exhibited a species of *Callistemon pachyphyllus* showing the delayed dehiscence of the fruits, corresponding, to a certain extent, to those of *C. rigidus* described by Professor A. J. Ewart (Annals of Botany, xxi., p.135, 1907). The specimen exhibited was taken from a plant cultivated at Ashfield, and is 7 feet long. It was originally raised from seed collected at Bullahdelah, in August, 1911. The seed was sown on 29th October, 1912, germinated on 6th November, 1912, and the plant flowered for the first time in October, 1914, but no fruits were set. In October, 1915, it flowered for the second time, and several fruits set; these, in October, 1918, were apparently fully developed, and measured 5 mm. in diameter. In October, 1916, the plant flowered for the third time, and again in April of the same year; the individual fruits of both of these clusters measure from 7 to 9 mm. in diameter. In October, 1917, a normal crop of flowers was produced; and a few spikes appeared in December, and again in April of the same year, so that there were three flowering-periods. In October, 1918, the plant had a profusion of spikes, and a branch (exhibited) was cut below the fruiting-spike of 1915. It will be seen from this, that the fruits were normally delayed for three years; and those of 1916 for two years, as the valves were unopened; but, ten days after the branch was cut, the seeds freely escaped, and some of them, when sown, readily germinated. The fruits of the October, December, and April (1917) flowers were not sufficiently matured, as no seeds have fallen from the fruits. It is interesting to note that the character of the delayed dehiscence is similar in all species of *Callistemon*, except *C. viminalis*, in which species the fruits are fully developed about ten months after the flowering-period; and the seeds germinate freely as soon as the twigs are cut, and the seeds liberated. Prof. Ewart's observations were made in connection with *C. rigidus*, cultivated in Melbourne; but, so far as the exhibitor knew, *C. rigidus* is confined to the Port Jackson district, and is not a native of West Australia, as stated by Prof. Ewart.

DESCRIPTIONS OF NEW SPECIES OF AUSTRALIAN COLEOPTERA. Part xiv.

By Arthur M. Lea, F.E.S.

LUCANIDÆ.

Lissotes grammicus, n.sp.

♂. Black, shining; parts of appendages obscurely diluted with red. Sides and undersurface very sparsely clothed, the legs moderately setose.

Head gently and almost evenly convex, a fairly large notch on each side, front incurved to middle and almost impunctate; with large, round, dense punctures at sides and about eyes, becoming smaller towards middle of base. Mandibles not very large and almost simple. Eyes small, round, completely enclosed, and four in number, the lower ones slightly smaller than the others. Antennæ with three apical joints moderately large, the apical one truncated. *Prothorax* with sides and base margined, sides lightly sinuous, dilated to near apex; with large, round, dense punctures on sides, becoming smaller towards middle, the middle itself almost impunctate and evenly convex. *Elytra* scarcely longer than head (including mandibles) and prothorax combined; each with four, rather wide, shining, impunctate lines from base to beyond the middle, elsewhere with crowded and comparatively small punctures, but a few larger ones at sides of the smooth lines Front *tibiæ* with two, strong, obtuse, apical teeth, and three smaller and still more obtuse ones. Length, 16 mm.

Hab.—New South Wales: Bodalla (Dr. R. H. Pulleine). Unique.

No other Australian species of *Lissotes*, except *L. luteus* (which by the figure looks like a *Lissotes*, and was doubtfully referred by Westwood to *Dorcus*; it was omitted from Masters' Catalogue), has been described as having four eyes; Westwood regarded the type of that species as a male, despite the feminine appearance of the mandibles: but it was described and figured as having six impressed striæ on each elytron; on the present species there are no striæ, their places being taken by smooth, shining lines not interrupting the general convexity; there are also many other differences in the head, antennæ, etc. On account of its eyes, the species should perhaps have been referred to *Lissapterus* (*howittanus* of that genus has sometimes been referred to *Lissotes*), but the head and mandibles are very different from those of the species at present referred to that genus. The mandibles of the type are touching at their tips, and enclose a top-shaped space; each has an obtuse swelling about the middle of the upper surface, and is obtusely bicuspidate at the apex.

SCARABÆIDÆ.

LIPARETRUS MAJORINUS, n.sp.

Black, shining; elytra and appendages reddish-castaneous. Front of head, pronotum (including disc), and elytra at base and near suture, with rather long, erect, and rather sparse whitish hair; undersurface, hind-parts, and legs with dense clothing.

Head with crowded (but not confluent) and not very large punctures, becoming larger and sparser on clypeus, sides of the latter conspicuously narrowed and sinuous to apex, which is evenly and moderately incurved to middle. Antennæ nine-jointed. *Prothorax* with strongly rounded sides, hind angles rounded off, front ones produced and acute, median line vague and traceable only towards base; punctures of somewhat uneven size, but mostly rather large, and not very crowded. *Elytra* with punctures moderately large, becoming smaller and more crowded posteriorly, geminate striæ feebly defined. *Hind-parts* with rather dense punctures, smaller and denser on propygidium than on pygidium. Front *tibiæ* strongly and obtusely tridentate; hind tarsi with basal joint distinctly shorter than second. Length, 9 mm.

Hab.—Queensland (unique).

The erect pilosity is continued on to the elytra from the pronotum, but is not very dense there; regarding the species, however, as belonging to Group 1, of Blackburn's Table,* it would be associated with *L. fulvohirtus*, from which it differs in being larger, with the prothoracic punctures considerably larger, and the surface more shining; regarding it as belonging to Group 2, it would not fit into either F or FF, as the clypeus is neither truncate nor rounded in front. It is larger than any previously described black species with red elytra from Queensland. Some parts of the pronotum are very obscurely diluted with red; the elytra of the type are without a membranous fringe.

LIPARETRUS ACUTANGULUS, n.sp.

♂. Black; elytra (base narrowly black), hind-parts and appendages (most of femora excepted) bright reddish-castaneous. Undersurface and legs with long, pale hair, a fringe of similar hair on each side of prothorax, but becoming darker in front, rest of upper surface glabrous.

Head with rather small and crowded, but not confluent punctures, becoming larger and less crowded on clypeus; sides of clypeus lightly elevated and strongly narrowed, apex strongly elevated, lightly emarginate and acutely produced at sides. Antennæ nine-jointed. *Prothorax* with sides strongly rounded, hind angles widely rounded off, front ones acute and produced, median line very feeble; with dense and sharply defined but rather small punctures, less numerous along middle than elsewhere. *Elytra* with fairly large punctures, becoming crowded towards sides and smaller posteriorly; geminate-striæ well-defined. *Hind-parts* with punctures as on pronotum. Front *tibiæ* strongly but obtusely tridentate; front tarsi rather thick, basal joint keeled internally, claws thickened at base; hind tarsi with first joint conspicuously shorter than second. Length, 7-7¼ mm.

♀. Differs in having the clypeus short, truncate in front, with the sides not produced, abdomen more convex, legs shorter, and front tarsi thinner.

Hab.—Queensland: Brisbane (T. McGregor).

Belongs to Blackburn's Group 4, and there would be referred to JJ, but the median line of the pronotum, although fairly

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* Trans. Roy. Soc. S. Aust. 1905, pp.287-296.

distinct, is feeble even at the base; but regarding it as belonging to K, it would be associated with *L incertus*, from which it differs in the acutangular clypeus of the male, larger punctures of pronotum, and glabrous hind-parts; if referred to KK, it would be readily distinguished from *L. vicarius* by the clypeus. Its front tarsi and clypeus are much as in *L. phœnicopterus*, of Group 1 (with which it would be associated in Macleay's system), but which has very different clothing. On the male, the club is slightly infuscated; on the female, it is no darker than the rest of the antennæ; on the female also, the whole of the abdomen and legs are reddish; on the male, many of the elytral punctures are transversely confluent towards the sides, but, on the female, this appearance is less evident. On both specimens, there are a few hairs at the tip of the pygidium, but, except for these, the hind parts are quite glabrous; both specimens are without a membrane at the apex of the elytra.

LIPARETRUS MIXTUS, n.sp.

♂. Black; elytra and appendages (parts of the legs deeply infuscated) bright castaneous. Undersurface with long, pale hairs, a fringe of similar (but darker) hair on each side of pronotum; hind-parts with short, dense, erect setæ in addition to long hair.

Head with rather small, crowded, and more or less transversely-confluent punctures, becoming sparser, non-confluent, and slightly larger on clypeus; clypeus with sides moderately elevated, strongly decreasing and incurved to apex, apex rather strongly but obtusely tridentate. Antennæ nine-jointed. *Prothorax* with sides rounded and rather strongly produced towards base, hind angles widely rounded off, front ones slightly produced and somewhat acute, median line feeble; punctures small and rather sparse, but more numerous towards sides and front angles. *Elytra* with punctures of moderate size and not very numerous; geminate-striæ fairly well-defined. *Hind-parts* with dense subasperate punctures of moderate size. Front *tibiæ* strongly and acutely tridentate; basal joint of hind tarsi slightly shorter than second. Length, 6 mm.

Hab.—New South Wales (unique).

At first glance, the second joint of the hind tarsi appears to be distinctly longer than the first, but in reality it is very little longer. Regarding the species as belonging to Blackburn's Group 4, it would be associated with *L. distans*, which is a much larger species with all parts more or less reddish; if not to Group 4, it could only be referred to Group 7, and there associated with *L. iridipennis*, from which it differs in its bright red elytra and clothing of hind parts (the setæ of these are very short and partially concealed by the hairs, but they are very distinct from the sides); each lateral fringe of the pronotum is partly pale and partly dark, and although Blackburn tabulated *L. iridipennis* as having the fringe whitish, it is almost as often dark or partly dark as whitish; at first glance, it appears to be close to *L. perkinsi* of Group 10, but the clypeus has less acutely projecting teeth (the type is certainly a male), and the hind parts are densely clothed; *L. bituberculatus* (also of Group 10) also differs in the hind parts and in the considerably longer basal joint of hind tarsi. Most of the upper surface is brightly iridescent; the femora are almost black; the elytra (of the type) are without an apical membrane.

LIPARETRUS INTERMEDIUS, n.sp.

♂. Black; elytra (except for a narrow space at base), most of tarsi, parts of front tibiæ, antennæ and tarsi, more or less castaneous. With long hair on most parts, but elytra glabrous

Head with crowded and small punctures, but a few of larger size scattered about; clypeus with sparser punctures than between eyes, and smaller than the large ones there; sides moderately elevated and decreasing (with curved outlines) to apex, which is strongly but obtusely tridentate. Antennæ nine-jointed. *Prothorax* with sides strongly rounded, hind angles widely rounded off, front ones subacute and scarcely separately produced; with comparatively large and not very dense punctures, mixed with smaller ones; median line represented by a feeble basal depression only. *Elytra* with not very dense punctures, no larger than the larger ones on pronotum, and becoming smaller and more crowded on sides; geminate-striæ fairly well-defined. *Hind-parts* with rather dense punctures, slightly larger on pygidium (where they are as large as on pronotum) than on propygidium. Front *tibiæ* strongly tridentate; basal joint of hind tarsi distinctly longer than second. Length, 7 mm.

Hab.—Queensland : Cunnamulla (H. Hardcastle); unique.

Belongs to Group 8, of Blackburn's Table, but could hardly be associated with *L tridentatus*, as the clypeal teeth are much less acute and less produced; it differs from that species also in the clothing of the pronotum being quite as dense at the base as in front, and in the clothing of the pygidium; the punctures of the pronotum are also sparser and considerably larger. The clothing of the head and base of prothorax is much paler than on most of the prothorax, where it is black or blackish (it is uniformly coloured on *L. parvidens* and *L. obtusidens*); from *L. parvidens* it differs also in having the clypeus more conspicuously tridentate (both sexes of that species are before me), and from *L. obtusidens* in having rather larger punctures (on the elytra as well as on other parts). The antennæ are paler than the other reddish parts, but the outer parts of the club are lightly infuscated. The elytra are terminated by an extremely short membrane.

LIPARETRUS QUINQUELOBATUS, n.sp.

♂. Black; elytra, antennæ and palpi bright flavo-castaneous, legs of a darker red. Sterna with rather long pale hair, abdomen sparsely clothed, clypeus with a few hairs, a pale fringe on each side of pronotum, and extended on to sides of front margin, rest of upper surface glabrous.

Head with crowded and small, non-confluent punctures, an irregular row of larger ones near clypeal suture; clypeus with sparser and larger punctures than between eyes, sides strongly narrowed and suddenly incurved near apex, which is strongly and acutely tridentate. Antennæ nine-jointed. *Prothorax* with sides strongly rounded, hind angles widely rounded off, the front ones acute, median line shallow; with dense and sharply defined but rather small punctures. *Elytra* with rather sparse punctures of moderate size, becoming smaller and denser at the sides and apex; geminate-striæ well-defined, apical membrane narrow but conspicuous. *Hind-parts* with dense punctures, much as on pronotum, but a few of larger size scattered about. Front *tibiæ* strongly but obtusely tridentate; basal joint of hind tarsi conspicuously longer than second. Length, 8-8¼ mm.

Hab.—Queensland : Cloncurry (H. Hacker).

In Blackburn's Table, would be associated with *L. perkinsi*, but differs from that species in being much larger, non-iridescent, prothoracic punctures considerably larger and more sharply defined, and elytral punctures larger. *L. tridentatus*, which has a somewhat similar clypeus and is similarly coloured, has the front half of the pronotum densely clothed; from *L. intermedius*, it differs in being larger, clypeus strongly incurved before the apical teeth, prothorax glabrous on disc, and with smaller and much denser punctures, elytra entirely pale, etc. The clypeus is conspicuously tridentate in front, but the sides near the apex are strongly incurved, so that, when viewed obliquely from behind, it appears to consist of five almost equal lobes; immediately behind its suture, the surface is shining and sparsely punctate, with large punctures marking the position where the sparse and dense punctures meet. On the two specimens before me, the hind parts are entirely glabrous, except for a few hairs on the pygidium.

HAPLONYCHA COLOSSA, n.sp.

Bright reddish-castaneous, elytra paler. Undersurface and legs with dense, golden hairs, a few similar hairs at sides of eyes, and forming a thin row in each lateral gutter of pronotum; membranous fringes of elytra very short; pygidium glabrous.

Head with rather small but sharply defined punctures, becoming somewhat larger and more numerous (but not confluent) about clypeal suture; front face of clypeus with numerous setiferous punctures on sides, but setæ confined to a single row across middle. Antennæ with fourth joint slightly longer than third, the five following joints forming a club. Maxillary palpi rather long, penultimate joint slightly longer than antepenultimate, and scarcely shorter than apical. *Prothorax* more than thrice as wide as long, sides rather strongly rounded and feebly arcuate to base and apex, front angles somewhat produced, hind ones obtuse and not completely rounded off; with rather small but distinct punctures, sparser in middle than elsewhere. *Elytra* moderately dilated to about the middle; punctures fairly numerous, except between the geminate striæ (these very close together); suture very feebly mucronate. *Pygidium* shining, lightly convex; with rather small, scattered punctures. Basal joint of hind *tarsi* distinctly shorter than second. Length, 32 mm.

Hab.—Western Australia.

I have had the type for many years under the name of *H. gigantea*, but although looking like a large specimen of that species, it may be at once distinguished by the maxillary palpi: on *H. gigantea*, the antepenultimate joint is slightly longer than the penultimate, hence Blackburn referred it to his Group 5. On the present species, the penultimate is slightly the longer, hence the species must be referred to CC, of his Group 4, and there associated with *H. nobilis*, from which it differs in having the prothorax more transverse, and the fifth joint of the antennæ (instead of the sixth) the first of the club. The rami of the club are decidedly long, but as that of its first joint is only about half the length of the second, the type appears to be a male. From some directions, the pronotum appears to have a fine, iridescent bloom.

NOVAPUS PARVUS, n.sp.

♂. Reddish-brown, head and parts of legs black. Under-surface, legs, and upper part of pygidium with dense, rusty-red hair, upper surface glabrous.

Head with crowded and irregular punctures; with a sharp, short, oblique, simple horn. Antennæ ten-, club three-jointed. *Prothorax* about one-fourth wider than long, hind angles rounded off, front ones produced and acute, with a large discal excavation, its front part with transverse sculpture; with punctures of moderate size, but very irregularly distributed. *Elytra* with sutural and lateral striæ well-defined, but the others represented by feeble depressions or oblique scratches; punctures small and sparse, but becoming numerous at apex and sides. *Pygidium* with numerous rather small punctures, becoming larger and crowded at base. Length, 15 mm.

Hab.—Western Australia: Swan River (A. M. Lea); unique.

Much smaller than any previously described species, with the prothoracic excavation unusually small and shallow (it scarcely occupies one-third of the width of the prothorax), and the cephalic horn very small and simple (scarcely half the length of that of *N. simplex*). At first glance, the type bears a strong superficial resemblance to the males of *Isodon pecuarius*, but the horn is on the head, not on the prothorax.

CRYPTODUS ABERRANS, n.sp.

Black, not very highly polished (the elytra subopaque), parts of undersurface and of legs obscurely diluted with red, club of antennæ paler. Upper surface almost glabrous, undersurface sparsely and irregularly clothed, pygidium with a few short setæ.

Head with rather large but not very dense punctures; clypeus with front margin rather strongly elevated and truncate, lateral margins lightly elevated and oblique, suture well defined towards sides but obsolete in middle, where the surface is slightly elevated; mentum large, with large, shallow punctures, depressed in front, base rather lightly notched, with a few setæ and long bristles. Antennæ apparently nine-jointed, club three-jointed. *Prothorax* rather strongly convex, about once and one-half as wide as long, sides strongly rounded, base bisinuate, front angles obtusely produced, the hind ones rounded off, median line rather vague; with fairly large but nowhere crowded punctures. *Elytra* at base the width of prothorax, slightly dilated to beyond the middle; surface finely shagreened, with well-defined rows of fairly large punctures towards suture, but becoming smaller and irregular towards side and apex. *Pygidium* with fairly large but rather shallow punctures. Four hind *tibiæ* strongly serrate or digitate at apex, each notch with a seta; front claws simple. Length, 11 mm.

Hab.—Northern Territory: Darwin (N. Davies); unique.

In its comparatively small size, convex body, and general appearance, the present species certainly does not look a *Cryptodus*;* but the wide mentum concealing all the mouth-parts

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* Neither does *C. grossipes*, at first glance, appear to belong to the genus, but its remarkable mentum is almost exactly as in *C. caviceps*, which is quite an ordinary species of *Cryptodus*.

is like that of *Cryptodus*, and utterly different from that of any other Australian genus of *Dynastides*: the projection in front of the prosternum, and the triangularly dilated basal joint of the antennæ are also as in *Cryptodus*; the four hind-tibiæ are digitate instead of truncate at apex, and are certainly not fringed with setæ (as on normal *Dynastides*), but, at the base of each notch, there is a seta; smaller and less distinct setæ, however, are present on several other species of *Cryptodus* (e.g., *C. tasmanianus*), although they need to be closely looked for. The base of the mentum is less deeply notched than is usual in those having it notched, in this respect agreeing with *C. gigas*; in *C. tasmanianus*, it is truncate; and, in *C. caviceps* and *C. grossipes*, it has a long and almost vertical process; the apex of the basal joint of antennæ is less conspicuously produced over the following joints than is usual in the genus, but, from some directions, it entirely conceals the two following joints. The elytra, at first glance, appear to be glabrous, but, on close examination, some very fine setæ become visible; there are three or four interstices on each elytron slightly more prominent than the others, but not one is conspicuously elevated. The sex of the type is doubtful, as many males of *Cryptodus* have the front claws simple.

CORYNOPHYLLUS INTEROCULARIS, n.sp.

♂. Black; antennæ, most of legs and of undersurface more or less castaneous-brown. Undersurface and legs with rather dense, rusty-red hair; upper surface and pygidium glabrous.

Head concave, and with irregular (but not very dense) transversely-confluent punctures between eyes; clypeus moderately long, punctures more or less confluent, apex and sides rather strongly elevated, basal carina strongly elevated (sub-tuberculate) in middle; mentum gently convex. Antennæ ten-, club three-jointed, rami large, about as long as head is wide. *Prothorax* not twice as wide as long, sides strongly rounded, apex bisinuate, front angles produced, hind ones rounded off, a rather small excavation in front, the middle of its front margin with a small tubercle, basal gutter distinct at sides, but not traceable across middle; with small and sparse punctures, becoming more numerous on sides and larger in excavation. *Elytra* the width of prothorax; with irregular rows of large punctures in distinct striæ, but becoming very irregular about apex. *Pygidium* with variolose punctures, almost absent along middle, but crowded in upper corners. Spurs of hind *tibiæ* stout, and very unequal. Length, 15½-17 mm.

Hab.—New South Wales (Dr. E. W. Ferguson), Jenolan (J. C. Wiburd).

With the general outlines of *C. modestus*, but elytra dark and club of antennæ considerably smaller than in the male (although much larger than in the female); from the dark form of *C. fortnumi*, it is at once distinguished by the very different clypeus and single cephalic elevation; *C. andersoni* has the clypeus different, and the club much larger. One of the specimens before me has the upper surface entirely deep black, but, on the other, it is obscurely diluted with red; on the latter specimen, the clypeus is distinctly bilobed in front, but, on the other, it is almost simple there. Some of the elytral striæ are irregularly geminate in arrangement.

EUCNEMIDÆ.

MICRORHAGUS RUFICOLLIS, n.sp.

Black; prothorax and legs red, tarsi paler, antennæ dull piceous-brown, the two basal joints somewhat brighter. Somewhat irregularly clothed with depressed, more or less stramineous pubescence.

Head with dense, partially concealed punctures; with a fine transverse carina near the base, and a very feeble longitudinal one near each eye; these large and prominent. Antennæ long and thin, second joint very short, third slightly shorter than first, and slightly longer than fourth, fourth to sixth somewhat wider than the others, fourth to tenth slightly produced on one side at apex, eleventh very thin, and conspicuously longer than tenth. *Prothorax* at base almost twice as wide as the median length, front angles rounded, hind ones strongly produced and acutely carinated; front margin carinated, the carina on each side with a short spur extended towards but not meeting the one on the basal angle; with a vaguely impressed median line, becoming carinated at base; punctures moderately dense. *Elytra* parallel-sided from near shoulders almost to apex; with punctures of moderate size about base, becoming smaller posteriorly, but about tip decidedly coarse. Length, 3¼ mm.

Hab.—N.S.W.: National Park (A. M. Lea); unique.

The second joint of antennæ has a curious appearance as of being forced out of alignment. The elytral punctures are more or less lineate in arrangement, but not placed in striæ, the sutural stria (and that only from about the middle) is the only distinct one on each elytron; elsewhere there are but vague remnants of striation, or none at all. The prosternal sulci are deep, parallel-sided to near the base, and somewhat narrower than the propleural parallelograms, which are about once and one-half as long as their basal width.

HEMIOPSIDA LONGICORNIS, n.sp.

Dull castaneous-brown; head, basal joint of antennæ, junction of prothorax and elytra, sterna, and hind coxæ, black or blackish. Rather densely clothed with moderately long, stramineous pubescence.

Head densely granulate-punctate; with a subfoveate impression between antennary sockets; clypeus widely depressed in middle. Antennæ long, slightly passing elytra, second joint very short, third slightly longer than first and distinctly longer than fourth, fourth slightly shorter than fifth, fifth-tenth subequal in length, eleventh almost as long as ninth and tenth combined. *Prothorax* strongly convex, front angles rounded, hind ones acute and obliquely produced on to shoulders, with a very feeble median line; with dense, rugose punctures. *Elytra* slightly wider than hind angles of prothorax, parallel-sided to beyond the middle; with rather dense and irregular, but sharply defined punctures, becoming crowded about base; striation well-defined throughout, but especially on apical fifth. *Abdomen* with a deep, conspicuous, hairy depression on each side of middle, extending from tip of first segment to tip of fourth. Length, 6-6½ mm.

Hab.—Queensland: Mount Tambourine (H. Hacker's No.895).

Readily distinguished from all other species, except *H. ventralis*, by the abdominal depressions; the antennæ are also of unusual length; *H. ventralis* has the abdominal depressions commencing nearer the base of the first segment, and not continued beyond the third, and its antennæ are shorter and more conspicuously (although not strongly) serrated.

DYSCOLOCERUS POROSUS, n.sp.

♂. Black; undersurface, antennæ, and legs obscurely reddish. With very short pubescence.

Head with crowded punctures, with a very feeble depression on clypeus. Antennæ rather stout, eight basal joints densely punctate, second joint slightly longer than fourth, third slightly longer than two following combined, fourth to eighth equal and strongly transverse, ninth about as long as three following joints combined, and conspicuously wider, slightly longer and wider than tenth and much shorter and distinctly wider than eleventh, three apical joints as long as the seven preceding combined. *Prothorax* with sides rather strongly rounded in front, hind angles acute, with the outer side of each somewhat oblique, median line rather shallow but well-defined; with crowded punctures of moderate size. *Elytra* parallel-sided to beyond the middle; punctures at base as on prothorax, becoming somewhat smaller, but almost as crowded posteriorly; striation well-defined throughout, becoming deep posteriorly. Length (♂♀), 7-11 mm.

♀. Differs in being slightly more robust, antennæ shorter, the three terminal joints distinctly shorter than the seven preceding combined, the ninth scarcely shorter than the eleventh, and the fourth-eighth not transverse.

Hab. N.S.W.: Forest Reefs.—W.A.: Swan River (A. M. Lea).

The antennæ and sterna are somewhat darker than the abdomen and legs, but no parts are conspicuously reddish; the front of the prothorax of several specimens is very obscurely diluted with red. The pubescence of the upper surface is black and very short, but on the head, and base and apex of prothorax, it becomes longer and greyish, on the undersurface it is uniformly pale. On one specimen, the head appears to have a feeble median line, but it is quite absent from the five others before me. The Swan River specimen has the sterna and femora quite black. In some respects, the female is close to the description of *Lycaon ater*, but the fourth joint of the antennæ is no shorter than the fifth, and the prothorax has a conspicuous median line. The types were taken *in cop.*

DYSCOLOCERUS RUBRIVENTRIS, n.sp.

♂. Black; abdomen and legs bright red, antennæ reddish, becoming darker towards base, with the basal joint black. Clothed with blackish and ashen pubescence, becoming paler and more uniform on the undersurface.

Antennæ with second joint slightly longer than fourth, third slightly longer than fourth and fifth combined, fourth-eighth subequal in length, ninth-eleventh as long as first seven combined, ninth slightly wider than the following ones, almost as long as the four preceding combined, about one-third longer than tenth, and about two-thirds the length of eleventh. Length, 5½-6 mm.

♀. Differs in having the fourth-eighth joints of antennæ slightly wider than long, the ninth-eleventh scarcely as long as the seven preceding combined, and the eleventh very little longer than the ninth.

Hab.—N.S.W.: Jenolan (J. C. Wiburd).

The description of the sculpture of the preceding species, except of the antennæ, applies exactly to the present species, but besides the conspicuously red abdomen (in striking contrast to the black sterna) it differs from that species in having the three terminal joints of antennæ longer (in both sexes) and the fourth-eighth joints of the antennæ of the male much less conspicuously transverse.

DICTYEUCNEMIS, n.g.

Head moderately large, antennary sockets comparatively small and widely separated. Mandibles large, prominent, strongly curved, their hind outline straight. Antennæ thin and rather long. *Prothorax* moderately transverse, hind angles small, produced slightly outwards but not backwards, and not embracing the elytra. *Scutellum* subquadrate. *Elytra* strongly convex, distinctly wider than elytra, parallel-sided to near apex, epipleural fold narrow but traceable almost to apex. *Prosternum* with propleural triangles each with a narrow carina internally, and a still finer one externally, the two touching the apex at a slight distance (about equal to the length of the second joint of antennæ) from each other. Metasternum with episterna narrow and parallel-sided. *Abdomen* with first segment at the side about as long as the fifth along middle. *Legs* rather long; inner half of hind coxæ moderately long (about half the length of second segment of abdomen), then strongly narrowed to sides; tarsi moderately long, second, third, and fourth joints of exactly the same shape but decreasing in size; claws each with an obtuse swelling at base.

The prothorax is very aberrant for the family, but the combination of entire absence of a visible labrum, mandibles closely applied to the breast and concealing the palpi within the buccal cavity, intercoxal process of prosternum narrow and received into a deep groove in the mesosternum, and abdomen with five segments, forbid its being placed in any other family. The face is vaguely suggestive of some females of the *Rhipidoceridæ*. In Blackburn's Table, the genus would be associated with *Lycaon* (= *Hemiopsida*), with some features of which it agrees, but the base of the prothorax is at once distinctive from that, as from all other Australian genera. There is nothing at all approaching it in the Plates accompanying Bonvouloir's monograph. The punctures of the head and prothorax are remarkable. The external face of the mandibles is densely punctate, the punctures (except towards the base) within a depression enclosed by shining carinæ, which meet near the tips.

DICTYEUCNEMIS MIRUS, n.sp.

Blackish-brown, or castaneous-brown, appendages somewhat paler. With not very dense, and very short, whitish pubescence.

Head with large, shallow, net-like punctures, margined by fine carinæ, and with the inner part of each puncture flat and shagreened; antennary sockets almost as far apart as the length of the three basal joints of antennæ. Antennæ extending almost to hind coxæ, first joint not carinated, and slightly longer than third, second about half the length of fourth, third about as long as fourth and fifth combined, fifth to tenth very feebly decreasing in length, eleventh slightly longer than tenth, and about the length of ninth. *Prothorax* truncate in front, front angles rather strongly rounded, sides thence feebly undulated to base, a transverse impression near base, marking off a wide and short median lobe, with vague remnants of a median line, and a vague foveate impression on each side of middle; punctures as on head. *Scutellum* with apical half polished and almost impunctate. *Elytra* about one-fourth wider than prothorax, and about five or six times as long; with numerous distinct punctures and small round granules, becoming more crowded about base; striation well defined. *Prosternum* with moderately large punctures, each with a central pit, on middle portion, the propleural triangles with punctures much as on upper surface, but less defined. Apical segment of *abdomen* with dense, asperate punctures, each side with a shallow depression. *Legs* densely asperate-punctate; first and fifth joints of tarsi of equal length, and each about as long as third and fourth combined. Length, 7-10¼ mm.

Hab.—W.A.: Mullewa (Miss J. F. May).

The two specimens taken by Miss May are evidently conspecific, but the larger one is much darker than the other, with some parts almost or quite black.

NEMATODINUS, n.g.

Head short, mandibles strongly sinuous posteriorly, antennary sockets short and widely separated. Antennæ short, first and third joints long. *Prothorax* subquadrate, entirely concealing head from above. *Scutellum* subquadrate. *Elytra* with an epipleural fold at apex, and with suture armed. *Prosternum* with a vague longitudinal impression towards each side, the impression bounded outwardly by a fine carina (representing the prosternal suture), then with a narrow, almost parallel-sided space between the carina and margin of pronotum (this represented by a thin but not continuous carina). Metasternum elongate; episterna very narrow. *Abdomen* evenly convex, apex evenly rounded. *Legs* not very long; hind coxæ moderately long near where they touch, suddenly narrowed, and then almost parallel-sided to sides; tarsi thin, fourth joint very small and simple; claws thin, with a slight basal swelling.

The only species known has the top-heavy appearance of *Nematodes* and *Trigonopleurus*, but it differs strikingly from these genera in the prosternal sclerites, and in the tips of the abdomen and of the elytra. Although the prosternal sutures are not deeply impressed (they are, however, almost parallel with each other) as they are in *Microrhagus* and *Entomophthalmus*, the side-pieces may be regarded as propleural parallelograms, as in those genera; whilst, in *Nematodes* and *Trigonopleurus*, the side-pieces are decided triangles. In Blackburn's Table, the genus would be associated with *Hypocœlus*, from which it is at once distinguished by the elytra. The only genus at all approaching it in the tips of the elytra is *Galba*, with which it has scarcely anything else in common. In catalogues, it may be placed near *Nematodes*.

NEMATODINUS ARMIPENNIS, n.sp.

Of a dull castaneous brown, legs and antennæ somewhat paler. Moderately clothed with short, stramineous pubescence.

Head with crowded but not very large punctures. Antennæ not passing middle coxæ, second joint very short, third about as long as the three following combined, fourth slightly longer than wide, fourth-tenth subequal in length but feebly dilated till the tenth is feebly transverse, eleventh scarcely wider but distinctly longer than tenth. *Prothorax* about as long as wide, front straight across middle, with a fine marginal carina curved at each side, and then continued parallel with the prosternal suture till it obliquely diverges to margin the hind angle, with a feeble medio-basal carina, each side of base depressed; densely granulate-punctate. *Elytra* with outlines continuously parallel with those of prothorax to near the apex, with crowded granulate-punctures about base, somewhat sparser elsewhere; tips with an epipleural fold from about level with base of fifth segment of abdomen, densely granulate and each with an oblique projection at the suture; striation feeble.

Hab.—Queensland: Cape York (H. Elgner).—Northern Territory: Darwin (N. Davies).

Seen directly from behind, the tips of the elytra appear to enclose the tip of the abdomen, and each to have a short semi-upright process at the suture. On one specimen there is a conspicuous carina on the prosternum extending from the left eye to the middle of the intercoxal process, but it is accidental, as it is not represented on the right side, and is absent from two other specimens.

ARISOCEPHALUS, n.g.

Head wide, antennary sockets large and moderately close together, clypeus sinuous in front, its edge finely carinated. Antennæ variable. *Prothorax* moderately transverse, basal angles not very long but acutely carinated. *Elytra* subparallel-sided, with a wide epipleural enlargement from base to hind coxæ. *Prosternum* with a conspicuous carina marking the suture on each side from front coxa to level with middle of eye, propleural triangles bounded externally as well as internally by a conspicuous carina. Metasternum with episterna rather narrow and parallel-sided for some distance, but dilated posteriorly. *Abdomen* with fifth segment about as long as the two preceding combined. Hind *coxæ* (except for an incurvature at trochanters) almost parallel-sided from inner to outer margins; tarsi compressed, fourth joint small and feebly produced on lower surface, claws each with an obtuse basal swelling.

In Blackburn's Table, this genus would be associated with *Microrhagus* and *Entomophthalmus*, but the propleural triangles (instead of parallelograms) and prosternal sutures not sulcate, make it certain that the genus is not even close to these. The tricarinated clypeus of two of the species is suggestive of affinity with *Arisus*, but that genus has prosternal lateral sulci, and metasternal sulci; the general outlines, however, and especially the head, are much the same. The propleural triangles are without the least traces of longitudinal sulci, but are gently concave, or flat throughout; the carina marking the prosternal suture touches the front margin inwards of the point where the marginal carina touches it, instead of meeting it there as on most genera of the family; in consequence, the triangles are not acutely pointed. The hind coxæ are very distinctive, being slightly wider at their outer than their inner margins; the tarsi, when viewed from the sides, appear to be moderately wide, but very thin from above or below. In *A. basalis*, the fifth segment of the abdomen is somewhat shorter than in the other species, but its tip is somewhat produced (although much less conspicuously so than in *Nematodes* and *Trigonopleurus*). The size and general appearance of all the species are suggestive of *Cardiophorus* of the *Elateridæ*. Type-species, *A. flavipes*.

Second joint of antennæ (viewed from above) distinctly shorter than third .... *flavipes.*
Second joint distinctly longer than third.
  Elytra entirely reddish .... *rufipennis.*
  Elytra reddish only about base .... *basalis.*

ARISOCEPHALUS FLAVIPES, n.sp.

Black; extreme apex and base of prothorax, apex of scutellum, and antennæ (basal joint darker) reddish, elytra (base, suture, and sides excepted) and undersurface (parts of abdomen paler) of a dingy reddish-brown, legs (hind coxæ excepted) flavous. Densely clothed with short, more or less upright pubescence, sooty on the head and prothorax, mostly paler elsewhere.

Head with crowded and rather small punctures; with a conspicuous median carina from near base almost to apex; antennary sockets bounded by a curved carina, the same joined in front to the side of the clypeal margining carina. Antennæ extending to about hind coxæ, second joint of antennæ (as viewed from above) somewhat shorter than third, third distinctly shorter than fourth, its apex somewhat produced to one side, fourth-eighth strongly serrate (almost pectinate), ninth-tenth less strongly so, eleventh distinctly longer than tenth. *Prothorax* not much wider than long, sides rather strongly rounded in front, hind angles feebly directed outwards, the carina on each acute and about once and one-half the length of the scutellum; with a rather feeble median line, altering at the base to a feeble carina; punctures crowded and small, becoming smaller and still more crowded on sides. *Scutellum* with moderately dense punctures, and a feeble median carina. *Elytra* parallel-sided to about the middle, thence gently decreasing in width to apex; densely granulate-punctate throughout, but more densely about base than elsewhere; striation well-defined throughout. *Metasternum* with a rather wide, shining, median line, lightly impressed along its middle. Tip of *abdomen* rather densely granulate-punctate. Length, 5 mm.

Hab.—N.S.W.: Sydney (A. M. Lea); unique.

From some directions, the pubescence of the elytra appears to be as dark as that of the prothorax, but, from others, most of it is seen to be paler; the front, produced portion of each of the fifth-eighth joints of antennæ is not much shorter than the joint itself.

ARISOCEPHALUS RUFIPENNIS, n.sp.

Black; extreme apex and base of prothorax, elytra, abdomen (in places feebly infuscated), legs (hind coxæ and femora excepted), and antennæ red or reddish. Densely clothed with short pubescence.

Head with crowded and rather small punctures; with a conspicuous median carina traceable to near base, but not on to clypeus; antennary sockets each with a narrow margining carina from eye to side at apex of clypeus. Antennæ moderately long, second joint distinctly longer than third, and almost as long as fourth, fourth-tenth equal in length, but fourth-seventh wider and more strongly serrated than the ninth and tenth, eleventh almost as long as the ninth and tenth combined. *Prothorax* slightly more transverse, but otherwise much as in preceding species. *Elytra* parallel-sided to beyond middle, with dense punctures about base, becoming less crowded (but quite sharply defined) elsewhere; striation lightly impressed and, in places, scarcely traceable. Length, 5 mm.

Hab.—Tasmania: Southport (John O. Dawson); unique.

In general appearance close to the preceding species, but elytra more brightly coloured, and with different punctures and striæ, second and third joints of antennæ differently proportioned, the following ones much less conspicuously serrated, and the median line on the metasternum less conspicuous. The clothing on the pale parts is somewhat stramineous; on the dark parts, it is darker. In this and the following species, the hind coxæ at the sides are a trifle longer than the second abdominal segment; in the preceding species, they are of exactly the same length.

ARISOCEPHALUS BASALIS, n.sp.

Black; basal fifth of elytra reddish, tibiæ reddish, femora and coxæ darker, tarsi paler, antennæ dull reddish-brown, second and third joints and the tips paler. Clothed with very short and mostly stramineous pubescence.

Head with crowded and rather small punctures; with a conspicuous median carina from base to apex, an oblique carina on each side of clypeus from apex to base, where they almost touch the median line between the antennary sockets. Antennæ not very long, second joint short but distinctly longer than third, the two combined slightly longer than fourth, fourth-tenth equal in length, but decreasing in width from the sixth, and rather feebly serrated, eleventh about once and one-half the length of tenth. *Prothorax* much as in *A. flavipes* except that the punctures are smaller. *Elytra* parallel-sided to about the middle; with rather dense, well-defined punctures, becoming crowded at base; striation fairly well-defined. *Abdomen* with fifth segment somewhat produced at apex, and densely granulate-punctate there. Length, 3½ mm.

Hab.—N.S.W.: Galston (A. M. Lea); unique.

The third joint of the antennæ, although very short, is not "excessively minute" as in *Entomophthalmus*; and the fourth joint, although somewhat larger than the fifth, is scarcely longer. The carination of the head is more pronounced than in the other species of the genus, and is much as on *Arisus carinaticeps*.

FORNAX NIGER, n.sp.

Black. Clothed with short, depressed pubescence, paler about base of prothorax and of elytra than elsewhere.

Head with crowded subasperate punctures; with a feeble longitudinal carina, and a conspicuous interocular one. Antennæ moderately long, first joint about as long as three following combined, second shorter than third, and third than fourth, fourth-tenth equal in length, eleventh somewhat longer. *Prothorax* with front angles somewhat rounded, sides thence parallel to base; with punctures as on head; median line well defined towards base, but feeble in front. *Elytra* with crowded, asperate punctures about base, becoming less crowded and more sharply defined posteriorly; striation distinct throughout. Hind *coxæ* evenly and strongly narrowed to sides, greatest length about equal to that of second abdominal segment; basal joint of hind tarsi about as long as the rest combined. Length, 4½ mm.

Hab.—W.A.: Mount Barker (R. Helms); unique.

In general appearance, strikingly close to *F. suturalis*, but readily distinguished by the comparative lengths of the third and fourth joints of antennæ. The pubescence on the under-surface appears ashen or blackish according to the point of view; on the upper surface, it is almost entirely dark.

FORNAX CASTANEUS, n.sp.

Castaneous, tarsi somewhat paler. Densely clothed with short, stramineous pubescence.

Head strongly convex; with crowded but rather small punctures; inter-antennary carina not continued beyond antennary sockets. Antennæ not very long, second joint slightly longer than fourth, third almost as long as fourth and fifth combined, fourth-tenth subquadrate, fourth and fifth short, but combined considerably longer than sixth, sixth to tenth subequal, eleventh distinctly longer. *Prothorax* with sides rounded in front, thence almost parallel-sided to base; with dense and sharply-defined but rather small punctures, becoming crowded on sides. *Elytra* parallel-sided to near apex; base with crowded subasperate punctures, becoming smaller and more sharply defined posteriorly; striation well-defined. Hind *coxæ* strongly and evenly narrowed to sides, which are very short, greatest length slightly more than that of second abdominal segment; basal joint of hind tarsi distinctly shorter than the rest combined, fourth slightly narrower than third, and scarcely produced on lower surface. Length, 6 mm.

Hab.—N.S.W.: Sydney (A. J. Coates).

In general appearance, strikingly close to some of the larger specimens, that I have referred, with doubt, to *F. parvulus*, but the fourth and fifth joints of antennæ, although short, are (combined) distinctly longer than the sixth; the hind tarsi are somewhat aberrant for the genus.

A smaller (4¾ mm.) specimen from Queensland (Dalby, Mrs. F. H. Hobler) appears to belong to the species, but is more lightly coloured, with a vague remnant of a median line on the prothorax (completely absent from the type) and with slightly shorter antennæ and legs.

FORNAX MAJORINUS, n.sp.

Dark castaneous-brown, antennæ and legs paler. Very densely clothed with rather short, stramineous pubescence.

Head with dense but not very large punctures; inter-antennary carina widely interrupted in middle. Antennæ moderately long, second joint slightly longer than fourth, third almost as long as fourth and fifth combined, fourth slightly shorter than fifth, and fifth than sixth, sixth-tenth subequal in length, eleventh almost as long as ninth and tenth combined. *Prothorax* with sides strongly rounded in front, thence parallel-sided to base; punctures dense, rather small and subasperate, becoming crowded on sides. *Elytra* parallel-sided to beyond the middle; with dense asperate punctures about base, becoming smaller posteriorly; striation well defined. Hind *coxæ* produced to points at the sides, greatest length distinctly more than that of second abdominal segment; hind tarsi with basal joint as long as the rest combined. Length, 8¼ mm.

