THE

PROCEEDINGS

OF THE

LINNEAN SOCIETY

OF

NEW SOUTH WALES

FOR THE YEAR.

1919

Vol. XLIV.

WITH FORTY-SEVEN PLATES

And 212 Text-figures.

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CORRIGENDA.

Page 145, *for* lines 28 and 29, *read*
.................(1) ALPHITOBIUS Steph.
27. Blind.........(3) TYPHLULOMA Lea.

Page 150, lines 4, 5, 8 and 11—for *H.*, read *P.*

Page 289, line 4 —read *Tessarotis rubra* Warr., Nov. Zool., 1903, p. 270.

Page 308, line 21—for *vittaligera*, read *vittuligera.*

Page 373, line 36—for *blabelloides* read *blattelloides.*

Page 377, line 11— „ „ „ „

Page 378, text-fig. 37—for „ „ „
line 23—for *Blabella* read *Blattella.*

Page 381, line 31—for *blabelloides* read *blattelloides.*

Page 538, *for* line 22, *read* The trichiation fails in only two cases, viz., (*a*) close to the

Page 588, *for* Text-fig. 53 *read* Text-fig. 58.

Page 594, line 38—*delete* Lepidoptera.
line 41—*read* Lepidoptera, Diptera.

Page 623, *interchange* lines 26 and 27.

Page 628, line 2—*for* Af_2, *read* Af_4.

Page 630, *interchange* lines 2 and 3.

Page 635, table II., character (4)—*add* "veinlet *dev.*"

Page 647, line 19—*for* Homoneura, *read* Heteroneura.

Page 650, table III.—in the headings *for* Eriocraniinae and Mnesarchaeinae, *read* Eriocraniidae and Mnesarchaeidae.

Page 682, text-fig. 100 and p. 686, text-fig. 102—in hindwing, for *acl* read *bc* (basal cell).

Page 685, line 1—complete bracket after *Euschemon.*

Page 701, line 2—*for* M, read M_5.
text.-fig. 110—The three forks R_{4+5}, M_{1+2} and M_{3+4} respectively, not labelled, but lying in line with cuf′ should be labelled *x*, *y* and *z* in conformity with the text.

Page 707, table V.—character (2), in column for Lepidoptera, *for* C, *read* D, and in bottom line *for* 44.6, *read* 43.8

Page 711, line 13—*for* evolutions, *read* evolution.

Page 717, in explanation of Plate xxxi., fig. 16, *for* The arrows point to, *read* The arrow indicates the position of.

Page 797, line 22—*for* millo, *read* nullo.

Page 802, line 18—*for* depresso, *read* depressa.

Page 809, line 5 —*for* Epivalva, *read* Epivalve.

Page 814, line 27—*for* cas, *read* eas.

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J. J. Fletcher

PROCEEDINGS

OF THE

LINNEAN SOCIETY

OF

NEW SOUTH WALES.

WEDNESDAY, MARCH 26TH, 1919.

The Forty-fourth Annual General Meeting, and the Ordinary Monthly Meeting, were held in the Linnean Hall, Ithaca Road, Elizabeth Bay, on Wednesday evening, March 26th, 1919.

ANNUAL GENERAL MEETING.

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

The Minutes of the preceding Annual General Meeting (March 27th, 1918) were read and confirmed.

The President delivered the Annual Address.

PRESIDENTIAL ADDRESS.

LADIES AND GENTLEMEN,

The war which has been wasting the lands and wealth of Europe has come to an end. Death no longer takes a high toll among the strongest of men. The fight has been won. The arms of our kinsmen and our friends have been blessed with victory. The armies of the proud foe, ambitious for military renown, have been driven to retreat, and their leaders have been forced to sue for peace. Peace still hovers over us, waiting to descend upon the blood-stained earth. The end of the strife raises many thoughts within us. Above all, we feel gratitude and thankfulness, too deep to be expressed easily in words, for those who left home, comfort and dear ones to defend our liberties overseas. They have given to us an example of unselfish patriotism, and we will do well to emulate the spirit which actuated those noble souls. Some will return to us no more. They lie in foreign soil, but they are remembered among us. Others have returned or will return, to help us forward in life's progress. It remains with us to see that we make full use of the awakening to national consciousness that these events have brought to us.

The statesmen of the world are engaged in determining the conditions of peace. The voices of the mass of the people are becoming articulate through Mr. Wilson. The populace is demanding that its interests will be considered in the development of national aspirations. The burden of war falls heavily upon the proletariat, and it seems impossible to deny the justice of the request for a direct opportunity to decide questions of national policy.

With the introduction of peaceful conditions arises the necessity for an improvement in the standard of living of the bulk of the people in the countries that have been at war. The urgent needs of the military situation have afforded a stimulus which has been lacking for many years. New methods have been tried in the desire to seek greater efficiency. It has been found that there are many better ways of doing things than had been formerly supposed. Better conditions of living can be instituted by making use of these improved methods.

The scientist possesses an opportunity at the present time which should not be missed. For years scientists have been amassing knowledge. They have been learning how to observe accurately different phenomena, and how to measure exactly various changes. It is this knowledge which constitutes the power of the scientist at the moment. He is conversant with the means by which a judgment can be made in the problems awaiting solution. The question arises as to how the people at large can be made aware of the utility of this knowledge. It has been said that the scientist is one of those with a mission to mankind who fails to present what he preaches in a form that ensures the attention of his fellows. A greater effort is required in the diffusion of scientific knowledge. The value of science in every walk of life should be impressed with more insistence. It does not appear to be enough to state reasonably what science can do and await the change which will follow recognition of the truth of the statement. More publicity seems to be required to hasten the adoption of the knowledge already gained. The importance of scientific information must be promulgated by enthusiastic preaching.

For some years I have been interested in the manufacture of bread. Bread is made in New South Wales by mixing flour and water with a little salt and yeast. The mass of dough thus formed is allowed to stand for about nine hours. The dough is then divided. The loaves are moulded, shaped, and baked in the oven. It was the practice to mix the doughs in the daytime and to carry out the heavier work of dividing the dough and baking the bread at night. Conditions have changed in the last few years. The dough-maker starts work about midnight and mixes doughs during the night. The operatives start work in the morning and prepare the bread. The State Government has built a bake-house in the Technical College. Since its opening, bread has been made in the School of Bakery three times a week in a commercial manner. The doughs are made at 9 o'clock in the morning, and the bread is taken from the oven at 6 o'clock in the afternoon. For three years there has been a continuous demonstration of this production. Not only so, but day after day bread has been made regularly in the same way and in the same time. With the assistance of the Advisory Council of Science and Industry, it has been possible to define exactly the conditions which make this regular production of bread possible. These conditions are very simple. They involve the use of scales in measuring exactly how much flour, water, and salt are put into the dough, and the employment of a thermometer in controlling the temperature at which the dough ferments. Under these conditions, the number of loaves obtained from a ton of flour remains constant. As soon as a dough has been made, a simple arithmetical calculation gives the number of loaves. Different flours will take up slightly different amounts of water, so that the yield of loaves from a ton of flour varies slightly with the kind of flour. The manufacture of yeast of uniform strength is also dependent on the use of scales and the thermometer. In addition, it is necessary to use simple bacteriological means to ensure sufficient purity in the yeast. These means of sterilisation are just as simple and as easily applied as those means used in every well regulated household in the cooking and preservation of food. For months together, bread has been made with the same yeast. A little yeast is kept over from each brew to start the brew for the next batch of bread.

The bakehouse is always open to inspection. Any baker can see how clean, spick and span a bakehouse can be kept. There are no mysterious processes that cannot be readily copied. The time saved in making the bread as compared with that of the average bakehouse is several hours daily. Yet there are difficulties in getting bakers to adopt the methods used. The baker looks with mistrust on the thermometer and the systematic use of scales. He claims that he knows without weighing or measuring how much water to add when making a dough. He is sure he can judge of temperatures without using a thermometer. He is surprised that the number of loaves from a ton of flour varies so much, and is sure that no one can always get the same number of loaves from a ton of the same flour. He remarks that he has made bread for thirty years, and that no one knows better how to make bread.

The School of Bakery in the Technical College is intended to afford instruction in making bread. The attendance of apprentices is small. There is a widespread feeling that the apprentice will learn sufficient in the bakehouse from the baker to whom he is apprenticed, without coming to the College. It is granted that he does not learn as much as he would by attending the Technical College, but it is asserted that he learns sufficient for his purpose. If he can make bread as well as his father or his grandfather, that is enough. Surely it will be advantageous to the whole community if the hours spent in making bread are materially lessened. This example serves to make evident what is the problem in the application of science to industry. The scientist must deal with opposition and indifference. How can we make the apprentice see that it will be to his advantage to learn to apply scientific knowledge, and very simple science at that, to his trade? The scientist must show the value of this information If the apprentice does not respond, we must conclude that we have not made it reasonably clear.

The wealth of Australia depends on its natural products, minerals, wool, and wheat. Other animal and vegetable products are rapidly gaining a place in the world's market. It rests with those with scientific training to add much to the value of these productions. There can be advanced many reasons why scientists should give some attention at the present time to applied science. It seems to me that members of this Society might well consider whether they cannot change the character of their scientific pursuits during the next few years. A perusal of our Proceedings shows that the great bulk of the investigations and observations recorded fall within the domain of pure science. It is far from my intention to decry the importance of scientific research directed towards no utilitarian end. I appreciate the zest and pleasure gained in the pursuit of the secrets of elusive Nature and the glow of satisfaction that comes when a new fact has been brought to light. We live, however, in a world with our fellows. They may have considered in the past that we were unpractical, stupid, and of little value, but a growing opinion alleges that we hold the keys that will unlock the gates barring progress along the paths the world desires to pass. There seems to be some notion that attention to applied science is beneath the dignity of the scientist. Some say that we should be above the search for gain, since undoubtedly the pursuit of applied science leads to more remuneration than the worship of pure science. It may be asked seriously whether there can be any more worthy aim for knowledge than its application to circumstances which ultimately have to do with the greater happiness of our fellow citizens. The directions in which the scientist can turn in regard to applied science are so numerous at the moment that the scientist may be bewildered by the numerous avenues to which he may pass. In entering any of these paths the scientist must retain the humble attitude of the student awaiting instruction from the contemplation and investigation of the objects before him, if he will be as successful in applied science as in the studies that he has already made. The assumption of knowledge based upon theoretical principles too often lures the unwary expert into sad pitfalls. We are aware that mass is estimated by the act of weighing. We know that matter is indestructible. Theoretically the weight of a quantity of matter does not alter. Neither heat nor cold influences mass. In practice, it is soon discovered that an object weighs more or less with changes of temperature. The problem is not simple. Objects are ever suspended in the air, more or less supported by its buoyancy. It is ever thus in applied science. The scientist who would assist the progress of any industry, must devote sufficient time and trouble to master its details. Wherever possible he should go through the training which the practical man takes to master his business. The amount of scientific information is already so vast that there is much room for its application without considering new discovery. If we take the application of science to the pastoral and grazing industries, wool, meat, and butter represent three products of much value. The breeding of sheep and cattle has had little scientific study in this country. I noted, a few years ago, that the weight of wool removed in the fleece from the champion sheep in the Adelaide Show had increased steadily each year. Can any scientist tell us how this has been accomplished? Would it not be worth much in Australia if a plain account of the process of selection needed to increase the yield of wool were available? The study of inheritance as applied to domestic animals might well engage some scientist's attention. The character of the wool affects its price. Here again is a field of applied science. Pests diminish the value of wool. At the present moment some of our members are studying the blow-fly pest. The fertility of sheep affects the size of the flocks. Food-supply influences the weight of the sheep and of the fleece. I need not remind you how these problems may be multiplied, and how few persons have ascertained any information about them. A group of scientists steadily observing and experimenting could do much in obtaining exact knowledge in a few years. In the meat industry, the export of the excess of beef and mutton is largely a matter of applied science. Frozen beef is not an appetising food. Chilled beef is superior. We still await the solution of the carriage of chilled beef to Europe and the East. There is much opportunity for canning meats. The canning industry consists of a series of partially solved problems. There is abundant scope for applying science. A National Canning Laboratory would be a boon to the State. It could deal not only with canned meats, but also with canned fruits and vegetables. An example for study is asparagus. It grows here in great profusion in some sandy soils. There is no canned asparagus made in Australia, and we pay large sums of money for Californian asparagus. So far we have failed to master this simple preservation. Fish abound in some of our waters. Is there not room for canning fish?

If we pass to the agricultural industries, the problems of applied science are perhaps even more numerous. Insects and fungi abound in our orchards. We want more knowledge of their life-histories. Prevention is better than cure. When we know sufficient of these pests, we shall learn whence they come. It will then be easy to arrange conditions in which the pests do not flourish. The orchardist needs scientists in the orchard, not books written for his instruction. There is a wide tendency to suppose that a problem is ended when its solution has been obtained and published. I would refer you to what I said earlier about experimental work with yeasts and bread-making. In reality, work begins only when the solution of a problem has been reached. Application needs constant endeavour. Again, in each locality the application is somewhat different. This is so often forgotten. The transport of fruit and vegetables needs study. The whole problem of cold transport is applied science. In this country, cold transport and the more extended use of refrigeration ought to be supplied. Those who use ice have often no accurate acquaintance with its conditions of use. Some years ago I saw fishermen netting whiting in an inlet of the sea some one hundred and fifty miles from Sydney. They obtained ice, in boxes containing saw-dust, from Sydney. The night before the steamer arrived, they made a wonderful haul of whiting. They considered that it was worth £300 at market prices. I watched them packing the fish. They did not use a sufficient weight of ice to cool the weight of fish to a temperature at which decomposition would be prevented. They put all their fish in the boxes and distributed the ice among them. The steamer came to time. It had a fast journey to Sydney, but all the whiting was condemned. I asked the fishermen if it often happened. They naively said that they always lost their large catches, and hazarded the opinion that the fish that occurred in large shoals, did not keep so well as those in small shoals. I asked them if they considered the weight of fish and ice, and they said that no fisherman ever paid attention to it. Cannot science be applied in this instance? Would it not be possible to mark on each box the weight of fish to be placed in it with the particular quantity of ice?

The conditions under which fruit and vegetables can be kept without decomposition, are well worthy of study by a scientist. The higher temperature, the low humidity of the central and western portions of the State, and the moist atmosphere of the coastal belt introduce factors different from those of Europe and America. The attempts so frequently made to bring European or American practice into this country are often only partially successful.

Forestry, again, needs the labours of the scientifically trained. We have such great numbers of timbers in this State that little is known about them. A few years ago, my attention was drawn to the absence of information on these matters. The very fundamentals are lacking, though in some cases work has been done despite the failure of information. The specifications sent from Woolwich to Australia for waggons and other vehicles used for military purposes contained definite standards in regard to the amounts of moisture in different woods used in the construction. Those who had been building vehicles for years in Australia, had not been accustomed to distinguish woods by terms other than seasoned, unseasoned, well-seasoned, badly-seasoned, and so forth. The use of numerical standards surprised them, and their introduction astonished them still more when they found that no information was available on these matters in Australia. It was necessary to get the information by study of the woods. I was able to direct an acute manufacturer as to the methods of determining moisture in wood. He was able then to make his own estimations and to proceed on a research, with occasional guidance. In the end, he was unable to comprehend how coachmakers had ever done without such determinations. A trap is wanted in Dubbo. If it is to remain a first-class vehicle without rattling and without opening cracks and joints, the wood employed must be dried so that it contains less than such and such a percentage of moisture. If the wood has been dried below this figure, then it has undergone sufficient contraction, and will not contract more in the dry climate of Dubbo. If the trap is needed at Grafton, it will not be necessary to obtain such dry wood, since the climate of Grafton is moist. Again, the dryness of timber affects its breaking-strain. Further, one timber will shrink as it dries in one relation to the grain more than in another. Like an investigation in pure science, that investigation on moisture in timber has no end. When the examination of one problem is ending, another question arises for answer.

Sufficient has been said to make you aware of the multiplicity of the opportunities for the study of applied science. If the scientist embarks on the new path of study, it will be well for him to take a companion. Much can be said in favour of the association of a practical man well versed in his business with the scientist. It seems to me that the scientist can be of greatest use when he suggests the principles on which something is carried out, and when he applies the controls to ascertain that the desired results are being obtained. It only happens occasionally that the scientist can suggest the best method of working. Let me give you an example. Weevils have been devastating the wheat stored in Australia for shipment abroad. Professor Lefroy was successful in defining the conditions under which the weevil multiplies in wheat. He was able to show that when the moisture in wheat fell below a certain figure, wheat will not be destroyed by this pest. The problem of drying wheat became of practical importance. Its solution was left to Professor Lefroy. It seems to me that this problem is one for an engineer or a physicist. It is a practical question that may carry several solutions. If a dozen or twenty engineers had been put to work to dry wheat, it would soon have been possible to determine who had designed the most economical and suitable mode of desiccation. It is a mistake to ask a biologist to solve an engineering problem.

My object in bringing this subject before you is to invite your attention to the importance of work on applied science in the the next few years. Our members include practically all the trained scientists in this State with knowledge of biology. If the country has to wait for others to be trained for special purposes, time will be wasted. Again, most of our members have already shown some ability to do scientific work. There have been few rewards for the scientist, and what work has been done has been carried out for the sake of Truth. Our members have thus been selected by an aptitude to do scientific work and by proved capacity to undertake research. Would it not be of benefit to our country and to our fellow-citizens if every member of this Society made an effort to do some work in applied science? The Bureau of Science and Industry will soon be established by the Commonwealth of Australia, and will be ready to assist every worker who will take up the study of an economic or industrial problem. May we not hope that every scientist in Australia will consider it his duty to do some research for the Bureau?

The Society has, during the year, prepared for a great change. Our Secretary, who has so worthily filled the place of our munificent benefactor, Sir William Macleay, has tendered his resignation, which has been accepted by the Council. The Council have been unanimously of opinion that there was only one position to which Mr. Fletcher might be elected. They were proud to recommend his election as President, and the Society has been honoured by its recognition of this proposal. Mr. Fletcher had been associated so long with the Society that he would form one of the earliest recollections of the Society in the minds of those present. It might, therefore, be of interest to you if I recall some facts in the history of the Society.

The dedication of the Hall in which we are now assembled, to the Society, on 31st October, 1885, provided an opportunity for Sir William Macleay, as donor, and for Professor W. J. Stephens, as President, to give some interesting particulars about the early history of the Society, and its future prospects and aims.

Sir William Macleay said that the Society was first formed chiefly through the exertions of Captain Stackhouse, R.N., about the beginning of the year 1875, so that it had been 10 years in existence, and had, during that period, published annually a volume, varying in size from 600 to 1400 pages with many plates, containing entirely original matter contributed by members of the Society. The estimation in which those publications had been held by the world of science had been evidenced by the large number of scientific Societies, in all parts of the globe, which had applied for an interchange of their publications with them. But during all this period in which they had been building up the scientific reputation of the Society, they had been labouring under serious difficulties of several kinds, but none so great as the want of sufficient space to meet their requirements. For the first year or so of the Society's existence, it occupied an upstairs room in Hunter-street, extremely inconvenient and difficult of access. It then, for about three years, held its meetings in a room in the Public Library, by the permission of the trustees of that institution. The next move was to very excellent and commodious apartments in the Garden Palace, which the Government of the day had most liberally placed at their disposal. Up till then they had no room for books or anything else, and the scientific publications sent to them from foreign

Societies were packed away in cases, and were literally inaccessible. But when they found themselves in possession of the ample space allotted to them in the Garden Palace, they were at once enabled to enter upon the course of usefulness which was the original intention of the founders of the Society. They had collected a large and valuable library of works on scientific subjects, and had completed the first series of lectures on natural history, open to the public, when the destruction by fire of the entire building rendered them once more homeless and destitute. It was only right to mention that the warmest sympathy for the misfortune which then befell the Society was evinced by kindred Societies. The Royal Society of Sydney had offered them the use of their house for their meetings, and from the learned Societies of all parts of Europe they had received sets of their publications to replace those destroyed by fire. For some months after the fire, they were again accommodated at the Public Library, and then for a few months they occupied a small room in Hunter-street, but in both these places the space at their disposal was so limited that they were precluded from making any attempt to again get together a collection of books. Subsequently they obtained possession of a convenient and central house in Phillip-street, in which the noise of the tram cars was their only serious disadvantage, and since then, that is to say, during the last two years, they had, though not overburdened with space, been enabled to invite contributions to the library, and the result, he was glad to inform them, was that they had now a large and excellent reference library, comprising over 5000 publications on scientific subjects. The necessity, however, for more room, and less noise, had induced him to build the edifice they were assembled in, which he begged to present, such as it was, to the Society for the period of 89 years, the unexpired term of his original lease of the ground for 99 years.

And now, having got to this point of their history, when he hoped that all difficulties had terminated, they might look forward to a prosperous future. To return once more to the occasion which had brought them together, he might confidently say that their Society had before it now a long career of untroubled usefulness. They had secured a home, a well-furnished library, a well-fitted laboratory, and, above all, a quiet and comfortable room for their meetings. To this he might add that the burden of generally directing the business of the Society, and of editing its publications, which, under the control of the Council, had, for some years past, chiefly fallen upon him, would, he hoped, henceforth be borne upon worthier shoulders. Mr. J. J. Fletcher, M.A., of Sydney University, and B.Sc., of London, was about to undertake the duties of Secretary and Director of the Institution, and it was worthy of note that he was one of the first two Australians who had taken a science degree.

The President of the Linnean Society (Professor W. J. Stephens, M.A.) then rose, and addressing their host, said that, in the brief history of the operations of the Linnean Society of New South Wales which he had just laid before its members, and in his notice of the inconveniences and even disaster under which its work had been hitherto maintained, he observed a serious omission of important facts. It was quite true that the Society was in the first instance confined to a very indifferent lodging, that their affairs were improved by the permission of the trustees of the Free Public Library to occupy for the purposes of their meetings a room in that establishment, and that their possession of excellent quarters in the Garden Palace was only terminated in a fatal conflagration. Their host had forgotten, however, to state that since that misfortune he had lodged the Society at his own expense, providing for its use in the first place an office in Hunter-street, and, secondly, a commodious house in Phillip-street, in which they had been for two years exceedingly comfortable, and which he ceased to place at their disposal only because he had now completed the building of this spacious and admirably planned Palace of Science which Mr. Macleay had that day presented to them. He had also neglected to inform them of the fact that he had himself supplied the salaries of the paid officers of the Society, that he had defrayed by far the greater portion of the cost of the Society's publications, and that he had purchased and presented to the Society two inestimable collections of scientific books and records, one unhappily doomed to perish in flame, the other, he trusted, likely to remain safely and conveniently arranged in the house for the continual use and advantage of the Society. One further benefit he had conferred upon all members, present and future, and he might add, upon the whole of Australia, in the incorporation of the Society by Act of Parliament. It was to Mr. Macleay that the country owed the establishment of a new and permanent Institution, founded, not for the sake of any pecuniary, social or political advantage to its members, but for assistance to students in their labours to promote knowledge, for the progress of this community, and for the welfare of humanity. There was a malignant old proverb which advised them not to look a gift horse in the mouth. Their host's horses, however, required no examination. They had been given with a warranty, a warranty absolute and perfect, which they all recognised with a kind of wonder, in the far-reaching and thorough-going character of his munificence. No higher guarantee for the soundness of his gift horses could be offered and his own delicacy and reticence prevented them from knowing, except on their own conjecture and estimate, how astonishing and prodigious his liberality had been. He purposely omitted on the present occasion any particular reference to the similar services which Mr. Macleay had rendered to other institutions, and hastened, as President of the Linnean Society of New South Wales, to offer him a faint and inadequate expression of the feelings which animated their whole body. The Society entertained an ardent gratitude towards him—a gratitude which was not dulled, as gratitude might sometimes be dulled, by any affectation of beneficence, or any haughty or inconsiderate phrase or touch of manner in his acts of donation, but was, on the contrary, ever quickened by the freedom from vulgar ostentation and by the generous simplicity which specially characterised his behaviour towards the Society. He would, he hoped, accept these few words, as an honest attempt to give some expression, however imperfect, to the sentiment dominant in every heart in this gathering of his friends and guests. In their name he thanked him for his services as an active partner in their labours, as a wise legislator and officer in the management of their affairs, and a benefactor whose munificence would have made us feel a heavy burden of obligation, had it been attended with scantier courtesy, or with less emphatic kindness.

Two months later, on 2nd January 1886, Mr. Fletcher entered upon his duties, which he has carried out up to the present time. For nearly six years, he had the great advantage of Sir William Macleay's friendly advice, co-operation, and help in every possible way, until Sir William was prostrated by his last illness. It has been his aim and best endeavour, during the subsequent period of more than twenty-seven years, to justify Sir William's expectations. The three Trusts which Sir William devised to the Society have been realised and in working order for some time—one providing for an income for general purposes; the second, which enabled the Society to equip and maintain a bacteriological laboratory, and to appoint a research-bacteriologist, has been effective for more than twenty years (since September, 1898); and the third, providing for the appointment of Research Fellows, has been operant since 1905. Now the time has come, he has asked the Council for his honorable discharge. No Society has received better service than that given by our Secretary. The welfare of the Linnean Society has been the sole care of his industry. Personal advantage has not been considered by him, and we owe him thanks for many hours of ungrudging toil. We do not, however, expect to lose the watchful control which has guided so well our affairs. We hope that Mr. Fletcher will still remain with us to offer that advice which is invaluable.

The resignation of Mr. Fletcher cast on the Council the responsible duty of selecting a successor. After much deliberation, the Council has selected Dr. A. B. Walkom as Secretary. He will commence his duties upon April 1st next. We can wish him every success.

During the year we have had the pleasure of welcoming back one of our Soldier-Members, Mr. R. W. Bretnall, after service abroad. We have also had favourable news of Lieutenant Goldfinch. Other Members are still absent, but we have had no direct news of any of them. Now that demobilisation is being carried out as fast as circumstances permit, and with an early prospect of the signing of peace, we may hope to see the absentees before our next Annual gathering.

The last Part of the Proceedings for 1918, completing a volume of 931 pp., illustrated with 93 Plates and 112 Text-figures, is now ready for issue. The year's volume contains thirty-eight papers, covering a wide range of subjects. Sixteen of these have been contributed by the Society's research-staff.

Our exchange-relations with Institutions and Societies outside the Commonwealth have been seriously hampered during the year, in consequence of war-conditions. To some extent, this has been due to the falling-off in our receipts from the United States. War-risks and a lack of ships have curtailed the benevolent services usually so efficiently rendered by the Bureau of International Exchanges at Washington, in receiving and distributing the publications of Scientific Institutions and Societies. The Bureau, however, has forwarded by post some of the accumulated parcels.

The receipts for the Session 1917-18 amount to only 687 additions to the library, received from 133 Institutions, Societies, &c., and six private donors, as compared with 846, 1243, 1028, and 1285 (1913-14) for the four immediately preceding Sessions. It will take some time and involve some correspondence to bring our exchange-relations up to date again, since, in some cases, there have been losses on both sides, due to the sinking of mail-steamers. Efforts will be made to re-establish this important section of the Society's activities as facilities for sending by mail increase.

Four Ordinary Members were elected during the year, one resignation was received, and we have lost, by death, three Ordinary Members, two of whom were among the Society's oldest Members.

Henry Houghton Burton Bradley, who died on 23rd November last, aged 73, had practised his profession as a Solicitor for many years, at first in partnership with his father. His interest in Natural History, especially in the Araneidæ, led to his co-operation when the establishment of this Society was first mooted in October, 1874; and he was elected the first Hon. Treasurer, which position he held for five years. He was the last of the eighty-five Foundation-Members, and had almost completed forty-four years of Membership. He was also a member of the Entomological Society of New South Wales; his paper on new species of *Stephanopis*, appeared in Vol. ii. of the Transactions (p.233). Mr. Bradley contributed four papers to Vols. i. and ii. of the Proceedings, two "On the Araneides of the 'Chevert' Expedition," "On some new Forms of Arachnidæ," and "On a new Genus of Arachnidæ." Thereafter, he still kept up his interest in Spiders, but sent his collections to, and corresponded with, specialists in Europe, especially the Rev. O. P. Cambridge, Dr. L. Koch, and Prof. T. Thorell, of Upsala, whose letters Mr. Bradley carefully treasured. He was also interested in horticulture, as a hobby, and was very successful in hybridising species of Hippeastrum. He had been Hon. Secretary of the Horticultural Society of Sydney for a long period; and, at the time of his death, he was President of the Board of Trustees of the Australian Museum. It is with great regret that I record the loss of one, not officially a biologist, who had been so long and so helpfully identified with this Society or with other Institutions, whose object it is to forward the study of Natural History.

Mrs. Bradley has been so kind as to present to the Society Mr. Bradley's set of the Proceedings (not quite complete), together with Vols. i.-ii. of the second edition of Koch's "Arachniden Australiens" [2 vols. Text; two vols. Plates (1871-1889)], Simon's "Histoire Naturelle des Araignées" [2^{me}. edit.; T. i., 1-4; T. ii., 1-4 (1892-1903)], Thorell's "Studi sui Ragni Malesi e Papuani" [Vols. i.-iii. (1877-87)], besides two minor papers—all welcome additions to the Society's library; and, besides these, a number of letters from Rev. O. P. Cambridge, Dr. Koch, and Prof. Thorell. These will be taken care of, and made available to Members interested in the groups to which the letters relate.

Augustus Simson, of Launceston, Tasmania, who died in the early part of the year, was also a senior Member, elected in 1880. He was born in London in 1836, and was educated in England and Germany. In 1863, he emigrated to Northern Queensland, but about ten years later he went to Tasmania, and settled on the east coast, which at that time was attracting much attention on account of the discovery of extensive tin-fields. From 1879, in partnership with his brother, he carried on the business of a stock and share broker, especially interested in mining enterprises. Mr. Simson was very much interested in Natural History, and made extensive collections of insects, shells, and plants. He was also a member of a Committee elected to report on and advise the City Council respecting the best means of developing the Launceston Museum.

Alexander Horsburg Turnbull, a Member elected in 1913, died at Wellington, N.Z., his birth-place, on June 27th, 1918. He was born in September, 1868, was taken to England by his parents in 1874, and was educated at Dulwich College. Subsequently he travelled through France, Italy, and Morocco. He entered a London mercantile house for a business training, in 1885; and, in 1892, returned to New Zealand to join his father's business. One of his associates in London was an enthusiastic lover of literature, and Mr. Turnbull also became a bibliophile; and, in 1887, began to collect books, having in the meantime inherited his father's library. At the time of his death, he had accumulated a library, estimated to comprise about 80,000 volumes, valued approximately at about £50,000; which he bequeathed to his fellow-citizens. Mr. Turnbull aimed first of all at making his collection as complete as possible in regard to the literature of New Zealand, Australia, and the South Sea Islands. But he was also interested in the English poets and in General History and Autobiography; and also paid some attention to choice examples of the bookbinder's art, as practised by the most noted of them. His hope was to do for students in New Zealand, what the late Mr. David S. Mitchell, founder of the Mitchell Library in Sydney, has done for students in

Australia. It is a boon, which will be more and more appreciated as their numbers increase, that investigators in all branches can successfully pursue their studies in these two valuable libraries without being unduly hampered by a lack of means or opportunity to visit the great libraries in Europe, desirable though that may be.

An event of historic interest came about last year in an unexpected way. In April last, the Society received a letter from the Director and Curator of the Australian Museum, offering, on behalf of the Trustees, the accompanying "Minute Book of the Entomological Society of New South Wales"; and explaining that "This old record was accidentally found in the Museum 'Strong-room' on the occasion of a search for another document." The recovery of this interesting relic of the scientific association which was, in a sense, the forerunner of the Linnean Society of New South Wales is very gratifying, because the Minute Book in question was supposed to have perished with our Society's early official records in the Garden Palace Fire. The Entomological Society published two volumes of Transactions, each of them comprising five Parts. The first of these contains a record of the proceedings, in addition to the papers read; but the second volume contains papers only. The minute-book shows that four Monthly Meetings, after that of October 8th, 1868, lapsed for want of a quorum; and with the brief statement that four members were present at the last of these, the record ends. The survival of the Minute Book is due to the fact that Mr. G. Krefft, then Curator of the Australian Museum, was Hon. Secretary of the Society when the formal meetings were discontinued; and that he retained and took care of the Minute Book. On some future occasion, such, perhaps, as the celebration of this Society's jubilee, it may be possible to supplement, from this new source of information, what is on record relating to the history of the Entomological Society of New South Wales. In his first Presidential Address to the Linnean Society of New South Wales, on 31st January, 1876, Sir William Macleay said, of the Entomological Society, that its scope was too limited in those early days;

and that "the sole charge of keeping up the Society ultimately fell upon such a very few individuals, that it was at length given up." The Society is very much indebted to the Trustees of the Australian Museum for the recovery of the Minute Book; and the Council has acknowledged its indebtedness to them, with an appropriate expression of its appreciation of their forethought in making this record of a bygone time available to the Society.

The year's work of the Society's research-staff may be summarised as follows:—Dr. R. Greig-Smith, Macleay Bacteriologist to the Society, completed two papers during the Session. One of these, the sixteenth of his "Contributions to a knowledge of Soil-Fertility," dealing with the search for toxin-producers, was published in Part i. of the Proceedings for 1918. The second, which is a first contribution to a knowledge of the germicidal activity of Eucalyptus Oils, will be read at the next Monthly Meeting. The results of this paper are, that when a serum-suspension of *Micrococcus aureus* was absorbed in cotton, and placed in dilutions of the Eucalyptus oils in olive oil for two hours at 20°C., it was found that the bactericidal power was proportional to the acidity of the oils. The germicidal effect, however, was not caused by the acidity, but was assisted by it. The effect upon *Bacillus coli-communis* was of much the same nature, although the action of the acid was not so clearly shown. The iodide reaction was no criterion of the germicidal value of the oils. The vapours of the oils have a decided bactericidal action. Jointly with Mr. W. W. L'Estrange, a paper explanatory of the "Springing" of Tins of Preserved Fruit will be found in Part 2 of the last year's Proceedings.

Dr. J. M. Petrie, Linnean Macleay Fellow of the Society in Biochemistry, completed an important paper on the occurrence of methyl lævo-inositol in an Australian poisonous plant (*Heterodendron oleæfolium*), which will be found in the concluding Part of last year's Proceedings. The substance isolated is apparently identical with Tanret's quebrachite, and had been previously recorded from three plants only. The occurrence of this methyl ester of lævo-rotatory inositol is, therefore, exceedingly rare, and is in great contrast to the occurrence of inactive inositol, which exists as a plastic substance in most plants. Dr. Petrie proposes to continue his work on the cyanogenesis of plants. He has also begun a preliminary analysis of the leaves of Macrozamia, with the object of obtaining some knowledge of its reputed poisonous properties.

Dr. R. J. Tillyard, Linnean Macleay Fellow of the Society in Zoology, is a contributor of twelve papers to last year's Volume. These comprise:—Nos. 3 and 4 of the series treating of the Mesozoic Insects of Queensland: Nos. 5, 6, and 7 of the series of Studies in Australian Neuroptera: the Introduction, and Nos. 1 and 2 of the series dealing with the Panorpoid Complex, a study of the phylogeny of the Holometabolous Insects, with special reference to the Subclasses Panorpoidea and Neuropteroidea: A critical discussion of the affinities of two interesting fossil insects from the Upper Carboniferous of Commentry, France: A description of a fossil insect-wing from the roof of the coal-seam in the Sydney Harbour Colliery: The second of a series of studies in Australian Mecoptera: and an account of the Australian Megaloptera or Alder-flies, with descriptions of new Genera and Species. The investigation of the Orders comprised in the Panorpoid Complex will continue to be Dr. Tillyard's first line of research; and Australian fossil insects, of which much and important material awaits study, will also receive his attention. Two papers have already been completed, and submitted. One of them, a first contribution relating to the *Micropterygidae*, is set down for the April Meeting. The other continues the series descriptive of the Mesozoic Insects of Queensland. Dr. Tillyard is to be congratulated on the important branches of his subject which he is opening up, and also all concerned upon the accumulation, in various ways, of the fruitful material he is studying.

Dr. H. S. Halcro Wardlaw, Linnean Macleay Fellow of the Society in Physiology, is a contributor of two papers to the Volume for 1918. The first treats of the relation between the fat-content and the electrical conductivity of milk. This has already appeared in Part 3 of the Proceedings. It is shown that the removal of fat from milk increases the electrical conductivity. That, in a given sample of milk, the increase of conductivity is directly proportional to the volume of fat removed. And that the increase of conductivity due to the removal of a given amount of fat is not the same in different samples of milk. The second paper is a note on the temperature of *Echidna aculeata*, in which the application of Galton's graphic method of statistical analysis to the results recorded in an earlier paper are discussed. This will be found in Part 4. From this, it is shown that the temperature-regulating mechanism of Echidna is only effective while the body-temperature lies between 27·6°C., and 32·6°C.; and that, outside of these limits, Echidna behaves as a poikilo-thermal animal. Dr. Wardlaw has also continued his investigation of the soluble salts of milk by the direct (electrometric) method. He proposes to complete his work on the variability of cows' milk; and also to investigate the action of rennin in the clotting of milk—a question of the greatest importance in connection with the digestion of milk in the stomach.

In response to the Council's invitation for applications for four Linnean Macleay Fellowships, 1919-20, six were received. I have the pleasure of making the first public announcement of the Council's re-appointment of Dr. J. M. Petrie, Dr. R. J. Tillyard, and Dr. H. S. Halcro Wardlaw to Fellowships in Biochemistry, Zoology, and Physiology; and of the appointment of Miss Vera Irwin Smith, B.Sc., to a Fellowship in Zoology—for one year from 1st proximo. On behalf of the Society, especially now that the gloom of war has abated, I have much pleasure in offering them all good wishes that success may attend their efforts to increase knowledge.

Miss Irwin Smith joins the Society's research-staff with an excellent University record, and with some experience in research-work. She has held a Science Research Scholarship in the University for two years and a half; and during that period she has been engaged in the study of Nematodes and allied worms. Her important paper on the *Chætosomatidæ* was published in the Society's Proceedings for 1917. In addition, she has contributed a paper "On a Strongyliform Nematode from the American Beaver," to the American Journal of Parasitology. Miss Irwin Smith has also undertaken the preparation of a report on a collection of parasitic Nematodes brought back from Antarctica by the expedition led by Sir Douglas Mawson. When that is completed, she proposes to study a collection of parasitic Nematodes and *Linguatulidæ* from Australian hosts, principally avian and reptilian. As this is the first time a woman has been appointed to a Fellowship, I take the opportunity of offering her a special welcome, and of assuring her of our sympathy and our desire to help her in every possible way in carrying out her work.

A year ago I sought your attention to the rarity of the capacity to make original observations. Minds in general travel along certain logical routes traced by a limited number of facts. What is not known is not perceived by the senses. Little weight is attached as yet in our community to the capacity to note what others have failed to observe. In the educational sphere, it would be wise to give more consideration to the ability to do research work. I have noticed that even Government Research Scholarships are awarded more for academic training and for the power of assimilating knowledge than for capability to undertake investigation. You will pardon me if I spend a few minutes in the examination of some studies which have been continued for several years in the Physiological Laboratories of the University. We have been engaged in making observations and performing experiments on the breath of man. That human life is intimately associated with respiration is acknowledged universally. The breath of life distinguishes the living from the dead person. It has been an object of interest to natural philosophers since the beginning of the historic age. The earliest savants noted the warmth of the breath, and believed that respiration was concerned with cooling the body. A few taught that the expired air was different in composition from the inspired air, but were unable to point out any tangible basis of their belief. The usual explanation of suffocation was that the absence of breathing occasioned over-heating of the body. We see in this conception the usual practice of seeking an explanation in accord with what is known of any phenomenon. For over a thousand years no one noted any more about the breath. The discoveries of carbon dioxide by Helmont and Black and of oxygen by Priestley opened a new era. By the end of the eighteenth century the methods devised for analysing gases were sufficiently accurate to permit the estimation of the constituents of expired air. Lavoisier, Menzies, and Sir Humphrey Davy collected, in a jar, the air passing from the nose and mouth and determined the compounds. Since this was done by these worthy scientists, thousands of analyses have been made. Great improvements have been introduced in the way in which the air has been collected, and in the process of estimating the quantities of the different gases, but the nature of the estimation has not altered. The figures express the amounts of the component gases in the jar holding the expired air. They inform us of expired air on the assumption that it is of uniform composition. Some of the earlier investigators thought that the composition of mixed expired air was similar in different breaths, and even from different persons. They therefore paid great attention to the process of analysis, because they supposed that such differences as were noticed, were due to defects in the method of analysis. They devoted much care to modifying the processes for measuring the amounts of gases in mixtures. One investigator took such care that he was able to measure the amount of oxygen in one sample of expired air with an accuracy of one part in 10,000. He obtained the figure 17·033 for the percentage of oxygen. The use of accurate methods soon made it evident that the results varied with the depth of respiration, with the rate of breathing, with movements of the body, with the character of the food, and with many other circumstances. A few still held that there was a definite composition for the expired air which might be discovered by a study of the effects of the factors influencing breathing. The majority ceased to pay much attention to the figures from any single analysis, and recorded the results of the examination of the air expired over long intervals of time.

There were, however, other scientists who noticed that the air collected after its expulsion from the respiratory passages into a jar might have a very different composition in the body. They perceived that the air of the mouth and nostrils might be differently constituted than the air in the trachea, that the air in the trachea might have another composition from the air in the small bronchial tubes, and that the air from the deep recesses of the lungs might differ from the remainder. They tested their hypothesis by collecting the expired air in successive portions, usually in two parts, but sometimes in three or more fractions. They put into practice the noble maxim of John Hunter, "do not think, but try." They found that each sample showed a different composition. The quantity of oxygen diminished from the first to the last fraction, while the amount of carbon dioxide increased. They inferred that the air in the nostrils and windpipe contained the most oxygen and the least carbonic acid gas, and that the air from the deep recesses contained most carbon dioxide and least oxygen. They were of opinion that the air in the upper respiratory passages closely resembled in composition the atmosphere, while that from the deeper parts was most altered. They concluded finally, that the expired air had a continually changing composition, that first breathed out being richest in oxygen, and that last expelled most laden with carbonic acid gas.

More than a century has elapsed since these conclusions were drawn from the experiment of analysing fractions of the expired air. Scores of scientists and hundreds of students repeated the experiment with many modifications. For eighty-five years no one perceived that the conclusions extended beyond what the experiment proved. The inferences would have been correct if the fractions had been collected in sufficient numbers to show that the air was changing in composition in some regular manner. As the volume of expired air is rarely less than 500 c.cm., and often is more than 1000 c.cm., it is obvious that analysis of the whole in three or four fractions does not furnish figures for this purpose. The inference as to the continually changing composition may or may not be true. If it were true, the figures would vary in a similar manner to those found, but they are also compatible with other conclusions. The samples analysed were too large and were collected in too haphazard a manner to give figures of the accuracy needed to prove the inference by the use of a mathematical study of their distribution. As a matter of fact, the inference is wrong. The expired air has no continually changing composition. Had the fractions of the expired air been collected with accuracy and analysed, the proper inference could have been made, but very great exactness is requisite if this method of study is adopted. These difficulties disappear when small samples are taken for analysis at considerable intervals during the expiration.

In 1905, Haldane and Priestley published the account of their experiments on expired air. They made use of the discovery of Haldane that there was little difference in the percentage of carbon dioxide in the last air expired from a deep or shallow rapid expiration. Haldane had accustomed himself to breathe evenly and regularly for some minutes while seated in a chair. He took samples at the end of a forcible expiration. On analysis, these samples were found of "identical composition" whatever was the depth of the expiration. Whether 600 c.cm., 1200 c.cm., or 1500 c.cm. were driven from the air passages, the last part of the breath showed the same percentage of carbon dioxide. Haldane recognised that the results showed the composition of the expired air leaving the air-passages was not continuously changing, but that a considerable part of the expired air had an unvarying composition. To quote an example,*

	Volume of air expired.	Percentage of CO_2 in sample.
1.	492 c.cm.	5·71
2.	1050 c.cm.	5·72

To obtain samples, Haldane introduced the method of breathing into a long rubber tube fitted with a side-piece of narrow bore close to the mouth. After expiration, the end of the tube is closed with the tongue, and the sample for analysis withdrawn from the tube through the side-piece. Haldane and Priestley

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* Haldane and Priestley, Journ. Physiol., xxxii., p.228, 1905.

were much interested in physiological problems of respiration, and utilised this discovery to ascertain the average composition of the air in the deepest recesses of the lungs. This air is usually known as alveolar air, and Haldane called the last portion of the expired air "alveolar air," though it is better to adopt the suggestion of Keogh to call this part of the breath the "alveolar expired air." By taking the samples from forcible expirations at the end of inspiration and of expiration, Haldane obtained two figures, and concluded that their average yielded the composition of average alveolar air. Haldane and Priestley* found much constancy in this figure, so that they conclude that "for each individual the normal alveolar CO_2 pressure appears to be an extraordinarily sharply defined physiological constant." In different persons, the figure varied, but remained constant in the individual. These able experimentalists then carried out a research to which I must refer you for details. They came to the opinion that the volume of inspired air was doubled when an increase of 0·2% of an atmosphere occurred in the carbon dioxide pressure in the alveolar air. By this statement, Haldane and Priestley mean that the ventilation of the lung is increased twofold when the percentage of carbon dioxide in the alveolar air rises from 5·5% to 5·7%, or some similar alteration of 0·2%.

A series of studies on the distribution of gases in expired air was commenced by Linhard and Keogh in 1911. Linhard, on whom many experiments were made, has a slow, deep respiration. In their investigation, they studied expired air not according to quantity but to time. They collected samples at intervals of a tenth or a fifth of a second as it was expired. They showed that during work the composition of the expired air seems to change continuously, that breathed later having a higher percentage of carbon dioxide.

Our attention was called to this subject by repeated failures to observe uniform figures for the tension of carbonic acid gas in the alveolar air obtained from persons working in the laboratory under easy conditions. We had supposed that the volume of the

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* Haldane and Priestley, *ibid.*, p. 253.

inspired air was regulated so nicely that the tension of carbon dioxide in the alveolar air remained practically constant from minute to minute in any individual not performing heavy work and breathing in a natural manner. We were surprised to obtain figures varying 0·5%, and generally lower than those noted in Europe. A gas-burette was arranged by which a series of samples of alveolar expired air could be obtained. With this method it was possible to obtain exactly 10 c.cm. in each sample. In this way it became possible to collect ten samples of alveolar expired air, five at the end of inspiration and five at the end of expiration, and to obtain the average figure by two duplicate analyses. The method was accurate when the samples were taken within a sufficiently short period of time to avoid any material change in the barometric pressure and in the temperature. The results showed a similar variation in the range of tensions of carbonic acid gas. It was thus evident that the tension or percentage of carbon dioxide in the alveolar expired air of persons moving easily about a room was by no means constant, but varied over a range approximately 10% of the tension. These variations did not seem to be accompanied by such great alterations in the depth of inspiration as might have been expected from our knowledge of the results obtained by Haldane and Priestley. A perusal of the original publication showed that the individual figures obtained by Haldane and Priestley showed a much wider range of difference than might have been supposed from the wording of their conclusions

While we were engaged in the work which has been in part published by Dr. Wardlaw and Miss E. Pinkerton, Haldane published some further results as a consequence of some American studies on the "dead space" which raised doubts as to the soundness of the original contention as to the uniform composition of the last part of the expired air. In this publication,* Haldane recorded a series of observations showing how constant was the tension of alveolar carbon dioxide. He made use of the fact "that the frequency of breathing may be varied within wide

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* Amer. Journ. Physiol., xxxviii., p.20, 1915.

limits without altering the alveolar tension of carbon dioxide, provided that the depth of the breathing is allowed to regulate itself naturally with no forcing or holding back. Thus by varying the frequency, one can greatly vary the depth without altering the mean tension of alveolar carbon dioxide." Haldane then stated how he had verified this fact upon himself with such a wide range of rates of breathing as 30 and 4 per minute, 24 and 6 per minute, and so on. In these experiments, Haldane obtained a close agreement. We have not been able to observe this constancy under the conditions of ordinary life. We feel quite confident in asserting that the tension of carbon dioxide in the alveolar air of persons not obviously doing work and breathing naturally varies over a range of 4 mm.Hg. every few seconds. We believe and are satisfied that constancy can be obtained by resting on a couch for an hour, by avoiding food and keeping quite still and free from excitement. With these precautions, the variation in the tension of carbon dioxide in the alveolar expired air may be reduced to one millimetre of mercury.

At the same time Haldane presented some figures of experiments confirmatory of his original contention that the deeper part of the expiration contains no more carbon dioxide than the middle part. Haldane employed the simple method of analysing a sample from the last portion of the expired breath in a series of expirations varying in depth from 190 c.cm. to 1350 c.cm. When the expiration exceeded 650 c.cm., the averaged figures showed a close agreement. If the individual figures are examined, the range of variation is greater. Thus, in a series, the maximum and minimum figures are 5·37% and 5·63%, while the average is 5·48%.

It seemed desirable to examine more carefully the composition of the successive portions of the expired breath. It would be more accurate to do this upon a single breath than by comparing portions of different expirations. We made use of a long brass tube fitted with side-pieces at intervals. In this way it was possible to draw off samples from about each 100 c.cm. in the last part of the expired air. Numerous experiments were performed with a number of modifications in detail, to make quite certain that the issuing stream of the breath swept the tube free from contained air, at any rate in the portion from which samples would be taken. These showed that a stream issuing with the velocity of the air in a quick, forcible expiration sweeps out the gaseous contents of the tube in such a complete manner that it would appear as if the issuing stream pushed the air already in the tube in front of it.

Two sets of the results obtained in the Physiological Laboratory have been published by Miss E. Pinkerton in the Proceedings of this Society. In the first series, estimations were made only of the amount of carbon dioxide, while in the second series the percentage of oxygen was also measured. In the first series, the conclusion was reached that analysis of the last 625 c.cm. of expired air shows that the difference in percentage of carbon dioxide in any portion of it, does not exceed the error in the analytical method when the expulsion is performed within two seconds for amounts of two litres and over, and within one second for quantities of one or two litres of expired air. When the air is expelled more slowly, the successive portions of expired air continue to show higher percentages of carbon dioxide. The error in the analytical method was such that there might be an error as great as 0·2% in the calculated percentage of carbon dioxide, though the duplicates all yielded figures lying within 0·1% in the calculated percentage. In the second series, more accurate methods for estimating carbon dioxide were used, so that attention could be paid to the figure in the second decimal place. The oxygen estimations were of corresponding accuracy. With the greater accuracy, it became quite evident that there is a slow rate of change in the last part of the expired air. This change does not amount to more than 0·22% in the last 625c.cm. expired in the case of carbon dioxide, and to more than 0·36% in the case of oxygen. The amount of alteration is dependent on the speed with which the air is driven from the lungs. These results are of great importance, since they make it clear that the air remaining in the air-passages at the end of an expiration will contain more carbon dioxide than that which has been expelled through the nose and mouth.

I trust that I have not wearied you with this brief account of what has been interesting us during these last few years. I hope that the desire to continue to study this problem will not die out, but that other studies may be made which will accomplish the desire of our great benefactor, Sir William Macleay, that the investigation of natural science may be promoted among us.