Hab.—N.S.W.: Byron Bay (C. Watson); unique.

A comparatively large, robust species.

DYSTRIGONISTHIS LATICOLLIS, n.sp.

Of a rusty-castaneous, appendages somewhat paler. Densely clothed with short, rusty pubescence.

Head with rather coarse, crowded punctures; clypeus shallowly concave. Antennæ with second joint short, third about as long as fourth and fifth combined, fourth-eighth subequal in length and with rounded sides, ninth almost as long as three preceding combined, slightly shorter than eleventh and slightly longer than tenth. *Prothorax* with sides strongly rounded in front, and then increasing in width to base, extreme base distinctly wider than elytra, and about twice the width of apex, with a rather feeble median line disappearing before apex; with very dense, and moderately large, round punctures; with a small, round fovea on each side, close to middle of base. *Elytra* parallel-sided to beyond the middle, base densely granulate-punctate, elsewhere with fairly dense but smaller and more sharply defined punctures; striation well-defined, first and second striæ on each elytron opening out into a short, deep, oblique sulcus close to apex. Hind *coxæ* with greatest length about equal to that of second abdominal segment, obliquely decreasing to each side, which is about one-third the greatest length. Length, 15 mm.

Hab.—N.S.W.: Mount Irvine (Dr. E. W. Ferguson); unique.

The prothoracic punctures, although dense, are quite sharply-defined on the disc; on the sides, they are more crowded and irregular. From some directions, the basal fifth of the elytra appears to be closely covered with fine, transverse corrugations. The three, long, terminal joints of antennæ are suggestive of (the Australian species of) *Dyscolocerus*, but the deep, lateral channels of the prosternum at once exclude it from that genus.

It is with some doubt that I refer this and the following species to *Dystrigonisthis*, with which, however, they would certainly be associated in Blackburn's Table; the antennæ of the two species differ considerably from each other, and also from those of *D. paradoxus*, and, in other families of beetles, these differences would almost certainly be regarded as of generic importance; but as Bonvouloir, and other workers at the family, have allowed an even greater range of variation in the antennæ, it does not appear desirable to propose a new genus (or new genera) for them at present. The lateral channel on each side of the prosternum is deep and conspicuously closed posteriorly (and receives the antenna throughout its length); on the basal third of the inner side, it is distinctly carinated, but, from the basal third to its front margin, the side is gently rounded, without the least trace of a carina. Although Blackburn separated *Dystrigonisthis* from *Phœnocerus* by the former having "Prosternal sulcus margined within by an elevated line only in its hinder part" as against "a continuous elevated line," it is to be noted that Bonvouloir says of *Phœnocerus* "*Sillon-marginal . . . étant bordé en arrière intérieurement par une ligne élevée.*" Quite possibly the following species should have been referred to *Phœnocerus*, but it is evidently distinct from *P. subclavatus* by its larger size, and different antennæ and hind coxæ.

DYSTRIGONISTHIS FERRUGINEUS, n.sp.

Dark rusty-castaneous, appendages somewhat paler. Densely clothed with short, rusty-red pubescence.

Head with crowded punctures of moderate size; with a short and rather wide median line; clypeus shallowly concave. Antennæ rather stout, second joint short, third cylindrical, almost as long as the three following combined, fourth-eighth short, subequal and distinctly transverse, ninth and tenth somewhat longer and wider (and with small foveæ at apex), eleventh about as long as the three preceding combined. *Prothorax* with sides rather strongly rounded in front, and then obliquely increasing in width to near base, which is somewhat wider than elytra, and almost twice the width of apex; with dense punctures of moderate size, smaller in middle than elsewhere, and becoming crowded on sides. *Elytra* feebly decreasing in width from base; densely granulate-punctate about base, punctures becoming smaller and sparser posteriorly; striation as in preceding species. Hind *coxæ* with greatest length about equal to that of second abdominal segment, curvilinearly decreasing to sides, which are very short; basal joint of hind tarsi somewhat shorter than the rest combined; second, third, and fourth regularly decreasing in length and width, fourth not bilobed and scarcely produced on under surface. Length, 11-12½ mm.

Hab.—Tasmania: Hobart (A. M. Lea).

The antennæ so regularly increase in width, that the three apical joints can scarcely be regarded as forming a club; from above, the second joint appears to be slightly shorter than the fourth; but, from below, it is seen to be slightly longer. The general outlines of the prothorax and elytra are much as figured for those of *Phænocerus subclavatus* (Bonv., Mon., Pl. xiii., fig.1).

On one specimen, the eighth and ninth joints of each antenna appear to be combined to form but one (with the suture completely obliterated in places); but, as the antennæ of the type are normal, this would appear to be accidental. On this specimen, also, there is a short, shining, median line, and two, small, medio-discal foveæ on the pronotum (quite absent from the type).

PHÆNOCERUS CLAVICORNIS, n sp.

Black, antennæ and legs somewhat obscurely diluted with red, tarsi paler. Rather densely clothed with short, ashen pubescence.

Head with small, crowded, partially concealed punctures, interantennary carina not continued across middle. Antennæ stout and not very long, first joint as long as the three following combined, second short, third slightly longer than fourth and fifth combined, fourth slightly longer than fifth, fifth-eighth short and transverse, ninth-eleventh forming a conspicuous club, ninth and tenth each conspicuously wider and longer than eighth, eleventh as wide as tenth at base, but rapidly narrowing to apex. *Prothorax* with sides strongly rounded in front, thence parallel-sided to base, with a slight but almost continuous median line; with dense and rather small, but sharply defined punctures, becoming crowded on sides. *Elytra* feebly diminishing in width from near base; densely granulate-punctate about base, elsewhere with small but sharply defined punctures; striation well-defined throughout. Hind *coxæ* at sides about one-third their greatest length, this slightly more than that of second abdominal segment; basal joint of hind tarsi about as long as the two apical joints combined. Length, 7¼ mm.

Hab.—Tasmania: Hobart (A. M. Lea); unique.

The antennæ have a distinctly three-jointed club, a character which excludes the species from all the genera noted by Bonvouloir, except *Phænocerus*; but the club is even more distinct than as figured for *P. subclavatus*; from the description of that species, also, it differs in being somewhat smaller, much darker, and prothorax with a conspicuous median line. In Blackburn's

Table, *Phænocerus* is placed with three other genera distinguished by having "Prosternal sulcus margined within by a continuous elevated line." This, however, is not the case with the present species, whose lateral channel is carinated on the posterior half, but gently rounded in front; its posterior end is also open.

GALBA* AUSTRALIÆ, n.sp.

Black, appendages reddish. Densely clothed with golden pubescence, becoming golden-red in places; on the undersurface somewhat ashen.

Head with crowded punctures mostly concealed, but more distinct on clypeus than elsewhere; with a very thin, median carina from base almost to apex. Antennæ rather short, second joint short, curvilinearly triangular, third-tenth each with a long ramus, that of third somewhat shorter and thicker than the others; eleventh joint slightly longer and thicker than the ramus of the tenth. *Prothorax* gibbous, not much wider than long, sides rounded in front, thence almost parallel to base; disc with irregularly granulate (in places vermiculate) elevations; the sides with irregular, more or less concealed punctures. *Elytra* narrowed from base to apex, tips obliquely carinated and produced; with series of fairly large punctures, becoming smaller posteriorly, but close to apex becoming larger. Hind *coxæ* with posterior edge somewhat sinuous, outer edge quite as long as elsewhere; tarsi with second, third, and fourth joints each with a wide and conspicuous lamella. Length, 11-14 mm.

Hab.—Queensland: Coen River (H. Hacker).

The first of its genus† to be recorded by name from Australia, although Bonvouloir (Mon., p.807) stated that the genus occurs there; Blackburn, however, thought‡ that this may have been due to confusion with *Galbodema*, there recorded as a synonym of *Galba*, but elsewhere (Mon., p.442) treated as distinct. The beautiful pubescence on the whole of the upper surface has a

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[*] Guér.-Men., Voy. Coq., Entom., p.68; Bonv., Mon., p.806.

[†] Readily recognisable by the large size and robust form of its species, with three tarsal joints conspicuously lamellate.

[‡] Manuscript note.

curious waved or mottled appearance, due to the varying directions in which it is applied to the derm; thus, the elytra, when viewed from behind, appear to have two golden fasciæ alternated with brownish ones; on altering the point of view, the brownish ones become golden, and *vice-versâ*, whilst, from other directions, the clothing appears to consist of irregularly mixed golden and brownish spots. The third joint of the antennæ is about as long as the two following combined, and its ramus is slightly shorter than the first joint, the rami of the other joints being slightly longer and subequal *inter se*. The elevations on the prothorax may be regarded as forming an irregularly lobed mass, of which the median lobe is the most conspicuous, appearing as an abrupt, obtusely pointed elevation near the scutellum (from the sides, its posterior end appears vertical), then, towards the middle, it bifurcates, each arm being irregularly continued to near the apex; on each side of it there are two other elevations feebly connected with it, the front one somewhat oval, the back one concave inwards and almost right-angled outwards; of the species figured by Bonvouloir, the nearest approach to this structure is that of *G. wallacei* (Pl. xl., fig. 1), but the elevations are all somewhat different; they are clothed with more ruddy pubescence than on the adjacent parts. The rows of elytral punctures are in very feeble striæ, but, about the tip, the striæ become deep; the derm is densely covered with minute punctures, but these become visible only after abrasion; the sides of the elytra, from the base of the fifth abdominal segment, are obliquely flattened, so as to appear as enlargements of the (elsewhere extremely narrow) epipleuræ, with the upper edge acutely ridged, and, at the suture, rather acutely produced.

PYTHIDÆ.

NOTOSALPINGUS BRUNNEUS, n.sp.

Obscure piceous-brown, basal half of antennæ and legs somewhat paler. Clothed with short and sparse but fairly distinct pubescence, more noticeable about apex of elytra than elsewhere.

Head wide and gently convex, with two shallow depressions in front, separated by a short, shining space; with crowded, sharply defined punctures. Antennæ rather thin, extending to base of prothorax, slightly dilated to apex. *Prothorax* lightly transverse, sides regularly increasing in width from base to near apex, and then rather abruptly narrowed, on apical half with several very feeble denticulations; with dense and moderately coarse punctures, more crowded on sides than on middle. *Elytra* at base slightly wider than head across eyes, shoulders square, sides subparallel or feebly dilated to near apex, and then widely rounded; with distinct rows of fairly large punctures, larger and more irregular about base than elsewhere, and becoming rather small posteriorly. Length, 1½-2 mm.

Hab.—Tasmania: Hobart, Launceston, Bruni Island.—Western Australia: Swan River, Newcastle (A. M. Lea).

A depressed, densely punctate species, readily distinguished from all others of the genus by the uniformly dingy-brown elytra. The apical joints of the antennæ are gradually enlarged, not abruptly clavate as in *Neosalpingus*. The denticulations on the sides of the prothorax are so very feeble that, from most directions, they are quite invisible; one specimen has a shining median line on the basal half of the pronotum; and, on several, there are two vague basal depressions; the elytra are without striæ, although their punctures are in very evident rows.

TASMOSALPINGUS, n.g.

Head wide, obtusely produced in front. Eyes small, lateral, prominent and coarsely faceted. Antennæ inserted considerably in front of eyes; with a conspicuous, three-jointed club. *Prothorax* wide, sides acutely margined. *Scutellum* small and strongly transverse. *Elytra* short. *Metasternum* elongate. *Legs* not very long; front coxæ rather widely, the others moderately separated, front coxal cavities open behind; tibiæ dilated towards, and minutely spurred at apex; tarsi moderately long, two basal joints of hind pair and three of the others moderately wide and close together, penultimate small and simple, claw-joint rather stout, almost as long as the rest combined; claws swollen towards base but not dentate.

The acutely carinated margins of prothorax, each separated by a narrow gutter from the disc, and rather widely separated front coxæ, readily distinguish the genus from *Notosalpingus*, to which, at first glance, the two species appear to belong. Type of genus, *T. quadrispilotus.*

TASMOSALPINGUS QUADRISPILOTUS, n.sp.

Brassy-black; undersurface, legs, and antennæ (club excepted) paler, elytra piceous-brown, with four, large, pale spots. Head and prothorax with distinct but somewhat straggling pubescence, elytra glabrous.

Head obliquely flattened, as wide across eyes as length of antennæ, with a shallow depression on each side in front; punctures dense and sharply defined but not very large, becoming smaller in front. Antennæ with second joint almost as stout as first but distinctly shorter, third-eighth small. *Prothorax* at widest (which is near the apex) slightly wider than head, apex distinctly wider than base, each side of base distinctly impressed, margins rather acutely carinated throughout but incurved at base; punctures much as on head. *Elytra* at base about the width of prothorax at its widest, feebly dilated to beyond the middle and then widely rounded; with rather coarse punctures in distinct but irregular series near base, becoming smaller and irregularly disposed elsewhere. Length, 1½-1¾ mm.

Hab.—Tasmania: Mount Wellington, in moss; Launceston (A. M. Lea).

A short, dumpy species, with prothorax rather conspicuously clothed, and elytra glabrous. On the type, the first spot on each elytron is a large, irregular one, commencing on the shoulder and obliquely directed towards the suture, near which it terminates at the basal third; the second one commences just beyond the middle, and is obliquely subtriangular. On one specimen, the pale markings are considerably enlarged, so that they appear to be the ground-colour, with the infuscate portions marginal, sutural, and forming three, large, median spots; the smaller one, on the suture, narrowly connected with the others, and these connected with the marginal infuscation.

Tasmosalpingus promiscuus, n.sp.

Dark piceous-brown, antennæ (club excepted) and legs slightly paler, elytra with obscurely flavous markings. Head and prothorax with rather conspicuous pale pubescence, elytra glabrous. Length, $1\frac{1}{2}$-$1\frac{3}{4}$ mm.

Hab. – Tasmania: Hobart, Swansea (A. M. Lea).

Structurally, close to the preceding species, but elytral punctures distinctly smaller and nowhere seriate in arrangement. The elytral markings, although conspicuous, are not sharply defined, and consist, on each elytron, of a humeral spot, lightly or not at all connected with a small subsutural one at the basal third; and a larger, post-median spot, fairly wide near the suture, and strongly narrowed obliquely upwards and outwards.

Neosalpingus brevis, n.sp.

Black, appendages (club excepted) obscurely paler; head and prothorax with a slight bluish or greenish gloss.

Head wide, gently convex between eyes, and somewhat flattened in front, with very minute punctures. Eyes very widely separated, and almost basal. Antennæ moderately long, third-eighth joints small, the three following forming an abrupt and conspicuous club. *Prothorax* widely transverse, rather strongly convex; base and apex of subequal width, sides rounded, and each with four, small, unisetose denticulations, each side of base with a small depression; with numerous, small but rather sharply defined punctures, becoming somewhat crowded and larger on sides. *Elytra* short, at base slightly wider than prothorax, sides distinctly dilated to about the middle, and then widely rounded to apex; smooth and apparently impunctate. Length, 1-$1\frac{1}{4}$ mm.

Hab.—Queensland: Cairns (Macleay Museum, and E. Allen).

In general appearance, like small, dumpy specimens of *N. politus*, but prothoracic punctures considerably smaller, basal impressions smaller and oblique, head smoother, and elytra considerably more dilated. The upper surface is entirely glabrous, the undersurface almost so. The head, when seen from the front, appears to be of subtriangular shape, but with sinuous sides; the elytra might fairly be regarded as impunctate, as the punctures are so extremely small that it is only from certain directions, and in a good light, that they may be seen under a Coddington lens.

CURCULIONIDÆ.

Cyrotyphus variegatus, n sp.

Black, parts of tarsi obscurely diluted with red. Densely clothed with variegated, depressed pubescence or setæ, the elytra with numerous, small fascicles.

Head and base of rostrum with dense, normally concealed punctures of moderate size, apical half of rostrum with small, dense punctures. Antennæ moderately long, third joint twice the length of second, and distinctly longer than fourth, eleventh about once and one-half the length of tenth. *Prothorax* about as long as basal width, which is considerably more than that of apex, sides bisinuate, with an irregular ridge on each side of middle, rising into a small tubercle near base, each side with a feeble, granulate elevation; with dense, more or less concealed punctures, and a few scattered granules. *Elytra* much wider than prothorax, almost parallel-sided to near apex, each elytron with two obtuse ridges near base, the inner one moderately elevated about summit of apical slope; with small, distinct granules about base, but other granules, and dense punctures, normally concealed. *Femora* stout, rather lightly but distinctly dentate. Length, 13 mm.

Hab.—Tasmania (J. E. Philp); unique.

Readily distinguished from *C. fasciculatus*, by the prothorax being without a conspicuous, transverse series of four tubercles; the elytra also are much more conspicuously variegated. The apical half of the rostrum is glabrous, but all other parts are more or less densely clothed, the pubescence being mostly stramineous, but varying to white (there is a conspicuous, bisinuate, white mark traversing the suture slightly beyond the middle) and black; on the elytra, there are numerous, small fascicles (especially along the suture), all of which are black; the abdomen has a vaguely striped appearance.

ON A NEW SPECIES OR FORM OF EUCALYPTUS.

By Cuthbert Hall, M.D., Ch.M., Parramatta.

(Plate lxxv.)

Eucalyptus Marsdeni, f. vel sp.nov.

Arbor, 30′-50′ altitudine, cortice fibroso inferne superne lævi, foliis petiolatis, lanceolatis, acuminatis, falcatis, obliquis, fere membraneis; cymis axillaribus; pedunculis 4‴ longis, pedicellis $1\frac{1}{2}$‴; operculo hemisphærico, umbonato; fructibus hemisphæricis, valvis parum exsertis.

A tree, 30 feet high in specimen observed, and probably would attain a height of 60-80 feet when fully grown.

Seedling.—Cotyledons very small, orbicular-reniform, entire, purplish on undersurface, glabrous. Leaves opposite, decussate, obtuse, shortly petiolate, lanceolate, venation pinnate, rather oblique, edges sinuate. Stem reddish, and both it and the leaves covered with fine, stellate hairs.

Juvenile leaves of a more advanced stage than in the small seedling are alternate, petiolate, narrow-lanceolate, acuminate, glabrous. *Mature leaves* alternate, petiolate, lanceolate, falcate, acuminate, oblique, greyish on drying, almost membranous, occasionally shiny, and having a pleasant, aromatic scent. Laminæ 6″-8″ long by $\frac{3}{4}$″ broad, petiole slender, $\frac{1}{2}$″ long. Lateral veins oblique, alternately fine, intramarginal vein fairly distant from edge.

Inflorescence axillary, peduncles $\frac{1}{2}$″ long, with rather few flowers in head, 6-9; buds turbinate, 5‴ long, operculum hemispherical, shortly acuminate. Stamens all fertile, anthers kidney-shaped. Fruits hemispherical, 3‴ in diameter, rim domed, valves small, slightly exserted.

Bark of an unusual character for a Eucalypt. While it falls in the group of the stringy-barks, yet it is laminated, with a sort of ochreous deposit on the outer surface of each layer. Inner bark very hard and compact. But while the trunk and lower branches have such bark, that of the upper branches and branchlets is smooth and greyish, so that the tree is really a half bark.

Timber light brown in colour, fairly heavy, close, straight in the grain, annual rings prominent in the young stage, planes and dresses well, and should be useful for technical purposes; gum-veins few.

Locality.—Toongabbie, New South Wales, at the rear of the Public School, on the Wianamatta clay.

Remarks.—As seen from the description, this form of Eucalypt, on a cortical classification, seems intermediate between the smooth-barks and the stringy-barks. The timber has not the texture of that of the stringy-barks, but more nearly resembles that of *E. viminalis* in physical characters. The early buds resemble those of *E. obliqua*, but there is no resemblance in the mature stage. The mature leaves are generally markedly oblique. The fruit resembles that of *E. eugenioides*, but it tapers more into the pedicel, and is not so flat; nor are the fruits so clustered on the peduncle. The seedling is intermediate between those of *E. eugenioides* and *E. Moorei*; and, in its hairy seedling-leaves and reniform cotyledons, approximates strongly to the stringbarks. The reniform anthers also place it in that category, but the bark, timber, and oil, are quite distinct from those of this class. As, so far, only a single tree is known, one is strongly inclined to conclude that it is either a hybrid or a sport. Strong colour is lent to the hybrid theory by the fact of its possessing so many of the characters of the stringy-barks, especially in the seedling-stage; yet differing from them in others in the mature stage, as for instance in the bark, oil, and timber. Since the only known tree has, unfortunately, lately been cut down, further comparison is at present impossible. Now that a description has been published, search may reveal further specimens, and more definitely establish its status. The tree was a young one, about 12-15 years old, and growing on land that had been mostly cleared, but with a few well grown trees of *E. hæmastoma*, *E. resinifera*, and *E. siderophloia* in proximity. Other trees near by were *E. crebra*, *E. eugenioides*, *E. hemiphloia*, *E. punctata*, and *E. tereticornis*. I have named this form or species, tentatively, *E. Marsdeni*, after the Rev. Samuel Marsden, the first incumbent of St. John's Church, Parramatta.

Oil.—Mr. H. G. Smith reports that the oil of this Eucalyptus was obtained by steam-distillation, in the ordinary way, from the leaves and terminal branches. It was somewhat thick and viscous, having almost the viscosity of castor oil. It has little resemblance, either in appearance or constitution, to the majority of ordinary Eucalyptus oils, but is more closely allied to the oils distilled from *E. nova-anglica* and a few others. It has no resemblance to the oils of the members of the *E. tereticornis*-group. Cineol was practically absent, and phellandrene could not be detected. The amount of oil available did not permit of the active terpene being isolated in a pure condition, but it is probable that dextro-rotatory pinene occurs in small amount.

Only 38 pounds of material were received for distillation, from which 4 ounces of oil were collected, equal to 0·66 per cent. The oil was but little coloured, and had a fairly pleasant odour. It gave the following results:—

Specific gravity at 15°C. = 0·9469.

Rotation aD = + 4·8°.

Refractive index at 20°C. = 1·4989.

Insoluble in 10 volumes 80 per cent alcohol at 16°C.

Saponification number of esters and free acid = 2, so that esters were practically absent. The small amount of free acid was removed, and this gave a strong odour of butyric acid. The phenol gave the reactions for Tasmanol, but it is probable that both phenols occur. The indications are that the oil consists largely of sesquiterpenes. Probably some high-boiling alcohols are also present, as indicated by the odour.

I have to record my sincere thanks to Messrs. R. T. Baker and H. G. Smith for much help in preparing this paper.

EXPLANATION OF PLATE LXXV.

Portion of branchlet of *Eucalyptus Marsdeni*, f. vel sp.n.

STUDIES IN AUSTRALIAN *NEUROPTERA.*

No.6. The Family *Psychopsidæ*, with Descriptions of new Genera and Species.

By R. J. Tillyard, M.A., D.Sc., F.L.S., F.E.S., Linnean Macleay Fellow of the Society in Zoology.

(Plates lxxvi.-lxxviii.; and four Text-figures.)

In No.4 of this series of Studies (**15**, pp.271, 289), I gave my reasons for considering the *Psychopsidæ* to be a separate family, and stated that it was my intention to deal with these insects in a monograph to follow later.

In a paper read in October, 1915 (**13**), but unfortunately not bearing upon it any indication of the actual date of publication, Navás published, in Spain, a monograph of these insects, and classified them as a separate family. This paper has only recently reached me, and I cannot tell whether it should take priority over mine or not; however, in view of the earlier date of reading of Navás' paper, I feel that I must give him the credit of having first raised these insects to family rank.

The conditions arising from the War have made it impossible for me to receive, for study, the material that I had hoped for, in the non-Australian species of this family. For this reason, as well as because of the publication of Navás' paper, I have decided to abandon my projected monograph, and to confine myself mainly to a study of the Australian species. Only in so far as this study affects the classification of the family, will it be necessary to discuss the other genera and species.

During the past three years, a large amount of work has been carried out upon this family. Of special importance has been the working-out in detail of the life-history of one species, *Psychopsis elegans* (Guérin), and the dissection and photographing of the wings of the pupa, in order to study the tracheation. Including a considerable number of bred specimens of this species, I have had through my hands for study, at one time or another, about one hundred examples of these rare insects, and have thus been enabled to gain a first-hand knowledge of all the Australian species except one. That exception is *Psychopsis meyricki* McLachlan, of which the only known specimens are in the McLachlan Collection, and are, therefore, not available for study.

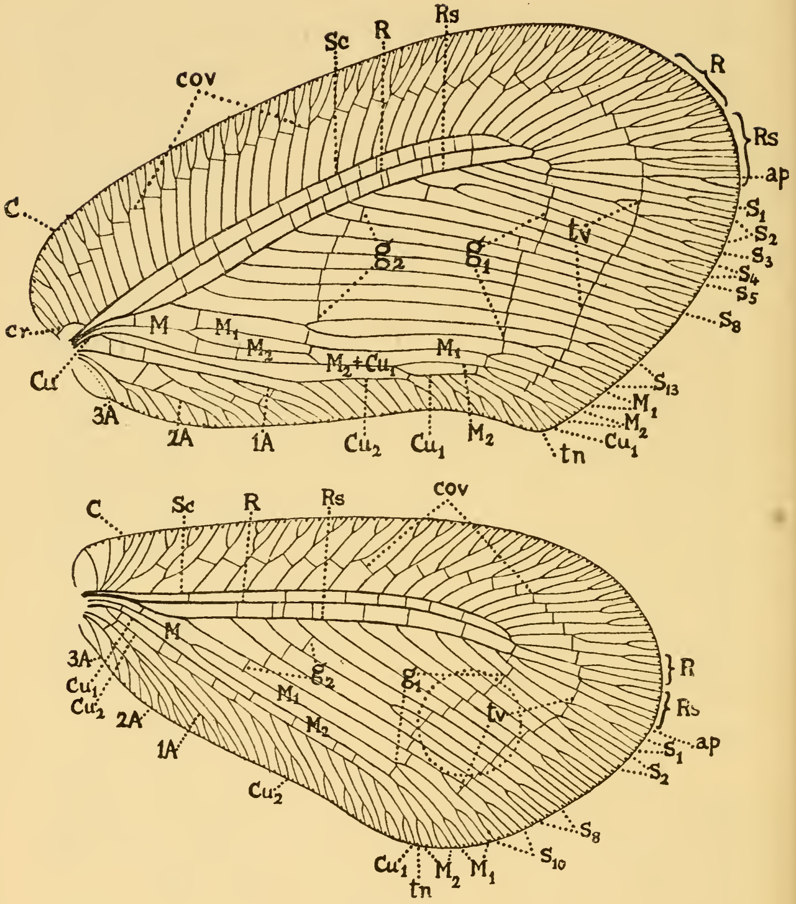
In the present paper, I propose to deal fully with the wing-venation of the family, firstly by a study of the pupal wing-tracheation, and secondly by applying the results so obtained to elucidating the best method of founding genera in the family. This matter is one of considerable difficulty, owing to the essential variability of the characters selected for this purpose by Navás, viz., the amount of cross-venation present. Descriptions of new genera and species will also be included, together with a general discussion of the relationships of the family. The full account of the life-history of *Psychopsis elegans* (Guérin) will form a separate paper, No.7 of this series of Studies.

My thanks are due to Dr. R. Hamlyn Harris, Mr. H. Longman, and Mr. H. Hacker, for the three fine photomicrographs reproduced in Plate lxxvi.

The Venation of *Psychopsis elegans* (Guérin).

In Text-fig. 1, the complete venation of *Psychopsis elegans* (Guérin), is shown. Text-figs. 2, 3A, give, for comparison, portions of the precedent tracheation of the pupal wing, drawn by means of the camera lucida from freshly dissected pupal wings.

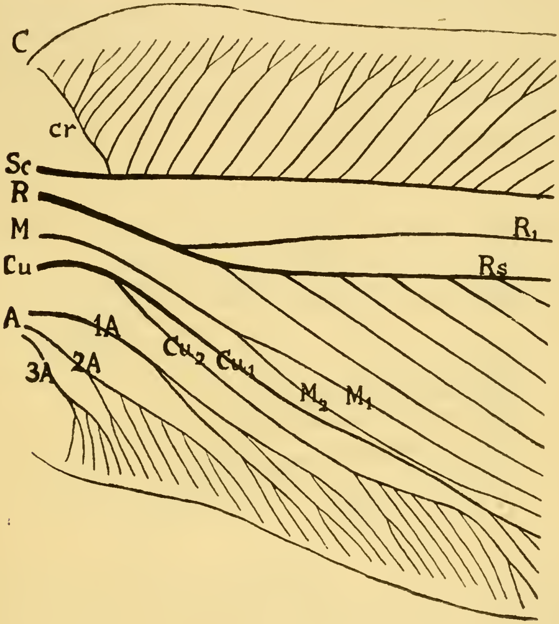
It will be seen at once that, broadly speaking, the venation and the precedent tracheation agree remarkably closely, as is the case with all the more archaic members of the Order Planipennia. Tracheæ precede every main vein, right down to its tiniest branchlets; but no tracheæ precede the cross-veins, which are only lightly indicated on the pupal wing. It is, therefore, very necessary that we should be careful to distinguish between the true *cross-veins* in the imaginal wing, and those *veinlets* (or



Text-fig. 1.

Psychopsis elegans (Guérin). Wing-venation; (× 5). 1A, first analis; 2A, second analis or basilar; 3A, third analis or axillary; *ap*, apex; C, costa; *cov*, costal gradate series of cross-veins; *cr*, recurrent costal or humeral veinlet; Cu, cubitus; Cu_1, Cu_2, its branches; g_1, discal gradate series of cross-veins; g_2, internal gradate series of cross-veins; M, media; M_1, M_2, its branches; M_2-Cu_1, anastomosed portion of M_2 with Cu_1; R, radius; Rs, radial sector; S_1-S_{13}, its branches; *tn*, tornus; *tv*, terminal gradate series of cross-veins.

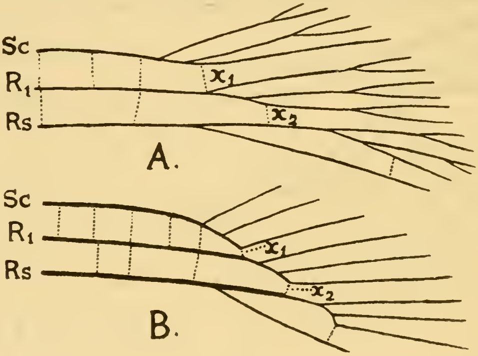
branchlets of main veins) which are preceded by tracheæ. For example, the veinlets passing from Sc to the anterior border are true veinlets or branches of Sc; but, in families where they are not so prominently developed as in the *Psychopsidæ*, they are frequently spoken of as cross-veins. The small veins which join these veinlets together, forming a longitudinal series of gradate veins, are true cross-veins, and are to be regarded as a comparatively late acquisition, correlated with the broadening out of the costal area in this family. So, also, the three other series of gradate veins are true cross-veins, not being preceded by tracheæ. A further point of distinction between veinlets and cross-veins, in this and all other archaic families of Planipennia, is that the veinlets, like the main veins of which they are part, are hairy, whereas the cross-veins are not.



Text-fig.2.

Psychopsis elegans (Guérin). Tracheation of basal half of pupal wing; (× 18). Lettering as in Text-fig.1.

The most striking specialisation in the venation of the *Psychopsidæ*, apart from the great enlargement of the costal area, is the manner in which the three parallel main veins, Sc, R, and Rs, have become strengthened, for from two-thirds to three-quarters of their lengths, to form a kind of midrib, from which the rest of the wing, apart from the much reduced median, cubital and anal areas, is supplied with numerous, delicate, radiating veins. I propose to term this strengthened portion of these three veins the *vena triplica*; its distal end is already known as the *anastomosis*. In order to understand this structure, we must consult the precedent tracheation. There (Text-fig.3,A) we shall find that the tracheæ run normally through the anastomosis, without any thickening basad to it, and without any true anastomosing between them. The strengthening of these veins, from the base to the anastomosis, to form the vena triplica, their apparent unions at the anastomosis, and the strong differentiation of their distal portions so as to appear exactly the same as the branch-veins above and below them, are purely imaginal specialisations, peculiar to this family, and not found elsewhere in the Planipennia. The development of the irregular series of cross-

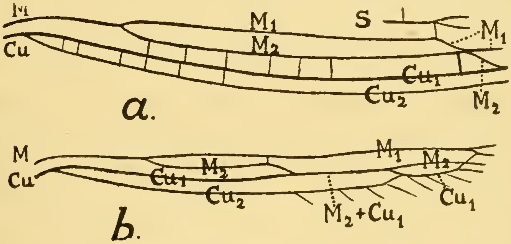


Text-fig.3.

Psychopsis elegans (Guérin). The radial anastomosis in the forewing. A, pupal tracheation; B, imaginal venation; x_1, x_2, the two cross-veins which join the distal ends of the vena triplica.

veins between Sc, R, and Rs may also be correlated with the development of the vena triplica, as an additional strengthening for the midrib.

Let us now study the so-called anastomosis more fully. In Text-fig.3, A and B, I have contrasted the pupal tracheation with the imaginal venation in this region. It will be seen at once that the actual termination of the vena triplica is not accomplished by means of an anastomosis between any of the main veins, but by the interpolation of the two cross-veins, x_1 and x_2, together with the bending-down of the portions of Sc and R_1 preceding them. We must contrast this strongly with the condition to be seen in the *Osmylidæ*, where Sc and R_1 approach one another distally at a very slight angle, and then fuse together, *without the intervention of an auxiliary cross-vein*, for a considerable distance. There is then, in the *Osmylidæ*, a *true* anastomosis between these two veins; whereas, in the *Psychopsidæ*, there is no true anastomosis, and it would appear to be somewhat misleading to term it so, as Navás has done. However, the term has already been applied, in Perlaria and Trichoptera, to junctions between main veins, brought about by means of cross-veins in line with one another; so that we may allow it to remain, provided that we understand that we are speaking of a junction of this type, and not a true anastomosis between two or more main veins.



Text-fig.4.

Types of anastomosis between M and Cu in *Psychopsis*. *a*, usual type in *Ps. mimica* Newman, forewing; *b*, usual type in *Ps. elegans* (Guérin), forewing. In *Ps. insolens* McLach., there is usually no anastomosis in this region at all. Lettering as in Text-fig.1.

Turning next to the region of the media and cubitus, on the character of which Navás attempts to divide the Australian species from the African, as two separate tribes, on the ground that the former have no anastomosis in this region, the condition to be seen in *Psychopsis elegans* is shown in Text-fig.1 and Text-fig.4, *b*. In the tracheation, M_2 approaches Cu_1 very closely for a considerable distance, and then diverges from it again. In the corresponding venation, M_2 fuses with Cu_1 for this same distance, and the parts of M_2 just before the fusion, and of Cu_1 just after it, are bent so as to appear like oblique cross-veins. It is clear that here we have a *true anastomosis*, comparable with that between Sc and R already mentioned in *Osmylidæ*. But this anastomosis is not a constant character, either for the species *elegans* or for the genus *Psychopsis*, as I have noted more fully on p.761. The type of anastomosis in this region in *Psychopsis mimica*, in which, usually, M_1 just anastomoses with M_2 at a point, and M_2 in its turn with Cu_1, is shown in Text-fig.4, *a*. In other species, such as *Ps. insolens*, there may be, in the majority of specimens, no anastomosis whatever in this region.

The arrangement of the cross-veins, which are not represented in the precedent tracheation, is of great interest. In *Ps. elegans* (Text-fig.1), we note, first of all, the presence of a gradate series closing the disc distally (g_1). This may be termed the *discal gradate series.* Internally to this, and crossing the disc not far from its middle, there is another series (g_2), which may be called the *internal gradate series.* These two series will be at once recognised as the homologues of the two gradate series normally present in the wings of *Chrysopidæ.* Besides these, there will be seen a long series of cross-veins connecting the veinlets of the costal space, and extending right from near the base to the apex. This may be termed the *costal gradate series* (*cov*). Below the apex, this series is continuous with a gradate series roughly parallel to the discal series, but lying between it and the termen of the wing. This may be called the *terminal gradate series* (*tv*). Except for a slight development of costal cross-veins in such genera as *Drepanepteryx*, the costal gradate series does not appear in any of the lower Planipennia; the terminal gradate series is absolutely peculiar to the *Psychopsidæ.*

Of these series, only the discal is invariably present. The internal series is usually present also, but not always. The costal and terminal series are later developments, confined to the larger species, and evidently correlated with the greater expansion of the areas which they help to support. Further, there is great variability in the condition of these series in almost all species. As an example of this, I would point out, in Text-fig. 1, the presence of a single cross-vein in the forewing between the anterior ends of the internal and discal series. This is frequently absent; but, in some specimens, it may be replaced by either half of an extra series, in others by a complete series of as many as thirteen cross-veins, crossing the disc between the internal and the discal series! In one case, I noted the presence of this extra series upon one forewing of a specimen, while it was absent upon the other! It will be at once obvious that attempts to define genera on such variable characters as these, are foredoomed to failure.

In conclusion, it is interesting to note that, regarded as a whole, the wing of *Psychopsis* presents a very close analogy in structure to the feather of the wing of a bird—an analogy which is also suggested by such wings as that of *Drepanepteryx*, but by no means so closely. The vena triplica corresponds with the rachis, forming the main support or midrib in both cases; the position of this support is the same in both cases, viz., nearer to the anterior than to the posterior margin. The numerous veins radiating out from both sides of the vena triplica are the analogues of the barbs of the bird's feather; and the series of connecting cross-veins, or gradate series, are analogues of the barbules, which serve to connect the barbs together.

Classification of the Family.

We are now in a better position to consider the true value of the various venational structures which have so far been used in subdividing it into tribes, and in defining genera.

Our study of the venation shows us that the cross-veins are not preceded by tracheæ, and that they are to be considered as a later addition to the main scheme of venation. This applies more especially to the costal series of cross-veins and its continuation, the terminal gradate series, which are not fully developed in any other family, and are evidently comparatively recent acquirements, correlated with the great enlargement of the costal area. With regard to the discal and internal gradate series, it must be evident that variations in the amount and position of the cross-veins forming them will depend partly on the size of the insect, and partly upon the number of branches of the radial sector possessed by it; we should, therefore, be prepared to find a great deal of variation in these characters. If, then, the present system of classification should fail to stand the test that we propose to apply to it, we shall be faced with the problem of finding more reliable characters, on which to rebuild a sounder arrangement of the species.

Though it is not the purpose of this paper to deal exhaustively with the non-Australian species, it will be first of all necessary to call attention to certain errors and omissions in Navás' most recent work. A paper that claims to be a monograph of a family should surely contain a complete bibliography of all the more important papers concerning it, and should also at least list, if not describe, all the known species. But I find that Navás omits from his work all reference to two of McLachlan's most important papers (**9**, **10**), in which that fine entomologist described a new South African species on the one hand, and the only known Burmese species on the other (*Psychopsis marshalli* McL., and *Ps. birmana* McL., respectively). Consequently, Navás gives only four species instead of five for South Africa (unless, indeed, one of his own species is synonymous with McLachlan's!), and is quite unaware that a Burmese species exists at all! As there are only fifteen species known altogether, it will be seen that these omissions are very serious for a monograph.

We must now note some further errors of equal gravity. In 1910, Navás described specimens of *Psychopsis elegans* (Guérin), surely one of the best known and most typical species of the family, as a new genus and species of *Hemerobiidæ*, under the name *Zygophlebius verreauxinus* Navás(**11**). The description clearly shows that, at the time, Navás was quite unaware that there was such a genus as *Psychopsis*, though it had been proposed nearly seventy years before, and its type-species was one of the most striking of all known Planipennia. Later in the same year, N. Banks(**1**) pointed out that *Zygophlebius* was clearly synonymous with *Psychopsis*; whereupon, in his next publication, Navás suppressed his generic name in favour of *Psychopsis*. If he had stopped there, all would have been well. But, in his monograph(**13**), he proceeded to resurrect Guérin's old generic name *Arteriopteryx* (given by that author in ignorance of Newman's then quite recently published name, *Psychopsis*), the type of which is *elegans* Guérin, synonymous with *verreauxinus* Navás. He then, quite illegally, further resurrects his generic name *Zygophlebius*, of which the original type was *verreauxinus* Navás (= *elegans* Guérin), and proceeds to redefine it, and to give it a new genotype, *Psychopsis zebra* Brauer, from South Africa. At the same time, he forms the tribe *Zygophlebini* to receive the whole of the South African species, leaving *elegans* Guérin, together with all the other Australian species, in the tribe *Psychopsini*!

Now *Zygophlebius* was proposed by Navás as a monotypic genus, and hence there can be no question as to which species was its type. Hence, whether Navás was correct in placing that species in *Psychopsis*, as he did in 1912, or in *Arteriopteryx*, as he did in 1916, is immaterial to the question. In either case, *Zygophlebius* sinks as a synonym, either of *Psychopsis* Newman, or of *Arteriopteryx* Guérin. As a *nomen nudum*, it may not again be resurrected in the form of a new genus, to receive, as its type, another species of *Psychopsis*, viz., *Ps. zebra* Brauer. Further, the tribal name *Zygophlebini* must sink with it. If *Ps. zebra* Brauer, is really generically distinct from *Ps. mimica* Newman, it now requires a new name. I therefore propose the name *Notopsychops*, n.n., to replace *Zygophlebius* Navás, 1916, (type *zebra* Br.), invalidated by *Zygophlebius* Navás, 1910, (type *verrauxinus* Navás = *elegans* Guérin) itself a synonym for *Arteriopteryx* Guérin, synonymous with *Psychopsis* Newman.

Having thus cleared the ground to some extent, let us now pass to the consideration of the division of the family into tribes, as proposed by Navás in 1916 (**13**, p.188). I give herewith his key, translated from the original Spanish:—

(1) Costal area of both wings divided, at least partly, by a median longitudinal series of gradate veinlets (*venillas en escalinata*) 2.
Costal area simple or totally undivided in both wings. Asiatic species .... 3. *Balmesini*, nov.

(2) Two anastomoses in both wings; the anterior formed by the subcostal, the radius and its sector, which are united in the region of the stigma, the posterior by the procubitus (= M), the cubitus and its sector, which are connected in a similar manner. African species................ 2. *Zygophlebini* Navás, restr.
One evident anastomosis, viz., the anterior or radial, formed by the three veins mentioned; the others run parallel without bending manifestly in an anastomosis. Australian species... .... 1. *Psychopsini*, nov.

In his description of *Psychopsis birmana* (**9**), which Navás has evidently not seen, McLachlan says:—"It differs from all Australian species except *Ps. meyricki* in the absence of a line of oblique connecting nervules in the costal area"; and, lower down, he divides the known species of *Psychopsis* into two groups, of which the first, consisting of *Ps. meyricki* and *Ps. birmana*, is defined by the words "No line of oblique nervules in costal area, only two series of transverse gradate veins."

The facts of the case are that *Ps. meyricki* normally lacks the costal series of cross-veins, as McLachlan here states. Navás, however, who admits that he has never seen this species, is compelled to place it in his genus *Magallanes*, together with *Ps. insolens* McLach., though he defines this genus as having the costal space of the forewing subdivided by the presence of the series of costal cross-veins, which *Ps. meyricki* lacks. For, if he had anywhere mentioned this character, which McLachlan emphasises, his tribe *Balmesini* at once breaks down!

Here, then, we have an instance of an entirely artificial subdivision into two tribes, *Balmesini* and *Psychopsini*. We may well ask, what is the essential point in the subdivision? Is it to divide the Asiatic from the Australian species? If so, then the division on the character of the costal space breaks down, and *Ps. meyricki*, agreeing with the Asiatic species in this respect, must nevertheless stand apart from them in the tribal division. But if it is the character of the costal cross-veins that is the essential matter, the case becomes even worse; for then the Australian species *Ps. meyricki* must at once be removed from the tribe *Psychopsini* to the tribe *Balmesini* (all the rest of which are Asiatic species), and must also be removed from the genus *Magallanes*, of which its close ally, *Ps. insolens* McL., is the genotype, and find its proper place in the Asiatic genus *Balmes*!

There is only one escape from this dilemma, and that is, to admit that the tribal characters here under discussion are of no value, and to suppress the tribe *Balmesini* altogether.

Turning next to the characters of the tribe *Zygophlebini* Navás, as here defined, it is only necessary to draw attention to my remarks on the condition of the venation of *Psychopsis elegans* in the region of M and Cu (p.756). Navás' definition for the tribe *Zygophlebini* indicates the presence of an anastomosis in the region of these two veins for this tribe, but the absence of the same anastomosis in the tribe *Psychopsini*. One would have little hesitation in deciding that both *Psychopsis mimica* Newman, and *Ps. elegans* Guérin, must go into the tribe *Zygophlebini*, on this definition. Whether the form of anastomosis is the same in these species as it is in the African ones, I am not able to say; the point is, that the amount of anastomosis in this region is very variable, not only for different species, but also for different individuals of the same species. There is only one species known to me, viz., *Ps. insolens* McL., in which it can truly be said that the great majority of the known individuals have no anastomosis in this region; hence, strictly speaking, this is the only species that can be rightly admitted into the tribe

Psychopsini, as defined by Navás. Thus we come to a *reductio ad absurdum*, which it is not necessary to pursue any further. The only remedy is to admit, at once, that the tribal characters under discussion are of no value, and to suppress the tribe *Zygophlebini* altogether. We are then left with only the tribal name *Psychopsini*, which ceases to have any value as restricted by Navás' definition, and may be disregarded; leaving us with a single family of closely united species, the *Psychopsidæ*, within which no legitimate tribal divisions can so far be recognised.

Having settled these questions, we may now proceed to define the family *Psychopsidæ* afresh, and to deal more fully with the Australian genera and species. This will necessitate a discussion of the validity of the genera proposed by Navás for the Australian species, a re-grouping of the species, and descriptions of two new genera and species.

Family PSYCHOPSIDÆ.

Head: size small or medium; *eyes* large and rounded, well separated, projecting laterally; *ocelli* absent or vestigial; *antennæ* short, set fairly close together, many-jointed. *Mandibles* small, with only a single internal tooth below apex; *maxillæ* with five-jointed palpi; labial palpi three-jointed.

Thorax: broad and strongly built; *prothorax* short and comparatively narrow; *mesothorax* very broad and large; *metathorax* also broad, much shorter than mesothorax, and not fused with it. *Legs* short, the tibiæ with a pair of terminal spurs, the tarsi five-jointed, with small terminal claws and a broad empodium.

Wings very broad, with broadly rounded apices. Costal space excessively widened from base to apex without any differentiated pterostigma; the costal veinlets numerous and frequently branched, generally connected by a more or less complete series of longitudinal cross-veins (absent or reduced in the smaller species); a recurrent vein at the base of the costal space. Sc, R, and Rs are strong veins, and run closely parallel, forming a strong midrib to the wing, the *vena triplica*, supported by numerous cross-veins; this formation ends at a point between one-quarter and one-third of the length of the wing from the apex, where Sc, R, and Rs become joined by strong cross-veins, forming the *anastomosis*; from this point onwards, these three veins continue only as weak branching veins, indistinguishable from those around them. Branches of Rs very numerous, closely parallel to one another, their direction almost parallel with that of the dorsal border of the wing. Central area of wing marked off as a *disc*, bounded anteriorly by Rs, posteriorly by Cu, and distally by a series of gradate cross-veins, the *discal series*. Other series of gradate cross-veins may also be developed; in particular, an *internal series* crossing the disc near its middle, and a *terminal series*, lying between the discal and the termen, and continuing the line of the costal cross-veins; apart from these, there is little or no development of cross-veins upon the wing. M variable, but always with its branches closely parallel, and occupying only a little of the wing-space. Cu either two-branched or simple, with or without a variable amount of anastomosis with M. Anal veins short, three in number, mostly much branched.

Abdomen short, moderately stout, completely covered by the wings in the position of rest. *Appendages* variable, usually either forcipate or valve-like in the males.

Eggs oval, with rounded ends; laid separately and attached by one side.

Larva very distinct on account of its large, squarish head, from which the enormous jaws project like a pair of calipers; mandibles without internal teeth; the body somewhat flattened, of moderate width, fairly long, tapering posteriorly to the anal sucker; the legs short and formed for running backwards. Colouration greyish-brown, with pruinescence. Inhabits crevices in the bark of large forest-trees; fiercely carnivorous.

Cocoon spherical, or nearly so, resembling a large pearl; spun from the anus, of fine cream-coloured silk, in crevices of the bark.

Pupa short and stout, of normal Planipennian form. Active at metamorphosis, when it cuts open the cocoon and ascends the tree for some distance before disclosing the imago.

(A full account of the egg, larva, and pupa will be given in dealing with the Life-History of *Psychopsis elegans* Guér., which will form the next of this series of Studies).

Distribution: Australia (but not Tasmania), South Africa, Burma, Thibet, and China; suggesting a Gondwanaland origin for the family Close relatives of the family were present in the Trias of Ipswich, Q.

The *Psychopsidæ* are at once distinguished from all other Planipennia by their shortened antennæ, the joints of which remain distinct and similar, and by their remarkable wing-structure, in which the most striking characters are the great enlargement of the costal area, with formation of the connecting costal cross-veins; the strengthening of Sc, R, and Rs to form the *vena triplica*, supported by cross-veins between them; the strong differentiation between the vena triplica and the parts of Sc, R, and Rs lying beyond the anastomosis; the formation of the anastomosis by interpolation of two small cross-veins; and the great abundance and closeness of the branches of Rs.

As regards the definitions of the four Australian genera, I give herewith Navás' key to them (**13**, p.188), translated from the original Spanish:—

(1) Forewing with four transverse series of gradate veinlets, three in the disc and one the external continuation of the costal series; hindwing with only three such series, two discal and the external one which continues that of the costal field parallel to the external margin of the wing.... 1. Psychopsis Newman.
Forewing with only three series of transverse veinlets............ 2.

(2) Both wings with three series of gradate veinlets, two in the disc between the radial sector and procubitus (=M), and the external one which is continuous in a curve with that of the costal field.. 2. Arteriopteryx Guér.
Hindwing with two or one series of gradate veinlets............... 3.

(3) Three transverse series of gradate veinlets, very distinct and complete, in forewing; only two in hindwing... 3. Wernzia Navás.
Disc of forewing with two complete series of gradate veinlets, at times a trace of a third in continuation of the costal series; hindwing with only one ... . 4. Magallanes Navás.

According to Navás, the arrangement of the gradate series shown in Text-fig.1, determines the insect as belonging to the genus *Arteriopteryx* Guér. If, however, the forewing has an extra series interpolated in the disc, between the internal and discal series, then the insect belongs to *Psychopsis* Newman. If the arrangement for the forewing remains as in Text-fig.1, but the hindwing has one series missing, then the insect goes into *Wernzia* Navás. If, in addition to this, the terminal series in the forewing is absent, or only partially formed, then the insect belongs to *Magallanes* Navás.

A complete study of the whole of the cross-veins in the specimens in my collection has been carefully carried out. The total number of specimens studied was sixty-four; but many of these have since been given away or exchanged. They represent eight species, two of which are new. The following very interesting and instructive results are here given:—

Psychopsis illidgei Froggatt.—The male in my collection has three complete series in all four wings. In the forewings, there are numerous scattered cross-veins in the upper distal portion of the disc (Plate lxxvii., fig.4), but no sign whatever of a fourth series between g_1 and g_2. Hence, according to Navás, this insect belongs to *Arteriopteryx* Guér.

In a large female of the same species, which I examined in the Queensland Museum, and of which photographs are given in Plate lxxvi., figs.1-3, there are only three series in the forewings, and no irregularly placed cross-veins elsewhere in the disc. This specimen, then, also goes into *Arteriopteryx*, according to Navás.

Of two specimens in Mr. Froggatt's Collection, one has three complete series of gradate cross-veins in all four wings. The other has four complete series on the left forewing, and only three on the right. Hence, according to Navás, the first specimen belongs to *Arteriopteryx*, the second partly to that genus and partly to *Psychopsis!*

Psychopsis mimica Newman.—I have examined seven specimens altogether. The forewing shows also three complete series; in addition, there are a variable number of cross-veins in the disc, between g_1 and g_2, numbering from four to thirteen. In only one specimen do these form a complete fourth series; in the rest, they form either an incomplete series, or are just scattered irregularly. In the hindwing, the terminal and discal series are complete, but the internal series is very variable, being sometimes complete, and sometimes very incomplete, with as few as seven veins in it.

This is the type-species of the genus *Psychopsis*. Of the seven specimens examined by me, Navás would place only one definitely within *Psychopsis*; the rest are either intermediate between *Psychopsis* and *Arteriopteryx*, or between *Psychopsis* and *Wernzia*.

Psychopsis gracilis, n.sp., (Plate lxxviii., fig. 10).—The only known specimen shows the three series of the forewing complete, together with a very irregular, incomplete fourth series in the disc between g_1 and g_2. In the hindwing, the discal and terminal series are practically complete, but the internal series consists of only four cross-veins, not forming a continuous series, and not close together in line. One would like to know where Navás would place this specimen.

Psychopsis elegans (Guér.), (= *Ps. newmani* Froggatt).—Twenty-eight specimens of this species have been examined, most of them bred specimens. The cross-venation is very variable. In the forewing, the three series are always complete; but there may or may not be a fourth. In some specimens, this fourth series is complete, consisting of as many as thirteen veins in line; in others, there is only half a series; in others again, only three or four irregular veins; while, in the majority of specimens, there is only one intermediate cross-vein (as in Text-fig. 1), or none at all. I have seen one specimen having four complete series in one wing, and only three in the other! In the hindwing, the terminal and discal series are always complete, but the internal series is very variable, being sometimes a complete series of from eight to ten veins in line, and sometimes merely from three to five irregularly placed cross-veins. Thus, different specimens of this species might almost be placed in three of Navás' genera, and we are not surprised to find this author himself placing *elegans* in *Arteriopteryx*, and *newmani* in *Psychopsis*, although they are one and the same species!!

Psychopsis cœlivagus (Walker).—Five specimens have been examined. The forewing has the terminal and discal series complete, the internal series either complete or incomplete. In the hindwing, the internal series is absent, the terminal series is complete, and the discal series is very variable. It may be complete and in normal position, or it may be removed inwards to a position midway between the normal positions of the discal and internal series, or it may be entirely replaced by irregular cross-veins; in one specimen, the disc is covered nearly all over by irregular cross-veins, not forming any gradate series at all. This variability should be contrasted with Navás' definition of the genus *Wernzia*, of which this species is the genotype.

Psychopsis insolens Walker.—Twenty-one specimens have been examined. In this species, the forewing has the discal series complete, the internal either complete or nearly so. The terminal series is usually quite absent; but, in some cases, there are from one to five cross-veins belonging to the upper end of this series. In the hindwing, the discal series is complete, the internal series very variable. Normally either absent or represented by only one cross-vein, it is nevertheless present in a fair percentage of specimens, either as an incomplete series of two or three veins, or as a complete series of four consecutive veins; further, right and left wings do not always show the same condition. The terminal series is absent in the hindwings; and the costal series, which is complete in both wings of all the preceding species, is here reduced to a shorter series, running from the base outwards for a variable distance, from one-third to two-thirds the entire length of the costal area. Thus we see that Navás definition of the genus *Magallanes*, of which this species is the genotype, will not include the whole of the specimens examined.

Finally, in a single specimen of a new species (Plate lxxviii., fig.11), which will form the type of a new genus, we find the discal and internal series present on both fore- and hindwings, the discal series of the hindwings being not quite complete, and removed somewhat inwards from the normal position. The marginal series is absent from both wings, and there is only a mere vestige of the costal series, at the base of the wing.

(*Psychopsis meyricki* McLachlan, which I have not seen, is stated by its describer to have both discal and internal series present in the forewing; but nothing is said as to the condition of the hindwing; the costal series is absent).

Reviewing the above evidence, it is clear that:—

(1) The genus *Psychopsis* Newman, being founded upon *Ps. mimica* Newman, a species which itself shows great variability in the number of its series of cross-veins, cannot be restricted by any definition which attempts to limit this variability.

(2) The genus *Arteriopteryx* Guér., founded upon *Ps. elegans* Guér., a species very closely allied to *Ps. mimica*, and with almost equally variable cross-venation, must be suppressed entirely, and its type-species retained within *Psychopsis* Newman.

(3) The genus *Wernzia*, as defined by Navás, does not even include all the specimens of its type-species. If, however, the definition of the genus be widened, then it at once forms a part of the *Psychopsis*-series of species, and should be included in that genus.

(4) The genus *Magallanes* is founded upon a type-species which grades into *Wernzia* in the characters of some of its individual members. This should also, therefore, be removed back to *Psychopsis*.

If these conclusions be accepted, the genus *Psychopsis* will include forms showing a gradual transition, from four series to two in the forewing, and from three series to one in the hind, with scarcely a break anywhere in the series. Bearing in mind that the gradations are not specific constants, but essentially *of individual value only*, it must be evident that any attempt to subdivide this genus, upon the basis of these variable characters, is bound to fail.

We have, therefore, to ask whether we should be content to leave all the Australian species in the genus *Psychopsis*, or whether we should seek for some new division.

I believe that a natural division of the Australian species is possible, without attempting to make use of characters so essentially variable as the cross-venation. Anyone who has studied these insects at all fully will be at once struck with the very great difference exhibited between *Psychopsis illidgei* Froggatt, and all the other species. This may be seen at once by comparing Plate lxxvii., fig.4, with Text-fig.1 and Plate lxxviii., fig. 10. Apart from its much greater size, *Ps. illidgei* differs from all the other species by the shape of the wings, in which (but more especially in the forewing), the dorsal margin is strongly excavated, so that the tornus projects very prominently beyond the rest of the wing-area. This species is also unique in possessing raised or embossed areas upon the forewing. Further, there is a great difference in the venation, in that the branches of the radial sector are far more numerous and closely set in this species than in any other, giving the wings the appearance of having been made from spun silk or some other fine material. Finally, if we examine the condition of the median vein, we shall find that it has from four to six branches within the disc; whereas, in all the other species, it is only two-branched. These differences are so striking, that I have no hesitation in separating out *Ps. illidgei* from the other species of the genus, to form the type of a new genus *Megapsychops*, whose full definition will be found below.

All the Australian species left over in the genus *Psychopsis* agree in possessing a moderate number of branches of the radial sector, in having a hindwing about two-thirds as wide as the fore, and with a very characteristic, dark, round spot upon it, towards the apex. But I have, in my collection, a small new species, in which the hindwing is much narrower, being only about half as wide as the forewing, and the dark spot is absent. Though these characters do not separate this species so distinctly from the rest as do those of *Ps. illidgei*, yet they have the merit of being obviously constants. Hence I propose to describe this new species under a new generic name, *Psychopsella*, of which it will form the type. The full definition of this genus is given below.

There now remain within the genus *Psychopsis* the six Australian species *mimica* Newman, *gracilis*, n.sp., *elegans* Guér., *cœliragus* Walker, *insolens* Walker, and *meyricki* McLach. Of these, the first three are distinguished by their usually larger size, the somewhat angulated tornus of the wings, and the pink or red colouration of the markings above the tornus of the forewing. Contrasted with these, the other three are usually of smaller size, with more rounded wings, the tornus not prominent, and the colouration either fawn, brown, or black. It would appear at first sight that these two groups suggest a natural division of the genus into two. But, unfortunately, the species *elegans* Guér., is so variable that it forms a connecting link between the two groups. I have a number of specimens that are no larger than well-sized examples of *Ps. insolens*; moreover, the smaller the specimen, the more rounded does the wing become; so that my series of *elegans* offers almost a complete transition from the angulated tornus, seen in *mimica*, to the rounded tornus of *insolens*. There remains, therefore, nothing but the colour to go upon. The only conclusion I can legitimately come to, is, that these six species form a natural assemblage, which is best expressed as a single genus. But, having said that, it should also be remarked that all six species are very distinct forms, and there is no difficulty whatever in separating them at sight. A key to these species will be found below.

Key to the Australian Genera.

(1) Ocelli vestigial. Fore and hindwings of almost equal width, with the branches of Rs excessively numerous (27 to 32 in forewing, 18 to 24 in hind), exceedingly close together, so as to give the wing the appearance of the close texture of spun silk; dorsal margin strongly excavated before the tornus, the latter very prominent, especially in the forewing. M at least four-branched. Forewings with raised or embossed areas.... .... MEGAPSYCHOPS, n.g. (Type, *Psychopsis illidgei* Froggatt).

Ocelli absent. Hindwing distinctly narrower than fore. Branches of Rs moderately numerous (from 7 to 16), not excessively close together; M only two-branched; dorsal margin straight or only slightly excavated; no raised or embossed areas on forewing.. 2.

(2) Hindwing about two-thirds as broad as forewing; and with a distinct dark rounded spot towards apex or termen............ .... PSYCHOPSIS Newman.

Hindwing only just over one-half as wide as forewing, and without any such spot ....PSYCHOPSELLA, n.g. (Type, *Psychopsella gallardi*, n.g. et sp.).

MEGAPSYCHOPS, n.g. (Plates lxxvi., lxxvii.).

Characters as given above. Large insects, expanse over 50 mm.

Genotype, *Psychopsis illidgei* Froggatt.

MEGAPSYCHOPS ILLIDGEI (Froggatt). (Plates lxxvi., lxxvii.).

Psychopsis illidgei Froggatt, These Proceedings, 1903, xxviii., p.455, Pl. xxi., figs.7, 9. Navás, Congreso de Valladolid, 1916, p.191, fig.2.

There is no need to add very much to the excellent description given by Froggatt. The insect is so distinct and remarkable, that it cannot fail to be recognised at sight.

Hab.—Mount Tambourine, South Queensland; 1,900 feet. Exceedingly rare, only five specimens having been taken during twenty years, all attracted to light.

Plate lxxvi., fig.2, is a very fine photograph of the magnificent specimen in the galleries of the Queensland Museum. This specimen is an exceptionally large female. Plate lxxvi., figs.1, 3, show the venation of the fore- and hindwings of the same specimen.

Plate lxxvii., fig.4, shows the venation of the small male in my collection. This is apparently the only known male of this species. A short description of the points in which it differs from the female is here given:—

Total length, 13·5 mm.; *forewing*, 26 mm.; *hindwing*, 22 mm.; *expanse*, 54·5 mm. Colouration not quite as dark as in female; the spots near tornus of hindwings pale and semi-transparent.

Abdomen very short, only 7·5 mm. long, narrowed at base, but much swollen anally. *Appendages* consisting of a pair of superior and a pair of inferior, broadly triangular, valve-like laminæ, forming a pyramid, which almost completely hides the end of the abdomen from view (Plate lxxvii., fig.5).

Type, in Coll. Froggatt.

As the extinction of this fine insect would seem to be only a matter of a few years, owing to the gradual clearing of the mountain which is its only known home, the following account of its habits and resting position, taken from notes supplied by Miss M. Davidson, of Cedar Cottage, Mount Tambourine, will be of considerable interest to all entomologists. The figures given on Plate lxxvii., figs.6-7, were drawn from pencil-sketches of the living insect made by Miss Davidson.

At rest, the position of the wings depends upon the kind of surface on which the insect is placed. When, as usual, it rests upon the bark of a tree, or some fairly wide and flat surface, the wings are held roof-wise over the body, but inclined wide apart, at an obtuse angle, as is shown in Plate lxxvii., fig.6. In this position, the resemblance to a Reptilian head is very striking, as is also said to be the case with the gigantic Hepialid, *Leto staceyi* Scott. Both insects have the embossed area in much the same position, resembling a pair of wide-open eyes. But, in *Megapsychops*, there is the additional suggestion of the forwardly projecting snout, formed by the coalescence of two dorsal bands right up to the head.

The local name for this insect on Mount Tambourine is, as I am informed by Mr. W. H. Davidson, the "Cross-bones." This would appear to have been suggested by the resemblance of the transverse band on the forewing, with its somewhat narrow stalk, terminated at either end by an enlarged embossment, to the crossed femoral bones in the traditional pirate's emblem of the "skull and cross-bones."

When resting on a twig, the wings are brought closer together, so as to form a steep roof over the body, as may be seen in Plate lxxvii., fig.7. The head is almost completely retracted, and the antennæ folded beneath it out of sight. At night-time, when the insect becomes active, or when feeding, the head is protruded and raised up, while the antennæ are held almost vertically upwards.

In either position of rest, Miss Davidson states that the resemblance of the insect to a moderate-sized fungus is very marked. Certainly, the white colour of the wings, with their yellowish-brown markings, would suggest this; but I do not know whether there is actually any fungus growing on the mountain for which the insect might be readily mistaken. Unless there is, we cannot say that the appearance of the insect is such as to afford it readily any protection from birds. From the fact that its wings have been seen several times lying upon the ground, the insect having evidently been seized and eaten by a bird, and also that Mr. Davidson himself lost a fine female from his verandah, through a bird seizing it, there would seem to be *prima facie* evidence that its appearance affords it no protection whatever. Birds may, therefore, have been one of the main factors in the reduction of the *Psychopsidæ* to a mere remnant since Jurassic times, and also in the total extinction of their Jurassic allies, the *Prohemerobiidæ* and the gigantic *Kalligrammatidæ*.

Miss Davidson's sketches were made from the specimen in my collection, which was captured on Dec. 7th, 1916, and was kept alive for about a fortnight on sugar and water, in the hope that it might lay some eggs. Unfortunately, it proved to be a male. A fine female, which was apparently attracted to it one night, was seen in the early morning resting upon the verandah; but, as already recorded, was seized and carried off by a bird, before Mr. Davidson could secure it.

PSYCHOPSIS Newman.

Newman, Entomologist, 1842, p.415. Hagen, Stett. ent. Zeit. 1867, p.375.

Arteriopteryx Guérin, Iconographie du Règne Animal, 1845, iii., p.389.

Arteriopteryx (partim) Navás, Congr. Valladolid, 1916, p.189.

Zygophlebius Navás, Broteria Braga, 1910, p.82.

Wernzia (partim) Navás, Mem. R. Acad. Ci. Art., Barcelona, 1912, x., p.195.

Magallanes (partim), Navás, Mem. R. Acad. Ci. Art., Barcelona, 1912, x., p.197.

Characters as given in the key on p.771, with the following additions:—Moderate-sized insects, expanse varying from 25 to 50 mm.; with or without anastomosis between M and Cu in forewing.

Genotype, *Psychopsis mimica* Newman.

With regard to the variable character of the amount of anastomosis between M and Cu in forewing, Text-fig.4 shows two of the variable conditions to be found in the genus. In the type-species, *Ps. mimica*, the most frequent condition is that shown in Text-fig.4*a*; but a condition resembling that shown in *b* may also occur in one or both wings. In *Ps. elegans*, the commonest condition is that shown in *b*, but there are many irregularities in one or both wings. In *Ps cœlivagus*, either of the two conditions shown in *a* and *b* may be present, or the anastomosis may be complicated by the presence of numerous cross-veins, or there may be no anastomosis at all; this last condition is the most usual one for *Ps. insolens*.

Not having seen any of the African species, I cannot say whether the type of anastomosis on which Navás bases his separation of these species, as a tribe separate from the Australian ones, is of the type here shown or not; but, as he qualifies his statement that M, Cu and its sector (by which, I presume, he means Cu_2) are anastomosed, by the phrase "magis vel minus sensibili" (**13**, p.199), I anticipate that here, as almost everywhere else, he has failed to select a constant character for his subdivision, and that a thorough revision of the African species will result in the complete collapse of his tribal distinctions.

Key to the Species of *Psychopsis*.

(1) Larger species, expanse 33 to 50 mm., with definite, transverse fasciæ in forewing, and pink or red markings near tornus; forewing with more or less prominent tornus. Dark spot on hindwing placed well *below* the anastomosis of Sc, R, and Rs. 2.

Smaller species, expanse 25 to 36 mm., with tesselated, fawn-coloured, grey or black markings on forewing; tornus well rounded. Dark spot of hindwing placed either upon the anastomosis itself, or between it and the apex .... 4.

(2) Fasciæ of forewing very distinct; no blood-red patch situated about one-fourth of the wing-length from the base............. 3.
Fasciæ less distinct; a blood-red patch on forewing, at about one-fourth of the wing-length from base .... *Ps. elegans* (Guér.).

(3) Two very distinct and well separated black spots, of moderate size, situated near tornus of forewing; at least five transverse fasciæ, of which the first ends in a dark blotch overlying Sc, R, and Rs at about one-fourth of the wing-length from the base, while the last three converge towards the tornus........ .... *Ps. mimica* Newman.
Two very minute black spots close together at tornus of forewing; only four transverse fasciæ, of which the first completely crosses the wing to the dorsum, while the third and fourth converge to meet above the tornus...........*Ps. gracilis*, n.sp.

(4) Spot of hindwing covering the anastomosis................. .... 5.
Spot of hindwing placed about half-way between anastomosis and apex; colouration of forewing yellowish-brown or fawn-colour... .... *Ps. insolens* McLach.

(5) Forewing heavily marked with black; spot of hindwing black... .... *Ps. cœlivagus* (Walker).
Forewing tesselated with pale grey; spot of hindwing pale fuscous......................... .... *Ps. meyricki* McLach.

Psychopsis mimica Newman.

Newman, Entomologist, 1842, p.415.

Froggatt, These Proceedings, 1903, xxviii., p.454, Pl. xxi., figs. 3-5 (nec *Psychopsis mimica* Froggatt, These Proceedings, 1902, xxvii., p 367).

Navás, Congr. Valladolid, 1915, p.190, fig.1.

Hemerobius mimicus Walker, Cat. Neuroptera Brit. Museum, 1853, p.279.

Type, in British Museum.

This is the most widely distributed of all the known species, but by no means the commonest. I have seen specimens from several localities in the south-west of Western Australia, from South Australia (including several taken at light in Adelaide), from Victoria, and from the western parts of New South Wales. Along the coastal strip of New South Wales, it is replaced by *Ps. elegans*; but it reaches the coast again around Brisbane, Q., where a number have been taken at electric lights. I know of no record further north than this.

PSYCHOPSIS GRACILIS, n.sp. (Plate lxxviii., fig.10).

♂ *Total length*, 11 mm.; *abdomen*, 5·5 mm.; *forewing*, 20·5 mm; *hindwing*, 17·5 mm.; *expanse*, 42·5 mm.

Head pale brownish in colour, 1·8 mm. wide, *eyes* black, *antennæ* pale ochreous, 4 mm. long.

Thorax: *prothorax* pale ochreous, 0·6 mm. long by 1·2 mm. wide. *Pterothorax* pale ochreous anteriorly, shading to dark greyish-brown behind, irregularly marked with brown blotches; greatest width 2 mm. *Legs* very short, very pale ochreous in colour, slightly darker on tibiæ and tarsi.

Wings with a general resemblance to those of *Ps mimica*, but much more transparent, more delicately built, and less hairy. If placed upon a dark background, the wings of *Ps. mimica* appear white, with their pattern of dark fasciæ and other markings showing up very distinctly; those of *Ps. gracilis*, on the other hand, are very transparent, so that neither the venation nor the colour-pattern shows up well under these conditions. Forewings more triangular in shape than those of *Ps. mimica*, more narrowed towards the base, and slightly wider at the level of the tornus. Only four distinct transverse fasciæ, of which the first two are only lightly indicated in the costal area (those of *Ps. mimica* are most strongly marked in this area); the most basal fascia runs as a slight arc from Sc to the dorsum, at about one-fourth of the wing-length from the base; the second is incomplete, and passes from Sc transversely only half-way across the disc, a little basad of the middle of the wing; the third is well marked on the costal area, slightly broken as it approaches Sc, then well marked as it passes downwards, somewhat obliquely, to meet the fourth above the tornus; the fourth fascia is also well marked in the costal area, and passes just outside the anastomosis, transversely downwards, to meet the third at an angle of about 50°. On this fourth fascia, just before it meets the third, are two distinct blackish spots; below the union of the fascia, and extending to the tornus, is a broad pinkish band, carrying two small black spots at the tornus itself. All the above fasciæ are formed, as in *Ps. mimica*, of two more or less parallel dark lines placed fairly close together, and enclosing a paler area. The only other markings are an irregular brownish area close to the base, between R and Cu, a series of irregular markings along the dorsum, and indications of an extra fascia lying below the apex of the wing, parallel and close to the termen (as also in *Ps. mimicà*). Hindwing quite differently shaped from that of *Ps. mimica*, the base being much narrower, the terminal border cut off straight, and the tornus approaching a right angle; hind border or dorsum slightly excavated. Dark spot somewhat larger than is usual in *Ps. mimica*, less definite in shape, and brownish instead of black.

Abdomen pale brownish, with darker markings, somewhat narrowed basally (apparently much shrunken), enlarged anally. *Appendages* (Plate lxxvii., fig.8) consisting of a pair of superior and a pair of inferior, triangular, valve-like laminæ, partly embracing the terminal segment, but with their apices not meeting together in the middle line.

Type, ♂, in Coll. Tillyard.

Hab.—Booyong, N.S.W , Nov. 1904 (S. W. Jackson). There is also a very damaged specimen in the Queensland Museum, Brisbane, from Mount Tambourine.

This very delicate and graceful species is easily distinguished from all the known species except *Ps. mimica;* the differences which separate it from this latter species have been emphasised in the key and in the description given above.

PSYCHOPSIS ELEGANS (Guérin). (Text-figs.1-3).

Arteriopteryx elegans Guérin, Iconographie du Règne Animal, 1845, iii., p 389. Navás, Congr. Valladolid, 1916, p.193.

Zygophlebius verrauxinus Navás, Broteria Braga, 1910, p.84, fig.23.

Psychopsis mimica Froggatt, These Proceedings, 1902, xxvii., p.367.

Psychopsis newmani Froggatt, These Proceedings, 1903, p.454, Pl. xxi., figs.1-2. Navás, Congr. Valladolid, 1915, p.191.

Type, in Paris Museum.

Hab—Eastern coast of Australia, from Sydney to North Queensland (Cairns, Kuranda, Herberton).

This species is occasionally taken at light, or beaten from bushes, but was considered quite a rarity until Mr. Luke Gallard, of Epping, N.S.W., discovered the larva. Since then, he has succeeded in breeding a number from larvæ found around Epping, and I have bred out nearly two dozen from larvæ taken in various localities, including Hornsby and Berowra, in the Sydney district, Wauchope on the North Coast of New South Wales, Brisbane, Stradbroke Is., Caloundra, Caboolture, Landsborough and Mount Tambourine, in Queensland Mr. F. P. Dodd has taken the insect at Kuranda and Herberton, N. Queensland.

From larvæ taken on One-tree Hill, Brisbane, under the bark of an Ironbark tree (*Eucalyptus leucoxylon* F.v.M.), I bred both *Ps. elegans* and *Ps. cœlivagus*. There is so little difference between the two larvæ, except in size, that I was not able to distinguish which was which. This seems to me to be a further argument against removing *Ps. cœlivagus* from the genus *Psychopsis*.

PSYCHOPSIS CŒLIVAGUS (Walker).

Hemerobius cœlivagus Walker, Cat. Neuroptera Brit. Mus., 1853, p.279.

Psychopsis cœlivagus Froggatt, These Proceedings, 1903, xxviii., p.455, Pl. xxi., fig.8 (nec Froggatt, *l.c.*, 1902, xxvii., p.368).

Wernzia cœlivaga Navás, Mem. R. Acad. Ci. Art., Barcelona, 1912, x., p.195. Navás, Congr. Valladolid, 1916, p.194.

Type, in British Museum.

Hab.—Queensland coast, from Brisbane to Kuranda and Herberton. A rare species.

This exceedingly striking species is at once distinguished by the remarkable metallic black markings of the forewings, as well as by the pure whiteness of the venation, which gives it a most striking appearance. Some years ago, it was not uncommon on One-tree Hill, Brisbane; but recent severe bush-fires seem almost to have exterminated it.

PSYCHOPSIS INSOLENS McLachlan.

McLachlan, Journ. Entomology, 1866, ii., p.114.

Psychopsis cœlivaga Froggatt, These Proceedings, 1902, xxvii , p.367.

Psychopsis insolens Froggatt, *l.c.*, 1902, xxvii., p.367; Froggatt, *l.c.*, 1903, xxvii., p.454, f.6.

Magallanes insolens Navás, Mem. R. Acad. Ci. Art., Barcelona, 1912, x., p.197. Navás, Congr. Valladolid, 1916, p.196.

Type, in British Museum.

Hab.—New South Wales and Queensland; not uncommon. It occurs only sparingly in the Sydney district, but is commoner on the tablelands, particularly on the Queensland border. I have good series from Killarney, also from Mount Tambourine. It has been taken as far north as Herberton (F. P. Dodd). Most of the specimens appear to have been taken at light. Nothing is known of its life-history.

This species is less beautiful than any of the others, but freshly emerged specimens are of a very effective fawn-colour, which fades considerably with age.

PSYCHOPSIS MEYRICKI McLachlan.

McLachlan, Ent. Mo. Mag., 1887, xxiv., p.30.

Magallanes meyricki Navás, Congr. Valladolid, 1915, p.197.

Type, in Coll. McLachlan.

Hab.—Jindabyne, N.S.W., 2,800 feet.

I have not seen this species, of which the unique series of seven specimens taken by Mr. Meyrick on Jan. 20th, 1885, is in the McLachlan Collection. McLachlan gave the habitat as "Kosciusko, 2,800 feet," but this is evidently an error. Mr. Meyrick informs me (*in litt.*) that the specimens were actually taken near Mr. Body's Station at Jindabyne. This latter township is on the main route to Mount Kosciusko, but more than thirty miles from its summit; the Kosciusko Range does not begin to rise from the Monaro Plateau until the junction of the Snowy and Thredbo Rivers is reached, and this is some miles beyond Jindabyne. It seems desirable to point this out, since the type of country in which the insect was taken differs very greatly from that found at higher elevations on the Kosciusko Range.

PSYCHOPSELLA, n.g. (Plate lxxviii., fig.11).

Characters as given in the key on p.771. Small insects, with an expanse of about an inch; the hindwings very much shorter than the fore.

Genotype, *Psychopsella gallardi*, n.sp.

PSYCHOPSELLA GALLARDI, n.sp. (Plate lxxviii., fig.11).

♂. Unique. *Total length*, 7·8 mm.; *abdomen*, 5 mm.; *forewing*, 12·5 mm.; *hindwing*, 9·5 mm.; *expanse*, 24·5 mm.

Head 1·3 mm. wide, pale ochreous; *eyes* dark grey; *antennæ* dull brownish, very short, 1·8 mm.

Thorax: *prothorax* pale ochreous. *Pterothorax* dull brownish, with darker markings. *Legs* very short, with pale ochreous femora, slightly darker tibiæ and tarsi.

Wings: *forewing* with discal and internal gradate series complete, the former consisting of fifteen cross-veins, the latter of nine. Costal series of cross-veins rudimentary, consisting of only about six cross-veins near base, and a single one about halfway along the costal area; marginal series absent. Colouration a very pale ochreous, tesselated all over with slightly darker markings, and here and there small dark brown patches; of these, the most prominent are three sets along the vena triplica, another just beyond the anastomosis, one near the middle of the discal series, two in the marginal area, and some irregular dark markings along Cu. *Hindwing* with short discal and internal gradate series, not complete, the former of six or seven cross-veins, the latter of only four; no marginal series, and only one or two costal cross-veins near base. *No markings at all upon the hindwing*, which is dull whitish and quite transparent.

Abdomen pale ochreous, prettily marked with a mid-dorsal series of dark spots and smaller lateral spots on each segment. *Appendages*: *superior*, a pair of very conspicuous, depressed, subtriangular processes, laterally flattened, and appearing somewhat forcipate from above; these project well beyond the tip of the abdomen; each one has its apex rounded, and carries near its base, on the outer side, a raised embossment; the whole of the appendage above the embossment, and outwards to the tip, carries long, curved, whitish hairs. Ventrally, these appendages are separated by a broad, short, trapezoidal *inferior appendage*, whitish in colour (Plate lxxvii., fig.9).

Type, in Coll. Tillyard.

Hab.—The specimen carries no label; but Mr. Gallard, from whom I obtained it, informs me that he bred it from a larva found near Gosford, N.S.W.

At first sight, this species appears to resemble a small specimen of *Ps. insolens*. It may readily be separated from the latter species by the much more delicate build, the much shorter and narrower hindwings, with any markings on them, and the more delicate, paler, narrower, and less strongly marked forewings.

Relationships of the *Psychopsidæ*.

There can be little doubt that the nearest relatives of the *Psychopsidæ* are to be found in the Mesozoic Fossil families *Prohemerobiidæ* and *Kalligrammatidæ*. The former, which very probable represent the original type of the Order Planipennia, are known from the Upper Trias of Ipswich, Queensland, and from the Lias and Upper Jurassic of Europe. The genus *Protopsychopsis* Tillyard, appears to connect the *Prohemerobiidæ* with the *Psychopsidæ* very closely. This relationship has since been further emphasised by the discovery of a second fossil from these beds, differing very little from *Megapsychops illidgei* itself. This fossil will shortly be described by me in Part 5 of my "Mesozoic Insects of Queensland." The differences between the *Psychopsidæ* and the *Prohemerobiidæ* are simply those in which the former family shows specialisation, viz., the enlargement of the costal area, with development of a series of connecting cross-veins, the formation of the vena triplica and anastomosis, and, very probably, the shortening of the antennæ. In all known *Prohemerobiidæ*, the costal space is either quite narrow, or only moderately wide, for its whole width, or only widened at the base; costal veins are never developed; Sc, R, and Rs run close together, but quite separate, to the apex of the wing, without being partially strengthened and separated off to form a vena triplica, as in *Psychopsidæ*; cross-veins appear to be entirely absent from most species, but may be very weakly indicated between Sc, R, and Rs, and also in the position of the gradate series (these, though shown in my figure of *Protopsychopsis*, are so faintly indicated, that I have been doubtful how far they really existed). The oldest forms of *Prohemerobiidæ* were only of small to moderate size, with only moderately numerous branches of Rs; specialisations in this family appear to have led to the development of forms with an immense number of closely-set branches of Rs. The Upper Jurassic forms are, on the whole, considerably larger than the Liassic forms.

As regards the *Kalligrammatidæ*, these gigantic insects differ from the *Prohemerobiidæ* only in the development of a close series of connecting cross-veins all over the disc; in the beginning of an anastomosis, by connection of Sc with R distally by means of a short cross-vein, very much as in *Psychopsis*; and in the development of the large eye-spots on the wings, recalling those of *Megapsychops illidgei*. The rise and fall of this wonderful family was probably very quick; for, if their larvæ, as is probable, were at all like those of *Psychopsis*, they could scarcely have attained to dominance before the rise of the Birds must have quickly exterminated them.

Here let it be noted that *Megapsychops illidgei* shows, in the possession of a media with more than two branches, a character that was evidently possessed by the *Kalligrammatidæ* (the true M of this family is labelled Cu by Handlirsch), and by certain of the Liassic *Prohemerobiidæ*, if not by all. Combining this fact with another obvious one, viz., that the development of numerous branches of Rs, occupying a very large area of the wing, is a specialisation confined to the Planipennia, and must, of necessity, have caused a squeezing out and consequent reduction of the media, we are bound to conclude that the ancestors of the Planipennia approached more closely to the Panorpoid type, as regards the structure of Rs and M, than they do to-day, and that the many-branched media of *Megapsychops illidgei* is an archaic survival that stands to remind us of this fact.

I regard the *Psychopsidæ* as a Mesozoic remnant, considerably isolated, at the present day, from all other existing families. In order to understand their position, it must be emphasised that they have closest affinity with those groups in which the cross-venation is limited to gradate series, and Sc is not united with R in a *true* anastomosis (*i.e.*, by actual fusion of the two main veins). Thus they show affinity, on the one hand, with the *Hemerobiidæ* (s.str.) and *Dilaridæ*, but remain more primitive than either of these, on account of the single radial sector of the forewing; while, on the other hand, they are related to the *Trichomatidæ*, *Apochrysidæ*, and *Chrysopidæ*. The *Trichomatidæ*, like the *Psychopsidæ*, appear to be a direct offshoot of the old *Prohemerobiidæ*; but their tendency has been towards reduction and narrowing of the wings; whereas that of the *Psychopsidæ* has proceeded in the opposite direction. In the *Apochrysidæ*, we recognise a group of insects with certain characters of the wings strongly suggestive of Psychopsid affinities, viz., the widening of the costal area and the extreme differentiation of the disc. Bearing in mind, however, the slender build and elongated antennæ, and their evident close relationship with the *Chrysopidæ*, I am inclined to regard these venational characters as the result of convergence, rather than of true relationship. Both the *Apochrysidæ* and the *Chrysopidæ* differ radically from the *Psychopsidæ* in the manner of development of the branches of Rs, which tend to cross the wing transversely, and have thus brought about new tendencies in the development of the gradate series, and finally the unique formation of the pseudomedia and pseudocubitus.

The larval form of *Psychopsis* is such that, from it, there can be equally easily derived the small-jawed series of larvæ found in the *Hemerobiidæ*, *Chrysopidæ*, etc., or the long-jawed series of the *Berothidæ* and *Osmylidæ*, or the large-jawed series of the *Nymphidæ*, *Myrmeleontidæ*, etc. In the last series, there has been a gradual addition of internal teeth to the mandible, beginning with one only in *Nymphidæ*, and passing up to three or more in *Myrmeleontidæ*. Hence we shall probably be on safe ground, if we regard the larval type found in *Psychopsis* as closely similar to that of the extinct *Prohemerobiidæ*.

From the *Berothidæ* and *Osmylidæ*, the *Psychopsidæ* are at once distinguished by the lack of a true anastomosis between Sc and R. The *Berothidæ* are clearly a specialisation from the older *Trichomatidæ*, the *Osmylidæ* from a type resembling the still existing *Polystœchotes*, which, to my mind, will go well enough into the *Berothidæ* as at present defined. It should be noted that both palæontological and morphological evidence tends to show that the groups with numerous cross-veins in the disc are of more recent origin than those without; it is only by stressing this point that we can be sure of obtaining a correct view of the Phylogeny of the Planipennia, which are an essential portion of the Panorpoid Complex, and originated from more open-veined ancestors.