In moving the subjoined Resolution, Dr. T. Storie Dixson said that, as a Member of the Society since 1881, as a Member of the Council of long standing who had known Sir William Macleay, as a guest present at the historic gathering on October 31st, 1885, and as a past President, he had had an excellent opportunity of watching the Society's development since its early days, and could speak with knowledge of Mr. Fletcher's services to the Society. At first, and during Sir William's lifetime, all went well. But just about the time that some of the latter's plans were in course of realisation, the commercial crisis of 1892 so seriously affected business matters, that recovery was slow; and the Society's finances suffered in consequence. This, for a considerable period, necessitated economy in all possible directions, in order to save reduction in the size of the Society's annual volume of Proceedings. Mr. Fletcher, under these circumstances, did his best to economise in the matter of office and other expenses, and put up with less efficient assistance than he had previously had. The Trusts committed to the Society by Sir William Macleay for a Research-bacteriologist, and for Fellowships, partly for financial reasons, were not realised quite so simply or so soon as he expected. This involved more responsibility for the Council, and more work for the Secretary. Nevertheless, by patience, the difficulties were gradually surmounted. But soon after the trusts were in working order, and the value of securities had begun to improve, the war broke out, entailing a substantial increase in the cost of publication, and a corresponding discounting of the improvement in the financial outlook. Still, as far as circumstances had permitted, the work of the Society had been carried on as usual, and with due regard to the original aims and objects of its founders. The Society's annual volumes had continued to be regularly and interruptedly issued in Parts, in addition to the Macleay Memorial Volume. Mr. Fletcher had made the best of the difficulties in his department. He carried out his duties for the first six years in association with Sir William. His heart had been in his work. He had co-operated harmoniously with the Council, the Office bearers, and the Members throughout his long period of service, justifying Sir William's expectations of him, and earning the appreciation and gratitude of the Society.

Mr. E. C. Andrews, on behalf of the younger Members of the Society, in seconding the Resolution, said that Mr. Fletcher had been to them a guide, philosopher, and friend; and had never made the charge against them of the unpardonable crime of being young. He had always stood to them as the symbol of fidelity to a trust; that trust being devotion to the cause of Science through the medium of the Linnean Society of New South Wales. If Mr. Fletcher's opportunities for research-work had been limited by his official duties, yet this was counterbalanced, in some degree, by his active interest in the success of a Society whose aim it was, in a special way, both directly and indirectly, to foster scientific research-work. He had sowed that others might reap, and he had been connected with the Society sufficiently long to see them doing so. While the younger Members would regret the absence of Mr. Fletcher's guiding hand in the old way, they looked forward to his being free, to assist in the elucidation of some of the interesting but often complex problems, which still confront the biologist in Australia.

On the motion of Dr. T. Storie Dixson, seconded by Mr. E. C. Andrews, it was resolved—That this Society desires to place on record its appreciation of the invaluable services of Mr. J. J. Fletcher, the retiring Secretary. Through his resignation, the Society will suffer loss, in many ways irreparable, especially by reason of that complete understanding which existed between him and the founder of the Society, Sir William Macleay, on all matters concerning its policy, whether financial or administrative. Thoroughly imbued with the spirit which actuated Sir

William in his relations with this Society, and gifted with an unbounded and rare loyalty to his responsibility, he untiringly, unflinchingly, and often at great self-sacrifice, steered the destinies of this his trust toward the consummation of the policy of its founder. Thus, far more than a Secretary, he has been the chief and often the only guide. He joined keenly in the inevitable struggle of its infancy, and has happily lived to see its present high position with an already honoured tradition behind it, and an ever increasing activity in scientific research of the highest standard well established, and portending a promising future, with which his name will ever be inseparably associated.

Mr. A. H. S. Lucas, on behalf of the subscribers, asked the President to accept, for the Society, a portrait of the retiring Secretary to be hung in the Society's Hall, in recognition of his sustained efforts for the welfare of the Society extending over a period of more than 33 years, and of his helpfulness to Members.

The President, when accepting the portrait on behalf of the Society, said that future generations would view with interest the features of the man who had brought to fruition the plans of the founder of the Society.

Mr. C. Hedley asked Mr. Fletcher to accept a study-desk and chair, and a portrait from the Members, as a token of their esteem, and of their appreciation of his work. Attention was called to the thirty-three volumes of the Proceedings which he had edited and distributed during his term of office, making, with the preceding ten, a goodly array of forty-three volumes; and reference was made to his readiness to co-operate with the authors of papers in presenting the results of their work for publication. As a past-President, Mr. Hedley said that he thought the best view of Mr. Fletcher in relation to the Society was that from the Chair, because it was the President who saw most of, and could appreciate best, the thought and care the retiring Secretary had bestowed on the Society's comprehensive affairs.

Dr. R. J. Tillyard, in supporting Mr. Hedley's remarks, spoke briefly of Mr. Fletcher's relationship to the Linnean Macleay Fellows, and of his attitude to Science in general. The Macleay

Fellows, from time to time, needed the guiding counsel and advice of a Director: and Mr. Fletcher's experience and knowledge of the Society's affairs had always been available, with the object of helping them, and promoting harmonious relations. Kipling had divided the race of men into two classes:

> The Sons of Mary seldom bother, for they have inherited that good part.
> But the Sons of Martha favour their Mother of the troubled soul and the
> careful heart.

If Mr. Fletcher had, for the most part, become a Son of Martha, it was not, as they knew, from a lack of interest in scientific work; but because the Society's activities covered a more extensive field than usual, and the consequent official duties fully occupied his working hours.

The President presented the portrait, desk and chair from the Members to Mr. Fletcher. He referred to the indebtedness of every Member for many acts of courtesy and assistance.

Mr. Fletcher, in reply, returned heart-felt thanks to the President and to the speakers for their kind and appreciative words, and to the Members both for the Resolution which had been recorded, and for the handsome gifts with which they had endowed him. These he should value not only for what they were, but for what he thought they were intended to mean. While he had fairly definite ideas about his long official connection with the Society, these could be very simply and modestly stated. He would remind them of the ancient but sound maxim, *qui facit per alium, facit per se.* The inaugural Meeting of the Society was held on January 25th, 1875. From that date, for eleven years, Sir William Macleay relieved the Council of all anxiety and responsibility in the matter of ways and means in carrying out the executive work of the Society. Then, as he was getting on in years and wished to have more time for his own work and affairs, as he was contemplating providing a permanent home for the Society, and was desirous of attending to the preliminary foundational work for the development of the Society's sphere of usefulness which he had in mind, he entered into an arrangement with the speaker. This, in effect, though it was not how Sir William stated it, was, that he should become the senior, sleeping partner, while the speaker became his coadjutor in the enterprise. Inasmuch as Sir William made the arrangement possible, financially and otherwise, on the basis of the maxim quoted, he was the all-important sleeping partner, and was entitled to the larger share of any credit for the results attained. The arrangement was made in such a way that, when the proper time came, the Council could accept it, or not, as it might decide. When the time arrived, the Council accepted the arrangement in the spirit in which it was offered. Thereafter, thanks to the co-operation and help on the part of all concerned, the arrangement had continued to operate as Sir William hoped it would. Mr. Fletcher added that, when taking leave of the Council, he had had an opportunity of cordially thanking the Council for the consideration and help he had always received; and of acknowledging his indebtedness to fifteen Presidents, and to four out of the five Hon. Treasurers who had so well served the Society, for their never-failing assistance and co-operation. It now remained for him to acknowledge, with sincere thanks, his obligations to the Members, and especially to the contributors of papers.

Mr. G. A. Waterhouse, on behalf of the Hon. Treasurer, who was absent from Sydney, presented the balance sheets for the year 1918, 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.

No nominations of other Candidates having been received, the President declared the following elections for the ensuing Session to be duly made:—PRESIDENT: J. J. Fletcher, M.A., B.Sc.—MEMBERS OF COUNCIL (to fill six vacancies): Messrs. R. H. Cambage, F.L.S., J. H. Campbell, Prof. H. G. Chapman, M.D., B.S., J. B. Cleland, M.D., Ch.M., T. Storie Dixson, M.B., Ch.M., and A. F. Basset Hull.—AUDITOR: Mr. F. H. Rayment, F.C.P.A.

On the motion of Mr. A. G. Hamilton, a very cordial vote of thanks to the retiring President, Professor Chapman, was carried by acclamation.

The Linnean Society of New South Wales.

GENERAL ACCOUNT.

Balance Sheet at 31st December, 1918.

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
Contingencies Reserve A/c	670	0	0
Income A/c at 31st December, 1918 ...	392	16	2
	£21,062	16	2

ASSETS.	£	s	d	£	s	d
Society's Freehold	105	0	0			
Investments:						
War Loan...	6,665	0	0			
N.S.W. Treasury Bills ...	4,000	0	0			
Loans on Mortgage ...	9,900	0	0			
				20,670	0	0
Cash:						
Current A/c	132	16	2			
Savings Bank A/c... ...	250	0	0			
In hand	10	0	0			
				392	16	2
				£21,062	16	2

Audited and found correct. Securities produced.
F. H. RAYMENT, F.C.P.A., Auditor.
Sydney, 12th March, 1919.

J. H. CAMPBELL, Hon. Treasurer
Sydney, 4th February, 1919.

Dr. **INCOME ACCOUNT, year ended 31st December, 1918.** Cr.

	£	s	d	£	s	d
To Salaries and Wages				567	0	0
,, Printing (Publications)... ...	259	9	11			
,, Illustrations	146	2	0			
				405	11	11
,, Rates	30	5	8			
,, Insurance	7	17	9			
				38	3	5
,, Postage, Advertising and Petty Cash	32	11	1			
,, Printing (sundries), Stationery, etc.	7	8	6			
,, Maintenance Fee, Sir William Macleay's grave	1	10	0			
,, Audit Fee	5	5	0			
,, Bank Charges	1	3	10			
				47	18	5
,, Appropriations, viz.—						
Society's Freehold	480	0	0			
Contingencies Reserve ...	577	12	0			
				1,057	12	0
,, Balance to 1919				392	16	2
				£2,509	1	11

	£	s	d	£	s	d
By Balance from 1917				792	7	9
,, Subscriptions						
1918	107	15	6			
Arrears	30	9	0			
In advance	1	1	0			
				139	5	6
,, Entrance Fees				5	5	0
,, Interest on Investments				1,094	6	0
,, Sales (including 100 copies of Proceedings purchased by the Govt. of N.S.W.) ...				117	4	2
,, Rent (Bacteriology A/c)				16	0	0
,, Fellowships A/c: surplus income transferred				344	13	6
				£2,509	1	11

BACTERIOLOGY ACCOUNT

Balance Sheet at 31st December, 1918

LIABILITIES.	£	s	d
Capital: Amount bequeathed by Sir William Macleay	12,000	0	0
Accumulated Income capitalised	2,000	0	0
Income A/c at 31st December, 1918	72	15	6
Commercial Banking Co.—War Loan A/c ...	4,865	0	0
	£18,937	15	6

ASSETS.	£	s	d	£	s	d
Investments:						
New South Wales Inscribed Stock ..				13,900	0	0
War Loan				100	0	0
Cash: Current A/c	66	15	6			
In hand	6	0	0			
				72	15	6
War Loan Bonds as per contra				4,865	0	0
				£18,937	15	6

INCOME ACCOUNT, year ended 31st December, 1918

DR.	£	s	d	CR.	£	s	d
To Balance from 1917 .. .	1	16	11	By Interest on Investments	526	14	2
,, Salary	400	0	0				
,, Rent . . .	16	0	0				
,, Rates	10	1	11				
,, Insurance	1	6	0				
,, Gas	5	18	4				
,, Apparatus and Chemicals	9	1	9				
,, Petty Cash and Expenses	9	13	9				
,, Balance to 1919	72	15	6				
	£526	14	2		£526	14	2

Audited and found correct. Securities produced.
F. H. RAYMENT, F.C.P.A., Auditor.
Sydney, 12th March, 1919.

J. H. CAMPBELL, Hon. Treasurer
Sydney, 4th February, 1919.

LINNEAN MACLEAY FELLOWSHIPS' ACCOUNT.

Balance Sheet at 31st December, 1918.

LIABILITIES.	£	s	d	ASSETS.	£	s.	d.	£	s.	d.
Capital: Amount bequeathed by Sir William Macleay, £35,000, less Probate Duty, £1,750	33,250	0	0	Investments:						
				War Loan	10,235	0	0			
				N.S.W. Inscribed Stock	7,715	0	0			
Surplus Income capitalised	10,050	0	0	Loans on Mortgage	25,350	0	0			
Suspense A/c	33	6	8					43,300	0	0
Commercial Banking Co.—War Loan A/c	2,135	0	0	Cash: Current A/c				33	6	8
				War Loan Bonds as per contra				2,135	0	0
	£45,468	6	8					£45,468	6	8

INCOME ACCOUNT, year ended 31st December, 1918.

DR.	£	s	d	CR.	£	s	d
To Salaries of Linnean Macleay Fellows	1,266	13	4	By Interest on Investments	2,169	14	6
,, Cost of publishing Fellows' Papers	225	1	0				
,, Salaries (Suspense)	33	6	8				
,, Capital A/c	300	0	0				
,, General A/c	344	13	6				
	£2,169	14	6		£2,169	14	6

Audited and found correct. Securities produced.
F. H. RAYMENT, F.C.P.A., Auditor.
Sydney, 12th March, 1919.

J. H. CAMPBELL, Hon. Treasurer.
Sydney, 4th February, 1919.

ORDINARY MONTHLY MEETING.

March 26th, 1919.

Mr. J. J. Fletcher, M.A., B.Sc., President, in the Chair.

The Donations and Exchanges received since the previous Monthly Meeting (27th November, 1918), amounting to 22 Vols., 154 Parts or Nos., 25 Bulletins, 11 Reports, and 9 Pamphlets, received from 75 Societies, Institutions, etc., were laid upon the table.

EXHIBIT.

Miss S. Hynes showed two beautiful watercolour drawings of a remarkable, undetermined Phalloid fungus, executed by Mrs. E. Rowan, who collected the specimens in New Guinea.

AUSTRALIAN *TABANIDÆ*[DIPTERA]. No.iv.*

By Frank H. Taylor, F.E.S.

(From the Australian Institute of Tropical Medicine, Townsville.)

(Plates i.-ii.)

The Tabanidæ comprising most of the subject-matter of this paper have been received from Mr. Longman, Director of the Queensland Museum, and Messrs. W. W. Froggatt, R. J. Tillyard, and G. F. Hill. I wish to tender my best thanks to these gentlemen for affording me the opportunity of studying these forms.

Mr. Hill's collection contained by far the greater number of novelties, but the most distinctive and beautiful *Tabanus* yet described, *T. walteri*, was contained in Mr. Froggatt's collection, the type of which he has generously presented to the Institute. The Institute is also indebted to Mr. Hill's generosity in giving the types of his new species.

One new genus has been proposed for a striking species of the subfamily Tabaninæ, and descriptions of twenty-six new species and one variety are given, which are distributed in the following genera —*Silvius* (three, and one variety), *Cydistomyia* (g. et sp.n.), and *Tabanus* (twenty-two).

Subfamily PANGONINÆ.

PELECORHYNCHUS FULVUS Ricardo.

Ann. Mag. Nat. Hist., (8)., v., p.406 (1910).

Hab —N.S.W.: Mount Bindo, 4,100 feet, near Hampton (R. J. Tillyard).

PELECORHYNCHUS NIGRIPENNIS Ricardo.

Ann. Mag. Nat. Hist., (8), v., p.405 (1910).

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* Continued from Vol. xlii., 1917, p.528.

My reference to *P. maculipennis* Macq., (Proc. Linn. Soc. N. S. Wales, 1917, xlii., pp.513 and 515), should refer to *P. nigripennis* Ricardo.

EREPHOPSIS LASIOPHTHALMA Boisd.

Voy. "Astrolabe," Zool., ii., p.666 (1832); Ricardo, Ann. Mag. Nat. Hist., (8), xix., p.210 (1917); Taylor, Records Aust. Mus., xii., No.5, p.56 (1918).

A specimen in Mr. Froggatt's collection agrees with Miss Ricardo's description in all details except the antennæ, which are black, and the palpi black, with the apical third of the second joint dark red, pubescence mainly black.

Hab.—W.A.: Darlington (J. Clarke; Coll. W. W. Froggatt, No.83F).

EREPHOPSIS SUBMACULA Walker.

List. Dipt., i., p.142 (1848); *id.*, Dipt. Saund., i., p.13 (1850); Ricardo, Ann. Mag. Nat. Hist., (7), v , p.115 (1900).

A specimen under review agrees with Miss Ricardo's description. The third joint of the antennæ is broken. The wings are yellowish along the costa, and at the base, and have the first and fourth posterior cells closed for a short distance from the border.

Miss Ricardo remarks that this species should belong to *Scione* Walker, (*Diclisa* Schiner), but that it is too nearly allied to *E. guttata* Don., and *E. media* Walker, to make it advisable to remove it from *Erephopsis* at present.

Hab.—W. Australia (C. French, 1909; Coll. W. W. Froggatt, No.84F).

DIATOMINEURA BREVIROSTRIS Macquart.

Dipt. Exot., Suppl., iv., p.326 (1842); Ricardo, Ann. Mag. Nat. Hist., (8), xix., p.208 (1917).

Hab.—Q.: Mt. Tambourine (W. H. Davidson, *per* R. J. Tillyard).

DIATOMINEURA AURIFLUA Donovan.

Gen. Illustr. Ent. Hym. et Dipt. (1805) [*Tabanus*]; Ricardo, Ann. Mag. Nat. Hist., (8), xix., p.208 (1917).

Hab. Tasmania: Launceston (F. M. Littler). N.S.W.: Hampton (R. J. Tillyard).

DIATOMINEURA IANTHINA White.

Pap. and Proc. Roy. Soc. Tasmania, 1915, p 19.

Hab.—Tasmania (F. M. Littler).—N.S.W.: Hampton (R. J. Tillyard).

SILVIUS NOTATUS Ricardo.

Ann. Mag. Nat. Hist., (8), xvi., p.264 (1915).

A specimen sent by Mr. Froggatt agrees with this species in all details except as regards the clothing of the front, which is a dark brown colour, yellowish between the sub- and frontal calli, frontal callus shining black, about two-thirds the width of the front, upper edge oval, no lineal extension, its base a short distance from the subcallus, the latter with a shallow median groove; ocelli prominent, with grey tomentum round them as in the type.

The third joint of the antennæ and the palpi are broken off.

A second specimen also appears to represent this species, but both the thorax and the abdomen are somewhat denuded: there is scarcely any trace of spots on the abdomen, and the stripes on the thorax are indistinct, otherwise it is typical

Hab.—N.S.W.: Hay, Moree (W. W. Froggatt, Nos.72, 74F).

The specimen from Hay was taken on the trunks of red-gums (*Eucalyptus* sp.) on the banks of the Murrumbidgee River; the one from Moree was taken by sweeping grass on marsh-land.

SILVIUS ELONGATULUS Taylor.

Proc. Linn. Soc. N. S. Wales, 1915, xl., p.812 (1916).

S. ELONGATULUS, var. PERSIMILIS, var.nov.

♀. Similar in all details to the typical form, except the legs and abdomen.

Legs black; basal third of fore-tibiæ yellowish-brown, tibiæ and tarsi of midlegs yellowish-brown, tibiæ and tarsi of hindlegs dusky brown, first tarsals paler.

Abdomen: first three segments honey-yellow (one specimen has the first four segments honey-yellow), fourth brownish, the remainder grey-black, pubescence pale, segmentations pale.

Hab.—N. Territory: Brock's Creek, Batchelor, and Darwin (G. F. Hill).

There is a striking similarity between *S. elongatulus* and the specimens described as var. *persimilis*, so much so that the above distinctions do not appear to warrant their separation as distinct species I omitted to state, in describing *S. elongatulus*, that the front is nearly twice the width anteriorly than posteriorly.

SILVIUS ANGUSTICALLOSUS, sp.n.

♀. Length, 9·5; width of head, 3: length of wing, 10 mm.

A small, slender, black and yellowish species. Frontal callus a narrow line reaching the ocelli; legs black, tibiæ yellowish: wings yellowish-brown, basal cells clear. Abdomen with first three segments yellowish-brown, darker in the middle. Eyes pubescent.

Head: face and cheeks with blackish tomentum, grey toward sides of cheeks: pubescence black, interfacial cheek-grooves deep: beard black and grey, scanty; eyes with scanty pubescence: front narrow, slightly narrower at the vertex: tomentum grey, yellowish-brown in the centre; pubescence dark; frontal callus black, consisting of a narrow line from the subcallus to the ocelli: subcallus black, tomentum grey; palpi as long as proboscis, reddish, tomentum grey, pubescence black, pale at base; first two joints of antennæ yellowish, pubescence pale, third joint reddish-yellow, the three apical annuli blackish.

Thorax chocolate-brown with grey tomentum [somewhat denuded], pubescence pale; scutellum similar: pleuræ black, tomentum and pubescence grey.

Abdomen: first three segments pale yellowish-brown on the sides, less so on first segment, blackish-brown elsewhere, the remaining segments black, segmentations pale on all segments, with pale pubescence, black elsewhere: venter pale, blackish towards apex, pubescence pale.

Legs black, basal half of fore- and midtibiæ yellowish-brown, hind darker, coxal pubescence pale, black elsewhere.

Wings yellowish-brown, darker on fore-border; except the discal, inferior basal, anal, axillary, and bases of the fourth and fifth posterior cells, which are clear, the veins of these cells are faintly clouded, the veins blackish-brown; stigma blackish-brown: no appendix.

Hab. Q.: Stradbroke Island (H. Hacker).

A very distinct species on account of the frontal callus alone. It is most nearly related to *S. niger* Ricardo, but is markedly distinct.

Type in the Queensland Museum.

SILVIUS HACKERI, sp.n.

♀. Length, 15·5; width of head, 5·5; length of wing, 13; proboscis, 4 mm.

A large, blackish brown species; antennæ and palpi brownish; legs reddish brown; abdomen with median grey, apical flecks, segmentations grey.

Head: face and cheeks black, tomentum grey, pubescence mainly black; grooves between face and cheeks deep; subcallus shining chestnut-brown; front broad, parallel, tomentum dull golden, tinged with brown, brighter anteriorly, pubescence black; frontal callus kite-shaped, constricted near the base of middle third, dull reddish-brown, about half the width of front at widest part; first two joints of antennæ dark reddish-brown, third black, base broad, concave laterally, pubescence black, scanty; palpi conspicuously long, second joint greyish-black, apex black, truncate, base concave laterally; proboscis long, black; beard grey; eyes bare.

Thorax chocolate-brown, with three brownish stripes, the median one broad and half the length of thorax; tomentum grey; shoulders pale reddish, pubescence black, long laterally, with grey hairs beneath; scutellum dark reddish-brown, posterior pubescence grey; pleuræ pale reddish-brown, tomentum and pubescence grey.

Abdomen blackish-brown; second segment reddish-brown, grey in profile, segmentations grey, median grey-haired, apical, triangular flecks on the first six segments, lateral borders of segments pale with pale hairs, more pronounced posteriorly; venter pale on the sides, black in the middle, tomentum grey, pubescence grey and black.

Legs reddish-brown, tarsi darker, pubescence black, grey on coxæ.

Wings clear; veins dark brown; stigma brown; no appendix.

Hab.—Q.: Brisbane (H. Hacker).

Allied to *S. grandis* Ricardo, from N.W. Australia, but distinguished from it by the frontal callus, thorax, abdomen, legs, and wings.

Type in the Queensland Museum.

SILVIUS VICINUS, sp.n.

♀. Length, 11; width of head, 4; length of wing, 10 mm.

A small species with yellowish thorax and brown abdomen, with traces of median spots. Femora reddish-yellow, tibiæ and tarsi black. Wings clear, appendix rudimentary.

Head: face and cheeks covered with grey tomentum and scanty grey pubescence; beard grey, scanty; first two joints of antennæ reddish-yellow, pubescence black; third joint darker; apex dark brown, base broad; palpi pale yellowish-red, tapering to a blunt point, pubescence pale at base, scanty: front about twice as wide at vertex, tomentum golden, pubescence black, frontal callus wedge-shaped, brownish-yellow, about one-third the width of the front, lineal extension reaching the ocellar triangle; ocelli prominent; subcallus paler than front: eyes bare.

Thorax with dense golden-yellow tomentum, pubescence pale yellow and black, the latter very scattered, grey on the sides: scutellum similar to thorax; pleuræ slate-coloured, pubescence grey, dense at the wing-roots.

Abdomen: first two segments yellowish-brown, the rest blackish-brown, segmentations pale, pubescence black, pale on segmentations: there are indefinite, yellow-haired, median, apical, triangular spots on the segments.

Legs: coxæ and femora reddish-yellow, with pale pubescence; tibiæ and tarsi black, the former pale at the base, pubescence black.

Wings clear; veins dark brown; stigma yellowish-brown; appendix rudimentary on one wing, absent on the other.

Hab.—Q: Stradbroke Island (H. Hacker).

Related to *S. fulvohirtus* Taylor, but separated from it, *inter alia*, by its abdomen and legs.

Type in the Queensland Museum.

Subfamily TABANINÆ.

CYDISTOMYIA, gen.nov.

Face protuberant, with sublateral grooves; antennæ rising from well-defined cavities, third joint with six divisions, last division very obscure; first segment fairly long, cylindrical, second about one-third the length of the first, base of third as in *Tabanus*, long. Palpi about two-thirds the length of the proboscis, with first joint short and swollen, second as in *Tabanus*; eyes nude; wings about twice the length of abdomen, radial vein slightly curved, all cells widely open except the anal, which is closed near the border. Abdomen short and comparatively broad, as long as the thorax.

Genotype, *C. doddi* Taylor; ♂ unknown.

This genus is proposed for a species having a general resemblance to a Pangonid. It is abundantly distinct from all species described from Australia known to me.

CYDISTOMYIA DODDI, sp.n.

♀. Length, 12; length of wings, 11; width of head, 5 mm.

Head: face and cheeks grey, faintly tinged with cream, lower half of face between the grooves brown; pubescence pale, face slightly protuberant; grooves between face and cheeks not continuous, terminating about one-third the depth of the face from the bottom; beard scanty, pale cream-coloured; first and second joints of antennæ black, pubescence black, long on the ventral surface, base of third blackish-brown, with dense, short, black and grey pubescence, annuli black, base with a small tooth; palpi black, pubescence black, second joint tapering to a fine point; front narrow, sides parallel, covered with yellowish-brown tomentum, with a narrow border of pale pubescence from the base to the apex of the extension of the frontal callus, the latter spear-shaped, shining brown, about two-thirds the width of the front at the base, not quite resting on the subcallus, the lineal extension reaching the middle of the front; subcallus grey, very slightly tinged with cream.

Thorax: anterior half olive-brown, with two sublateral olive stripes reaching the posterior third, posterior half deep olive-brown, sides and posterior border broadly golden, also a short, pale band from the sides joining the olive stripes at the apex of the anterior third, pubescence golden on the golden areas, elsewhere black; pleuræ covered with grey tomentum and pubescence, the latter golden beneath the shoulders.

Abdomen deep olive-brown; all the segments with creamy-white, apical, triangular flecks, segmentations narrowly pale, sides of segments with apical, more or less triangular flecks diminishing in size towards the apex of the abdomen; pubescence pale on the creamy areas, black elsewhere; venter entirely greyish with pale pubescence.

Legs blackish-brown, pubescence black.

Wings very faintly tinged brown: veins black, the radial vein slightly curved; stigma yellowish; no appendix.

Hab.—Q.: Kuranda (F. P. Dodd).

Described from a single specimen. It is a very distinct and beautiful insect, and is named in honour of its discoverer.

Group iv. Forehead with no callus.

TABANUS ANGUSTICALLUS Ricardo.

Ann. Mag. Nat. Hist., (8), xix., p.218 (1917).

A single specimen before me shows that the thorax has numerous pale hairs in addition to the black pubescence. The annuli of the third joint of the antennæ are brownish when viewed from above.

Hab.—N. Territory: Howard Creek (G. F. Hill).

Group vii. Abdomen with one or more stripes, usually continuous.

TABANUS WALTERI, sp.n.

(Plate i., fig.1).

♀. Length, 15·5; length of wing, 14; width of head, 5·5 mm.

Head: face with grey tomentum and pubescence, darker on the cheeks; subcallus with brown tomentum; front grey, with grey pubescence, somewhat darker in the centre, very slightly narrower at the base, frontal callus almost square with a lineal extension reaching the centre, upper portion and extension reddish-brown, the rest reddish-yellow; beard grey, scanty: palpi pale reddish-yellow tapering to a fine point, pubescence black: first and second joints of antennæ dark red, apex of first black, pubescence black, with scattered pale hairs, third joint black, with a small tooth on the expanded basal portion.

Thorax grey, with a narrow, whitish, median line reaching the scutellum; a dark brown, fairly broad stripe on the sides, in which is a narrow, grey stripe from the suture to near the posterior extremity of the brown stripe, a narrow, grey stripe from the wing-roots to the scutellum, shoulders, and sides to the wing-roots reddish; scutellum red, with a dark blotch anteriorly, tomentum grey, pubescence of thorax and scutellum dark; pleuræ with grey tomentum and pubescence.

Abdomen reddish-brown, becoming almost black on the last two segments, segmentations and sides of all segments grey; all the segments with median, trapezium-shaped, grey patches, which are wider at the apex than at the base, pubescence grey on the stripe, segmentations, and sides, dark elsewhere; venter grey, with a broad, median dark stripe.

Legs: coxæ and femora slate-grey, with grey pubescence, basal half of the fore- and mid-tibæ and knees yellowish-brown, hind-tibiæ yellowish, apex of mid-tibiæ blackish, pubescence grey, tarsi blackish, pubescence black

Wings with prominent, grey patches in all cells: veins black, stigma yellowish-brown; appendix on right wing very short, rudimentary on the left.

Hab.—N.S.W.: Hay (W. W. Froggatt, No 71F.: 20-12-17).

This is one of the most distinct and handsome Australian species of *Tabanus*. The thoracic ornamentation, and the shape of the abdominal spots are very marked.

It affords me very great pleasure to dedicate this species to its discoverer.

TABANUS EIDSVOLDENSIS, sp.n.

(Plate ii., fig.2)

♀. Length, 10·5-14; width of head, 4·5; length of wing, 9·5-11mm.

Head: face and cheeks black, with grey tomentum and pubescence; subcallus reddish-brown, tomentum grey; front parallel, tomentum grey, brownish round the apical extremity of the frontal callus, pubescence black, fairly long on vertex, frontal callus dark reddish-brown, resting on subcallus, as wide as front, almost square with a stout lineal extension reaching beyond the centre of front; palpi pale reddish-yellow, ending in a blunt point, pubescence black, with numerous, fairly long, pale hairs on basal portion: antennæ reddish-yellow, darker than palpi, annuli appearing dusky, pubescence on first two joints black, with a few pale hairs beneath, base of third broad, no angle or tooth; beard grey.

Thorax black, sides reddish, tomentum grey, with three chocolate-brown stripes, pubescence black, with intermixed grey hairs especially noticeable on the posterior half, mainly black laterally and fairly long: scutellum black, with mixed black and pale pubescence; pleuræ black, reddish beneath wing-roots, tomentum and pubescence grey.

Abdomen: first segment dusky, next three reddish-brown, remainder darker, segmentations grey, fairly broad on first four segments, with median, grey, triangular spots forming a continuous stripe on segments two to six, pubescence black, pale on posterior borders; venter reddish-yellow, apex darker, pubescence pale.

Legs: coxæ and forelegs black, coxæ and femora with grey tomentum and long grey pubescence, black elsewhere, very dense on tarsi, basal two-thirds of fore-tibiæ dark yellowish-brown, with a few pale hairs; mid- and hindlegs yellowish-brown, femora dusky, tomentum grey.

Wings clear; veins brown; stigma yellow; a short appendix present.

Hab.—Q.: Eidsvold (Dr. T. L. Bancroft).

This species appears to be most nearly related to *T. laticallosus* Ricardo, but is readily differentiated from it. It bears a superficial resemblance to *T. circumdatus* Walker, of Group xi.

TABANUS OBSCURILINEATUS, sp.n.

(Plate i., fig.3).

♀. Length, 11·5; width of head, 4·5; length of wing, 10 mm.

Head: face and cheeks with grey tomentum and white pubescence; subcallus pale chamois, with a median furrow; front about one-third narrower anteriorly, darker than subcallus, pubescence pale, frontal callus brown, small, oblong, no lineal extension, about one-third of the width of front, and not quite resting on subcallus; palpi creamy, first joint with long, grey pubescence, second swollen, ending in a blunt point, pubescence black and pale, mainly the former: first two joints of antennæ and base of third reddish-yellow, annuli darker, tooth represented by a large, shallow angle, pubescence black on first two joints; eyes black.

Thorax covered with brown tomentum, and black and coppery pubescence, shoulders pale reddish, with long, dark pubescence, scutellum similar; pleuræ grey, with grey pubescence.

Abdomen honey-yellow, the first four segments with black, triangular, median patches, their bases resting on the posterior margin of segments, except in the first segment, stripe covered with brown tomentum, in the remaining segments the median patches do not reach the posterior margin, pubescence black; venter reddish-yellow changing to black posteriorly, with brown tomentum, pubescence pale.

Legs black, basal half of fore-tibiæ yellowish, with pale pubescence, mid- and hind-tibiæ and apex of femora yellowish, coxæ and femora with grey tomentum and pubescence, hind-tibiæ with black and pale pubescence, black elsewhere.

Wings clear; veins yellowish-brown; stigma yellow; no appendix present.

Hab.—N. Territory: Darwin (G. F. Hill).

Described from two specimens, which bear a certain relationship to *T. reducens* Walker, from Macassar and Celebes, and to *T. queenslandii* Ricardo, but are abundantly distinct from them. The specimens bear the following note—"In house, daytime. Eyes green."

Paratype in Coll. Hill.

TABANUS OBSCURIMACULATUS, sp.n.

(Plate ii., fig.4).

♀. Length, 13-17; width of head, 4-5·5; length of wings, 11-14·5 mm.

Head: face, cheeks, subcallus, and front chamois-coloured, pubescence on face and cheeks white, scanty: beard grey; front slightly narrower anteriorly, pubescence black, with a tuft of pale and black hairs on the vertex, frontal callus reddish-brown, pear-shaped, with a long, linear extension, about two-thirds the length of the front: palpi pale creamy, second joint swollen, tapering to a fine point, pubescence pale, with a few, short, scattered, black hairs: first two joints of antennæ pale reddish-yellow, with greyish tomentum and black pubescence, third joint darker, annuli dusky, expanded portion with a very small tooth.

Thorax black, shoulders yellowish-red, tomentum grey, pubescence black and pale, fairly long on the sides, scutellum similar to thorax: pleuræ with grey tomentum and pubescence.

Abdomen: first three segments honey-yellow, the remainder black, second and third with an obscure black spot, somewhat variable in size, tomentum grey, pubescence black and pale; venter pale reddish-yellow, darker towards apex, with dense grey pubescence, lateral margins with pale pubescence except at the apex.

Legs reddish yellow, tarsi darker, pubescence pale on coxæ and femora, black and pale on tibiæ, and black on tarsi.

Wings clear; veins yellowish-brown; stigma yellow; no appendix present.

Hab.—N. Territory: Darwin (G. F. Hill, No.105).

A medium-sized species, more or less closely related to *T. obscurilineatus* mihi, and *T. queenslandii* Ricardo.

Paratype in Coll. Hill.

TABANUS QUADRATUS, sp.n.

♀. Length, 9-10·5; width of head, 3-3·5; length of wing, 8-9mm.

Head: face with yellowish tomentum, slightly protuberant, grooves well developed; cheeks grey, tomentum and pubescence grey; beard grey, scanty; subcallus yellowish, with dull golden tomentum; front black, broad, with dark pubescence, giving it a dusky appearance, and a few pale hairs on the sides, parallel, about twice as long as broad, frontal callus dark red-brown, square, about half as wide as the front, and resting on the subcallus: first two joints of antennæ yellowish, with scanty black pubescence, base of third reddish-yellow, annuli darker, tooth represented by a shallow angle: palpi yellow, tomentum and pubescence grey, the latter mainly black on second joint.

Thorax black, with grey tomentum, pubescence black and pale, shoulders reddish, with fairly long, dark pubescence, scutellum similar to thorax: pleuræ black, with grey tomentum and pubescence.

Abdomen: first three segments tawny, the remainder dark brown, fourth segment paler, segments two and three with obscure, median, black spots, all the segments with indications of a continuous pale stripe, pubescence black, with scattered pale hairs, posterior and lateral borders with pale pubescence, sides of last three segments yellowish; venter pale reddish-yellow, the three apical segments dusky, pubescence mostly pale.

Legs yellowish, apex of fore-tibiæ and all the tarsi darker, pubescence pale on coxæ, and mid- and hind-femora black elsewhere.

Wings grey: veins brown, paler basally: stigma yellow; an appendix present.

Hab.—N. Territory: Darwin (G. F. Hill; Nov. 1913).

Described from two specimens, one of which is slightly damaged, and with a dirty wing. Close to *T. similis* Macq., from Tasmania, but distinguished by the abdomen in the latter species being warm buff, and having a broad, median, mummy-brown stripe, with a narrow, grey, tomentose stripe on it. Mr. Hill notes that the eyes are bright green in life.

TABANUS AUSTRALICUS, sp.n.

♀. Length, 13; width of head, 4·5; length of wing, 10·75 mm.

A blackish-brown species. Thorax slate-coloured. Abdomen blackish-brown, first two segments yellowish. Legs black, tibiæ yellowish. Wings grey.

Head: face and cheeks with grey tomentum and pubescence: beard grey, scanty; first joint of antennæ reddish-yellow, apex black above, second segment black, very short, almost obscured by the first when viewed from above, pubescence black on both segments, third joint black, base with an obtuse angle, no tooth present; palpi pale reddish-yellow, very stout, ending in a blunt point, pubescence grey and black, mainly the former; front parallel, tomentum grey, brownish in the centre, pubescence black and creamy; frontal callus reddish-brown, almost circular, about one-third of the width of front, and not quite resting on the subcallus, which is creamy; lineal extension black, long.

Thorax slate-coloured, pubescence golden, shoulders pale reddish; scutellum similar to thorax, pubescence pale, long on posterior border; pleuræ black, tomentum and pubescence grey.

Abdomen: first two segments and basal half of third brownish, first segment darker; the remainder blackish-brown, segmentations pale, a continuous, grey tomentose-stripe on segments one to six, pubescence black, grey on the stripe, sides of segments, and bands; venter slate-coloured, segmentations and pubescence pale.

Legs black, coxæ and femora with grey tomentum and pubescence, basal half of fore-, basal two-thirds of mid-, and the whole of hind-tibiæ reddish-yellow, the rest of legs black, pubescence pale on tibiæ, black on tarsi.

Wings grey; veins blackish-brown; stigma yellowish; no appendix.

Hab.—Q.: Brisbane (H. Hacker)

A species most nearly related to *T. queenslandii* Ricardo, but differing chiefly in the thorax, abdomen, and legs.

Type in Queensland Museum.

TABANUS DAPHŒNUS, sp.n.

♀. Length, 10-11·5; width of head, 3·5-4·5; length of wing, 8-9·5 mm.

Head: face and cheeks with grey tomentum and pubescence; subcallus darker, yellowish at base of antennæ; front parallel, narrow, tomentum dull golden, grey on vertex, pubescence black, densest on vertex, frontal callus about half the width of front, lenticular, brownish-yellow, with a median groove, lineal extension black, reaching middle of front; first two joints of antennæ golden, second joint obscured by first from above, pubescence black, base of third dull reddish-yellow, with a blunt tooth, annuli dusky; palpi creamy-yellow, second joint stout at base, pubescence black and pale; beard grey.

Thorax black, shoulders reddish, tomentum slate-grey, pubescence black and pale, fairly long on the sides, scutellum similar; pleuræ with grey tomentum and pubescence.

Abdomen: first three segments reddish, the remaining segments darker, pubescence mixed pale and black; all the segments show an indistinct, pale median stripe when viewed from behind forwards; one specimen has the first two reddish, and the remaining segments dusky; venter reddish, darker towards apex.

Legs: forelegs black, except basal half of tibiæ reddish-yellow, with pale pubescence; mid- and hind-femora with the basal half faintly dusky, and with grey tomentum, the rest of femora and the tibia reddish-yellow, with pale pubescence, tarsi dusky, with black pubescence.

Wings clear, subcostal, first long vein, and veins on basal half yellowish, the rest brown; stigma yellowish; no appendix.

Hab.—N. Territory: Darwin, and thirty miles east of Darwin (G. F. Hill, Nos.111, 113).

A well defined species, and, apparently, not closely related to other members of Group vii. Mr. Hill notes that the eyes are greenish-bronze, and that it is a persistent biter of horses.

Paratype in Coll. Hill.

Group viii. Species with median or lateral spots, or both, on abdomen, not usually forming a continuous stripe.

TABANUS GRISEUS, n.sp.

♀ Length, 11·5; length of wing, 10; width of head, 4 mm.

Head: face and cheeks with grey tomentum and pubescence, face slightly convex in the middle, with a shallow groove on either side, pubescence and tomentum grey, yellowish beneath subcallus, with black pubescence, subcallus with pale golden-yellow tomentum; front converging slightly towards vertex, tomentum golden, pubescence black, frontal callus shining black, bottle-shaped, with a short, thick extension; beard grey, scanty; first two joints of antennæ golden, with short, black pubescence, third joint pale reddish-yellow, annuli darker, basal portion with an inconspicuous angle; palpi yellow, ending in a blunt point, pubescence short, mixed pale and black.

Thorax deep greyish-olive, pubescence dark, scanty, scutellum similar; pleuræ with grey pubescence and tomentum.

Abdomen deep greyish-olive, pubescence black, short, segmentations with scanty pale pubescence; segments three to five with pale, median, apical, triangular spots when viewed from the head toward the abdomen; sides of segments yellowish; venter black, with grey tomentum and pubescence.

Legs black, apices of femora yellowish-brown, apical third of fore-tibiæ blackish, the remainder with mid- and hind-tibiæ yellowish-brown, tarsi black; pubescence on femora and tibiæ mainly pale, black on tarsi; coxæ grey, with grey pubescence.

Wings: upper half lightly shaded with pale brown, veins black, faintly clouded with brown, except the anal vein and those forming the posterior cells; stigma dark yellowish-brown; appendix present.

Hab.—Q.: Brisbane (H. Hacker; 20.12.17).

Type in the Queensland Museum.

This species does not seem to be closely related to any other member of Group viii. It appears to be a very distinct species.

TABANUS APREPES, sp.n.

♀. Length, 13·5; width of head, 5; length of wing, 11·5 mm.

Head: face, cheeks, and subcallus grey, pubescence on face and cheeks grey; front parallel, with grey tomentum, creamy on the sides, pubescence black, with scattered yellow hairs, chiefly on the sides, frontal callus black, pear-shaped, half the width of front and resting on subcallus, with a long extension reaching the middle of the front; palpi white, with black and white pubescence, stout, ending in a blunt joint; first two joints of antennæ yellowish, pubescence black above, grey laterally, third black, tooth represented by a broad angle; beard grey, scanty.

Thorax slate-grey, pubescence golden, sides reddish, pubescence black, scutellum similar to thorax; pleuræ with grey tomentum and pubescence.

Abdomen pale yellowish-red, pubescence black, all segments with a small, median, apical, triangular, pale fleck; pubescence pale laterally; venter yellowish-red, pubescence pale.

Legs: forelegs and basal two-thirds of mid- and hind-femora black, basal two-thirds of tibiæ and knees yellowish-brown, with pale pubescence, apical third of mid- and hind-femora, and the tibiæ and tarsi paler than fore-tibiæ, coxæ and femora with grey tomentum and pubescence, the latter mixed pale and black on femora, very dense on tarsi.

Wings clear, grey; veins dark brown; stigma yellow; no appendix present.

Hab.—Q.: Kuranda (F. P. Dodd).

Described from a single specimen, and apparently closer to *T. innotabilis* Walker, than to other members of Group viii.

Group ix. Species with paler bands, and sometimes spots on the abdomen.

TABANUS BREVIOR Walker.

List. Dipt., i., p.188 (1848); Ricardo, Ann. Mag. Nat. Hist., (8), xv., p.279 (1915).

Hab.—N. Territory: Darwin, Howard Creek (G. F. Hill, No.110).

The specimens before me do not agree well with Miss Ricardo's description of this species; but, until a specimen has been compared with the type, it is deemed advisable to leave them under the above name.

TABANUS MACQUARTI Ricardo.

Ann. Mag. Nat. Hist., (8), xiv., p.277 (1915).

Hab.—N.S.W.: Kendall (R. J. Tillyard).—Q.: Mt. Tambourine (W. H. Davidson *per* R. J. Tillyard).

TABANUS SEQUENS Walker.

List. Dipt., i., p.178 (1848); Ricardo, Ann. Mag. Nat. Hist., (8), xv., p.278 (1915).

Hab.—N. Territory: Darwin (G. F. Hill, No. 106).

TABANUS KURANDÆ, sp.n.

(Plate i., fig.5).

♀. Length, 17·5; width of head, 6·5; length of wing, 15 mm.

Head: face and cheeks black, with grey tomentum and black pubescence, lower third of face yellowish; beard grey, scanty; subcallus black, tomentum dull golden; front black, parallel, narrow, tomentum dull golden, pubescence black, frontal callus scarcely as wide as front, resting on subcallus, bottle-shaped, black, tumid, lineal extension thin, reaching the middle of front; palpi large, swollen, yellow, with dense black pubescence and a few pale hairs at the base, almost as long as proboscis, and ending in a blunt point; antennæ red, first joint long, about thrice the length of second, pubescence black, annuli dusky, tooth represented by a broad angle.

Thorax shining black, tomentum a dirty yellowish-brown, pubescence black, very short, sides red, with black pubescence, fairly long; scutellum red, base black, tomentum as on thorax, pubescence pale on posterior border; pleuræ with grey tomentum and pubescence.

Abdomen: segments one to four black, second to fourth with broad red segmentations, first with grey tomentum and a median tuft of yellowish hairs, segmentations pale, five to the apex red, pubescence black; venter with dark tomentum, pubescence black, segmentations pale.

Legs: femora and first tarsals dull red, tibiæ yellowish, apices reddish, pubescence black, dense on tarsi, tibiæ with pale hairs in addition.

Wings clear; veins brown; stigma pale yellow; no appendix present.

Hab.—Q.: Kuranda (F. P. Dodd).

Type unique. Very distinct and readily distinguishable on account of its abdominal ornamentations.

TABANUS BATCHELORI, sp.n.

(Plate ii., fig.6).

♀. Length, 13·5; width of head, 5; length of wing, 11 mm.

Head: face and cheeks covered with grey tomentum and pubescence, the latter fairly dense on the face, beard white: front parallel, tomentum grey-brown, pubescence black and golden, frontal callus brownish-black, small, about half the width of the front, pear-shaped, with a short lineal extension and resting on the subcallus, the latter with grey tomentum: eyes black: palpi creamy, with black and white pubescence, second joint swollen and tapering to a blunt point; first two joints and base of third of antennæ yellowish-brown, pubescence black and white on the first two joints, the remainder of third joint black, with a prominent angle and tooth.

Thorax black, shoulders reddish, pubescence black and copper-coloured; scutellum similar; pleuræ black, tomentum and pubescence grey, the latter long.

Abdomen yellowish-brown, becoming darker toward the apex, first two segments with small, black, median spots, pubescence black, dense, with indistinct, median, grey spots on all but the first segment; venter grey, with dense grey pubescence.

Legs black, basal half of fore-tibiæ yellowish, with pale pubescence, apex of femora and the tibiæ of mid- and hindlegs yellowish, with black and pale pubescence, tarsi dusky, pubescence black, coxæ and femora with grey tomentum and pubescence, the latter long on the coxæ.

Wings grey, brownish below the stigma, the base of the anterior branch of the third long vein, apex of the discoidal, the apex and basal portion of the inferior basal cells shaded brown; stigma dirty yellow; veins black; no appendix present.

Hab.—N. Territory: Batchelor, and near Darwin (G. F. Hill).

A species related to *T. sequens* Walker, but abundantly distinct from it.

Paratype in Coll. Hill.

TABANUS ATMOPHORUS, sp.n.

(Plate i., fig.7).

♀. Length, 10; width of head, 4; length of wing, 9 mm.

Head: face grey, with grey tomentum; cheeks ash-coloured, pubescence grey; subcallus black, tomentum ash-coloured; front black, tomentum ash-coloured, paler on the sides, pubescence black, narrow, parallel, frontal callus square, reaching the eyes, black, with a stout lineal extension with a well marked groove, and reaching the apex of the middle third; palpi black, ending in a fine point, pubescence mostly grey; first joint of antennæ black, second and expanded portion of the third red, annuli black, pubescence on first and second joints black; beard grey.

Thorax black, red above the wing-roots, tomentum grey, pubescence black, lateral pubescence black, fairly long, scutellum similar to thorax; pleuræ with grey tomentum and pubescence.

Abdomen black, with black pubescence, first segment with grey tomentum, two to five grey on the sides, segmentations brown, with grey-white pubescence and tomentum, pubescence black on the last two segmentations, lateral pubescence grey-white; first two segments of venter grey, with grey pubescence, the remainder as on dorsum.

Legs black, knees orange-yellow, pubescence black.

Wings clear; veins dark brown; stigma yellowish-brown; no appendix present.

Hab.—Q.: Kuranda (F. P. Dodd).

Very close to *T. griseoannulatus* Taylor, but distinguished from it by the different frontal callus, colour of cheeks, and the knees. This species is also less robust in build.

TABANUS CRYPSERYTHRUS, sp.n.

Length, ♂, 10·5; ♀, 9-10·5: width of head, ♂, 4; ♀, 3-4 (vix): length of wing, ♂, 9; ♀, 8·5-9 5 mm.

♂. *Head:* face sunken, covered with whitish tomentum and pubescence; cheeks with grey tomentum and pubescence; subcallus grey, with a median groove, apical portion with grey-brown tomentum; palpi pale yellowish, first joint about half as stout as second, the latter nearly uniform in width, and tapering to a blunt point, pubescence grey, with a few scattered dark hairs on the apex; first two joints of antennæ slender, yellowish, with black pubescence, third reddish-yellow, tooth represented by a broad angle, with some black pubescence on the apex, annuli dusky-brown; eyes composed of fairly large, brown facets, the lower fourth and a narrow band encircling the eyes composed of very small, black facets; beard grey, scanty.

Thorax black, with dull golden tomentum and dark, erect pubescence, sides with mainly pale pubescence, scutellum similar; pleuræ black, with grey tomentum and pubescence, with some yellowish-hairs below the wing-roots.

Abdomen: first two segments yellowish-brown, third and fourth reddish-brown, the fourth darker than third, the rest blackish, their sides pale reddish-yellow, segmentations pale, pubescence black; first three segments of venter pale reddish-yellow, fourth dark red-brown, remainder blackish with pale segmentations, pubescence pale.

Legs: forelegs black, basal two-thirds of tibiæ dusky-red, mid- and hind-femora black, tibiæ yellow, apices tinged with reddish, first tarsals with basal half tinged reddish, the rest dusky, pubescence black, mixed with pale hairs on the coxæ and femora, tomentum on coxæ and femora grey.

Wings clear; veins brown, those on the basal half of wings and the subcostal yellow; stigma pale yellowish-brown; no appendix present.

♀. *Head:* face and cheeks as in ♂, but face *not* sunken; subcallus with grey tomentum; front parallel, narrow, with grey tomentum and black pubescence, frontal callus dark reddish-brown almost reaching the eyes, pear-shaped, with a moderately stout, blackish, lineal extension reaching the middle of the front; palpi pale yellowish, with mixed black and pale pubescence. There is a small, indefinite, black spot in the centre of the second segment of the abdomen, which is almost absent in ♂.

Hab.—N. Territory: Darwin, Stapleton, and 34-Mile Railway Station (G. F. Hill, No. 8).

Apparently, a well-defined species, most nearly related to *T. nigrimanus* Walker, but readily differentiated from it, *inter alia*, by the legs and antennæ.

TABANUS FUGITIVUS, sp.n.

♀. Length, 13; width of head, 5; length of wing, 12 mm.