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Note.—This Bibliography is not intended to be a complete one, but only to list the papers actually mentioned in this work. The references to Australian species are, however, complete.

EXPLANATION OF PLATES LXXVI.-LXXVIII.

Plate lxxvi.

Megapsychops illidgei (Froggatt).

Fig.1.—Venation of forewing of large ♀ in Queensland Museum; (× about $2\frac{1}{2}$).

Fig.2.—Large ♀ in Queensland Museum; (× about $1\frac{1}{2}$).

Fig.3.—Venation of hindwing of same specimen; (× about $2\frac{3}{4}$).

(Photomicrographs of figs.1 and 3 taken by Mr. H. Hacker, Entomologist to the Queensland Museum, and sent by Mr. H. Longman, F.L.S., Director of the Queensland Museum. That of fig.2 sent by Dr. R. Hamlyn Harris, late Director of the same Institution).

Plate lxxvii.

Megasychops illidgei (Froggatt).

Fig.4.—Complete venation of both wings of small ♂ in Coll. Tillyard; (× 4). (Compare with Plate lxxvi., and contrast with Text.fig.1: *tn*, tornus: venational notation as in Text-fig.1).

Fig.5.—Appendages of the same ♂, postero-dorsal view; (× 11½).

Fig.6—The same insect, alive, resting upon a flat surface. Dorsal view; (× 1½).

Fig.7.—The same insect, alive, resting upon a twig. Lateral view; (× 1½).

Psychopsis gracilis, n.sp.

Fig.8.—Appendages of ♂. Postero-dorsal view; (× 11½).

Psychopsella gallardi, n.g. et sp.

Fig.9.—Appendages of ♂. Postero-dorsal view; (× 27).

(Figs. 6-7 drawn from pencil-sketches sent by Miss M. Davidson, of Cedar Cottage, Mount Tambourine, Q. The dark colouration is a rich brown, and resembles a fairly thick layer of varnish. In fig.4, the dotted double-arc indicates the external raised edge of the large embossment in the forewing; the dotted oval represents the area covered by the dark spot in the hindwing. In fig.7, the abdomen of the insect is slightly visible through the semitransparent wings).

Plate lxxviii.

Fig.10.—*Psychopsis gracilis*, n.sp., ♂, in Coll. Tillyard; (× 4).

Fig.11.—*Psychopsella gallardi*, n.g. et sp. Unique ♂ in Coll. Tillyard; (× 6).

STUDIES IN AUSTRALIAN *NEUROPTERA*.

No.7. The Life-History of *Psychopsis elegans* (Guérin).

By R. J. Tillyard, M.A., D.Sc., F.L.S., F.E.S., Linnean Macleay Fellow of the Society in Zoology.

(Plate lxxix., and twelve Text-figures).

The only account of the life-history of any species of the family *Psychopsidæ* is the short, popular account of the life-history of *Psychopsis elegans* Guérin, given by Mr. Luke Gallard in the "Australian Naturalist" of 1914.* From this we learn that Mr. Gallard captured a female of *Ps. elegans* (he uses the synonym *newmani* Froggatt, throughout, for this species) at Kenthurst, N.S.W., in 1904. This insect laid over fifty eggs, some of which Mr. Gallard raised to about one-third of the full larval size. Mr. Gallard informs me that it was one of these specimens, newly hatched, which is figured on p.62 of Mr. Froggatt's "Australian Insects" as the larva of *Psychopsis mimica* Newman.

Mr. Gallard did not succeed in rearing the imago until 1911. A larva taken in March, 1911, by Mr. J. Blake, of Narara, near Gosford, N.S.W., was kept alive by Mr. Gallard until December 11th of the same year, when it spun a cocoon in the box, the imago emerging on January 16th, 1912. Since then, Mr. Gallard has discovered the larvæ in many localities round Sydney, and has bred a number of specimens.

In 1915, when I had begun the study of the Neuroptera Planipennia, and was very anxious to study the *Psychopsidæ* in particular, Mr. Gallard very generously invited me to accompany him in the field, and showed me the ingenious ways by which he found these larvæ. I shall never forget the skill and energy that he displayed in this work. As the whole credit for the discovery of this larva rests with him, and is simply due to his

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* "Notes on *Psychopsis newmani*." By Luke Gallard, Australian Naturalist, iii., Part 3, 1914, pp.29-32.

persistence and keenness in following up clue after clue for many years, I should like to take this opportunity of congratulating him upon the fine results of his work, and of thanking him very heartily for the help offered to me, without which I feel quite certain that neither I nor anyone else could possibly have hit upon the track of such a remarkable larval form as this.

Since Mr. Gallard first taught me how to find this larva, I have discovered it in many localities around Sydney, also near Wauchope on the North Coast of N.S.W., and in many places in S. Queensland, including Brisbane (One-Tree Hill), Stradbroke Island, Mount Tambourine, Caboolture, Caloundra, and Landsborough. It probably occurs all along the Eastern Coastline of New South Wales and Queensland, wherever there are suitable rough-barked, Myrtaceous trees for the larva to hide in.

In the present paper, I propose to give a full description of the egg, larva, and pupa, together with an account of the habits of the larva, the spinning of the cocoon, the emergence of the imago, and some details about the latter that have not yet been carefully investigated.

My thanks are due to my wife for the execution of Plate lxxix., from the living larva and pupa, in collaboration with myself.

The Life-cycle of Psychopsis elegans (Guérin).

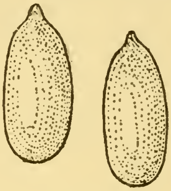
The complete life-cycle of this species occupies about two years. The larva, like almost all others of this Order, has only three instars, during each of which an enormous increase occurs in the size of the body, the size of the head remaining constant in the meanwhile. The following Table exhibits the duration of each period :—

Period.	Duration.
Egg	About twelve days.
First larval instar ..	About eight months, including hibernation. (Feb.-Sept.).
Second larval instar ...	From four to five months, without hibernation. (Sept.-Feb. or March).
Third larval instar ...	About nine months, including a second hibernation, and a fortnight to three weeks within the cocoon before pupation. (March-Nov.).
Pupa	About three weeks.
Imago	About two months. (Dec.-Feb.)

The Egg. (Plate lxxix., fig.1; Text-fig.1).

The eggs are laid separately, or only two or three together, at considerable intervals of time; probably, in the natural state, upon the bark of Myrtaceous trees, especially Eucalypts. In captivity, most of the eggs were laid upon cotton-wool. They are not stalked, and are laid upon one side, which is attached to some object by a slight secretion of gelatinous matter.

The egg itself is oval, about 1 mm. long by 0·45 mm. wide in the middle, and is of a semi-opaque creamy colour, tinged with pale green. At its anterior end there is a distinct micropylar projection, as shown in Text-fig. 1. The egg is quite smooth, without any pattern or sculpture.



Text-fig. 1.*

The eggs are usually laid in January or February. At the end of about twelve days, they hatch. The young larvæ, hitherto curled up inside, crawl straight out of the broken shell, and at once make for some small crack or crevice in the bark, where they may escape the numerous enemies that would otherwise speedily compass their destruction.

First Larval Instar. (Plate lxxix., figs.2-3; Text-fig.2).

The newly-hatched larva is somewhat more than three times as long as the egg in which it was confined, the measurement being taken from the tip of the mandible to the anal papilla. As with all Planipennia, such a comparatively large larva can only be contained within the egg by considerable folding of parts; the head being tucked down below the breast, and the posterior half of the abdomen being again folded forwards under the head.

At first, before the larva has taken any food, the head is very large in comparison with the rest of the body. But, after one or two large meals, the abdomen begins to be distended with food, and the general appearance of the larva undergoes a great alteration, as can be seen by comparing Plate lxxix., figs. 2 and 3. This change takes place in every instar of all Neuropterous larvæ

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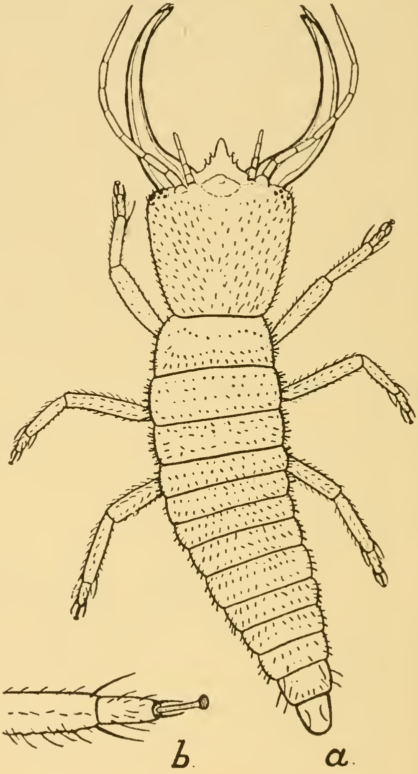
* Two eggs of *Psychopsis elegans* (Guér.); (×20).

known to me. The reasons for it are two; firstly, that there are only three or four larval instars in this Order; and, secondly, that no food at all is excreted, the waste-products being stored in a special sac or chamber of the alimentary canal, which is not cast out until the emergence of the imago. Hence it is clear that a large increase in the size of the abdomen is inevitable during each larval instar, whereas the size of the head can only be increased at ecdysis.



Text-fig.2.*

The head of the young larva is somewhat flattened, trapezium-shaped, and wider in front than behind; length about 0·6 mm., breadth in front about the same. At the two anterior angles, which are somewhat rounded, are the two groups of simple eyes, occupying the area from which the compound eyes of the pupa and imago are later developed. There are five ocelli in each group. The anterior border of the head projects in the middle to form the prominent triangular *labrum*, on either side of which lie the long, slender *antennæ*, which are eight-jointed. The mouth-parts are very extraordinary, consisting of a pair of

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* Newly-hatched larva of *Ps. elegans* (Guér.); (×30): *b*, part of hind leg of same, to show tarsal claws and empodium, the latter in the form of an elongated process terminating in a sucking-disc; (×87).

enormous caliper-like mandibles, 0·7 mm. long, a similar but slenderer pair of maxillæ without palpi, and a small triangular labium carrying a pair of four-jointed palpi. There are no teeth on the mandibles.

The segments of the thorax are slightly narrower than the head, and subequal, the prothorax being the longer, but somewhat the narrower. The legs are short, the femora being fairly stout, the tibiæ shorter and slenderer, and the tarsi very short and unjointed. Distally, the tibiæ are armed with a pair of strong spurs. The tarsi end in a pair of short, strong claws, between which there projects a long, slender empodium, ending in an enlarged suction-disc, and closely resembling the same structure in the larva of *Chrysopidæ*. The larva is able to crawl forward slowly, but prefers to walk backwards, which it can do with considerable speed, using its anal papilla as well as its legs.

The segments of the abdomen are nine in number, together with a terminal anal papilla, which represents the reduced tenth segment and the anal appendages. These segments are narrow, and taper from before backwards. The whole of the abdomen, as well as the head and thorax, is clothed with short, stiff hairs.

The spiracles in the newly-hatched larva are eighteen in number, there being a pair upon the prothorax, and also upon each of the first eight abdominal segments. They are, however, very difficult to make out, the spiracular openings being small and devoid of armature.

When first hatched, the larva is semi-transparent, with very little colour-pattern. Later it darkens to a greyish-brown, which tends to become overlaid with a whitish pruinescence. These changes become more marked in the following instars.

At the end of the first instar, the larva has about doubled its length, and the segments of the thorax and abdomen have increased greatly in width and length, so that the head now appears very small in comparison.

As soon as the cold weather sets in, in May or June, the larva ceases to feed, and remains motionless, hiding away in a crevice of the bark, until the warmer weather begins in September. It then becomes active again; but, after one or two good meals, it again rests for some days, and then undergoes its first ecdysis. This appears to be fatal to many of the larvæ, chiefly owing to the great difficulty experienced in removing the head from the very hard shell of the cuticle enclosing it.

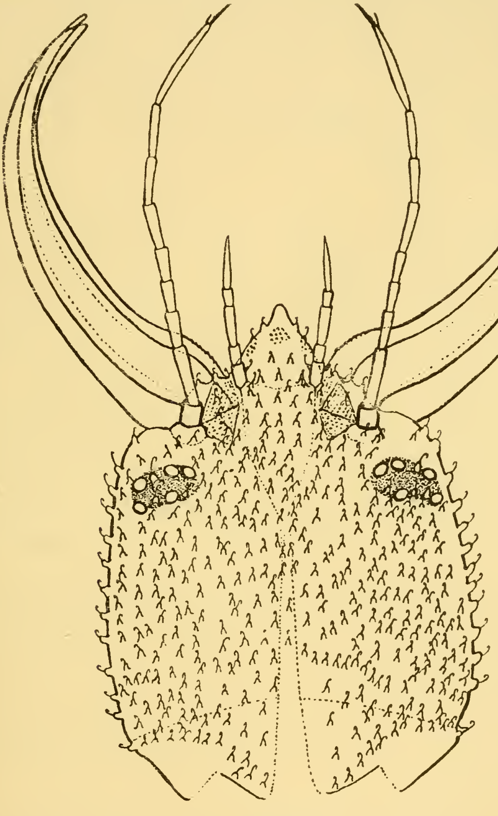
Second Larval Instar. (Plate lxxix., fig.4; Text-fig.3).

At the first ecdysis, there is a great increase in the size of the head of the larva, which now becomes about 1·4 mm. long in an average-sized larva. (There is considerable variation in the sizes of individual specimens, and this is not rectified in the imagines, which also vary greatly in size). The head becomes more definitely trapezium-shaped than before, owing to the increased definiteness of the four angles; its colour is a rich brown. An extra joint is added to the antennæ, which are now nine-jointed, and to the labial palps, which become five-jointed. The mandibles and maxillæ are almost as long as the head, shaped as in the first instar, but of stronger build. The ocelli become more plainly marked, each set of five being placed upon an irregular darkened area just behind the base of the antenna.

Text-fig.3 shows the cast skin of the head of the larva at the end of this instar. The armature of the head is very remarkable, consisting of numerous raised papillæ, from each of which a tiny hooked hair projects; these are especially conspicuous upon the sides of the head, and upon the projecting triangular labrum. The figure shows very plainly the mid-dorsal and lateral splits which take place in the cuticle at ecdysis.

As at hatching, so also at the beginning of the second instar, the three thoracic segments are approximately equal in size, the prothorax being somewhat longer and narrower than the other two. After a meal, the meso- and metathorax swell up, like the abdomen. But the prothorax can only swell up posteriorly, the neck-constriction remaining unchanged; so that this segment soon becomes much narrower than the other two. The legs remain small, and formed as in the first instar, with unjointed tarsi.

The abdomen is at first fairly slender and tapering towards the anus. As the larva feeds, it swells up rapidly, and assumes the somewhat broad, flattened shape shown in Plate lxxix., fig.4. A slight pattern becomes noticeable upon the abdomen and thorax, more markedly in some individuals than in others. This is mainly due to the onset of pruinescence, which leaves the original dull brownish colour of the body more definitely marked mid-dorsally and in the sutures. A pair of darkish spots can be made out on the meso- and metathorax, marking the positions of the *pinacula* of these segments (see p.800).



Text-fig.3.

Cast skin of head of larva of *Ps. elegans* (Guér.), at second ecdysis; (× 30).

At the end of the second instar, the larva has increased to about 8 mm. in length, and is very stout. As this instar has been passed entirely in the summer-months, with an abundance of food and warmth, growth is comparatively rapid, and the second ecdysis usually takes place during February or March of the second year of larval life. This ecdysis does not appear to be such a crisis in the life of the larva as was the first one; possibly because the larvæ are more active in the warm weather, and make greater efforts to free themselves from the hard cuticle of the head, which is again the principal cause of any mortality that occurs at this period.

Third Larval Instar. (Plate lxxix., fig.5; Text-figs.4-9).

As before, this second ecdysis results in a great increase of the size of the head, which broadens considerably, becoming squarish, as shown in Plate lxxix., fig.5. The increase in length is only a moderate amount, but in breadth it is more than 50 per cent. of the width at the end of the second instar. The labrum broadens with the head, and loses its triangular shape, as may be seen by comparing Text-figs. 3 and 5. The antennæ sometimes become ten-jointed, but I have only been able to count nine in several specimens. The labial palps remain five-jointed, and there is no change in the shape of mandibles or maxillæ.

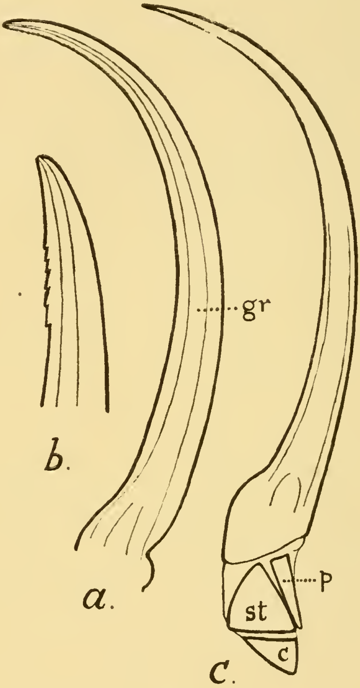
Thorax, legs, and abdomen remain of the same shape as in the second instar. The pattern varies greatly for different individuals, some being brown all over, others brown with grey pruinescence, and others entirely grey, or almost white, and strongly pruinescent all over. The head usually remains a rich dark brown; but I have seen specimens with strong pruinescence upon the head also.

During March and April of its second year of existence, the larva feeds up rapidly, and many specimens become apparently full-fed by the time winter sets in. None, however, attempt to spin up, but remain dormant in crevices of the bark until the warmer weather of the Spring returns. During this second hibernation, great mortality occurs, many larvæ being attacked by some obscure fungoid disease, and others apparently dying of cold. Out of thirty larvæ brought from Wauchope, N.S.W., in February, 1917, I succeeded in rearing only six to maturity.

Before describing the spinning of the cocoon, we may profitably study, somewhat more minutely, certain of the larval structures. as they are to be seen at the end of the third instar.

The Mandibles (Text-fig.4, *a*, *b*) are a pair of huge curved jaws, immensely strong, and of a rich dark brown colour. They are smooth in outline, and without visible teeth; but an examination under a higher power will show the presence of about six small, backwardly directed serrations on the inner edge, close up to the tip, as in Text-fig.4, *b*. These undoubtedly help in preventing the escape of the prey, when once it has been pierced by these powerful jaws. On the ventral side of each mandible, there is a very definite groove (*gr*) which receives the maxilla, lying directly below it. The length of the mandible is 2·7 mm.

The Maxillæ (Text-fig.4,*c*) are not unlike the mandibles in size and shape, but are slenderer, and slightly more curved towards the tip. They are entirely devoid of armature, except for their very sharp points. Each maxilla carries a very faint groove upon its dorsal surface, a little wider than the groove



Text-fig.4.*

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[*] *a*, Mandible of larva of *Psychopsis elegans* (Guér.), third instar; (× 30). *b*, Tip of same, to show the series of fine serrations; (× 87). *c*, Maxilla of same; *c*, cardo; *p*, palpiger; *st*, stipes; (× 30).

of the mandible. In the living larva, the maxillæ may be seen at times playing freely forwards and backwards beneath the mandibles; so that it is evident that they have considerable freedom of movement, in spite of being designed to act as a pair of complete sucking-tubes in conjunction with these latter.

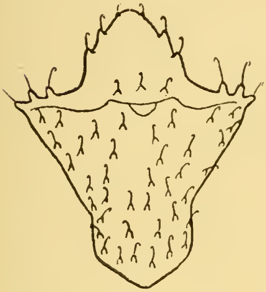
Whereas the groove in the mandible can be followed with ease right up to the tip, that of the maxilla cannot be so followed, and is evidently of a much more imperfect nature. Hence the complete sucking-tube must be formed at least partly by pressure of the two pairs of jaws, one upon the other, and not by a close interlocking of parts. I have frequently seen the tips of the maxillæ pushed a considerable distance forward beyond the tips of the mandibles; this could scarcely happen unless the fit of the maxilla upon the ventral surface of the mandible were a somewhat loose one, seeing that the calibre of the groove varies greatly from base to tip.

When the maxilla is dissected out, it is seen to be considerably swollen near the base, and to carry, below the swollen part, three flat, chitinised plates, two of which are broadly triangular, the third very narrow. These are placed in the positions of *cardo*, *stipes*, and *palpiger* of a normal maxilla, and appear to represent those three sclerites. As regards the elongated spear that forms the principal part of the maxilla, this would appear to be the galea. But, unless the transformation of these parts, from their abnormal form in the larva to their normal form in the pupa, can be followed out at metamorphosis, in such a way that there can be no doubt upon the matter, I do not think that we can be sure of their homologies.

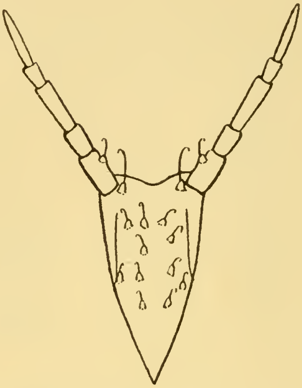
The Labrum and Clypeus (Text-fig.5). These together form one piece in the larva, indistinctly divided transversely, as shown in the figure. The clypeus is covered with the usual hooked hairs, set upon raised papillæ The labrum is a strongly projecting curved lobe, carrying only three rather large hooked hairs on either side.

The Labium (Text-fig.6). This consists of an undivided triangular basal portion, from the two anterior angles of which project the five-jointed palpi. The basal joint of each palp carries a single hooked hair on its inner side, and there is a larger one situated just below it. Five or six smaller hooked hairs are situated on either side of the middle line, upon the basal portion of the labium.

This basal portion of the labium remains undivided throughout all stages in *Psychopsis*, and probably represents both mentum and submentum combined.



Text-fig.5.*



Text-fig.6.†

The Body-Armature (Text-figs. 7, 8). We have already described the peculiar hooked hairs, set upon raised papillæ, which are found upon the head of the larva. They also occur upon the hard tergal plate of the prothorax, which is formed of tough, dark brown chitin, like that of the head. Upon the rest of the thorax, and upon the abdomen, these hairs are almost entirely replaced by more highly specialised structures, which I shall call *dolichasters* (Greek δολιχός, long; and ἀστήρ, a star). The dolichaster is a more or less elongated, hollow, chitinous structure, set upon a definite papilla; it is very narrow at the base, but expands distad in narrow pyramidal form, and ends distally in from four to nine sharply projecting points, which pass beyond the general periphery of the enclosing chitinous membrane.

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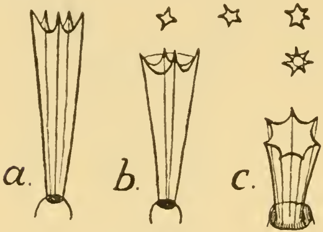
* Labrum and clypeus of larva of *Ps. elegans* (Guér.), third instar; (×30).

† Labium of larva of *Ps. elegans* (Guér.), third instar; (×30).

Viewed end on, it is more or less star-shaped, being in the form of a fairly regular polygon with concave sides. Typical dolichasters are shown in Text-fig. 7, *a*, *b*, and *c*. These structures are very abundant all over the abdomen and thorax, excepting upon the hard tergal plate of the prothorax, on which only an occasional one can be seen.

The dolichaster is clearly a specialisation from a normal hollow sensory hair or macrotrichion. This may be proved by a study of the eighth and ninth segments of the larva. On the ninth segment, the macrotrichia are of normal form. On the eighth, there are a few of normal form, but most of them are slightly thickened and blunted at the tips, and a few can be seen having the projecting distal points or angles of the true dolichaster-form. On the seventh, the dolichaster-form is fully established, but remains very elongated, for the most part. On the rest of the abdomen, all stages from a very narrow, elongated dolichaster with only four or five rays, to a shorter and stouter dolichaster with from seven to nine rays, can be easily followed.



Text-fig.7.*

Dolichasters vary from 40 to over 100μ in length, and from about 20 to 30μ in extreme width distally.

We may compare the dolichaster with the *bulla*, such as is found in the larva of *Micropteryx* (Order Lepidoptera). In the bulla, the macrotrichial chitin becomes very soft, and the internal cavity is enlarged so that the hair expands into the form of a soft, swollen bulb. Weak longitudinal supporting rays are, however, present, as may be seen by a careful examination of the bulla under a high power. Moreover, when the bulla is viewed end on, it, too, like the dolichaster, exhibits the star-shaped

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* Dolichasters from integument of larva of *Ps. elegans* (Guér.), third instar; (× 330). *a*, Long, five-rayed form; *b*, four-rayed form; *c*, shorter, seven-rayed form. Above *b* and *c* are shown four examples of micrasters, also × 330.

distal end, though the periphery of the soft chitinous bulb, in this case, projects out well beyond the outline of the star. Thus the bulla is a higher specialisation from the original macrotrichion than is the dolichaster, and can be developed from the latter by further softening of the chitin forming it, and further swelling up of the internal cavity.

The *dolichaster* may also be compared very closely with a typical *scale*, such as is found upon the bodies of Collembola, or upon the wings of Lepidoptera. If the dolichaster were to become flattened down upon itself symmetrically from the side, it would differ very little from a scale; the longitudinal edges or rays would become the longitudinal striæ of the scale, and the sharp distal points of the dolichaster would remain as a series of distally projecting angles, such as are very commonly found in a large number of Lepidopterous scales, particularly amongst the Heteroneura.

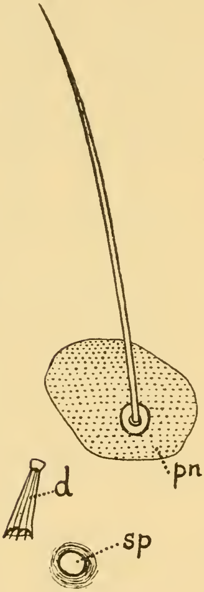
Besides the dolichasters, the body of the larva in *Psychopsis* carries, in a number of places where the chitin is very soft, an immense number of minute, star-shaped structures, which I shall call *micrasters* (Greek μικρός, small; and ἀστήρ). Where they occur, they are developed from every single hypoderm-cell in the neighbourhood, and are thus many times more numerous than the dolichasters of the same region. The micraster is a minute, sessile, flattened star, not set upon any definite papilla, and raised but little above the general surface of the integument. Text-fig.7 shows a set of four micrasters with four, five, six, and seven rays or points respectively.

The micrasters vary from 1 to 3μ in height, and from 8 to 12μ in extreme width. Thus they are always smaller than the basal papillæ of the dolichasters, which range from 12 to over 20μ in width.

It can be easily seen that the micraster is simply a specialisation of the minute microtrichia which occur normally upon many parts of the body of an insect, especially in the sutures and other places where the chitin is soft, in the form of tiny hooked hairs. A search over the larval integument of *Psychopsis* shows that, for the most part, these microtrichia are only feebly developed, as minute processes flattened down close to the integument itself. In other places, they can be seen to be divided into two short processes at an obtuse angle to one another. From this form, the transition to a four-rayed micraster is quite a simple one. As microtrichia are developed from every single unspecialised hypoderm-cell, in the regions in which they occur, it follows that the same will be true of the micrasters in any given region, as we find to be the case here.

Pinacula, or small plates of hardened brown chitin, carrying one or more hairs or setæ, occur upon the meso- and metathorax, and also upon the sixth to eighth abdominal segments. Each segment mentioned has a single pair of pinacula placed more or less dorso-laterally.

The simplest pinacula are those of the abdomen, of which one is shown in Text-fig. 8, together with its corresponding spiracle. It is a somewhat irregular oval patch, which carries a single excessively elongated and slender hair, quite unlike any other hair to be seen in this larva, and about one-third of a millimetre long. The two pinacula of the eighth segment are placed rather close together, on either side of the mid-dorsal line. Those of the seventh segment are placed further apart. Those of the sixth are much smaller, and still further apart. Sometimes a vestige of a similar pinaculum may be observed upon the fifth segment also, in good chitin-preparations.



Text-fig. 8.*

The pinacula of the meso- and metathorax are much larger and darker areas, whose position has been already indicated in

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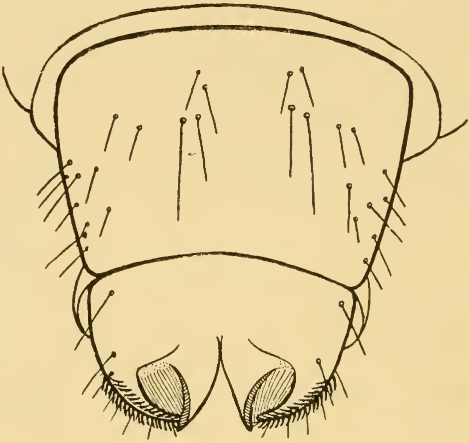
* Details from the integument of seventh abdominal segment of larva of *Ps. elegans* (Guér.), third instar. *d*, A dolichaster; *pn*, pinaculum with long, slender macrotrichion; *sp*, spiracle, in situ; (× 167). Three other dolichasters surrounding the spiracle are omitted.

describing the colour-pattern on p.793, since they occupy the darkish spots there mentioned, and shown in Plate lxxix., figs.4, 5. Each pinaculum carries from two to four dolichasters, and a single small seta upon a raised papilla. In specially good preparations, I have seen the blind ending of a small trachea upon the integument close to the pinaculum; this would appear to indicate the original position of the meso- or metathoracic spiracle, which has evidently become suppressed.

The Spiracles.—In all three larval instars, the number of functional spiracles is eighteen, viz., a pair upon the prothorax, and a pair upon each of the first eight abdominal segments. They are all very small, simple openings, the rim of which is slightly strengthened and darkened. As far as I can see, they are quite devoid of armature or ornamentation of any sort. A single trachea, whose calibre is approximately equal to that of the spiracle itself, passes inwards from it to the main tracheal trunk on each side. The prothoracic spiracles are the largest pair; next in size are those of the eighth segment, with those of the seventh, sixth, etc., in descending order of magnitude up to the first. Text-fig.8, *sp.*, shows one of the spiracles of the seventh segment *in situ*, with its corresponding pinaculum (all but one of the surrounding dolichasters removed). Owing to the great number of these latter, it is always difficult to locate the spiracles in this larva.

The Anal Papilla (Text-fig.9).—The last two segments of the abdomen, viz., the ninth and tenth, are much narrower than the rest, and are more or less retractile within the eighth. They do not carry dolichasters, but only very delicate, slender macrotrichia of reduced size. The tenth segment forms the *anal papilla* or *sucker*, by means of which the larva is enabled to move rapidly backwards, or to hold on tight when attacking its prey. This segment is furnished with a pair of dorso-lateral curved processes, probably representing the original cerci, and a pair of ventral processes, somewhat cornute in shape, and curving outwards to meet the incurving tips of the dorsal processes. These latter are armed with two series of closely set, short, sharp setæ, one set directed outwards and the other inwards. I have found it impossible to observe how these organs are used by the larva; but the result is certainly to give it a very powerful grasp upon anything that they grip, and the whole papilla appears to act as forcefully as a true sucker. Whether there is, besides the actual grasping effected by these appendages, any sucking action performed by the tenth segment, I cannot say. Remembering that the silk for the cocoon is spun from the anus, it seems possible that an exudation of the same nature may help in the action of the anal papilla as a grasping or sucking organ.



Text-fig. 9.
Anal papilla of larva of *Ps. elegans* (Guér.), third instar; ventral view; (×87).

Habits of the Larva.

In order to discover the larva in its natural haunts, it is necessary to provide oneself with a stout, wide-bladed chisel, or some other instrument that will act as a lever for removing the bark of Myrtaceous trees. The ordinary methods of bark-collecting, as practised by Coleopterists, are useless in this case. All old trees, in which the bark is hanging in shreds or long strips, or is dry and attacked by white ants, are of no use in searching for *Psychopsis* larvæ. Instead, it is necessary to select healthy, medium-sized trees, in which the sap is running freely, and in which, consequently, the bark, when torn away, is found to be slightly moist inside. The best trees are those in which the bark is thick and rough, with many crevices, as in the case of the Ironbark (*Eucalyptus siderophloia* Benth.) and Bloodwood (*E. corymbosa* Sm.). Probably the Ironbark is one of the best trees of all for this larva; but it is so difficult to work, on account of the extreme toughness of its bark, that it is best to leave it alone, unless one sees a piece of bark that can be levered off without damage to one's tools. Around Sydney, one of the very best trees is the Bloodwood; but in Queensland, where the bark of this tree is thinner and more scaly, I met with little success in exploring it. Another excellent tree is the Forest Apple (*Angophora intermedia* DC.). Trees in which the bark comes away in long strips of considerable thickness, such as the Tallow-wood (*E. microcorys* F.v.M.), Turpentine (*Syncarpia laurifolia* Ten.), and Stringy-bark (*E. capitellata* Sm.), generally provide very good hunting also; but those with thin bark are useless.

In searching for the larva, of which, probably, not more than five or six at the most would be found on any given tree, even if all the bark were to be stripped from it, much time and trouble may be saved if one watches for likely places where the larva may be expected to hide. Such are, for instance, particularly thick or richly creviced portions of bark; and, above all, the cracks and crannies surrounding a gum-flow. Many insects come at night to taste this gum; and it is to be presumed that the *Psychopsis* larva takes up his station near by, with the special object of attacking these insects. On One Tree Hill, Brisbane, I noticed a rather small Ironbark-tree, in which there was a good gum-flow, caused by a small cut with an axe. By levering up the two tough projecting ends of the bark, above and below this cut, I secured four larvæ of *Ps. elegans* and two of *Ps. cœlivagus*—the best haul I ever obtained from a single tree.

When a piece of bark is removed, the *Psychopsis* larva will almost always be found upon the trunk of the tree, with its body flattened down, and quite motionless. Thus, the trunk and its exposed crevices should be examined first; then, if nothing is seen there, the piece of bark may be likewise examined, and sometimes yields a larva. Very soon the larva will begin to move rapidly backwards, feeling all the time, with its mobile anal papilla, for a suitable crevice in which to hide. If once it succeeds in reaching one, it will not be easy to secure it. Hence it should be picked up at once with the forceps, and transferred to a glass-tube, whose open end should be stopped up with cotton-wool. Not more than one larva must be put into one tube, unless each is separated from the next by a plug of cotton-wool; for one is sure to attack the other and suck him dry.

The larva may be reared right through, in a single small glass-tube. The best food for the earlier stages is white-ants. These should be given alive, but with their heads crushed; otherwise there will be a fight between the larva and its intended victim, in which the tables may be turned. In the second and third instars, the larvæ of the Codlin Moth make excellent food; but these also must be offered with their heads crushed, unless one is willing to take the risk of damage to the *Psychopsis* larva from the strong mandibles of the Codlin grub. Under natural conditions, the *Psychopsis* larva guards himself from attacks of this kind by retreating into a crevice, after he has seized his prey. With his body thus covered, and only his large jaws projecting, he is perfectly safe. But it is different in a glass-tube, where the whole of the larva's soft body is exposed to attack from the jaws of his writhing victim.

The larvæ feed but seldom; each meal, however, is a very substantial one. A larva supplied with a Codlin grub will usually attack it at once, advancing cautiously with its jaws wide apart, until they are well placed on each side of its victim. Then, with a sudden vicious snap, the jaws are driven home, and the victim is secured. If the victim struggles furiously, the *Psychopsis* larva will frequently let go its hold, and retreat into a corner, with every sign of fear; nor will it be induced to attack the same victim a second time. Generally, however, the larva is able to hold on, until the loss of blood occasioned by the wound weakens the victim sufficiently to prevent its struggling further. Then the jaws are driven far in, and the play of the maxillæ to and fro beneath the grooved mandibles shows that the larva is sucking vigorously at its victim. It may take some hours before the latter is completely emptied of its juices. By this time, the *Psychopsis* larva will have swollen out to a very great extent, and will frequently be quite torpid, like a snake. After such a meal, no food should again be offered for two or three weeks. Larvæ that are overfed usually die from the effects of it; so that it is necessary to keep a strict watch on the feeding, and only to offer food to those that are really in need of it.

The Cocoon. (Plate lxxix., fig.6).

When the larva is full-fed, it remains torpid for a considerable period, usually two or three weeks. It then sets about constructing its cocoon. First of all, a number of loose and irregular threads are spun from the anus, making an irregular meshwork, the size and appearance of which depends entirely upon the place selected for the cocoon. Under natural conditions, the cocoon is spun in a crevice of the bark, which is usually barely wide enough to contain it. In such a case, the preliminary meshwork is reduced to a minimum, and only consists of a slight scaffolding or anchorage for the cocoon. But, in such an artificial condition as in a glass-tube, the larva may expend a considerable amount of skill upon this meshwork, before it is satisfied that conditions are satisfactory for the actual building of the cocoon.

Having selected the exact position for the cocoon, the larva next spins a small platform within the meshwork already mentioned. Upon this it lies, back downwards, while it weaves around itself, with marvellous dexterity, the beautiful spherical cocoon. The outer sheath of the cocoon is mostly composed of fairly loose and irregular threads; as these are spun in larger and larger number, the spherical shape of the cocoon begins to take shape. Within this loose outer covering, the threads are spun with wonderful accuracy and closeness, so that the larva is finally enclosed in a dense white or cream-coloured ball of silk, which, when cleared of its outer and looser threads, closely resembles a pearl. As the spinning proceeds, the larva shrinks more and more in size, and becomes doubled right over upon itself. When the cocoon is finished, it becomes almost impossible to conceive how so large a larva could have managed to encase itself in it.

As regards the actual mode of spinning the thread, the mobility of the anal papilla is very marvellous. Lying upon its back, the larva can protrude this papilla to a great distance, and spin silk all round itself, even behind its head and thorax, with very little effort. Most of the threads, however, are spun transversely across the larva, beginning with a small arc at the anal end, then swinging out into a longer arc across the middle of the abdomen, and finally making shorter arcs behind the back of the thorax. All these transverse strands appear to be carefully connected, on both sides, with the small platform already mentioned, which itself is made to form a part of the outermost coat of the cocoon. When the first complete layer of the sphere is finished, the larva has its head bent over so as almost to touch the tip of its abdomen; but the mobility of the anal papilla appears to be but little decreased in this position. In spinning the inner layers of the cocoon, the larva changes its position every now and then, so that the anal papilla may cover all parts of the sphere with an equally thick layer of silk.

As found under natural conditions, the cocoon is an oblate spheroid, with the two poles in contact with the sides of the crevice in which it is placed, and the larva lying so that its sagittal section is in the equatorial plane of the spheroid. When spun, however, in an open tube, the cocoon is practically a sphere. It closely resembles the cocoon of a Chrysopid, particularly that of the genus *Nothochrysa*, from which it would not be possible to distinguish it for certain. But, unlike most of the *Chrysopidæ*, *Psychopsis* does not attempt to spin any external matter into the outer mesh of the cocoon. Such a proceeding is, of course, unnecessary, considering the position in which it is placed. The diameter of the cocoon varies with the size of the larva, but is usually about 5 mm. (Plate lxxix., fig.6).

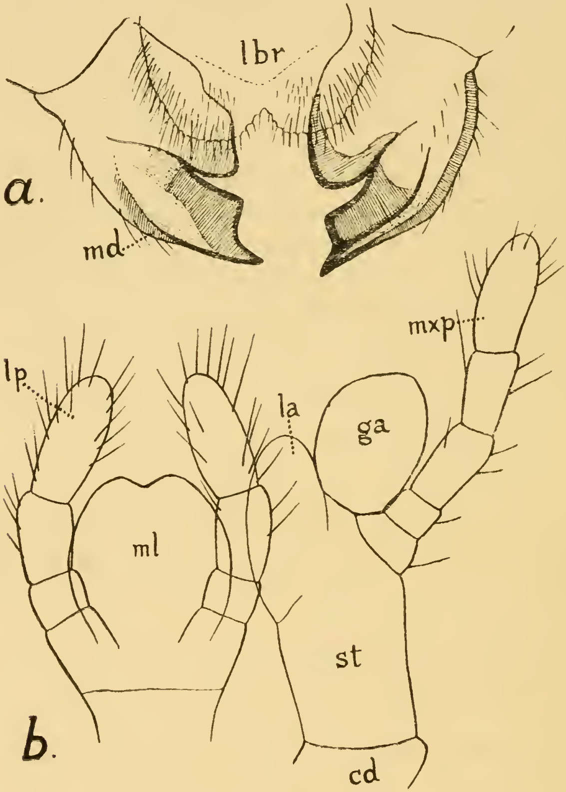
The Pupa. (Plate lxxix., fig.7; Text-fig.10).

As far as the external form is concerned, the true metamorphosis is that between larva and pupa. The latter is a *pupa* *libera*, closely resembling the imago in everything except its unexpanded wings (Plate lxxix., fig.7). At the metamorphosis, the pupa experiences a great difficulty in casting off the hard larval head, and a number perish from inability to do so. The rest of the larval skin is soft, and shrivels up into a minute mass within the cocoon; the head may be found sometimes almost intact, sometimes with the mandibles and maxillæ broken off from it. The splitting of the head is mid-dorsally and postero-transversely, as in the other larval ecdyses (Text-fig.3).

The change from larva to pupa does not take place until a considerable time after the spinning of the cocoon, generally from a fortnight to three weeks. At first, the fresh pupa is almost colourless, the body having a slight greenish tinge, the head and wings cream-coloured. The compound eyes are large, and soon become dark brown and functional. If the cocoon be opened, the pupa watches every movement with anxiety, and can be made to turn round and round, merely by the movement of a pin held at a short distance in front of the head.

The *antennæ* are fairly short (Plate lxxix., fig.7), but are composed of a large number of joints, there being thirty-five in the pupa which I dissected. Each joint is less than half as long as wide, except only the first three; of these, the basal joint is stouter than the rest. Unlike those of the imago, the antennæ in the pupa are devoid of hairs.

The mouth-parts are of considerable interest (Text-fig.10). The *labrum* is distinctly bifid, and carries numerous hairs on small raised bases. Below the labrum, on either side, are the large and very strongly chitinised *mandibles*. Each of these consists definitely of two lobes, separated by a narrow slit. The outer or distal lobe has a sharply pointed, tooth-like apex, and, below it, a more or less broad and flat cutting-area, forming a right-angled projection. The inner or basal lobe is rounded, and much less prominent. The two mandibles are not similar in shape. The right mandible has the smaller basal lobe, but the broader and flatter cutting-surface; whereas the left mandible has the cutting-area narrower, and the apical tooth raised above it on a high ridge. Thus, in the action of cutting open the cocoon, for which these strong mandibles are employed, it is evident that the apex of the right mandible plays in and out of the groove formed between the apical ridge of the left mandible and the rectangular shelf below it. This is also proved by the fact that the cutting-edge of the distal lobe of the right mandible is very sharp, whereas that of the left mandible is thicker and blunter,



Text-fig. 10.

Mouth-parts of pupa of *Ps. elegans* (Guér.). *a*, Labrum (*lbr*) and mandibles (*md*). *b*, Right maxilla and labium; *cd* cardo, *ga* galea, *la* lacinia, *lp* labial palp, *ml* median lobe of labium, *mxp* maxillary palp, *st* stipes; (× 48).

and is evidently formed more as a pad or receptacle, against which the right mandible can work.