Head: face and cheeks covered with grey tomentum, pubescence grey, lower portion of face yellowish; beard grey, front black, tomentum a dirty-grey, frontal callus black, pear-shaped, no lineal extension, resting on the subcallus, and about one-third of the width of the front; subcallus black, tomentum grey; palpi yellowish, pubescence pale, apical third of second joint uniform in width, and ending in a blunt point; first two joints of antennæ reddish-brown, pubescence black, basal portion of third darker than first two, annuli black.

Thorax black, tomentum brown, greyish anteriorly, pubescence black, scutellum similar; pleuræ with grey tomentum and scattered grey pubescence.

Abdomen: second segment yellowish-brown, the remaining segments brown, the apical four black when abraded, pubescence black; all segments with indistinct, apical, median, grey spots, segmentations yellowish; venter black, with greyish tomentum and pale pubescence, segmentations pale.

Legs black, femora and coxæ with grey tomentum and pubescence, long on coxæ, knees pale, apical half of femora and basal two-thirds of tibiæ yellowish-brown, mid-tibiæ entirely so, tarsi dusky, with black pubescence.

Wings clear; veins dark brown, cross-veins at base of discoidal and adjacent cells faintly clouded brown; stigma yellow; appendix present.

Hab.—N. Territory: Darwin (G. F. Hill).

Type unique. Apparently more closely related to *T. sequens* Walker, than to others of Group ix.

TABANUS SILVIFORMIS, sp.n.

♀. Length, 8·5-11·5; width of head, 3-4; length of wing, 7·75-10 mm.

A small, reddish-brown species, very similar to *Silvius frontalis* Ricardo, in appearance. Thorax, abdomen, and legs reddish-brown. Antennæ reddish. Wings with brown veins, no appendix.

Head: face with cream-coloured tomentum, tomentum on cheeks grey, pubescence brownish; beard pale, very scanty; front with dark-brown tomentum, narrower at the vertex; frontal callus chestnut-brown, almost square, resting on subcallus, nearly as wide as front, with a short, stout, extension; subcallus grey, paler in centre: first two joints of antennæ reddish, with grey tomentum and black pubescence, third yellowish-brown, apical annuli darker, base with a small, distinct tooth; palpi slender, basal half of second joint slightly swollen, yellowish, tomentum grey, pubescence black, very sparse.

Thorax reddish-brown, with two, narrow, grey stripes, pubescence pale, brown laterally; scutellum reddish-brown, pubescence pale; pleuræ reddish, with grey tomentum and pubescence.

Abdomen reddish-brown, pubescence brown, brown and black on apical segment, segmentations and pubescence pale, segments one to six with median, apical, pale, triangular spots, with pale pubescence: venter blackish-brown, tomentum, pubescence, and segmentations pale.

Legs reddish, coxæ with grey tomentum, tarsi blackish, pubescence on femora and tibiæ grey, black on tarsi.

Wings clear; veins brown; stigma brownish: no appendix.

Hab.—Q.: Stradbroke Island (H. Hacker).

A species strikingly similar to *Silvius frontalis* Ricardo, in general appearance. It is most nearly related to *T. townsvilli* Ricardo, but is easily separated from it by the thorax, abdomen, and legs.

Type in Queensland Museum: paratype in Institute Coll.

TABANUS TOWNSVILLI Ricardo.

Ann. Mag. Nat. Hist., (8), xv., p.281 (1915).

Four specimens appear to be of this species, and a fifth is included till further material is available. They all differ more or less from the description, but, on the whole, appear to belong to this species.

Hab.—Q.: Brisbane, Stradbroke Island (H. Hacker).

Group x. Species with the abdomen unicolorous, or almost so, sometimes darker at apex.

TABANUS SPATIOSUS Ricardo.

Ann. Mag. Nat. Hist., (8), xv., p.288 (1915).

Hab.—Q.: Stradbroke Island (H. Hacker).

Represented by a single specimen, which agrees well with the description, but the abdomen is very greasy.

TABANUS SANGUINARIUS Bigot.

Mém. Soc. Zool. France, v., p.675 (1892) [*Atylotus*]: Ricardo, Ann. Mag. Nat. Hist, (8), xv., p.287 (1915).

Hab.—N.S.W.: Wauchope (R. J. Tillyard).

TABANUS MINOR, sp.n.

(Plate i., fig.8).

♀. Length, 8-9; width of head, 3; length of wing, 8-8·5 mm.

Head: face grey, lower portion yellowish, tomentum and pubescence grey, cheeks grey; beard grey, scanty; front parallel, black, with brownish tomentum and black pubescence, frontal callus black, shining, pear-shaped, with a short, stout extension, about two-thirds the width of the front and resting on the sub-callus; palpi creamy, with black and pale pubescence, fairly stout and ending in a blunt point: first two joints of antennæ yellow, with black pubescence; third joint reddish-yellow, with a small angle, some black pubescence on its apex, annuli black.

Thorax black, tomentum brown, pubescence pale; shoulders pale, with black and grey pubescence; pleuræ with grey tomentum and pubescence; scutellum similar to thorax.

Abdomen: first two segments yellowish-brown, the remainder brown with pale segmentations, tomentum brown, pubescence pale; venter similar to dorsum.

Wings: veins brown, faintly clouded with yellowish-brown; stigma yellowish-brown; a long appendix present.

Legs yellow, apex of fore-tibiæ brown, fore-tarsi black, mid and hind brown.

Hab.—N. Territory: Darwin (G. F. Hill, Nos.109, 112).

A small, obscure species closely related to *T. nigrimanus* Walker, but differing, *inter alia*, in the antennæ and wings.

Paratype in Coll. Hill.

TABANUS HILLI, sp.n.

(Plate ii., fig.9).

♀. Length, 11·5-13; width of head, 4-5: length of wing, 11-12 mm.

Head: face and cheeks ashen, lower portion of face yellowish, pubescence pale, scanty; beard grey; subcallus reddish-brown, with ash-coloured tomentum; front parallel, black, tomentum yellowish, frontal callus dark brown, pear-shaped, with a short lineal extension, about one-third the width of the front; palpi yellowish, second joint moderately slender, ending in a blunt point, pubescence pale, with a few, scattered, black hairs; first two joints of antennæ yellow, pubescence black, base of third reddish-brown, annuli black, tooth represented by an obtuse angle.

Thorax black, with brown tomentum, sides faintly reddish, scutellum similar to thorax, pubescence black, pale laterally; pleuræ with grey tomentum and pubescence.

Abdomen brown, first segment darker, with a brown posterior border, segmentations greyish, pubescence black; venter dark brown, with grey tomentum and pubescence.

Legs yellowish-brown, tarsi darker, pubescence mostly black.

Wings clear; veins dark brown; stigma yellow; a short appendix present.

Hab.—N. Territory: Darwin (G. F. Hill, No.67).

This species appears to be related to *T. spatiosus* Ricardo, and to *T. nigritarsis* Taylor, but is readily distinguished from them.

I have much pleasure in dedicating this species to its discoverer.

Paratype in Coll. Hill.

TABANUS DAVIDSONI, sp.n.

♀. Length, 15·5; width of head, 5; length of wing, 13 mm.

Head: face yellowish, black on the upper third, with grey tomentum, pubescence pale; cheeks with dark brown tomentum and black pubescence; subcallus dark brown, with a shallow median groove; front slightly narrower anteriorly, tomentum dark brown, pubescence black, frontal callus about half the width of the front and resting on the subcallus, pear-shaped, with a lineal extension reaching the middle of front, black, lower half of basal portion reddish-brown; beard grey; palpi pale reddish, stout, ending in a fine point, pubescence black, dense; antennæ dusky-red, annuli black, pubescence black on first two joints, a well defined tooth on expanded portion of the third joint.

Thorax dark reddish-brown, tomentum brown, greyish on anterior and posterior margins, two lateral black stripes are visible when denuded, scarcely discernible under the tomentum. sides reddish, pubescence black; scutellum reddish-brown, tomentum brown; pleuræ with grey tomentum and pubescence.

Abdomen reddish-brown, pubescence black, pale on the segmentations and laterally; venter reddish-brown, blackish in the centre and toward the apex, pubescence and tomentum pale.

Legs: forelegs black, basal two-thirds of tibiæ yellowish, with pale pubescence, mid- and hind-femora reddish-brown, pubescence pale, tibiæ yellowish-brown, hind paler, pubescence mainly black, tarsi black, pubescence black.

Wings clear; veins dark brown; stigma pale yellow; no appendix.

Hab. —Q.: Mt. Tambourine (W. H. Davidson *per* R. J. Tillyard).

This is a very distinct species, and is most nearly related to *T. kershawi* Ricardo, but may be distinguished from it, *inter alia*, by the face, cheeks, palpi, and antennæ.

TABANUS PALPALIS, sp.n.

♀. Length, 9; width of head, 3; length of wing, 9·25 mm

Head: face and cheeks yellowish, pubescence pale; beard pale; front yellowish, pubescence black, slightly narrower posteriorly, about three and a half times as long as wide anteriorly, frontal callus small, reddish-brown, almost quadrate, about half the width of the front, lineal extension very short and thin; first two joints of antennæ reddish-yellow, pubescence black, third joint bright reddish, basal portion broad, no angle or tooth present, apical annuli black; palpi yellowish, second joint long, thin (resembling the palpi of *Silvius*), and ending in a blunt point, pubescence mainly pale.

Thorax dark olive-buff, shoulders reddish, pubescence pale on the sides, scutellum darker than thorax; pleuræ greyish.

Abdomen reddish-yellow, apex darker, pubescence apparently pale, mostly denuded, venter similar to dorsum, pubescence pale.

Legs reddish-yellow, fore-femora and tibiæ darker, tarsi dusky, pubescence pale, black on tarsi.

Wings clear; veins brown; stigma lemon-yellow; a long appendix present.

Hab.—N. Territory: Batchelor (G. F. Hill, No.2).

A species readily distinguished by its palpi and general colour. Apparently not closely related to other species of Group x.

Group xi. Species with pubescence on the eyes (*Therioplectes*).

TABANUS CIRCUMDATUS Walker.

List. Dipt., i., p.185 (1848); Ricardo, Ann. Mag. Nat. Hist., (8), xvi., p.280 (1915); White, Papers and Proc. Roy. Soc. Tasmania, 1915, p.14; Taylor, Records Aust. Museum, xii., No.5, p.67 (1918).

Hab.—N.S.W.: Palm Beach (R. J. Tillyard), Cordeaux Dam (*per* W. W. Froggatt).—Victoria: Gisborne (G. Lyell *per* R. J. Tillyard).—Tasmania: George Town, St. Helen's, Mt. Arthur (F. M. Littler).

TABANUS REGIS GEORGII Macquart.

Dipt. Exot., i., p.132 (1838); Ricardo, Ann. Mag. Nat. Hist., (8), xvi., p.276 (1915).

I refer two specimens before me, provisionally, to this species. They agree with Miss Ricardo's note on the species, and also bear some affinity to the description of *T. postponens* Walker, which, Miss Ricardo states, it closely resembles.

Hab.—Q.: Townsville (Dr. A. Breinl).

TABANUS BRISBANENSIS Taylor.

(Plate ii., figs.10, 11).

Proc. Linn. Soc. N. S. Wales, 1917, xlii., p.526.

Three specimens before me bear a striking similarity to this species, differing only in having the annuli of the third joint of antennæ black, the basal portion broad, with a shallow angle; the frontal callus is slightly larger, with a short, stout, extension; the beard is also distinctly yellowish. These distinctions are not sufficient to separate them specifically.

Hab.—Tasmania: St. Helen's, George Town, and St. Mary's (F. M. Littler, No.2741).

In describing the type, I inadvertently described the frontal callus inaccurately, owing to the surrounding frontal area being glossy. It should read as follows:—Frontal callus a reddish-brown, shining, irregularly oval plug without a lineal extension, its base about half the width of the front and resting on the subcallus. The annuli of the third joint of the antennæ are also slightly dusky.

TABANUS KENDALLENSIS, sp.n.

♀. Length, 9 5-10; width of head, 4; length of wing, 9 mm.

Head: face and cheeks with grey tomentum and pubescence: beard grey; front about one-third wider anteriorly, tomentum golden-yellow, brownish on the vertex, pubescence black, frontal callus shining, dark reddish-brown, almost square, about two-thirds the width of front and resting on subcallus, with a stout, black, lineal extension reaching the middle of the front; subcallus yellowish, with grey tomentum; palpi yellowish, tomentum grey, pubescence mainly black: first two joints of antennæ pale reddish-yellow, pubescence black [third joint wanting]; eyes greenish, when moistened, and very faintly pubescent.

Thorax black, with brown tomentum and erect black pubescence with numerous golden hairs, sides reddish, with long pubescence, mainly dark, scutellum similar; pleuræ grey with long grey pubescence.

Abdomen: first three segments ochraceous orange, with a broad, median, black stripe, second to fifth segments with median, triangular, golden-haired flecks, base of first dusky, segments four to the apex black, with lateral margins ochraceous-orange, tomentum yellowish, pubescence black, pale on the posterior and lateral margins, segmentations ochraceous-orange; venter with the first three segments reddish-yellow, rest black, tomentum greyish, pubescence pale.

Legs black, basal half of fore-tibiæ yellowish-brown, mid- and hind-tibiæ paler; coxæ and femora with grey tomentum, pubescence black, a few pale hairs on the femora and tibiæ.

Wings clear; veins dark brown, yellowish at the base: stigma yellow; an appendix present.

Hab.—N.S.W.: Kendall (R. J. Tillyard; 25.2.17).

A species close to *T. neobasalis* Taylor, but differing markedly in the clothing of the front, and in the legs.

TABANUS ROBUSTUS, sp n.

♀. Length, 17; length of wing, 14; width of head, 6 mm.

Head: face and cheeks covered with white tomentum and pubescence, the latter fairly long on the face; beard white, dense; first two joints of antennæ deep red, with black pubescence, and scattered, white and grey hairs on inner sides: third joint missing; palpi reddish-yellow, tapering to a blunt point, pubescence white; subcallus covered with grey tomentum; front broad, narrower at vertex, tomentum greyish-white, vertex with brown tomentum; frontal callus black, shining, as wide as front, resting on subcallus, and gradually tapering to a blunt point, ending about the middle of the front; eyes black, pubescence short and pale.

Thorax pale reddish, with grey tomentum, a broad, median, dark brown stripe terminating on a level with the wing-roots, from whence it is continued to the scutellum as a very narrow line, on either side is a brown stripe the full length of the thorax, and a short one above the wing-roots; shoulders yellowish, lateral pubescence grey, dorsally dark on the stripes, grey elsewhere; scutellum dark, posterior border grey; pleuræ grey, with patches of long, grey pubescence.

Abdomen: first segment dark, with grey tomentum, posterior border yellowish except centrally, remaining segments somewhat greasy, appearing brown, segmentations paler, with remains of grey tomentum; venter black, segmentations pale, tomentum grey, pubescence grey, scattered.

Legs: coxæ and femora grey, with long, grey pubescence, the latter shorter on the femora, fore-tibiæ pale red-brown, mid dark red-brown, hind black, pubescence pale, tarsi black, pubescence black, hind-tibiæ with a dense white fringe of hairs on the external margin.

Wings clear; veins dark brown; stigma yellowish-brown; appendix present.

Hab.—Q.: Brisbane (H. Hacker; 29.10.17).

A very distinct and robust species, not closely related to any species known to me. The white fringe on the hind-tibiæ is very noticeable.

Type in the Queensland Museum.

TABANUS GERALDTONENSIS, sp.n.

(Plate i., fig.12).

♀. Length, 12; length of wing, 11; width of head, 4·5 mm.

Head: face and cheeks grey, with grey pubescence; subcallus pale dirty yellow; front parallel, grey, yellowish toward the base and along the sides, pubescence black, frontal callus about one-half the width of the front at base, deep red, flask-shaped, with a stout, lineal extension reaching the middle of the front, a few black hairs on the vertex; eyes black, pubescence very short and scanty; first two joints and basal half of base of third joint dull reddish, rest of basal portion of third joint dusky, annuli black, pubescence on first two joints mainly black; palpi slender, about two-thirds the length of proboscis, yellowish, ending in a fine point, pubescence yellowish, beard grey.

Thorax black, shoulders obscurely reddish, tomentum grey, pubescence black and golden, grey on sides, scutellum similar to thorax; pleuræ obscurely black and reddish, tomentum and pubescence grey.

Abdomen reddish-brown, darker on last three segments, segments one to four black in the centre, all segments with median, grey, triangular spots, with their bases resting on the posterior border, segmentations and sides of segments yellowish, pubescence black, pale on the pale areas; venter reddish, black in the centre, pubescence pale.

Legs: fore-coxæ pale, with long, grey pubescence, mid and hind dusky, tomentum and pubescence grey, the latter shorter than on fore-coxæ, femoro-coxal joint of foreleg slate-coloured, fore-femora and basal half of tibiæ yellowish, the rest dusky, mid-femora and tibiæ yellowish, tarsi dusky, basal half of hind-femora dusky, the rest yellowish, tibiæ and tarsi wanting, tarsi of fore- and midlegs black, pubescence pale and dark on femora, black on tibiæ and tarsi.

Wings clear; veins brown; stigma yellow; a small appendix present.

Hab.—W.A.: Geraldton (J. Clarke, Coll. W. W. Froggatt, No.75 F).

Closely related to *T. antecedens* Walker, but differing in having a smaller frontal callus, in the absence of stripes on the thorax, and in the scanty pubescence on the eyes. The abdomen and legs also differ.

TABANUS POSTPONENS Walker.

List. Dipt., i, p.179 (1848): Ricardo, Ann. Mag. Nat. Hist., (8), xvi., p.282 (1915); Taylor, Records Aust. Mus., xii., No.5, p.69 (1918).

Hab.—Q.: Stradbroke Island (H. Hacker).

Two specimens, ♂♀, the latter agreeing well with Miss Ricardo's description. The male has already been described by me from a specimen in the Australian Museum Collection.

EXPLANATION OF PLATES I.-II.

Plate i.

Fig.1.—*Tabanus walteri*, sp.n.
Fig.3.—*T. obscurilineatus*, sp.n.
Fig.5.—*T. kurandae*, sp.n.
Fig.7.—*T. atmophorus*, sp.n.
Fig.8.—*T. minor*, sp.n.
Fig.12.—*T. geraldtonensis*, sp.n.

Plate ii.

Fig.2.—*Tabanus eidsvoldensis*, sp.n.
Fig.4.—*T. obscurimaculatus*, sp.n.
Fig.6.—*T. batchelori*, sp.n.
Fig.9.—*T. hilli*, sp.n.
Fig.10.—*T. brisbanensis* Taylor, from Queensland.
Fig.11.—*T brisbanensis* Taylor, from St. Helen's, Tasmania.

THE GERMICIDAL ACTIVITY OF THE EUCALYPTUS OILS. PART i.

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

(With one Text-figure).

Eucalyptus oil is generally considered to have some disinfecting properties, but, as a disinfectant, it has gone out of fashion. The reason for its scanty recognition at the present time is probably to be found in the greater ease with which solutions or emulsions of the coal-tar products and of other disinfectants can be made. Eucalyptus oil does not dissolve or emulsify readily, and, on standing, gives a floating film, all of which militate against its use. Added to this, there is the uncertainty about its activity. It finds a place in certain ointments, such as Unguentum Eucalypti and the paraffin-preparation recently devised for spraying burns; but, in these, its action as a cutaneous stimulant is probably more considered than its value as a bactericide. Again, in ailments of the respiratory system, Eucalyptus oil is used in combination, as, for example, with menthol. The popular idea is that it acts as a disinfectant, but the medical opinion is that it acts as an indirect expectorant.

The chemistry of the Eucalyptus oils has been extensively investigated by Baker and Smith, who possess a large number of oils of undoubted botanical origin, and, in view of the uncertainty of the disinfecting action of the oils, it seemed opportune to examine their activity while the material was available. The possibility of finding a trade oil of good quality, with a high disinfecting power, was worthy of some investigation; and, upon consulting Mr. H. G. Smith, he kindly offered to supply me with specimens from the material collected by Mr. Baker and himself.

The Eucalyptus oil of the text-books upon Materia Medica is referred to as the oil of *Eucalyptus globulus*. This oil was originally sent to Europe, and is still distilled in Tasmania; but there is reason to believe that many oils of mixed and doubtful origin were exported in the past under the name of *E. globulus*. At the present time, much of the oil can be trusted to be true to species-name. *E. globulus* is also found in the South-Eastern States of the Commonwealth, but the trees are usually too scattered to be profitably collected, while the yield is poor; and as other species give higher yields of good quality, these furnish the oils to the trade.

In New South Wales, the chief sources of oil at present are *E. polybractea* (the "Blue Mallee" of the Wyalong district), *E. cinerea* (the "Argyle Apple"), *E. australiana* (the "Narrow-leaf Peppermint"), and *E. dives* (the "Broad-leaf Peppermint"). The three first species yield cineol (eucalyptol) oils for pharmaceutical purposes The oil of *E. dives* has the terpene, phellandrene, as the chief constituent, and is mainly used for the flotation of minerals.

The action of the oils when used in ointments was given first consideration, and, as these are generally used for skin-ailments caused by the white and yellow staphylococci, it was thought that much useful information would be gained by testing dilutions of the Eucalyptus oil in an inert oil, such as olive oil, against the yellow staphylococcus suspended in serum. An exposure of two hours was deemed sufficient.

The test-organism was grown on nutrient agar overnight at 37°, and, in the morning, a loop was smeared over the surface of an agar-slope, which was incubated at 37° for three hours, during which the dilutions were prepared. Blood-serum was obtained in the manner used in opsonic work, and a loop of the agar-growth was thoroughly mixed with some of the serum. In preliminary experiments, the infected serum was smeared within the lower ends of glass-tubes, but, as it subsequently fell away in flakes, the method was altered, and a loop of the serum was absorbed in strands of cotton attached to wire-loops. These loops were made by bending a seven-inch length of wire, B.W.G. No.21, round a thick wire, and thickly coating the loop and the two inches of wire further up with tin by means of a soldering iron. This extra tinning was found to be necessary to prevent the wire rusting and vitiating the tests. A strand of thick darning cotton (Chadwick, No.10) was looped on the eye of the wire with a wire hook, and the loose ends were cut, leaving two strands about a centimetre in length. The wires were sterilised, the cotton was touched with a loop of infected serum and put into the diluted oil. The wire-loops could be used over and over again, but the cotton had to be renewed after every test.

The infected cotton remained in the diluted disinfectant for two hours at 20°, when the wire was withdrawn, and the excess of oil was removed from the cotton by twirling the wire against the inner sides of the tube. The cotton and wire were then dropped into a tube containing three c.c. of meat-extract broth,* after passing the stem of the wire through a flame. The tubes of broth were incubated at 37°, and were observed daily for four days.

The Eucalyptus oils do not appear to have previously been tested by means of their dilutions in a neutral oil. Some years ago, Cuthbert Hall examined the activities of the undiluted oils. His paper was presented as a thesis for the doctorate of Sydney University, and was subsequently issued as a private publication.† From the booklet, I have in the following paragraphs abstracted the main items which bear upon this investigation.

The action of the oils upon the staphylococcus and the colon bacillus was investigated, and it was found that the constituents of the oils possessed individual activities. Aromadendral was most active, as it destroyed the staphylococcus in 15 minutes. The other constituents took much longer—phellandrene 2½ hours, piperitone and dextro-pinene each 4 hours, lævo-pinene 5½ hours,

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* This was war-time broth; it had no peptone. A litre of tap-water contained 20 grams of Lemco meat-extract and 5 grams of common salt; the reaction was made decidedly but not strongly pink to phenolphthalein. It gave very satisfactory growths.

† On Eucalyptus Oils especially in relation to their Bactericidal Power. By Cuthbert Hall, M.B., Ch.M. [Little and Co., The Argus Printing Works, Parramatta, 1904].

aromadendrene 6 hours, and cineol (eucalyptol) 2 days.* It took less time to destroy *Bac. coli communis*, but the lethal times ran in much the same order.

The crude oils were found to be very variable in their activity, and this was considered to be caused by a greater or less proportion of free acid because the more toxic oils were markedly acid, and the less toxic were neutral or very faintly acid. From this generalisation, and bearing in mind that acid media are unfavourable to bacteria, the conclusion was come to that the activity of the acid oils was due entirely to the acid. A definite test, however, showed that when the crude oil of *E. Smithii* was neutralised with soda solution, the lethal time was lengthened from thirty minutes to three and a half hours.

The refined oils were found to be much less active than the crude oils. In their case, the variability in bactericidal power was traced to the ozone dissolved in them. The oil of *E. Smithii*, for example, took six and a half hours to destroy the staphylococcus, but when a small amount of ozone was present, it took less than two hours. Cineol took two days, but, when it contained ozone, the time was reduced to three hours. Thus the variation in the refined oils was traced to the ozone, and, in the crude oils, to the acidity, from which we must infer that the refined oils were neutral or faintly acid, and that the crude oils did not contain ozone. Both the acid and the ozone were considered to be strongly bactericidal, in fact, when speaking of aromadendral, it was said that "as compared with the other constituents of the oils, it is a strong bactericide, being only exceeded by acetic acid and ozone."

Some forty or fifty specimens of crude and refined oils were obtained from Mr. H. G. Smith, and dilutions in olive oil were tested upon serum-suspensions of the yellow staphylococcus, *Micrococcus aureus*, absorbed in cotton. The results are summarised in Table i.

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* Aromadendral is a lævo-rotatory, high-boiling, aromatic aldehyde, and is the characteristic constituent of most of the "Mallee" oils and those belonging to the "Box" group of Eucalypts. Piperitone is a ketone, and is the characteristic constituent of the oils of the large group of Eucalypts known as "Peppermints."

Table i.

M. aureus, suspended in serum and absorbed on cotton.

	Percentage dilution, bactericidal in 2 hours at 20°.		Acidity of oil in degrees.
	As determined.	Probable	
Group iii*a*.			
E. cinerea, rect.	20—20	20	96
,, ,, ,,	20	20	95
,, ,, ,,	000—100—100	100	18
,, ,, crude	60—50—50	50	81
,, ,, ,,	000—000	000	12
E. Smithii, rect.	50—50	50	—
,, ,, ,,	50	50	37
,, ,, crude	000—000	000	35
E. sp. "Ribbon Gum," crude, 10 yrs. old	30—30—30	30	127
,, ,, ,,	100—100—100	100	18
Group iii*b*.			
E. polybractea, rect.	000—000	000	10
,, ,, ,,	000—000	000	10
,, ,, crude	50—40	45	76
,, ,, ,,	30—30	30	—
,, ,, ,,	100—100	100	4
E. cneorifolia, crude	70—70	70	41
Group iii*c*.			
E. australiana, rect., 1st hour	20—20—20—10	20	108
,, ,, ,,	100—90	100	5
,, ,, ,,	100	100	5
,, ,, crude, 1st hour	60—60—50	60	—
,, ,, ,, ,,	100—100	100	10
,, ,, ,, 2nd hour	30—30—10	30	150
,, ,, ,, 3rd hour	30—30—30	30	116
,, ,, steam residue	40—40	40	—
,, ,, commercial residue	70—60—60	60	—
E. Considenana, rect.	60—50—50	50	29
,, ,, ,,	40—40	40	—
,, ,, boiling above 190°	000	000	31
Group iv.			
E. albens, crude	100—100	100	25
Group vi*a*.			
E. amygdalina, crude	000—000	000	7
E. linearis, rect., thickened	10—10—10	10	160
E. australiana (Braidwood), crude	60	60	—
,, ,, ,,	000—000	000	6
,, ,, ,,	100—90	95	7

"000" means that the oil was inactive.

TABLE i. *(continued).*

	Percentage dilution, bactericidal in 2 hours at 20°.		Acidity of oil in degrees.
	As determined.	Probable	
Group vi*b*.			
E. dives, crude	70—70—60—60	65	17
.. ..	70—60	65	12
.. ..	50—50	50	52
E. radiata, rect., 1st hour	80—80—60	80	—
.. .. crude	80—80—70	80	18
Miscellaneous.			
E. nova-anglica	100	100	33
E. citriodora	60—60	60	140
Melaleuca Maidenii, crude	70—70	70	49
Prostanthera cineolifera	40—40	40	63
Cineol (H. G. Smith)	000—000	000	—
Cineol (G. I. Hudson)	000—000	000	2
Ol. Eucalypti, P.B. (purchased) ...	000—000	000	12
Essential Eucalyptus Oil (purchased)...	100—90	95	34
Piperitone	60—50	55	—
Geranyl Acetate (*E. Macarthuri*) ...	40—30	35	—
Phenol, crystals at 28° with 0·33% water	6	6	—
Phenol, liquid at 22°, coloured ...	6—6	6	—
Ol. Olivæ	000	000	28

"000" means that the oil was inactive.

The Eucalyptus oils have been classified by Baker and Smith* according to the relative amounts of cineol (eucalyptol), pinene, phellandrene, piperitone, or aromadendral which are contained in the crude oils. The groups or subgroups, containing the oils that were examined, are as follows:—

Group iii*a*.—The oils consist principally of cineol, which is over 40%, and of pinene. Phellandrene is absent. *E. globulus* belongs to this subgroup.

Group iii*b*.—Similar to the last, but aromadendral replaces some of the pinene.

Group iiic.—Similar to iii*a*., but phellandrene replaces some of the pinene.

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* The Eucalypts and their Essential Oils. By R. T. Baker and H. G. Smith.

Group iv.—The oils never contain more than 30% of cineol, the other constituents being pinene and aromadendral.

Group vi*a*.—The oils never contain more than 30 of cineol. The chief constituent is phellandrene, and there is some piperitone.

Group vi*b*.—Cineol is almost absent. The chief constituents are phellandrene and piperitone.

Some of the oils were, at first, tested several times to determine the accuracy of the method, and it was found to be quite trustworthy when the dilutions were made in steps of 10, *i.e.*, falling by 10% progressively from the undiluted oil through 90%, 80%, and so on to a 10% dilution.

Several samples of the same kind of oil gave the same toxicity-numbers, and it was afterwards learned that they had been taken from one original specimen. The rectified oil of *E. cinerea* is a case in point; the identity of the toxicity and the acidity-numbers brings this out clearly.

The oils of *E. australiana* were extensively tested, because it was one of the first to be examined, and the high toxicity of the first sample compared with the other oils and with the crude oil led to the belief that the disinfecting power might be due to a constituent which accompanied the cineol during rectification, and which might prove to be more efficient than phenol. A second specimen of the rectified oil dispelled the idea. *E. australiana* was once known as *E. amygdalina*, but, owing to the difference from the Tasmanian tree bearing this name, it was renamed by Baker and Smith. The quality of the oil differs according to the location of the tree. When growing on the ridges of the Dividing Range at a high altitude, the quality of the oil is poor compared with that obtained from trees growing at a lower elevation.*

The cineol had been obtained by freezing the rectified oil

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* In the latter case, the phellandrene (which is in fair amount in the oil from the species growing at the higher altitudes, such as the Braidwood district), has practically disappeared, and the cineol has correspondingly increased. The alteration in the percentage amount of the constituents is only shown between the cineol and the phellandrene.

obtained from *E. polybractea* or *E. sideroxylon*; one sample came from Mr. H. G. Smith, and the other from Mr. G. I. Hudson.

The Ol. Eucalypti, P.B., was purchased from a chemist, who put it up in ounce bottles at 1s., with a label which, after enumerating the various ailments for which the oil is recommended, continued with "The extract is a thorough deodorant and disinfectant. A few drops on a cloth in a sick-room renders the air refreshing. In fever-rooms the floor should be sprinkled with it."

The Essential Eucalyptus Oil was purchased from the same druggist. It was sold in four ounce bottles at 2s. The oil was of a pale straw-colour and was apparently a crude oil. The label, *inter alia*, affirmed "The oil is a thorough deodorant, disinfectant, and an antiseptic of great value."

The most striking point brought out by the investigation is the irregularity in the action of the oils from the same tree. Two specimens of *E. australiana*, rect., for example, gave widely different bactericidal activities: one was almost inactive, while the other was among the most active of the oils. *E. polybractea*, crude, was almost a similar case. Since there is so much difference between specimens of the same oils, it is not surprising to find that there is no regularity among the groups. One cannot group the oils by their bactericidal activities. If aromadendral* is the most toxic of the components of the oils, those members of the groups which have it as a typical component should be the most toxic, but such is not the case. The aromadendral oils of groups iii*b* and iv are no more bactericidal than the oils of the other groups; indeed the oil of *E. albens*, the only member of group iv. tested, is a very poor disinfectant.

Cineol was inactive when tested in oil, and if an ointment were made with Ol. Eucalypti P.B., which would be used by any druggist dispensing it, the preparation would have no disinfecting action towards the ordinary pus organism.

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* I did not have enough aromadendral to test by the method adopted in this research, but as I shall show in a following paper, it is a strong disinfectant in aqueous suspension.

The oils as a whole were weak compared with phenol, although the thickened oil of *E. linearis* was very nearly as good.

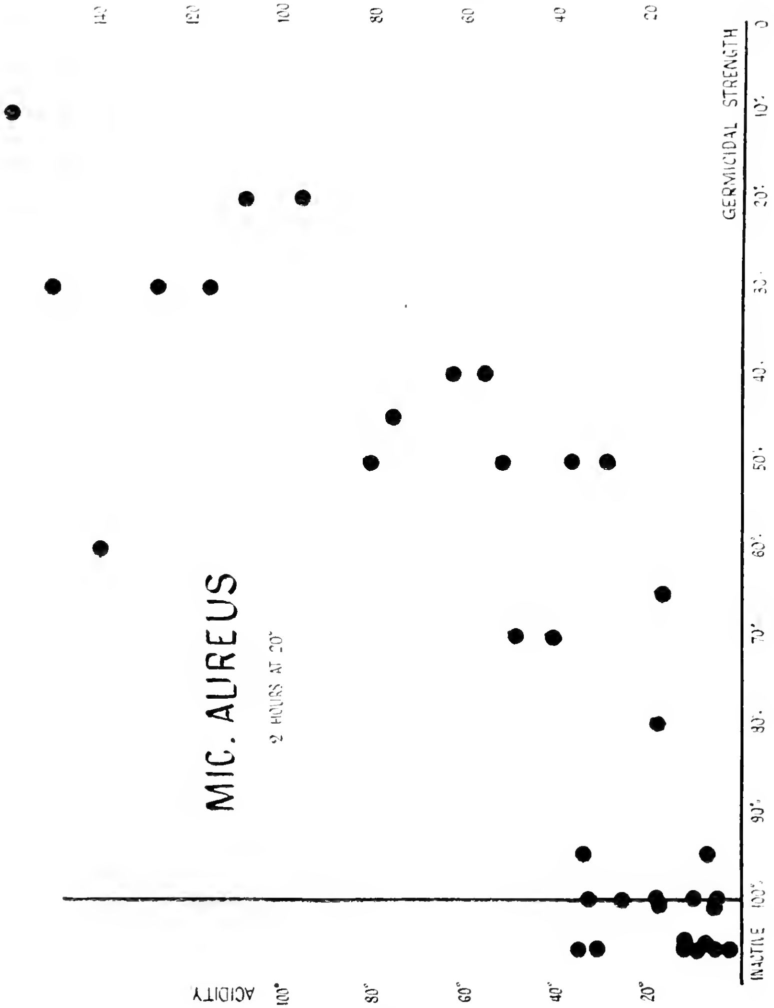
While a 10% solution of phenol in oil is used as a disinfectant, the statement occurs in Hale White's Materia Medica that "The solution in oil has no antiseptic properties." The staphylococcus was destroyed in two hours in a 6% solution in oil.

The irregularity of the disinfecting action of the oils leads to the belief that any power which they possess is not occasioned by any of the chief constituents. The oils which have most cineol or most phellandrene or most pinene or most aromadendral are no better than others with less. We must therefore look to the minor constituents which may be occasionally absent. The oils which were most active were pronouncedly acid to litmus paper, as Cuthbert Hall also found, and this led to the determination of the acidity of such samples as had not been completely used up.

The method consisted in taking 20 c.c. of methylated spirit, adding a few drops of phenolphthalein and running in N/100 sodium hydrate until a faint pink colour was produced. One c.c. of Eucalyptus oil was added, and the solution titrated with N/100 sodium hydrate. The numbers in the Table represent c.c. of normal acid per litre of oil, *i.e.*, the degrees of acidity.

The acidity of the oils of each group is as variable as the toxicity, and while the most acid of the oils are also the most toxic, no definite relation between the acidity and the bactericidal power could be detected until the acidities were plotted against the toxicities, and, but for the comparatively large number of oils examined, a relationship would not even then have been capable of demonstration. The curve is of the nature of a broad band within which most of the oils fall. Some are exceptional, such as the oil of *E. citriodora*, which is itself an exceptional oil. The case of *E. australiana*, crude, 2nd hour, cannot at present be explained.

It was shown by Cuthbert Hall, that the undiluted oils were more active towards the colon bacillus, *B. coli communis*, than towards the staphylococcus, *M. aureus*. Tests were made to show that this would also hold for dilutions in oil. Several of the oils with varying activities towards the staphylococcus were tested with the colon bacillus, and the results are summarised in



Text-fig. 1.

the Table. With *B. coli communis* the dilutions were made in steps of five, *i.e.*, 5%, 10%, 15%, and so on up to 50%, then they rose by 10 to 100%. The numbers obtained with the staphylococcus are given for purposes of comparison.

TABLE ii.

Bacteria suspended in serum and absorbed on cotton.

Acidity in degrees.		Bactericidal dilutions in oil. 2 hours at 20°.		
		B. coli communis.		*M. aureus.*
		Lethal dilution in tests.	Probable lethal dilution.	As previously determined
160	*E. linearis*, rect., thickened	10, 10	10	10
95	*E. cinerea*, rect.	10, 10	10	10
29	*E. Consideniana*, rect.	10	10	50
116	*E. australiana*, crude, 3rd hour	10, 10	10	30
150	*E. australiana*, crude, 2nd hour	10, 15	12	30
52	*E. dives*, crude	15, 20	17	50
126	Ribbon Gum	20, 20	20	30
7	*E. australiana* (Braidwood)	25, 25	25	95
37	*E. Smithii*, rect.	25, 25	25	50
5	*E. australiana*, rect.	25, 25, 30	25	100
63	*Prostanthera cineolifera*, crude	30	30	40
81	*E. cinerea*, crude	30, 35	32	50
41	*E. cneorifolia*, crude	30, 35	32	70
34	Essential Oil	35	35	95
4	*E. polybractea*, crude	40, 40	40	inactive
18	*E. cinerea*, rect.	45	45	100
12	*E. cinerea*, crude	50	50	inactive
2	Cineol	60	60	inactive
10	*E. polybractea*, rect.	60	60	inactive
33	*E. nova-anglica*, crude	inactive	inactive	inactive
—	Phenol	4	4	6

The oils which were bactericidal towards *B. coli communis* in the more dilute solutions, were also generally most active towards the staphylococcus, and, as with the staphylococcus, the activities went roughly with the acidity. But there were exceptions, so that when the acidities were plotted against the activities, as represented by the bactericidal dilutions, instead of obtaining a band, as in the staphylococcus, the numbers fell into a wedge-shaped area.

When it had been shown that the acidity of the Eucalyptus oils was a measure of their bactericidal power, the question arose, as to whether the acids were entirely responsible for the toxicity, or whether the acidity was only the index of some strongly bactericidal constituent. The simplest method of testing the matter seemed to be to neutralise the acid, and then compare the toxicity of the neutral oil with the original.

Some of the oils containing an appreciable amount of acid were treated with lime and filtered. They slowly became less acid, and the neutralisation was accelerated by the addition of a drop of water (0·03 c.c. to 10 c.c. of oil). The treated oils were either neutral or very faintly acid. Four oils were tested against the staphylococcus.

TABLE iii.—*M. aureus.*

Original acidity.		Dilutions in oil, bactericidal at 20°.	
		Untreated.	Neutralised with lime.
95	*E. cinerea*, rect.	20	45
81°	*E. cinerea*, crude	60	100
52	*E. dives*, crude	50	65
127	Ribbon Gum, crude, 10 yrs. old	30	80

It is clear that the neutralisation of the oils resulted in a diminution of the bactericidal activity, but it is also clear that the acid or the acidity is not the only thing which contributes towards the disinfecting properties. Were it otherwise, the lime-treated oils would have been inert towards the staphylococcus.

The crude oils of *E. cinerea* and of *E. dives* were treated with dry sodium carbonate until the acidity was, in each case, reduced to 7°. They had the same disinfecting power as the lime-treated oils.

If the alkali does nothing but remove the acid from the oils, it is reasonable to suppose that the addition of acid will render them more toxic. A preliminary experiment with acetic, propionic, isobutyric, and valeric acids, gave a certain amount of promise that the addition of acetic acid would increase the bactericidal properties of the oils, and a further test was made. In this, acetic acid* did, in some cases, increase the toxicity, but the higher acids were without effect upon the rectified oil of *E. polybractea.* The results are shown in the following Table.

Table iv.—*M. aureus.*

Acidity in degreees.		Oil and date of acidification.	Bactericidal percentage dilution, 2 hours at 20°.							
Original.	As prepared.		Original.	16/7	26/7	29/7	5/8	12/8	22/8	4/9
2	128	Cineol 11/7	000	000	90	—	—	—	—	—
34	129	Essential oil 11/7 ..	9.5	60	50	—	50	40	—	50
52	150	*E. dives*, crude 26/7 ..	50	—	30	—	30	—	—	—
12	110	*E. cinerea*, crude 29/7	000	—	—	000	000	—	100	000
10	112	*E. polybractea*, rect. 29/7	000	—	—	90	70	60	60	50
10	9.5	*E. polybractea*, rect. 12/8	000	—	—	—	—	000	000	000
52	109	*E. dives*, crude 12/8 ...	50	—	—	—	—	40	40	40

000 = inactive.

An increase in the bactericidal power, as indicated by the reduction in the lethal percentage of oil, was obtained with the crude Essential Oil purchased from the druggist, with *E. dives*, crude, and in one test with *E. polybractea*, rect. *E. cinerea*,

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This is the most pronounced acid in the Eucalyptus oils. It is derived largely from the acetic acid esters they contain, and also from the oxidation of the corresponding aldehyde. Practically all Eucalyptus oils contain low boiling aldehydes which are more pronounced in the oils of some species than in others Butaldehyde and valeraldehyde are quite common, and in many oils of one class, the ester, butylbutyrate, is a common constituent. The oxidation of the aldehydes to acids and the alteration of the esters are responsible for the presence of the acids in the oils, and, naturally, the older the oils the more acid they become.

crude, was unaltered, and the same was the case with the second test of *E. polybractea*, rect. The higher acidification of *E. dives*, crude, gave an enhanced effect, and it seemed as if the slightly higher acidity of the altered *E. polybractea* might have been responsible for the increased activity of the oil. With the phellandrene oil of *E. dives*, the increase of the toxicity took place at once, while it was slowly developed in the Essential Oil and in *E. polybractea*. The irregular behaviour of the oils led to a further test, in which progressive amounts of acid were added.

TABLE V.—*M. aureus*.

Acidity in degrees.		Oil acidified on 9/9.	Bactericidal percentage dilution, 2 hours at 20°.				
Original.	As prepared.		Original.	9/9	24/9	1/19	14/10
2	104	Cineol ...	000	000	000	—	000
2	151	,, ...	000	000	000	—	000
10	97	*E. polybractea*, rect.	000	000	100	000	000
10	119	,, ,, ,,	000	100	100	000	000
10	136	,, ,, ,,	000	000	000	000	000
12	93	*E. cinerea*, crude	000	70	60	50	50
12	118	,, ,, ,,	000	60	50	50	50
12	133	,, ,, ,,	000	60	40	50	40

000 = inactive.

In this experiment, cineol and *E. polybractea*, rect., were not affected by the addition of considerable amounts of acetic acid. *E. cinerea*, crude, did have its germicidal activity increased, but not definitely in proportion to the acid added.

The two experiments are at variance, and there is apparently some unknown condition, which regulates the action of the acid in producing bactericidal substances in the oils.

The acid itself must have a certain germicidal action, and several tests were made to see how much was necessary to prohibit growth under the conditions of the previous experiments. A quantity of olive oil was acidified with glacial acetic acid, and dilutions of this were made with the neutral oil.

TABLE vi.—Acetic acid dissolved in Olive Oil.

	Acidity in degrees.	
	Growth.	No growth.
11/9	139	186
24/9	163	172
14/10	154	168
4/11	154	168

The amount of acid which checks growth under the conditions of the experiments appears to be about 165°. Although this was never reached in the acidified oils, one cannot but believe, that a high acidity will have a certain influence in assisting the germicidal power of the Eucalyptus oils

There is some foundation for this belief, because the simple neutralisation of the oils by lime or by sodium carbonate removes only a certain amount of the toxicity. The residual germicidal activity must be assumed to belong to the neutral oil.

E. dives, crude, with an acidity of 81°, was toxic in two hours, when in 60% dilution. Upon neutralising the acidity, the same effect was obtained with the undiluted oil, that is to say, the germicidal power was reduced by the neutralisation. In another sample of the oil from the same species, the oil with an acidity of 12° was inactive, and when the acidity was raised to 93°, the oil became toxic when in 50% dilution. Thus an amount of acid, insufficient by itself to destroy the test-organism, caused an inactive oil to become bactericidal under the conditions of the experiment.

THE IODIDE REACTION.

It has been noted that the Eucalyptus oils contain a certain amount of ozone, that is to say, they show, when tested with potassium iodide and starch, the blue reaction. The potassium iodide is oxidised, with the liberation of free iodine which combines with the starch, forming the well-known blue iodide of starch. The reaction is characteristic of an oxidising agent and many substances, such as peroxide of hydrogen or chromic acid, would produce the blue colour. The test shows that the oils contain an oxidising constituent and whether it is ozone, peroxide of hydrogen, or another oxidising substance, is open to proof. If it were peroxide of hydrogen, it should give off oxygen in contact with binoxide of manganese, but no gas is evolved when manganese dioxide, previously digested with Eucalyptus oil to eliminate occluded air, is added to a fresh specimen of a strongly reacting oil. This test was made under the microscope, and also in a bent tube with a closed capillary end. Mr. H. G. Smith pointed out that this does not negative the presence of peroxide of hydrogen, as the nascent oxygen would remain dissolved and immediately oxidise the constituents of the oil. It, however, appears reasonable to suppose that if the constituents of the oil are so easily oxidised, the dissolved peroxide of hydrogen would itself, in the course of time, be consumed in doing the same work and would not be evident in the oils. The same would apply to ozone.

The amount of this oxidising substance in the oils can be roughly judged by means of iodide and starch paper, but, as the differentiation between the oils, by the method, is very crude, and as it appeared to be advisable to obtain exact numbers relating to the oils, the following method was devised.

A drop of the oil under examination was put into a depression of a porcelain plate, where it diffused more or less over the surface. On the top of this a drop of reagent was allowed to fall. It remained in the middle of the depression and, after a time, became blue, first at the edge and later throughout the drop. By means of a mirror behind the plate, the light from the window above the bench was so arranged that, upon looking down upon the plate, one could not see the edge of the drop of reagent until the margin became tinted. The time required for the edge to become visible was quite definite for each oil, and duplicate tests, made at different times upon the same day, were generally exact to a second. The method was therefore quite reliable. The reagent was a 1% solution of potassium iodide in a 1% starch emulsion. Some 37 oils which were available at the time were tested. In the Table, the toxicity of the oils towards the staphylococcus is given so that they may be compared.

TABLE vii.

Toxicity %		Iodide of Starch, reaction time in seconds.		Acidity in deg.
		a	*b*	
20	*E. cinerea*, rect.	7	5	96
65	*E. dives*, crude	7	8	17
65	*E. dives*, crude	9	8	12
10	*E. linearis*, rect.	11	9	160
45	*E. polybractea*, crude	13	13	76
50	*E. Considenuana*, rect.	15	8	29
60	*E. australiana*, rect.	15	4	—
100	*E. australiana*, crude, 1st hour ...	15	11	10
40	*E. Smithii*, rect.	16	13	56
30	*E. australiana*, crude, 3rd hour ...	18	16	116
000	*E. polybractea*, rect.	20	8	10
30	Ribbon-gum, crude	23	14	126
100	*E. australiana*, rect.	24	—	5
40	*Prostanthera cineolifera*, crude ..	25	18	63
50	*E. Smithii*, rect.	25	14	37
30	Ribbon-gum, crude, 10 years old ...	27	10	127
100	*E. australiana*, rect.	30	15	5
60	*E. australiana* (Braidwood), crude...	32	15	—
50	*E. dives*, crude	37	14	52
30	*E. australiana*, crude, 2nd hour ...	42	12	150
95	*E. australiana* (Braidwood), crude...	45	12	7
70	*Melaleuca Maidenii*, crude ...	50	43	49
000	*E. amygdalina*, crude	50	23	7
100	*E. albens*, crude...	54	8	25
100	Ribbon-gum, crude	55	50	18
80	*E. radiata*, crude	85	60	18
000	*E. polybractea*, crude	80	30	4
000	*E. australiana* (Braidwood), crude...	120	40	6
70	*E. cneorifolia*, crude	130	75	41
50	*E. cinerea*, crude	000	000	81
95	Essential Oil	000	000	34
60	*E. citriodora*, crude	000	000	140
100	*E. nova-anglica*, crude	000	75	33
000	*E. Considenuana*, over 190° ...	000	000	31
000	Ol. Eucalypti, B.P.	000	000	12
000	Cineol	000	000	2
000	*E. polybractea*, rect.	—	000	10
000	*E. cinerea*, crude	—	150	12
100	*E. cinerea*, rect....	—	25	10
000 = inactive.		000 = over 180″.		

The second column, with the lower numbers, was obtained 48 days later, and although variations were made in the strength of starch and of iodide, the high numbers of the earlier tests could not be obtained. It must be concluded that the activity of the oils had increased. But even with the new numbers, no relation between them and the toxicity of the oil could be traced.

Some of the oils showed a marked decrease in the reaction time, and in order to see if the toxicity had increased in the interval, one of them was tested. This was the crude oil of *E. polybractea*, which had decreased from 80 to 30 seconds. It was found to be inactive to the staphylococcus when tested in oil just as it was at an earlier date.

When the iodide numbers are plotted against the disinfecting powers of the Eucalyptus oils as determined in dilutions of olive oil, no close relation can be noted between the two. The Eucalyptus oils may be divided into two groups, one taking less than 60 seconds to develop the iodide reaction, and this contains two-thirds of all the oils. The other, which took more than 60 seconds, contains thirteen oils, of which seven are inactive to the staphylococcus, and two are slightly active. The two most active oils towards the staphylococcus are certainly among those which show the most vigorous iodide reaction, but they are not sufficiently differentiated from the others to enable one to say that the iodide test is any indication of the disinfecting properties of the oils.

There does not appear to be any relation between the acidity of the oils and the iodide test, as a glance at the acidity column will show. When they are plotted against the acidity, no relation of any kind can be deduced, a fact which could not have been proved in the absence of a rigid test for the reaction. By simply testing with starch-iodide paper, one obtains strong reactions with the oils which are strongly acid, and generally a feeble reaction with those that are weakly acid. It does now, however, take long to make one realise that the paper test is very unsatis_ factory.

When the oils are neutralised, the colour takes longer to develop. This was seen in a few oils that had been neutralised about the time that the iodide tests were made.

Table viii.—Iodide reaction of neutralised oils.

	Time in seconds.			
	Untreated.	Neutralised with lime	Neutralised with Na_2CO_3	Treated with sodium bisulphite, then with lime.
E. dives, crude ...	37	300	180	over 3,600
E. cinerea, rect. ...	7	15	—	—
E. australiana (Braidwood)	45	—	—	540

The lengthening of the time of reaction certainly points to the acidity having some influence upon the test. If, however, the problem is attacked in another way, viz., by adding acid to a feebly-reacting oil, it is found that the acid has no influence. The crude oil of *E. polybractea* had an acidity of 4°, and gave the reaction in 80 seconds. A quantity had been acidified with acetic acid seven days previously and had increased in its toxicity towards the staphylococcus. The acidity was 95°, but the time of reaction was the same as with the original oil, viz., 80 seconds. We must conclude that the lime or the sodium carbonate, used in neutralising the oils, removes much of the substance which gives the iodide reaction.

When considering the activity of the oils, there is no reason for separating the rectified from the commercial. They are no less germicidal than the crude oils, and indeed some of the rectified oils were among the most active. Acidity may be developed in the oils by aëration during a considerable period of time, and concomitantly an amount of iodide-reacting substance may be formed, but no relation was found to exist between the acid and the ozone-like oxidising substance. Neither was there any relation between the iodide reaction and the bactericidal activity, so that the iodide test is of little importance in determining the bactericidal power of the oils.

The Activity of the Vapours of the Oils.

The vapours of the Eucalyptus oils are supposed to possess a disinfecting action, and some experiments were made with them to see how far this was justified. Wide-mouthed ounce bottles were used, and each received 2 c.c. of the Eucalyptus oil, which was sufficient to cover the dome-shaped bottom of the bottle. The bottles were then heated in the incubator at 37° for half-an-hour to get them warmed up, and so ensure the temperature being constant during the test. Threads of cotton, attached to wires similar to those used in the tests with olive oil, were impregnated with loops of a 20-hour broth-culture of the test organism. Each received the charge of one loop made by twisting a thin wire around a thicker wire (B.W.G. 12). The infected thread was suspended in the middle of the air-space of the bottle, the wire being held in place by the cotton plug. During the test, the bottles were kept in the incubator at 37°.

A few tests were made with the ordinary oils, but, as there was the possibility that the acid in them might have some influence upon the bactericidal power, three of the oils were treated with lime before testing. For the sake of simplicity, all the tests are grouped in one Table. The time when the bacteria were destroyed and the time just short of this are given in order to show the spacing between the times in each case. Growth is indicated in the usual manner by a "+" and absence of growth by a "O" in the headings of the columns.

TABLE ix.—Germicidal Effect of the vapour.

Acidity of the oils in degrees.	Kind of Oil.	Seconds at 37°.							
		B. coli communis.				*M. aureus.*			
		untreated.		limed.		untreated.		limed.	
		+	O	+	O	+	O	+	O
2	Cineol	24	25	—	—	210	240	—	—
4	*E. polybractea*, crude ...	28	30	—	—	80	100	—	—
7	*E. australiana* (B'dwood), cr.	18	20	—	—	40	45	—	—
52	*E. dives*, crude ...	20 25	25 30	15 20	20 25	70	80	over 100	—
81	*E. cinerea*, crude...	20	25	30	40	60	80	over 100	—
96	*E. cinerea*, rect.	15	20	20	25	40	45	100	120
—	Phenol	4	6	—	—	4	6	—	—

The vapours of the oils have an undoubted disinfecting action at 37°. When neutralised, they certainly are less active, but there does not appear to be any relation between their acidity and their activity. Towards *B. coli communis*, they were all bactericidal in from 20 to 30 minutes, and the acidity appeared to have little or no influence. So far as the yellow staphylococcus is concerned, the possibly exceptional case of the oil from *E. australiana* (Braidwood) prevents a generalisation from the comparatively few tests that were made. At the same time, the results point to the toxicity being proportional to the acidity, and it would appear that the relationship is shown more clearly with *M. aureus* than with *B. coli communis* in the cases of the vapours and of the dilutions in oil.

SUMMARY.

When a serum-suspension of *M. aureus* was absorbed in cotton and placed in dilutions of the Eucalyptus oils in olive oil for two hours at 20°, it was found that the bactericidal power was proportional to the acidity of the oils.

The germicidal effect was not caused by the acidity, but was assisted by it.

The effect upon *B. coli communis* was of much the same nature, although the action of the acid was not so clearly shown.

The iodide reaction was no criterion as to the germicidal value of the oils.

The vapours of the oils had a decided bactericidal action.

I have to thank Mr. H. G. Smith for the many specimens of oils and for his kindness in reading the manuscript and supplying certain useful notes upon the chemistry of the oils, most of which appear as footnotes. I am also indebted to Mr. W. W. L'Estrange for much kindly assistance.

THE EXTERNAL PARASITES OF THE DINGO (*CANIS DINGO* Blum.).

By Thos. Steel, F.L.S.

Any information regarding the parasites infesting the above animal may be of assistance in discussing the question of its origin.

In Proc. Roy. Soc. Queensland, xxviii., p.96, 1916, Dr. T. Harvey Johnston has a valuable paper dealing with the endoparasites: but, so far as I am aware, nothing has been published on the external parasites. Mr. R. Etheridge has dealt historically, and from the palæntological view-point, with the origin of the dingo, in a very able paper,* in which is included a most comprehensive bibliography.

In the year 1883, while resident on the Tweed River, N.S.W., I got a fresh specimen of a full-grown, pure-bred male dingo, which was poisoned through eating a bush rat which, in turn, had taken a strychnine-bait. I collected the external parasites, which have been in my possession ever since. Recently I submitted the fleas to the Hon. N. C. Rothschild, and the other parasites to Dr. T. H. Johnston; and, from these gentlemen, I have received the result of their examination, which I now desire to place on record.

The fleas proved to be *Ctenocephalus felis* and *C. canis*, the species commonly occurring on the domestic cat and dog, no others being present. The other parasites consisted of a larval tick, and a louse. Dr. Johnston reports that the larval tick is apparently a new species, near *Ixodes holocyclus*; and that the louse appears to be *Trichodectus latus*, or a nearly related species. *I. holocyclus*, Dr. Johnston informs me, has, in Australia, been found on man, cat, dog, cattle, horse, marsupials, and perhaps reptiles; and he considers that the specimens under review belong to a related species. *T. latus* is not common in Australia; it has been recorded from the dog (Sydney) by Johnston and Harrison, in 1912. On the dingo, I found a considerable number, about two dozen, but I did not get all that were present.

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* Memoirs Geol. Survey N. S. Wales. Ethnological Series, No.2, 1916.

ORDINARY MONTHLY MEETING.

April 30th, 1919.

Mr J. J. Fletcher, M.A., B.Sc., President, in the Chair.

In consequence of the restrictions imposed by the Government on account of the influenza epidemic, the Meeting was shortened and the business restricted to the reading of papers.

The President announced that the Council had elected Messrs. C. Hedley, F.L.S., W. W. Froggatt, F.L.S., A. G. Hamilton, and Professor H. G. Chapman, M.D., B.S., to be Vice-Presidents; and Mr. J. H. Campbell [Royal Mint, Macquarie Street] to be Honorary Treasurer, for the current Session, 1919-20.

The Donations and Exchanges received since the previous Monthly Meeting (26th March, 1919), amounting to 2 Vols., 43 Parts or Nos., 6 Bulletins, 2 Reports, and 4 Pamphlets, received from 33 Societies, etc., and two private donors, were laid upon the table.

ON THE MORPHOLOGY AND SYSTEMATIC POSITION OF THE FAMILY *MICROPTERYGIDÆ* (SENS. LAT.).

INTRODUCTION AND PART i. (THE WINGS).

BY R. J. TILLYARD, M.A., D.Sc., F.L.S., F.E.S., LINNEAN MACLEAY FELLOW OF THE SOCIETY IN ZOOLOGY.

(Plate iii. and fourteen Text-figures).

In carrying out my researches on the Panorpoid Complex(**9**, **10**), it was necessary to study very carefully the remarkable family of archaic Moths known as the *Micropterygidæ*, since these are supposed to represent the oldest existing types of Lepidoptera. The results obtained would, under ordinary circumstances, have been included, piece by piece, in the various parts of my work on the Panorpoid Complex, and would have been used simply as part of the evidence in the more general problem of the relationships of the Orders composing the Complex.

However, during the last year, two events have occurred which appear to me to make it essential that a more exhaustive study of this interesting family should be undertaken, with the special object of determining, as exactly as possible, its true relationships and systematic position. These events are: firstly, the receipt of a paper by Dr. T. A. Chapman, M.D., F.R.S., in which(**2**) he definitely removes the genus *Micropteryx* itself from the rest of the *Micropterygidæ*, and proposes for it a new Order Zeugloptera; and, secondly, the receipt of Professor Comstock's new book on the Wings of Insects (**3**), in which he removes the whole family *Micropterygidæ* from the Lepidoptera, and places them in the Trichoptera as a new Suborder, the Micropterygina or Terrestrial Trichoptera, of equal value with the Phryganeina or Aquatic Trichoptera, which includes all the Trichoptera as usually understood by entomologists.

My own research, in which the presence of the frenulum in all *Micropterygidæ* was demonstrated (**9**), was first published before I received either of the above works; in actual date of publication (March, 1918) it was later than Dr. Chapman's paper, but earlier than Professor Comstock's book. The dates of all three were, however, close enough together to prevent the knowledge contained in any one of them from being used by either of the other authors. Had this been possible, I do not doubt that the views of each of us would have been profoundly modified by the work of the other two.

As instances of this, I would mention the unfortunate selection of the name Zeugloptera for the new Order proposed by Dr. Chapman. The name was suggested by Mr. Durrant, from the Greek ζεύγλοη = jugum. Had either Dr. Chapman or Mr. Durrant known of the existence of the frenulum in these insects, this name, at any rate, must have been barred; as it is, it is a most unfortunate choice. Again, Professor Comstock says, in justification of his removal of the *Micropterygidæ* to the Order Trichoptera (**3**, p.318): —"If the *Micropterygidæ* be retained in the order Lepidoptera, they must be considered the most generalised members of the order, being near the stem form from which the Trichoptera and the Lepidoptera have been evolved. This view necessitates the explanation of the manner in which the *Hepialidæ*, with their peculiar jugum, and the Frenatæ were evolved from a form having a well-developed fibula, like that of *Mnemonica* and *Rhyacophila*. This must be done if the Lepidoptera, including the Micropterygidæ, is to be shown to be a monophylitic group." As the explanation here asked for was actually given in my work on the Panorpoid Complex, Part i. (**9**), it is quite clear that Professor Comstock's decision would have been materially affected if my paper had been available to him. On the other hand, my own results would have been altered to some extent, if I had had access to his account of the jugal lobe of *Mnemonica* (**3**, p.315), a genus of which I had very little material.

The *Micropterygidæ* have long been of especial interest to entomologists, but it does not appear that any study of their internal organs has yet been carried out; and the present condition of our knowledge of the family is wholly due to the study of set specimens, of cleared mounts of the wings and of the mouth-parts. The same is true of those larval and pupal forms known. Thanks to the labours of Dr. Chapman, the complete life-history of the genus *Eriocrania* is known; while, in the genus *Micropteryx*, the same indefatigable worker has succeeded several times in rearing the insect from the egg as far as the last larval instar, though, so far, baffled in obtaining the pupa. The larva and pupa of the genus *Mnemonica* are known: they are closely related to those of *Eriocrania*.

The differences between the larva of *Micropteryx*, on the one hand, and those of *Eriocrania* and *Mnemonica* on the other, are so great as almost to justify in themselves Dr. Chapman's original separation of the family *Micropterygidæ* (sens. lat.) into the two families *Micropterygidæ* (s.str.) and *Eriocraniidæ*(1). If we take into account also the differences in the mouth-parts of the imagines, this separation is surely justified entirely. Nevertheless, in entering upon the discussion with which this paper has to deal, I have felt it advisable to follow Meyrick in treating these insects as a single group, provisionally taken as of family rank, merely for convenience of title, and for facilitating the discussion itself. Whether they belong to one family or two, to one Order or two, or to what Order they are to be relegated, it is the purpose of this paper to try to discover. Hence, in the title, I speak of them simply as the *Micropterygidæ* (sens. lat.), without prejudicing the case by indicating that this group belongs to any definite Order of Insects.

The receipt of Dr. Chapman's paper(2), and my own discoveries, so stimulated my interest in this group that I proceeded to get into touch with Dr. Chapman himself by correspondence, and asked him whether he could assist me to carry out a full biological study of it. Less than a year has passed since this correspondence, already so fruitful of results for me, was inaugurated; and I find it hard to realise that the fine collection of material now in my hands is the result of so short a period of contact with Dr. Chapman's wonderful generosity and kindness. I feel that no words of thanks of mine can possibly convey to him my deep appreciation of what he has done; nevertheless, I here express my profound gratitude and thanks to him, and trust that the results which he has made possible, by his unselfish and painstaking supplying of the requisite material, may be in themselves the best acknowledgment of my deep debt to him. In saying this, I have in mind especially the fact that he knew, from my first letter, how disinclined I was to accept his removal of the genus *Micropteryx* from its (as I hold) nearly related genera to a new Order: yet, knowing this, he has not spared himself, at his age, in obtaining for me all the rare material which he, and nobody else in the world, is able to secure, as the result of many years untiring study of this group. One would have to search far indeed for a finer example of the true scientific spirit, in which one's own conclusions, however dear they may be on account of the work and sacrifices which gave them birth, are nevertheless not considered at all, when there is a possibility of supplying another scientist, holding perhaps opposite views, with the material for carrying out his researches

That I have not overstated the case it is now my pleasure to prove, by an enumeration of the various consignments of material which I have already received from Dr. Chapman. The first consignment was sent off in January of this year (1918); the last was received last month (Nov , 1918), and more are promised. Of more than a dozen consignments altogether, only one (the second) has been lost by the action of submarines. The following is a list of the material so far received, on which this paper is chiefly written :—

(1) Dried cocoons and pupæ of *Eriocrania semipurpurella* Steph.

(2) Slides of the exoskeleton of the last larval instar of *Eriocrania semipurpurella*.

(3) A slide of the exoskeleton of the first larval instar of *Micropteryx calthella* Linn.

(The lost consignment contained further material of the above).

(4) Two consignments of well-grown larvæ of *Eriocrania semipurpurella*, in spirit.

(5) Three consignments of first instar larvæ of *Micropteryx calthella*, fixed in Carls' Fixative, as requested by me.

(6) Two consignments of female imagines of *Micropteryx calthella*, similarly fixed in Carls' Fixative.

(7) Two consignments of cocoons of *Eriocrania semipurpurella*, freshly dug up, and containing living larvæ when posted.

Besides the material sent by Dr. Chapman, I have received specimens from the following correspondents, to all of whom I now offer my best thanks for their generous help.

From Mr. Edward Meyrick, F.R.S., set specimens of the following genera:—*Sabatinca* (two species), *Micropteryx* (three species), *Mnemonica* (two species), *Eriocrania* (one species), and *Mnesarchaea* (two species); in all, five genera, ten species, and twenty-two specimens.

From Mr. Alfred Philpott, Invercargill, N.Z., set specimens of the genera *Sabatinca* (four species), and *Mnesarchaea* (two species), of which three species, *S. caustica* Meyr., *S. barbarica* Philpott, and *M. paracosma* Meyr., were not included in Mr. Meyrick's consignment. Also a single larva of *Sabatinca* sp.

From Mr. K. J. Morton, of Edinburgh, numerous examples of *Micropteryx aruncella* Scop., in alcohol.

From the Museum of Comparative Zoology, Cambridge, Mass., by exchange, through Mr. Preston Clark, of Boston, Mass., two larvæ, a pupa and a set imago of *Mnemonica auricyanea* Wals.

From Dr. A. J. Turner, of Brisbane, set specimens of *Sabatinca calliplaca* Meyr., the only known Australian representative of the family.

Thus the material upon which this paper is based consists of representatives of five genera and fourteen species, together with the larval forms of four genera and pupæ of two. The genera *Epimartyria* (two species from N. America), *Micropardalis* (one species from New Zealand), and *Neopseustis* (one species from India) remain unknown to me except through the published descriptions. No larval or pupal forms appear to be known of genera other than those received for this work.

Classification.

For the purpose of this work, it will not be necessary to go back beyond Meyrick's classification in "Genera Insectorum"(6), which is here accepted provisionally, as already explained. A short outline of this classification is here given:—

Subfamily MNESARCHÆINÆ.

No mandibles. Tongue short. Labial palpi well-developed. Middle tibiæ with two apical spurs.

Mnesarchæa Meyr., type *paracosma* Meyr. N.Z., three species.

Subfamily ERIOCRANIINÆ.

No mandibles. Tongue short. Labial palpi well-developed. Middle tibiæ with one apical spur.

Neopseustis Meyr., type *calliglauca* Meyr. India, one species.

Eriocrania Zeller, type *semipurpurella* Steph. Europe, nine species.

Mnemonica Meyr., type *subpurpurella* Haw. Holarctic, eight species.

Subfamily MICROPTERYGINÆ.

Mandibles developed. No tongue. Labial palpi rudimentary or obsolete. Middle tibiæ with apical group of bristles, without spurs.

Epimartyria Wals., type *pardella* Wals. N. America, two species.

Micropteryx Hubn., type *aruncella* Scop. Palæarctic, twenty-seven species. (= *Eriocephala* Curtis, type *calthella* Linn.).

Micropardalis Meyr., type *doroxena* Meyr. New Zealand, one species.

Sabatinca Walker, type *incongruella* Walker. New Zealand, five species; Queensland, one species. (= *Palæomicra* Meyr., type *chrysargyra* Meyr.).

A new genus, *Anomoses*, has been recently added by Dr. A. J. Turner(**11**), based on a single new species from Queensland. This insect is, however, so different from the rest of the *Micropterygidæ* that I doubt whether it really belongs here. I think it should be placed in the family *Prototheoridæ*, hitherto only known from South Africa.

The literature of the family is somewhat involved, owing to the continued inversion of the two names *Eriocrania* and *Micropteryx*. This was due to the adoption of the name *Eriocephala*

Curtis, for the genus *Micropteryx*, by a considerable number of authors, amongst whom we may mention Packard, Chapman, and Meyrick in their earlier works, as well as Sharp in the "Cambridge Natural History," following these. The name *Micropteryx* was then applied wrongly to *Eriocrania*, by those who used *Eriocephala* for *Micropteryx* itself. One has, therefore, always to bear in mind, that, in works where the names *Eriocephala* and *Micropteryx* are used to contrast these two very distinct generic types, *Eriocephala* should be correctly *Micropteryx*, and *Micropteryx* correctly *Eriocrania*.

The subdivision of the family *Micropterygidæ* into two separate families, *Eriocephalidæ* and *Micropterygidæ*, corresponding with the two subfamilies *Micropteryginæ* and *Eriocraniinæ* as defined by Meyrick, was first proposed by Chapman in 1894(**1**); this arrangement was followed by Sharp in 1909(**8**), though not by Meyrick in 1895(**6**). In this latter year, Packard(**7**) emphasised the primitive condition of the mouth-parts in *Micropteryx* (which he called *Eriocephala*) by his division of the Order Lepidoptera into two Suborders, Lepidoptera Laciniata (or Protolepidoptera), containing only *Micropteryx*, and Lepidoptera Haustellata, containing all the rest, including *Eriocrania* (which he calls *Micropteryx*). He further emphasises the difference between *Eriocrania* and the remainder of the Lepidoptera Haustellata, by dividing this Suborder into two series, of which the first, or Palæolepidoptera, contains only the *Eriocraniidæ*, while the second, or Neolepidoptera, contains all the rest.

In 1917, Chapman(**2**), as already stated, raised the genus *Micropteryx* to ordinal rank, with the title Zeugloptera, on the characters mentioned by Packard, together with the new character emphasised by him, that the female of this genus possesses only a single terminal genital opening in the tenth abdominal segment, whereas all other Lepidoptera possess only nine segments in the female, and have two genital openings, one in the eighth segment for pairing, and a terminal one for oviposition. He says: – "It remains difficult to suggest that *Micropteryx* has any lepidopterous character except the possession of scales. The neuration is also, perhaps, *primâ facie*, lepidopterous; but both this particular neuration and the possession of scales are to be found in insects having no claim to be lepidopterous."

On the other hand, Comstock in 1918(**3**), in removing the whole of the *Micropterygidæ* (sens. lat.) to the Trichoptera, as stated above, bases that removal wholly upon the characters of the wings. These characters are, "in the *fore wings*, the coalescence of veins Cu and 1st A* at the base of the wing; the Z-shaped course of vein Cu; the formation of a serial vein consisting of the base of the media, the posterior arculus, and the longitudinal part of vein Cu; the coalescence of the tips of the second anal vein and of two of the branches of the third anal vein; and the cross-vein between the first and second anal veins. In the *hind wings*, the coalescence of veins Cu and 1st A at the base of the wing; the Z-shaped course of the cubitus; the anastomosis of the first and second anal veins; the longitudinal direction of the cross-vein connecting the second anal vein and the first branch of the third anal vein; and the form of the branching of the third anal vein. In addition to these common venational features, the fibulæ of the two insects are identical in structure." He concludes:—"The possession of this remarkable series of common features of their wings by these representatives of the Phryganeina and Micropterygina, and which is found in no insect not belonging to one of these two groups, can be explained only by assuming that it indicates a community of descent of the two groups. This conclusion is confirmed by the results of Dr. T. A. Chapman's study of pupæ. For these reasons, the Micropterygina must be regarded as more closely allied to the Phryganeina than they are to any other group of insects; that is, they are obviously Trichopterous insects."

We see, then, that there are three conflicting views as to the nature of the *Micropterygidæ*, which may be summarised as follows:—

(1) *The Micropterygidæ are true Lepidoptera.* This is the original view held by all past generations of entomologists, and still championed by Meyrick.

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* It must be remembered that Comstock's Cu is really Cu_1, his 1A is Cu_2, his 2A is 1A, and his anterior branch of 3A is 2A.

(2) *The Micropterygidæ are terrestrial Trichoptera.* This is the new view formulated by Professor Comstock.

(3) *The genus Micropteryx belongs to a new Order Zeugloptera. Eriocrania, on the other hand, is a true Lepidopteron.* This is Dr. T. A. Chapman's view.

It is the object of this paper to try to discover which of these three views is correct: or, if none of them be acceptable, to try to find a substitute for them. The decision to be made is of the very greatest importance, not only in determining the vexed question of the true position of these archaic insects, but also because it radically affects the definition of the Archetype of the Order Lepidoptera; and hence, our decision as to the origin of that Order as a whole.

The first part of this paper is confined to the study of the wings alone. The rest of the Morphology of the *Micropterygidæ* will be dealt with in a series of succeeding Parts.

Part i.—THE WINGS OF THE MICROPTERYGIDÆ.

Section i.—THE WING-VENATION.

In his book on the Wings of Insects (**3**, pp.314-318) Professor Comstock deals with the venation of this group. No attempt has been made to study the pupal tracheation, probably because the necessary material was not available. But drawings are given of the tracheation as partially preserved in a pair of cleared and mounted wings of *Mnemonica* sp., which offered very striking results, and on which Professor Comstock's conclusions are chiefly based.

My request to Dr. Chapman for cocoons of *Eriocrania* containing living larvæ was made principally with the object of obtaining the living pupa and studying the tracheation of the wings. Dr. Chapman very kindly obtained for me the larvæ in the spring of this year, and fed them until they went into the ground to spin up. In the South of England, these larvæ, apparently, are full fed about Midsummer, and soon go into the ground, making their tiny oval cocoons of grains of sand spun together. In these they remain until the following February, when they pupate, emerging as imagines in the spring. Dr. Chapman dug up the first lot of cocoons, fifteen in number, on Sept. 2nd, and a second larger consignment of sixty-one cocoons was dug up and posted on Sept. 18th. Owing to the unfortunate and very severe outbreak of pneumonic influenza in New Zealand, the vessels carrying these consignments were both quarantined at Auckland, where they underwent a thorough fumigation. On arrival at Sydney, they were again quarantined and fumigated. Finally the mails were released, and again fumigated by the Postal Department. Thus the length of the journey was increased by at least a fortnight; and the insects, besides having to stand the great heat of a voyage across the Equator, were subjected to three severe fumigations.

I must confess that I did not expect that, under such conditions, any of these insects would reach me alive. However, they were little affected by their adventures, the larvæ being normal, the pupæ mostly alive but very weak. Out of the seventy-six cocoons so far received, only four contained live larvæ, seventeen contained pupæ, five were destroyed by fungus, and all the rest, amounting to 66%, or about two-thirds of the entire total, were parasitised by at least two species of Chalcid wasps. Most of these latter were still in the larval stage; a few were subpupæ or pupæ, but all were equally lively, and quite unaffected by their long journey.

The effect of the higher temperature on the larvæ of *Eriocrania* is then very obvious, in that they pupated long before their normal time. Of the seventeen pupæ examined, three were dead and somewhat shrivelled, two were only recently turned, one was apparently about half-developed towards the imaginal stage, and no less than eleven were very fully developed, with their wing-sheaths jet black and shiny, and all the parts of the imago fully formed.

It will thus be seen that, out of seventy-six specimens sent, only two were in a state suitable for my purpose, while a third could be used with less certainty. All three of these were carefully dissected, and the results here given are based on the study of all three, which agreed with one another in every particular.

Both the opening of the cocoon and the dissection of the pupa are surprisingly simple matters, considering their small size.

The cocoons were opened with a dissecting needle, by scratching the sand away along a zone corresponding with that along which a boiled egg is usually opened at breakfast. The appearance of a shiny black inner envelope was a sign that the larva had been parasitised, this being the cocoon of the Chalcid. The *Eriocrania* pupæ were free inside the cocoon, and could easily be lifted out without damage, on the point of the needle. They were all very inert, and made no attempt to move. I therefore killed and dissected them straight away, and was pleased to find that the removal of their wings was a very simple operation. The wings are even less glued together than is the case with the Mecoptera and Planipennia, being only slightly joined at their apices. These were at once separable with a needle, while the bases were easily cut away from the thorax with a sharp dissecting-knife. The separate wings were then floated out on to a slide, and examined first of all without a cover-slip. At this stage, drawings were made with the camera-lucida.

The tracheation being so fine, a high power was required for the study of the basal specialisations. For this, it was necessary to let down a cover-slip upon the wings. This had to be done very carefully, for fear of disarranging the delicate tracheation; but in each case the operation proved successful: so that further drawings under a higher power, together with photomicrographs, could be taken

The wings being different in certain important particulars, in spite of their homoneurous appearance in the imago, it is advisable to deal with each wing separately, and then to make a comparison between them.

The Forewing. (Plate iii., figs.1-3; Text-figs.1-2).

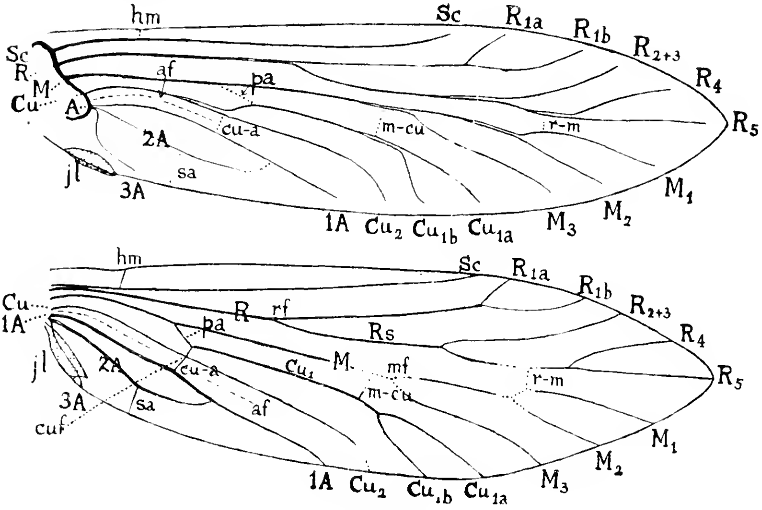
The tracheation of the forewing is of a very generalised type, as may be seen from Text-fig.1. All the main tracheæ are quite distinct and separate from their bases outwards. The points to be noted are:—

(1) R_1 gives off a pterostigmatic veinlet R_{1a}, homologous with one of the corresponding veinlets in many Mecoptera, Megaloptera, Planipennia, and in a few Trichoptera.

(2) R_{2+3} is a simple, unbranched trachea. This is a constant character for the genus.

(3) The median fork is placed far distad, well beyond half-way along the wing.

(4) There is no sign of a separate trachea M_4. In this, *Eriocrania* agrees with the great majority of Lepidoptera, both Homoneura and Heteroneura, but differs from the Trichoptera, in which all the more archaic genera have M_4 not only present, but quite separated from Cu_{1a}.



Text-fig. 1.

Forewing of *Eriocrania semipurpurella* Steph. Above, the pupal tracheation, (× 54); below, the imaginal venation, (× 18). For lettering, see p. 136.

(5) *The Cubitus is definitely three-branched*, the first dichotomy into Cu_1 and Cu_2 taking place at about one-fourth of the wing length from the base; further distad, Cu_1 forks again into Cu_{1a} and Cu_{1b}.

This very important character is also to be found in the Megaloptera, where the comparison with *Eriocrania* is exact; in the Planipennia, where the branching of Cu_1 usually consists of a series of descending branches arranged more or less pectinately; and probably also in the older Trichoptera, though the homologies in this Order are not yet quite clear, owing to the absence of the preceding tracheation in the pupal wing.

(6) The *anal furrow* (*af*) is very definitely marked, and quite distinctly separates the cubitus from the first analis.

(7) There are three separate anal tracheæ present, none of them branched. Trachea 2A tends to bend towards 1A distally, but does not meet it. Trachea 3A is very short, and descends to the wing-border just beyond the distal end of the jugal lobe.

The above interpretation is so obvious that it can scarcely be questioned. Nevertheless, Professor Comstock, in his recent book already quoted (**3**), while figuring the tracheation, as far as he could make it out in the imago, as essentially the same as that here figured for the pupa, gives a different interpretation to the limits of the cubital and anal tracheæ. The reasons for this appear to be two:—

(1) Professor Comstock starts with the assumption that the cubitus was originally only two-branched. This assumption is applied to the Aquatic Trichoptera, where it appears to fit, and then the tracheation of the Micropterygina is interpreted along the same lines. In order to do this, it is asserted that trachea 1A has migrated forwards and become fused with Cu basally; but no proof is offered of such an astonishing specialisation, in so archaic a group as the *Micropterygidæ*.

(2) In many Lepidoptera, the original dichotomy of Cu into Cu_1 and Cu_2 occurs very close to the base; and, as is usual in this Order, the tracheæ split back even further than the veins; so that, in the higher groups, the division of Cu may take place almost or quite on the alar trunk trachea. This lends support to the idea that there are here two main tracheæ, Cu and 1A. Against this, it may be mentioned that, firstly, the anal group of three tracheæ can always be made out, arising very far away from these other two; secondly, that, in many cases, especially in the older families, this splitting back does not reach as far as

the alar trunk; and, thirdly, that, in a number of families (*e.g.*, in the *Saturniidæ* and some Butterflies*) the radius is likewise split back to the alar trunk, and may even arise as five separate tracheæ (*Antherea eucalypti*); yet nobody questions that these all belong to the radius.

If Professor Comstock's interpretation be correct, we are bound to ask, how is it that it is in the ancient *Micropterygidæ* that this specialisation (*i.e.*, the fusion of Cu and 1 A) reaches its highest expression; and how is it that, in the most highly specialised of all Lepidoptera, viz., the *Saturniidæ* and the Butterflies, we find a retrogression to what, on this view, must be the nearest approach to the primitive type, viz., that in which Cu and 1 A arose separately from the alar trunk? This question is unanswerable, except by the admission that it is the higher families of the Lepidoptera which show the greatest splitting back of the tracheæ, while the original condition is preserved more completely in the older families, and especially in the *Micropterygidæ*. In other words, the cubitus is three-branched, and the true 1 A is the first of the quite separate anal group of tracheæ, lying in its natural position, *posterior to the anal furrow.*†

It should also be noted that there are already three separate anal tracheæ recognisable in the anal group, without the supposed 1 A of Comstock's interpretation. If Comstock is right, then it is necessary to explain how the *Micropterygidæ* (and most Lepidoptera) come to possess four anal veins, whereas the older Orders Mecoptera, Megaloptera, Planipennia, and Trichoptera are admitted to possess only three.

In Plate iii., fig.3 and Text-fig.2, the actual condition of the primary cubital fork in the pupa of *Eriocrania* is shown. It will be seen that the line of the main stem of Cu is continued beyond the fork, not by Cu_1, as we might have expected, but by Cu_2. From the fork itself, Cu_1 arches up at an angle to the main stem, and then turns to run parallel to and above Cu_2 until it again forks into Cu and Cu_{1b}. A pale band passing from M to

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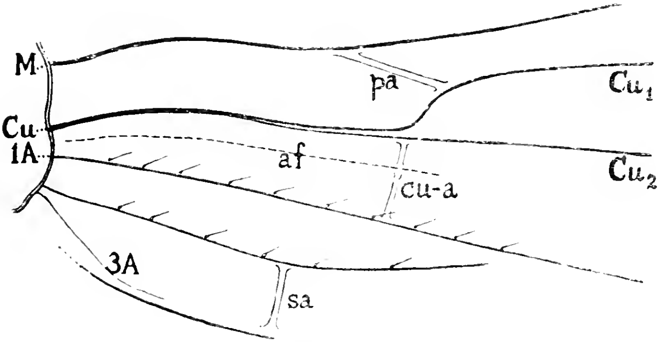
* Also sometimes in the ancient *Hepialidæ!*

† The full proof of the limits of Cu in Lepidoptera will be given in Part iii. of the "Panorpoid Complex."

Cu_1 a little distad from the fork indicates the position in the imago of the *posterior arculus*, which is destined to form part of the serial vein made up of the base of M, the posterior arculus, and the distal portion of Cu_1. A very careful examination of the tracheæ forming Cu in the pupal wing shows that the actual dichotomy of Cu into its two main branches lies slightly basad from the point which becomes the cubital fork in the imago, as shown in Text-fig.2. It will be seen that the same type of splitting back to a point before the actual bifurcation of the imaginal veins is also to be found in all the other dichotomies, not only in *Eriocrania*, but likewise in all Lepidoptera.



Text-fig.2.

Portion of basal tracheation of forewing of the pupa of *Eriocrania semipurpurella* Steph., to show the *cubital fork* (Cu dividing into Cu_1 and Cu_2), the *posterior arculus* (*pa*), the *anal furrow* (*af*), the *cubito-anal cross-vein* (*cu-a*), and the courses of the three anal veins, with the *subanal cross-vein* (*sa*). Note the splitting back of the cubital trachea basad from the true position of the cubital fork in the imago; also the macrotrichia developed along the courses of the future first and second anal veins; (× 132).

Careful dissections of the pupal forewings of *Hepialidæ* show that this family also possesses the same conditions in the region of Cu, the arching up of Cu_1 and the position of the posterior arculus being exactly the same as in *Eriocrania*. The differences between the two wing-types lie only in the more generalised shape of the Hepialid wing, the more basal position of the dichotomies of R and M, and the somewhat greater reduction of the anal area. R_{1a} is, of course, absent in *Hepialidæ*, and R_{2+3} is always forked near the apex.

Text-fig.1 shows also the venation of the imaginal forewing of *Eriocrania*, for comparison with the pupal tracheation. It will be seen that the serial vein formed from M, *pa* and Cu_1 is by no means straight, as it is in some higher types, and there is little difficulty in recognising the parts that go to its composition. The only other specialisations are (*a*) the distal union of 2A with 1A to form the forked anal vein (note that trachea **2A** does not meet 1A); and (*b*) a great weakening of portions of the imaginal venation, giving rise to three hyaline areas, within which the main veins and cross-veins alike are obliterated. These areas are known as *thyridia*, and are also to be found in Trichoptera, Mecoptera, and Planipennia. In Text-fig 1, I have indicated the courses of the veins on the thyridia by dotted lines; one of them covers the median fork, another runs from R_{4+5} to the dichotomy of M_{1+2}, and a third covers the distal end of Cu_2. The only true cross-veins present in the forewing of *Eriocrania* are the humeral (*hm*), the radio-median (*r-m*), the medio-cubital (*m-cu*), the posterior arculus (*pa*), the cubito-anal (*cu-a*), and the subanal (*sa*). It should be noted that the basal piece of Cu_1 has frequently been mistaken for the cubito anal cross-vein, as by Forbes*(**4**), while the misapprehension as to the real identity of 1A has led to an incorrect naming of the true cubito-anal itself.

The Hindwing. (Plate iii., fig.1, Text-figs.3-4).

The tracheation of the hindwing of the pupa, though on the whole resembling that of the forewing, differs from it in at least two very important points. Firstly, the cubital fork lies much closer to the base of the wing; and, secondly, there is a very important specialisation in the course of 1A, this trachea coming to lie alongside Cu_2 for a considerable distance, as may be seen in Text-figs.3-4. Consequent upon the changed position of the cubital fork, the posterior arculus (*pa*) is shorter and much less

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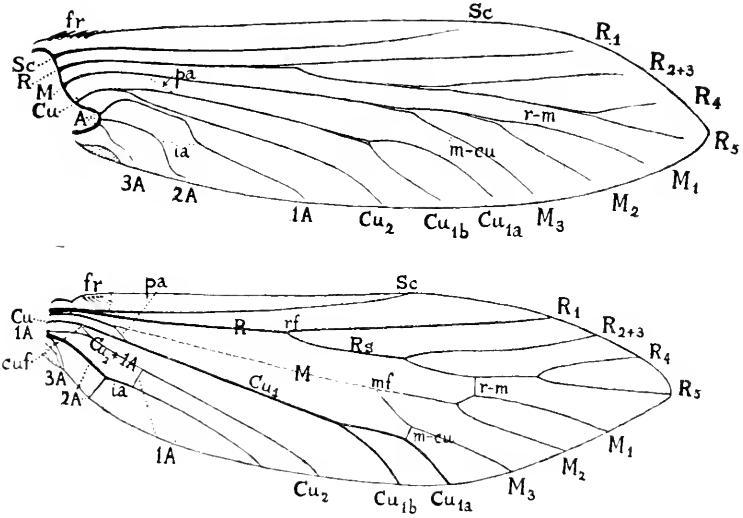
* The wing figured by Forbes is actually that of *Micropteryx (Eriocephala) thunbergella*.

conspicuous in the hindwing than in the fore; this is well seen by comparing Text-figs. 2 and 4.

The course of 1A is very tortuous, as may be seen from Text-figs.3-4. Arising with the other anal veins far from the base of Cu, it bends forward, and approaches Cu_2 just as the latter leaves the cubital fork. It runs alongside this latter vein for some distance, and then bends downwards again away from it, finally running subparallel to and below it to the wing-border. If, now, we turn to the imaginal venation, we see that the course of this vein is even more carefully concealed, since a single vein, $Cu_2 + 1A$, there occupies the portion where the two tracheæ ran alongside one another; in other words, a complete fusion of these two veins has taken place in this region. The part of 1A descending from Cu_2 distad from this fusion appears like a cross-vein, and has been so considered by some authors. The distal part of 1A forms, in the imago, the distal portion of a serial vein, of

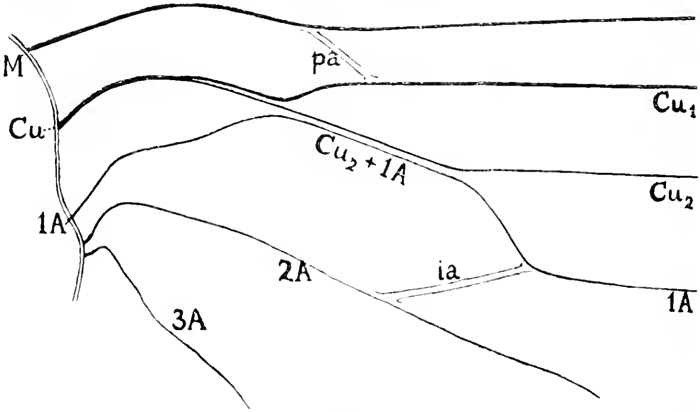


Text-fig.3.

Hindwing of *Eriocrania semipurpurella* Steph. Above, the pupal tracheation, (×60); below, the imaginal venation, (×19). For lettering, see p.136.

which the basal part is formed from 2A, and the middle connecting piece by a longitudinally placed cross-vein, the inter-anal (*ia*). The distal end of 2A descends transversely to the wing-border, and thus resembles a cross-vein.

Thus we see that the cubital and anal portions of the fore- and hindwings in *Eriocrania* are really very different, though there is a superficial analogy between non-homologous parts; as, for instance, between the curved distal part of 2A in the forewing (where it joins up with 1A) and the inter-anal cross-vein of the hind; and again, between the sub-anal cross-vein of the forewing and the descending distal portion of 2A in the hind.



Text-fig. 4.

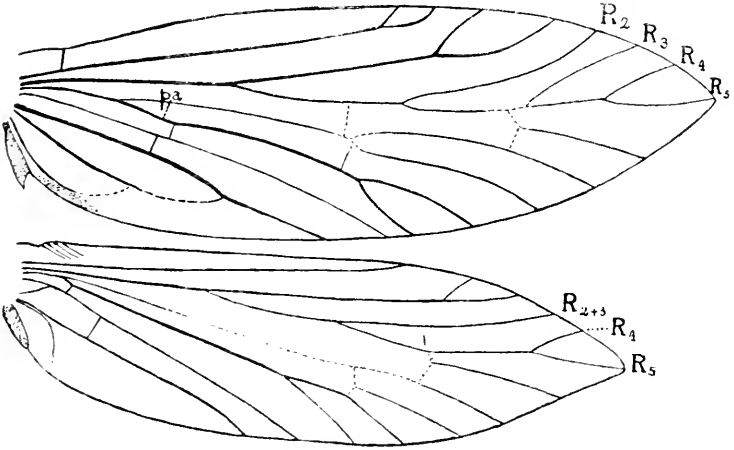
Portion of basal tracheation of hindwing of the pupa of *Eriocrania semipurpurella* Steph., to show the *cubital fork* (contrast its position with that of the forewing) and the tortuous course of trachea 1A, with the manner of formation of the fused vein $Cu_2 + 1A$. *ia*, inter-anal cross-vein; *pa*, posterior arculus; (× 165).

It should be noted that the subcostal vein is proportionately shorter in the hindwing than in the fore, ending only a little beyond half-way along the costal border The costal space is proportionately narrower. The pterostigmatic region is longer and narrower, and not crossed by a vein R_{1a}. The radio-median cross-vein is plainly visible; whereas, in the forewing, it is lost in the thyridium. The imaginal venation of the hindwing is much weaker than that of the fore; and most of the main stem of the media is obsolescent, from just distad of the posterior arculus to the median fork. The medio-cubital cross-vein is placed much more distad than in the forewing, descending from M_3 upon Cu_{1a}. Cu_2 is also a very weakly indicated vein. There are no true thyridia in the hindwing.

Other differences between the two wings, apart from that of size, are the obsolescence of the humeral cross-vein, the presence of the frenulum, and the reduction of the jugal lobe, in the hindwing.

Comparison with the Venation in other Genera.

The pupal tracheation is not available for the study of other genera of the *Micropterygidae*. This is, however, very little drawback, now that we have the pupal tracheation of *Eriocrania*; for we shall be able to show that the same type of venation holds throughout the group, with only minor differences of detail.



Text-fig.5.

Wings of *Mnemonica subpurpurella* Haw., (× 19). *pa*, posterior arculus.

The genus that is most nearly allied to *Eriocrania* is *Mnemonica* (Text-fig.5), which was separated out from the older genus *Eriocrania* by Meyrick in 1912, its type (*subpurpurella* Haworth) having been placed originally in *Micropteryx*, and removed to *Eriocrania* when that genus was formed later on. *Mnemonica* differs from *Eriocrania* in having R_2 and R_3 existing as separate veins in the forewing. I have marked these veins in Text-fig.5. It will be seen that, in this genus, Rs is not dichotomously branched, but that R_3 arises from what we usually regard as the common stem of R_4 and R_5. All specimens examined by me show this condition, which is also the one figured by Meyrick (**6**, p.802), as well as by Comstock (**3**, p.314). I fail, therefore, to understand the remark of the latter author on the same page that "this is an exceptional feature: usually the forking of the radius is dichotomous."* From an examination of all the specimens in my possession, representing sixteen wings belonging to three species of this genus, all of which agree in this character, I have very little doubt that the condition figured is the more usual one for the genus.

Further differences between *Eriocrania* and *Mnemonica* are the presence of an extra distal branch of Sc in the forewing of the latter, and the distal forking of R_1 in the hindwing as well as the fore. There is also the complete joining-up of the distal end of 3A on to 2A in the forewing, apparently brought about by a union of 3A with the cross-vein *sa*, and the more primitive condition of vein 2A in the hindwing. Both these characters, however, appear to be subject to some variation in individual specimens.

It will thus be seen that the differences between *Mnemonica* and *Eriocrania* are most certainly of no higher than generic value (as regards the wing-venation), and that there is nothing to prevent us naming all the parts of the venation of *Mnemonica* with certainty, now that we know the tracheation of the wings of *Eriocrania*. The peculiar differences in the course of the cubitus and anal veins in fore- and hindwings can all be made out easily in *Mnemonica*, simply by comparing the venation with that of *Eriocrania*.

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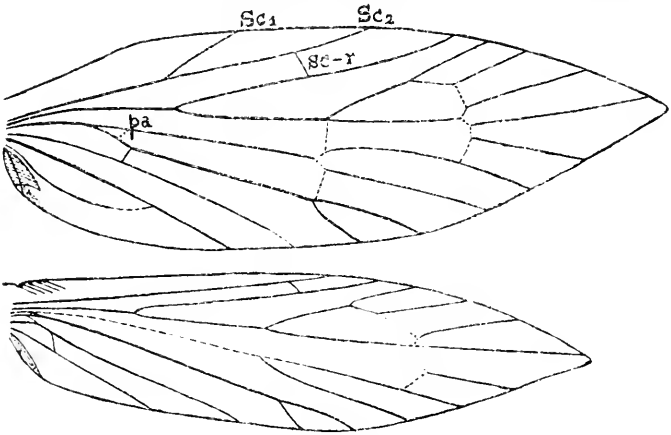
* So also the forking of R_{2+3} far distad in the hindwing, figured by Comstock, would appear to be aberrant, since Meyrick states that "vein 10 is absent" in hindwing, and my specimens agree with this.

Turning next to the older genus *Micropteryx* (Text-fig.6), representing a different subfamily from that in which *Eriocrania* and *Mnemonica* are placed, we again find a closely similar type of venation present. The radial sector is, however, dichotomously branched in both wings, and possesses the full number of branches (four). R_1 is unbranched; but a strong branch (Sc_1) is developed, in the forewing only, from the middle of Sc, running obliquely across an enlarged costal area. A cross-vein (*sc-r*) is developed distally between Sc and R_1 in both wings, but the humeral cross-vein is absent. The posterior arculus (*pa*) is very prominently shown in the forewing, but is almost obliterated in the hind, the cubital fork being placed exceedingly close to the base of the wing. Vein 3A does not loop up with 2A in the forewing, but remains primitive, the cross-vein *sa* being apparently absent.

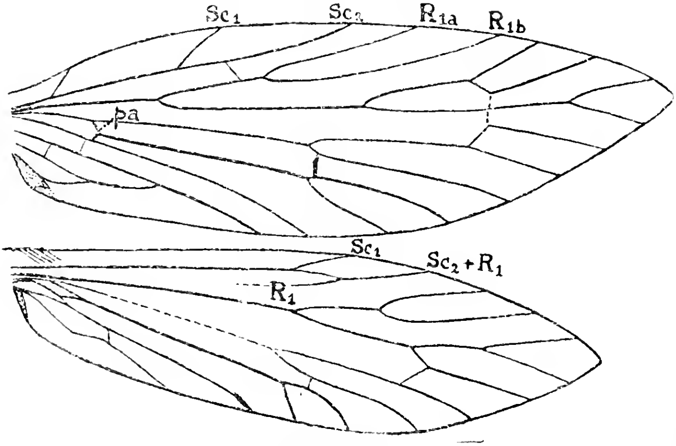


Text-fig.6.

Wings of *Micropteryx aruncella* Scop. (×27). *pa*, posterior arculus; *sc-r*, cross-vein from Sc to R_1; Sc_1, oblique branch of Sc crossing enlarged costal area of forewing.

The wings of *Micropteryx* are more sharply pointed than those of the *Eriocraniinæ*, and show more markedly that secondary tendency towards a symmetrical shape, about a median longitudinal axis, which is more or less characteristic of the whole family. This I regard as a specialisation, probably due to the manner of flight, and strictly comparable with the similar specialisation to be seen in the wings of the *Psychodidæ* amongst the Diptera. The broadened costal area of *Micropteryx*, with the oblique branch developed from Sc, is to be regarded as correlated with this specialisation rather than as an archaic feature of the wing; it should be noted that both are absent from the narrower hindwing.

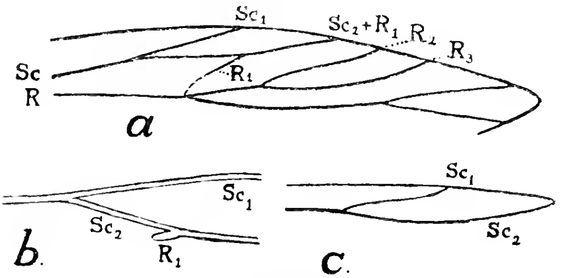
There is, then, no difficulty in recognising the same type of venation in *Micropteryx* and in *Eriocrania*; though, if we did not possess the tracheation of the latter to guide us, we might indeed find it difficult to recognise the true courses of the cubitus and anal veins in the hindwing of this genus.



Text-fig. 7.

Wings of *Sabatinca incongruella* Walk. (× 18). *pa*, posterior arculus; R_1, in hindwing, the obsolescent portion of the main vein R_1; $Sc_2 + R_1$, in hindwing, the fused distal ends of Sc and R_1; Sc_1, oblique branch of Sc crossing enlarged costal area of forewing.

Passing from *Micropteryx* to the closely allied *Sabatinca* (Text-fig. 7), we find a very similar type of wing, both in shape and venation. The costal area of the forewing is enlarged, as in *Micropteryx*, and carries not only the extra branch from Sc, but also the archaic humeral cross-vein. A remarkable feature of this wing is the strong distal fork of R_1, comparable with that of *Mnemonica*, but larger, and not occurring in the hindwing. This is properly regarded by Meyrick as a primitive character, since R_1 was certainly originally a branched vein. In the same region of the hindwing, however, we meet with a very remarkable specialisation, viz., the capture of R_1, not far from its distal end, by Sc_2. As a consequence of this, R_1 tends to shorten, and finally to become aborted basad from this point In the type species of the genus, *S. incongruella* Walk., the basal portion of R_1 is already obliterated, and the rest of the vein appears as a short "returning" or "recurrent" vein attached to Sc_2, as shown in Text-fig.7. I find this condition in all my specimens of this species, and also in *S. barbarica* Philpott. In *S. caustica* Meyr., the recurrent portion of R_1 is reduced to a small stump, about the size of a scale from the same wing, as shown in Text-fig.8,*b*. In *S. calliplaca* Meyr., the only known Australian species, even this stump is absent, and there is no sign at all of the presence of R_1 (Text-fig.8, *c*). On the other hand, in both my specimens of *S. chrysargyra* Meyr., R_1 is still complete, though very weakly formed basally. One specimen shows R_1 arising exactly from the forking of Rs into R_{2+3} and R_{4+5} (Text-fig.8, *a*), while the second shows it arising somewhat further distad along R_{2+3}. Both conditions are, of course, specialisations from the original



Text-fig.8.

a. Portion of venation of hindwing of *Sabatinca chrysargyra* Meyr. (× 25) to show the complete R_1. *b*. Portion of venation of hindwing of *S. caustica* Meyr., to show small remnant of R_1 attached to Sc_2, (× 60). *c*. Portion of venation of hindwing of *S. calliplaca* Meyr., with R_1 entirely eliminated, (× 25).