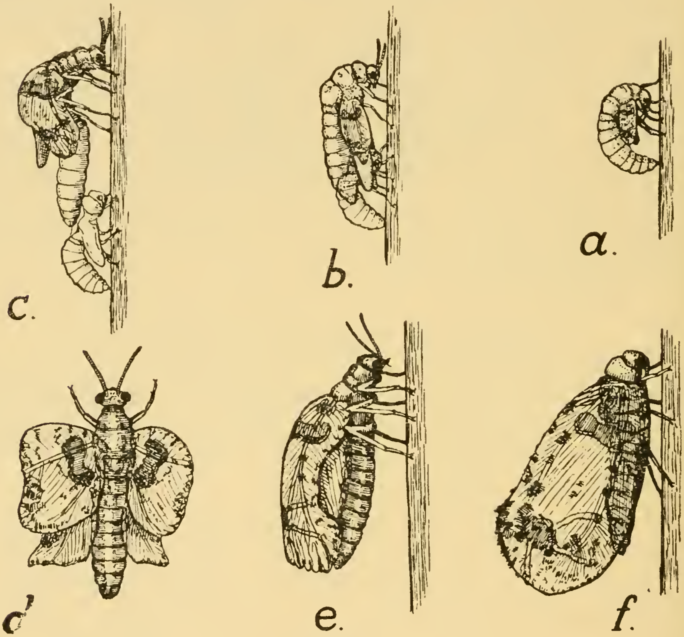
The *maxillæ* and *labium* resemble those of the imago fairly closely, but are broader and softer, as if the parts were all swathed in whitish bandages. The principal differences are that the galea of the maxilla is a broad rounded lobe without a small distal joint, and the median lobe of the labium is simply bifid, instead of being formed as in the imago.

After about a week, the imaginal colours begin to appear upon the body and wings of the pupa. Before emergence, the whole beautiful pattern of the wing-colouration becomes set forth upon the wings of the pupa. It was by this means that I was able to recognise the pupa of *Ps. cœlivagus*, with its intensely black wings, in spite of the fact that it failed to complete its emergence, after escaping from its cocoon.

Emergence of the Imago. (Text-fig.11).

The pupa emerges from the cocoon by cutting it neatly open with its sharp mandibles, whose scissor-like action is specially adapted to this purpose. About one-fourth of the circumference is left uncut, forming a strong hinge. The pupa pushes up the lid of the cocoon, and climbs out.

On Dec. 1st, 1915, at 5.30 p.m., I noticed a pupa emerging from its cocoon, which was placed upon some sand in a glass-jar. The pupa crawled along the sand to a strip of blotting-paper, placed nearly vertically, near by. Up this it climbed to a height of about one and a half inches, and then took a firm grip of the blotting-paper with its claws, and remained resting for a few minutes. During this time, it gradually swelled up and became very taut, as shown in Text-fig.11, *a*. At 5.37 p.m., it began to work its abdomen and wing-sheaths about; so that, in a few seconds, the fine pupal skin split dorsally down the thorax, the abdomen became straightened out, and the imago began to emerge from the pupal skin. During emergence, the wings begin to expand at once, the insect arching them strongly outwards, as may be seen in Text-fig.11, *c*, *d*. The basal portions of the wings begin to enlarge before the apical portions are freed from the pupal wing-sheaths. Consequently, as in the case of the Stoneflies or Perlaria, the wings, when finally withdrawn, have the distal portion bent at an angle to the basal portion, as shown in Text-fig.11, *d*. This applies more to the forewing than to the hind, which becomes freed with less difficulty.



Text-fig. 11.

Emergence of the imago of *Ps. elegans* (Guér.). *a*, Pupa just before metamorphosis, 5.36 p.m. *b*, Imago emerging, 5.40 p.m. *c*, Imago freed from pupal skin, 5 42 p.m. *d*, Imago expanding its wings, 5.47 p.m. *e*, The same at 5.49 p.m. *f*, Imago resting with wings fully expanded, 6.8 p.m. (Drawn from sketches made while watching the actual emergence on Dec. 1st, 1915; *d*, dorsal view, the rest lateral).

As soon as the imago was quite free, it climbed upwards further away from the pupal skin, the latter being left clinging to the blotting-paper, as shown in Text-fig.11, *c*. Having taken up a position well above the pupal skin, the imago remained stationary with its wings arched strongly outwards, the forewing at first completely hiding the hindwing. While the basal half of the forewing expanded rapidly, the distal half remained bent under it for some time. Meanwhile, the hindwings expanded rapidly, and their apical portions appeared beneath the still bent forewings, as seen in Text-fig.11, *d*. Next, the distal portions of the forewings became straightened out, though at first they remained full of longitudinal rucks, as seen in Text-fig.11, *e*. The wings were held well away from the abdomen up to 5.49 p.m., by which time they were about three-fourths expanded. Then the apical rucks became rapidly smoothed out, and the wings were arched forwards, forming a steep roof over the body, so that the costal margins of the forewings come almost into contact with the blotting-paper (Text-fig.11, *f*). From the time of leaving the cocoon to the time that the wings were fully expanded, only thirty-eight minutes elapsed. After resting for some time in the position shown in Text-fig.11, *f*, until its wings were sufficiently hardened, the imago spread them out in the broad, flattened, roof-like manner usually adopted in this family.

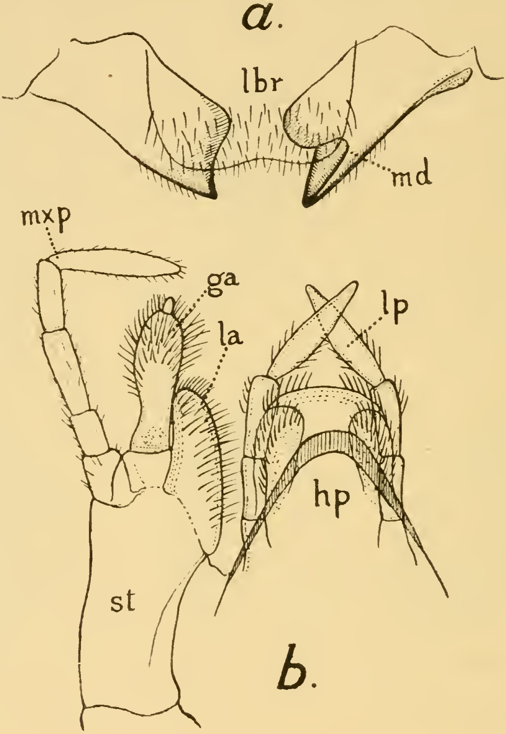
The pupal skin left behind is a flimsy, white structure. It is very difficult to detach from its position. But, when once this has been done, the slightest breath of air causes it to move readily, so light and delicate is its construction. The thorax and base of the abdomen are flattened, and wide open dorsally. From the prothoracic spiracles, two long threads stand up; these are the intima of the tracheal trunks, withdrawn through these spiracles when the imago emerges. The back of the head is split open, and the large dark brown pupal mandibles are left gaping wide apart.

The Imago. (Text-fig.12).

A few details about the imago which have not been published may suitably be given here.

The mouth-parts are figured in Text-fig.12. The *labrum* resembles that of the pupa, but is not definitely bifid, there being only a very slight indication of the division into two distinct lobes. It carries numerous hairs, not set upon raised bases.

The *mandibles* are smaller and weaker than in the pupa, and show considerable modification in shape. The right mandible in the imago has only a single lobe, with a less prominent apical tooth and a broader cutting-blade. The left mandible, on the other hand, is still bilobed, the basal lobe being rounded as in the pupa, but the distal lobe forming a single strongly projecting tooth, whose internal border is definitely hollowed out. Thus, in the imago, the cutting-edge of the right mandible works into the groove of the left in a very simple manner. These mandibles may possibly be used for feeding upon gum-exudations. In cap-



Text-fig. 12.

Mouth-parts of imago of *Ps. elegans* (Guér.), ♀. *a*, Labrum and mandibles. *b*, Left maxilla and labium; *hp* hypopharynx; rest of lettering as in Text-fig. 10; (×48).

tivity, the insects feed willingly upon sugar moistened with water and spread upon cotton-wool, using their mandibles to chew the sticky crystals.

The *maxillæ* are of a very generalised type, with complete and separate galea and lacinia, and an elongated, five-jointed palp. The stipes is long, the cardo very short. The lacinia arises from a broad oblique base, in the form of a simple elongated lobe with rounded apex, and carrying numerous hairs. The galea is remarkable in being set well above the lacinia, upon a short transverse base formed as a definite projection from the stipes, and also in carrying a small but very definite distal joint. The basal joint is somewhat club-shaped, and carries numerous hairs upon its distal half. It is possible that the existence of a distal joint is an archaic feature, and that it may prove to be of importance in the study of the Phylogeny of the Holometabola.

The maxillary palp is carried, in the position of rest, with its distal joint turned inwards almost at right-angles to the other four, as shown in Text-fig.12, *b*. The first and second joints are short, the third twice as long as the second, the fourth shorter than the third, and the distal joint longer than any, with a somewhat pointed tip.

The *labium* is in the form of a broadly rounded median lobe, on each side of which there is a narrower lobe, also rounded, but folded over above the median lobe, between it and the hypopharynx. The median lobe carries hairs on either side, distally; the two lateral lobes carry numerous hairs upon their upper surfaces. The palps, which arise low down towards the base of the median lobe, are three-jointed, the basal joint being the shortest, and the distal the longest; each joint carries a few hairs.

In the natural position, if the mouth be opened, there will be seen a broad sub-triangular lobe projecting outwards and slightly upwards above the labium. This is the *hypopharynx* (Text-fig. 12, *hp*). Its distal border is well rounded, rather strongly chitinised, and curved over; it carries no hairs.

Bearing in mind the fact that the *Psychopsidæ* are the most ancient of existing Planipennia, as far as the Palæontological record of this Order is known, it would seem that much valuable evidence should be obtainable when a careful comparison can be made between the mouth-parts here described and those found in other families of the Order. This research, I hope to carry out later on.

Habits of the Imago.

During the day-time, the imagines rest concealed and motionless, either upon the underside of a leaf, or hidden away in *débris* of dead leaves and sticks. Hence they are seldom captured, though occasionally one may be taken by beating.

At night-time, they become comparatively lively. *Ps. elegans*, kept in a large glass-jar, was watched by me for several nights from 8 to 10 p.m. During this time, it fluttered about the jar, visited the moist sugar supplied as food for it, and fed upon it for periods up to half-an-hour in duration. The third night, after all the insects had fed, I was fortunate enough to see the process of pairing. The female took up a position upon a strip of bark, resting with her wings in the usual position, but continually vibrating them. A male, after several short flights, at last alighted upon the same piece of bark, lower down, and began to climb up towards the female, also vibrating his wings. At last he arrived alongside her, on her right side. The female then raised her right pair of wings, and the male moved in towards her from the side, so that the abdomens of the two insects were almost parallel, and the right pair of wings of the female covered the left side of the male. In this position they remained for pairing, occasionally vibrating their wings. It was not easy to make out exactly how copulation was effected; but it appeared that the male bent the tip of his abdomen round towards the female, and seized her with his anal appendages, at the same time pulling the tip of her abdomen partly round towards him. Thus they remained for some twenty minutes, until a second male came and alighted close to them, and began to flutter around and over them.

The female apparently did not lay any eggs until some time after pairing, as I searched the jar the following morning and found none. However, during the next few days, she deposited eggs singly, and at long intervals of time apart, in the cotton-wool which I had supplied for that purpose. She also explored the bark, but found it for the most part unsuitable, laying only one egg there, as against eleven laid on the cotton-wool. The two eggs shown in Text-fig.1 were laid close together as drawn, but all the rest were quite separate. This female may, of course, have laid other eggs which I failed to find. I should say that a single female must contain at least fifty eggs;* but it is possible that they would not usually all be laid after a single pairing.

The males were kept alive for periods varying from ten days to three weeks. The females live longer, and one was kept alive for over a month, by which time her wings were considerably torn. The only nourishment given, during all this time, was sugar and water, which I find sufficient for most Planipennia and Mecoptera. A very slight degree of moisture is required in the jar. Either excess of moisture, or exposure to a hot drying wind, is equally injurious to these insects. The same may be said of all Planipennia, although the *Myrmeleontidæ* and *Ascalaphidæ* can stand greater heat and desiccation than any of the others.

The Economic Value of the Psychopsidæ.

There is no Order of Insects, with the exception of the Hymenoptera, whose members are so generally beneficial to mankind as the Planipennia. It seems, therefore, of considerable importance that we should now attempt to estimate the value of the *Psychopsidæ* in this respect.

From the account of the life-history here given, it will be seen at once that these insects are entirely beneficial to man throughout their whole life. The preference shown by the larva for feeding upon such obnoxious insects as the larvæ of Codlin Moth, and other of the smaller Lepidoptera, at once establishes it as *potentially* a very useful factor in the checking of insect-pests. Hence, if colonies of *Psychopsis* could be established in our apple-, pear-, and quince-orchards, there is no doubt that they would help very materially in checking the Codlin Moth and other Lepidopterous pests that still do so much damage therein.

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* Mr. Gallard's original female laid over fifty eggs. See p.787.

In attempting to estimate the practicability of such a suggestion, we have to bear in mind certain factors that must, at the best, very much limit the efficacy of the *Psychopsidæ* :—

(1) Although a single larva of *Ps. elegans*, during its life, would most certainly consume a considerable number of Codlin Moth larvæ, yet the value of this is much discounted by the long life of the larva, which takes up the best part of two years. The economic value of this insect would be many times enhanced if it were able to pass through all three larval stages in a few weeks, as is the case with the *Chrysopidæ* and *Hemerobiidæ*.

(2) The larva requires rough-barked trees to live in. Thus it would seem that it could only be successfully introduced into orchards in which the trees were of considerable age. Such trees would probably afford the requisite amount of shelter to the larva, which would certainly take heavy toll of any other insects that attempted to hide away in the crannies and crevices of the bark.

(3) As an archaic survival of a very old stock, the *Psychopsidæ* could scarcely be expected to show that readiness to adapt themselves to new conditions, that is to be found, for instance, in the more specialised *Chrysopidæ* and *Hemerobiidæ*. Many of our Australian species of these two families have readily established themselves in our orchards and gardens, without any attempt on the part of entomologists to place them there; and are already acting very effectively as checks upon Aphidæ and Scale Insects. So far, no similar tendency has been noted in the *Psychopsidæ*; unless, indeed, the apparent increase in the numbers of *Ps. insolens* in such districts as Killarney and Mount Tambourine, in South Queensland, where orchards are rapidly replacing the original bush, is an indication that this species is beginning to accommodate itself to new conditions. It would be natural to suppose that insects which, in a state of nature, are so rare as the *Psychopsidæ*, would not take kindly to a change of environment which man might attempt to force upon them. Thus, if a selected orchard of old trees were to be well stocked with *Psychopsis*-larvæ, one would anticipate that the resulting imagines, after pairing, would return to the nearest piece of untouched

bush, and lay their eggs, as usual, on the bark of Myrtaceous trees.

(4) The apparent association of the *Psychopsidæ* with trees belonging to the Natural Order Myrtaceæ must be considered as a disadvantage, if it is actually a fact. But, so far, we do not know the life-histories of most of the *Psychopsidæ*; and it may well be that this supposed limitation does not hold for most of the species. Moreover, it is noteworthy that, although *Ps. insolens* is our commonest species, no larva of this insect has yet been found under Eucalyptus-bark. If the life-history of this species can be worked out, it seems probable that it might prove to be of considerable value as a beneficial insect in checking orchard-pests.*

(5) The small number of eggs laid by the females is a distinct disadvantage economically. Against this, however, we may place the fact that the females live a long time, and deposit their eggs singly in many different places, instead of all in a lump. Thus the maximum effect is produced for the small number of larvæ hatched, and the danger of a quick reduction through cannibalism is eliminated.

Taking all these factors into consideration, I have come to the conclusion that, although the *Psychopidæ* do not offer us the promise of such immediately beneficial results as could be obtained by a scientific breeding and distribution of *Chrysopidæ* or *Hemerobiidæ*, yet they are a group that most certainly ought not to be neglected by economic entomologists. A few carefully devised experiments upon old and badly infected orchards, either with the larvæ of *Ps. elegans*, or with those of *Ps. insolens*, if they can be obtained by pairing the imagines, should be well worth carrying out, and might conceivably yield results much superior to the expectations that I have here indicated. There is also the possibility that these insects, like so many other Australian animals, would do exceptionally well in some new region,

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* *Psychopsidæ* occur also in Africa and Asia, but nothing is known of their life-histories in these regions. Large, rough-barked Myrtaceous trees, like the Eucalypts, being absent from these regions, it is evident that they must be associated with trees of other Orders.

such as California or South Africa. As they are entirely beneficial, I would call the attention of entomologists to their possible value in this respect; particularly as there would not be the slightest difficulty in sending the larvæ to any part of the world, since they are very hardy, and will go without food for several weeks at a time.

EXPLANATION OF PLATE LXXIX.

Psychopsis elegans (Guér.).

Fig.1.—Two eggs; (× 7).
Fig.2.—Newly hatched larva; (× 7).
Fig.3.—The same larva at end of first instar; (× 7).
Fig.4.—The same larva, at end of second instar; (× 7).
Fig.5.—The same larva, at end of third instar; full-fed; (× 7).
Fig.6.—Cocoon; (× 4).
Fig.7.—Pupa, ten days old, extracted from cocoon; (× 7).

AUSTRALIAN MEGALOPTERA OR ALDER-FLIES,

WITH DESCRIPTIONS OF NEW GENERA AND SPECIES.

By R. J. Tillyard, M.A., D.Sc., F.L.S., F.E.S., Linnean Macleay Fellow of the Society in Zoology.

(With three Text-figures.)

The Megaloptera are an archaic Order of Holometabolous Insects, which contains, at the present day, only about one hundred known species, all of them of large or moderate size. The Order is divisible into two very distinct Sub-orders, viz., the Sialoidea, or true Alder-flies, and the Raphidioidea, or Snake-flies. Of these, the aquatic Sialoidea are clearly the more archaic, the terrestrial Raphidioidea being a highly specialised offshoot from them.

The Raphidioidea are not represented in Australia, their place in the economy of Nature being already occupied by the older *Psychopsidæ* of the Order Planipennia, whose larvæ, though differing in the nature of their mouth-parts, live, like those of the Snake-flies, in crevices of the bark of trees, and prey upon the insects frequenting them.

The Sialoidea, or true Alder-flies, are represented by some sixty species throughout the world. They may conveniently be divided into two very distinct families, according to the following key:—

Large insects (expanse 45 to 100 mm.), with three ocelli present; fourth joint of tarsus not bilobed; venation regular, with cross-veins weakly formed. Larvæ with eight pairs of lateral gills and a pair of hooked anal prolegs, but without any terminal filament .... Corydalidæ.

Much smaller insects (expanse 20 to 40 mm.), without ocelli; fourth joint of tarsus strongly bilobed; venation less regular, with strongly developed cross-veins. Larvæ with only seven pairs of lateral gills and a terminal filament, but without any anal prolegs .... Sialidæ.

Of these two families, the *Corydalidæ*, containing the great majority of the genera and species of the Sub-order, may be again divided into two subfamilies, as follows:—

More than three cross-veins between R and Rs; head quadrangular.. .... CORYDALINÆ.
Only three cross-veins between R and Rs; head triangular...... .... CHAULIODINÆ.

Up to the present, only one species of Alder-fly has been recorded from Australia, viz., *Archichauliodes guttiferus* (Walker). It is a large, dull-coloured insect, recorded occasionally from many localities in Eastern Australia, but nowhere very common. Both in size and markings, it is very variable, some individuals having large black spots on the wings (especially on the hindwings) and others having none at all. The larva is a familiar object to naturalists in the Sydney district, being found under rocks and stones in small rocky creeks. In New Zealand, the allied species *A. dubitatus* (Walker), is very abundant, and its larva is much esteemed as bait for trout, being known as the "Black Creeper," a name that would suit the larva of the Australian species equally well.

Turning now to the smaller family *Sialidæ*, of which no representatives have hitherto been found in Australia or New Zealand, we find that, of the two known genera, *Sialis* is Holarctic, reaching from Canada through Europe and Siberia to Japan, and down into Asia Minor; while *Protosialis* is confined to the New World, one species being found as far south as Chili.

It would thus appear that, as the *Sialidæ* do not occur in the Oriental region, there is no possibility of their ever having reached Australia from the North. But, in so far as they are admittedly archaic forms, and one species is recorded from Chili, it has to be admitted that there is a bare possibility of their having been able to reach Australia from the South, provided that we admit the truth of the Antarctic Theory so ably championed by Mr. Hedley.

That being so, I have always kept in mind the possibility of a true Sialid being discovered in Tasmania, or on some isolated mountain-top in Eastern Australia. I now have the pleasure of recording the discovery of two very distinct new species of this family, each of which will form the type of a new genus. The first of these was taken by Mr. G. H. Hardy, late of the Tasmanian Museum, Hobart, during a visit to Maria Island in December, 1915. Only a single specimen was taken; but it is in good condition, except for the loss of the antennæ. The second is a remarkable slender form, taken at light in December, 1916, on Mount Tambourine, South Queensland (elevation 1900 feet) by Mr. W. H. Davidson. Not realising what a prize he had got, Mr. Davidson unfortunately enclosed this specimen in an envelope with a letter to me; with the result that, when I received it, the insect was completely flattened out, and otherwise damaged. However, I managed to relax and set it, though the pin had to be inserted through the thorax from side to side, the wings being extended at right angles to the flattened thorax.

I have delayed publishing these fine discoveries, in the hope that further material might be obtained in better condition. Mr. Hardy again visited Maria Island last year, but he failed to find any further specimens of the new Sialid; likewise Mr. Davidson, who has kept a sharp look-out for his new species, has met with no further success. As the new insects are of great scientific interest, further delay is no longer justified.

The following key will enable the two new genera to be distinguished from each other and from the two genera already described, at a glance:—

(1) Wings about one-third as broad as long, the costal field of the forewing noticeably broadened .... 2.
Wings much narrower, the costal field of the forewing not noticeably broadened .... 3.

(2) Hindwing with M_{1+2} and M_{3+4} both simple veins .... *Sialis* Latr.
Hindwing with M_{1+2} forked, M_{3+4} simple.. .... *Austrosialis*, n.g.

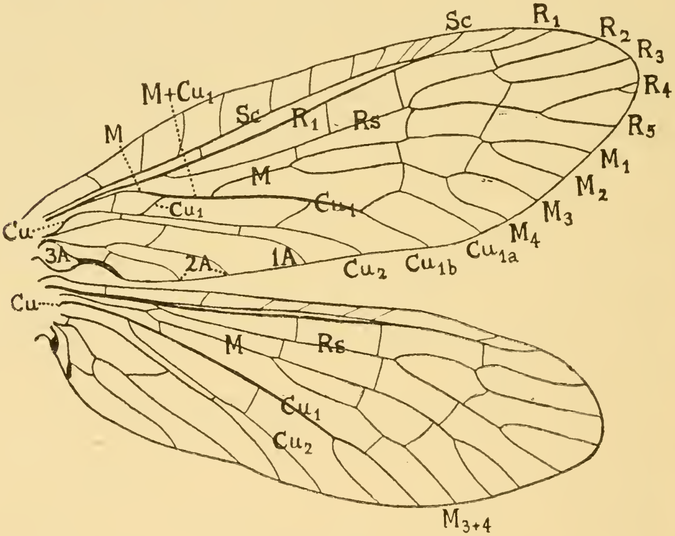
(3) Both wings with R_{2+3} and R_{4+5} both forked .... *Stenosialis*, n.g.
Both wings with R_{2+3} simple, and R_{4+5} forked ... *Protosialis* Weele.

AUSTROSIALIS, n.g. (Text-figs.1-2).

Closely related to *Sialis* Latr. General colouration black, with orange-red prothorax and smoky wings. Forewing with about ten veinlets in costal space, hindwing with about six. In forewing, Cu_1 unites with M for a space, the short basal free portion of Cu_1 resembling an oblique cross-vein. The fused portion, $M + Cu_1$, is continued by Cu_1 itself as a stout vein in line with it, whereas M departs from it anteriorly at a sharp angle. In hindwing, Cu remains quite distinct from M. In forewing, the full complement of branches is present for both Rs and M; in hindwing, there is one less for M, M_{3+4} remaining unbranched. Neither R_2 nor R_3 is secondarily forked, as is the case with one or both in *Sialis*.

Genotype, *Austrosialis ignicollis*, n sp.

Hab.—Tasmania.



Text-fig. 1.

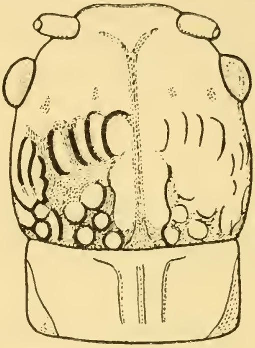
Wings of *Austrosialis ignicollis*, n.g. et sp. In forewing, $M + Cu_1$ is the fused portion of M and Cu_1. Rest of notation as usual in the Comstock-Needham system. The small forking distally on R_4 does not occur on the left forewing. (Hindwing 12 mm. long).

The black and orange colouration is also that of *Protosialis*, to which the Chilian species belongs. It is also interesting to note that, in the number of its branches to Rs and M, the new genus offers an exact parallel to the oldest Trichoptera, in which M_{3+4} is always a simple vein in the hindwing.

AUSTROSIALIS IGNICOLLIS, n.sp. (Text-figs.1-2).

Total length, 8 mm.; *abdomen*, 4 mm.; *forewing*, 14 mm.; *hindwing*, 12 mm.; *expanse*, 28·5 mm.

Head shining black, smooth anteriorly, with a shallow mid-dorsal depression; the large occipital region curiously sculptured, with raised longitudinal and circular areas, arranged as shown in Text-fig.2. *Antennæ* with large, stout basal joint, black; the rest missing. *Mandibles* black, tipped with orange-red.


Text-fig.2.

Thorax: *prothorax* bright orange-red, flattened cylindrical in shape, with slightly indicated mid-dorsal groove; less than half as long as wide, the width being slightly less than that of the occiput. *Pterothorax* jet black. *Legs* black, of medium length and slenderness.

Abdomen [shrivelled] dull blackish.

Type, in Coll. Tillyard.

Hab.—Maria Island, East Coast of Tasmania. A unique specimen, probably a female, taken on Dec. 29th, 1915, by Mr. G. H. Hardy.

STENOSIALIS, n.g. (Text-fig.3).

Closely related to *Protosialis* Weele. General colouration brown, with pale smoky-brown wings. Forewing with narrow costal space containing only four veinlets, the hindwing with only two. The arrangement of the veins M and Cu is the same as described for *Austrosialis* above, and the number of branches for the veins Rs and M is the same as in that genus. The cross-

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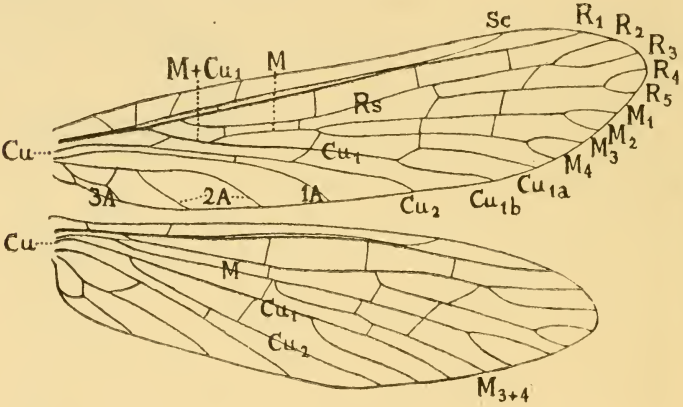
* Head and prothorax of *Austrosialis ignicollis*, n.g. et sp., to show sculpture of the occiput; the light arranged so as to fall nearly horizontally; (×15).

vein between R_{2+3} and R_{4+5} is exceptionally oblique in direction.

Genotype, *Stenosialis australiensis*, n.sp.

Hab.—South Queensland.

As with *Austrosialis*, so with this genus; the arrangement of the branches of Rs and M corresponds exactly with that of the oldest Trichoptera, M_{3+4} being branched in the forewing, but simple in the hind. One is tempted to ask, is this merely the result of a chance convergence, or does it indicate a closer relationship between the two Orders Megaloptera and Trichoptera than has hitherto been suspected?



Text-fig.3.

Wings of *Stenosialis australiensis*, n.g. et sp. Notation as in Text-fig.1. (The wings of the type-specimen being considerably torn, the figure was completed by combining portions of both right and left pairs of wings). (Hindwing 10 mm. long).

STENOSIALIS AUSTRALIENSIS, n.sp. (Text-fig.3).

Total length, 8 mm.; *abdomen*, 4 mm.; *forewing*, 11·5 mm.; *hindwing*, 10 mm.; *expanse*, 25 mm.

Head brownish, a darker area posteriorly on occiput, isolating several paler raised circular areas placed close together on either side of the mid-dorsal depression. *Eyes* dark brown. *Antennæ* dark brown, the basal joint large and stout, the second joint small; the rest missing.

Thorax dark brown. *Prothorax* apparently slightly wider than occiput. *Legs* brown. [Too crushed for accurate description].

Abdomen [shrivelled] blackish basally, shading to brown anally.

Type, in Coll. Tillyard.

Hab.—Mount Tambourine, South Queensland (1900 feet). A unique specimen, probably a female, taken on Dec. 17th, at light, by Mr. W. H. Davidson.

In concluding this paper, I desire to record my grateful thanks to Mr. Hardy and Mr. Davidson for these two fine species, and to congratulate them on their discoveries. The knowledge that, in this Order, archaic forms of great scientific value are still to be found in isolated places in Australia, should stir up other entomologists to look out for these insects, which are easily caught and recognised.

CONTRIBUTIONS TO A KNOWLEDGE OF AUSTRALIAN *CULICIDÆ*. No. iv.*

By Frank H. Taylor, F.E.S.

(*From the Australian Institute of Tropical Medicine, Townsville*).

(Plates lxxx.-lxxxiii.)

This paper may be divided into two parts, synonymical and descriptive, with notes on previously described species.

Two species described by me from the Northern Territory belong to species recorded from extra-Australian localities; their distribution is noted in the text. The Australian *Anopheles* are also tabulated. It will be seen that very few of the Anopheline genera are recognised, and those only as subgenera, except in the case of *Bironella*.

The new species are distributed in the following genera:—*Pseudoskusea* (one), *Mimeteomyia* (two), *Culicada* (one), *Lophoceratomyia* (one), *Uranotænia* (four), and *Hodgesia* (one).

The type-specimens are contained in the Institute Collection.

The following tabulation of the Australian *Anopheles* is given in the hope that it may prove useful in the determination of the species in question.

Anopheles corethroides, *A. stigmaticus*, and *B. gracilis* have been tabulated from descriptions only, as the Institute does not possess specimens of them. *A. punctulatus* Dönitz, is omitted from the Table, as it is unknown to me either from specimens or description.

It will be seen that all the species, except *B. gracilis*, are placed in the genus *Anopheles*. This is best explained by referring the reader to a paper by A. Alcock,† which deals with the "Classification of the Culicidæ," and with which the writer

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* Continued from these Proceedings, 1916, p.574.

† Ann. Mag. Nat. Hist., (8), viii., p.240 (1911).

entirely agrees, as the genera cannot, in some cases, be regarded even as subgenera; while, in others, they form convenient subgeneric or group-names.

Alcock* retains the following as subgenera: *Anophiles* (s.r.), *Myzorhynchus*, *Myzomyia*, and *Nyssorhynchus*. I would add to these the genus *Bironella*, as valid on venational characters—if it really be an *Anopheline*. Theobald, himself, throws doubt on its systematic position.

ANOPHELES.

- A. Wings spotted.
  - i. Legs unbanded.
    - *a.* Wings with the third, fourth, fifth, and sixth long veins brown- and white-scaled. No costal spots .... *atratipes* Skuse.
    - *b.* Wings with one fringe-spot......... . ... *barbirostris* V. d. Wulp.
    - *bb.* Wings with several fringe-spots...*barbirostris* var. *bancrofti* Giles.
  - ii. Legs banded.
    - *a.* Wings with numerous light and dark spots. Costa with six spots. Femora and tibiæ with numerous pale bands, tarsals 1-4 with apical and basal banding .... *annulipes* Walker.
- B. Wings unspotted.
  - i. Legs unbanded.
    - *a.* Thorax with long, curved, hair-like scales... *corethroides* Theobald.
    - *aa.* Thorax with three rows of golden-yellow, narrow-curved scales ... . *stigmaticus* Skuse.

BIRONELLA.

- A. Wings unspotted, third long vein, stem of second fork-cell, and fifth long vein curved.
  - i. Legs unbanded.
    - *a.* First fork-cell very small .... *gracilis* Theobald.

ANOPHELES (MYZORHYNCHUS) BARBIROSTRIS Van d. Wulp, var. BANCROFTI (Giles).

(Plate lxxx., fig.1).

Theobald, Mon. Culicid., v., p.50 (1910); Taylor, Proc. Linn. Soc. N. S. Wales, 1915, xl., p.176.

This is a common and widely distributed species, extending from Darwin, N. Territory, to Eidsvold, S. Queensland.

The male is evidently very retiring, as the only known specimens have been bred from larvæ.

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* Journ. Lond. Sch. Trop. Med., ii., p.153 (1913).

ANOPHELES (NYSSORHYNCHUS) ANNULIPES Walker.

Ins. Saund., p.433 (1850); Theobald, Mon. Culicid., v., p.57 (1910); Taylor, Proc. Linn. Soc. N. S. Wales, 1914, xxxix., p.454; Quarantine Service Publication, Melbourne, No.12, 1917.

Hab.—N.S.W.: Hay (W. W. Froggatt). —Victoria: Melbourne (Dr. J. H. L. Cumpston); Kyabram, Bamawm, Echuca, Swan Hill, Mildura, Cohuna, Lake Boga (F. H. Taylor).—S. Australia: Renmark, Cobdogla, Pompoota (F. H. Taylor).—W.A.: Perth, Kalgoorlie (Dr. Atkinson).

This mosquito is probably the most widely distributed species in Australasia, as it extends from Darwin, in the North, across to Papua, throughout the mainland, and southward to Tasmania. It is not improbable that this species will be found in the Pacific Islands.

TOXORHYNCHITES INORNATUS (Walker).

Proc. Linn. Soc Lond , viii., p.102 (1865); Theobald, Mon. Culicid., i., p.223 (1901); *op. cit.*, v., p.110 (1910).

Two male specimens, one of which is quite typical; the other has the mid cross-vein confluent with the posterior cross-vein instead of not meeting it, and also has the second tarsals of the hindlegs with a broad, white, almost basal band, which occupies more than half the joint. It agrees in all other points with Theobald's description of this species.

Hab.—Papua: Itikinumu Plantation (F. P. Dodd).

TOXORHYNCHITES SPECIOSUS (Skuse). (Plate lxxx., fig.2).

Proc. Linn. Soc. N. S. Wales, 1888, xiii., p.1722 (1889); Theobald, Mon. Culicid., v., p.108 (1910).

Hab.—Q.: Townsville (Dr. A. Breinl).

MUCIDUS ALTERNANS (Westwood).

Ann. Soc. Ent. Fr., iv., p.681; Taylor, Proc. Linn. Soc. N. S. Wales, 1914, xxxix., p.455; *op. cit.*, 1915, xl., p.176.

Hab.—Victoria: Kyabram (F. H. Taylor).

This species is known to range from Darwin to Victoria.

ARMIGERES BREINLI Taylor; *Neosquamomyia breinli* Taylor.
(Plate lxxx., fig.3).

Trans. Ent. Soc., London, 1914, Pt. i., p.186.

The genus *Neosquamomyia* was founded partly on the male genitalia, the other characters agreeing with *Armigeres.*

When proposing the genus, I was unaware that similar characters were to be found in species of the genus *Armigeres*, notably *A. malayi* Leicester.

Edwards* notes the similarity of *A. malayi* Leic., and *N. breinli* Taylor, and suggests that the correct position for the latter species is in *Armigeres*, a decision with which I quite agree. The two species are distinct, but certainly closely related.

PSEUDOSKUSEA CAIRNSENSIS, sp.n.

♀. Head clothed with black, flat, and upright-forked scales; palpi dusky; antennæ dark brown; proboscis black.

Thorax dark reddish-brown with brown scales, scutellum similar; pleuræ brown, with white, flat scales.

Abdomen black-scaled, unbanded, segments three to the apex with basal, lateral, white patches; venter pale-scaled.

Legs black, unbanded; ungues equal and simple.

Wings brown-scaled; first fork-cell longer and narrower than the second, its base nearer the base of the wing; stem of first fork-cell one-third the length of its cell, stem of second fork-cell slightly more than half the length of its cell; anterior basal cross-vein longer than, and twice its own length distant from, the anterior cross-vein. Length, ?

Hab.—Queensland : Cairns (F. H. Taylor).

Described from a single specimen bred from a mixed lot of larvæ. It is readily distinguished from *P. multiplex* Theobald, on venational characters, ungues, and the abdominal spots. It differs from *P. basalis* Taylor, in not having a banded abdomen.

MIMETEOMYIA ATRIPES (Skuse).

Stegomyia punctolateralis Theobald.

Proc. Linn. Soc. N. S. Wales, 1888, xiii., p.1750 (1889); Theobald, Mon. Culicid, iv., p.190 (1907); Taylor, Proc. Linn. Soc. N. S. Wales, 1914, xxxviii., p.750 (1915) (*Scutomyia*); *op. cit.*, 1915, xl., p.177 (*Stegomyia*).

It is quite evident, from specimens recently collected by myself,

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* Bull. Ent. Res., vii., p.207 (1917).

that Skuse's species has the apical lateral spots on all the abdominal segments, and *not* only on the sixth to eighth segments, as stated in my paper (1914). The Ingleburn specimens show that the spots vary somewhat in size on the basal segments, so that they were either overlooked in the type, or the abdomen was partially abraded.

There is also no doubt at all that *Stegomyia punctolateralis* Theobald, is the same as *M. atripes* (Skuse). *S. punctolateralis* Theob., was unknown to me, except from description, when I stated (1914) that the two were different species; but, since then, Dr. Bancroft has presented a series of both sexes to the Institute, which clearly show they are the same as Skuse's species.

Theobald states that the mid-ungues of the male are unequal and simple; this is an error, as the larger is uniserrate.

Neveu-Lemaire* places *M. atripes* in *Theobaldia*, and records it from Guyane. He states that the fore- and mid-ungues of the female are uniserrate; and he gives a figure of the wing-scales of his specimens, which proves conclusively that he was not dealing with Skuse's species. He also states that the palpi are four-jointed.

There is no doubt that it belongs to the genus *Mimeteomyia*, as, *inter alia*, the apex of the abdomen is very bristly.

Hab.—Q.: Eidsvold (Dr. Bancroft), Burketown, Townsville (F. H. Taylor).—N.S.W.: Milson Island (Dr. Ferguson), Blackheath (W. A. Thompson), Ingleburn (F. H. Taylor).—Vic.: Mildura (F. H. Taylor).

MIMETEOMYIA ATRA (Taylor).

Stegomyia atra Taylor, Trans. Ent. Soc. London, 1914, p.190.

A re-examination of the type of this species reveals the fact that it should, more correctly, be placed in the genus *Mimeteomyia*, on account of its bristly and truncated apex of the abdomen, among other points of agreement with the genus.

MIMETEOMYIA PULCHERRIMA, sp.n.

♂. Head covered with brown, flat scales, with a median row of white ones, and white ones laterally; antennæ pale, nodes and

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* Arch. Parasitologie, vi., p.615 (1915).

plumes brown, basal lobes with white, flat scales; eyes wine-red; palpi brown-scaled, first segment with two prominent white bands, penultimate and apical segments with white, basal bands.

Thorax with dark brown scales, and ornamented with a lyre-shaped pattern of small, white, flat scales; prothoracic lobes with white scales and black bristles; scutellum with white, flat scales; pleuræ brown, with patches of white, flat scales.

Abdomen brown-scaled, expanded apically, segments one to six with small, median, white, basal patches; all segments, except the first, with white, lateral, basal patches, prominent in the last three segments; genitalia with numerous black bristles; venter brown-scaled, with median, white, basal patches on the first seven segments.

Legs brown, knees white, first and second fore- and mid-tarsals with basal, white banding, posterior tarsi one to three with broad, white, basal bands, fourth white, with a narrow, brown, apical band, fifth white; ungues of fore- and mid-legs unequal, the larger with a distinct notch, hind equal and simple.

Wings : bases of fork-cells equal, first longer and narrower than second, stem of first fork-cell not quite half the length of its cell, stem of second slightly more than half the length of its cell, anterior basal cross-vein longer than, and twice its own length from, the anterior cross-vein; vein-scales brown.

Length, 3 mm.

Hab.—Q.: Cairns (F. H. Taylor).

Described from a single specimen, bred from a collection of larvæ. It is abundantly distinct from all other Australian species of *Mimeteomyia*.

MIMETEOMYIA DODDI, sp.n.

♂. Head covered with black scales, a median row of white, flat ones, and white, flat ones laterally; antennæ brown, plumes brown, internodes pale; palpi brown, penultimate segment basally banded white, apical segment white-scaled; eyes silvery.

Thorax covered with dusky-brown scales; scutellum with brown scales; pleuræ brown, with patches of white, flat scales.

Abdomen covered with coppery-brown scales, first segment brown-scaled, second with a median, basal, white-scaled spot, third to fifth and apical segments with white, basal banding, all segments with white, lateral, basal spots; venter brown, with white basal banding and numerous pale hairs.

Legs dusky-brown, first tarsals of forelegs basally banded white, the rest unbanded, first tarsals of mid-legs basally banded white [the rest broken off], posterior tarsi one to three basally banded white, fourth unbanded, fifth white: ungues of forelegs unequal, the larger with a tooth, hind equal and simple,

Wings: first fork-cell longer and narrower than the second, its base nearer to the base of the wing; stem of first fork-cell one-third the length of its cell, stem of second slightly more than half the length of its cell, anterior basal cross-vein longer and twice its own length from the anterior cross-vein.

♀. Similar to ♂. Antennæ brown, basal half of first joint yellow; apical third of palpi white. Abdomen: fourth and fifth segments with basal, white banding, apex of abdomen white-scaled, and with numerous pale bristles, all the segments, except the first, with lateral, white, basal spots; second segment with a white, median, basal spot; venter pale-scaled, apical segments black-scaled.

Legs similar to those of ♂, second tarsals of mid-legs with white basal banding; ungues equal and simple. Wings as in ♂.

Length: ♂, 2·5; ♀, 3·5 mm.

Hab.—Papua: Itikinumu Plantation (F. P. Dodd).

A very distinct species, readily distinguished from *M. pulcherrima* mihi, by its palpi, thoracic and abdominal markings. There is little doubt that the female belongs to the same species.

It affords me much pleasure to name it in honour of its discoverer.

GRABHAMIA THEOBALDI Taylor. (Plate lxxxi., fig.4).

Theobald, Mon. Culicid., iv., p.304 (1907). *C. flavifrons* Theob., *nec* Skuse, Proc. Linn. Soc. N. S. Wales, 1913, xxxviii., p.751 (1914).