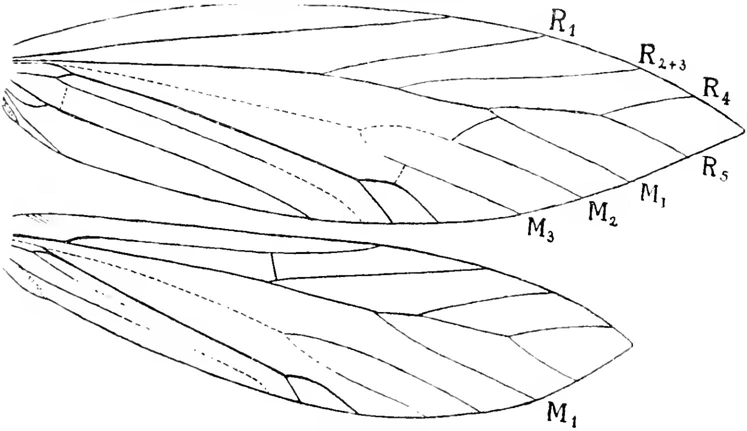
position; and hence we may say that R_1, though very variable in the hindwing of this genus, is always more or less specialised in its formation.

Meyrick figures the hindwings of both *S. chrysargyra* and *S. incongruella* with a complete and normally placed R_1, and omits Sc_2 from the hindwing of the former species (**6**, Plate, figs. 11, 12). If these figures are correct, then the variability in the structure of R_1 in the hindwing of *Sabatinca* must be very great. I have, however, mounted and studied a considerable number of hindwings of this genus, and in none of them have I seen anything comparable with what Meyrick figures.

Reviewing the above evidence, we see that the four genera *Sabatinca*, *Micropteryx*, *Mnemonica*, and *Eriocrania* are closely allied as regards their wing-venation. *Sabatinca* is perhaps the most archaic, but cannot be the direct ancestor of *Micropteryx*, on account of the specialisation of R_1 in the hindwing. Both *Sabatinca* and *Micropteryx*, again, are more specialised than the other two on account of their more symmetrical, sharply-pointed wings; and hence they can neither of them be the direct ancestor of the *Eriocraniinæ*. *Mnemonica* is older than *Sabatinca*, not only in the shape of its wings, but also in having R_1 forked in both wings; but it has mostly lost the original dichotomic arrangement of the branches of Rs — a very important specialisation — and has one branch of Rs absent from the hindwing. *Eriocrania* may well be a direct derivative from *Mnemonica*, by loss of one branch of Rs in the forewing also.

The remaining genus, *Mnesarchæa*, (Text-fig. 9) presents a remarkable venational problem. In both wings, one vein has been lost; and a careful examination of the courses of the remaining veins, in the two species *M. paracosma* Meyr., and *M hamadelpha* Meyr., shows us at once that this vein is the same as the one lost in *Eriocrania*; in other words, R_{2+3} is an unbranched vein in this genus. In my specimens of the type species *paracosma*, the vein M_3 is quite clearly to be seen, still attached to M_2 by a definite stalk, as well as to R_5 by the cross-vein *r-m*. Meyrick, however, figures the forewing of this species with M_1 directly attached to R_5, and with no attachment at all to M_2.

Further, he states that the missing vein is No.11, *i.e.*, R_1. This is obviously wrong, as may be seen at once from Meyrick's own figure, and the one here given of the allied species *M. hamadelpha.* Other specialisations are: the great reduction in the size of the jugal lobe and the frenulum (in some specimens, it is not at all easy to see that either of them exists); the position of the cubital fork very close to the base in both wings, and the consequent reduction in the size of the posterior arculus; the great reduction in 2A in the forewings, so that it loops up with 1A very close to the base: and the reduction of Cu_2 and the anal veins through the narrowing of the base of the hindwing.



Text-fig.9.

Wings of *Mnesarchaea hamadelpha* Meyr. (× 20). Note M_1 entirely captured by Rs in the hindwing.

In *M. hamadelpha* Meyr., (Text-fig.9) there is a further specialisation (at least, in the two specimens examined by me) in that R_5 has completely captured M_1 in the hindwing, the original connection with M_2 being completely lost. As this is exactly similar to the condition shown by Meyrick for the *forewing* of *M. paracosma*, it is possible that this particular specialisation occurs fairly frequently in either wing of either species, when a sufficient number of individuals is examined.

From the above remarks, it will be seen at once that *Mnesar-*

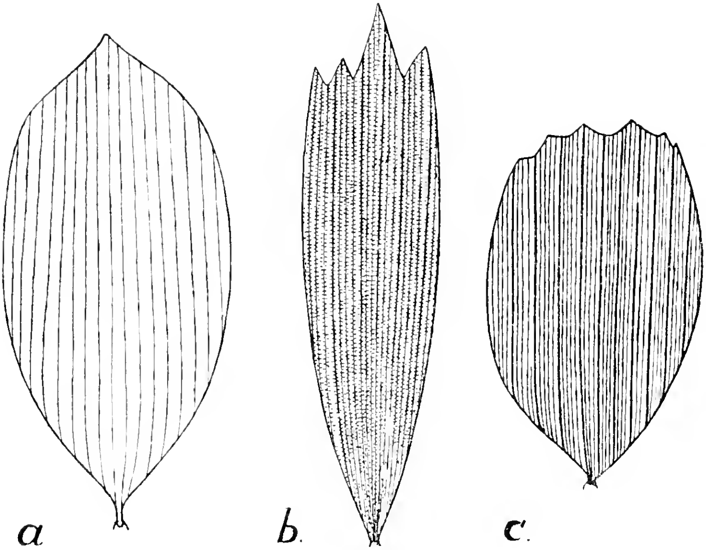
chæa might well be a direct derivative from *Eriocrania*, considerably more specialised, and, therefore, rightly placed in a separate subfamily. In the next section, it will be seen how very different the scales of this genus are from those of all the rest of the *Micropterygidæ*. If, therefore, it should turn out that the life-history of this genus, when discovered, is very distinct from that of both *Eriocrania* and *Micropteryx*, there would then be a strong case for its separation out as a distinct family *Mnesarchæidæ*, characterised by the combination of the loss of the forking of R_{2+3}, together with the remarkable specialisation in the structure of the scales. As these latter are of the greatest importance in considering the claim of the *Micropterygidæ* to be included in the Lepidoptera, I shall deal with them fully before comparing the wings of this family as a whole with those of Lepidoptera and of other Orders.

Section ii. The Scales.

In all the *Micropterygidæ*, both microtrichia and macrotrichia are present, as in all the more archaic members of the Orders Megaloptera, Planipennia, Mecoptera, Diptera, Trichoptera, and Lepidoptera. The presence of microtrichia in itself is, therefore, no argument in favour of the inclusion of this family in any one of these Orders, in preference to any other. But the fact that they are of exceptionally small size, as they are in all Lepidoptera that possess them, must speak for the Lepidopterous nature of the family. In the same way, the presence of macrotrichia in itself is no argument in favour of any one of the six Orders as against another; but the fact that most of them are highly specialised as *scales* is of the greatest importance.

Various authors have depreciated the value of the presence of scales in this respect, by remarking that scales also occur in the Trichoptera and Diptera. They forget to add, however, two very important facts; firstly, that scales only occur in a few specialised representatives of these two Orders, and are certainly not to be found in the most archaic groups of either Order; and, secondly, that, in the Trichoptera at any rate, the scales are of a much more primitive type, even in the highest genera. Leaving out of account the supposedly androconia-like bulbous macrotrichia of the males of one particular, highly-specialised genus (*Enoicyla*), which clearly do not enter into the question, the only scales known in the Trichoptera are very narrow, elongate, lanceolate scales, with not more than four or five longitudinal striæ at the most. These are confined to a few isolated genera in the families *Sericostomatidæ* and *Leptoceridæ*, but are never found in any representatives of the *Rhyacophilidæ* or *Hydropsychidæ*, which are rightly regarded as the most archaic families of the Order. Nobody could possibly point to any connection between the *Micropterygidæ* and the Trichoptera, except through the *Rhyacophilidæ*, in which the venational similarity between fore- and hindwings is still to a great extent preserved. Hence the fact that broad, well-developed scales are to be found on all *Micropterygidæ* is strong evidence in favour of their being true Lepidoptera, since this Order is *the only one known in which scales occur universally from the lowest to the highest members of the Order.*

Let us then examine the types of scales to be found within the *Micropterygidæ*. Text-fig.10, *a* shows a greatly magnified, broad scale from the wing of *Sabatinca incongruella*. (As in all Lepidoptera, the macrotrichia in this genus show all stages from a simple hair, through a flattened hair and various grades of narrow to moderately wide scales, to broad scales; the latter being the most highly developed, we shall study these only). The principal characteristics of this scale are: its transparency, due to absence of internal pigment; its regular shape, without any scalloping of the distal border; the uniform delicacy of the parallel longitudinal striæ; and the absence of any sign of cross-striolation. This combination of characters marks off this type of scale very distinctly from any other known in the whole of the Lepidoptera (excluding *Micropterygidæ*). A careful examination of the scales to be found in the genera *Micropteryx*, *Mnemonica*, and *Eriocrania* shows us that they all possess broad scales very closely similar in type to those of *Sabatinca*. The most generalised of all would appear to be those of *Mnemonica* (Text-fig.11, *c*), from which it is easy to derive the broader and somewhat distally flattened scales of *Eriocrania* (Text-fig.11, *d*) on the one hand, and the slightly pointed scales of *Sabatinca* (Text-fig.11, *b*) on the other. From this latter form, by a considerable shortening, and a further specialisation in the form of the distal portion, we arrive at the form seen in *Micropteryx* (Text fig.11, *a*) Thus all four genera agree very closely in the form of their broad scales. Further, as this type of scale is very distinct from any other known in either of the Orders Trichoptera or Lepidoptera, it is clear that the affinity of these four genera is placed beyond serious doubt by the possession of this character in common.



Text-fig.10.

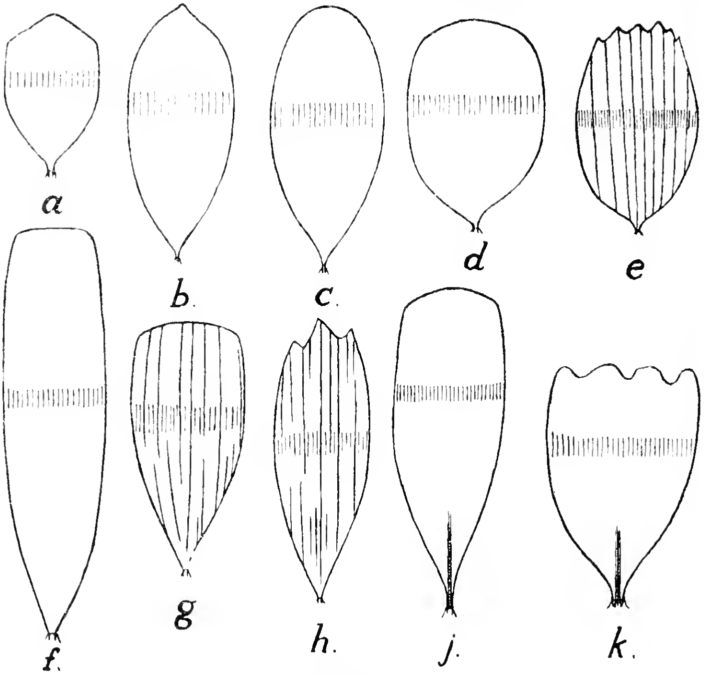
Scales of *Micropterygidæ* (× 600). *a*, broad scale from wing of *Sabatinca incongruella* Walk.; *b*, medium width scale, and *c*, broad scale from wing of *Mnesarchæa hamadelpha* Meyr., (cross-striolation somewhat emphasised in *b*, but omitted in *c*, being too delicate for reproduction).

Turning next to the genus *Mnesarchæa*, I have figured both a broad scale (Text-fig.10, *c*) and one of medium width (Text-fig. 10, *b*), since both afford comparisons with scales from other families of Lepidoptera. Both these scales are remarkable for the following series of characters:—the scalloping of the distal border; the large number and consequent closeness of the parallel longitudinal striæ; the presence of a number of thickened or coarsened striæ; the presence of cross-striolation; and its attendant character, the presence of pigment granules in the scale itself. It should be further noted that the membrane of the wing in *Mnesarchæa* is quite transparent, while that of the other *Micropterygidæ* always has more or less brown pigment deposited within it. Thus the beautiful metallic effects found in this family are due to the combination of pigment in the membrane with striation of the scales; but in the non-metallic *Mnesarchæa* the whole colour-producing apparatus is located in the scales.

We have now to enquire whether the scales of *Mnesarchæa* show any close resemblance to those of any known family of Lepidoptera. In Text-fig.11, *h*, I give a drawing of the hitherto undescribed scales of *Prototheora* (Suborder Homoneura, family *Prototheoridæ*), which will be seen to be exactly comparable with the medium-width scale from *Mnesarchæa* figured in Text-fig.10,*b*. The only difference between the scales in this family and in *Mnesarchæa* is that the type of scale shown in Text-fig.11, *h*, is the *broadest* to be found in the *Prototheoridæ*, and it is interspersed with a number of scales that are not scalloped at the distal end, but merely lanceolate, or even oval. Cross-striolation is present in all the scales of this family, and, indeed, in those of every family of Lepidoptera, as far as I know, except only in the four genera of *Micropterygidæ* already mentioned.

Two types of scale from the family *Hepialidæ* are shown in Text-fig-11, *f*, *g*, the first from *Charagia*, the second from *Perissectis*. Kellogg(5) supposed that the presence of coarsened striæ was peculiar to this family, since it had not been found in any other. We now see that this type of striæ is to be found in all three families of the Homoneura, but not in any known Heteroneura. The scales of *Hepialidæ* appear to be distinguished by their flattened distal borders, as contrasted with the scalloped border of the scales of *Mnesarchæa* and *Prototheora*, and the rounded or slightly pointed distal border found in the other *Micropterygidæ*, and also in *Prototheora*.

Text-fig. 11, *j*, *k*, shows two types of scale from *Cebysa conflictella* Walk., an archaic Heteroneurous Lepidopteron usually placed in the *Plutellidæ*. These are figured for comparison with *Mnesarchæa*, which Meyrick considers not far removed from the



Text-fig. 11.

Different types of Lepidopterous scales (×330). *a*, from *Micropteryx*; *b*, from *Sabatinca*; *c*, from *Mnemonica*; *d*, from *Eriocrania*; *e*, from *Mnesarchæa*; *f*, from *Charagia* (*Hepialidæ*); *g*, from *Perissectis* (*Hepialidæ*); *h*, from *Prototheora* (*Prototheoridæ*); *j*, *k*, from *Cebysa* (*Plutellidæ*). In all figures, the normal delicate striation is not completely filled in, but only indicated by the short parallel lines; the coarsened striæ, when present, are indicated in full; and the cross-striolation, which is present in all except *a*-*d*, is entirely omitted, being too delicate to be properly visible at the given magnification.

Plutellidæ in the venation of its forewing. Like those of all other Heteroneura, these scales are devoid of coarsened striæ; but they show a kind of thickened stalk basally, such as may also be found in the *Oecophoridæ* and other families. The longitudinal striæ are very numerous and close together, and the cross-striolation very marked. The scales of most Heteroneura are scalloped or deeply angulated along the distal margin: a marked exception to this rule is the archaic family *Cossidæ*, in which scalloping is never found.

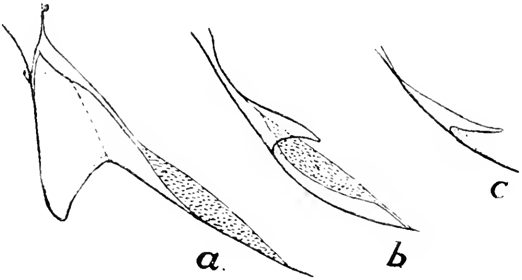
Section iii. THE WING-COUPLING APPARATUS.

In Part i. of my paper on the Panorpoid Complex (**9**, p.298, Text-fig.10; Plate xxix., figs.1-3) I dealt with the wing-coupling apparatus of the *Micropterygidæ*, and showed that it was of a jugo-frenate type, there being both a jugal lobe on the forewing and a distinct frenulum on the hind.

The conclusions arrived at in that paper were based for the most part on the study of New Zealand material, consisting of species of the genera *Sabatinca* and *Mnesarchæa*, and also on a long series of *Micropteryx aruncella* from Scotland. Of *Mnemonica*, I had at the time only three specimens, and of *Eriocrania* two, all received from Mr. Meyrick. Of these, only one specimen of each genus was sacrificed for the making of microscopic preparations, the others being kept intact.

In studying these preparations, I noticed that, of all the slides prepared by me, that of *Mnemonica* appeared to be the only one in which the jugal lobe was not doubled under the wing. As I had made a special effort to get this lobe spread out on the slide, I did not at the time attach much importance to this observation; particularly as, in the mounted wings of *Eriocrania*, I found the jugal lobe to be partly folded. However, on receipt of Professor Comstock's recent work (**3**, pp.314-6), it was at once evident to me that the jugal lobe of the *Eriocraniinæ* was quite different from that of *Sabatinca* and *Micropteryx* Hence I made a further study of the whole of my material, with the result that I am now convinced that there are two very distinct types of jugal lobe to be found within the *Micropterygidæ*.

In text-fig.12, I show these two types. The jugal lobe of *Sabatinca* and of *Micropteryx* is, as I have already described it, small, bent under the wing in a unique position, and able to engage the bristles of the frenulum, for which it acts as a primitive retinaculum (Text-fig.12, *b*). Further, there is an extensive patch of short, stiff spines, a specialisation from the macrotrichia of vein 3A, arranged in such a position as to aid in the retention of the frenulum. These were not figured in my former paper.



Text-fig.12.

Jugal lobes of *Micropterygidæ*; *a*, from *Mnemonica subpurpurella* Haw., with elongated patch of short, stiff spines placed well distad from it: *b*, from *Sabatinca incongruella* Walk., with patch of similar spines placed just distad from it; *c*, from *Mnesarchæa hamadelpha* Meyr., without any spiniferous area. (Drawn from cleared mounts, viewed from beneath, all three equally enlarged, × 54).

In *Mnemonica* and *Eriocrania* (Text-fig.12, *a*), the jugal lobe is much larger, and does not pass under the forewing, but projects from it in the same manner as in *Rhyacophila*. It passes above the costal portion of the hindwing (in the position of flight), and thus helps in the coupling of the two wings. Beyond the jugal lobe, upon the distal part of vein 3A, there is developed an area of short, stiff spines, which probably also help in coupling the wings, by catching the bristles of the frenulum, though my material is not sufficient to decide this point for certain.

In *Mnesarchæa* (Text-fig.12, *c*), the jugal lobe is very weakly formed, but is of the same type as in *Sabatinca* and *Micropteryx*. There is no area of short, stiff spines, and the frenulum is also very weakly formed.

It is thus very evident that a single type of wing-coupling apparatus characterises the *Micropteryginæ* and *Mnesarchæinæ*, the latter being, as regards this character, an asthenogenetic offshoot from the former. The *Eriocraniinæ*, on the other hand, have a jugal lobe resembling that of *Rhyacophila*. Thus we are placed in somewhat of a dilemma: since, on the characters of the wing-venation and mouth-parts, *Mnesarchæa* would appear to be an offshoot of the *Eriocraniinæ*; while the latter, judged by these same characters, are not so archaic as the *Micropteryginæ*, and hence should be further removed from *Rhyacophila*, if a Trichopterous origin for the family is to be maintained.

Section iv. Discussion of the Results.

We have now to consider the bearing of the results of our study of the wings of the *Micropterygidæ* upon the systematic position of the group We may best do this by asking the following questions in order, and answering them from the evidence now available :—

(1) *Are the Micropterygidæ, or any part of them, rightly to be considered as forming a separate Order Zeugloptera ?*

Dr. Chapman's new Order Zeugloptera includes only the genus *Micropteryx*. But it will be evident that, if it is to stand at all, it must also include the genera *Sabatinca* and *Micropardalis*; since these are so closely allied to *Micropteryx*, that any attempt to distribute the subfamily *Micropteryginæ* between two separate Orders could not be countenanced for a single moment.

I take it, then, that Dr. Chapman would hold that the *Micropteryginæ* form the Order Zeugloptera, while the *Eriocraniinæ* and *Mnesarchæinæ* are to remain within the Lepidoptera.

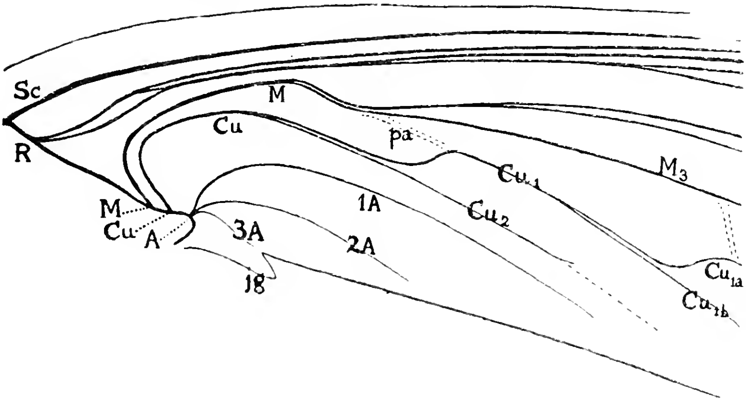
As far as the characters considered in this Part are concerned, it may be said at once that there is not a single one of them that is not to be found already in some Order other than Zeugloptera. The venational scheme is common to the Trichoptera and Lepidoptera; and some of its specialisations, notably the fusion of 1A with Cu_2 for some distance in the hindwing, are also to be found in many genera of the Mecoptera and Planipennia. The jugo-frenate type of wing-coupling is to be found in archaic genera of the Orders Mecoptera and Planipennia. The scales of the *Micropteryginæ* and *Eriocraniinæ* are of similar structure, though those of *Mnesarchæa* are more highly specialised.

We can only conclude from this that, *on the characters considered in this Part*, there is no justification whatever for removing the *Micropteryginæ* to a separate Order Zeugloptera.

(2) *Are the Micropterygidæ terrestrial Trichoptera?*

Professor Comstock relies almost entirely upon the venational scheme and the form of the jugal lobe (which he calls the *fibula*) for the justification of his removal of this group to the Order Trichoptera.

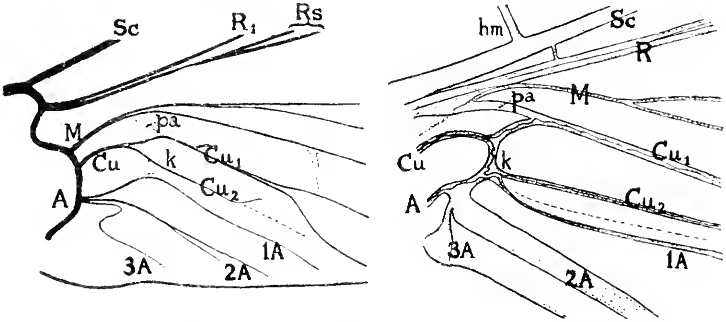
The complete discussion of the relationship between the wing-venational schemes of the Trichoptera and Lepidoptera has been selected by me as a necessary portion of the argument of the paper on the Panorpoid Complex, Part iii., which, I trust, will be available in print at the same time as this paper. Hence there is no need for me to go into the same details here, but simply to refer the reader to that paper. The results, however, may be given here, with just two illustrations that will carry conviction. *There can be no doubt that the venational schemes of the Trichoptera and Lepidoptera are identical in all essential particulars.* In Text-fig.13, I give the tracheation of the base of the pupal forewing in the Hepialid *Charagia eximia* Scott. If this be compared with the tracheation of the forewing of the pupa of *Eriocrania* (Text-figs.1, 2), it will be seen at once that there is no difference of importance. *Charagia* is the more specialised, in that trachea Rs has been split back right to its very origin on the alar trunk, and the three anal veins are somewhat reduced The variability in the condition of the anal *venation* in the forewings of Lepidoptera is very great, and in contrast with the specialised and very constant condition found in the forewings of all Trichoptera, in which 2A loops up with 1A, and 3A with 2A. In Lepidoptera, exclusive of the *Micropterygidæ*, 3A is either very reduced or absent, and does not loop up with 2A. But 2A is frequently found to be looped up with 1A, giving the so-called "forked anal vein." Now the *Micropterygidæ* as a whole repeat on a smaller scale this variability, as may be seen by studying the anal venation of the five genera here figured. The Trichoptera, on the other hand, are constant in this character, throughout an immense series of known forms. Thus we can only conclude that, on this character, the *Micropterygidæ* agree more closely with the Lepidoptera than with the Trichoptera. As regards the other venational specialisations of the forewing, they are all shared equally in common with the *Hepialidæ* and with the Trichoptera, and there is no reason why anyone should prefer to remove them to the Trichoptera rather than to the *Hepialidæ*.



Text-fig.13.

Tracheation of forewing in pupa only two or three days old of *Charagia eximia* Scott, drawn *in situ* after removal of the upper wing-sheath. Note the splitting back of trachea R, and the two separate origins of Rs; (× 11). For lettering, see p.136.

As regards the hindwing, there is the additional specialisation of the partial fusion of vein 1A with Cu_2. In Text-fig.14, I show the condition of the tracheation of the pupal hindwing, near the base, in the genus *Leto* (*Hepialidæ*), together with the corresponding imaginal venation. It will be seen that there is exactly the same condition, except only that the two tracheæ Cu_2 and 1A do not lie so closely alongside one another. But the pupa studied was only a few days old, and the fusion may well become much closer towards the end of pupal life. It is important to notice that, in the venation of *Leto*, the fusion of 1A with Cu_2 is actually accomplished for a short distance (Text-fig. 14, *k*), the basal piece of Cu_2 being bent transversely so as to look like a cross-vein. The reduction in the length of the fused portion in this family is surely to be expected, when we consider that the anal area has undergone reduction, through the narrowing of the base of the wing; the change in the direction of the anal veins from an inclination of about 30° to the longitudinal axis of the wing, in *Micropterygidæ* and *Prototheoridæ*, to more than 45° in *Leto* and other *Hepialidæ*, and the comparative shortening of 1A, so that it ends up at less than one-fourth of the whole wing-length from the base in these insects, instead of at more than one-third as in *Micropterygidæ*, must surely account for some slight alteration of this kind.



Text-fig. 14.

Hindwing of *Leto staceyi* Scott; to the left, the pupal tracheation; to the right, imaginal venation, basal part of wing only. *k*, in both figures, the point where fusion of veins Cu_2 and 1A takes place. As the tracheæ Cu and 1A were clearly visible in the fresh imaginal wing, they are drawn *in situ* in the right-hand figure. (Both figures $\times 4\frac{1}{2}$). For lettering, see p. 136.

Though it should be obvious that the presence or absence of a particular cross-vein ought not to be used as an ordinal character—since these structures, not being preceded by tracheæ, are exceedingly liable to variation—yet Professor Comstock includes in his ordinal diagnosis for the Trichoptera (inclusive of the *Micropterygidæ*) the presence of the cross-vein between "the first and second anal veins," *i.e.*, between 2A and 3A of our notation in this paper, and its *longitudinal direction* in the hindwing. Now, this cross-vein is present in some *Hepialidæ*, as may be seen by referring to Comstock's own figures of *Pielus* and *Sthenopis* (**3**, figs.334, 335, 337); and, in the genera in which it is clearly visible in the hindwing (it is not to be seen in *Leto*, owing to the great swelling and fusion of 2A and 3A basally) it has an oblique position, not far removed from the longitudinal direction. Further, in many Trichoptera, as, for instance, in the *Hydropsychidæ* with wide hindwings, its position is not longitudinal, but transverse or oblique, and in some cases it is eliminated by fusion of the two veins at a point. This character, then, is of no ordinal value at all. However, it should be noted that the *Hepialidæ* do actually possess all those cross-veins which are generally regarded as Trichopterous, viz., *hm*, *r-m*, *m cu*, *cu-a*, and *ia*; they also possess the inter-median cross-vein (*im*) which joins M_{1+2} to M_3, and which is found in most archaic Trichoptera, though not in *Rhyacophila*. They do not possess the inter-radial cross-vein (*ir*) which joins R_{2+3} to R_{4+5}; this occurs in most archaic Trichoptera, but not in *Rhyacophila*: in *Micropterygidæ* it is confined to *Sabatinca* and *Micropteryx*.

Though the presence or absence of cross-veins cannot be used as a character of ordinal value, yet we are bound to notice another character, about which Professor Comstock is significantly silent, though it is well known to all students of the Trichoptera. I refer to the presence of the unique "wing spot," in the angle of the fork made by R_4 and R_5, in both wings. Dr. Ulmer, who has examined more Trichoptera than any man living, says of this wing-spot (**12**, p.16):—"Allen Trichopteren, und zwar auf beiden Flügelpaaren, ist ein dunkler, horniger Punkt (Flügelpunkt) eigentümlich, welcher sich an der Basis der zweiten Apicalgabel, oder wenn diese nicht entwickelt ist, doch in der entsprechenden Region, findet: nur bei Hydroptiliden habe ich diese Punkte nicht sehen können." Putting aside, then, the highly specialised and reduced *Hydroptilidæ*, which cannot be brought into any discussion upon the relationships of the *Micropterygidæ*, we have this outstanding test to apply:—Do the

Micropterygidæ possess this wing-spot, which all other archaic Trichoptera possess, and *no other insects?* The answer is, that they do not; and hence they are not true Trichoptera. Professor Comstock must surely explain away this discrepancy before we could possibly consider the acceptance of his conclusions. Seeing that this wing-spot is visible even in the known fossil Trichoptera, we are bound to insist on its importance as an essential character of the Archetype and of all archaic members of the Order Trichoptera.

There are really four important ordinal differences between the wings of Trichoptera and Lepidoptera :—

(*a*) In all archaic Trichoptera, M_4 exists as a separate vein in the forewing. In archaic Lepidoptera, M_4 is either absent, or fused with Cu_{1a}.

(*b*) In all Trichoptera except only the highly reduced *Hydroptilidæ*, the characteristic *wing-spot* is present. It is never found in Lepidoptera.

(*c*) In all Trichoptera, the tracheation of the pupal wing is reduced to two tracheæ only. In all Lepidoptera, the tracheation remains complete.

(*d*) In Trichoptera, scales only appear in a few isolated and highly specialised genera, and are then of only very primitive, elongated, narrow form, with few striæ. In Lepidoptera, scales of a broad, specialised form, with numerous striæ, occur throughout the Order, from the lowest to the highest forms.

Now, in the whole of the *Micropterygidæ*, M_4 is *not* present as a separate vein of the forewing; the characteristic Trichopterous wing-spot is absent; the pupal wing-tracheation is complete; and scales of a broad form, with numerous striæ, are present. On all four characters, then, the *Micropterygidæ* must be adjudged to be archaic Lepidoptera, and not archaic Trichoptera.

Functional frenula have yet to be found in the Trichoptera. Their presence, then, in *Micropterygidæ* is an additional argument in favour of the non-Trichopterous nature of these insects. As true frenula occur in the Orders Mecoptera, Planipennia, and Lepidoptera, and a true jugal lobe, resembling that of *Rhyaco-*

phila, in certain Megaloptera as well as in some Trichoptera (by no means in all), it is clear that the presence or absence of these structures does not determine the Order to which the *Micropterygidæ* are to belong; it only marks them as archaic.

(3) *Are the Micropterygidæ true Lepidoptera?*

As this question is clearly the alternative to (2), the arguments used against (2) are those that tell in favour of (3). Hence there is no need to repeat them. We have already shown that (*a*) the general venational scheme might be regarded with equal reason as either Trichopterous or Lepidopterous; and (*b*) judged by four outstanding wing-characters, the *Micropterygidæ* are most certainly archaic Lepidoptera.

It is only necessary to add that the wings do not exhibit a single character inconsistent with the inclusion of this family within the Order Lepidoptera.

While the final decision still rests to a large extent upon characters to be studied in the other parts of this paper, yet it will be seen that the study of the wings yields results that are strongly in favour of the Lepidopterous nature of the *Micropterygidæ*. It is also strongly in favour of the unity of the group as a whole, either as a single family *Micropterygidæ*, as Meyrick holds them to be, or as three separate but closely allied families, forming the division Jugofrenata of the Suborder Homoneura. The choice between these two alternatives rests, of course, not only upon the wing-characters, but upon the differences to be found in the mouth-parts, and the larval and pupal forms. It is, however, quite feasible to give good definitions, on wing-characters only, for the determination of these three families, if it should be found finally necessary to adopt them, as follows:—

(1) Family *Micropterygidæ* (s.str.):—Wings sharply pointed and very symmetrical about their longitudinal axes; costal area of forewing enlarged and crossed near its middle by an oblique branch from Sc. Original dichotomous branching of Rs preserved. Scales *without* scalloping of distal border, cross striolation, enclosed pigment, and coarsened longitudinal striæ. Jugal lobe small, bent under forewing; a patch of short, stiff spines placed just distad from it to help in the holding of the frenulum...
......(Genera *Micropteryx*, *Sabatinca*, *Micropardalis*, *Epimartyria*).

(2) Family *Eriocraniidæ*:—Wings more normally shaped, less pointed and symmetrical; costal area of forewing not enlarged, and not crossed by an oblique branch of Sc near its middle. Original dichotomous branching of Rs usually lost (sometimes preserved in *Mnemonica*). Scales closely resembling those of (1). Jugal lobe large, projecting outwards from forewing, so as to overlap the costa of the hind from above; a patch of short, stiff spines placed well distad from it...... ....(Genera *Eriocrania*, *Mnemonica*, *Neopseustis*).

(3) Family *Mnesarchæidæ*:—Wings sharply pointed and symmetrical as in (1), but without any very definite enlargement of the costal area of the forewing, and with no branch of Sc in either wing. Original dichotomous branching of Rs lost, and one of the original four branches of this sector absent from both wings. Scales very highly specialised, with the distal border scalloped; cross-striolation, pigment granules, and coarsened longitudinal striæ, all present. Jugal lobe and frenulum both much reduced in size, the former turned under the forewing, as in (1). ....(Genus *Mnesarchæa*).

In defining the Division JUGO-FRENATA of the Suborder HOMONEURA of the LEPIDOPTERA (**9**, p.315), I gave the following characters :—

"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 frenulum."

This definition will only apply strictly to the family *Micropterygidæ* (s.str.), since we now see that, in *Mnesarchæa*, the jugal lobe and frenulum are so reduced as to be only doubtfully functional, while in the *Eriocraniidæ* the jugal lobe is not turned under the forewing, and does not engage the frenulum. I therefore suggest an emendation of the definition, by the omission of the second portion of the statement. The definition of the JUGO-FRENATA will then read :—

"With archaic jugo-frenate coupling-apparatus consisting of jugal lobe, humeral lobe and frenulum."

This definition will hold for the whole group *Micropterygidæ* (sens. lat.), in whatever Order it may be finally determined that they should be placed.

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EXPLANATION OF PLATE III.

Fig.1.—Left fore- and hindwings of pupa of *Eriocrania semipurpurella* Steph., to show tracheation and the pale banding which precedes the imaginal venation; (×40). Photographed before dissection, the wings being raised away from the body upon a glass slide, whose edge is seen crossing the lower right-hand corner obliquely.

Fig.2.—Right forewing of same, dissected off; distal two-thirds of wing only; (× 60).

Fig.3.—A small portion of the basal part of the same wing as in Fig.2 (× 155), to show the cubital fork (a little above the actual centre of the photograph).

(Two photographs of the fusion of Cu$_2$ with 1A in the hindwing were also taken at same enlargement as that of Fig.3, but the tracheæ are unfortunately slightly out of focus, and cannot be reproduced sufficiently well for publication).

LETTERING OF TEXT-FIGURES.

A, anal veins or tracheæ; 1A, 2A, 3A, first, second, and third analis respectively; *af*, anal furrow; Cu, cubitus; Cu$_1$, first cubitus, dividing distally into Cu$_{1a}$ and Cu$_{b}$; Cu$_2$, second cubitus; *cu-a*, cubito-anal cross-vein; *cuf*, cubital fork; *fr*, frenulum; *hm*, humeral cross-vein; *ia*, inter-anal cross-vein; *jg*, jugum; *jl*, jugal lobe; *k*, point of fusion of Cu$_2$ with 1A; M, media; M$_1$-M$_4$, its branches; *m-cu*, medio-cubital cross-vein; *mf*, median fork; *pa*, posterior arculus; R, radius; R$_1$, its main stem dividing into R$_{1a}$ and R$_{1b}$ distally in *Mnemonica* and in forewing of *Eriocrania*; Rs, radial sector; R$_2$-R$_5$, its branches; *r-m*, radio-median cross-vein; *sa*, sub-anal cross-vein; Sc, subcosta; Sc$_1$, Sc$_2$, its two branches in *Sabatinca* and *Micropteryx*; *sc-r*, subcosto-radial cross-vein.

NOTES ON AUSTRALIAN *COLEOPTERA*, WITH DESCRIPTIONS OF NEW SPECIES.

By H. J. Carter, B.A., F.E.S.

(Plates iv.-v.)

This paper originated from notes on material collected by Mr. A. M. Lea and myself in January, 1918, during a visit to the western districts of Tasmania—especially to Cradle Mountain, Wilmot, Waratah, and Strahan. The new insect life discovered through Mr. Lea's painstaking sifting of moss – especially moss growing on trees, so prolific in those moist regions - demands new generic names for small but interesting members of the fungus-eating *Tenebrionidæ* (*Bolitophaginæ*).

An examination of the *Tenebrionidæ* and *Buprestidæ* in the fine collection made by the late Mr. Augustus Simson, of Launceston, and acquired by the South Australian Museum, has given me special information on Tasmanian species that seems worth recording.

The remainder of the paper deals with miscellaneous material that has either accumulated in my own collection, or has been sent for identification from the National Museum, Melbourne. A table of the genera of the Subfamily *Ulominæ* is included, which may help students to a more ready identification of a difficult and cosmopolitan group of insects, which comprise some notorious grain pests.

BUPRESTIDÆ.

The following list contains the fourteen species of *Stigmodera* that I know to have been taken in Tasmania: the four species marked with an asterisk are found only in Tasmania. *S. australasiæ* C. & G., *S. bremei* Hope, *S. cyanipes* Saund., *S. dimidiata* Cart. (with its var. *leai* Cart.), *S. erythromelas* Boisd., *S. flavopicta* Boisd., **S. insularis* Blackb., **S. jubata* Blackb., *S.*

mitchelli Hope, **S. ocelligera* C. & G., *S. octospilota* C. & G., *S. Thomsoni* Saund. (with its var. *dulcis* Blackb.), **S. virginea* Erichs., *S. Wilsoni* Saund.

Four of the above, together with *S. viridis* (a Victorian variety of *S. cyanicollis* Boisd., found also at King Island, Bass Strait) are often so alike in size and colour (metallic green, rarely blue, with or without yellow markings) that it may be useful to note the distinguishing characters.

S. virginea Erichs.—Each elytron with four carinate costæ; the yellow markings are a shoulder spot, two straggling, often disjointed and thin fasciæ, the first median, the second anteapical, generally with one elongate spot between the first and second costæ opposite the shoulder spot, sometimes with an irregular yellow line at apical sides. Pronotum irregularly, not closely, punctate. *Dimensions:* 8-13½ × 3-5½ mm.

Hab.—Strahan, Waratah, West Coast.

S. flavopicta Boisd.—The typical form has an oval shoulder spot, a long, fiddle-shaped band from base to sides, and a latero-apical band. The intervals are almost smooth, or very faintly punctate: the pronotum is closely punctate. The prothorax is very convex, with its sides widely and evenly rounded. Varieties contain every possible variation of colour to be found by omitting parts of the yellow markings, down to a concolorous metallic green. *Dimensions:* 8-11 × 3-4 mm

Hab.—Hobart, Launceston, Strahan, &c. The commonest of the Tasmanian species.

S. ocelligera C. & G.—An elongate, orange shoulder spot, a wide, subapical, orange fascia surrounding a green centre on each elytron, intervals minutely punctate and wrinkled, pronotum very closely punctate. *Dimensions:* 9-11 × 3½-4 mm.

Hab.—Bellerive (Hobart).

S. dimidiata Cart.—The typical form has a small shoulder spot, a median fascia widely separated at the suture, a narrow, arcuate, preapical fascia, joining a well-marked, latero-apical band. The intervals closely and rather coarsely punctate, the pronotum *not* closely punctate.

Var. *leai* Cart., is without the median fascia. [N.B.—In the original description (Trans. Roy. Soc. S. Aust., 1916, p 136) it was suggested that *S. leai* was a variety of *S. cyanicollis* Boisd., but I have since clearly discerned the distinctions from that species in sculpture]. Both *S. dimidiata* and *S. leai* are in the Simson Coll. from the W. Coast of Tasmania. *Dimensions:* 9-12 × 3½-4½ mm.

Hab.—Tasmania: W. Coast and Huon River.—N.S.W.: Blue Mountains and Sydney.

S. cyanicollis Boisd , var. *viridis* C. & G.—An elongate shoulder spot, subapical lateral spot. Pronotum densely, elytral intervals very finely punctate. *Dimensions:* 10 × 4 mm.

Hab.—King Island, Bass Strait; and Victoria.

The five species may be tabulated as follows :—

Tasmanian *Stigmodera*, having metallic green surface, with yellow markings.

1. Each elytron with four carinate costæ .... *virginea* Erichs.
2-8. Elytral intervals normal.
3. Prothorax strongly convex, sides widely and evenly rounded.............. .... *flavopicta* Boisd.
4-8. Prothorax lightly convex, sides arcuately converging to apex.
5. Each elytron with wide, preapical, orange band, surrounding a green spot .... *ocelligera* C. & G.
6-8. Elytra not as in 5.
7. Elytral intervals strongly punctate, pronotal punctures not close...... .. .. *dimidiata* Cart.
8. Elytral intervals minutely punctate, pronotal punctures densely crowded .... *cyanicollis* Boisd., var. *viridis* C. & G.

STIGMODERA OCTO-SIGNATA, n.sp. (Plate iv., fig.1).

Navicular, convex, finely attenuated behind; head blue, pronotum and groundcolour of elytra metallic blue-black (pronotum showing opalescent gleams on sides), elytra each with four yellow spots, the first oval, near scutellum, the second triangular, on sides near shoulder, the third round, medial, the fourth smaller than third, half way between the third and the apex; underside, legs, and antennæ deep blue.

Head channelled, strongly punctate. *Pronotum* convex, sides evenly rounded, all angles acute, apex feebly arcuate, base strongly sinuate, the middle lobe produced backwards:

disc densely and finely punctate, the median line irregularly indicated by smooth spaces, a large, pre-scutellary fovea and two transverse depressions near hind angles. *Scutellum* triangular, punctate, brilliant green. *Elytra* impressed near shoulders, sides entire to apex, striate-punctate, the intervals regular, convex, and impunctate, apices finely and obliquely lunate; prosternum transversely strigose, the flanks punctate; abdomen with sparse, fine pubescence. *Dimensions:* 10-11 × 3-3½ mm.

Hab.—Kuranda (F. P. Dodd).

Two examples, the sexes, from Mr. Dodd show a species of the *S. mansueta*, *S. læna* group in my classification. In form near *S. elongatula* Mael., its apical structure is like that of *S. atricollis* Saund. The groundcolour is apparently black, but in a strong light shows metallic and even coppery gleams on the forehead and sides of pronotum. In my Table (Trans. Roy. Soc. S. Aust., 1916, p.101) it should be placed as follows :—

152. Pronotum without medial sulcus.
152*a*. Groundcolour violet, apices trispinose .... *læna* Thomas.
152*b*. Groundcolour blue-black, apices bispinose........... *octosignata*, n.sp.

In the ♀ specimen, the basal and median spots coalesce and form an irregular vitta – a common variation with this class of pattern.

Types in Coll. Carter.

TENEBRIONIDÆ.

EXANGELTUS RUFIPENNIS, n.sp. (Plate iv., fig.2).

Elongate, subparallel, convex. Head and prothorax opaque black; elytra, antennæ, and tarsi dull red, legs and underside piceous red, whole surface lightly clothed with pale, recumbent hair.

Head rather sharply rounded and ciliate in front, without any suture to separate epistoma from frontal area; eyes large and prominent, surface rough and rather thickly clad with recumbent hair, a small, nitid, black tubercle at middle, near prothorax; antennæ rather long, its joints sublinear, first two very short, joint 3 as long as 4-5 combined, 4-8 successively shorter, 9 longer than 8, 10-11 very short and nearly round, 11 smaller than 10. *Prothorax* subsinuate at apex, subtruncate at base, sides well rounded, greatest width slightly in front of middle, lightly sinuate behind; anterior angles obtuse, posterior sharply rectangular, surface rugose (apparently longitudinally strigose under thin clothing of hair). *Scutellum* oval. *Elytra* wider than prothorax at base and thrice as long, covered with a number (about 16) of closely placed striæ each containing closely placed, large, square punctures, not cancellate as in *E. gracilior* Blackb.; hairy clothing more obvious at sides and apex. Underside and epipleuræ closely and coarsely punctate, each puncture bearing a short hair; legs thin, tibiæ not enlarged nor spined at apex. *Dimensions:* 13 × 5 mm.

Hab.—Chillagoe, N. Queensland (National Mus., Melbourne).

A specimen, sex uncertain, sent by Mr. Kershaw, shows near affinity to Blackburn's two species, from which it is clearly separated by larger size, bicolorous surface, coarser sculpture, hairy clothing and antennæ (the tenth joint sharply differentiated from ninth in size and shape).

N.B. I have identified specimens of *E. angusta* Blackb., from Perth, W.A., and have seen other examples from widely distant parts of that State. My specimens of *E. gracilior* Blackb., are from Lillimur, Victoria, and correspond well with the description except in their larger size (11 × 3½ mm.).

MNIONOPHILUS, n.g. Bolitophaginarum.

Convex, widely ovate or obovate; mandibles bifid, last joint of maxillary palpi clavate, of labial palpi subulate, maxillæ fringed (at least in *M. costatus*), antennæ rather short (not extending to base of prothorax), with joint 2 as long as, but much stouter than, joint 3, the apical two forming a pronounced club; prosternum not produced backward, sides of pronotum explanate, serrated or toothed, body more or less nodulose and squamose, tibiæ unspined at apex, tarsi and tarsal claws short; intercoxal spaces wide.

Minute insects with a facies of *Mychestes*, remarkable for the length of the second joint of antennæ.

MNIONOPHILUS HORRIDUS, n.sp.

Widely ovate and convex, reddish-brown, underside opaque brown, antennæ and tarsi pale red; whole surface shagreened and pilose with sparse, upright, spiny bristles.

Head large, epistoma truncate, labrum emarginate, canthi forming two large, convex lobes, eyes large, round, and coarsely faceted; antennæ: joint 1 long, stout and cylindrical, 2 clavate, as long as 1, 3 slender, obconic, 4-8 gradually shorter, more or less triangular, 9-10 cupuliform, 9 intermediate in size between 8 and 10, 11 ovate-acuminate, one and a half times as long as 10. *Prothorax* widely transverse, widest at middle, explanate at apex and sides, truncate at base: apex overhanging head, of uneven outline, notched in middle, with about eight, strong, straight bristles pointing forward; disc strongly raised, the middle part consisting of two elongate, convex lobes, one on each side of medial depression; surface pustulose, each pustule bearing a short, curled bristle, margins more or less flat, outlined by six broad teeth, each bearing a spiny bristle, the space between the sixth tooth and the truncate base forming an oblique, curved excision. *Scutellum* not evident. *Elytra:* the base terminating in two dentate processes, fitting the excision in the pronotum, thence obliquely widening to a widely rounded, humeral callus, thence ovately widening to behind half-way; apex abruptly and sharply pointed; disc uneven, coarsely bristled, the sculpture near suture consisting of large punctures in a longitudinal arrangement, with six large, conical nodules, four of these on the apical declivity, and two wide, sinuous costæ starting from middle of base and more or less continued obliquely outwards, derm with two kinds of bristles, the closer kind short and curved, the sparser long and upright. Underside and legs with short, white bristles, tibiæ not serrated. *Dimensions:* 3 mm. long (vix) × 1½ mm. wide.

Hab.—Cradle Mountain, Tasmania.

Three specimens taken by Mr. Lea by sifting moss from trees: also in Coll. Simson. A spiky insect; the anterior angle of the prothorax consists of the widest of the six lateral teeth referred to above: the elytral part is shaped somewhat as in some species of *Leptops*

Type in Coll. Carter; two cotypes in S. Australian Museum.

MNIONOPHILUS COSTATUS, n sp.

Elongate-ovate, convex, reddish-brown, moderately nitid, underside dull brown (the raised parts castaneous), legs, antennæ, and palpi castaneous, elytra, tibiæ, and antennæ with short, sparse, white hairs.

Head less wide than in *M. horridus*, epistoma rounded, canthus moderately raised, eyes large, surface pustulose, antennæ with joints 1-3 of equal length, but successively thinner, 4 subconic, shorter than 3, 5-8 moniliform, 9 wider than 8 and oval, 10 strongly transverse and rounded, 1½ times as long as 9, 11 pear-shaped, as wide as and longer than 10. *Prothorax* truncate at base, widest near basal excision, trilobed at apex, middle lobe overhanging head, with round excision at middle; exterior lobes forming widely emarginate front angles; whole surface rather closely pustulose, margin widely explanate, serrated externally with about twelve irregular serrations; suddenly excised near base, the excision showing a pustulose outline. *Scutellum* not evident. *Elytra* elongate-obovate, of same width as prothorax at base, thence very slightly widening till near apex; each elytron with about three slightly raised, shining costæ, terminating in small nodules near apex, suture also costate; between the costæ are two rows of large, square, foveate punctures, the intervals forming a raised, shining network, tibiæ uneven but scarcely serrate on outer edge. *Dimensions:* 3 mm. long, 1 mm. wide.

Hab.—Waratah, Tasmania.

Two specimens, taken by Mr. Lea in moss, differ from *M. horridus* in the smoother derm, more elongate form, more parallel sides of prothorax, with distinct anterior angles to the last.

Type in Coll. Carter.

ENHYPNON, n.g. Bolitophaginarum.

Sides of pronotum involute, tibiæ strongly serrated on outside, other characters as in *Mnionophilus;* body having the general facies of *Otiorrhyncus.*

ENHYPNON LATICEPS, n.sp.

Ovate, opaque reddish-brown above, piceous beneath, antennæ and tarsi pale red.

Head very wide, epistoma short and square, canthus wide and protuberant, eyes very large, round, and coarsely faceted, forehead flat and asperate, antennæ with joint 1 long, stout, cylindric; 2 subconic, as long as, but less stout than, 1; 3 subconic, slender, not as long as 4-5 jointly; 4-5 subconic: 6-8 moniliform: 9 transverse, intermediate in width between 8 and 10; 10 cupuliform, nearly twice as wide as 9; 11 ovate, as wide as 9 and 1½ times as long. *Prothorax* very convex, subtruncate at base, at apex produced forward and overlapping the head (as in *Mychestes*), and notched in the middle by the medial channel, anterior angles obsolete, the sides enveloping the body, showing crenulations formed by row of rounded knobs, posterior angles widely obtuse; widest behind middle (here slightly wider than head); surface pustulose and clothed with short, pale hair. *Scutellum* triangular. *Elytra* as wide at base as prothorax, convex and widely obovate, surface pustulose, with hairy clothing following the lines of three faint costæ on each elytron, these terminating on apical declivity in large nodules, the middle one in front of the other two: abdomen covered with round, slightly raised, nodulose impressions, legs beneath with sparse hairs, gular region smooth, fore-tibiæ strongly, mid- and hind-tibiæ minutely serrated on outside edge. *Dimensions*: 3 mm. long (vix) × 1½ wide.

Hab.—Cradle Mountain, Strahan, and Waratah, Tasmania.

Two specimens taken by Mr. Lea from moss are probably the sexes, since, in one specimen, the joints forming the antennal club are less widened.

Types in Coll. Carter.

Five more specimens since sent by Mr. Lea for examination, from Strahan, show some variations in colour from pale red to brown, while the apical nodules are variable in size. One of these shows such variation as to suggest another species.

Table of Australian *Ulominæ* (including cosmopolitan genera recorded from Australia).