Were it not for intergrading forms, it would be possible to make two distinct "species" out of the series of specimens before me, on abdominal markings alone, as, in some specimens, the abdomen is quite typical, whilst, in others, it varies from specimens with distinct basal banding on the first two segments of the abdomen, and the remainder with more or less indefinitely banded and mottled, to those with indefinite basal banding and dense mottling of creamy scales on all the abdominal segments.

The base of the second fork-cell is slightly nearer the base of the wing than that of the first, while they are nearly level in the type.

Specimens from Eidsvold, Queensland, show similar intergradient forms to the above Victorian specimens.

Hab.—Vic.: Bamawm, Kyabram, Mildura, and Echuca (F. H. Taylor).

CULICADA WILSONI, n.sp. (Plate lxxxi., figs.5, 6, 7).

♂. Head black, covered with yellowish, narrow-curved and upright-forked scales, with a few yellowish hairs projecting over the eyes, sides of head with flat ones; palpi longer than proboscis, black, first joint pale-scaled, except the apical fourth, pubescence black on the apical segment, and apex of first, yellowish-brown on the penultimate segment; antennæ pale, nodes dark, plumes brownish-black, dense.

Thorax black, covered with yellowish, narrow-curved scales; prothoracic lobes with flat ones; scutellum similar; pleuræ black, with flat scales.

Abdomen black, first segment pale-scaled, second to seventh with broad, yellowish, basal banding; sixth, seventh, and eighth mottled; some specimens show median pale-scaled bands on most of the segments; genitalia with some long, black hairs, lateral pubescence dense, yellowish; venter pale.

Legs black, femora pale beneath; femora, tibiæ, and tarsi mottled; fore-ungues unequal, uniserrate, mid unequal, the larger deeply notched, the smaller uniserrate, hind equal and simple.

Wings with brown scales; first fork-cell longer and narrower than the second, base of latter nearer the base of the wing, stem of the first almost as long as its cell, stem of second as long as the cell; anterior basal cross-vein about as long as, and nearly its length from, the anterior cross-vein; second incrassation well marked.

♀. Similar to ♂; antennæ black, basal lobes black, with creamy-yellow scales, basal half of second joint pale, verticillate hairs black, pubescence pale; palpi four-jointed, black-scaled, with intermixed, scattered, pale scales; proboscis black; fore femora pale-scaled, mid and hind pale, with an apical black ring, tibiæ and first tarsals mottled with pale scales; fore- and mid-ungues equal, uniserrate; penultimate abdominal segment creamy-scaled except for a small oblique apical line of dark scales, apical creamy-scaled. Wings similar to those of the male; but fork-cells relatively longer, stem of first fork-cell two-thirds the length of its cell, that of second about three-fifths of the cell.

Length: ♂, 7·5; ♀, 6 mm.

Hab.—Vic.: Kyabram, Echuca, Bamawm, Swan Hill, and Mildura (F. H. Taylor).

This appears to be a well-defined species related to *C. tasmaniensis* Strickland, differing, *inter alia*, in the wing-venation, and the mottled femora, tibiæ, and first tarsals. *C. wilsoni* was present in enormous numbers in the Goulburn Valley district, Kyabram and Bamawm being inundated with them. There is a small area of cypress-pine (*Callitris* sp.) at Bamawm, and it was impossible for man or beast to remain in it for even a few minutes, owing to the abundance of this mosquito.

I have much pleasure in dedicating this species to Mr. Wilson, of Bamawm, who rendered me much help and kindly service while I was in that district.

OCHLEROTATUS NOTOSCRIPTUS (Skuse).

Proc. Linn. Soc. N. S. Wales, 1888, xiii., p.1738 (1889) [*Culex*]; Theobald, Mon. Culicid., v., p.200 (1910) [*Scutomyia*]; Edwards, Ann. Mag. Nat. Hist., (8), ix., p.523 (1912).

Hab. N.S.W.: Ingleburn.—Vic.: Swan Hill (F. H. Taylor).

CULEX SITIENS Wiedemann.

Aussereurop. zweiflüg. Ins., p.544 (1828); Theobald, Mon. Culicid., v., p.331 (1910); Taylor, Proc. Linn. Soc. N. S. Wales, 1916, xli., p.570.

Hab.—Q.: Cairns, Innisfail (F. H. Taylor).—Papua (F. P. Dodd).

This common mosquito enjoys a wide distribution, being found from Java through Papua and Torres Straits to Victoria.

CULEX CONCOLOR Desvoidy.

Mém. Soc. d'Hist. Nat. Paris, iv., p.405 (1825); Edwards, Bull. Ent. Res., ii., p.262 (1911).

Hab.—Q.: Innisfail (F. H. Taylor).

A short series, bred from larvæ, have been compared with specimens from other Australian localities, and also with specimens of *C. concolor*, *C. tigripes*, *C. consimilis*, and the form described as *C. tigripes* var. *fusca*, which have been received from the Imperial Bureau of Entomology; and there is absolutely no doubt, as Edwards states, that the Australian form belongs to *C. concolor*.

All references dealing with *C. tigripes*, as from Australia, should, therefore, refer to *C. concolor*, and *C. tigripes* should be expunged from the Australian list.

CULEX BITÆNIORHYNCHUS Giles.

Journ. Bombay Nat. Hist. Soc., xiii., p.607 (1901); Edwards, Bull. Ent. Res., iv., p.231 (1913). *C. abdominalis* Taylor, Rep. Aust. Inst. Trop. Med., 1911, p.53 (1913).

Edwards gives several synonyms of *C. bitæniorhynchus* Giles, in his paper, and mentions *Culicelsa abdominalis* Taylor, also as a possible synonym.

I have compared specimens of my species with six specimens of *C. bitæniorhynchus* Giles, from Hong Kong, and can see no valid reason for treating them as a distinct species, thus confirming the opinion held by Edwards.

CULEX VISHNUI Theobald.

Mon. Culicid., i., p.355 (1901) (♀ only); Edwards, Bull. Ent. Res., iv., p.233 (1913). *C. parvus* Taylor, Bull. N. Territory, 1*a*, p.27 (1912).

Edwards included *C. parvus* Taylor, as a probable synonym of *C. vishnui*, when dealing with its synonymy in his paper. I quite agree with this, and place *C. parvus* definitely as a synonym of *C. vishnui* Theobald.

It seems to me that *C. vishnui* Theobald, is closely related to *C. sitiens* Wied.

CULEX TOWNSVILLENSIS, nom.nov.

Culicelsa fusca Taylor.

Trans. Ent. Soc. London, 1914, p.699.

A change of name is necessary, as *fuscus* is preoccupied in Culex.

The sixth and seventh segments of the abdomen have the sides covered with white scales, except the apex; eighth pale-scaled, unbanded. The fore- and mid-ungues are unequal, and *not* equal, as stated in the description, the mid more so than the fore. There is also a small branched process on the undersurface at the base of the ungues in both legs. Genitalia of male of typical Culex-form.

♀. Similar to ♂. Palpi brown-scaled; apex of abdomen hairy. First fork-cell longer and narrower than second, its base nearer the base of the wing than that of the latter, stem of the first about one-third the length of the cell, stem of the second slightly more than half the length of the cell; hind-tibiæ the same length as first tarsals; ungues equal and simple.

Hab.—Q.: Townsville (F. H. Taylor).

The above corrections in the description of the male are based on fresh material, which agrees perfectly with the type. It appears to be an uncommon species.

CULEX FATIGANS Wied.

Aussereurop. zweiflug. Ins., p.10 (1828); Taylor, Trans. Ent. Soc. London, 1914, p.197.

Hab.—N.S.W.: Sydney (F. H. Taylor).—Vic.: Melbourne (Dr. Cumpston), Kyabram, Echuca, Mildura, Bamawm, Swan Hill (F. H. Taylor).—S. Australia: Renmark, Cobdogla, Overland Corner, Pompoota, Adelaide (F. H. Taylor).

C. fatigans is a common mosquito in Southern Australia. It occurred abundantly at Kyabram and Echuca, where it was breeding in enormous numbers in the irrigation-channels and street-watertables.

LOPHOCERATOMYIA CAIRNSENSIS, sp.n. (Plate lxxxii., figs.8, 9).

♂. Head clothed with brown, narrow-curved, and black, upright-forked scales; antennæ pale, apical segments and nodes dark brown, plumes brown, accessory organs long on segments five, eight, and ten, apices spoon-shaped on eighth, short on sixth and seventh; palpi black, penultimate and apical segments with black hairs beneath, thumb-like process dark brown; eyes black.

Thorax and scutellum with brown, narrow-curved scales; scutellar bristles black, long; pleuræ brownish.

Abdomen black-scaled, unbanded, apex bristly, segments three to seven with faint, lateral, basal spots; venter dark.

Wings: first fork-cell longer and narrower than the second, the former nearer the base of the wing; stem of first fork-cell about half the length of its cell, stem of second about two-thirds; anterior basal cross-vein longer than anterior cross-vein, and nearly thrice its own length distant from it; scales brown.

Legs black, unbanded; ungues of forelegs unequal, the larger uniserrate, mid-ungues unequal and simple, hind equal and simple.

♀. Similar to ♂. Palpi black-scaled, first segment with a few black bristles; clypeus black; antennæ brown; ungues all equal and simple; abdominal spots well defined.

Length: ♂, 3·5; ♀, 4 mm.

Hab.—Q.: Cairns (F. H. Taylor).

Described from seven males and ten females, bred from larvæ. It is abundantly distinct from *L. annulata* Taylor, and *L. cylindrica* Theobald.

Two males and one female have the bases of the fork-cells almost level, but there are no other differences from the typical specimens.

LOPHOCERATOMYIA ANNULATA Taylor.

Proc. Linn. Soc. N. S. Wales, 1916, xli., p.571.

Hab.—Q.: Cairns (F. H. Taylor).

A single specimen, bred at the same time as *L. cairnsensis* mihi; it agrees with the type in all respects.

LOPHOCERATOMYIA CYLINDRICA Theobald.

Mon. Culicid., iii., p.202 (1903) [*Culex*], Pl. ix.; *op. cit.*, v., p.361 (1910); Edwards, Bull. Ent. Res., vii., p.228 (1917).

Hab.—Q.: Eidsvold (Dr. T. L. Bancroft).

I quite agree with Edwards in placing this species in *Lophoceratomyia.* It is typical in every respect. The figure of the head of the male on Plate ix., though small, shows the plates on the antennæ.

MANSONOIDES UNIFORMIS (Theobald).

Theobald., Mon. Culicid., v., p.448 (1910); Edwards, Bull. Ent. Res., ii., p.253 (1911).

Hab.—N. Territory: Darwin (G. F. Hill).—Q.: Eidsvold (Dr. Bancroft), Cairns, Townsville.—N.S.W : Newcastle (Dr. Dick).

This is a very abundant and widely distributed species, being found from Africa to the Philippine Islands, New Guinea across to Darwin, and extending as far as Newcastle, N.S.W.

FINLAYA POICILIA Theobald.

Mon. Culicid., v., p.464 (1910); Taylor, Proc. Linn. Soc. N. S. Wales, 1914, xxxix., p.465.

Hab.—Q.: Cairns (F. H. Taylor).

MOLPEMYIA PRIESTLEII (Taylor). (Plate lxxxii., fig.10).

Calomyia priestleii Taylor.

Trans. Ent. Soc. London, 1913, Part iv., p.684 (1914).

Calomyia cannot be retained as distinct from *Molpemyia*, there being no structural differences. The writer was in error in describing the scales on the centre of the head and bordering the eyes as spindle-shaped, as they are, in reality, only large *narrow-curved* scales.

The species seems to be somewhat variable, as a specimen, taken at a later date than the type, shows complete broad banding on the abdomen, whereas, in the type, the abdomen has large, basal spots on the segments.

SKUSEA PSEUDOMEDIOFASCIATA Theobald.

Mon. Culicid., v., p.489 (1910).

Hab.—Q.: Cairns (F. H. Taylor).

Two specimens, both males, before me, agree perfectly with the description of this species They were bred from larvæ. It was originally described from Ceylon.

URANOTÆNIA ALBESCENS Taylor.

Trans. Ent. Soc. London, 1914, Pt. i., p.705.

Hab. – Q.: Cairns (F. H. Taylor).

The fourth segment of the abdomen is more correctly described as brown, with a median, apical, white-scaled area. The Cairns specimens, bred from larvæ, show the fourth segment entirely black.

URANOTÆNIA CAIRNSENSIS, sp.n.

♀. Head with dusky-brown, flat scales, with a fairly broad band of bluish-white scales round the eyes; antennæ dark brown, basal lobe and base of first segment yellowish, palpi black; clypeus dark brown; eyes silvery; proboscis dusky-brown.

Thorax brown, with brown scales and black bristles; scutellum with flat, black scales; pleuræ with white, flat scales; there is a short, pre-alar, white line of scales.

Abdomen with dusky-brown scales, all the segments with lateral, white scales; venter with white scales.

Legs dark brown, femora pale beneath, ungues very small, equal and simple.

Wings longer than abdomen; first fork-cell shorter and narrower than second, latter considerably nearer the base of the wing, stem of first more than twice the length of its cell, stem of second slightly longer than its cell; anterior basal cross-vein longer than the anterior cross-vein, and nearly twice its length from it; halteres pale, with black knobs.

Length 1·5 mm. (vix).

Hab.—Q.: Cairns (F. H. Taylor; July, 1917).

Described from two specimens, bred from larvæ. It is easily separated from other Australian species by its venational and abdominal markings.

URANOTÆNIA TIBIALIS, sp.n. (Plate lxxxii., fig.11).

♂. Head clothed with white scales, except in the centre, where they are brown; antennæ brown, basal lobes black, basal half of first segment pale; palpi dark brown; eyes black; proboscis brown.

Thorax with brown scales, and long, black bristles, apparently in four rows; a short, pre-alar line of bluish-white scales; scutellum with brown scales, pleuræ brownish, with bluish-white, flat scales.

Abdomen covered with black scales; venter brown-scaled.

Wings longer than abdomen; first fork-cell shorter and narrower than second; base of latter much nearer the base of the wing; stem of the first nearly twice the length of its cell; stem of second about the length of its cell; anterior basal cross-vein longer than anterior cross-vein, and once and a half its length from it.

Legs dusky-brown, femora basally pale beneath; apex of fore-tibiæ with a tuft of long, brown, hair-like scales, second tarsal clothed with fairly long scales, tarsi three to five pale; ungues of forelegs simple, rectangular, mid apparently the same.

♀. Similar to male Scales on the costa, subcostal and first longitudinal veins dusky as in male. Fore tibiæ normal.

Length: ♂, 1·75; ♀, 1·5 mm.

Hab.— Q.: Cairns (F. H. Taylor).

Described from one male and two female specimens, bred from larvæ. The black abdomen, venation, and fore-tibiæ of the male render this species distinct from its Australian congeners. The lengths are only approximately correct, as the specimens are doubled up.

URANOTÆNIA PROPRIA Taylor.

Trans. Ent. Soc. London, 1914, Pt. iv., p.704.

♀. Similar to male. First fork-cell shorter and narrower than second; stem of former nearly twice the length of its cell, stem of latter slightly longer than cell, anterior basal cross-vein longer than anterior cross-vein, and once and one-half its own length from it. Legs normal.

Hab. Q.: Cairns (F. H. Taylor).

This species was, previously, only known from the male.

URANOTÆNIA ANTENNALIS, sp.n.

♀. Head with pale scales in the centre, blackish elsewhere; eyes black; antennæ brown, basal lobes yellowish, first segment very long, about twice the length of the second, its base pale; palpi blackish.

Thorax brown, with brown scales and black bristles, and a short, narrow, pre-alar, white line of scales; scutellum with black scales; pleuræ brown, with white scales.

Abdomen covered with black scales; venter brown-scaled.

Legs dusky-brown; femora pale beneath, apical tarsi pale.

Wings: first fork-cell shorter than second, stem of first fork-cell about twice and one-half the length of the cell; stem of the second slightly longer than the cell; anterior basal cross-vein longer than anterior cross-vein, and twice its own length from it; scales on the costa, subcostal, and first long vein dusky, paler elsewhere.

Length 1·75 mm.

Hab.—Q.: Cairns (F. H. Taylor).

Described from two specimens, bred from larvæ. The first joint of the antennæ, and the venation separate this species from other described Australian species.

URANOTÆNIA HILLI, sp.n. (Plate lxxxiii., fig.12)

♂. Head covered with brown, flat scales; antennæ pale, nodes brown; eyes black and silvery; palpi brown, slightly longer than usually found in the genus.

Thorax covered with dusky-brown scales, prothoracic lobes prominent, dark-scaled; scutellum dark, denuded of scales; pleuræ yellowish-brown.

Abdomen with black scales; venter pale-scaled.

Legs dark brown; femora pale beneath.

Wings: fork-cells the same length, base of the second nearer the base of the wing; stem of the first fork-cell slightly shorter than its cell, stem of second not quite one-third shorter than its cell; anterior basal cross-vein longer than the anterior cross-vein and about once and one-half its own length distant from it.

Length 2 mm.

Hab.—N. Territory: Darwin (G. F. Hill; No.321).

Described from two specimens. The length of the first fork-cell is relatively longer in comparison with the second than is found in *Uranotænia,* but I prefer to regard this species as belonging to that genus.

Mr. Hill notes "larvæ in crab-holes in mangrove-swamps." It affords me much pleasure to dedicate this species to its discoverer.

Paratype in Coll. Hill.

HODGESIA CAIRNSENSIS, sp.n. (Plate lxxxiii., figs.13, 14).

Head with black and bluish scales. Thorax orange, with prominent black markings. Abdomen black-scaled, fifth segment apically white, the second to sixth segments laterally white. Legs unbanded.

♀. Head with black scales, with a triangular patch of bluish-white scales on the occiput and on the sides towards the base; eyes, palpi, and proboscis black; antennæ black, first joint long, basal half yellowish.

Thorax orange, with a prominent black spot above the wing-roots, and a broad, median, brown stripe from the centre to the posterior margin of the scutellum, sparsely covered with short, hair-like scales: scutellum pale on the sides, covered with small, black scales; prothoracic lobes with pale, flat scales.

Abdomen with black scales, first segment paler, segments two to six with lateral, white patches, fifth with a broad, white-scaled, apical band, apex bristly; venter pale-scaled, apical segment dark.

Wings considerably longer than abdomen, black-scaled: first fork-cell longer and narrower than second, base of the latter a little nearer the base of the wing; stem of the first fork-cell about three-quarters the length of the cell, stem of second about two thirds of its cell; base of second long vein carried well beyond the transverse vein; halteres pale, with black knobs.

Legs black; femora with the basal half above, and the under-surface, creamy; ungues very small, equal and simple.

Length, 1·5 mm.

Hab. – Q.: Cairns (F. H. Taylor).

Described from a long series taken in shady situations, on the edges of swamps, mainly sheltering in tree-holes. It is readily distinguished from *H. triangulata* Taylor, by its thorax and abdominal banding.

HODGESIA TRIANGULATA Taylor. (Plate lxxxiii., fig.15).

Trans. Ent. Soc. London, 1914, Pt. i., p.204; Proc. Linn. Soc. N. S. Wales, 1915, xl., p.184.

Hab.—Q.: Cairns (F. H. Taylor).

Fresh specimens show that segments two, three, five, and six have white, lateral spots, and that the venter is white-scaled.

This species is wrongly recorded as *Hodgesia trimaculatus* in the Zoological Record, li., Insecta, xii., p.277, 1914 (1916).

EXPLANATION OF PLATES LXXX.-LXXXIII.

Plate lxxx.

Fig.1.—*Anopheles* (*Myzorhynchus*) *barbirostris* var. *bancrofti* (Giles); head of male.

Fig.2.—*Toxorhynchites speciosus* (Skuse); head of male.

Fig.3.—*Armigeres breinli* Taylor; genitalia of male.

Plate lxxxi.

Fig.4.—*Grabhamia theobaldi* Taylor; wing.

Fig.5.—*Culicada wilsoni*, sp.n.; head of male.

Fig.6.—*Culicada wilsoni*, sp.n.; genitalia of male.

Fig.7.—*Culicada wilsoni*, sp.n.; wing of female.

Plate lxxxii.

Fig.8.—*Lophoceratomyia cairnsensis*, sp.n.; head of male, showing antennary organs.

Fig.9.—*Lophoceratomyia cairnsensis*, sp.n.; wing.

Fig.10.—*Molpemyia priestleii* Taylor; wing of female.

Fig.11.—*Uranotænia tibialis*, sp.n.; wing.

Plate lxxxiii.

Fig.12.—*Uranotænia hilli*, sp.n.; wing.

Fig.13.—*Hodgesia cairnsensis*, sp.n.; wing.

Fig.14.—*Hodgesia cairnsensis*, sp.n.; portion of wing under high power.

Fig.15.—*Hodgesia triangulata*, sp.n.; wing.

NOTE ON THE TEMPERATURE OF *ECHIDNA ACULEATA.*

By H. S. Halcro Wardlaw, D.Sc., Linnean Macleay Fellow of the Society in Physiology.

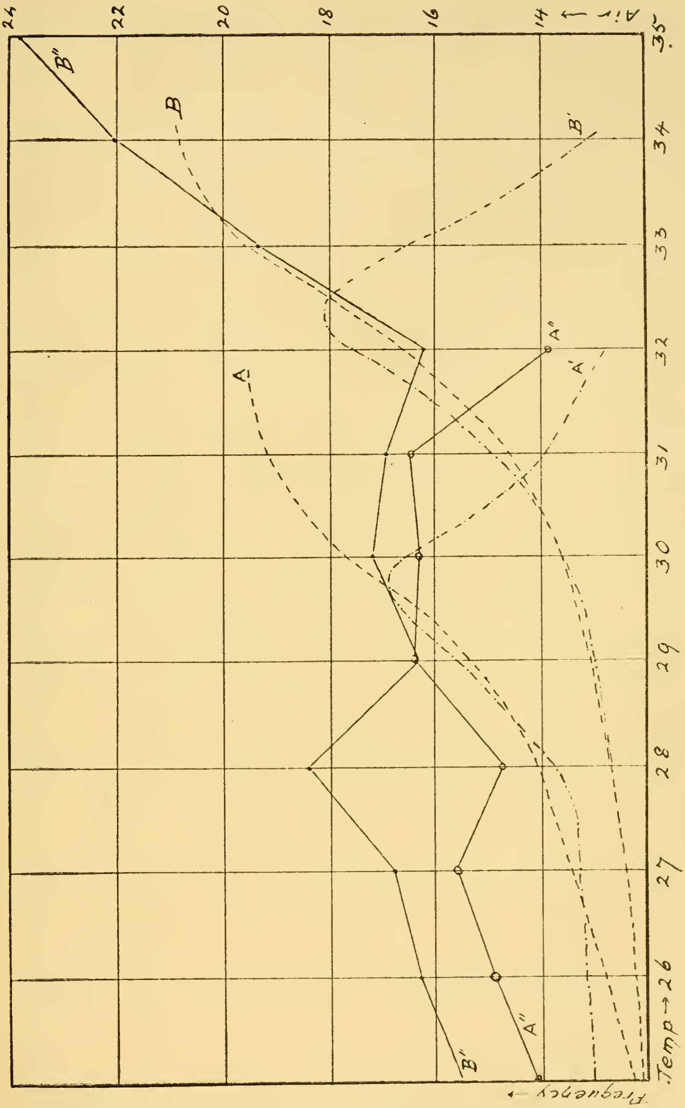
(From the Physiological Laboratory of the University of Sydney.)

(With two Text-figures).

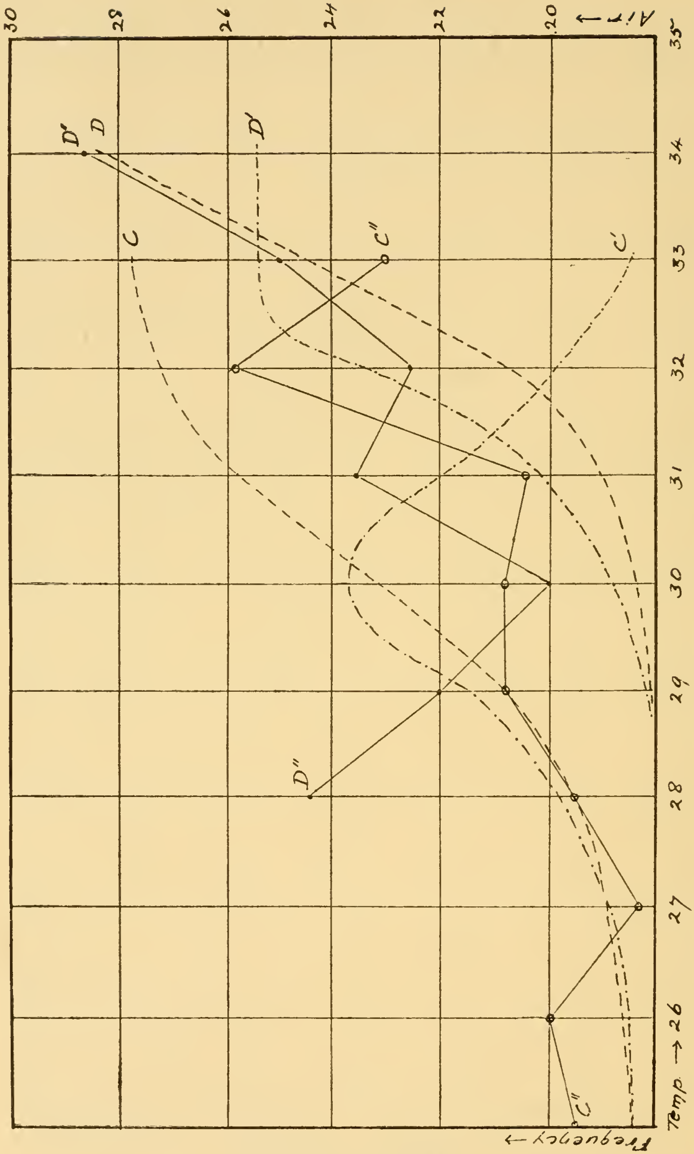
In a previous communication, the present writer has recorded a number of observations of the rectal temperature of *Echidna aculeata* (Wardlaw, 1915). The observations were made at different times of the day, and during different seasons of the year. As the temperatures showed considerable variations, even outside of the periods during which the animals were hibernating, some difficulty was experienced in arriving at an estimate of their normal waking temperature. Average values calculated from results varying like those obtained have no precise meaning. Yet to give the range of variation alone is hardly sufficient: a central value is necessary as a point of departure.

These results, therefore, have been submitted to a further examination, in which the graphic method of statistical analysis, due to Galton, has been applied in the manner described in a former paper (Wardlaw, 1917). In this way, it has been shown that the observations of temperature are not distributed at random over their whole range of variation, but occur more frequently in the vicinity of certain values, and that the temperature of this animal has certain definite most probable values for different times of the day at different seasons of the year.

In the accompanying diagrams (Text-figs. 1 and 2), the frequency of occurrence of different temperatures of Echidna, outside of the periods of hibernation, have been plotted. Temperatures of the animals are measured along the abscissæ. The relative



Text-fig. 1. (See p. 849).



Text-fig. 2. (See p. 849).

frequencies of occurrence of the various temperatures are proportional to the ordinates. Autumn and winter temperatures are given in Text-fig.1; spring and summer temperatures are given in Text-fig.2. The morning and afternoon temperatures are plotted separately in each diagram. The mean air-temperatures, corresponding to each range of 1°C. of the animal's temperatures, are also shown. The numbers of results represented by each of the four pairs of curves are as follows: autumn-winter period, morning, 188, afternoon, 242; spring-summer period, morning, 98, afternoon, 102. As these numbers are different, the ordinates of the different curves are not directly comparable with each other. This does not matter, however, as only the different ordinates of the same curve require to be compared.

Curve A, Text-fig.1, shows the ogive of the morning temperatures of Echidna during the autumn-winter period. Each ordinate is proportional to the number of observations occurring at and below the corresponding temperature. Curve A′ is the derived or frequency-curve; each ordinate is proportional to the number of observations occurring at the corresponding temperature. It will be seen that the maximum of this frequency-curve lies at 29·7°C.; this is the most probable morning-temperature of Echidna during the autumn-winter period. It will also be noticed that the curve A′ flattens out and becomes almost horizontal below a temperature of about 27·6°C. This portion of the curve continues down to about 8·0°C., but has not all been shown. The curve indicates that, below 27·6 C., Echidna allows its temperature to vary at random, and displays no tendency to bring it towards a definite value. By the time its body-temperature has fallen to 27·5°C., Echidna has thus become a completely poikilothermal animal.

The line A″ joins the mean air-temperatures corresponding to the different body-temperatures of Echidna, and is marked by circles.

Curve B, Text-fig.1, is the ogive of the afternoon-temperatures of Echidna during the autumn-winter period. Curve B′ is the corresponding frequency-curve. Its maximum occurs at 32·3°C., and this is the most probable afternoon-temperature of Echidna during the period in question. The line B″ joins the air-temperatures corresponding to the different temperatures of Echidna, and is indicated by dots.

Curve C, Text-fig. 2, is the ogive of the morning-temperatures of Echidna during the spring-summer period. C′ is the corresponding frequency-curve. Its maximum lies at 30·0° C., and this is the most probable morning-temperature of Echidna during spring and summer. The line C″ joins the average air-temperatures as before, and is indicated by circles.

Curve D, Text-fig. 2, is the ogive of the afternoon-temperatures of Echidna during the spring-summer period. D′ is the corresponding frequency-curve. The curve, it will be noticed, does not fall after rising to its maximum, but remains constant. The maximal value is reached at a temperature of 32·6° C. Above this temperature the frequency-curve is horizontal, and the temperature of Echidna varies at random. These facts indicate that there is an upper, as well as a lower, limit of temperature beyond which the temperature-regulating mechanism breaks down, and Echidna behaves as a poikilothermal animal. This mechanism is only effective while the animal's body-temperature lies between about 27·6° C. and 32·6° C., that is, over a range of variation of about 5° C.

The line D″ joins the average air-temperatures corresponding to the different afternoon-temperatures of Echidna during the spring-summer period.

The four curves show, that most probable temperatures of Echidna are 2·6° C. lower in the morning than in the afternoon during both of the periods in which the observations were made.

The most probable temperatures of the spring-summer period were very slightly (0·3° C.) higher than the corresponding temperatures of the autumn-winter period. The average air-temperatures were about 5° C. higher in the former than in the latter period.

SUMMARY.

The most probable temperatures of Echidna are: in the morning, 29·7°C. during autumn and winter; 30·0°C. during spring and summer. In the afternoon, 32·3°C. during autumn and winter; 32·6°C. during spring and summer.

The temperature-regulating mechanism of Echidna is only effective while the body-temperature lies between 27·6°C. and 32·6°C. Outside of these limits, Echidna behaves as a poikilothermal animal.

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————————*Ibid.*, 1917, xlii., p.815.

LEGENDS OF TEXT-FIGURES.

Text-fig.1 (p.845).

Relative frequency of occurrence of different autumn and winter temperatures of Echidna. Abscissæ, body-temperatures of Echidna. Ordinates of curves A and B are proportional to numbers of observations at and below the corresponding temperatures. Ordinates of curves A′ and B′ are proportional to numbers of observations at the corresponding temperatures. The points joined by the lines A″ and B″ indicate the average air-temperatures corresponding to each degree range of body-temperature. Letters A, A′, A″ refer to morning-temperatures; letters B, B′, B″ to afternoon-temperatures.

Text-fig.2 (p 847).

Relative frequency of occurrence of different spring and summer temperatures of Echidna. Abscissæ, body-temperatures of Echidna. Ordinates of curves C and D are proportional to numbers of observations at and below corresponding temperatures. Ordinates of curves C′ and D′ are proportional to numbers of observations occurring at the corresponding temperatures. The points joined by the lines C″ and D″ indicate the average air-temperatures corresponding to each degree range of body-temperature. Letters C, C′, C″ refer to morning-temperatures; letters D, D′, D″ to afternoon-temperatures.

THE OCCURRENCE OF METHYL LÆVO-INOSITOL IN AN AUSTRALIAN POISONOUS PLANT.

By James M. Petrie, D.Sc., F.I.C., Linnean Macleay Fellow of the Society in Biochemistry.

(With two Text-figures.)

(From the Physiological Laboratory of the University of Sydney.)

Heterodendron oleæfolium Desf., (Family Sapindaceæ) is a large shrub growing on the plains of the Western and Northern Interior of New South Wales, and is also found in all the other States of Australia. It has been described as a valuable forage-plant in the stock country because of its drought-resistant character.

Some time ago this plant was suspected to be the cause of certain fatalities among cattle and horses, and a sample was received by the writer for chemical investigation. It was found, when examined, to be a strongly cyanogenetic plant.

The main object of the extensive investigation carried out on this plant was, therefore, the attempt to isolate the cyanogenetic principle and to study its properties. During the course of the work there was separated a remarkable and interesting compound of lævo-inositol, and this paper will be confined to an account of the method by which it was obtained, and a general description of its characteristic features.

The material for the investigation was collected near Coonamble by Stock Inspector E. W. Procter, and forwarded to the University through the kindness of the Chief Inspector of Stock, Mr. S. T. D. Symons, M.R.C.V.S., to whom the author expresses his indebtedness and thanks.

METHOD OF EXTRACTION.

The plants were air-dried, and then the leaves were separated, crushed, and afterwards finely powdered. Of this air-dried leaf-powder, 2·5 kilos, corresponding to about 11·5 kilos. of fresh leaves, were extracted with 80% alcohol. The extraction was continued until almost complete; and the alcoholic fluid, measuring 31 litres, was distilled under diminished pressure, and at a temperature not exceeding 35 C. The distillation was continued till the residue was free from alcohol, and concentrated to a thick syrup. This viscous residue was treated with warm water, filtered through calico, and the residue washed until no more was dissolved. There was collected on the cloth-filter a black, sticky mass, consisting mostly of chlorophyll and resins, and weighing, when dried, 200gms., or 8% of the air-dried leaves. The aqueous filtrate, after standing in tall cylinders for a few days, deposited a considerable quantity of brown, amorphous resin. The latter was removed and washed with cold water.

The opaque, dark brown solution was next purified by the addition (1) of an equal volume of 10% lead acetate solution, and (2) of an excess of basic lead acetate, after removing the previous bulky deposit. These very voluminous yellow precipitates were separated by spinning in the centrifuge, and were washed in the same manner with cold water, and reserved. Next, the solution was made free from lead by saturation with hydrogen sulphide, and the precipitate removed and well washed.

The aqueous solution, measuring 18 litres, was now concentrated by distillation at a low temperature, to a volume of about 2 litres. At this stage, the solution was thoroughly extracted by shaking out with ether, and in this way the free acetic acid was removed.

CRYSTALLISATION.

Two volumes of strong alcohol were then added to the solution, and, on standing to settle, a dark syrupy deposit formed, from which the solution was decanted. The latter was then concentrated by evaporation to a viscous mass, and on the addition of 95% alcohol to this residue, an insoluble viscous substance remained. The alcoholic fluid was allowed to stand for some days, when there was formed a considerable quantity of clear glassy crystals. On evaporation at 35°C., and again treating with alcohol, a further separation of crystals took place. This evaporation and treatment with 95% alcohol was repeated three times, the mass of crystals was drained on a Buchner funnel, and washed with alcohol. The whole was then recrystallised from dilute alcohol, and the crystals dried. The weight of this substance, with the addition of a smaller amount obtained in the subsequent treatment of the solution, was 15 gms., equivalent to—

0·65 per cent. of the dried (at 100°) leaves.
0·60 per cent. of the air-dried material.

Purification of the crystals.—The whole of the substance was now dissolved in water, in which it was exceedingly soluble, and alcohol was carefully added to the point of incipient precipitation. On cooling the solution to 0°C., the substance slowly separated in fine transparent crystals. During this separation, the superfluid was decanted at intervals, till finally there were obtained twenty separate fractions. The first, tenth, and twentieth fractions, when dried, gave melting-points between 188° and 189·5°C. (uncorrected), thus proving the presence of a single substance only. The combined fractions were recrystallised three times, and dried in a desiccator.

PROPERTIES OF THE CRYSTALS.

The following tests are described in the order in which they were performed, and show the method by which the constitution of the compound was gradually elucidated.

Preliminary tests.—(1) On fermentation with a very active preparation of emulsin, no hydrocyanic acid was evolved. The compound is, therefore, not the active principle of the plant.

(2) When heated, the substance melted, charred, and burned entirely away without residue.

It consisted of the elements carbon, hydrogen, and oxygen only. The crystals possessed a very sweet taste, and were excessively soluble in water; from which facts it may be inferred that the compound contains a number of hydroxyl groups. When examined by the microscope, the crystal form was similar to that of cane sugar.

Molisch's reaction with sulphuric acid and α-naphthol or thymol gave no colour, and Fehling's solution was not reduced. The compound is, therefore, not a sugar.

(3) The melting-point, taste, and crystalline form are identical with those of the hexahydric alcohol, dulcitol; the latter, however, yields mucic acid when oxidised with nitric acid, whereas no mucic acid could be obtained from this substance.

(4) By treatment of the solution with phenylhydrazin acetate, no hydrazone or osazone could be obtained.

Silver nitrate in ammoniacal solution gave no precipitate in the cold; but, on warming, the solution slowly darkened with precipitation of the silver.

On boiling with dilute acids and alkalies, and subsequently recovering the compound, no apparent change in its properties was noted.

(5) *Quantitative determinations.*—The crystals, which had been formed in dilute alcoholic solution, and dried in a desiccator at the ordinary temperature, were heated at 110°C. for two hours, but showed no decrease in weight, and then at 150°C. for 30 minutes, with a similar result. The substance, therefore, contains no water of crystallisation.

The solubility showed that 1 gm. required 1·9 c.c. of water at 21°C., or 53%.

(6) The melting-point, as carefully determined on a standard Anschütz thermometer wholly immersed, was 190°C.

(7) Ultimate analysis of the substance yielded the following results:—

0·1262 gm. gave ... 0·083 H_2O and 0·1983 CO_2.
Equivalent to ... 7·3% H and 42·9% C.
$C_7H_{14}O_6$ requires 7·2% H and 43·3% C.

This formula, which conforms most closely to the figures obtained for the substance, is possessed by the methyl-hexoses, simple glucosides, and certain derivatives of benzene.

(8) A determination was made of the number of methoxy

groups present in the molecule, by Perkin's modification of the method of Zeisel. By heating in pure hydriodic acid, methyl iodide distilled over into silver nitrate solution.

0·2 gm. gave	... 0·2315 gm. silver iodide.
Representing	... 0·0306 gm. CH_3O.

$C_7H_{14}O_6$ requires 0·0310 gm. for one CH_3O group.

The substance can, therefore, be represented by the formula $CH_3 \cdot C_6H_{11}O_6$, and the residue remaining in the Zeisel apparatus should possess the formula $C_6H_{12}O_6$. In order to recover this substance for examination, the solution, from which the methyl iodide had been driven off, was heated on the water-bath to remove hydriodic acid, and then evaporated to dryness. By extracting this residue with alcohol and cooling to 0°C., white crystals were recovered.

Crystals dried in desiccator and weighed...	0·160 gm.
Crystals dried at 110°C. and weighed ...	0·160 gm.
$C_7H_{14}O_6$—0·2 gm. requires	0·186 gm.

The crystals are, therefore, without water of crystallisation. The low yield may be accounted for by partial decomposition during the boiling with hydriodic acid, as the odour of benzene and phenol was distinctly detected.

(9) *Properties of the demethylated substance.*—After three crystallisations, the substance gave a melting-point of 238°C., and charred at 239°C., carefully determined on an Anschütz standard thermometer with the column submerged.

This substance also gave a negative result with Molisch's test, proving the absence of all open-chain carbohydrates; and since benzene and phenol were identified as decomposition-products of the ester, the possible cyclic compounds may next be considered.

The formula $C_6H_{12}O_6$ is contained in the inositol ring, for the identification of which the following reactions are specific:—

(*a*) *Scherer's test* gave positive reactions with this substance, and likewise with the original methyl derivative. When a little of the solution is evaporated with nitric acid, neutralised with ammonia, and calcium or barium chloride added, a brilliant rose-red colour appears. (Liebig's Annalen der Chemie u. Pharm. 81, 1852, 375).

(*b*) *Gallois' test* gave positive results with both substances. When the crystals are treated with mercuric nitrate, a yellow precipitate first forms, which, on evaporating to dryness, gives a deep red colour; on cooling, this colour slowly disappears, to return on being reheated. (Fres'. Zeitschrift für anal. Chemie, iv., 1865, 264).

These two characteristic reactions are due to the oxidation of inositol to a quinonoid substance known as rhodizonic acid, whose salts with calcium, barium, and mercury, possess the bright colours described.

The reduced substance is thus proved to be one of the inositols, and the original compound isolated from the plant-extract is its methyl ester.

(10) *Optical properties.*—A polarimetric determination of the two substances was made with a Schmidt and Haensch polarimeter reading to one-hundredth of a degree.

Methyl inositol 0·5 gm. was dissolved in 10 c.c. of distilled water at 16°C., and a lævo rotation was recorded of $-4{\cdot}01^\circ$ in a 1 dcm. tube.

The specific rotatory power $[\alpha]_D^{16} = -80{\cdot}2$; $[M]_D^{16} = -155{\cdot}6$.

The solution was boiled for two minutes, and after cooling to 16°C., was again read in the polarimeter. No change was observed, such as is due to mutarotation among the hexoses.

Inositol, the de-methylated compound, 0·0741 gm. was dissolved in 10 c.c. of water at 16°C., and showed a lævo rotation of $-0{\cdot}48^\circ$ in a 1 dcm. tube.

Specific rotatory power $[\alpha]_D^{16} = -64{\cdot}8$; $[M]_D^{16} = -116{\cdot}7$.

(11) *Hydration.*—The lævo-inositol was obtained by crystallisation from cold aqueous alcohol, and contained no water of crystallisation. When crystallised from water, it was also obtained in anhydrous crystals.

Now Maquenne and Tanret have described some important differences with regard to the water of crystallisation in the isomeric inositols.* They found that—

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* Recherches sur l'inosite, Maquenne—Annales de chemie et de physique, xii., 1887, 94; Comptes rendus, cx., 1890, 87.

Inactive-inositol	
from dil. alcohol, or water under 50°C., gave	crysts. with $2H_2O$.
from dil. alcohol, or water above 50°C., gave	anhydrous crysts.
Dextro-inositol	
from dil. alcohol, or cold water, gave	anhydrous crysts.
from cold water seeded with hydrate crysts., gave	crysts. with $2H_2O$.
from hot water, gave	crysts. with $2H_2O$.
Lævo-inositol	
from cold water, gave	crysts. with $2H_2O$.
from hot water, gave	crysts. with $2H_2O$.
from dil. alcohol, gave	anhydrous crysts.
Dl-inositol	
from cold water, gave	anhydrous crysts.

It is to be pointed out that the inactive and dextro forms give reverse results with the same treatment. Maquenne, in comparing the dextro- and lævo-isomers, could always obtain the former from cold water in anhydrous crystals, but was quite unable to obtain the same with the lævo form.