1(14) Antennæ clavate (apical joint or joints abruptly enlarged).
2(11) Tibiæ not denticulate on outside edge.

3. Head of male horned .... (1) Gnathocerus Thun.
4(11) Head of male without horns.
5(7) Elytra striate-punctate.
6. Antennal club 4-jointed .... (1) Tribolium Muls.
7. Antennal club 1-jointed .... (3) Micruloma, n.g.
8. Elytra seriate-punctate, antennal club 3-jointed... (3) Microcilibe, n.g.
9(11) Elytra irregularly punctate.
10. Form cylindric, antennal club 4-jointed .... (2) Lyphia Muls.; Lindia Blackb.
11. Form depressed, antennal club 3-jointed ....(3) Mesotretis Bates.
12(14) Tibiæ (front and mid at least) denticulate.
13. Form depressed, antennal club 4-jointed .... (3) Platycilibe Cart.
14. Form convex, antennal club 2- or 3-jointed ... (3) Brachycilibe Cart.
15(27) Antennæ not clavate (joints gradually enlarged).
16(22) Tibiæ not denticulate on outside edge.
17. Head of male horned (at least in *S. hololeptoides* Cast.) .... (1) Sitophagus Muls.
18(22) Head of male without horns.
19(21) Elytra striate-punctate.
20. Form moderately convex, antennæ short .... (1) Palorus Muls.
21. Form depressed, antennæ long .... (3) Ulomoides Blackb.
22. Elytra irregularly punctate... (2) Hypophlœus F.; Corticeus Crotch.
23(27) Tibiæ denticulate (except in *Uloma torrida* Cart.).
24(26) Species with eyes.
25. Males with depression on prothorax, tibiæ enlarged at apex.. .... (2) Uloma Cast.; Acthosus Pasc.
26. Without sexual distinction on prothorax, tibiæ little enlarged at apex. .... (1) Alphitobius Steph.; (3) Typhluloma Lea.
27. Blind.

(1) Genera containing cosmopolitan species—mostly grain pests.

(2) Genera containing species from every continent (*Lyphia* not recorded from America).

(3) Genera recorded only from Australia, Norfolk Island, or Lord Howe Island.

Synonymy: *Uloma* Casteln. = *Acthosus* Pasc.—This synonymy was suggested by Blackburn (Trans. Roy. Soc. S. Aust., 1894, p.219), and I entirely concur.

Sitophagus (Ipsaphes) nitidulus Macl. After an examination of the type in the Australian Museum (so far as is possible with a carded specimen in which the legs are scarcely visible), I have little doubt that it belongs to the Cucujidæ, probably to the genus *Platisus*. It seems to have been placed amongst the Tenebrionidæ through Olliff's note, "*Ipsaphes nitidulus* of Macleay appears to be allied to the heteromerous genus *Sitophagus*" (These Proc., Vol. x., Part 2, p.7). The genus *Sitophagus* is only represented in Australia by the ubiquitous *S. hololeptoides* Cast., of which I have specimens taken in Sydney.

Ulomoides humeralis Blackb., *Hypophlœus australis* Champ.—Of these two I possess cotypes, kindly presented by the authors.

Campanotus fimbricollis Lea.—This insect was placed with some doubt amongst the *Ulomina*; but I consider that the foliate prothorax, and *carinate prosternum, inter alia*, point rather to a position under *Cyphaleinæ*, near *Barytipha* and *Mithippia*: it has, therefore, been omitted from my Table.

Platydema spicata Olliff = *P. striata* Montr.—Amongst the many things taken by Mr. Lea at Lord Howe Island, occurs the above, which is however, identical with *P. striata* Montr. = *P. kanalense* Perroud = *P. oritica* Pasc., a much named insect, recorded also from New Caledonia.

It may be of use to note here the synonymy pointed out by Mr. K. G. Blair (Ann. and Mag. Nat. Hist., Ser. 8,, xiii., 1914).

Aethosus sanguinipes F., (Tenebrio) = *laticornis* Pasc., and must now appear as *Uloma sanguinipes* F.

Alphitobius lævigatus F., (Opatrum) = *piceus* Ol., = *Microphyes rufipes* Macl.

Uloma (*Aethosus*) *minuta* Cart.—On a re-examination of this species with a Zeiss binocular—not available when I described the species in 1906—I find characters inconsistent with its inclusion in *Uloma*; while the antennæ were incorrectly described as having the final four joints enlarged. I now propose the name *Micruloma* for the reception of this insect, a genus having the following distinctions from *Uloma*.

MICRULOMA, n.g. Ulominarum.

Antennæ with apical joint greatly enlarged and ovate; the 10th only slightly wider than preceding joints and forming a cup for the reception of the one-jointed club; other joints small and closely fitting. All coxæ widely separated: prosternum between fore-coxæ almost flat: intercoxal parts between mid- and post-coxæ without any triangular depression: femora swollen, tibiæ without external spines. Facies above very similar to *Palorus*, but slightly flatter, with the anterior angles more rounded, and widely differing in the antennæ, the position of the coxæ, and the swollen femora.

Uloma (*Acthosus*) *pygmæa* Cart.—Having recently received, through the courtesy of Mr. G. C. Champion, specimens of four species of *Palorus*, namely, *P. austrinus* Champ., *P. depressus* F., *P subdepressus* Woll., and *P. Ratzeburgi* Wissm , I find that *U. pygmæa* is congeneric with these. More robust than *P. austrinus*, its pronotal and elytral punctures are finer, with the punctures on the medial elytral interstices irregular (not seriate). The proportions of the antennal joints are very similar. The name is very unfortunate, since while being a pigmy amongst *Uloma*, it is larger than either of the four species of *Palorus* under examination. It must now stand as *Palorus pygmæus* Cart.

P. Ratzeburgi Wissm.—Three specimens in my cabinet from Sydney (Mr. DuBoulay and myself), and two from Cairns (A. M. Lea) are identical with this cosmopolitan grain pest. [The distinctions between the species of *Palorus* have been very thoroughly treated by Champion (Ent. Mo. Mag., 2nd Ser., Vol. vii., Feb. 1896)].

MICROCILIBE, n.g. Ulominarum.

Elongate-ovate, convexity as in *Palorus*, antennæ with apical three joints abruptly enlarged—9 cupuliform, 10 rhomboidal, 11 ovate and largest—tibiæ without spines on external edge; elytra seriate-punctate: rest as in *Uloma*.

MICROCILIBE CASTANEUM, n.sp.

Nitid castaneous above and below, legs pale yellow.

Head coarsely, not closely punctate, epistoma rounded in front, antennæ rather short, eyes small and round. *Prothorax* subtruncate at apex, truncate at base, the former slightly produced forward in the middle, sides subarcuately converging from base to apex (front half more strongly narrowing than basal half), anterior angles obtuse, posterior rectangular, lateral border narrowly horizontal, and separated from disc by a row of setiferous punctures, disc with fine punctures irregularly and diffusely placed. *Scutellum* arcuate-triangular, punctate. *Elytra* of same width as and closely fitting prothorax, shoulders rectangular, sides parallel to half-way, with a row of lateral setæ: rather widely rounded behind; seriate-punctate without a sign of striation, the punctures in series, rather widely distant: intervals each with a single row of even more widely placed punctures: these more distant on outside intervals. Underside with large, diffuse punctures. Tibiæ straight, slender, little widened at, and with a row of stout bristles near apex. Posterior tarsi with claw-joint approximately as long as the rest combined. *Dimensions:* 3 × 1½ mm.

Hab.—Mount Wilson (Blue Mountains, N.S.W.).

I took seven specimens in a rotten Eucalyptus log during March of the present year (1919), and cannot find an existing genus for their reception. The 3-jointed club of antennæ, slight convexity of form, non-denticulate tibiæ, and non-striate elytra form a combination requiring a new generic status.

Types in Coll. Carter.

BRACHYCILIBE TASMANICUM, n.sp.

Reddish-brown, very convex.

Head coarsely, not closely punctate; joint 1 of antennæ very stout, 2 intermediate in thickness between 1 and 3, 3-8 submoniliform and closely packed, apical three forming a club, 9 and 10 strongly transverse and cupuliform, 11 round and large. *Prothorax* bulbous, the narrow lateral border not seen from above; base and apex truncate, sides evenly and rather widely rounded, all angles very obtuse, disc coarsely and rather distantly punctate. *Scutellum* small and bead-like. *Elytra* of the same width at base and less than twice as long as the prothorax, with about eight rows of foveate punctures on each elytron, placed in sulci, the punctures almost contiguous; intervals convex; front and mid tibiæ finely spinose on the outside edge, hind tibiæ flattened and expanded at apex; underside deeply pitted with coarse, distant punctures; front coxæ very close. *Dimensions:* 3(vix) × 1(vix) mm.

Hab. - Wilmot, Tasmania (A. M. Lea and H. J. Carter).

Several specimens taken from rotten logs by Mr. Lea and myself, of which six are before me. The species is the smallest of all described Australian *Ulominæ*, and is near *Brachycilibe antennatum* mihi (from Lord Howe Island) in its convex, short form, coarse puncturation, and widely clavate antennæ, while differing in the proportions of the antennal joints. In *B. antennatum* the club is two-jointed, with the ninth somewhat enlarged. In both species the mandibles are bifid at the extremity.

Types in Coll. Carter.

PTEROHELÆUS DARLINGENSIS, n.sp.

Elongate-ovate, rather flat, moderately nitid, black above and beneath, antennæ and tarsi reddish-brown.

Head closely and finely punctate, epistoma narrowed in front, its suture indistinct, eyes remote, antennæ slender, the proportions similar to those in *P. gilesi*. *Prothorax* of same size and general outline as in *P. gilesi*, but the anterior angles obtusely blunted (not rounded), the posterior acute, not dentate, the explanate margins horizontal, extreme border not reflected, medial impression evident, but not always continuous; disc finely, distinctly punctate, the punctures smaller and less close than on head, closer and more distinct on the margins, basal foveæ deep. *Scutellum* triangular, punctate. *Elytra* of same width as prothorax at base and thrice as long, sides parallel for the greater part, explanate margins narrow (narrower than in *P. planus* Bless.), extreme border raised throughout; regularly seriate-punctate, or substriate, fine punctures being set in scarcely defined striæ (the punctures much smaller than those in *P. planus*), the intervals minutely punctate and subplanate, the 1st, 5th, 9th, and 13th very feebly raised, and the 1st and 5th wider than the rest; seriate punctures evanescent at base and on apical declivity. Prosternum and flanks of metasternum finely pustulose, metasternum clearly punctate, abdomen striolate, its apical segments finely punctate. *Dimensions:* 18-19 × 9 mm.

Hab.—Bourke, N.S.W. (R. Helms)

Three specimens given me some time ago by the late Mr. R. Helms show a species near *H. abdominalis* Lea in sculpture, near *H. memnonius* Pasc., in form. It belongs to Macleay's Sect. ii., Subsect. iii., and may be distinguished by the combination of large size, parallel form, moderately nitid surface, with unusually fine sculpture. It is quite distinct from *H. depressiusculus* Macl., which I have from the same district, and which has distinct costate intervals and larger seriate punctures. It is separated from *H. hepaticus* Pasc., by structural as well as colour differences. I can find no sexual characters.

Type in Coll Carter.

PTEROHELÆUS GILESI, n.sp.

Ovate, rather convex, opaque piceous-black above, nitid black beneath, antennæ and tarsi castaneous.

Head and pronotum apparently quite smooth, epistoma rounded in front, its suture well defined at sides only, eyes separated by a distance little more than the width of one eye, antennæ robust, joint 3 as long as 4-5 combined, 4-7 obconic, 8-10 transverse, 11 ovate. *Prothorax* 4 × 9 mm., length measured in middle, width at base, arcuate-emarginate at apex, strongly bisinuate at base, sides arcuately converging from base to apex (where it is less than half as wide as base), anterior angles well rounded but prominent, posterior acute and slightly dentate, explanate margins moderately wide, and subhorizontal, with extreme border slightly reflexed; disc rather convex, medial line clearly impressed, basal foveæ shallow. *Scutellum* smooth and rounded. *Elytra* of same width as prothorax at base and about thrice as long, ovate and rather convex, explanate margins widest at middle (here about one-fifth of width of an elytron), obsolete at apex, extreme border reflected; finely seriate-punctate, intervals quite flat and smooth, the 1st (sutural), 3rd, 5th, and 9th wider than the rest; the punctures evanescent towards apex, mere pinpricks elsewhere, except on lateral row, where some six punctures of large size are apparent. (In the ♀ specimen the two lateral rows contain larger punctures). Sternum smooth, abdomen striolate, apical segments smooth. In ♂ three basal joints of fore-tarsi much wider than 4th joint. In ♀ fore tarsi of normal size, body more convex. *Dimensions:* 19 × 9 mm.

Hab.—Broome, N.W.A. (H. Giles).

A pair, showing clear sexual characters, given me by their captor. The species is nearest *P. dispar* Macl. (in the 1st Section of that author), but differs from it in the following details:—different sexual characters, less convex and more oval form, falcate posterior angles to prothorax, and smooth undersurface. (In *P dispar*, if correctly identified by me in specimens from Kookynie and Kalgoorlie, the prosternum is transversely rugose and the metasternum finely pustulose). *P. dispar* was described as from Swan River, but it must be noted that, until recently, the whole State was so denominated. With considerable experience in collecting, and with collectors in the Perth district, I have seen nothing like *P. dispar* from this neighbourhood.

Types in Coll. Carter.

Pterohelæus reichei Brême.—In my revision of this genus, I failed to identify, though having specimens before me, the larger Tasmanian species as Dr. Brême's insect. The figure given in that author's monograph shows prominently sculptured elytral costæ, which then seemed inconsistent with the Tasmanian specimens in the collections of Mr. Lea, and the Australian and Macleay Museums. In the last two cases, they were erroneously labelled *guérini* Br. Knowing the great difficulty in illustrating this form of sculpture with accuracy, and allowing for some exaggeration in this, I now concur with Mr. Champion in his identification of this species, which appears to be common in the northern parts of Tasmania.

P. walkeri Brême (= *P. riverinæ* Macl.). Having re-examined the presumed types of *P. riverinæ* in the Macleay Museum, I am convinced that it is, at most, but a slight variety of *P. walkeri*; the differences noted being such as commonly occur in numerous and widely distributed species; the slight difference in distance between the eyes can be accounted for sexually.

P. pascoei Macl., is also under suspicion as a synonym of *P.*

piceus Kirby, one of the commonest of Australian insects; but I have undoubtedly two species, clearly separated by the size of seriate punctures of elytra, otherwise very similar. A cotype of *P. pascoei* from Gayndah was given me by the late Mr. Masters. After a close re examination of the Macleay Museum specimens, I find my cotype to be nearer the species labelled *P. piceus*, while the differences between those labelled *P. piceus* and those labelled *P pascoei* are slight. The species in my collection, showing *much finer* seriate punctures than either of these, from regions as widely separated as Wodonga (Vic.), and Endeavour River (N.Q.), is thus either a new species or the true *P. piceus* Kirby. Only an examination of the type of *P. piceus* will settle this question. I consider the specimens labelled *P. piceus* and *P. pascoei* in the Macleay Museum to be conspecific.

P. abdominalis Lea, (? *pruinosus* Pasc.) is easily distinguished from the above by (1) the more parallel form, (2) much smaller seriate punctures, with irregular punctures of the same size on the intervals of the basal half, and (3) quite obsolete costæ.

SYMPETES BROWNI, n.sp.

Widely obovate, moderately convex, dull black, antennæ and tarsi castaneous.

Head finely rugose, epistoma truncate in front, sides raised and rounded, forehead with prominent ridges in front of eyes, antennæ short, joints 8-11 enlarged, round and of nearly equal size. *Prothorax* 3 x 10 mm., length measured in the middle, width at base, apex arcuate-emarginate, base bisinuate, anterior angles widely obtuse, posterior acute and falcate-wise, overlapping elytra; explanate margins wide, at base together nearly half total width, extreme border reflected at sides, narrowed on apex; disc with a few small punctures showing through the fine silky derm, central carina lightly raised. *Scutellum* very transversely triangular. *Elytra* of same width as prothorax at base, widest behind middle, margins wide and separated from disc by a row of large punctures, disc strongly carinate at suture throughout full length, surface punctures half concealed by derm; underside opaque, metasternum punctate, abdomen with lines of red, recumbent hair at margins of segments, epipleuræ smooth. *Dimensions:* 15 × 12 mm.

Hab.—Cue, West Australia (Mr. H. Brown).

Another of Mr. Brown's discoveries, showing a species near *S. orbicularis* Brême, and *S. excisifrons* Cart., in convexity and outline, but distinguished from both as from *S. patelliformis* Pasc., by its thick clothing and opaque surface. From the last it is distinct by its greater convexity and wider form.

Type in Coll. Carter.

SYMPETES DEPRESSUS, n.sp.

Nearly round, depressed, black, glabrous, moderately nitid above, opaque beneath, antennæ and tarsi reddish.

Head minutely punctate, lightly ridged in front of eyes. *Prothorax* 3 × 10 mm., length measured in middle, width at base; anterior angles subrectangular (lightly rounded at apex), posterior acute and overlapping elytra (also a little rounded at tips), margins wide, the disc forming half total width at base, apparently smooth, not carinate at middle (obsolete carina faintly indicated by slight convexity near middle front). *Elytra* depressed, widely margined, densely and clearly punctate (somewhat as in *S. patelliformis* Pasc.), the suture not, or scarcely, carinate: underside in general smooth, epipleuræ finely punctate. *Dimensions:* 14-16 × 11½-12 mm.

Hab.—Geraldton, W.A. (H. Brown and W. DuBoulay).

Three specimens, 2 ♂ and 1 ♀, of which the female has the larger dimensions, show a species near *S. patelliformis* Pasc., in its flat form, differing from that species in (1) larger size, wider margins and still flatter form, (2) head with ante-ocular ridges, though much less raised than in *S. browni*, (3) prothoracic angles more rounded, and (4) elytral punctures larger, the suture scarcely carinate.

Types in Coll. Carter.

SARAGUS CONVEXUS, n.sp.

Lightly obovate, very convex, pale brown (head, disc of pronotum, and underside darker, where denuded of the pale, squamose clothing), elytra with short, upright, red hairs.

Head flat, punctate, epistoma truncate, labrum prominent, antennæ short, joints moniliform, the last three transverse. *Prothorax* 2 × 5 mm , length measured in middle, width at base; apex semicircular, embracing nearly half the head, all angles rounded, the posterior rather narrow ; sides converging and nearly straight, from base to apex; explanate margins wide, subhorizontal, disc convex, roughly and rather closely granulose, showing smooth spaces along middle line; base bisinuate. *Elytra* slightly wider than prothorax at base, very convex, widest a little behind middle, without explanate margins, lateral border not seen from above (through convexity), each with three fine, linear, and slightly undulate costæ and a rudimentary fourth costa on side; the first and third extending from base to apical declivity, the second continuous for about two-thirds of length, an elongate nodule forming its continuation; the fourth costiform only for a short distance, thence represented by a few small, distant nodules; a few scattered nodules on apical region; suture quite flat, the whole covered with a pale, squamose meal, with short, upright hairs; underside and legs with close, short, hairy clothing ; anterior tibiæ coarsely, intermediate finely serrated on outside. *Dimensions :* 9 × 6 mm.

Hab.—Cambo-Cambo, Northern N.S.W. (S. W. Jackson).

A single specimen, given me by the late Mr. R. Helms, is nearest *S. lævicostatus* Macl., in general facies, but the costæ are more continuous; it is without the intermediate rows of nodules, the pronotum is more roughly granulose, *inter multa alia.* (The pronotum of *S. lævicostatus* Macl., is more rugose than granulose, showing small granules only near base. The presumed types in the Macleay Museum are larger than as given in the description, and they measure 11-12 × 7-7½ mm.). The form of the elytra, without any sign of flange, and the hairy clothing, give it a likeness to *Trichosaragus pilosellus* Blackb., but the marginal prothorax and wider form proclaim it a true *Saragus.*

Type in Coll. Carter.

OSPIDUS VESTITUS, n.sp.

Widely ovate, convex, nitid brown, upper surface obscured in patches by short, squamose clothing, underside and legs opaque reddish-brown, almost smooth.

Head subquadrate, epistoma widely rounded in front, without any sign of suture, surface rather flat, antennæ at rest (from below) extending to base of prothorax, last four joints considerably enlarged. *Prothorax* $2\frac{1}{2} \times 5$ mm., semicircularly emarginate, enclosing head beyond eyes, widest at base, sides arcuately converging to apex, anterior angles obtuse, posterior acute, base sinuate and closely adjusted to elytra, surface lightly clothed with adpressed pale brown hairs. *Scutellum* triangular. *Elytra* of same width as prothorax at base, slightly widening behind this, thence roundly converging to apex, gibbous behind the scutellum; surface covered with close lines of large punctures, these lines by irregular punctures near middle; lateral depressions, basal and apical areas squamose. Legs short, femora not extending to sides of body, sternum carinate, underside finely rugose. *Dimensions*: $8\frac{1}{2} \times 6\frac{1}{2}$ mm.

Hab.—King R., N. Territory (National Museum, Melbourne).

A single specimen, sex doubtful, sent by Mr. Kershaw shows a species quite distinct from its nearest ally *O paropsoides* Cart., in its smaller size, squamose clothing, and different sculpture. The four species, so far described, of this interesting genus can be distinguished as follows:—

OSPIDUS Pasc.

1-6. Surface smooth.
2-4. Elytra irregularly punctate.
3. Colour brown-bronze, elytra finely punctate......... *chrysomeloides* Pasc.
4. Colour chestnut-red with black spots, elytra coarsely punctate........................ *gibbosus* Blackb.
5-7. Elytral punctures more or less longitudinally arranged.
6. Colour purple-bronze .... *paropsoides* Cart.
7. Surface lightly squamose .... *vestitus*, n.sp.

Note.—*Ospidus* was placed by Pascoe under *Helæinæ* as an ally of *Cilibe*. It now seems to me better placed amongst the *Cyphaleinæ*, where its carinate prosternum, metallic surface, non-striate elytra, and general facies would place it not far from *Bolbophanes*.

STYRUS PUNCTICOLLIS, n.sp. (Plate iv., fig.3).

Elongate-ovate, opaque black, apical joints of antennæ brown, tarsi clad with golden tomentum.

Head closely rugose-punctate, antennæ with joint 3 as long as 4-5 combined, gradually increasing outwards, last four joints oval. *Prothorax* widest behind middle, base wider than apex, arcuate-emarginate at apex, front angles acute and produced, base subtruncate, sides moderately rounded, with an irregular more or less undulate outline, feebly sinuate behind, posterior angles subrectangular and, in general, scarcely dentate; lateral border thick and round, somewhat recurved, concave within: disc closely but not evenly punctate, with occasional smooth spaces, without medial line. *Scutellum* widely transverse, smooth. *Elytra* wider than prothorax at base, and more than twice as long, lightly obovate; surface irregularly alutaceous, the suture raised, and three irregular, shining, crenulate costæ occasionally connected by finer transverse ridges; the interstices everywhere showing large punctures; underside similarly pitted, the punctures smaller on apical segments. Tibiæ nearly straight and unarmed. *Dimensions:* 16-20 × 6½-8 mm.

Hab.—Capertee, N.S.W. (T. G. Sloane and H. J. Carter).

Twenty-one specimens taken in Dec., 1918 (during a very dry period), under logs or dead leaves, show a species allied to *S. latior* Cart., but differing as follows: sides of prothorax less widened, not sinuate anteriorly and much less so posteriorly, elytral costæ more sharply defined—the most definite distinction being the strongly punctate pronotum (that of *S. latior* being almost impunctate). There is considerable variation in the hind angles of prothorax, which in general are scarcely dentate, but in a few cases the sinuation is more marked and subangulate, forming a distinct tooth.

Types in Coll. Carter.

BYALLIUS RETICULATUS Pasc.

The inadequate description of this species makes its identification difficult, even with the accompanying figure (Ann. and Mag. Nat. Hist., Ser. 4, Vol. 3, Pl. x.), since the six described species are rather close, though distinct. Three specimens lately sent by Mr. Kerslake, labelled "Casselis, Gippsland," belong, I consider, to the species which was wrongly identified by me when describing *B. orensensis* (These Proceedings, 1909, p.139) as an insect taken at Cunningham, Lakes Entrance, Gippsland. The Cunningham species, therefore, requires description and a name. I propose to preface this by the following description of what I consider to be *Byallius reticulatus* Pasc.:—

Black, little nitid, except legs; antennæ reddish, tarsi and apex of tibiæ clothed with golden tomentum.

Head closely, clearly punctate, labrum prominent, epistoma truncate in front, sharply angular at sides; antennæ with basal joints sublinear, apical three or four slightly enlarged, the third joint longer than fourth and fifth combined. *Prothorax* 5 × 6·5 mm., widest behind middle, anterior angles rather widely acute, and pointing forward, sides lightly rounded, *not* sinuate; posterior angles widely obtuse and depressed, base truncate, basal and apical border narrow, lateral border thick, strongly reflexed and nitid, surface clearly, rather closely, but not coarsely, punctate. *Scutellum* transverse, triangular. *Elytra* vermiculately rugose and wrinkled, each with three subobsolete costæ, evident on apical half; the whole surface also closely studded with round punctures, coarser than those on prothorax; epipleuræ finely, abdomen more coarsely punctate and longitudinally wrinkled, flanks of prosternum almost smooth, tibiæ nearly straight. *Dimensions:* 20 × 9 mm.

Hab.—Cassilis, Gippsland, Vic. (Dr. Leach).

Three examples, all, I think, female, from the National Museum. A fourth example sent by Mr. Kerslake, labelled "Buchan, Gippsland, Dr. Leach," shows a few, but strong, distinctions from the above, and must be at present considered as a variety or ♂ of *B. reticulatus*. Form narrower and more con vex, sides of prothorax sinuate in front, the acute anterior angles pointing obliquely outwards, lateral border less strongly raised, pro-tibiæ slightly, mid-tibiæ more strongly curved. *Dimensions:* 19½ × 8 mm.

Hab.—Buchan, Gippsland.

N.B.—A somewhat similar sexual difference in structure of prothorax exists in *Anausis metallescens* Westw., (*vide* These Proceedings, 1913, p.71). The identity of sculpture of the Buchan and Cassilis specimens, and the near neighbourhood of these places are reasons for considering the Buchan as the ♂ of the Cassilis specimens.

BYALLIUS PUNCTATUS, n.sp.

Elongate, obovate, subopaque black, elytra and legs more nitid, antennæ reddish; tarsi and apex of tibiæ clothed with golden tomentum.

Head as in *B. reticulatus*, but more coarsely punctate. *Prothorax* 5 × 7 mm., arcuate-emarginate at apex, anterior angles sharply acute, pointing a little outwards and upwards, sides widest behind middle, thence arcuately converging gradually forward, more abruptly behind, sinuate near front and hind angles, the latter subrectangular and emphasized by the sudden termination of the strongly reflexed and thickened lateral border, base truncate; apex and base narrowly bordered, disc strongly but unevenly punctate, with a clearly defined, smooth, medial line and some smooth spaces near centre. *Scutellum* transversely triangular and punctate. *Elytra* lightly obovate, vermiculately rugose, with three well-raised wavy costæ, the intervals showing sparse, rather large punctures. Whole underside and legs coarsely and closely punctate, the abdominal punctures becoming finer and denser towards apex, the last segment very densely pitted. *Dimensions:* 18 × 8½ mm.

Hab.—Cunningham (Lakes Entrance), Gippsland, Vic.

A single example taken by me in January, 1909, can be clearly distinguished from *B. reticulatus* by its strongly raised elytral costæ, its thinner and more vertically raised lateral border to prothorax, with its smooth medial line, sharper posterior angles, and much more coarsely punctate surface above and below. All the other species have the pronotum much more finely punctate.

Type in Coll. Carter.

The six species may be distinguished thus:—

BYALLIUS.

1(3) Anterior angles of pronotum pointing forward.
2. Medial line of pronotum obsolete .... **reticulatus* Pasc.
3. Medial line of pronotum canaliculate .... *mastersi* Cart.
4(10) Anterior angles of pronotum pointing outward.
5(7) Border of pronotum thick.
6. Hind angles of pronotum dentate..... .... *orensensis* Cart.
7. Hind angles of pronotum not dentate .... *laticollis* Cart.
8(10) Border of pronotum not strongly thickened.
9. Border lightly reflexed, disc minutely punctate...... *kosciuskoanus* Cart.
10. Border strongly reflexed, disc strongly punctate ...... *punctatus*, n.sp.

BOLBOPHANES SERICATUS, n.sp.

Shortly ovate, very convex, (longitudinally and transversely) glabrous, moderately nitid; above, rich dark purple, underside, metallic blue; elytral suture greenish, pronotum with some varicoloured reflections; legs and antennæ violet.

Head densely punctate, epistomal suture straight, eyes separated by a distance equal to the diameter of one, antennæ rather fine, scarcely reaching base of prothorax, its joints slightly enlarging outwards. *Prothorax* 2·5 × 5 mm., widest at base, apex strongly emarginate, anterior angles rounded but prominent, base strongly bisinuate, median lobe widely produced; sides rounded, posterior angles rectangular, lateral margins thick on basal two-thirds, evanescent on anterior third. A rather wide concavity within this margin; disc densely and uniformly finely punctate; without trace of medial line. *Scutellum* equilatero-triangular, finely punctate. *Elytra* of same width as prothorax at base, slightly gibbous at shoulders; the whole surface with a satiny gloss, finely wrinkled and lined; the lines in the sutural region irregular; those on the disc and lateral regions becoming wavy but longitudinal (substriate), with transverse wrinkles of a

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* The male of this appears to come under 4, but has been differentiated from the other species as described above.

sinuate, vermiculate form; breast coarsely, episterna finely punctate: epipleuræ coarsely wrinkled, abdomen thickly striolate, the apical segment finely punctate. *Dimensions:* 9·5 × 6 mm.

Hab.—Brisbane (Mr. H. Hacker).

A single specimen, sent by its captor, shows a species clearly differentiated from its allies, by its greater convexity and thick lateral margins of prothorax *inter multa alia.* The elytral sculpture is somewhat similar to that of *B. rugatus* Cart., but it is less nitid, with the transverse wrinkling more pronounced, while its pronotum is sculptured more like that of *B. varicolor* Cart. The sutural region is depressed.

Type in the Queensland Museum.

CARDIOTHORAX CONSTRICTUS, n.sp. (Pl. iv., fig.1; Pl. v., fig.10).

Head, pronotum, and underside black, elytra bronze, antennæ and tarsi reddish, the whole moderately nitid.

Head smooth, epistoma subtruncate, frontal impression square, with a few small, irregular depressions; antennæ stout. *Prothorax* 4½ × 6 mm., arcuate-emarginate at apex, anterior angles rounded, sides widely rounded with greatest width behind middle, then sinuately and strongly constricted to the widely dentate posterior angles, these directed obliquely outwards and downwards: a large basal fovea within these angles, base (between foveæ) truncate; foliate margins wide and horizontal, with distinct separating sulcus, and (in general) three setiferous punctures on each; disc smooth, with two punctures on front half, medial channel deep and clear. *Elytra* considerably wider than prothorax at base, shoulders wide, epipleural fold strongly reflexed, each elytron with eight deep sulci, intervals convex, smooth, and of equal width; underside glabrous and nitid; fore-tibiæ widened at apex and rather thickly clothed with pale red tomentum. The male having hind tibiæ greatly widened and hollowed within. *Dimensions:* 18-19 × 6-7 mm.

Hab.—Capertee and Kandos (Mudgee Line), N.S.W. (H. J. Carter and T. G. Sloane).

A great many specimens taken at Capertee in Nov., 1918, and four by Mr. Sloane at Kandos in Feb., 1918, show a robust species allied to *C. æripennis* Blackb., and *C. laticollis* Cart. In structure they are nearer the former, with the elytra the colour of the latter, and readily distinguished from both by the widely sinuate hind angles of prothorax. Compared with *C. æripennis* as follows:—Size, form, colour (except that *C. æripennis* has the elytra green-bronze), sexual differences very like *C. æripennis.* The chief differences are: (1) Prothorax generally narrower, the average of five specimens being *C. æripennis* 5 × 7 mm., *C. constrictus* 4$\frac{1}{2}$ × 6 mm., but proportionately wider in front, with anterior angles less convergent. The lateral sulcus is also much less pronounced; (2) Hind angles more widely dentate, the prominent tooth pointing outwards (*see* fig.); (3) Raised border of pronotum finer; and (4) Without special feature mentioned by Blackburn "oblique carina" (rather *sulcus*, H.J.C.) "running across the foliaceous margins . . . . . cutting off the front angles." (My specimens of *C. æripennis* were taken at Mount Wilson and identified by Mr. Blackburn himself).

Types in Coll. Carter.

CARDIOTHORAX KERSHAWI, n.sp. (Plate iv., fig.6).

Elongate-ovate, nitid black, antennæ brown (apical half opaque), tarsi reddish.

Head: epistoma rather sharply rounded in front, frontal "horse-shoe" impression well marked, having two large foveæ within; antennæ stout, its joints oval and enlarging outwards. *Prothorax* 4 × 4 mm., widest before middle, considerably wider at apex than at base, anterior angles prominent and acute, sides converging behind and sinuate before the sublobate hind angles, the latter forming a blunt tooth pointing backwards; lateral border thickened and raised, base bisinuate; foliate margins moderately wide, containing two or three setæ; disc with deep medial sulcus continuous throughout, and two irregular sulci not reaching apex, one on each side of middle line (each formed by two longitudinal foveæ connected by a sulcus). *Scutellum* small. *Elytra* considerably wider than prothorax at base, and twice as long, shoulder (formed by epipleural fold) widely obtuse; sulcate, each with nine sulci, the fifth interval rather wider and more raised—especially at base—than the others. Epipleuræ and abdomen smooth; legs thin, fore-tibiæ slightly curved. *Dimensions:* 15 × 5 mm.

Hab.—Townsville, Q. (Ejnar Fischer).

Two specimens, sent by Mr. Kershaw, after whom I name it, show no sexual distinctions and belong to a species intermediate between *C. eucephalus* Pasc., and *C. rotundicollis* Cart. It can be distinguished from both by its narrow, subcordate prothorax, with thickened lateral border and posterior tooth directed backward. In both the other species this tooth is twisted outwards. In colour, and form of prothorax, there is a likeness to *C. cordicollis* Pasc., but it is smaller and narrower than Pascoe's species, and has, moreover, acute anterior angles (rounded in *C. cordicollis*).

Type in the National Museum, Melbourne.

CARDIOTHORAX MACLEAYENSIS, n.sp. (Plate v., fig.8).

Elongate-elliptic, brilliant violet-bronze, antennæ and tarsi reddish-brown, underside and legs black.

Head with scattered punctures on frontal area. *Prothorax* subcordate, widest before middle, little convex, finely bordered at base, apical border obsolete in middle, anterior angles prominent but wide; sides widely rounded on anterior half, contracted at base; the dentate hind angles small and outwardly directed, base truncate; foliaceous margins wide and separated from disc by strong sulcus; disc smooth, medial sulcus well marked throughout, a triangular depression near hind angles, and (in general) one foveate puncture on each side of medial sulcus. *Scutellum* small, oval. *Elytra* wider than prothorax at base, elliptic, shoulders very obtusely rounded; sulcate, each with five well marked sulci and a sixth (external) faintly marked; intervals regular, convex, not connected and obsolescent at apex, sides, epipleuræ, and underside smooth; legs thin, without any sexual distinction, tibiæ not thickened at apex. *Dimensions:* 15 × 5⅓ mm.

Hab.—Macleay River, N.S.W. (S. Jackson).

Five specimens, given me some years ago by the late Mr. R.

Helms, were not previously described, as I then considered the species possibly conspecific with *C. captiosus* Bates, (from Cape York). A specimen was sent to the British Museum for comparison with this species, and Mr. Blair answered my query very definitely "No! Bates' species has the thorax much less cordiform, the elytra flatter on the disc and not so gradually rounded to the declivous sides"; also, in *C. captiosus*, "the transition" (from foliate margins to disc) "is gradual" (without separating sulcus). The hind angles of *C. macleayensis* are very much as in *C. æricollis* Pasc., to which it bears a close likeness, but may be distinguished by (1) more brilliant coppery surface, (2) more cordate form of thorax (widest at middle in *C. æricollis*), and (3) five striæ only on each elytron, distinct, these not connected behind.

Type in Coll. Carter.

CARDIOTHORAX ALTERNATUS, n.sp. (Plate v., fig.7).

Elongate-ovate, opaque brown-black; antennæ, palpi, and tarsi chocolate-brown, legs and underside nitid black.

Head: labrum advanced, epistoma evenly rounded, its suture straight, with lateral sutures running obliquely to the front of epistoma and backwards to the eye, enclosing the sharply raised canthus; antennæ stout, its joints obconic, thickening outwards, 1-5 nitid; forehead with usual depression, containing a central fovea. *Prothorax* arcuate-emarginate at apex, apex wider than base (as 7 to 5), the latter feebly arcuate; anterior angles advanced, subrectangular, the points a little blunted; sides moderately rounded to near base, then rather suddenly constricted and sinuate, forming a widely dentate hind angle, twisted downwards and outwards; foliate margins horizontal, with narrow border throughout; disc rather flat, with clear-cut medial sulcus, two foveæ on each side of this (more or less connected by impressed line) and a foveate depression towards the posterior angles. *Scutellum* oval. *Elytra* wider than prothorax at base; sulcate, with nine convex intervals, the 1st (sutural), 3rd, and 5th wider than the rest, the 7th, 8th, and 9th rather sharply carinate, an indistinct row of punctures outside the 9th interval; humeri rounded, showing carinate epipleural fold, underside smooth, tibiae near apex and tarsi with red tomentum. *Dimensions:* ♂ 15 × 5 mm., ♀ 17 × 6 mm.

Hab.—Wingham, N.S.W. (W. DuBoulay).

I am indebted to Mr. DuBoulay for specimens of this, three of which are under examination. The sexual differences are as in *C. rugosus* Cart., *i.e.*, ♂ with narrower form, humeri squarer and more prominent, hind tibiae thinner. It also resembles *C. rugosus* in the form of the prothorax, but may be easily distinguished from that species by the less widely rounded sides of prothorax, with sharper anterior and wider posterior angles, the last less outwardly directed, while the elytral intervals are not undulate, nor do the sulci contain punctures.

Types in Coll. Carter.

Note.—The six species described since the publication of my Table of *Cardiothorax* (Trans. Roy. Soc. South Aust., 1914, pp. 395-8) may be added as follows, following the numbers of that Table.

A. Posterior tibiae widened in male; foliate margins of pronotum limited by sulcus, posterior tooth prominent.
  31. Posterior tooth subrectangular .... *aripennis* Blackb
  31*a*. Posterior tooth very acute and pointing outward... *constrictus*, n.sp.
B. Tibiae without sexual characters, posterior angles dentate.
  39. Posterior tooth pointing outwards .... *encephalus* Pasc.
  39*a*. Posterior tooth pointing backwards .... *kershawi*, n.sp.
C. Posterior tooth of prothorax very small, shoulders distinct.
  57. Elytra each with six well marked sulci .... *aericollis* Pasc.
  57*a*. Elytra each with five well marked sulci .... *macleayensis*, n.sp.
D. Species subopaque, sides of prothorax entire, posterior tooth depressed and acute.
  80. Elytral intervals unequal, alternately costiform . ... . *haagi* Bates.
  80*a*. Sixth interval broken, flattened and punctate, seventh and eighth narrow.. . ... *interstitialis* Carter.
E. Species quite opaque.
  89. Elytral intervals undulate ... . *rugosus* Carter.
  90. Elytral intervals not undulate.
  91. Foliate margins wide and horizontal, elytra sulcate...*alternatus*, n.sp.
  92. Foliate margins narrow, elytra punctate-striate ... *asperatus* Carter.

ADELIUM DELICATULUM, n.sp. (Plate v., fig.21).

Dark bronze (coppery on pronotal margins), glabrous, subnitid above, very nitid beneath, antennæ and tarsi castaneous.

Head closely, evenly punctate, clypeal suture straight; antennæ extending to base of prothorax, joint 3 not as long as 4-5 combined, 6-9 subtriangular, 11 large and oval. *Prothorax*: apex arcuate, base truncate, sides widely rounded, widest behind middle, thence converging to the acute front angles, sinuately narrowed behind, posterior angles rectangular; disc closely and rather regularly punctate, with a few fine ridges, a well-defined medial furrow throughout and two defined foveæ at base, one near each angle; explanate margins not clearly differentiated from disc, but containing larger and more distant punctures. *Elytra* wider than prothorax at base, shoulders rounded, tapering rather finely at apex, each with nine interrupted striæ and the sutural stria uninterrupted; the interruptions irregular; the sixth stria more or less a series of punctures, intervals equal, flat and smooth. *Prosternum* and epipleuræ coarsely punctate, last segment of abdomen thickly punctured, other segments smooth. Male with anterior tarsi enlarged. *Dimensions*: 8½-9 × 3½-4 mm.

Hab.—Brisbane, Q. (Mr. H. W. Cox).

Mr. Cox generously gave me a pair of the above some time ago, when I erroneously diagnosed it as a var. of *A. geminatum* Pasc. A close examination shows it to be very abundantly distinct, though its general form and elytral sculpture are similar. The differences are best shown by the following comparison.

A. geminatum.	*A. delicatulum.*
Size larger; length, 10-12 mm.	smaller; length, 8½-9 mm.
Antennal joints subconic, nowhere transverse.	subtriangular, 2 penultimate joints (at least) transverse.
Pronotum coarsely rugose-punctate, with smooth spaces, posterior angles acutely pointing outwards.	closely punctate (a few fine ridges only), posterior angles rectangular.
Elytra: alternate intervals wider and convex.	intervals equal and flat.
Prosternum smooth.	coarsely punctate.

Types in Coll. Carter.

ADELIUM MCCULLOCHI, n.sp. (Plate v., fig.11).

Ovate, robust, nitid bronze, glabrous, legs greenish-black, antennæ red.

Head coarsely, not closely punctate, antennæ with joint 3 as long as 4-5 combined. *Prothorax* arcuate at apex, truncate at base, anterior angles obtuse, sides widely rounded, sinuate behind, posterior angles widely rectangular; disc with shallow and ill-defined medial channel, irregularly and rather coarsely punctate, with some scattered foveæ; foliate margins horizontal and separated from disc by short sulcate foveæ. *Elytra* striate-punctate, the seriate punctures of unequal size, intervals more or less convex, pustulose on the posterior half; underside and epipleuræ nearly smooth. *Dimensions:* 16 × 7½ mm.

Hab.—Walcha (New England District, N.S.W.; A. R. McCulloch).

Three specimens in the Australian Museum, taken by Mr. McCulloch, after whom I name the species, show an ally of *A. pustulosum* Blackb., and of *A. subdepressum* Cart. From both, it is readily distinguished by the well marked sinuation of the posterior sides of the prothorax, and the widely rectangular posterior angles.

Type in the Australian Museum, Sydney.

Adelium abbreviatum Boisd.—With a large amount of material from widely separated districts of Tasmania, I have been much exercised with the vagaries of variation in this species. Here is a fine field for the species maker. Nevertheless, though there is good evidence of species in-the-making, I am inclined rather to withdraw one of my own species, *A. foveatum*, into the ranks of a *variety* rather than add to the confusion of this difficult genus. As other students of the group may differ from this view, I propose below to name and describe certain apparently fixed varieties, first describing what I consider to be the typical form, from the Hobart district, a certain collecting ground of the Astrolabe voyagers.

A. ABBREVIATUM Boisd. (Plate v., figs. 13, 14).
A. impressum Blanch.

Wide, rather flat, moderately nitid bronze, tarsi reddish.

Head distinctly, not closely, punctate, with a transverse frontal impression: antennæ having joint 3 shorter than 4-5 combined, 4-7 ovate, 8-10 increasingly widened, 11 pear-shaped, $1\frac{1}{2}$ times longer than 10. *Prothorax* moderately convex, widest behind middle, base subtruncate, apex arcuate-emarginate, front angles rounded, sides widely and rather evenly rounded, lightly (♂) or not (♀) sinuate behind; posterior angles obtuse; disc lightly (or not) channelled in middle, with a few irregular foveæ (one more regularly placed near sides), a few large setiferous punctures (these more thickly set on explanate margins), and a fine, close system of punctures throughout. *Elytra* wider than prothorax at base, widely ovate and depressed, finely striate-punctate (striæ often more or less obliterated), intervals flat, the 2nd, 4th, 6th, and 8th (on sides) wider than the rest, and containing irregular series of shallow, foveate impressions; these sometimes single, sometimes forming or containing groups of smaller punctures, the 1st (sutural) generally smooth (sometimes with one or two small setæ), 3rd and 5th with setiferous punctures, from which spring long, upright, white hairs; epipleuræ strongly punctate, abdomen and sternal regions rather smooth, the latter with sparse setæ sending out white hairs; intercoxal process rather squarely rounded. *Dimensions:* 9-12 × $4\frac{3}{4}$-6 mm.

Hab.—Hobart, Strahan, Waratah, Great Lake District, Mole Creek, Launceston, etc.

Var. A. *dentatum*, n.var. (Plate v., fig. 15).—With sides of prothorax clearly sinuate behind, the posterior angle acutely dentate and pointing outwards, the anterior angles obtusely pointed. *Dimensions:* 12 × 5 mm. in ♂: 12 × 6 mm. in ♀.

Hab.—Tyenna (C. E. Cole).

Two specimens given me by Mr. Cole from a series of similar form taken by him.

Var. B. *lomondense*, n.var.—The pronotum with many large, setiferous punctures, and proportionately more pilose: these setæ overflowing on to the frontal area of the head; elytra with coarser sculpture than typical form, seriate punctures larger, the interstitial setæ larger and more numerous, the humeral, basal, and epipleural regions especially showing coarse, irregular punctures with long, white hairs. *Dimensions:* 11 × 5½ mm.

Hab.—Ben Lomond, 4,000 ft. alt. (A. Simson).

Var. C. *latum* Pasc. (Plate v., fig.16).—More convex and nitid than the typical species; sides of prothorax evenly rounded without sinuation, the posterior angles widely obtuse; elytra with coarser punctures and pilosity as in Var. B.

Hab.—Melbourne, Vic. (Aust. Mus.); West Tamar (A. Simson), Launceston (C. E. Cole).

Var. D. *foveatum* Carter. (Plate v., fig.17).—Form very flat, pronotum more rugose, elytral foveae larger. *Dimensions:* 10 × 4½ mm.

Hab.—Mount Horror (Scottsdale District, Tasmania).

Of the above varieties, A and C are the most distinct, but intermediate forms between each of these and the typical form occur, so that I have sometimes found it difficult to say whether a specimen is actually *abbreviatum* or *latum*, while Plate v., figs. 13 and 14, show the variations in "hind angle of thorax" in typical forms. Hence arise my reasons for considering these as variations.

SEIROTRANA SIMSONI, n.sp. (Plate v., fig.18).

Oval, black-bronze, palpi, tarsi, and coxæ yellow, antennæ (six joints only present) castaneous.

Head sparsely punctate, epistomal suture arcuate and deeply impressed, antennæ with joint 3 not as long as 4-5 combined, 4-6 subconic, rest wanting. *Prothorax* 2½ × 3½ mm., lightly emarginate at apex, subtruncate at base, anterior angles obtusely rounded, sides well rounded, widest at middle, sinuate behind, posterior angles rectangular; disc covered with close, fine, shallow punctures, with a few larger setiferous punctures near sides and apex, without medial line or distinct foliate margins, extreme border fine and scarcely raised throughout. *Scutellum* triangular and apparently smooth. *Elytra* slightly wider than prothorax at base and less than thrice as long: seriate-punctate, each with nine rows of close, round, deep punctures (slightly larger than those in *Licinoma* (*Adelium*) *nodulosa* Champ.), intervals flat, the 1st, 3rd, 5th, and 7th with larger setiferous punctures; on the intervals also a row of small nodules perceptible, besides some almost microscopic punctures; epipleuræ punctate, prosternum and abdomen nearly smooth; intercoxal process arched. *Dimensions:* 12×4½ mm.

Hab.—Ben Lomond, Tasmania (at 4,000 ft. altitude).

A single specimen in the Simson Coll. should be placed in Group ii. of my Table (These Proceedings, 1908, p.398) under *S. punctifera* Macl., from which it is easily distinguished by smaller size, darker colour, *et multa alia.* The interstitial setæ are large and distinct, while the nodules are only to be seen by close scrutiny.

Type in the South Australian Museum.

Note.—In my Table of *Seirotrana* (These Proceedings, 1908, p.397), I distinguished *S. vicina* from *S. proxima* Pasc., by its depressed form. With more material of both species, I find this distinction of doubtful value. Their sculpture is, however, widely different, and they should be thus separated.

Elytral intervals smooth, alternately bearing rows of elongate or small shining nodules .... *proxima* Pasc.
Elytral intervals densely punctate, alternate rows of small nodules absent. .... *vicina* Cart.

LICINOMA PUNCTA-LATERA, n.sp.

Elongate-convex, nitid black, antennæ piceous, tarsi red.

Head with convex epistoma, limited behind by a straight suture with branches at each side, at right angles, extending to the eyes; coarsely punctate; antennæ moniliform, 3rd joint slightly longer than the 4th, apical four considerably and successively enlarged, 11th twice as long and wider than 10th; eyes small. *Prothorax* subrhomboidal, length equal to breadth, apex lightly arcuate, front angles rounded and feebly advanced, apex wider than base, the latter truncate, sides arcuately converging to base, posterior angles obtuse; disc closely, finely, but clearly punctate, with feeble indications of a medial line in some examples, one or two setiferous punctures near sides, and *a regular row of closely set punctures immediately within the narrow border.* *Scutellum* nitid and bead-like. *Elytra* wider than prothorax at base and more than twice as long, punctate-sulcate, the intervals clearly convex, of even width, the 3rd with a seta slightly behind the middle; the flanks of sternum with deep, round, scattered punctures, the narrow epipleuræ also punctate, abdomen smooth and nitid. *Dimensions:* 9-11 × $2\frac{3}{4}$-$3\frac{1}{2}$ mm.

Hab.—Capertee, N.S.W. (T. G. Sloane and H. J. Carter).

Eleven specimens taken show a species clearly distinct from *L. sylvicola* Blackb.,—which was also common in this region—by the following comparison.

L. sylvicola.	*L. puncta-latera.*
Size: larger and wider.	narrower and more convex.
Pronotum: sides more rounded, disc nearly smooth (in general with two large foveæ).	sides less rounded, disc clearly punctate, with lateral row of larger punctures.
Elytra punctate-sulcate, intervals flat.	punctate-striate, intervals convex.

S. nitidissima Lea, is a much shorter insect, with very transverse thorax. The lateral row of punctures on prothorax is a rare character in this and allied genera.

L. puncta-latera, var.—Three examples taken by myself near Orange have dark castaneous legs, but are, I consider, conspecific with the above.

BRYCOPIA DIEMENENSIS, n.sp. (Plate v., fig.19).

Oblong-ovate, robust, dark bronze; legs, antennæ, and palpi pale red.

Head with sparse, coarse punctures, epistomal furrow deep and straight, forehead convex, eyes small but prominent, antennæ short (not extending to base of prothorax), moniliform, and rather slender, 3rd joint little longer than 4th, apical joints slightly enlarged. *Prothorax* $2 \times 3\frac{1}{2}$ mm., convex, subparallel, apex and base truncate (or nearly so) and almost equally wide, sides scarcely (or very feebly) rounded, anterior angles widely rounded, the posterior subrectangular; margins not explanate, the narrow lateral border not evident from above, disc rather coarsely and not very closely punctate, with some larger setiferous punctures irregularly scattered, and without any vestige of medial line. *Elytra* wider than prothorax at base and twice as long, shoulders rather squarely rounded, showing the reflected epipleural fold, sides scarcely widened behind middle: apical declivity steep; striate-punctate, each with about nine striæ containing round punctures of uniform size, distant from each other about the diameter of one; intervals of even width, clearly punctate, the 3rd, 5th, and 7th containing some larger setiferous impressions. In the male, the basal joints of front tarsi enlarged. *Dimensions:* ♂, 7 × 3 (vix) mm.; ♀, slightly smaller.