The following results were obtained with the lævo-inositol from *Heterodendron*, and are of interest when compared with the figures in the previous table.

	gm.
1. Heated at 110°C. for 1 hour	0·5505
2. Dissolved in cold water, dried in desicc. at 25°C. for 2 days	0·5522
,, ,, ,, 25°C. for 1 day	0·5511
,, ,, ,, 25°C. for 1 day	0·5508
3. Dissolved in water at 70°C., crystd. at 70°C., dried in desicc.	
at 25°C. for 2 days	0·5678
at 25°C. for 1 day	0·5650
at 15°C. for 3 days	0·5530
at 15°C. for 3 days	0·5512
4. Heated at 100°C. for 3 hours	0·5508
5. Diss. in water, dried in the open at 15°C.	0·5508
Inositol $\cdot 2H_2O$ requires	0·5660

The crystallisation from cold water, therefore, left anhydrous inositol when kept over sulphuric acid, or dried in the open.

When crystallised at 70°C., and subsequently kept over sulphuric acid for two days, the crystals contained an equivalent of two molecules of water; but since this water was gradually lost at the ordinary temperature standing over sulphuric acid, or in the open, apparently it was not combined as hydrate in the crystals.

The hydrates obtained by Maquenne and others were only decomposed at 100°C. If the hydrate exists in the above case, it is decomposed by drying at the ordinary temperature.

The lævo-inositol of this research, therefore, was obtained in anhydrous crystals only. The hydrates prepared by the French chemists could not be obtained.

The substance isolated from *Heterodendron oleæfolium* is thus proved to be the methyl ester of *lævo-rotatory* inositol.

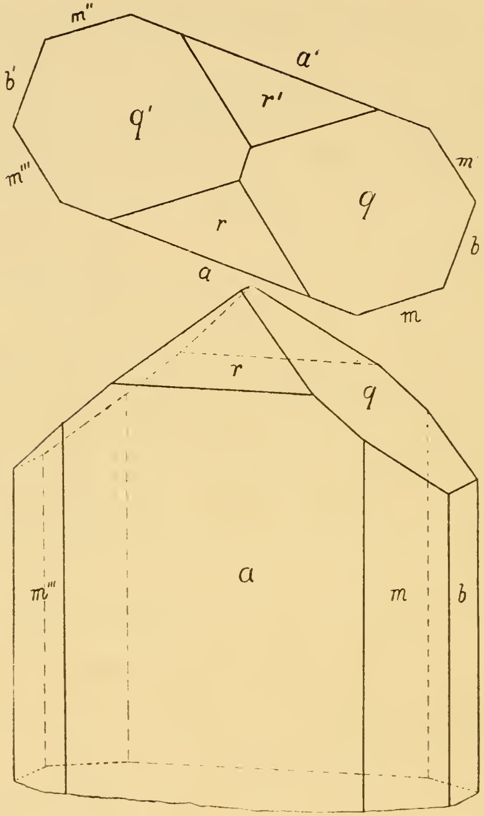
(12) *Crystal Form.*—The outward structure and measurements of the crystal forms are intimately related to the internal structure of the isomeric molecules, and, therefore, form an essential part in the elucidation of the individual members of a group. The methyl inositols apparently have never been examined by crystallographers, and indeed, as far as the author can ascertain, only inactive inositol crystals have been examined by the goniometer.

The goniometric determinations of the crystal forms of l.-methyl inositol were kindly made by Dr. C. Anderson, Mineralogist to the Australian Museum, and are here included.

Crystal Measurements of Methyl lævo-inositol.

By Charles Anderson, M.A., D.Sc.

The crystals are small, the largest being about 2 mm. in length. They belong to the orthorhombic system and are very uniform in development and habit; of the five crystals measured, four show the forms *a*(100), *b*(010), *m*(110), *q*(011), while one has, in addition, one face of the form *r*(101), and they are all tabular on *a*. The faces are by no means perfect, being interrupted and wavy, the signals are only fair, and, consequently, the measurements are not in close agreement. The crystals were measured on a two-circle goniometer, the reducing lens being used.



Text-fig. 1.

The axial ratios were calculated from the following angles.

Form.	ϕ		ρ		No. of obs.
	Mean.	Limits.	Mean.	Limits.	
*m*110	52°44′	51°30′—53°27′	—	—	17
*q*011	—	—	39°26′	39°0′—39°49′	8

The elements deduced from these angles are

$$a:b:c = 0{\cdot}7609:1:0{\cdot}8224.$$

Forms and angles.

Form.	Symbol.	Measured.		Calculated.	
		ϕ	ρ	ϕ	ρ
a	100	89°54′	90°4′	90°0′	90°0′
b	010	0°5′	90°22′	0°0′	90°0′
m	110	52°44′	90°2′	—	90°0′
q	011	0°0′	39°26′	0°0′	—
r	101	88°33′	47°43′	90°0′	47°13′

THE INOSITOLS.

Position of the group.—The relative position of the group, and the mode of occurrence of its members in nature, are of considerable interest to the biochemist, especially since the discovery of "phytin" in plants by Paladin, in 1895.

The basis of inositol is the hexamethylene ring $(CH_2)_6$. Hexamethylene, C_6H_{12} (Text-fig. 1), occurs only in the hydrocarbons of the petroleum of Russia, Galicia, Baku, East Indies, and California, in the fraction boiling about 80°C. It has not been detected in plants or animals.

By the substitution of hydroxyl groups (OH) in the hexamethylene ring, the following series of compounds is obtained:—

(OH), $(OH)_2$, $(OH)_3$—synthetic compounds only.

$(OH)_4$—betite, isolated from beet sugar residues.

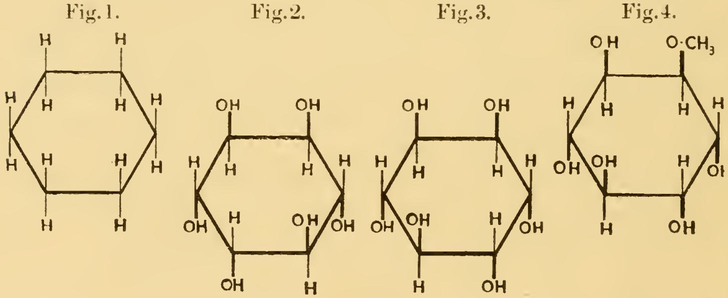
$(OH)_5$—quercite, in oak and other plants.

$(OH)_6$—inosite, in many animals and plants.

Inosite, or inositol, has, therefore, the constitution of a hexahydroxy hexamethylene $C_6H_6 \cdot (OH)_6$, and although its formula may be written $C_6H_{12}O_6$, it is nevertheless, in its relationships, far removed from the carbohydrates.

The constitution of Inositol.—The configuration of the inositol molecule, or, in other words, the arrangement of its atoms in space, admits of eight different geometrical groupings resulting in eight possible isomeric forms. When these and their mirror-images are built up in models, it is found that seven of the forms may be superimposed on, and, therefore, coincide with, their mirror-images. This condition, arising from a certain degree of molecular symmetry, is accompanied by inactivity towards polarised light. These seven forms having their asymmetric carbon atoms internally compensated, are, therefore, optically inactive in the polarimeter. One form alone is found to possess an entirely asymmetric molecule, and, in consequence, this arrangement can exist as active dextro and lævo compounds, and, in addition, their *dl-* or racemic inactive combination may also exist.

Constitution of the methyl esters.—As has just been stated, the active forms of inositol are the result of one particular arrangement of the hydroxyl groups. This arrangement, which may be readily discovered in the models, is that where the six hydroxyl groups occupy the positions 1, 2, 4, on each side of the ring. This form (Fig.2) and its mirror-image (Fig.3) constitute the dextro- and lævo-inositols.



Hexamethylene. dextro- and lævo- inositol. methyl lævo-inositol.

Text-fig.2.

The methyl ester, $C_6H_6(OH)_5\,(OCH_3)$ is obtained by substitution of a methyl group in one of the hydroxyl groups, and again from the models it can be proved that substitution in the hydroxyl 1, 2, or 4 results in three possible and different compounds being obtained. The first of these is represented by Fig.4. The corresponding three positions in the mirror-image (Fig.3)—which are identical with the alternate three positions below in the other form (Fig.2)—produce their optical antipodes. The possible existence of three dextro- and three lævo-methyl esters is thus determined. It now remains to ascertain (*a*) whether the few inositol esters which have been isolated up to the present time, represent the same stereo-isomer, (*b*) whether the compound obtained from *Heterodendron* is identical with any of the others, or represents the second or third isomer.

Occurrence in nature.—It has been previously stated that theoretically there can exist ten stereo-isomeric forms of inositol as a maximum possible number:—

7 inactive by internal compensation (meso),
2 active, dextro and lævo,
1 inactive, racemic or *dl*,
—
10 isomeric forms.
—

Only the inactive inositols have yet been found existing in the free state in nature, but esters of both active and inactive inositols are found.

(*a*) *Inactive inositol.*—This form, widely distributed in animal tissues, and already well known to physiologists, possesses the formula of one or other of the seven internally compensated molecules, and it is worthy of note that this is the only form found in the animal kingdom. It has always been referred to in physiological chemistry as one substance, with definite and constant general properties. But no one so far has troubled to examine minutely, material from widely different sources or organs, as to the particular properties which would differentiate these inactive isomers, such as crystallographic measurements, or optical properties.

It was discovered in animals, in 1850, by Scherer, in extracts of flesh,[*] and in plants, six years later, by Vohl.[†] This author was examining the sap of unripe pods of *Phaseolus vulgaris*, and after completely fermenting the sugars, and distilling off the alcohol, he found that the solution still possessed a very sweet taste. He then separated a manna-like substance, which he called

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[*] Liebig's Annalen der Chemie und Pharm., lxxiii., 1850, 322.

[†] *Ibid.*, xcix., 1856, 125.

phaseo-mannite. In the following year, the same chemist proved the identity of his mannite with Scherer's inosite from animals.

The occurrence has been recorded of three other substances, which are believed to be isomeric with inactive inositol, since they, although differing widely in crystalline form, melting-point, and solubility, possess the same general characters. These are the scyllite of Stædeler, from certain elasmobranch fishes, the quercinite of Delachanel, from the oak, and the cocositol of Mueller, from the cocoanut.

The compounds of inactive inositol which have been found in nature are:—

Bornesite—the methyl ester, obtained from caoutchouc.

Dambonite—the dimethyl ester, obtained from caoutchouc.

Phytin—the phosphate ester, an essential constituent of all plants and animals.

(*b*) *Dextro-inositol* occurs only as the methyl ester, pinite. It was discovered by Berthelot,[*] in 1856, in the resins from Oregon pine, and has since been found in senna leaves, and caoutchouc.

(*c*) *Lævo-inositol* is likewise found only as the methyl ester, and the following is a complete record of its occurrence:—

1. In quebracho bark, *Aspidosperma quebracho* (Apocynaceæ), discovered by Tanret, of Paris, in 1889,[†] and named by him quebrachite.

2. In *Hevea brasiliensis* (Euphorbiaceæ), in the aqueous solutions of the latex after coagulation of the rubber,[‡] and in Para rubber.[§]

3. In *Grevillea robusta* (Proteaceæ).[||] It is associated in the leaves with the glucoside arbutin.

4. In *Heterodendron oleæfolium* (Sapindaceæ), this paper.

(*d*) *Racemic inositol* was discovered in mistletoe by Tanret in

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[*] Annales de chimie et de physique, xlvi., 1856, 66.

[†] Comptes rendus de l'Acad. des Sciences, cix., 1889, 908.

[‡] de Jong, 1906, thro. Wehmer's "Die Pflanzenstoffe."

[§] Pickles and Whitfield, Proc. Chem. Soc. Lond., 1911, 54.

[||] Bourquelot et Fichtenholz, Journ. pharm. et de chimie, Paris, vi., 1912, 346.

1907.* It was found to exist free in the berries and leaves, and associated with much (meso) inactive inositol, but no active isomers were present.

THE ACTIVE FORMS OF INOSITOL.

The following Table shows the physical constants by which the active forms and their compounds are identified.

	melting-point.	spec. rot. power.
(1) *Dextro-methyl ester.*		
From Pinus (Maquenne)	186°C.	+65·5
Pinus (Combes)	186·5	65·7
caoutchouc (Combes)	187	66
caoutchouc (Girard	181	64·7
(2) *Lævo-methyl ester.*		
From Quebracho (Tanret)	190°C.	−80
Rubber (Pickles and Whitfield)	191-2	80
Grevillea (Bourquelot)	190	80·3
Heterodendron (this paper) ...	190	80·2
(3) *Dextro-inositol.*		
From pinite (Maquenne)	247°C.	+65
pinite (Berthelot)	245	—
caoutchouc (Combes)	246	67 6
caoutchouc (Girard)	235	64·7
(4) *Lævo-inositol.*		
From Quebracho (Tanret)	238°C.	−65
Quebracho (Maquenne) ...	247	65
Rubber (Pickles and Whitfield)	237	—
Grevillea (Bourquelot)	247	65
Heterodendron (this paper) ...	238	64·8

Table showing the amount of methyl lævo-inositol obtained from the different sources:—

Aspidosperma quebracho ...	0·1% of dried leaves.
Hevea brasiliensis rubber ...	(2·5% of the rubber).
Grevillea robusta	0·4% of dried leaves.
Heterodendron oleæfolium ...	0·65% of dried leaves.

From the first Table, it is apparent that the lævo-methyl inositols (2) from the four different sources, have identical melting-points and specific rotatory powers, and therefore, in all probability, represent one only of the three possible stereo-isomers previously mentioned.

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* Comptes rendus de l'Acad. des Sciences, cxlv., 1907, 1196.

When converted to lævo-inositol (4), however, there would appear to be two groups of melting-point figures, one 10° higher than the other, but since there can be only one possible *l*-inositol, this difference must be otherwise explained.

The Table also shows that while the dextro- and lævo-inositols (3 and 4) are optical antipodes of one another, their esters (1 and 2) are not. The optical properties especially are so very divergent that, in all probability, the methyl group occupies a different position in the two compounds. The compound isolated from Heterodendron is, therefore, shown not to be an optical isomer of Maquenne's pinite.

BIOCHEMICAL RELATIONSHIPS AND SIGNIFICANCE.

(*a*) *The chemical aspect.*—Since the researches of Maquenne, cited in the previous paragraphs, no subsequent work has shown any relationship between the inositols and the carbohydrates, other than the sweet taste and the molecular formula common to both. Perhaps one exception to this is found in Neuberg's identification of furfural among the products of decomposition, when inositol is boiled with acids.* Although furfural is also obtained from the hexoses and heptoses in small amounts (about 0·2%), it is characteristic of the pentose sugars. It must be also remembered that the production of furfural is the basis of Molisch's group-test for all carbohydrates, and with this reagent the inositols gave negative results.

However, it seems probable from the results of many workers that the hexamethylenes form a kind of stepping-stone between the open chain compounds and the true benzene ring derivatives.

Open chain comps.	*Closed ring comps.*	
hexose sugars	*hexamethylene derivs.*	*Benzene derivs.*
dulcitol	quercitols	phenols
mannitol	inositols	
sorbitol		

The hexamethylene derivatives are much more easily decomposed than the simple benzene compounds. In fact, it has been

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* Biochem. Zeitschrift, ix., 1908, 551.

found by Drechsel that fungi and bacteria may be grown in solutions of the former, especially the oxidised forms quercitol and quinic acid. It has also been proved that when phenol is exposed for some time to the alternating electric current, it is first converted to hexamethylene derivatives, before being finally oxidised and split up into various fatty acids.*

Though there are many instances of the closing up of open chain carbon compounds into ring compounds, such as the conversion of citral into cymol, the cyclo-citrals, and terpenes; geraniol into dipentene, etc.; yet no such conversions have been accomplished between the carbohydrates and the inositols Griffin and Nelson, in their researches on inositol and pinite, tried by various methods to close up the hexose chain, and to open out the inositol ring, but were entirely unsuccessful.†

(*b*) *The biochemical aspect.*—On the other hand, in favour of the biochemical possibility, there exist the important observations of Neuberg: that quercitol and inositol may be reduced in a few minutes to open chain carbohydrates (reducing Fehling's solution, etc.) by the action of sunlight and a catalyser such as uranium salt, also by the action of the alternating current.‡

These processes, however, are all reverse reactions, resulting in cleavage of the hexamethylene ring. Concerning the direct synthesis—carbohydrate to inositol, we have no evidence at all, and Maquenne had no experimental basis for his belief that the alcohol mannitol was the source of inositol.

Rosenberger observed the appearance of inositol in post mortem tissues, where previously no inositol existed; and he assumed the pre-existence of an "inositogen" from which, by enzyme-action, the inositol was formed.§

The inactive inositol combines with inorganic phosphates, and in this form exists as "phytin" in nearly all living organisms. This substance is always accompanied by the enzyme phytase,

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* Journ. für prakt. Chemie, xxxviii., 1888, 65.

† Journ. Amer. Chem. Soc., xxxvii., 1915, 1552.

‡ Biochem. Zeitschrift, xiii., 1908, 308.

§ Zeitschrift für physiol. Chemie, lvi., 1908, 373.

which effects its cleavage and yields inositol again, in the free state. Starkenstein's investigations show that the source of free inositol in tissues is the phytin, and that inositol is a decomposition-product of the phosphoric acid metabolism in both plants and animals.* Indeed, much work has been done in elucidating the conditions of this transformation on the side of the phosphoric acid, but again, as to the inositol side, nothing is known.

The few definite observations concerning the part played in metabolism, by inositol, are here summarised:—

1. In *unripe seeds*, inositol and quercitol accumulate just at the time when the transport of carbohydrates to the fruit begins.
2. As the *fruit ripens*, Vohl observed that inositol and quercitol disappear, and are changed into "phytin" (not carbohydrate).
3. On the *germination of the seeds*, inositol again makes its appearance, both when grown in the dark and in the light.
4. During the metabolism of the *growing plant*, inositol disappears gradually with the rest of the reserve-substances.

Thus it comes in at the beginning and later passes out again, without a clue to its precursors or katabolites.

When fed to animals, or injected into the blood-stream, inositol is about three-fourths decomposed, and the remainder may be recovered from the urine unchanged. Mayer injected large doses into rabbits, and obtained, from the urine, racemic lactic acid. It is likewise decomposed by fungi into butyric and lactic acids.

This inactive inositol, which occurs so widely in fresh green plants, has been shown by many workers to be present in much larger quantities in young growing plants (and animals) than in the adult forms. It almost entirely disappears from plants when they are slowly dried.

The esters of active inositol, on the other hand, do not vanish on drying the plants. When we consider the great rarity of their occurrence, and the fact that the active forms have never been identified in nature as free inositol, it almost leads one to assume for them a different origin. Such an origin would be more in common with that of certain well known plant-con-

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* Biochem. Zeitschrift, xxx., 1911, 98.

stituents, which also possess side-chains in the 1. 2. 4. positions on the benzene ring, corresponding to the positions of the hydroxyl groups of the active inositol esters: a few of these may be mentioned, such as vanillin, eugenol, safrol, coniferyl alcohol, protocatechuic and caffeic acids.

In conclusion, the author desires to express his indebtedness to Professor Sir Thomas Anderson Stuart, in whose laboratory this work has been done.

SUMMARY.

The endemic Australian plant, *Heterodendron oleæfolium* Desf., Family Sapindaceæ, contains the methyl ester of lævo-rotatory inositol.

The amount isolated was equivalent to 0·65% of the dried (at 100°C.) leaves.

This substance is not optically isomeric with the pinite of Maquenne, which is the methyl dextro-inositol, possessing a different melting-point and optical rotation.

It is apparently identical with Tanret's quebrachite, and has been previously recorded from three plants only—*Aspidosperma quebracho* (Apocynaceæ), *Hevea brasiliensis* (Euphorbiaceæ), and *Grevillea robusta* (Proteaceæ).

The occurrence of this compound is, therefore, exceedingly rare, and is in great contrast to the occurrence of *inactive* inositol, which exists as a plastic substance in most plants.

Heterodendron also contains a cyanogenetic glucoside.

AN ACCOUNT OF SOME OBSERVATIONS UPON THE LIFE-HISTORY OF *PHOMA CITRICARPA* McAlp.,

The Cause of the "Black Spot" Disease in Citrus Fruit in New South Wales.

By G. P. Darnell-Smith, D.Sc., F.I.C.

(Plates lxxxiv.-xc.)

Historical.

A. H. Benson(**1**) briefly described the symptoms of a disease, to which he gave the name of the Black Spot disease of the Orange, in 1895. He stated that it was probable that it was identical with a disease of the orange in Europe, that had been alluded to by Sorauer, under the name of "Schwartz" or black disease of the orange. There is little doubt, however, from his figure, that it was the disease caused by *Phoma citricarpa* McAlp., with which Benson was dealing. Benson records the disease as occurring at Seven Hills, Castle Hill, Dural, the Kurrajong, and Emu Plains.

N. A. Cobb(**2**) described the Black Spot Disease of the orange in 1897. He gave some excellent figures of affected fruit. He also figured the spores. According to Cobb, "these spores arise after the manner of those of the genus *Glœosporium*. It is possible, therefore, that the Australian form is the *Colletotrichum adustum* of Ellis." He further stated that the spores were borne in large numbers in tandem-fashion from the mycelium at the base of the interior of the pycnidium in a manner entirely similar to those of the Bitter Rot of the apple, and gave the size of spores as 7-8 × 10-15μ.

The fungus causing the Black Spot Disease of Citrus fruit was described as a new species under the name of *Phoma citricarpa* by D. McAlpine, in "The Fungus Diseases of Citrus Trees in

Australia,"(3) November, 1899, and recorded in Vol. xvi., 854, of Saccardo's Sylloge Fungorum(4). McAlpine appears to have written a letter to Saccardo, in which he stated that the *Phoma* looked somewhat like a *Phyllosticta.*

In the Melbourne Herbarium there are a number of specimens marked *Phyllosticta citricarpa*—see *Phoma*. As no *Phyllosticta citricarpa* appears to have been described, it is probable that it is to the letter written by McAlpine that Saccardo refers in his footnote.*

McAlpine states that the Anthracnose disease in Florida, due to *Colletotrichum adustum* Ellis, and the black disease of oranges in Italy known as "La Nebbia," due to the fungus *Pleospora hesperidearum* Catt, are quite distinct from the Black Spot disease of Oranges found in New South Wales, due to *Phoma citricarpa* McAlpine.

He states that the disease has not been met with in Victorian orchards.

McAlpine's description of the fungus is as follows: *Phoma citricarpa*, n.sp.—"Spots dark brown, at first whitish or greyish towards centre, but may ultimately become of one uniform colour, round, sunken, solitary or confluent, varying in size from 1 mm. to 5 mm., and, when confluent, forming large irregular patches ($\frac{3}{4}$ in. or more)."

"Hyphæ permeating rind, hyaline, septate, branched, 4-5½μ broad."

"Perithecia, solitary or in groups, somewhat circularly arranged, minute, black, but dark brown by transmitted light, punctiform, globular, erumpent; pore about 20μ diameter, although it may be somewhat elliptical, 100-120μ diameter. Sporules hyaline, somewhat variable in shape, elliptical to ovate or even pear-shaped, with conspicuous granular contents, 8-11 × 4½-6μ, average 9½ × 5½μ. (Stained a light green by potassium-iodide-iodine); basidia hyaline, slender, about 6μ long."

"On ripe or still green Oranges, Lemons, and Mandarins, winter, spring, and summer, New South Wales."

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* For this information, I am indebted to Mr. C. C. Brittlebank, Plant Pathologist to the Department of Agriculture, Victoria.

"The round, sunken, conspicuous spots are generally of a ruddy-brown tint, and paler in the centre where the pustules are seated."

"This is a distinctive species in the small size of the perithecia, as well as in the size and shape of the sporules."

N. A. Cobb(**5**), in 1904, described some attempts to germinate the spores of *Phoma citricarpa.* He states that – "The spores of this disease do not germinate under the laboratory conditions ordinarily brought to bear in their examination, and, in this respect, they differ from most spores found in connection with prevalent fungus diseases. The following observations, though they are inconclusive, are inserted here out of regard to the rarity with which I have observed these spores to germinate. . . . Spores of this fungus were ringed in a small supply of water and numerous air-bubbles. After twenty-four hours, the spores had failed to germinate in those parts where they were completely surrounded with water. Spores located at the edges of air-bubbles where, on one side, they had access to air, each sent out into the air a single very fine unbranched mycelial thread about one micromillimetre wide, though slightly wider at the free end. The mycelium was colourless, and so fine as, under the circumstances, to preclude observation as to septa; none were seen. At the end of twenty-four hours, the length of these hyphæ averaged several times the length of the spores."

General Symptoms of the Disease.

The disease, which is now commonly known in New South Wales as Black Spot or Anthracnose of Citrus Fruit, appears as minute black spots upon the foliage throughout the year. Upon the fruit, it is seldom seen till the beginning of August. In September, particularly after hot westerly winds, it may quite suddenly make its appearance upon the fruit throughout an orchard. Dark brown, irregular spots first make their appearance upon the skin. The spots vary in size from one-eighth of an inch or less to half an inch or more in diameter. Later, these become depressed, and some may become confluent. The inner part of the spot next becomes of a light cream-colour, and somewhat parchment-like in texture. Shortly after, minute black pycnidia are formed beneath the surface; and, breaking through, form small irregular fissures or minute holes, at which points the spores are discharged through the necks of the pycnidia.

The disease almost invariably makes its appearance on the sunny side of the tree, and upon that side only of the fruit which is exposed to the sun. So constantly is this the case, that, in an affected orange, it is almost always possible to draw an equatorial line dividing the sunny from the shaded side of the fruit, and, on the former side only, will black spots be found. Even on the sunny side of the tree, if the fruit is well shaded by foliage, it is seldom affected by the disease, even when exposed fruits around it are badly marked.

That the rind has some principle that may inhibit the growth of spores, is suggested by the incidence of the disease in the various varieties of citrus fruit. It is common on the orange (navel, valentia, siletta), it is found less frequently on the Emperor mandarins, and quite exceptionally upon the thorny mandarin.

The infection of the fruit only upon one side of the tree suggests that it may be related to the prevailing wind, or to the effect of too much sunlight or heat upon the rind.

The development of the disease only upon the sunny side of the tree indicates that it is the sun, rather than the wind, that exerts an influence.

To test the effect of diminishing the amount of sunlight falling upon the trees, and to protect them from scorching winds, two trees in an orchard were completely covered-in with hessian in the form of a tent. They were covered in at the beginning of June, that is, at the commencement of the ripening period.

The fruit on these trees did not show black spot on the fruit for two or three weeks after the uncovered ones, and then the spots developed very slowly, remaining a dull brown colour; and they did not pit the fruit to such an extent as fruit exposed to the weather. The spots upon uncovered fruit soon become black. The following season, two trees were protected from the sun by putting up a screen of hessian upon the sunny side only. Here again, the disease was slower in developing upon the fruit, and the spots remained of a dull brown colour. Since dew would be just as heavy upon one side of the tree as another, its action, except in conjunction with the sun, may be left out of account. As regards the wind, the prevailing winds would tend to blow spores upon the east side of a tree in the Gosford district, where these observations were carried out; there is very seldom a north-west wind.

The spores from infected leaves, falling upon the fruit, become uniformly distributed in the dew-drops. This uniformity of distribution is shown in the equidistant positions that the ripe spores take up, when introduced into hanging drops.

From the foregoing considerations, it seems probable that the spores distributed on the surface of the fruit effect an entrance, with their germ-tubes, into the rind, when its natural inhibiting power, due to physical or chemical causes, has become impaired by exposure to the heat of the sun.

Culture of the Fungus.

By successive transportation of groups of spores to sterile drops of water, isolated spores were obtained. These were transferred to various culture-media, and pure cultures in Petri-dishes or test-tubes, were at length obtained. These were grown in an incubator at a temperature of 22°C. The media in which the fungus was most successfully cultivated were ordinary nutrient agar, glucose-agar, and agar impregnated with watery extract of orange-peel. The growth of the fungus upon each of these three media is very different.

Upon ordinary nutrient agar, growth proceeds very slowly. Little patches of dark brown hyphæ arise, creep over the medium, and penetrate it. But they seldom travel far from the site of inoculation, and, if several spores have been introduced into a Petri-dish, it is possible to obtain several isolated plants before the hyphæ have become interlaced.

Upon glucose-agar, the other extreme is reached. The plant grows so luxuriantly, that, in a test-tube, the agar quickly becomes a carbonaceous-looking mass, filled with quantities of dark brown hyphæ; on the surface, aërial hyphæ are sent up, covering the whole with a light grey mycelium (Plate lxxxiv., fig.1).

Upon agar impregnated with water-extract of orange-peel, an intermediate type of growth was obtained (Plate lxxxiv., fig.2). The fungus grew well but not luxuriantly, and there was little production of aërial hyphæ.

In these cultures, pycnidial formation began after about seven days, and ripe spores were obtained after thirteen days; but, in the glucose-agar, where growth was luxuriant, spore-production was much delayed.

PRODUCTION OF PYCNIDIA AND SPORES.

When grown upon a medium that is thoroughly moist, the spores that are formed in the pycnidia are expelled, and appear upon the ostiole in a mass. This mass is whitish in colour, viscid and semi-translucent. Usually it is globular, but it may take the form of a truncated cone. When placed in water, the spores do not readily separate from the mass. These spore-masses may be found in nature if the fruit is continually surrounded by a damp atmosphere. Much more generally, however, the spores are produced in pycnidia surrounded by a dry atmosphere. They do not then emerge till a drop of moisture falls upon the pycnidium, whereupon they escape in a thin stream. Observed in a hanging drop, they are seen to separate and spread themselves at spaces almost equidistant from one another over the surface of the drop, as if they were mutually repellant; and no two spores are found to remain in juxtaposition. This separation is probably brought about by surface-tension. Normally, the pycnidia are produced upon the peel of oranges, and the ostioles open at the surface. A surface-view of a pycnidium, with an ostiole in the centre, is shown in Pl. lxxxv., fig.3.

If, however, affected oranges be kept under a bell-jar, and remain free from attack by other fungi, they shrink somewhat, and the peel becomes harder. The mycelium of the fungus penetrates the whole of the pulp, which becomes black in colour, and pycnidia are formed in abundance throughout the tissue.

The hyphæ even penetrate the outer coat of the testa of the seed, and pycnidia are there produced (Pl. lxxxv., fig.4). A somewhat similar phenomenon is observed when the fungus is grown upon an orange rind-extract agar-slope in a test-tube. At first, the mycelium grows near the surface, and pycnidia are produced there; but, later, the hyphæ produce submerged pycnidia, which may eject their spores as spore-masses into the surrounding medium; in these cases, the ostiole appears to have no particular orientation.

It is noteworthy that oranges affected with *Phoma citricarpa* and free from any other disease, if kept under a bell-jar, give off, in the course of several days, very little moisture; but if they are attacked by *Penicillium italicum* (to which attack they are peculiarly liable in the presence of *Phoma citricarpa*), a large quantity of moisture condenses upon the surface of the bell-jar in a few hours.

STRUCTURE OF THE MYCELIUM.

The mycelium exhibits much diversity. The extreme tips may be pointed or round, the hyphæ being thin, hyaline, and almost devoid of septa. Further back, the hyphæ become somewhat suddenly thicker, the septa become more numerous, and the colour is olive-green. In the older hyphæ, the septa are very numerous, the colour is dark greenish-brown, and the contents of the cells granular; the cells may be oblong, or round, and often carry numerous, short, round, protuberances (Pl. lxxxv., fig.5; Pl. lxxxvi., fig.6).

STRUCTURE OF THE SPORES.

Two kinds of spore are produced. Both kinds may be produced in a pycnidium or one kind only. They differ considerably in size. The large spores are those described by McAlpine, whose measurements, in regard to the size of these spores and the pycnidia, I can confirm. These spores are usually hyaline, with granular contents; they have, however, frequently a greenish hue. The cell-wall is very thin. They may have one or two nuclei, generally there are two, and these are placed opposite to one another adjacent to the cell-wall in the region midway between the ends of the cell; frequently they are joined together by a narrow band which stains deeply with hæmatoxylin. When the spore is about to germinate, the protoplasm becomes much vacuolated and the nuclei appear to fragment (Pl. lxxxvi., fig.7).

The second kind of spore, which has not been previously described, is much smaller, measuring only 7·5 × 1·6μ.

The extremities are usually slightly thicker than the middle, the spores being somewhat dumb-bell shaped.

The spores have the following dimensions :

L. = length, c. = centre-width. E. broadest-end.

Range : (L.) 6·0 – 9·3 × c. (1·0 – 2·0) × E. 1·3 × 2·0μ.

Average : (L.) 7·5 × c. 1·3 × E. 1·6μ.

A highly refringent granule is usually present at each end. Sometimes there are three or four granules present, or there may be none at all. The spores themselves occasionally have the form of simple rods, or they are moniliform or hourglass-shaped. If present, they are discharged from the pycnidia with the larger spores in the viscid masses previously referred to, or they may be discharged in a stream from a ripe pycnidium when moistened (Pl. xc., fig.25). They do not separate from one another in the manner of the larger spores; indeed, they sometimes lie side by side like rouleaux of red blood-corpuscles (Pl. lxxxvi., figs.8, 9).

As I have not been able to induce these spores to germinate, or to determine their functions, I shall speak of them as "x" spores.

The presence of "x" spores in the pycnidia of various *Sphæropsidæ* is known in a few genera.

F. A. Wolf(**6**), in describing *Ascochyta hortorum*, which was formerly known as *Phoma solani*, states that, in the pycnidia, he finds typical conidia, 6-10 × 2·5-4μ, together with "a second type of spore which is hyaline, continuous, frequently curved or hooked at one end, 14-17 × 2-2·5μ. These spores may occur in the pycnidium together with the pycnospores, or alone in other pycnidia." . . . . . He continues, "Morphologically, at least, they are identical with the stylospores of Nitschke in *Diaporthe*, the "B" spores of Diedicke in *Phomopsis*, the scolecospores of Spear, and the paraphyses of Reddick in *Fusicoccum*, the pycnidial form of *Cytosporella viticola.* Only failure has thus far met the various attempts to germinate these bodies."

Germination of the Spores.

The normal pycnospores do not germinate readily in water. After several days, a few may send out an attenuated hypha, which seldom develops branches, and soon ceases to grow.

In a nutrient solution (containing ammonium nitrate, 1·0 gram; dihydrogen potassium phosphate, 0·5 gram; magnesium sulphate, 0·25 gram; iron chloride, trace; cane sugar, 5·0 grams; water, 100 c c.) the spores assumed a dark olive-green colour, and only a few commenced to germinate after several days. The hyphæ produced were a very dark green colour; they appeared stunted and unable to elongate (Pl. lxxxvi., fig.10). When a solution of equal parts of peptone-water and this solution was tried, germination was somewhat better, but unsatisfactory. In an aqueous extract of orange-peel, however, the spores germinated freely. The rapidity with which the spores germinated in this medium appeared to depend largely on the age of the spore If placed in the solution immediately they were discharged from the pycnidium, the spores had produced a germ-tube in twelve hours. If, however, the spores were three days old, they took several days to germinate; and, if much older, many of them failed to germinate at all. The germinating spore usually sends out a germ-tube from the side, but it may produce a germ-tube from one end, or from both ends simultaneously. The granules in the spore assume a greenish hue, and pass, for the most part, into the germ-tube. A septum may be produced in the germ-tube early, or the production of septa may be deferred (Pl. lxxxvi., fig.11). The hyphæ soon branch, their ends being at first round, and, immediately behind the tips, the cell-contents are usually highly granular (Pl. lxxxvi., fig.12).

By taking special precautions to prevent the hanging drop from drying up, and to have every part of the apparatus and instruments used sterile, I have been able to follow the development of a spore in a hanging drop from the production of a germ-tube to the formation of a pycnidium by the mycelium, and the discharge of spores from this pycnidium. Such a pycnidium is shown in Pl. lxxxvii., fig.13. A noticeable feature of the hyphæ is the ease with which they anastomose. Anastomosis may occur in two ways. A branch from one hypha may grow out and fuse with another lying parallel or nearly parallel to the one from which the branch originated, or branches may arise from two adjacent hyphæ, approach each other, meet, and fuse. Examples of this are seen in Pl. lxxxvii., fig.13. The pycnidium here figured took a little over three weeks to form, and ultimately discharged "x" spores only. In other hanging drop cultures, where normal pycnospores have been discharged, they have never been observed to germinate, without transference to a fresh medium, the mycelium having apparently exhausted the medium upon which it was growing before the production of pycnidia.

DEVELOPMENT OF THE PYCNIDIA.

By means of cultures in hanging drops, and serial sections of cultures upon agar, it has been possible to follow the development of the pycnidia in detail.

The beginning of pycnidia-formation consists in one or more adjacent hyphæ producing lobulated branches of much greater diameter than the ordinary hyphæ (Pl. lxxxvii., figs.14, 15). These lobulated branches stain rather more deeply with hæmatoxylin than the ordinary hyphæ. The lobulated branches become greater in number and interwoven, and many septa develop (Pl. lxxxviii., figs.16, 17). This leads to the formation of a firm, compacted pseudoparenchyma; the protoplasm which lines the cell-walls contains numerous deeply-staining particles, and becomes especially distinct (Pl. lxxxviii., fig.18).

Soon, the parenchymatous body is distinguishable into outer layers of small, thick-walled, brownish cells; and an inner region of larger, thin-walled, parenchymatous cells. In the inner region, we, later, find groups of hyphæ with thin lumina, and, in their place, arise, at a later date, the loculi of the pycnidia.

In the transition-stage from parenchyma to hyphæ, the walls of the parenchyma-cells frequently appear to be dissolved, and a mass of naked protoplasm, with deeply-staining granules, is seen (Pl. lxxxix., fig.19).

The following stages may be distinguished in the production of a pycnidium :—

1. Production of lobulated hyphæ, which become interwoven.
2. Formation of a pseudo-parenchyma.
3. Dissolution of cell-walls of the pseudo-parenchyma at certain foci, followed by formation of hyphæ.
4. Establishment of loculi at these foci, into which spores are abstricted from the hyphæ.
5. Gradual replacement of the pseudo-parenchyma by spore-bearing hyphæ.
6. Shrinkage of the spore-bearing hyphæ.
7. Pycnidium completely full of spores borne upon attenuated stalks.

The transition from pseudo-parenchyma to spore-bearing hyphæ is shown in Pl. lxxxix., figs.20, 21. A portion of the pseudo-parenchyma frequently lines the pycnidium until a late stage.

In the natural state, when growing upon the orange, the pycnidia are generally unilocular (Pl. xc., fig.22). But, in cultures upon orange-agar, they are frequently bi- or trilocular, in which case, the loculi are surrounded by a common wall (Pl. xc., fig.23).

In bilocular pycnidia, portions of the inner parenchymatous tissue have become firm, and the groups of thin-walled hyphæ have become separated.

Pycnidial formation has been briefly described in the case of *Diplodia zeæ* by Van der Bijl(**7**), and in the case of *Phoma lavandulæ* by W. B. Brierley(**8**).

The origin of the pycnidium by the interlacing of lobulated hyphæ with the formation of a pseudo-parenchyma is very similar in *Phoma citricarpa* and *Ph. lavandulæ.* The later stages in the development of the pycnidium of *Ph. citricarpa* resemble the description given of that of *Diplodia zeæ.* The marked visibility of the protoplasm lining the cells of the pseudo-parenchyma, and the disappearance of the cell-walls previous to the formation of hyphæ, described in the case of *Ph. citricarpa*, is not mentioned by the authors quoted.

The formation of hyphæ from naked protoplasm is not unknown, as it occurs in the Myxomycetes, when the capillitium, consisting of a system of solid or of tubular threads, appears before the spores are formed. The capillitium has been described by Harper & Dodge(9), as originating in vacuolar spaces in the cytoplasm, which elongate and take on the tubular form of young capillitial threads. They find that the capillitium is formed by the deposit of materials in the vacuoles from which the capillitial threads are formed; and that radiating threads run out from the larger granules, which are deposited by the process of intra-protoplasmic secretion. These radiating fibrils suggest, rather strongly, that they are cytoplasmic streams which are bringing materials for the formation of the capillitial wall and its thickenings, which are laid down as spirals, suggesting that the process is comparable with the ordinary process of cell-wall formation, but along internal plasma-membranes, rather than external.

Development of the Spores.

The stalks bearing the normal spores are unicellular, hyaline, and rich in protoplasmic contents, sometimes excessively so.

Paraphyses have not been distinguished, though stalks vary much in length; and sometimes old stalks, or stalks upon which the spores have not developed, have the appearance of paraphyses. The spore develops as follows :—

The stalk elongates, and the spore is abstricted from its end; at this stage, the spore is pear-shaped. The stalk is slightly cup-shaped at its extremity occasionally, and uni-nucleolate (Pl. xc., fig.24). The spore increases in size, and becomes binucleolate; at the same time, the stalk shrinks to a mere thread. On their discharge, the spores may show no traces of their point of attachment; or each spore may have, still joined to it, a minute thread. The "x" spores develop by abstriction in concatenation from minute hyphæ bordering the loculus of the pycnidium (Pl. xc., fig.24).

I am indebted to my assistant, Mr. W. A. Birmingham, for much careful work during the progress of this investigation.

Summary.

1. "Black Spot" is a serious disease of Citrus fruits in New South Wales, due to the fungus *Phoma citricarpa*.

2. It develops only on the sunny side of trees, and upon the parts of the fruit exposed to sunlight.

3. *Phoma citricarpa* produces two kinds of spores, normal pycnospores, and "x" spores.

4. Normal pycnospores germinate readily in suitable media; it has not been possible to induce the "x" spores to germinate.

5. The details of the formation of the pycnidia, and of the pycnospores have been worked out.

6. Spraying with Bordeaux (6 – 4 – 50) followed up by sprayings with weaker solutions, controls the disease.

7. A study of the life-history of the fungus indicates that spraying need not commence till the fruit is half-grown.

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EXPLANATION OF PLATES LXXXIV.-XC.

Plate lxxxiv.

Phoma citricarpa.

Fig.1.—Pure culture in glucose-agar. The culture grows very rapidly, produces numerous aërial hyphæ, forming a grey-coloured felt, but does not readily produce pycnidia.

Fig.2.—Pure culture growing upon orange-rind-extract agar. The culture grows at a moderate rate, remains dark in colour, produces few aërial hyphæ, and forms pycnidia readily.

Plate lxxxv.

Fig.3.—Surface-view of a pycnidium, showing the ostiole in the centre: (× 480).

Fig.4.—Section of the testa of an orange-seed which has been penetrated by the hyphæ of *Phoma citricarpa*, and in which two small pycnidia have been produced.

Fig.5.—Young hyphæ, showing elongated cell; (× 480).

Plate lxxxvi.

Fig.6.—Old hyphæ, showing dark brown-coloured cells, which are more or less circular, with numerous protuberances; (× 480).

Fig.7.—Spores in various stages of growth : *a*, a young spore showing two nuclei; *b*, *c*, *d*, spores about to germinate, showing vacuoles and fragments staining deeply with hæmatoxylin.

Fig.8.—"x" spores arranged in rouleaux.

Fig.9.—"x" spores showing highly refringent dots.