Hab.—Tasmania (Hobart and Waratah).

Three specimens examined, one ♂ (slightly immature) taken at Hobart by the late Dr. C. D. Clark, one (♂) given me by Mr. Lea some time ago; the third specimen (♀) was taken by Mr. Lea or myself, at Waratah. The species would come in my Table (These Proceedings, 1909, p.156) nearest *B. femoratus*, than which it is a shorter, more convex insect, with larger seriate and smaller interstitial punctures on the elytra, and of darker colour *inter multa alia*.

Types in Coll. Carter.

[Since writing the above, I find two specimens in Mr. Simson's Collection, one labelled Mt. Wellington; the other, from Launceston, varies from the type in having darker legs.]

BRYCOPIA PUNCTATISSIMA, n.sp. (Plate v., fig.20).

Oblong-oval, brilliant golden-bronze, antennæ and legs dark, tarsi reddish.

Head coarsely and sparsely punctate, forehead flat, epistomal furrow arcuate, with lateral branches extending at right angles before the eyes, antennal orbits prominently raised, eyes prominent, antennæ long (extending slightly beyond the base of prothorax), its joints unusually stout, moniliform, 3rd slightly longer than 4th, the apical four considerably and successively widened, the last oval and large. *Prothorax* 2 × 2½ mm., apex arcuate, base subtruncate, widest at middle, sides well rounded and sinuate behind; anterior angles obtuse, posterior acute; disc very coarsely punctate, the punctures close on the subexplanate margins, more distant on central part; with two discal foveæ and other smaller depressions, and with a slight rugosity near posterior angles. *Elytra* wider than prothorax at base, and twice as long, shoulders rounded, sides subparallel to beyond the middle: striate-punctate, with nine deeply impressed striæ, containing round, moderately large, closely-placed punctures; intervals subconvex and distinctly punctate, the 3rd and 5th much wider than the rest and bearing setiferous impressions. Whole underside punctate, the flanks of prosternum and epipleuræ coarsely so. *Dimensions:* 6½-7 × 2½ mm.

Hab.—Exeter, N.S.W. (H. J. Carter).

Two examples, I think the sexes, taken by me in November, 1911. The species comes nearest *B. cheesmani* mihi, in its wide and depressed form, but is easily distinguished by the following combinations: coarsely punctate surface, brilliant colour, wide 3rd and 5th elytral intervals, and robust antennæ. In *B. cheesmani* the elytral intervals are quite flat, the striæ very fine, and seriate punctures small.

Types in Coll. Carter.

AMARYGMUS INCULTUS, n.sp.

Ovate, moderately convex, black, nitid.

Head minutely punctate; eyes rather widely separated (at least full width of one eye); antennæ with last five joints considerably enlarged, 7-10 rhomboidal. *Prothorax* with sides arcuately converging from base to apex, anterior angles slightly advanced and (seen from above) acute, posterior widely obtuse; disc lævigate, or only microscopically punctate, with the faintest suggestion of a median line. *Scutellum* triangular, finely punctate. *Elytra* convex, finely striate-punctate, intervals quite flat and impunctate, the punctures in striæ small, uniform, and close: underside nearly smooth, the abdomen finely striolate: tarsal clothing black. *Dimensions:* 9 × 5 mm.

Hab.—Oempili, N. Territory (Mr. Cahill).

Two specimens, sent by Mr. Kershaw, show a species near *A. perplexus* Blackb., in general facies, but differing as follows: slightly larger—especially wider; eyes more distant, apical joints of antennæ much wider: sides of prothorax more arched, anterior angles more advanced: *elytral intervals quite flat*; tarsal clothing black (red in *A. perplexus*).

Type in National Museum, Melbourne.

EXPLANATION OF PLATES IV.-V.

Plate iv.

Fig. 1.—*Stigmodera octosignata*, n.sp.
Fig. 2.—*Exangeltus rufipennis*, n.sp.
Fig. 3.—*Styrus puncticollis*, n.sp.
Fig. 4.—*Cardiothorax constrictus*, n.sp.
Fig. 5.—*C. rugosus* Cart.
Fig. 6.—*C. kershawi*, n.sp.

Plate v.

Fig. 7.—*Cardiothorax alternatus*, n.sp.
Fig. 8.—*C. macleayensis*, n.sp.
Fig. 9.—Prothorax of *C. æripennis* Blackb.
Fig. 10.—Prothorax of *C. constrictus*, n.sp.
Fig. 11.—Prothorax of *Adelium McCullochi*, n.sp.
Fig. 12.—Prothorax of *A. pustulosum* Blackb.
Figs. 13, 14.—*Adelium abbreviatum* Boisd.
Fig. 15.—*A. abbreviatum* Boisd., var. *dentatum*, n.var.
Fig. 16.—*A. abbreviatum* Boisd., var. *latum* Pasc.
Fig. 17.—*A. abbreviatum* Boisd., var. *foveatum* Cart.
Fig. 18.—*Seirotrana simsoni*, n.sp.
Fig. 19.—*Brycopia diemenensis*, n.sp.
Fig. 20.—*B. punctatissima*, n.sp.
Fig. 21.—*Adelium delicatulum*, n.sp.

NOTES ON AUSTRALIAN MARINE ALGÆ, ii.*

Descriptions of Four New Species.

By A. H. S. Lucas, M.A., B.Sc.

(Plate vi.)

Laurencia Lamour.

Laurencia infestans, sp.nov.

Habitat.—Covering large areas of the surface of the fronds of *Ecklonia radiata* var. *exasperata*, and extending around the coarse spinules of the frond. Manly, N. S. Wales.

Attachment simple at the base of the frond, aided by nearly sessile discs growing from the under surface of the creeping branches and branchlets. Discs circular, of diameter greater than that of the branch, formed of very narrow, colourless, radiating cells. *Habit* simple (young) or with few main branches diverging from the attachment, some erect, others horizontally creeping. Extent of the frond, about 1 cm. Branches pinnate, bearing alternate patent ramuli, proceeding nearly at right angles to the ramus. The ramuli for the most part constricted a little above the base, linear, obtuse, the apices almost truncate, with shallow, median foveola. Erect branches rounded, creeping, compressed. *Structure:* in cross-section two strata of cells, cortical of smaller, densely coloured, rounded cells, interior of larger, oblong-angular, less deeply coloured cells: all the cells set in gelatine. All the cells are elongated in axial direction. *Colour* dull red, becoming darker on drying. *Tetrasporangia* immersed in the apical region of the ramuli, rarely extending

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* Continued from Vol. xxxviii., 1913, p.60.

beyond the apical half of the ramulus, triangularly divided, rounded, large when mature, maturing in acropetal succession. *Cystocarps* ovate-spherical, arising as modification of apex of ramulus, which may be terminal or lateral; producing large, pear-shaped, deeply coloured spores at the extremities of the colourless filaments, which radiate from a basal placenta; surrounded by a cellular pericarp, with apical opening.

Frons nana ad 1·5 cm. diam., ramis a disco basali divergentibus primo erectis, mox horizontaliter repentibus, compressis, huc et illuc disco ad frondem hospitis affinis. Ramuli valde patentes pinnati obtusi. Tetrasporangia in superiore regione ramuli immersa, triang. divisa, ampla. Cystocarpia ovato-spherica transformatione ramuli. Color fusco-ruber, obscurior exsiccatione. Substantia cartilaginea, frons chartæ vix adheret. Frondes gregariæ tegentes frondem hospitis. Rami primarii et ramuli tetrasporangiferi usque ad 430μ, ramuli steriles angustiores.

This is a dwarf but typical *Laurencia*. In size it appears to equal *L. pygmæa* Weber de Bosse, from Diego Garcia (Percy Sladen Expedition, 1905), described in Trans. Linn. Soc. London, Vol. xvi., Part 3, p.286, 1914. Our plant differs from *L. pygmæa* in being strongly compressed, the branches spreading over the *Ecklonia* frond almost like hoar-frost crystals on a window-pane, attached by circular discs at frequent intervals. The compressed branches are considerably wider than those of *L. pygmæa* (250μ), and the tetrasporangiferous ramuli are about as wide as the primary branches. *L. infestans* clearly belongs to the Section *Obtusæ* of the genus.

FALKENBERGIA Schmitz.

FALKENBERGIA OLENS, sp.nov.

Structure of the genus. No cystocarps or tetrasporangia observed. Free-floating in loose, intricate masses, more or less globular, but of irregular boundary, up to 2 cm. at most in diameter. Doubtful if the tangle of branches of each mass belonged to one plant, or had been brought together by the motion of the water. Examples of complete plants received later showed that the plant has the habit of the smaller species of *Sphacelaria*.

Diameter of rami to 40μ. On examining specimens of *F. vagabunda* and *F. rufolanosa* in Harvey's Alg. Austr. Exsicc., the diameter of the rami of the former reached 36μ at most, that of the latter 27μ.

Our form seems to be much stouter than *F. rufolanosa*, which it closely resembles in habit, and to be rather stouter than *F. vagabunda*, which has a much denser habit and occurs in smaller, non-distinct globes. The true Australian forms are all much slenderer than *F. Hillebrandii* of the Atlantic and Mediterranean (60-70μ).

F. olens is of a dull red colour when living, and gives a beautiful rose-colour to the superincumbent water in which it is kept. On drying from formalin, it becomes a brownish-purple, by no means so brown as the mounted specimens of *F. vagabunda*. Drying naturally it is quite red. *F. rufolanosa* dries a rosy red.

Great quantities of this weed, called locally the Red Weed, were brought in by the sea at Port Macquarie, and collected disastrously in heaps on the oyster beds. It seemed to decompose rapidly, evolving much gas and giving out a vile stench. In consequence, the oysters were killed and great damage was done to the local industry. Nothing is known of the habitat in which the plant grows, but it seems to be certain that it must grow on water plants in fairly deep water. The plague occurs at irregular intervals, not appearing every year. Since the Red Weed obtrudes itself so forcefully on the public notice, it seems useful to give it a scientific name.

Falkenbergia vagabunda (Harv.) Falk., was collected by Harvey at Eaglehawk Neck, Tasmania, free floating in the waves, and by J. Bracebridge Wilson off the Victorian Coast adhering to other algæ. *F. rufolanosa* (Harv.) Falk., was found growing on other plants in King George's Sound, W.A. It is interesting to meet with an Eastern Coast representative of this singular genus.

POLYSIPHONIA Greville.

POLYSIPHONIA ZOSTERICOLA, sp.nov.

Fronds gregarious, forming a thick fringe to the leaves of *Zostera*, not intricate, slender, to 2·5 cm. long. Attached by small basal disc, branching below dichotomous, above more pinnate. The branches come off at an angle of 45°, giving off, at rather long intervals, other like but gradually slenderer branchlets, the last very slender and sometimes secund. Diameter of main axis, 180μ. Basal articuli 1 × 1, of rami 2 × 1, of tetrasporangiferous ramelli 1 × 1. Four pericentral siphons. Substance rather firm, the plants suffering prolonged immersion in water. The frond adheres closely to paper when dry. Colour brownish-purple, darker on drying. Tetrasporangia small, on but little distorted ramelli. Cystocarps nearly sessile, ovate (326 × 258μ), contracted at base.

Frondes gregariæ secundum margines foliorum zosteræ dense crescentes. Axis disco basali affixus, deorsum dichotomus, sursum magis pinnatus, ramis ad angulum 45° emergentibus. Ramuli distantiis longioribus similiter emergentes, ultimi nonnunquam secundi. Axis primarius 180μ diam. Articuli inferiores 1 × 1, ramorum 2 × 1, ramellorum tetrasporangiferorum 1 × 1. Siphones pericentrales 4. Substantia firma, haud celeriter soluta: frons exsiccata arcte adheret. Tetrasporangia parva in ramulis parum distortis. Cystocarpia fere sessilia, ovata (326-258μ) basi contracta.

Growing abundantly on *Zostera* leaves in salt and in brackish water, Botany and Middle Harbour, N. S. Wales.

This species seems to be near to *P. amphibia* Harv., from New Zealand, which, however, I have not seen, and in which the median articuli are described as nodose, and the axils as patent.

TRICHODESMIUM Ehr.

TRICHODESMIUM SCOBOIDEUM, sp.nov.

Fasciculis brevissimis ad ·5 mm. longis, siccitate fuscis; trichomatibus rectis ad genicula haud constrictis, apice rotundatis haud attenuatis, 9, 10μ crassis; articulis diametro trichomatis 3 plobrevioribus, contentu tenuigranuloso farctis, dissepimentis non aut vix granulatis.

An Oscillatorian consisting of bundles of trichomes, apparently the shortest in the genus, not more than 0·5 mm. long. Colour when preserved in formalin dusky brown. Trichomes straight, not constricted at the genicula, nor attenuated toward the apex, 9 or 10μ thick, the articuli one-third the width of the trichome, with a finely granular content. Apices rounded, hemispherical, without calyptra. Dissepiments nearly or quite clear.

Samples of this alga were forwarded to me by Mr. A. R. McCulloch, of the Australian Museum. I append his notes:—"An alga which I collected at Hope Islands, near Cooktown, in June, 1918. It covered the sea like sawdust everywhere, and formed long streaks or waves across the wind. It was so abundant as to cause smooth patches unbroken by wavelets where it occurred, and was of a light brown colour, the tint apparently varying according to its stage of development. On the Hope Islands it had blown up on the wave-line, and formed felt-like flakes which could be picked up in pieces a foot square and 3-5 mm. thick; the flakes were very dark in colour, and stained the sand-grains settling on them a rich violet. The alga is very buoyant, and causes a muddy appearance in the water as the boat disturbs it. An old hand up that way assured me that its presence was a sign of good weather, and it certainly seems to disappear at the approach of wind and clouds.

I believe this alga was seen by Cook, whose sailors named the region the Sea of Saw-dust on account of its presence. It is of very great importance as a food item to a large number of the reef animals."

The genus *Trichodesmium*, as De Toni writes "A gen. *Oscillatoria* vix distinguendum," is a convenient subgenus at all events, for the inclusion of those Oscillatoriæ which are met with in immense societies floating on the surface of chiefly the equatorial seas They include the species *T. erythræum* Ehr., which gives the red colour, and hence the name, to the Red Sea. In the generic characters a calyptra is included. There is no calyptra in our species, but, as in *Oscillatoria* proper, forms occur both with and without calyptræ, it seems better to include it with its allies of similar habitat and habit.

The specific name is derived from the Latin *Scobs*, saw-dust.

EXPLANATION OF PLATE VI.

Laurencia infestans, sp.nov.

Fig.1.—The plant.
Fig.2.—A rhizoid expanding into an adhesive disc.
Fig.3.—Cross-section of ramus.
Fig.4.—Ramulus with tetrasporangia.
Fig.5. Cystocarps.

ON A COLLECTION OF JURASSIC PLANTS FROM BEXHILL, NEAR LISMORE, N.S.W.

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

(Plates vii.-viii.)

Introduction.

Mr. John Mitchell, of Waratah, recently forwarded me a large number of fossil plants from New South Wales for determination and description. Amongst them is a small collection of some thirty-five specimens from Bexhill, 6 miles from Lismore along the Lismore-Murwillumbah railway line, and these are described in the present paper. I have to express my indebtedness to Mr. Mitchell for his kindness in giving me the opportunity of examining his collections.

The specimens undoubtedly come from portion of the Clarence Series, and as the number of plant species recorded from this Series is very small, and also as there is not yet complete agreement as to the subdivision and exact correlation of the Series, the present collection is of more than passing interest.

There is no need to go into the history of the classification of the Clarence Series here; Carne has already discussed it at some length.* Suffice it to say that previous to Mr. Carne's examination, it was divided into Lower, Middle, and Upper Clarence Series, the Middle Series being of rather solid, massive sandstones. Mr. Carne, however, reported that he could see no reason for retaining this subdivision, and in the latest geological map of New South Wales the Series is not subdivided, and it is at present regarded as equivalent to the Artesian Series in New South Wales, and the Walloon Series in Queensland. There is certainly a massive, barren sandstone of considerable thickness

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* Mem. Geol. Survey N. S. Wales, Geol. No.6. p.26.

in the Clarence Series, as the writer had an opportunity of observing on a recent, very short visit to the Clarence River district. The sandstones, which form very bold outcrops in the Glenreagh district, certainly represent a very marked horizon in the Series, reminding one of the sandstones of the Hawkesbury Series physiographically as well as lithologically, and, having seen them, it is easy to understand the former tendency to correlate them with the Hawkesbury sandstones: there is, however, no sound evidence for such correlation, and it is practically certain that they represent a much higher horizon than the Hawkesbury sandstones. The massive sandstones at Maclean also form a noticeable feature, and may represent the same horizon as those at Glenreagh. My visit was too short to do any field work, but I was particularly struck by these two coarse, massive sandstones.

There is not much doubt that the Clarence Series is of Jurassic age; the upper part certainly is, but some doubt has been expressed regarding the lower portion. Mr. B. Dunstan, Chief Government Geologist of Queensland, in discussing this point with me, has suggested the possibility of the lower portion of the Clarence Series being the equivalent of the Ipswich Series in Queensland, and therefore of Upper Triassic Age. So far, our knowledge of the palaeontology does not confirm this suggestion. Carne has stated very definitely that *Tæniopteris Daintreei* (= *T. spatulata*) occurs in the basal part of the Series.* This species has not yet been found in rocks older than Jurassic in Australia, and so, if Carne's observation be correct, little hesitation is felt in placing the whole of the Clarence Series in the Jurassic.

In discussing the correlation of the Lower Mesozoic rocks in Australia,† I could only find record of four species of fossil plants from the Clarence Series, viz.:—*Cladophlebis australis*, *Thinnfeldia odontopteroides*, *Sphenopteris* sp., and *Tæniopteris spatulata* (= *T. Daintreei*). In addition, *Tæniopteris Tenison-Woodsi* had been seen among specimens collected by Mr. B. Dunstan. Mr.

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* Carne, *op. cit.*, p.34.

† Proc. Linn. Soc. N. S. Wales, 1918, Vol. xliii., pp.82-86.

Mitchell's collection contains the following eight species which are described below:—

Cladophlebis australis (Morris).
Coniopteris hymenophylloides, var. *australica* Seward.
Microphyllopteris pectinata (Hector).
Cycadites sp.
Tæniopteris spatulata McClelland.
Araucarites cutchensis Feistmantel.
Araucarites (*Podozamites*) *gracilis* Arber sp.
Araucarites (*Podozamites*) sp.

Although none of these species is new, some are new records for Australia, and they afford further evidence of a Jurassic age for the rocks in which they occur. *Coniopteris hymenophylloides* is a very widespread species in Jurassic strata; *Microphyllopteris pectinata* occurs in Jurassic and Cretaceous strata in New Zealand; species of *Cycadites* range from Rhætic to Cretaceous; *Tæniopteris spatulata* has not yet been found in rocks older than Jurassic in Australia, but has been recorded in rocks classed as Rhætic in New Zealand; *Araucarites cutchensis* occurs in (?)Rhætic and Lower Jurassic rocks in New Zealand and Jurassic rocks in India; *Araucarites* (*Podozamites*) *gracilis* occurs in the Jurassic in New Zealand. Thus it will be seen that there is abundant indication that the present collection as a whole represents a flora of Jurassic age.

The complete list of species known from the Clarence Series is now—

FILICALES.
    (?)OSMUNDACEÆ.
        Cladophlebis australis (Morris).
    CYATHEACEÆ.
        Coniopteris hymenophylloides, var. *australica* Seward.
    THINNFELDIEÆ.
        Thinnfeldia odontopteroides (Morris).
GENERA INCERTÆ SEDIS.
        Sphenopteris sp.
        Microphyllopteris pectinata (Hector).

CYCADOPHYTA.

Cycadites sp.

(?)CYCADOPHYTA.

Tæniopteris spatulata McClelland.

Tæniopteris Tenison-Woodsi Etheridge Junr.

CONIFERALES.

Araucarites cutchensis Feistmantel.

Araucarites (Podozamites) gracilis Arber.

Araucarites (Podozamites) sp.

Description of Specimens.

CONIOPTERIS HYMENOPHYLLOIDES var. AUSTRALICA Seward.

(Plate vii., figs. 2, 3, 4.)

1904. *Coniopteris hymenophylloides* var. *australica* Seward, Rec. Geol. Survey Victoria, Vol. 1, Pt. 3, p.163, figs. 6-9.

It is not necessary to repeat the full synonymy of the species here, as it has already been given in considerable detail by Seward* and Arber.†

Coniopteris hymenophylloides is a well-known species with a very wide geographical distribution in rocks of Jurassic age, and its description by Seward, based largely on material from Jurassic plant-beds of the Yorkshire Coast, is as follows: "Frond tripinnate; pinnæ linear acuminate, attached to the rachis at a wide angle; the pinnules vary considerably in size and shape, in some forms they have a few broad and rounded lobes, and in others the lamina is deeply dissected into narrow, linear segments. The fertile pinnules bear the sori at the ends of the veins; the lamina is usually much reduced, and in extreme cases the fertile segments agree closely with those of *Thyrsopteris elegans* Kze., or *Dicksonia Berteroana* Hook. The sori are partly enclosed in a cup-shaped indusium; the sporangia appear to have an oblique annulus of the cyatheaceous type. The two lowest pinnules of the pinna are often characterised by their unusual shape, the lower half of each pinnule consisting of long, spreading, and *aphlebia*-like lobes."‡

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* Rec. Geol. Survey Victoria, i., p.163.

† N. Zeal. Geol. Survey, Pal. Bull. 6, p.32.

‡ Seward, *op. cit.*, p.164.

In *Coniopteris hymenophylloides* there is considerable variation in the fertile pinnules, and the variety *australica* has been instituted for the Victorian examples in which the fertile pinnules are practically of the same form as the sterile. Comparing this variety with the European examples, Seward says: "The fertile pinnæ of the European fern are often characterised by a considerable reduction in the lamina, but in this respect there is not a little variation; in the Victorian specimens the fertile pinnæ are practically identical with the sterile, except in the occurrence of the sori at the tips of the lobes."*

In describing the species from Jurassic rocks in New Zealand, Arber has made an error in comparing the reduced type of fertile pinnule instead of the normal type with the Victorian form. He says: "The more reduced type of fertile pinnule recalls the specimens from the Jurassic of Victoria (Australia) described by Seward as *Coniopteris hymenophylloides* var. *australica*,"† and then quotes Seward's remarks that the fertile and sterile pinnules in the Victorian form are practically identical.

The specimens described here include both sterile and fertile examples, and appear identical with specimens from the Jurassic rocks in Victoria described by Seward. In the fertile specimens, the preservation is not sufficiently good to show details in the sori.

This is, as far as I know, the first record of this species in the Jurassic rocks of New South Wales. It has not yet been found in Queensland, but is of fairly frequent occurrence in the Jurassic of Victoria. In New Zealand it occurs in Lower and Middle Jurassic rocks. The species appears to be confined to Jurassic strata, but there are very similar forms in the Cretaceous.

The only other species of *Coniopteris* so far recorded from the Australian Mesozoic is *C. delicatula* from the Ipswich Series (Triassic) in Queensland, but this is quite distinct from *C. hymenophylloides.* In the Lower Cretaceous of Queensland (Burrum Series) there are numerous sterile examples referred to

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* *Loc. cit.*

† N. Z. Geol. Survey, Pal. Bull. 6, p.33.

Sphenopteris erecta which resemble the sterile pinnae of *Coniopteris hymenophylloides*: it is possible that the two may be identical, but no fertile examples have yet been found in the Burrum form.

Pittman* has recorded the occurrence of a *Sphenopteris* in the Clarence Series, and it may possibly be portion of a *Coniopteris*.

The specimens figured are Nos. L.10, L.26, and L.33 in Mr. Mitchell's collection.

CLADOPHLEBIS AUSTRALIS (Morris).

(Plate vii., fig.1).

For full synonymy, *see* Rec. Geol. Survey Victoria, Vol. i., p.171.

"Frond bipinnate, pinnae oblique. The pinnules are slightly falcate or straight, attached by the whole base and decurrent: apex generally rather acute. Well-defined midrib, usually persisting to apex: secondary veins make an acute angle with the midrib and bifurcate once or twice before reaching the margin; the margin is entire or slightly serrate. Fertile fronds have the pinnules somewhat narrower and inclined to be straighter than the sterile. Sori in two rows parallel to the midrib; the sori are close together and occupy nearly the whole of the under surface; each one is composed of four (rarely five) sporangia."†

This description is based on material from the Ipswich and Walloon Series of Queensland, the latter being, I believe, identical with the Clarence Series of north-eastern New South Wales. This species is of such common occurrence in the Australian Mesozoic strata, and has been frequently discussed at length, so it is not necessary to go into further detail here.

The specimens from Bexhill consist of impressions which show the general outlines clearly, and, in some cases, the venation; none of them represent fertile fronds. They are identical with Queensland and Victorian examples of the species, though perhaps somewhat closer to the former, and not quite so large as the Victorian specimens.

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* Ann. Rept. Dept. Mines, N. S. Wales, for 1880, p.244.

† Queensland Geol. Survey, Pub. 257, 1917, p.3.

Evidence which is gradually accumulating tends to confirm the reference of the Australian *Cladophlebis australis* to the family Osmundaceae. At some localities in the Jurassic (Walloon Series) of south-eastern Queensland, *Cladophlebis australis* is found very closely associated with stems of *Osmundites*, but the two have not yet been found actually connected. In some of the ferruginous sandstones of this Series, plant-remains are very abundant, but there is little variety as regards species, the material being made up almost wholly of *Cladophlebis australis*, *Taeniopteris spatulata*, *Otozamites* spp., and occasional *Osmundites* stems.

The specimen figured is No. L.24 in Mr. Mitchell's collection.

MICROPHYLLOPTERIS PECTINATA (Hector).

(Plate viii., figs.1, 4).

1886. *Lomarites pectenata*, Hector, Det. Cat. and Guide, N. Zeal. Court, Ind. and Col. Exhibn., p.66, fig.30A (5).

1917. *Microphyllopteris pectinata*, Arber, N. Zeal. Geol. Survey, Pal. Bull. 6, p.40, Pl. 7, figs.3-6, 8 11.

"Frond bipinnate ?; pinnae 8 cm. or more in length: rachis fairly stout, sometimes grooved, bearing subopposite or alternate small rounded pinnules, about 6 mm. long and up to 5 mm. across. Pinnules somewhat thick. Lateral nerves forking once or twice." (Arber).

Two specimens are referred to this species, representing pinnae 7 cm. and 9 cm. long respectively. The rachis is stout and the pinnules short, rounded, attached by the whole base, opposite or alternate and apparently thick: they are up to about 7 mm. long and 5 mm. across. No detail of the venation is preserved.

At first sight, these specimens suggest *Thinnfeldia*, but they are unlike any of the hundreds of specimens of that genus which have come under my notice. The pinnules gradually become smaller both towards the base and apex, giving the pinna(?) a somewhat lanceolate outline. In this respect they are unlike the pinnae of a *Thinnfeldia* such as *T. Feistmanteli*. It might also be suggested that they represent one branch of the dichotomous frond of *Thinnfeldia odontopteroides*, but the fact that the pinnules are not modified on the inner side towards the base, and also the general appearance of the basal portion do not support such a suggestion.

Little hesitation is felt in referring these specimens to *Microphyllopteris pectinata*, Arber having instituted the genus for fern fronds with small leaflets, his diagnosis of the genus being: "Fronds pinnate, bipinnate, or dichotomously branched: pinnules small or very small, subcircular or ovate, closely set, broadest at the base, and attached by their whole base. Median nerve feeble, breaking up into simple or forked branches not far from the base of the pinnule."*

Microphyllopteris pectinata occurs in the Lower Jurassic and Lower Cretaceous in New Zealand.

The specimens figured are Nos. L.3 and L.1 in Mr. Mitchell's collection.

(?)CYCADITES sp.

(Plate vii., fig.5).

A few specimens may be tentatively referred to this genus. They represent portions of fronds up to 5 cm. in width. The rachis has a breadth of about 2 mm.; the pinnæ are elongate, acute, with the lower edge slightly decurrent at the base; they are about 3 cm. long and 1·5 mm. wide, set close together (about 1 mm. apart) and almost at right angles to the rachis. There is a somewhat indistinct midrib which is, in some cases, broad, and its appearance then suggests the double vein of *Cycadites*.† There is no possibility of obtaining details of the epidermis in these specimens.

The general form in these examples as seen in Plate vii., fig.5, is similar to that of *Cycadites* and *Pseudocycas* (e.g., *Pseudocycas insignis*‡ from the Lias of Hör, Sweden, and *Cycadites* sp.,§ from the Middle Jurassic of Waikawa, New Zealand). There is also some resemblance to specimens from Queensland referred to

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* N.Z. Geol. Survey, Pal. Bull. 6, p.40.

† *See* Seward, Fossil Plants, Vol. iii., 1917, pp.558-562.

‡ Seward, *op. cit.*, fig.617.

§ N. Z. Geol. Survey, Pal. Bull. 6, fig.10, facing p.32

Elatocladus (*Taxites*), but in the present examples there is more regularity in the arrangement of the pinnae, which suggests that they were not spirally arranged as in *Elatocladus*.

The specimen figured is No. L.27 in Mr. Mitchell's collection.

TÆNIOPTERIS SPATULATA McClelland (= *T. Daintreei* McCoy).

(Plate viii., fig.3).

This species has recently been described and discussed both by the writer* and by Arber,† and it is not necessary to discuss it further. Typical examples of it are amongst the examples from Bexhill, and one is figured.

Tæniopteris spatulata in Australia is of very common occurrence in Jurassic strata, and also occurs sparingly in the Cretaceous; it has not yet been found in the Australian Triassic, though Arber has recorded it from strata which he classed as Rhætic in New Zealand.

The specimen figured is No. L.28 in Mr. Mitchell's collection.

ARAUCARITES CUTCHENSIS Feistmantel.

(Plate viii., fig.5[A]).

1876. *Araucarites cutchensis*, Feistmantel, Foss. Fl. Gondwana System, Vol. ii., Pt.1, p.62, Pl. vii., fig.7; Pl. viii., figs.2-6; Pl. ix., figs.1-3; Pl. xii., fig.10.

1877. *Araucarites cutchensis*, Feistmantel, *ibid.*, Vol. ii., Pt. ii., p.16 (96), Pl. xiv.

1879. *Araucarites cutchensis*, Feistmantel, *ibid.*, Vol. i., Pt. iv., p.27 (217), Pl. xiv., figs.6-9; Pl. xv., fig.1; Pl. xvi., fig.15.

1917. *Araucarites cutchensis*, Arber, N. Zeal. Geol. Survey, Pal. Bull. 6, p.56, Pl. viii., fig.5; Pl. xiii., fig.1.

"Seed-bearing scales of the Araucarian type. Scales more or less broadly wedge shaped, the base narrow, truncated, the apex broad; rounded, or truncated, often produced as a median, narrow, linear appendage. Seed single, ovoid, the broader extremity being towards the apex of the scale." (Arber).

A single specimen of an Araucarian seed bearing scale seems

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* Queensland Geol. Survey, Pub. 257, p.30.

† N. Z. Geol. Survey, Pal. Bull. 6, p.46.

identical with Feistmantel's species *A. cutchensis.* It is about 13 mm. long and is 11 mm. wide at the top and 3 mm. at the base; there is no apical spine, though one may have been present. The depression occupied by the seed shows quite distinctly and is about 8 mm. long and 3 mm. broad at the widest part: its broader end is towards the apex of the scale.

The specimen is very similar to those described from Rhaetic and (?)Lower Jurassic rocks in New Zealand and also from the Jurassic of India.

Two types of scale have been figured from the Jurassic of Victoria by Seward as *Araucarites* sp.A, and *Araucarites* sp.B, but both are rather different from the present example. From the Lower Cretaceous (Burrum Series) in Queensland, scales have also been described as *Araucarites Arberi*,* but they also are rather different from the Bexhill specimen.

In view of my description recently of a fragment of an Araucarian cone† borne on a stem to which were attached leaves of the *Podozamites* type, it is interesting to note that the present scale occurs in association with examples of *Podozamites.* Evidence is thus tending to show that the leaves we refer to *Podozamites* in Australia are coniferous, and it would give a better idea of their affinities if they were designated *Araucarites* (*Podozamites*).

The specimen figured is No. L.14 in Mr. Mitchell's collection.

ARAUCARITES (PODOZAMITES) GRACILIS Arber.

(Plate viii., fig.2).

1917. *Podozamites gracilis*, Arber, N. Z. Geol. Survey, Pal. Bull. 6, p.54, figs.11, 12.

"Shoots exceeding 20 cm. in length. Leaves spirally arranged, linear-lanceolate, up to 6 cm. in length, and 4 mm. to 5 mm. broad at their greatest width. Base gradually contracted but not decurrent, apex acuminate. Nerves about 5 to 7 in number, parallel." (Arber).

* Queensland Geol. Survey, Pub. 263, p.40.

† Queensland Geol. Survey, Pub. 262, p.11.

A number of our specimens may be referred to this New Zealand species which, as Arber points out, differs from *Podozamites lanceolatus* in having narrower and more linear leaves. *P. gracilis* occurs in New Zealand in rocks referred by Arber to the Middle Jurassic.

The specimen figured is No. L.12 in Mr. Mitchell's collection.

ARAUCARITES (PODOZAMITES) sp.

(Plate viii., fig.5[B]).

There are a few examples in the collection in which the leaves are even more slender and much farther apart than in those I have referred to *P. gracilis.* The leaves are about 5 cm. long and 2 to 3 mm. wide, with about five parallel veins.

The material is hardly sufficient to warrant specific identity, and it is possible that it may represent only a variation of *Araucarites (Podozamites) gracilis*; for the present it may be noted as *Araucarites (Podozamites)* sp.

The specimen figured is No. L.14 in Mr. Mitchell's collection.

EXPLANATION OF PLATES VII.-VIII.

(All figures approximately natural size.).

Plate vii.

Fig.1.—*Cladophlebis australis* (Morris).

Fig.2.—*Coniopteris hymenophylloides*, var. *australica* Seward. Fertile frond.

Fig.3.—*Coniopteris hymenophylloides*, var. *australica* Seward. Sterile frond.

Fig.4.—*Coniopteris hymenophylloides*, var. *australica* Seward. Part of fertile frond.

Fig.5.—*Cycadites* sp.

Plate viii.

Fig.1.—*Microphyllopteris pectinata* (Hector).

Fig.2.—*Araucarites (Podozamites) gracilis* Arber.

Fig.3.—*Taeniopteris spatulata* McClelland.

Fig.4.—*Microphyllopteris pectinata* (Hector).

Fig.5. { A. *Araucarites cutchensis* Feistmantel.
{ B. *Araucarites (Podozamites)* sp.

Locality: Bexhill, 6 miles from Lismore, N.S.W.

ORDINARY MONTHLY MEETING.

29th May, 1919.

Mr. J. J. Fletcher, M.A., B.Sc., President, in the Chair.

Miss **Marjorie Broughton**, Science Research Scholar, the University of Sydney, and Messrs. **John McLuckie**, M.A., B.Sc., Lecturer and Demonstrator in Botany, The University of Sydney, **Clarence Victor Ferriss**, 8 McLean Street, Edgecliff, T. **McCarthy**, Bertram Street, Mortlake, and **Marcus Stanley Barnett**, "Imbala," Fox Valley Road, Wahroonga, were elected Ordinary Members of the Society.

It was resolved that the President send a friendly message of greeting and welcome to Lieut.-Colonel Professor David on behalf of the Members.

The President extended a hearty welcome to Sir Douglas Mawson, who was present.

The President formally introduced Dr. A. B. Walkom, the newly-appointed Secretary, who entered upon his duties on 1st April. In response to the President's invitation, the Members, by acclamation, joined in offering a cordial welcome and their active co-operation.

The President offered the congratulations of Members to Dr. H. Leighton Kesteven (*in absentiâ*) on his attaining the Doctorate of Medicine.

The Donations and Exchanges received since the previous Monthly Meeting (30th April, 1919), amounting to 37 Vols., 55 Parts or Nos., 3 Bulletins, 1 Report, and 5 Pamphlets, received from 41 Societies, etc., and one private donor, were laid upon the table.

NOTES AND EXHIBITS.

Mr. E. Cheel exhibited specimens, together with a photograph of a white-flowering form of the local "Bottle-brush." *Callistemon lanceolatus*, taken by Mr. H. Burrell at the Coast Hospital, Little Bay, in April, 1919. Only one fruit was seen on the plant, which was not fully matured, although it appeared to be about two years old. When the valves opened it yielded a few seeds, some of which were apparently imperfectly developed, as only a solitary seed has germinated. A few cuttings have been handed over to the Botanic Gardens, with a view of propagating this interesting albino, which seems to be very desirable for our gardens.

Mr. A. A. Hamilton exhibited examples of precocious germination (vivipary), from the National Herbarium, in *Cucurbita Pepo* L., "Pumpkin" (E. N. Ward; May, 1917; and J. Angel; April, 1919): *Citrus medica* L., var. *limonum*, "Lemon" (Miss Wilbow; December, 1910; and W. M. Doherty: March, 1917): *Tagetes patula* L., "African Marigold" (W. F. Blakely: April, 1914): and *Impatiens balsamina* L., "Balsam" (Mrs. Hamilton: March, 1917). Seedlings which had produced roots and green cotyledons were found in the interior of both Lemon and Pumpkin in which the pericarp was intact, and seed germination had occurred in the capitula of the Marigold and the capsule of the Balsam, on the growing plants An example of this occurrence in a Melon is noted by Sir W. Thistleton-Dyer (Ann. of Bot., 16, 149), who suggests an analogy between the reproductive method of the "Brazil-nut," *Bertholletia excelsa*—in which precocious germination is a normal condition— and that of the wild Melon. Sachs (Text Book of Botany, p.665) says—"The green colouring substance is formed in the cotyledons of Conifers, &c., in complete darkness as well as when subject to light."

Miss Sarah Hynes exhibited a beautiful and interesting series of paintings in water-colours of *Dictyophora* (*Phalloideæ*) drawn from Nature in Papua by Mrs. Ellis Rowan. This Fungus is at first enclosed within a volva, concealed beneath the ground, which breaks through the ground, ruptures, and the internal part rises as a stipe which lengthens rapidly and elevates the pileus in the air (it grows six or more inches in from half to two or three hours) The pileus or membrane bears the gleba or spore-bearing pulp, which rapidly becomes viscid and offensive in odour to attract flies, which disperse the spores. The most striking feature in the fungus depicted is a veil or net-like membrane (the indusium), which hangs from under the pileus and spreads out around the stem. The veils in Mrs. Rowan's plants are black, apple-green, crimson, white, or orange, and also purple in colour. *Dictyophora* has hitherto been very imperfectly described, as the fungus is difficult to preserve in its original shape and colour. Some of these are new to science.

Mr. Fred Turner exhibited—(1) *Gastrolobium grandiflorum* F.v.M., collected in North-western Queensland by Mr. A. H. Cooper, and forwarded through the Hon. Dr. J. M. Creed, M.L.C. Mr. Cooper says "This plant is known as the 'Queensland Poison Bush,' and is fatal to stock that eat it. The foliage is bright green in dry times, and owing to this circumstance I suppose stock are attracted to it."—(2) *Nicotiana glauca* Grah., also collected by Mr. Cooper in North-western Queensland. This South American plant has long been acclimatised in Australia, but the exhibitor hitherto did not know that it occurred in such a remote portion of the continent. The first time Mr. Turner saw this species in New South Wales was on some vacant land at Bondi, but owing to the erection of residences it has long since disappeared from that area. The next time was near the Darling River, between Bourke and Wilcannia, where it was growing fairly plentifully in places. Stockowners in that part of the State held the opinion that "it caused blindness in horses."—(3) *Adriana acerifolia* Hook. This specimen was collected at Woodstock and forwarded through Messrs. Anderson & Co. to Mr. Turner. In the letter accompanying the specimen. the writer says: "The shrubs grow to a height of about 6 to 7 feet, and sheep eat the leaves and seem to be very fond of them. I would like to know the name, and whether it is injurious to stock, and is it worth cultivating as a fodder plant?" This species of the *Euphorbiaceæ* has often been forwarded to the exhibitor as a suspected stock poison plant. It used to grow fairly plentifully in the Camden district, and Colonel Onslow Thompson, of Camden Park, and Mr. Downes, of Brownlow Hill, always regarded the plant with suspicion.

MESOZOIC INSECTS OF QUEENSLAND.

No.5. Mecoptera, the new Order Paratrichoptera, and additions to Planipennia.

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

(Text-figs. 23-28).

The fossils dealt with in this Part belong to the *third* collection of fossil Insects from the Upper Trias of Ipswich, Queensland, already referred to in No.3 of this series (**4**, p.417). In No.1 of this series(**3**) I dealt with the Planipennia, Trichoptera, and Protomecoptera from the *second* collection made by Mr. Dunstan (if we count in also the Simmonds collection, this would be the *third* collection made at Ipswich altogether). As the new insects throw much light upon the important Orders which they represent, it seemed best to deal with them as soon as possible, even though many other fossils from the earlier collections still remain undescribed.

The material dealt with consists of two Mecoptera, two Trichopterous-like insects, one Planipennian, and one wing of uncertain position within the Panorpoid Orders. The Mecoptera are not well preserved, and one is too fragmentary to merit a name. The Planipennian, though not a complete wing, is one of the most beautifully preserved and most important of the new types found at Ipswich. One of the Trichopterous-like fossils is an almost complete and very beautifully preserved forewing, showing some quite new and unexpected characters, which prove that the wings from the Ipswich Trias which we have hitherto regarded as true Trichoptera, do not really belong to that Order, but to a distinct group separated from it by two very important characters. My original intention was to place these within a new Suborder Paratrichoptera of the Order Trichoptera. But this has been found to be quite incompatible with more recent evidence forthcoming from a fine new fossil wing found in the Upper Coal Measures of Newcastle, which I shall shortly deal with in a separate paper. It is therefore necessary, in this paper, to propose the recognition of a new Order Paratrichoptera for the four genera of Trichopterous-like wings so far found at Ipswich, and to explain carefully the essential differences between the two types of venation found in the Trichoptera on the one hand and the new Order on the other.

Order **MECOPTERA.**

Family STEREOCHORISTIDÆ, fam.nov.

Small Scorpion-flies having the radial sector four-branched, the media six-branched. Cubital fork placed close to base; Cu_1 united to M by an oblique vein, the posterior arculus (*pa*), which appears to be itself a true branch of M; the vein formed by the union of *pa* with Cu_1 continues as a straight, strong, convex vein for some distance, and then stops suddenly short, dividing into two weak and widely divergent branches, one joining up with M_4 above, and the other with $Cu_2 + 1A$ below. Cu_2 fuses with 1A not far from its origin.

Originally I placed the genus *Mesochorista* in the family *Panorpidæ*. But its affinities are very great with the recent genus *Tæniochorista* from Brisbane; and this genus, in its turn, is allied to the better known genus *Chorista*. These genera, distinguished amongst other characters by the five- or six-branched media of the forewings and the primitive form of the abdomen in the male, most certainly deserve to be separated out from the *Panorpidæ* as a separate family, *Choristidæ*. I therefore now propose to adopt this family, and to place the Triassic fossil *Mesochorista* in it, together with the two recent genera *Chorista* and *Tæniochorista*. The affinities of the Permian *Permochorista* with the *Choristidæ* are so close that it may also be advisable to reduce the *Permochoristidæ* to the status of a subfamily of the same family.

Genus STEREOCHORISTA, n.g. (Text-fig.23).

Characters of the family, with the following additions:— Forkings of Rs and M placed close together, at a level about two-fifths from base of wing. Apical forkings of the branches of Rs placed more than usually far distad. An oblique cross-vein connecting Rs with M at a level just before that of the origin of the posterior arculus. Branches of M intimately connected by three cross-veins, which form three well-defined closed cells distad from the median fork. 1A apparently three-branched.

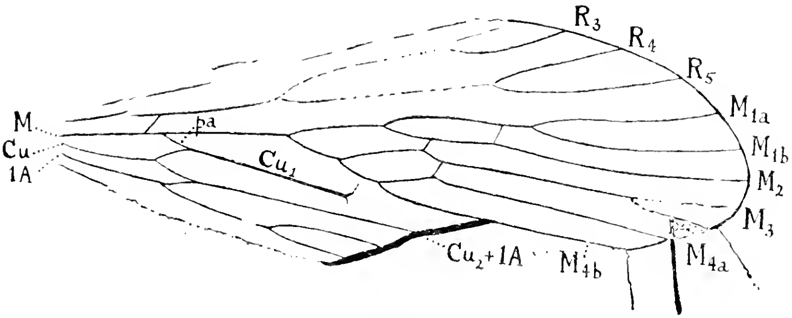
Genotype, *Stereochorista frustrata*, n.sp. (Upper Triassic, Ipswich, Q.).

This genus would appear to be allied to *Mesochorista* (**2**, p.29) from the same horizon; but the remarkable characters of the presence of a true posterior arculus and the shortened Cu_1 are absolutely unique, and appear to warrant the formation of a new family for its reception I do not know of any other Mecopteron in which the posterior arculus can be definitely picked out; either it is reduced to a transverse vein, not distinguishable from a cross-vein, or else it is entirely obliterated by reason of the complete fusion of Cu_1 with the main stem of M for a short distance. In this connection, it should be noted that, within the single family *Rhyacophilidæ* in the Order Trichoptera, species can be found showing all three conditions. Undoubtedly the most archaic condition is that exhibited by *Stereochorista*, in common with such species as *Agapetus fuscipes* Curtis (fam. *Rhyacophilidæ*) and with the majority of the *Micropterygidæ*, viz., the presence of a true posterior arculus in the form of an oblique vein connecting the main stem of M with Cu_1, not far distad from its origin at the cubital fork. The condition in *Stereochorista* strongly suggests that the vein usually called Cu_1, distad from *pa*, is in reality a fused vein consisting of Cu_1 and a posterior branch of M, which we may call M_5, and of which *pa* is the basal free piece. If so, then the name *posterior arculus*, due to Comstock, is a misnomer, and should be altered either to *anterior arculus* (this being the part of the Odonate arculus formed from M) or simply to *arculus*.

Further evidence on this interesting point may be found on p.207 of this paper.

STEREOCHORISTA FRUSTRATA, n.sp. (Text-fig.23).

Total length 7·5 mm., this being almost the full length of the wing (a little of the base missing). *Greatest width* of preserved portion, 2·3 mm., representing an actual greatest width of the complete wing of about 3 mm. The impression of the wing is faint but good; there can be no doubt of the correctness of the condition of Cu_1 as drawn, but the tracing of the closely arranged branches of M is not an easy matter. Cu_1 can be followed quite clearly as a strong vein for some distance, when it suddenly ends quite definitely, sending very weak and widely diverging branches (possibly cross-veins) to M_4 above and $Cu_2 + 1A$ below. A careful examination of these two veins shows us that M_{4b} and $Cu_2 + 1A$ are definitely tending to converge, so that there is not a sufficiently wide space left between them distally for Cu_1 to be continued: this may possibly account for the peculiar manner in which it ends. I have carefully examined the whole of the wing in this region, and can find no evidence of any break or damage: the condition of Cu_1 is evidently a natural one, though certainly most unusual.



Text-fig.23.

Stereochorista frustrata, n.g. et sp., forewing. Upper Trias of Ipswich, Q. *pa*, posterior arculus. Rest of lettering as usual in Comstock-Needham notation; (× 12).

The preserved wing was almost certainly the forewing of a highly reduced type, which may very possibly have closely resembled the recent *Nannochoristidæ* in appearance.

Type, Specimen No. 218 (Coll. Queensland Geological Survey).

Horizon: Upper Triassic, Ipswich, Q.

MECOPTERON INCERTÆ SEDIS. (Text-fig. 24).

Specimen No 168*a*, *b*, consists of two fragments of a small Mecopterous wing, fairly well preserved, but not sufficiently complete to merit a name. Text-fig. 24 shows the venation of these fragments. In the larger there are four forked veins, the third and fourth being separated by a simple vein, while the fourth is also followed by another simple vein. Hence it may be suggested that the wing belongs to the *Choristidæ*, the first two forked veins representing the branches of Rs (with R, Sc, and the costal border indicated above them in order): while the third and fourth forked veins, together with the simple vein between them, and the simple vein posterior to the fourth, represent the six branches of the media. The positions of these veins, and their angles of divergence from one another, agree closely with those of other *Choristidæ*, but the relative positions of the

Text-fig. 24.
Two fragments (*a*, *b*) of Mecopterous wings from Upper Trias of Ipswich, Q.; Specimen No. 168*a*, *b*; (× 13).

dichotomous branchings are quite different from those of any known form.

PANORPOID INSECT INCERTÆ SEDIS.

Specimen No.114*b* is a badly-preserved wing which appears to belong to one of the Panorpoid Orders, but which cannot be determined with certainty. Parts of Sc, R, M, and Cu_1 are visible. R_1 is forked distally, Rs dichotomously forked many times over, M apparently five-branched, and Cu_1 straight and unforked. Length of fragment, 9·5 mm.; greatest breadth, 3·5 mm. The costal space was moderately wide, and shows portions of an archedictyon; there are also some slight signs of the same kind of meshwork in other parts of the wing.

This insect may perhaps be related to the Protomecoptera; but is so poorly preserved that I do not propose to name it.

Order **PARATRICHOPTERA**, ordo nova.

Triassic insects with wings in which the venation is on the Trichopterous plan, but differing from the true Trichoptera in two very important points, as follows:—

(1) The three anal veins remain quite separate in the forewing. (In all true Trichoptera these three veins are looped up together in a very typical manner).

(2) Cu_1 is a strong, straight, convex vein, without any apical fork. (In all archaic genera of the true Trichoptera, Cu_1 is forked apically).

A separate costal vein may be present. Rs and M both four-branched, as in archaic genera of recent Trichoptera; both the radial and median cells closed

The discovery of the almost complete and remarkably well-preserved wing of *Aristopsyche*, n.g., shows that I was in error, in No.1 of this Series(**3**), in restoring the forewings of *Mesopsyche* and *Triassopsyche* on the typical Trichopterous plan, as regards the looping-up of the anal veins. I may also have been wrong in determining the presence of the wing-spot (a difficult thing to be certain of, in any fossil) since neither of the two new genera here dealt with shows any signs of it.

The archaic condition of the anal veins, and the unforked Cu_1, connect the new Order with the Mecoptera. It seems likely also that the Paratrichoptera were closely allied to the Diptera, which also have an unforked Cu_1, though the anal veins have undergone a reduction due to narrowing of the base of the wing.

The four genera of Paratrichoptera now known from Ipswich may be provisionally included within a single family, *Mesopsychidæ*, the characters of which were defined in No.1 of this Series (**3**, p.180). The following key will distinguish them :—

(1) A short costal vein present, separate from the costal margin; all four apical forks free of cross-veins .... ARISTOPSYCHE, n.g.
No separate costal vein (or basal part of costa not preserved); at least one apical fork with definite cross-veins .... 2.

(2) Sc and R very close together; pterostigmatic region very long and narrow .... 3.
Sc and R further apart; pterostigmatic region not so narrow, less regularly shaped; third apical fork with a cross-vein.. .... TRIASSOPSYCHE Tillyard.

(3) Only two or three costal veinlets present; second apical fork subdivided into three cells by cross-veins..... MESOPSYCHE Tillyard.
Numerous costal veinlets present; first apical fork with two cross-veins; second apical fork undivided ...... NEUROPSYCHE, n.g.

Genus ARISTOPSYCHE, n.g. (Text-fig.25).