Fig.10.—Pycnospores germinating in nutrient solution, showing stunted hyphæ with a tendency to bud; (× 480).

Fig.11.—Pycnospores germinating normally in orange-rind-extract, showing germ-tubes, septa, and granular contents; (× 480).

Fig.12.—Establishment of a mycelium from a germinating spore; (× 480).

Plate lxxxvii.

Fig.13.—Formation of a pycnidium from the mycelium growing in a hanging drop. The hyphæ of the mycelium are shown anastomosing by the union of adjacent branches or by the direct fusion of one hypha with another by a branch; (× 480).

Figs.14, 15.—Formation of lobulated branches, first stages in the development of a pycnidium; (× 480).

Plate lxxxviii.

Fig.16.—Formation of lobulated branches, first stages in the development of a pycnidium; (× 480).

Fig.17.—Section through a young pycnidium, showing the development of septa in the lobulated branches, and the establishment of a pseudo-parenchyma; (× 480).

Fig.18.—Section through an older pycnidium, showing the protoplasm, with granular contents, lining the cell-walls of the pseudo-parenchyma; (× 480).

Plate lxxxix.

Fig.19.—Section through a pycnidium at a later stage showing dissolution of the cell-walls of the pseudo-parenchyma before the establishment of spore-bearing hyphæ; (× 480).

Figs. 20, 21.—Portions of sections through a mature pycnidium, showing the outer layers of dark brown, thick-walled cells, lined by the remains of the pseudo-parenchyma from which the spore-bearing hyphæ arise; (×480).

Plate xc.

Fig. 22.—Section through a pycnidium upon orange rind. The pycnidium contains mature spores. The slightly increased development of the outer layers of thick-walled, brown cells just beneath the ruptured epidermis, is noticeable; (×480).

Fig. 23.—Section through a trilocular pycnidium grown upon orange-rind-extract agar. There is a common outer covering, and the loculi are separated by walls composed of fine hyphæ; (×120).

Fig. 24.—Section through a pycnidium in which "x" spores are being abstricted from fine hyphæ; (×120).

Fig. 25.—Group of normal pycnospores and "x" spores discharged from a pycnidium; (×480).

THE OCCURRENCE OF AN INVERTED HYMENIUM IN *AGARICUS CAMPESTRIS.*

By G. P. Darnell-Smith, D.Sc., F.I.C.

(Plates xci.-xciii.)

In 1917, some mushroom-growers, who were growing mushrooms on a large scale in an old disused railway-tunnel, brought to me, for examination, a number of mushrooms that were unsaleable on account of their appearance. The mushrooms were grown upon large beds of manure, the making of which I had superintended. The manure was fairly moist, it was lightly compacted, and the average temperature was 22°C. Both the stipe and the cap of the specimens were somewhat tough. The cap was quite unusual in appearance. Instead of having the normal, comparatively smooth skin, its surface was broken by one or more black protuberances, 1·25 cm. or more in diameter, that looked like boils (Plate xci., fig.1). It was this appearance that spoilt the sale of the mushrooms. Samples of mushroom-spawn from Sydney, from Adelaide, and from France, were growing in the same tunnel, and providing normal mushrooms; it was only a particular sample of spawn imported from France that was giving rise to these abnormal specimens. A close inspection of the black protuberances showed that they were composed of sinuous, labyrinthiform gill-lamellæ (Pl. lxci., fig.2). They had the appearance of small inverted caps, but no appearance of a stipe could be found. Sections through the cap showed that these structures were quite separate from the normal hymenium, which was present on the undersurface of the cap (Pl. xcii., fig.3).

Sections for microscopical examination were prepared and stained. They showed that the structure of the hymenium on the undersurface of the cap was quite normal.

Sections through the hymenium on the upper surface of the cap, however, showed it to be quite abnormal in character (Pl. xcii., fig.4). They showed that the "gills" had a most irregular outline, that they varied much in width, and that many of them were hollow. Spores in abundance were produced, both on the external surface of the gills, and on the walls lining the internal cavities. These spores were produced upon enlarged cells, and borne upon sterigmata, as in the case of normal gills. While, however, the normal number of sterigmata is four, cells bearing only one, or only two sterigmata were found, as well as cells bearing the normal number of four (Pl. xciii., figs.5, 6, 7). Crops of mushrooms, showing the abnormal development above described, are not unknown. W. A. Smith, according to Worsdell(**1**), found, on more than one occasion, crops of mushrooms, every individual of which had an inverted cap on its surface. According to Worsdell, an inverted hymenium may arise (1) through the congenital formation of an inverted cap, or caps, from the earliest stage onwards on the upper surface of the primary cap; (2) through the formation of inverted caps by local invagination of the margin of the primary one. It is held, however, that these two variations really represent the same phenomenon, of which (1) represents the final and completed stage of (2) arising congenitally and isolated.

In my specimens, no trace of the formation of inverted caps by local invagination could be found. Moreover careful examination of mushrooms in the "button"-stage showed, that these irregular gill-lamellæ, on the upper surface of the cap, were in process of formation in the very earliest stages, and long before the velum had separated from the stipe (Pl. xciii., fig.7). There can, therefore, be no question of invagination of the cap in these specimens.

The question arises, what light, if any, does this inversion of the hymenium throw upon the phylogeny of the Agaricaceæ? Is it an expression of a partial reversion to an ancestral character?

That certain spawn has particular characters peculiar to it, is the experience of professional mushroom-growers. In commercial practice, under the influence of the atmosphere and the heat of the manure-beds, the mycelium gets weaker and weaker, and eventually perishes. "Virgin spawn" obtained from the fields is, therefore, transferred to beds of manure, where it spreads and supplies the grower with a "frank spawn" for growing the edible mushroom. But "often twelve to fifteen kinds of virgin spawn as found in the fields or on heaps of refuse are discarded as useless before a good strain is obtained"(**2**). That the production of inverted caps was a feature inherent in the spawn under discussion, is shown by the fact that all mushrooms developed from it produced abnormal caps, whereas mushrooms produced from other spawn, under identical conditions, did not.

This phenomenon, together with the characters of the sporophores, lends support to the hypotheses that have been put forward as to the evolution of the cap, and as to the probable origin of the Agaricaceæ, which may be stated briefly as follows:

(*a*). *Evolution of the cap*

1. The production of the horizontally extended, flattened cap-form of fruit from an original, cylindric, dome-shaped form.

2. The relegation of the hymenial tissue to the lower surface of the cap.

3. The formation of "gills" from the original pore or alveolar structure.

(*b*). *Evolution of the* Agaricaceæ.

The most primitive type of fructification is probably that of *Clavaria*, in which a cylindric or club-shaped branch is uniformly covered with hymenium, which extends down the stalk as well for some distance.

"Cases in which the hymenium covers the whole of the upper exposed surface, in the form of a semi-alveolar structure, or labyrinthiform gill-formation, are seen in *Tremella* and *Næmatelia*, and these plants pertain to the Protobasidio-Mycetes; the Tremellineæ have, according to Maire's classification, branched off laterally from the Auriculariaceæ, and it is from these latter that the Agaricaceæ and Polyporaceæ have descended.

In this connection, it is interesting to note that, in one of my specimens that was fairly large, but was obtained in the "button-stage" before rupture of the velum, the whole of the upper surface of the cap is covered with sporogenous tissue (Pl. xciii., fig.9).

Moreover, this sporogenous tissue is completely covered by a thin membrane, so that there can be no question of its having attained its position through invagination.

The examination of these abnormal mushrooms, therefore, leads to the conclusion, that they represent a partial reversion to an ancestral character. One would hardly expect a complete reversion; and that it is only partial, is demonstrated by the manner in which the spores are borne.

The discharge and disposal of the spores in the Agaricaceæ, according to Buller(**4**), are brought about, as follows:—

The special conidiophore, or basidium, usually bears four spores, which are discharged successively, and each spore becomes violently detached. The violent discharge of the spores prevents the adhesive spores from massing together, and from sticking fast to the gill-surface. At first, the spore is shot out horizontally; then, under the influence of gravity, it describes a sharp curve, and then falls vertically. The path described by the falling spore has been appropriately called a sporabola. After falling, under the influence of gravity, in the still air between the gill-lamellæ till they reach the exterior, the spores are borne away by the breeze. Basidia, being four sterigmata with four spores attached, were found in my specimens in the inverted hymenium; and it is obvious that, if the spores were discharged in the normal way from the sterigmata and then started to fall under the action of gravity, they would not get free from the hymenium at all, but would fill up the spaces between the gills

We have, therefore, a reversion to an ancestral condition so far as the macroscopic characters are concerned, with a retention of the modern condition so far as the microscopic characters are involved.

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EXPLANATION OF PLATES XCI.-XCIII.

Plate xci.

Fig. 1.—Abnormal mushroom, showing protuberances of the cap. At the base of the stipe, two small "buttons" are seen.

Fig. 2.—Abnormal mushroom, showing hymenium on the surface of the cap.

Plate xcii.

Fig. 3.—Section of the same.

Fig. 4.—Transverse section through the hymenium on the surface of the cap, showing the irregular character of the gills, and the large spaces in their interior; (× 120).

Plate xciii.

Figs. 5, 6, 7.—Basidia bearing varying numbers of sterigmata (4, 2, 1) from the hymenium in the surface of the cap; (× 480).

Fig. 8.—Section of small "button" much enlarged, showing the formation of lens-shaped areas in the cap containing sporogenous tissue before the separation of the velum.

Fig. 9.—Section of a large "button" (nat. size), showing sporogenous tissue covered with a membrane over the whole upper surface of the cap. The velum has not yet split.

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(*a*) GENERAL INDEX.

(*b*) BIOLOGICAL INDEX.

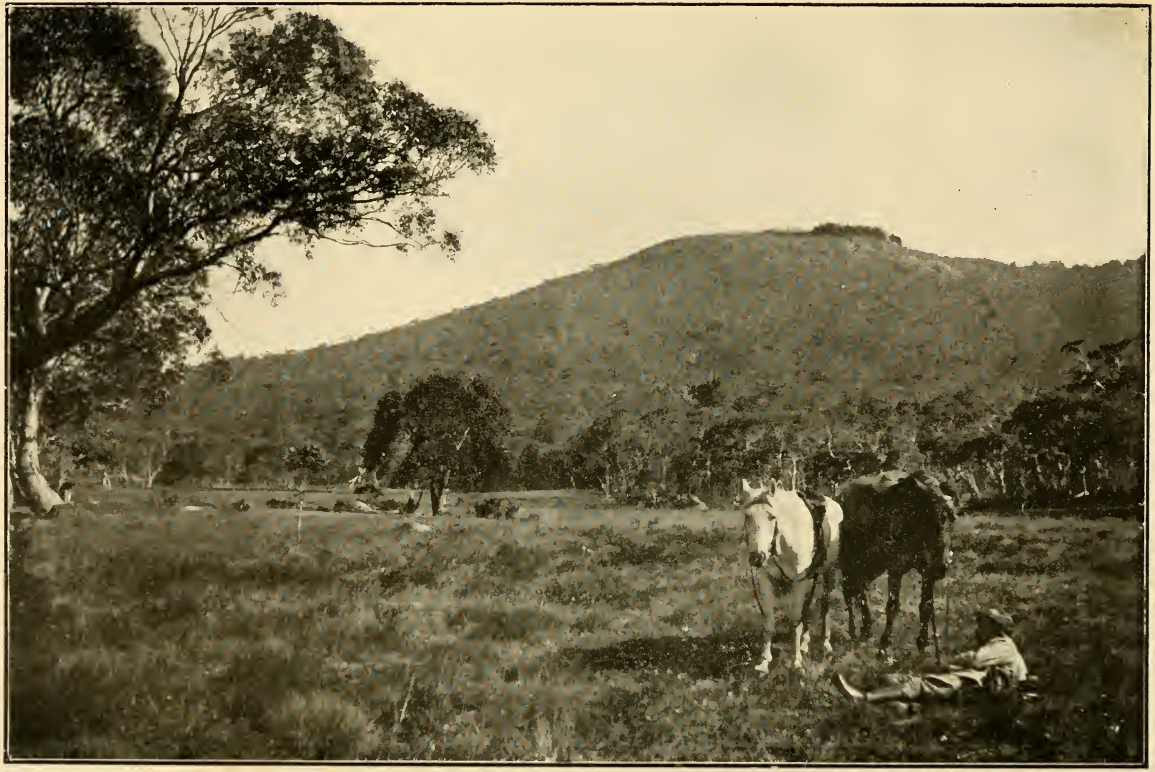
Names in italics are synonyms.

[Printed off March 21st, 1919.]

Casuarina Luehmanni R. T. Baker.

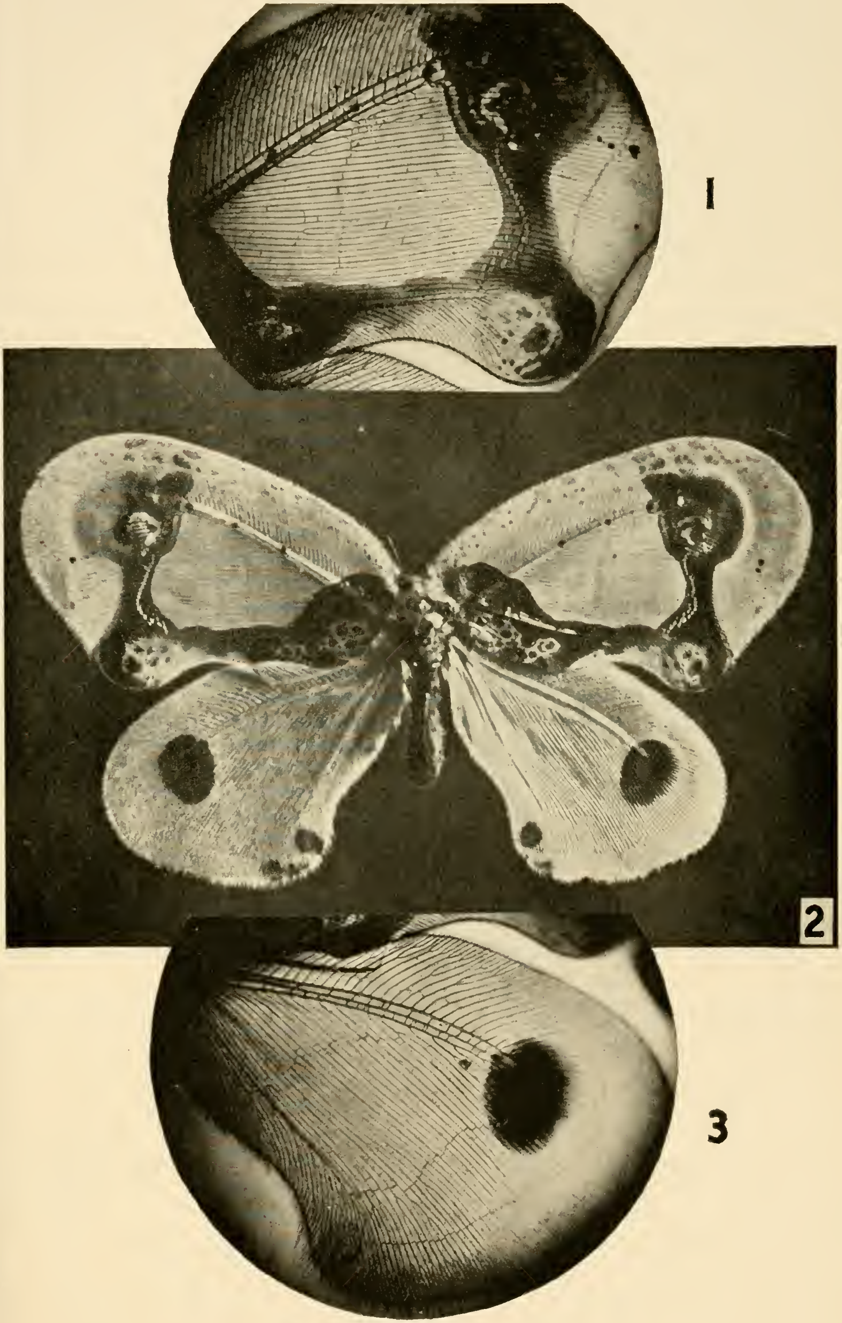
Grevillea juniperina R.Br

Banksia marginata Cav.

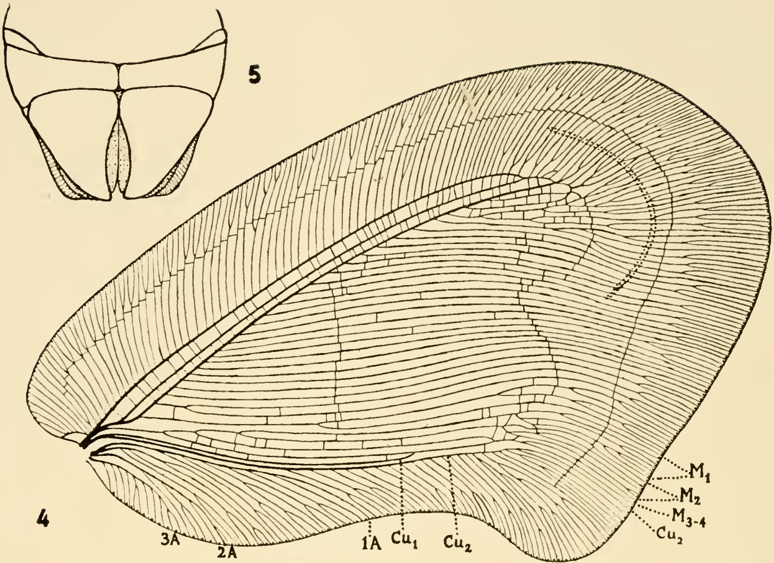


Swampy plain between Gudgenby and Cotter River, at about 4,500 feet level.

Eucalyptus Marsdeni, f. vel sp. n.



Megapsychops illidgei (Froggatt).



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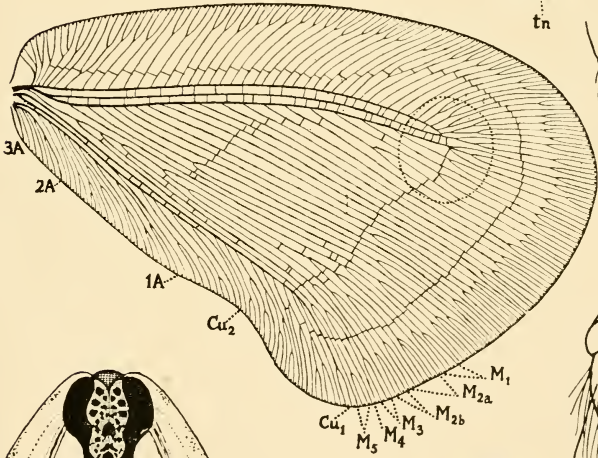

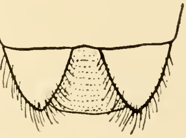

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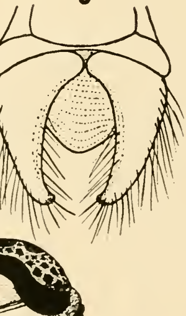

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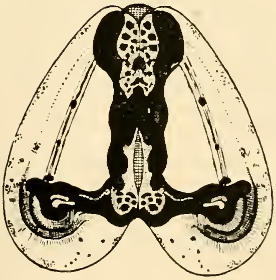

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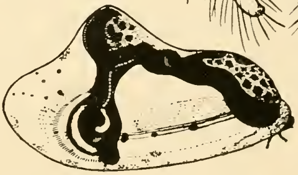

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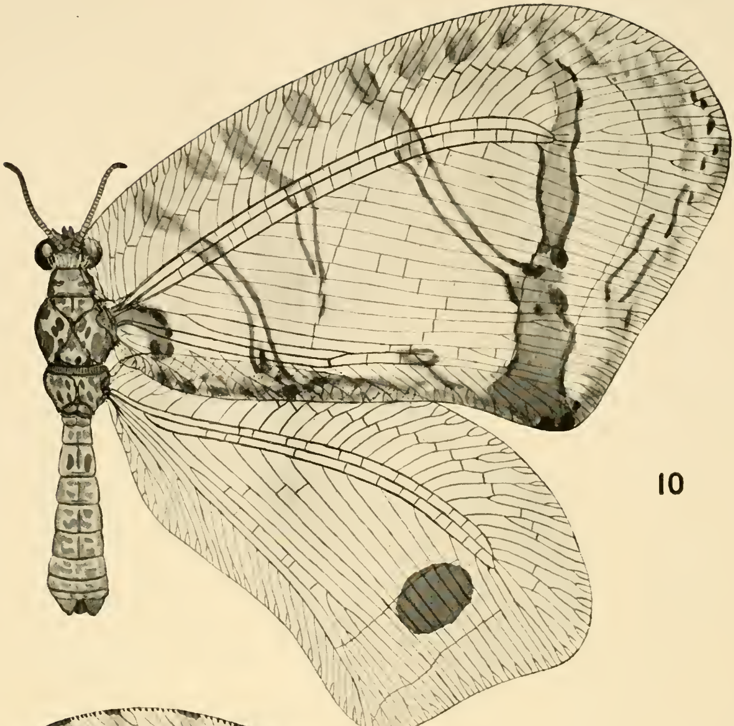
4-6. *Megapsychops illidgei* (Froggatt). 8. *Psychopsis gracilis*, n. sp.
9. *Psychopsella gallardi*, n.g. et sp.



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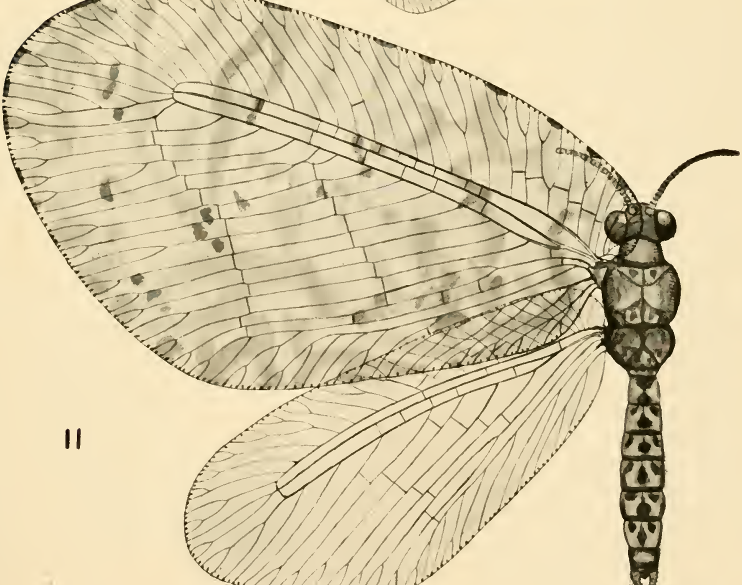

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10. *Psychopsis gracilis*, n. sp. 11. *Psychopsella gallardi*, n.g. et sp.

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Psychopsis elegans (Gúer.).

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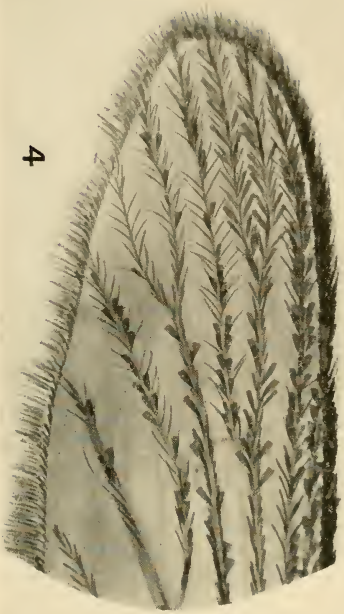

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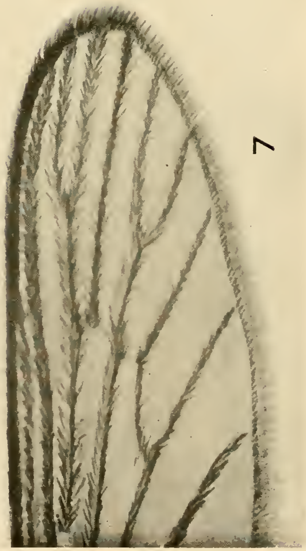
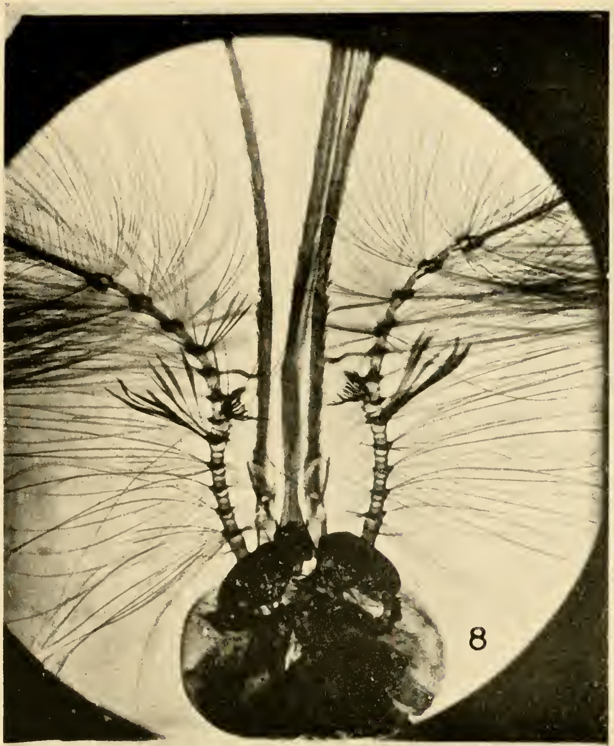


4. *Grabhamia theobaldi* Taylor. 5-7. *Culicada wilsoni*, sp. n.



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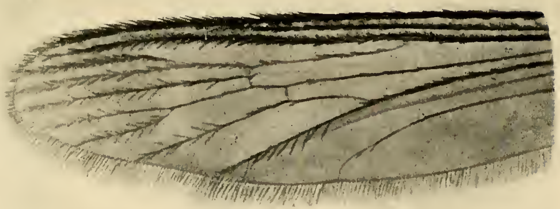

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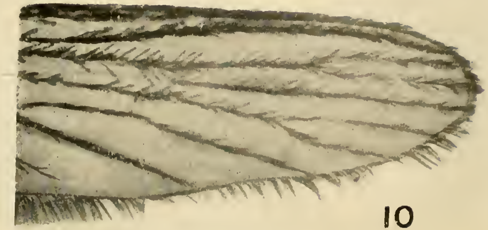

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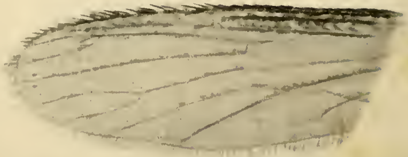

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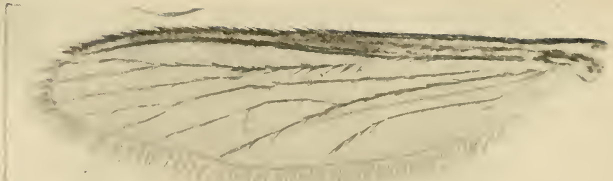

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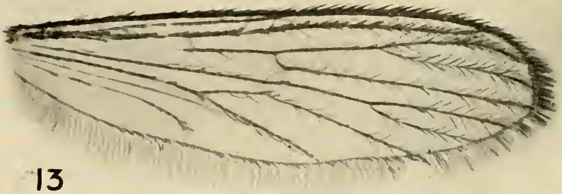

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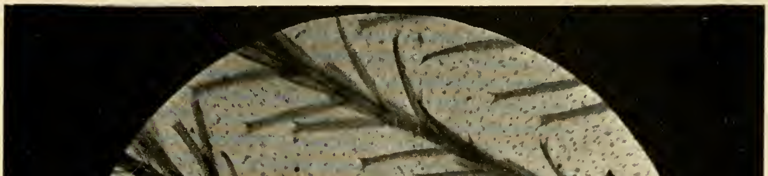

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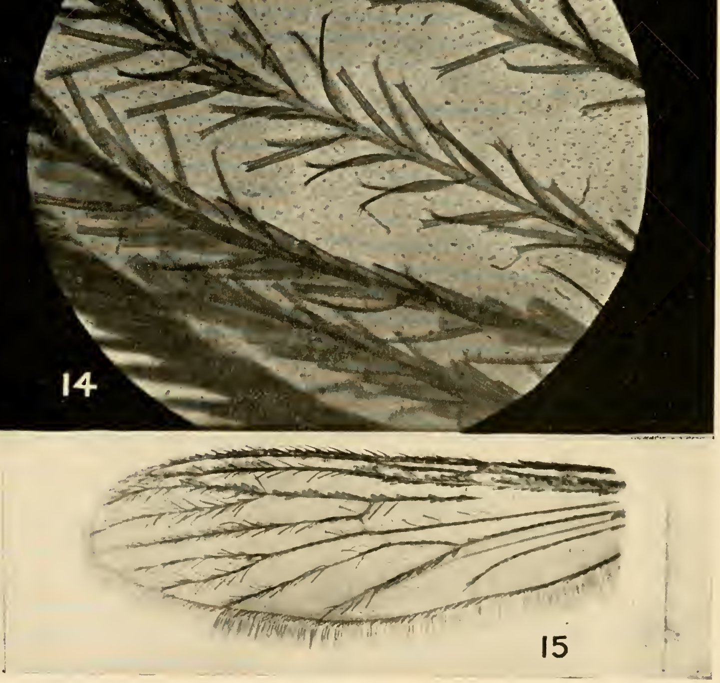

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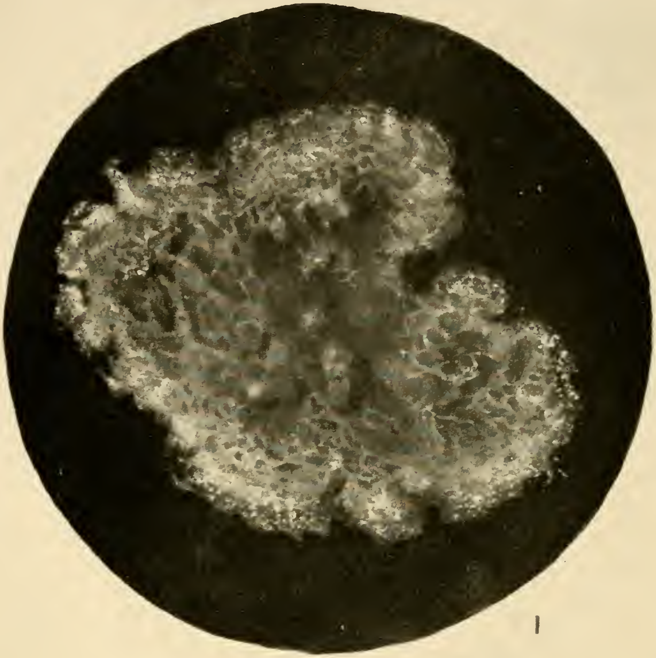

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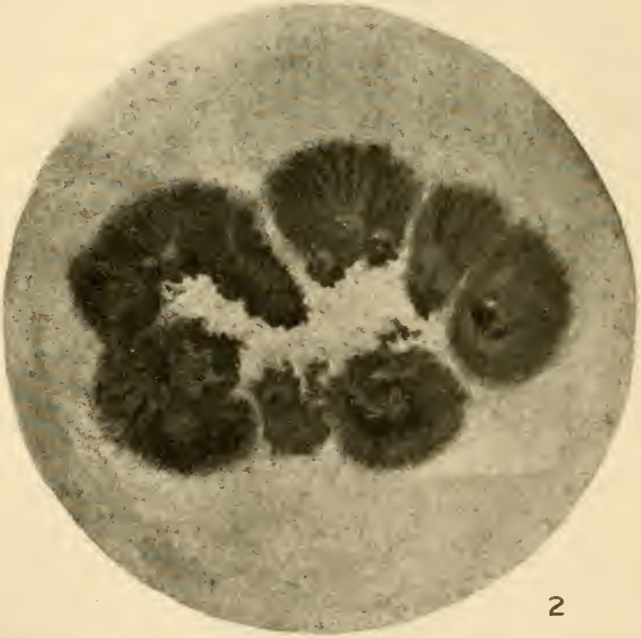

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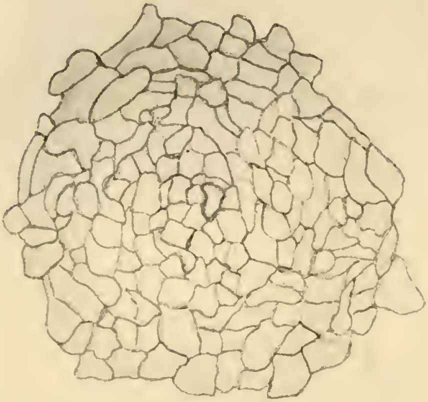

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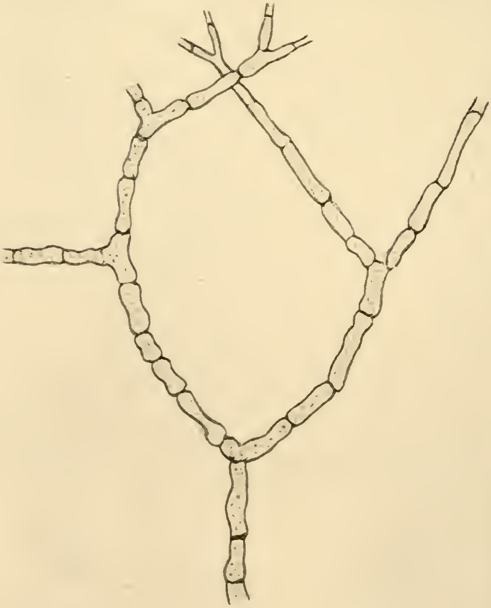

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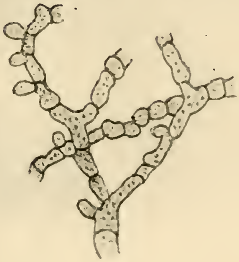

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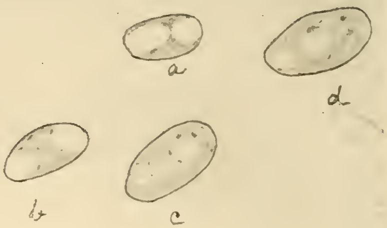

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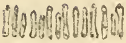

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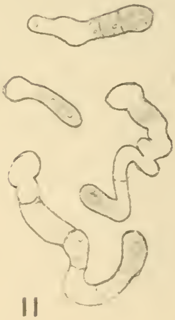

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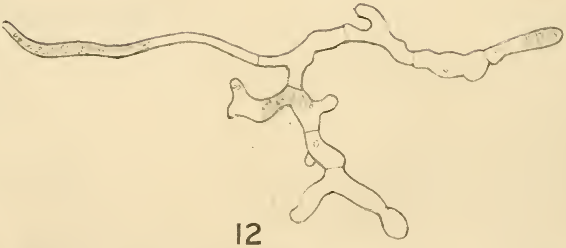

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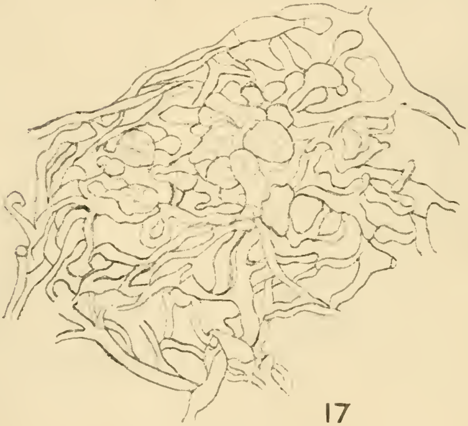

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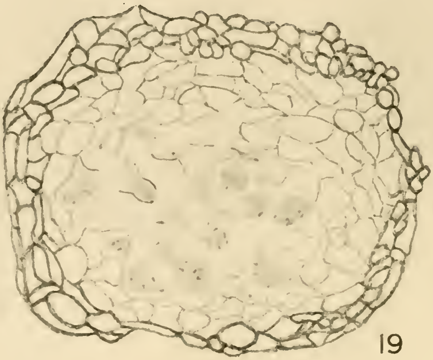

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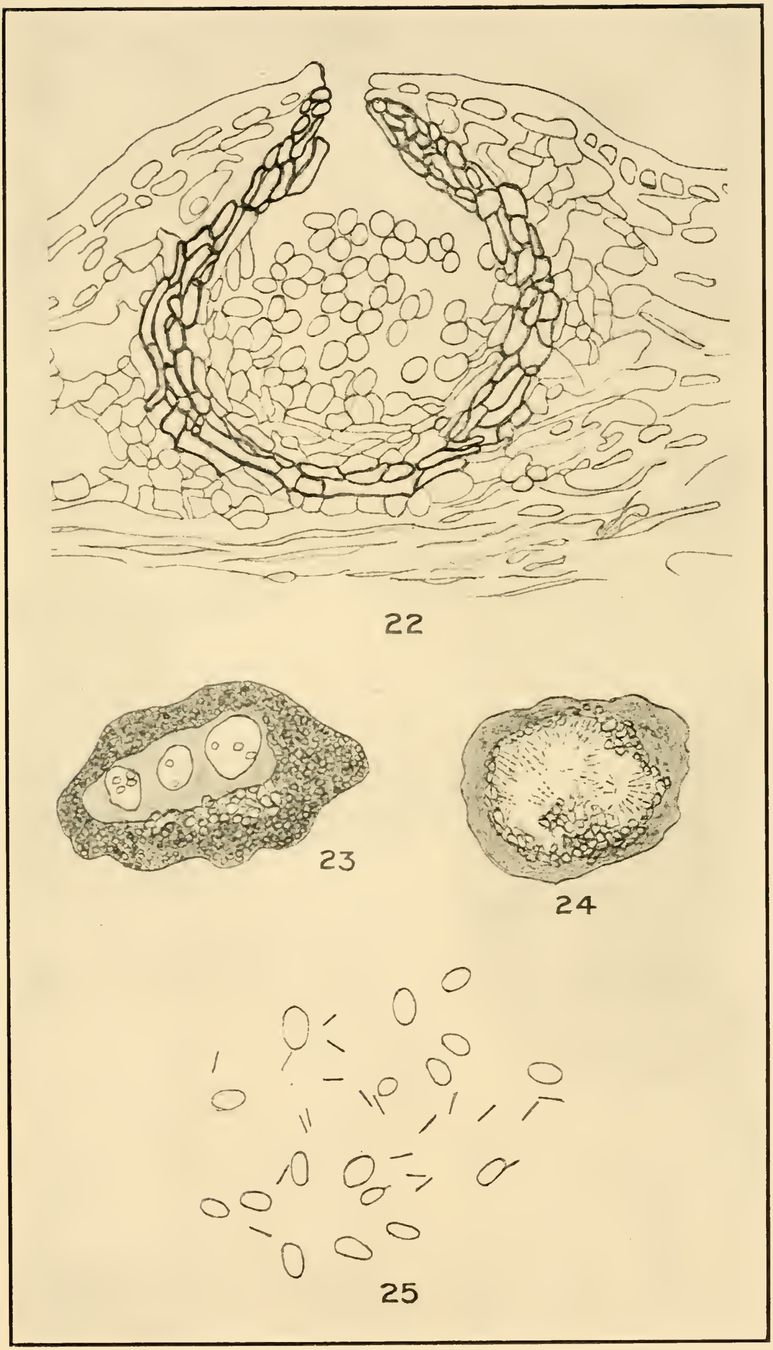

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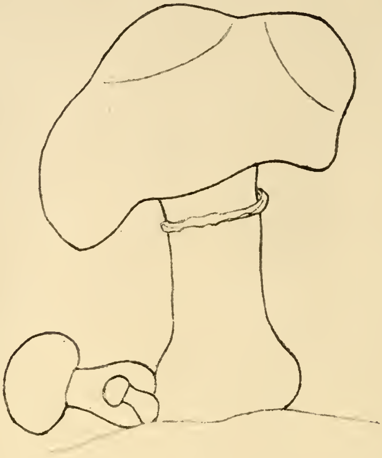

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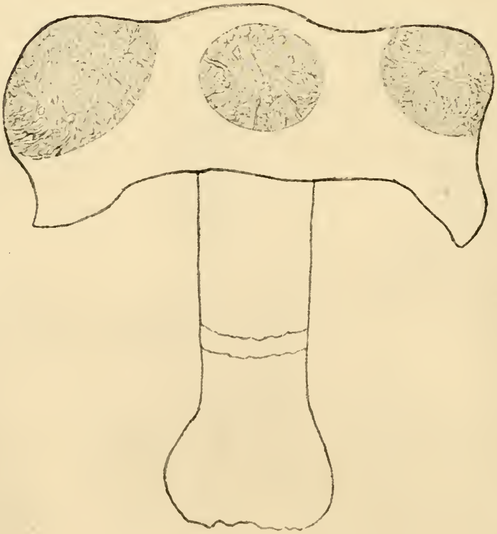

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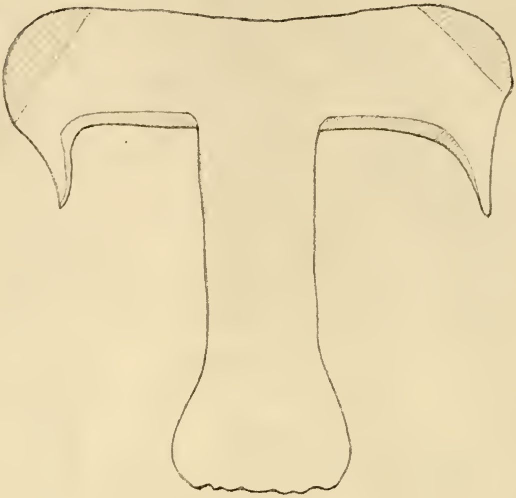

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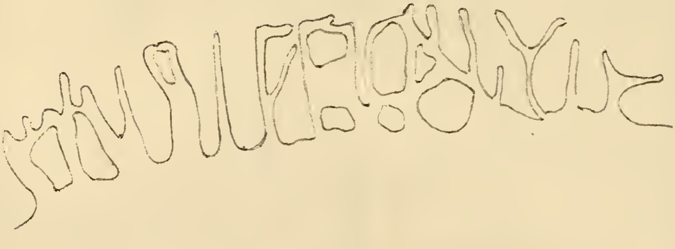

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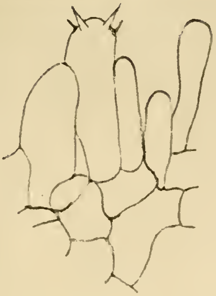

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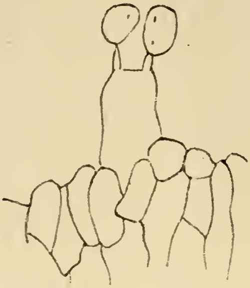

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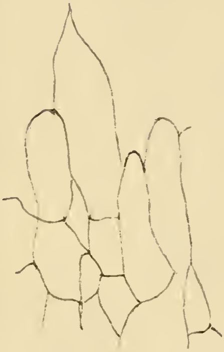

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Agaricus campestris.

Issued 3rd July, 1918.

Vol. XLIII.
Part 1.
No. 169

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FOR THE YEAR

1918

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OF

NEW SOUTH WALES

FOR THE YEAR

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