Characters of forewing :—Large wing with broadly rounded apex and very regular scheme of venation; no excess cross-veins in distal part of wing. A short but distinct costal vein present, ending on costal margin at about one-fifth of the total wing-length: veinlets are present both between this vein and the costal border, and also between Sc and the same border. Sc and R both straight, fairly close together: pterostigmatic region moderately long and narrow, with one veinlet. Both the radial (discoidal) and median cells closed, with all four apical forks sessile upon them, though the third fork is only just so. Cu_1 a very strong, convex vein slightly bent downwards distally; not forked, but giving off two very strong, oblique, posterior branches to join the vein below, which is probably Cu_2. Cu_1 distinctly joined to M near base. Anal veins distinct and quite separated distally.

Genotype, *Aristopsyche superba*, n.sp. (Upper Triassic, Ipswich, Q.).

This genus would appear to be fairly closely allied to both *Mesopsyche* and *Triassopsyche*. The form of the radial cell resembles that of the latter genus very closely, while the form of the median cell, with its peculiarity of having the medio-cubital cross-vein attached almost exactly to the origin of M_4, resembles that of the former genus. In the peculiar form of Cu_1 there is also a close resemblance to *Triassopsyche*; in this latter genus, only enough of the wing is preserved to show the more distal of the two descending branch-veins, and the more distal part of Cu_1 is somewhat zigzagged, through being braced by excess cross-veins, not present in *Aristopsyche*.

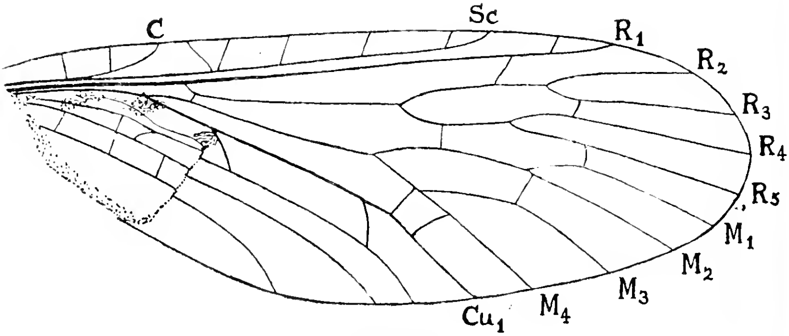
It is much to be regretted that, perfect as this fossil is (with the exception of a single break across the anal veins), some cuts made by the knife in exposing it have, most unfortunately, partially destroyed the impression in the region where the cubital fork should occur, so that it is not possible to determine with certainty the true course of the veins Cu_1 and Cu_2 at their origins.

That the wing is truly a forewing there can be little doubt, not only because the fourth apical fork is present, but also because of the distinctness of the impression, the evident strength of the veins, the well-formed costal area, and the general shape of the wing. The difference between the formations of the anal veins in this fossil and in the forewings of all true Trichoptera is very remarkable; and there seems to be no doubt that the anal areas of the forewings of the other three genera from Ipswich must closely resemble this also. For *Triassopsyche* is so close to *Aristopsyche* that we are bound to conclude a close similarity in the form of their anal veins, though these are not preserved in the former genus. Moreover, in *Neuropsyche*, n.g., which will be seen to be equally close to *Mesopsyche*, some of the anal area is preserved, and is found to be closely similar to that of *Aristopsyche*.

ARISTOPSYCHE SUPERBA, n.sp. (Text-fig.25).

Greatest length of fossil, 24 mm. (representing a complete wing about 25 mm. long, with a small piece of the extreme base missing); *greatest breadth*, 8·2 mm.

This fossil is perfectly preserved, except for a small portion of the base and anal area; the wing had evidently been torn transversely across the anal veins before becoming fossilised, so that these veins are all slightly displaced basally. A weak, irregular curved line below the basal portion of Cu_1 appears to represent the crinkle in the wing-membrane due to this displacement The first vein lying below this crinkle should be Cu_2, the second 1A, and the third 2A, 3A being apparently obliterated owing to the poor state of preservation of the wing near the base anally. It might be maintained, however, that these three veins were the three anals, Cu_2 being represented either by one of the two oblique descending branches from Cu_1, or possibly even by the weak, curved line which I have preferred to interpret as a crinkle in the membrane.



Text-fig.25.

Aristopsyche superba, n.g. et sp., forewing. Upper Trias of Ipswich, Q. C, distal end of short costal vein; rest of lettering as usual in Comstock-Needham notation; (× 4).

Cross-veins present are:—two between the costal border and the short separate vein C; five between the costal border and Sc, of which the most basal is bent backwards towards the tip of

C; one in the pterostigmatic space: one between R_1 and R_{2+3}; one between R_3 and R_4, closing the radial cell distally; one from R_{4+5} to M_{1+2}: one from R_5 to M_1; a short one connecting Rs with M, quite close to the origin of the former; one between M_2 and M_3, closing the median cell distally; one from near the origin of M_4 to Cu_1, with a second somewhat distad from it; an oblique one (possibly a branch veinlet) from 1A to Cu_2; and three between 1A and 2A. The two oblique veins running from Cu_1 downwards are very strongly marked, and quite different from the other cross-veins; so that I have little doubt that they represent true branches of this vein.

Type, Specimen No. 148*a*. (Coll. Queensland Geological Survey).

Horizon: Upper Triassic, Ipswich, Q.

Genus NEUROPSYCHE, n.g. (Text-fig.26).

Characters of forewing:—A moderate-sized wing with narrow costal area and very narrow, elongated radial cell; pterostigma very long, without any veinlets. Numerous veinlets in costal area, also a number of excess cross-veins scattered irregularly. Sc and R very close together. First and second apical forks very narrow and close together; third and fourth broad and normally placed. Cu_1 a straight vein without any branches in the preserved part; the same is true of Cu_2 and 1A. Both radial and median cells closed, the first, second, and fourth apical forks sessile, the third very definitely stalked.

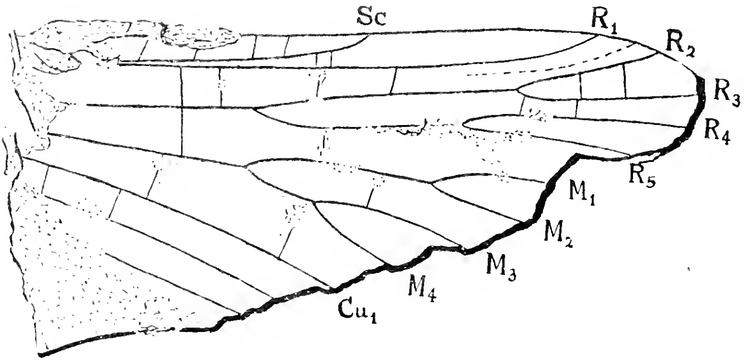
Genotype, *Neuropsyche elongata*, n.sp. (Upper Triassic, Ipswich, Q.).

Evidently closely allied to *Mesopsyche* from the same horizon. It differs from the latter genus in lacking the subdivision of the second apical fork into three separate cells, but possesses instead two cross-veins in the first apical fork. In *Mesopsyche* the costal area is not crossed by numerous veinlets, nor is the third apical fork stalked, but arises exactly from the upper distal angle of the median cell. *Mesopsyche* also lacks the excess cross-veins which are so conspicuous in the new genus.

NEUROPSYCHE ELONGATA, n.sp. (Text-fig.26).

Greatest length of fragment, 11 mm., representing a wing whose total length was about 16·5 mm. *Greatest breadth*, 4·8 mm.

The impression is a faint one, but can be made out with very little difficulty in a good light. All the basal part of the wing, together with the extreme distal part, from the apex obliquely downwards to the distal ends of Cu and 1A, is missing. In the short distal end of the costal area preserved, no less than four veinlets are visible; so that it is fairly certain that this area was well supplied with veinlets the whole way along. Below the apical end of Sc, two small cross-veins pass downwards to R; but the whole of the true pterostigma is smooth and free of veins.



Text-fig.26.

Neuropsyche elongata, n.g. et sp., forewing. Upper Trias of Ipswich, Q; (× 8). Lettering as usual.

The pterostigmatic furrow is well marked, between R_1 and R_2. Other cross veins present are:—four between R_1 and Rs, of which the most basal passes on in a straight line to M; two between R_3 and R_4, one closing the radial cell, the other slightly distad from it; one (not well preserved) between R_{4+5} and M_{1+2}; one closing the median cell distally; two between M and Cu_1; and two between Cu_1 and Cu_2.

Type, Specimen No. 228*a*. (Coll. Queensland Geological Survey).

Horizon: Upper Triassic, Ipswich, Q.

A study of the four genera of Paratrichoptera now known from Ipswich makes it extremely questionable whether they can be regarded as lying in the direct ancestral line of the present Trichoptera. It is, of course, quite certain that recent Trichoptera must have been originally derived from Trichopterous-like insects in which the high specialisation of the anal veins, now present throughout the Order, had not been established. But all archaic recent Trichoptera have a very definite dichotomy of the first cubitus distally, forming the *fifth apical fork*; whereas it is quite evident that the Paratrichoptera did not possess this fork, but had instead a straight Cu_1, of the type seen in all fossil and recent Mecoptera.

Order **PLANIPENNIA.**

Family PROHEMEROBIIDÆ.

In No.1 of this Series (**3**, p.178), I described from Ipswich the genus *Protopsychopsis*, placing it in the above family for reasons there given. Since then, I have received a very beautifully preserved fragment of a Prohemerobiid wing, showing most of the basal part of the wing, with all the most important veins preserved. This fossil appeared at first to be so exactly like the recent *Megapsychops illidgei* that I began to think that the family *Prohemerobiidæ* could no longer be maintained. However, a careful study of the new fossil shows certain important differences, which, taken in conjunction with our knowledge of the Liassic and Jurassic *Prohemerobiidæ* of Europe, and of the recent *Psychopsidæ*, make it quite certain that the former family must be maintained: while it is now capable of definite proof that the latter family is a direct descendant therefrom. This proof will be furnished below, after the definition of the new genus, and the description of the fossil, have been given.

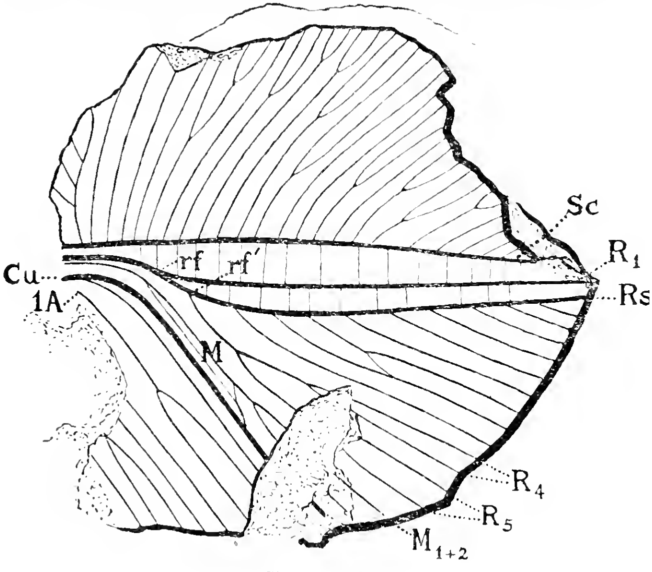
Genus ARCHEPSYCHOPS, n.g. (Text-fig.27).

Characters of preserved basal part of forewing as in the recent *Megapsychops*, with the following differences:—Costal veinlets at extreme base arising at right angles to Sc, the recurrent vein giving off anterior branches only (as in hindwing of *Megapsychops*); further distad, the direction of these veinlets changes rapidly, until, at the most distally preserved part of the wing, they make an angle of only about 30° with Sc. *No costal series of cross-veins between the costal veinlets.* The most basal branch of Rs ($=R_{4+5}$) still preserves its dichotomous branching, and both R_4 and R_5 again branch dichotomously in the preserved part. 1A also dichotomously branched.

Genotype, *Archepsychops triassica*, n.sp. (Upper Triassic, Ipswich, Q.).

ARCHEPSYCHOPS TRIASSICA, n.sp. (Text-fig.27).

Greatest length of fragment, 6·7 mm.; *greatest breadth*, 6 mm.



Text-fig.27.

Archepsychops triassica, n.g. et sp., preserved portion of forewing. Upper Trias of Ipswich, Q.: *rf*, primary radial fork; *rf′*, secondary radial fork; rest of lettering as usual; (× 10½).

(Measurements of the corresponding portions of the forewing of *Megapsychops illidgei* are almost exactly the same size; so that the fossil should represent a portion of a large wing of about the same size as that of *M. illidgei*, viz., about 27 mm. long). All the main veins and branches beautifully preserved, very strongly formed: the cross-veins, which are only present between Sc and R_1, and between R_1 and Rs, are weak and difficult to make out, but can be clearly seen in oblique evening sunlight. Sc, R_1, Rs, and Cu_1 are exceptionally strong veins, as also in *M. illidgei*. The direction of Cu_1, which makes an angle of as much as 50° with Rs, is quite exceptional, but is about the same as in the forewing of *M. illidgei*; likewise the weak formation of Cu_2, and its position parallel and very close up to Cu_1, is similar in both. No less than ten branches of Rs are present in the preserved portion of the wing; so that the total number of branches must have been very large, as also in *M. illidgei*. The formation of M is peculiar. Owing to the strength and thickness of Cu_1, which stands on a high ridge, it is not easy to make out the exact formation of the much weaker concave vein M near its base. But, viewed with a good light in the right direction, there can be seen a weak posterior branch of M arising from the main stem quite close to the base, and running between and parallel to M and Cu_1, until it meets with an oblique cross-vein descending from M just before the first clear dichotomy: it then curves in to join Cu_1 just below the dichotomy of M. Being in doubt as to the interpretation of this peculiar formation, I examined the forewing of *M. illidgei*, and there found, in the same position, a distinct but weak branch of M arising in the same manner, and ending on a cross-vein descending from the first evident dichotomy of M, as shown in Text-fig.28, *a*. As this character appears to be of some importance, I also examined the forewing of *Psychopsis elegans* (Guér.), and was surprised to find a closely similar formation there. I think that there can be little doubt that this vein, which I unfortunately overlooked in my previous studies of the *Psychopsidæ*, is really the posterior branch from the first dichotomy of M, and should therefore be called M_5. It must evidently be the homologue of the vein called the *posterior arculus* by Comstock in the Trichoptera and Lepidoptera, and also visible in the Mecopteron *Stereochorista* described on p.196

of this paper. It will follow from this that the primary median fork, like the primary radial and cubital forks, lies close to the base of the wing, and that the more distal fork, which has hitherto been regarded as the median fork, is really the secondary median fork, homologous with the secondary radial and cubital forks. Beyond the formation already described, only one dichotomy of M_{1-4} can be seen in the fossil: but there were almost certainly further dichotomies in the lost portion, judging by the somewhat diverging directions of the branches of M and of R_{4+5}. (M has at least four branches in *M. illidgei*, apart from the vein M_5 already mentioned).

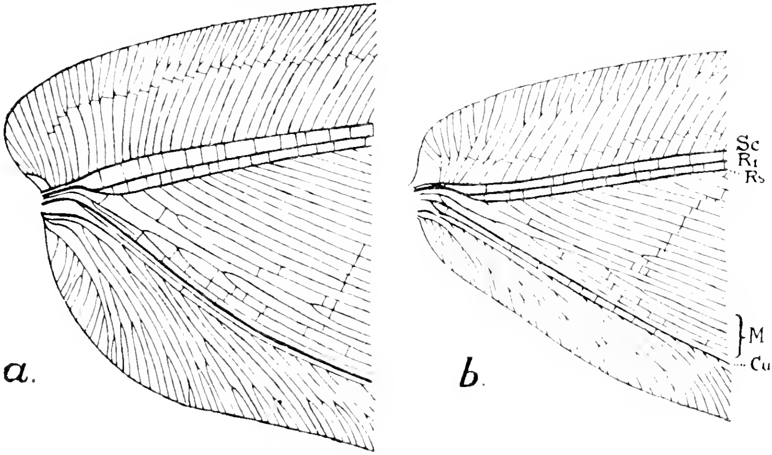
Type, Specimen No. 137*a*. (Coll. Queensland Geological Survey).

Horizon: Upper Triassic, Ipswich, Q.

Discussion of the Relationship between the Fossil Prohemerobiidæ *and the Recent* Psychopsidæ.

In Text-fig. 28, I show the bases of fore- and hindwings of *Megapsychops illidgei* (Froggatt), the most archaic of existing *Psychopsidæ*, for comparison with the fossil *Archepsychops*. It should be stated, at the start, that the venation of *Megapsychops* is absolutely unique, and that there is no other known insect, fossil or recent, which possesses the same characters, or anything closely approaching them. From the rest of the *Psychopsidæ* it is widely separated by the large number and closeness of the branches of Rs, the four- to six-branched media, and the remarkable structure of the cubitus.

Comparing Text-figs. 27-28, we see that the forewing of the fossil *Archepsychops* is intermediate between the fore- and hindwings of *Megapsychops* in the form of the costal veinlets—the immense breadth of the costal space resembling that of the *forewing* of this latter genus, while the type of branching of the recurrent costal veinlet is that found in the *hindwing* only of *Megapsychops*. Apart from the absence of the costal series of cross veins, which never occurs in any Prohemerobiid, the principal difference between the forewings of *Archepsychops* and *Megapsychops* is the great change in the direction of the costal veinlets in the former, even in the short space of the wing preserved in the fossil. This character might be passed over as of little importance, were it not quite incompatible with the fundamental character of the family *Psychopsidæ*, viz., the broadly rounded apex, with wide costal area from base to tip. Those Liassic and Jurassic *Prohemerobiidæ* which are best preserved show, for the most part, a costal area fairly broad at the base, but rapidly narrowing towards the apex, which is always much less rounded than that of the *Psychopsidæ*; concurrently with this more primitive shape, there is an entire absence of any formation of a *vena triplica*, the three veins Sc, R_1, and Rs remaining primitive in form from base to apex. Now, if we turn to the study of the wings of any Psychopsid, we see that the broad apex, together with the specialisation of the greater parts of Sc, R_1, and Rs as a *vena triplica*, is correlated with a condition of the costal veinlets which is quite different from that found in the fossil. In the *Psychopsidæ*, these veinlets, from near the base right up to near the end of the *vena triplica*, come



Text-fig.28.

Megapyschops illidgei (Froggatt). Basal third of forewing (*a*) and hindwing (*b*) for comparison with Text-fig.27; (× 5).

off at an angle exceeding 45°, and all are approximately parallel to one another. Thus, a little thought will show us that the condition of these veinlets shown in the fossil is definite proof that the wide costal area existing at the base does not continue further distad, and that the more distal portion is of the narrower Prohemerobiid type.

Further evidence in the same direction is afforded by the existence in the Ipswich Trias of the Prohemerobiid *Protopsychopsis venosa* Tillyard, described by me in No.1 of this series (**3**, p.178). This fossil is only represented by the apical portion of the wing, which is of true Prohemerobiid type, with narrow costal area. It is not possible, owing to obvious differences of size, that *Protopsychopsis* and *Archepsychops* represent apical and basal portions of the wing of the same species; but it is extremely probable that they are parts of the wings of two closely allied insects, and very unlikely that they represented two distinct families. Indeed, if we were to restore *Archepsychops* on the supposition that its apical portion resembled that of *Protopsychopsis*, we should obtain a Prohemerobiid wing in its entirety, and there would be no clashing of characters anywhere.

Turning now to the relationship of *Archepsychops* to the recent *Megapsychops*, we see at once that *there is not a single character present in the former which is incompatible with its being considered as the direct ancestor of the latter.* When we consider how unique *Megapsychops* is in its venation, we must see that this is a very remarkable thing. If we add to this, that the differences in size of the two insects, and in the strength and closeness of their veins, are practically negligible, and that *Megapsychops* at the present day is only known to inhabit an isolated mountain-top situated some thirty miles from the Ipswich Fossil Beds, we see how strong a case there is for considering the fossil *Archepsychops* to be the *direct ancestor* of the recent *Megapsychops*. If this be accepted, then it has also been demonstrated that the *Psychopsidæ*, as a family, are the direct descendants of the older *Prohemerobiidæ*; the changes required to evolve the one from the other, through the immense period of geological time beginning with the Upper Trias, being really only a change in the shape of the wing, with its consequent alteration in the size and direction of the costal veinlets, and with a correlated specialisation in three parallel main veins, to form the *vena triplica* (as a kind of backbone or rachis for the widened wing), and a further strengthening of the veinlets by formation of the costal series of cross-veins.

There is one other point of interest in the venation of *Archepsychops*. Comstock, in a recent work (**1**), has elaborated the theory of the origin of the Planipennia from an older stock with dichotomously branching wing-veins, such as we find in the Mecoptera and Trichoptera. The condition of R_{4+5} in the new fossil is direct evidence in favour of this, but *not* in favour of the restriction of the number of dichotomous branches of both Rs and M to *four*, which Comstock also holds. For it is quite clear that both R_4 and R_5, in this fossil, are again dichotomously branched not far from their origins; and quite possibly they may be even branched again, further distad. Thus, we should conceive of the ancestral form as having, indeed, truly dichotomously branching sectors of Rs and M, but without any unnecessary limitation of the number of those dichotomies. Such a type is to be seen in the Protomecoptera, also from the Ipswich Trias, in which the number of branches of Rs is very large, but all are clearly *primitive dichotomies*. If we could find the type that gave rise to both *Archipanorpa* and *Archepsychops*, we should most probably have discovered the ancestor of the whole of the Panorpoid Orders.

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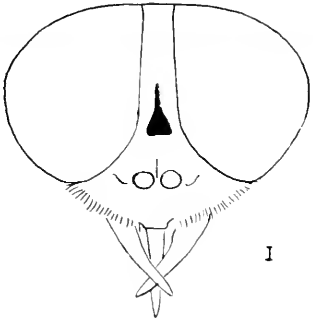
Note on Archipanorpa magnifica (Order Protomecoptera):—In No.1 of this series(**3**), I gave two drawings of the archedictyon or primitive meshwork of the wings of this fine fossil, one in Text-fig.6, the other on Pl. viii., fig.6. I now desire to draw attention to the fact that I have succeeded in making photomicrographs of this structure, and that they have recently been published in Part 2 of "The Panorpoid Complex" (These Proceedings, 1918, xliii., Part 3, Pl. lxvii.). These photographs give a much more accurate idea of the true appearance of the archedictyon, the previous drawings having been diagrammatic, and, therefore, possibly somewhat misleading as regards the detailed structure of the meshwork.

[Printed off, 16th June, 1919.]



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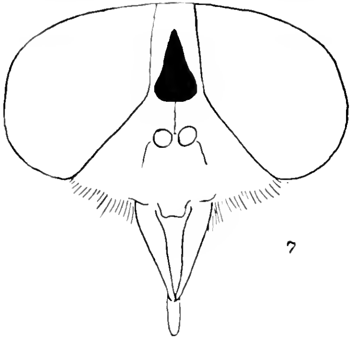

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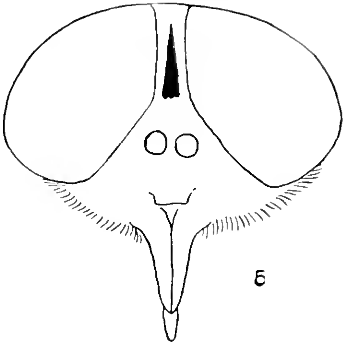

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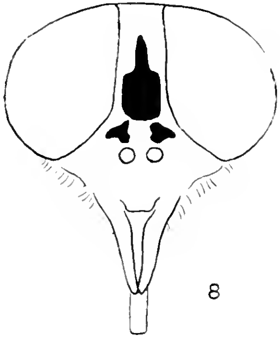

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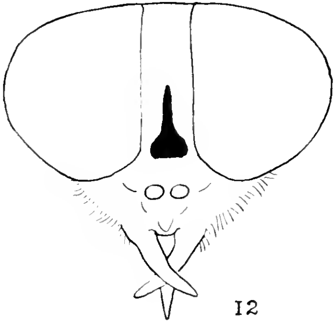

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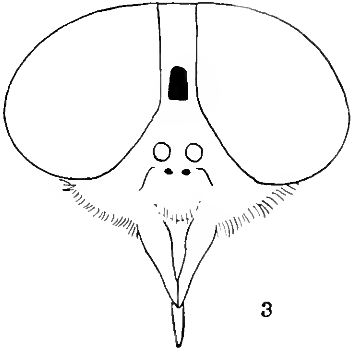

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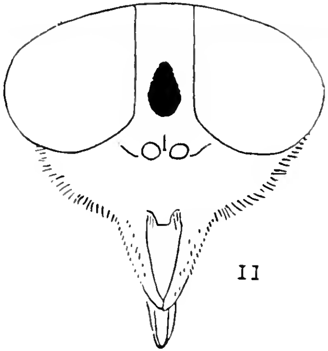
Australian Tabanidæ (*Tabanus*)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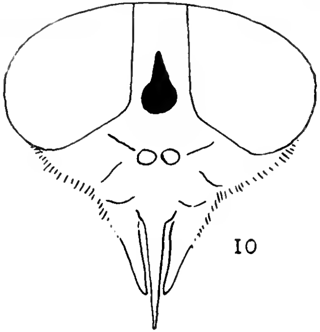
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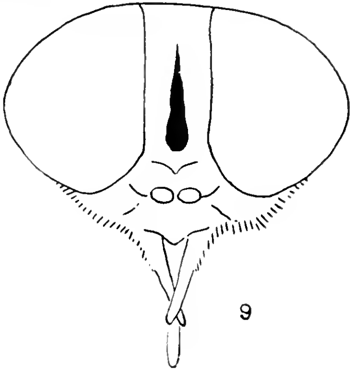
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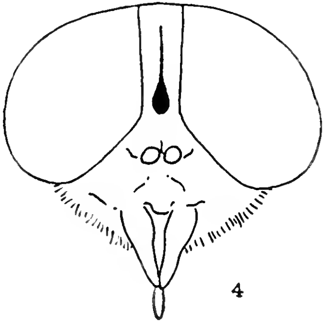
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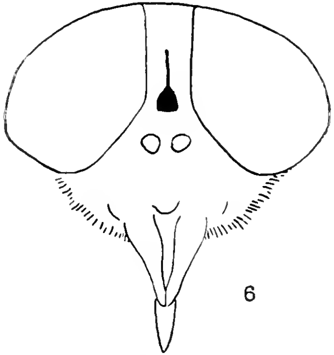
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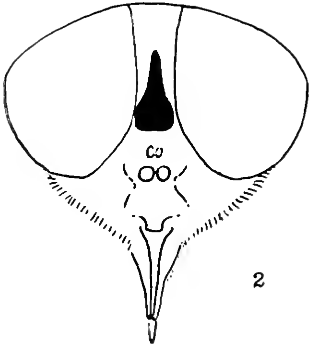
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Australian Tabanidæ (*Tabanus*)

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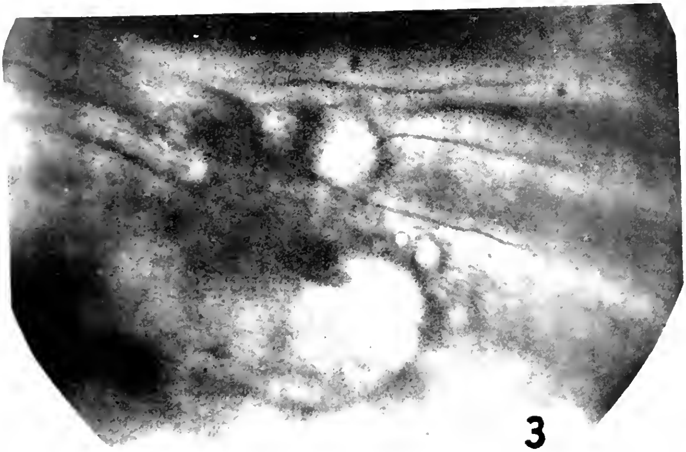

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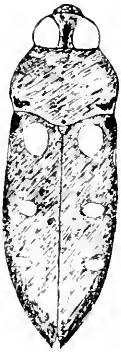
Eriocrania semipurpurella Steph.



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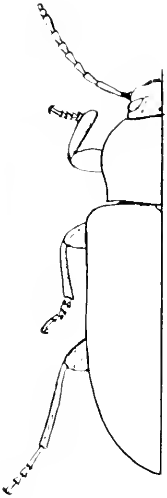

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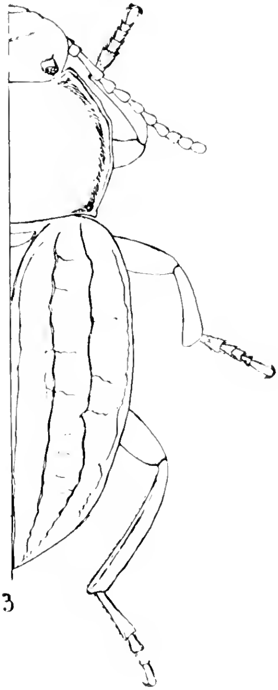

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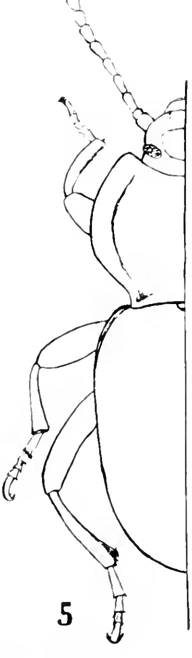

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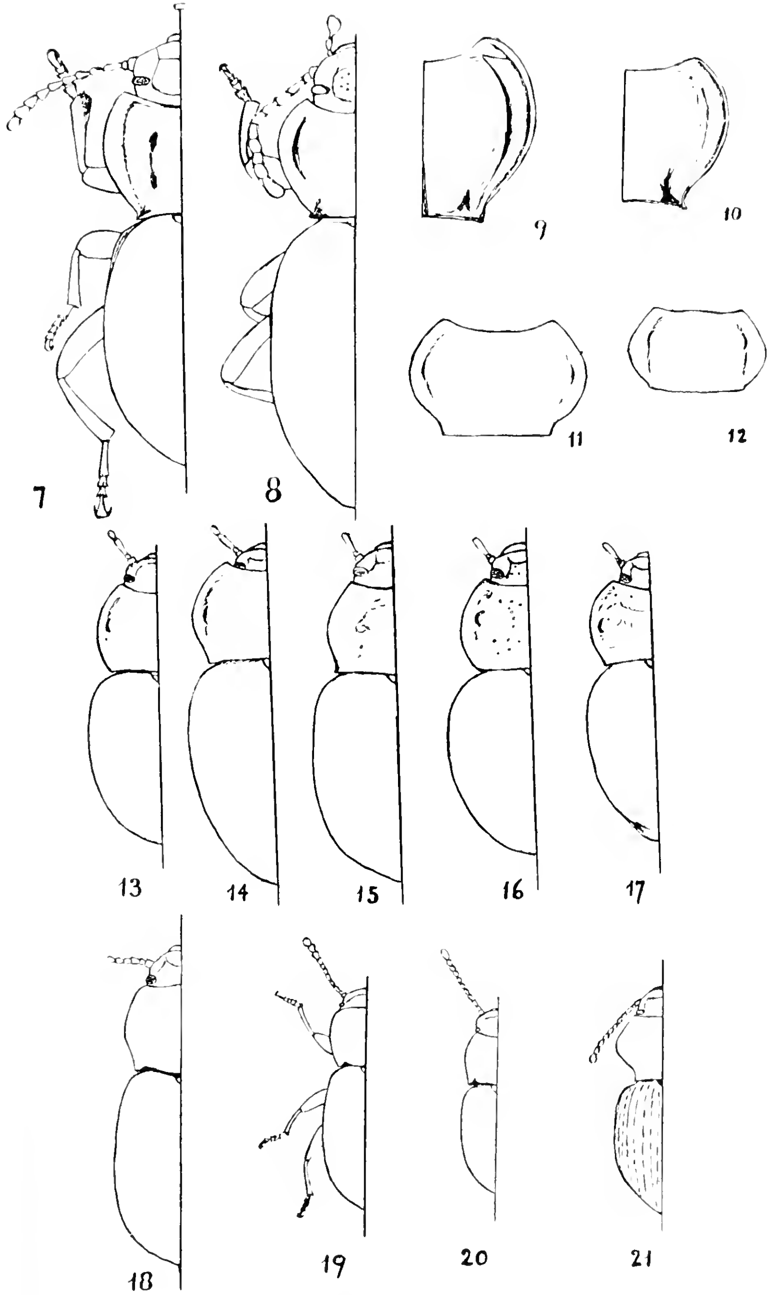
Australian Coleoptera.



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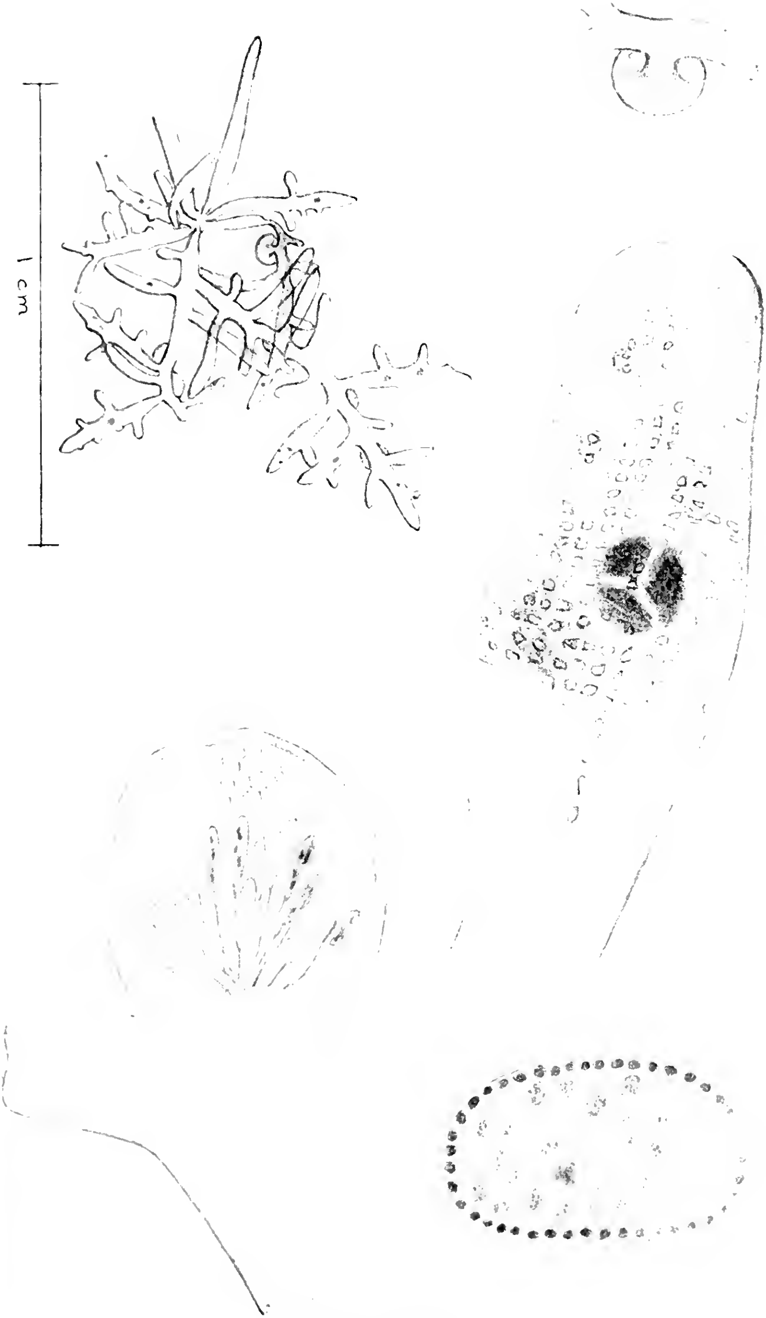
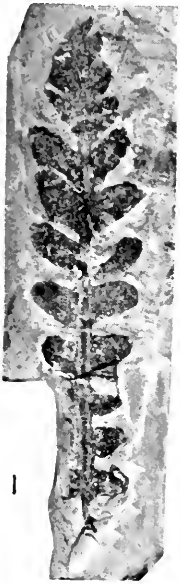


Laurencia infestans, sp. n.



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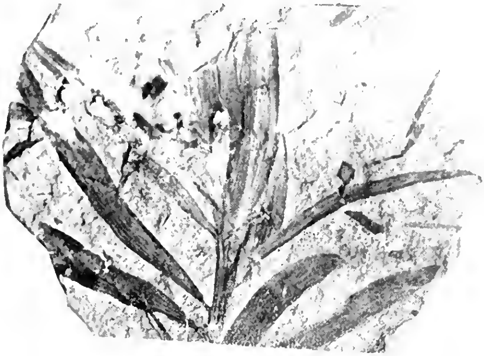

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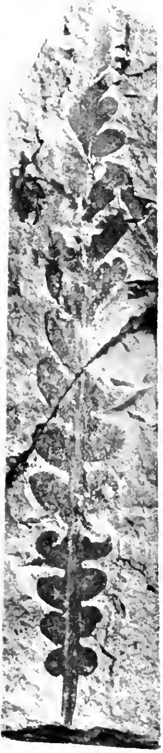

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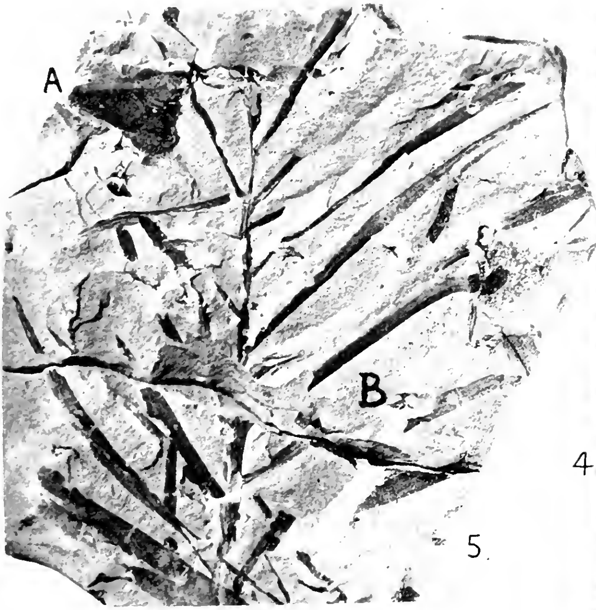

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Jurassic Plants from Bexhill, N.S.W.

PSEUDOBONELLIA, A NEW ECHIUROID GENUS FROM THE GREAT BARRIER REEF.

By Professor T. Harvey Johnston, M.A., D.Sc., C.M.Z.S., and O. W. Tiegs, B.Sc., Biology Dept., University, Brisbane.

(Plates ix.-xi.)

Very little appears to be known regarding Australian Echiuroids, although one genus, *Thalassema*, is well represented on the Queensland coast. We have collected specimens on many of the mud-sand flats in Moreton Bay (Myora, Amity, Swan Bay, Goat Island, Southport), where it is fairly common, being in places very abundant. This is the species referred to by Tosh (1902, p.180, Pl.12, fig.3). A related and perhaps identical species occurs in similar situations at Burnett Heads. Other species are represented in collections made by us from beneath stones and dead coral in Moreton Bay (Peel and Goat Islands); Port Curtis (Facing, Rat, and Curtis Islands); and on the Capricorn Reefs (Masthead and North-west Islets). A species is occasionally met with in Port Jackson, having been recorded by Whitelegge (1889, p.211) as *Thalassema* sp.

Shipley (1899) reported the presence of a number of species in New Guinea and adjacent islands lying to the north-east of Australia, mentioning other Eastern Pacific forms as well. Sluiter (1891, 1902) recorded a considerable number from the Dutch East Indies, while Ikeda (1904, 1907) gave an account of several of those occurring in southern Japanese waters. The genus is, then, well represented on the tropical and subtropical coasts of the Eastern Pacific.

Echiurus and *Hamingia* are represented each by one species—*E. unicinctus* Drasche, from the cold waters of northern Japan (Selenka, 1885, p.6; Shipley, 1899, p.344), and *H. sibogæ* Sluiter (1902, p.44) dredged by the Siboga Expedition from the very deep water in the East Indies.

We are aware of only one record of the occurrence of *Bonellia* or Bonellia-like echiuroids on the Queensland coast, Hedley (1906, p.462) having stated that he saw *Bonellia* in abundance in the lagoon in Masthead Islet, Capricorn Reefs. Only on one occasion (August, 1917) have we succeeded in finding a few specimens of a Bonellia-like worm in that locality, though searched for on several occasions between 1912 and 1917. He also made reference (1906, p.462; 1915, p.27) to the attempts of tropical animals such as *Bonellia* to colonise the shores of New South Wales while the Notonectian current floods the coast, many such perishing when this warm stream swings off-shore. This, no doubt, is the explanation of the occasional presence of a number of tropical invertebrates in Port Jackson.

Haswell (1885, p.331) reported the presence in Port Jackson of a *Bonellia* which he identified as *B. viridus* (a misprint for *B. viridis*, the Neapolitan species), mentioning, however, that there were certain differences from that species in regard to the reproductive organs. His specimen came from Neutral Bay. Whitelegge (1889, p.211) quoted the reference under *Bonellia* sp., and added another locality in Sydney Harbour, viz., Mosman Bay. Mr. Whitelegge informed us that he had obtained his from under a stone at Sirius Cove, Mosman, during a low tide.

Saville-Kent (1889, p.230) reported that *Bonellia* was obtained in abundance while dredging in the Cambridge Gulf, North-West Australia, while Dakin (1916, p.23) recorded the occurrence of a green species on the Abrolhos Islands, the Swan Estuary, and off Garden Island (near Fremantle) in South-Western Australia.

Shipley (1899, p.336) referred a small specimen found by Willey in the Loyalty Islands to the species *B. viridis*, mentioning (p.342) that the latter had noticed the same species in the D'Entrecasteaux Group, British New Guinea. Sluiter (1902, p.50) expressed the opinion that a detailed examination of the worms identified as *B. viridis* by Shipley and by Haswell would probably show that the Pacific species was distinct.

B. pumicea Sluiter (1891, p.111) occurs in the Dutch East Indies, while from Southern Japanese waters Ikeda (1904, 1907) has identified *B. minor* Marion, *B. miyajimai* Ikeda, and *B.*

misakiensis Ikeda. The known distribution of *B. minor* is remarkable, viz , Mediterranean (Bay of Naples and Marseilles) and the Loochoo (Riukiu) Islands, off Formosa. Ikeda, however, refers (1904, p.72) to certain differences in regard to the anal vesicles, so that it is not improbable that he was dealing with a distinct though closely related species.

PSEUDOBONELLIA BIUTERINA, n.gen. et sp.

During a visit in August, 1915, to North-West Islet, and in 1917 to Masthead Islet, two of the Barrier Reef atolls belonging to the Capricorn Group, situated due east from Keppel Bay, Queensland, some remarkable echiuroids were found which, from their external appearance, were then regarded as a small species of *Bonellia*, but subsequent examination showed anatomical differences of such a nature that it has been deemed necessary to propose a new genus for their reception. In general appearance, size, and colour, they remind one of the Japanese *B. minor*. They have, moreover, a similar habit, occurring between tide-marks on the coral reef flats and in boulders, with the dark green body hidden in crevices in the dead coral, from which the rather more lightly-coloured, bifurcated proboscis can be protruded for a considerable distance.

The size of the female varies within rather wide limits, due, no doubt, to differences in age. In specimens preserved in formalin, the body length ranged from 1·5 to 2·6 cm. and the breadth from 0·4 to 0·8 cm. Accurate measurements of the living proboscis were not made, but the organ was capable of extension to about 10 cm. In preserved material it varied in length from 1 to 3 cm., while the bifurcations reached from 0·4 to 2 cm. according to the degree of contraction.

The body is somewhat sack-like, broader posteriorly than in front (Plate ix., figs.1, 2). The groove on the ventral surface of the proboscis is broad and shallow distally, becoming deeper and more prominent as it approaches the mouth. At about 2 mm. behind the latter lie the ventral setæ. The external openings of the uteri were not recognisable in entire specimens, but in one out of twenty-six worms examined, there was to be seen a distinct pit, from the floor of which a definite papilla arose. In section, the apertures were seen to be quite small, and situated on the general body surface a short distance behind the setæ. The body is covered with small, flat-topped papillæ, closely arranged, being separated from each other by well-marked, narrow furrows. As a result of the bleaching of the bonellin pigment during preservation, the body wall was rendered fairly transparent, and the twisted intestine, with its mass of white granular contents, could be plainly seen.

The body wall.—Dorsally the body wall is very thin, while ventrally it is very much thicker, owing to the greater development of the musculature in that region. On the outside, next to the very thin cuticle, is an epidermis consisting of a single layer of columnar cells, below which lies the well-developed dermis with highly vacuolated connective tissue, traversed by fibres arranged vertically to the surface of the body. Abundant, branching, gland cells which stain deeply with hæmatoxylin are lodged in the dermal portion of each papilla and open through the epidermis (Plate x., figs.8, 9). These glands, no doubt, are responsible for the production of the mucous secretion which gives a slimy consistency to the preservative (formalin), from which it is readily precipitated by the addition of alcohol. Below the dermis are three series of muscles, an outer circular, a middle longitudinal which is about twice as thick as the preceding, and an inner oblique layer (inner circular layer of Sluiter, 1891) whose fibres travel partly circularly and partly obliquely. The last series is about half as thick as the outer circular musculature. The longitudinal layer is not divided up into separate bundles. The appearance of the body wall in section reminds one of that figured for *B. pumicea* by Sluiter (1891, Pl.1, fig.2).

In the proboscis, the first and second series alone are present. The circular layer is well-developed, but it is the longitudinal system which occupies the greater part of the organ (Plate ix., fig.6). The latter musculature consists of two sets of fibres, an outer composed of abundant, closely-arranged, small fibres, and an inner mass consisting of a great number of large fibres, well separated from one another by connective tissue when the organ is in a contracted state. The dermis of the proboscis is relatively thin and has a loose texture.

Setæ.—The setæ are rather prominent chitinous structures, situated ventrally, about 2 mm. behind the mouth in large specimens, and projecting downwards and slightly outwards in preserved animals. They vary in number from two to four, fourteen out of twenty-one specimens showing two setæ, three showing each three setæ, while the other four each had four. Since, with one exception, it was the larger forms that had the four setæ, of which one pair was always larger than the other, it would appear that the smaller setæ were in process of replacing the larger. Each seta is a flat, blade-like structure (Plate ix., fig.3), hooked at the free end, the larger type measuring from 2 to 3 mm. in length, the smaller 0·7 to 0·8 mm. Each lies in a deep setigerous sac, projecting far into the body of the worm, and ending internally close beneath the œsophagus. The setigerous sac is merely an invaginated part of the body wall, but the epidermal cells at its base are considerably elongated, and in longitudinal section have a fibrous appearance. The sac of each smaller seta is developed independently of, but in close connection with, that of a larger seta

Connected with the setæ is a powerful musculature. A strong, transverse muscle pad joins their internal ends, evidently serving to impart to them a lateral pincer-like movement, while a number of muscles, attached internally to the ends of the setæ and externally to the body wall, evidently serve to move them backwards and forwards, probably at the same time acting as protractors.

Cœlome.—The body cavity is well-developed, but in places is more or less fully occupied on account of the great development of the intestine (Plate x., fig.9). It is lined by a delicate peritoneum. Anteriorly, in the region of the setæ, it gives off two inward projections between the setigerous musculature, these travelling forwards on either side of the pharynx to enter the proboscis, at the end of the bifurcations of which they turn sharply backwards and inwards to meet one another. This could be made out in serial sections. Each cœlomic extension was associated with a lateral bloodvessel (Plate ix., fig.6).

The Alimentary Canal.—The mouth is a wide ventral opening at the junction of the body and proboscis. Behind, the buccal cavity leads into a muscular pharynx that becomes continuous with the irregularly coiled intestine, which in a specimen whose body was about one inch long, was found to measure about four inches in length (Plate ix., fig.2). The intestinal contents are arranged in oval pellets, probably by the muscular pharynx in which food was seen to lie in a loose mass.

The intestine is a rather thin-walled tube, consisting of a very thin internal layer of circular muscle next to the enteric epithelium, and surrounded by a slightly thicker layer of longitudinal muscle. On the ventral region of the alimentary canal the enteric epithelium is seen to be especially prominent anteriorly where the wall is thick, such modified structure being, however, limited to about one quarter of the circumference of this portion of the gut. Somewhat more posteriorly, where the intestine is wider but thinner-walled, this modified part is much more extensive, occupying at times about three-quarters of the circumference of the ventral and lateral walls, but the layer is then much less prominent. It appears to consist of a glandular epithelium, and stains deeply with hæmatoxylin. No doubt the structure is homologous with the ventral bandelette of some French authors.

Along its whole length the canal is attached to the body wall by thin, muscular strands or "mesenteries," more prominent posteriorly than anteriorly (Plate x., fig.9). They are much less numerous than those generally figured for *B. viridis.* A peritoneum lines the cœlomic surface of the intestine.

Lying dorso-laterally to the anterior region of the intestine is a siphon, a delicate tube about 5 mm. long, in close connection with the intestine, having in places a very narrow, compressed bore, but whose lumen, in most parts, is wholly obliterated. No definite opening into the pharynx exists. The siphon arises as a thickening on one side, more or less dorsally, soon becoming distinct from the pharyngeal wall, but remaining in close association with it, being separated merely by a very narrow, membrane-like tissue. After maintaining contact for some distance, it eventually comes to lie freely in the cœlome in the vicinity of the anterior parts of the uteri, but ultimately coalesces with the dorso-lateral wall of the intestine, the area of union being elongate and slit-like, with greatly folded walls (Plate x., figs.10, 11). The lumen of the folded portion is narrow, and the epithelium contains abundant gland cells like those of the intestine. This structure does not appear to be represented in *Bonellia.*

Nervous System.—The nervous system consists of a ventral nerve cord and a circum-œsophageal ring. The former lies mid-ventrally within the body cavity, attached to it by a short mesentery. About 25 pairs of nerves are given off to the body wall (Plate ix., fig.4). Ganglia are absent. Anteriorly at the base of the setæ the cord bifurcates, the two portions coming to lie at the sides of the muscular pharynx, and being included in the outer longitudinal layer of muscle, *i.e.*, they lie in the body wall. The two branches then travel along on either side of the proboscis, and, entering the bifurcation, proceed to the end, then turn back sharply, meeting one another so as to form an enormously elongated circum-œsophageal nerve ring (Plate ix., fig.5). Associated with the median bloodvessel of the proboscis, especially on its ventral aspect, is a mass of tissue which appears to be nervous (Plate ix., fig.6).

Vascular System.—There is a ventral bloodvessel, which travels in the body cavity immediately above the ventral nerve cord to which it is attached by a delicate membrane (Plate xi., fig.18). Posteriorly, at about the middle of the body, it dilates, and, leaving the ventral nerve cord, passes upwards to become applied to the nearest coil of the intestine. In this region, and to a less extent in other places more anteriorly, large numbers of colourless corpuscles can be detected. Posteriorly, the lumen of this dilated vessel appeared in section to be more or less occupied by a spongy mass resembling connective tissue, but which may have been coagulated fluid. Corpuscles were present entangled in it. The vessel travels backwards in close connection with the more dorsal portion of the intestine (serving evidently as a food-absorbing organ) till it gradually disappears. The condition is similar to that described by Spengel (1879) as occurring in *B.*

viridis. Anteriorly in the region of the setæ, the ventral vessel is much narrower. Between the setæ, it passes vertically upwards and then bifurcates, the branches passing around the œsophagus in whose muscular walls they lie; they enter the proboscis, and, passing forwards in close connection with the corresponding proboscis nerve to which they each lie ventrally, travel to the anterior end (Plate ix., fig.5). Still closely associated with the nerve, they each enter a bifurcation of the proboscis, to the extremity of which they extend, then turn back, meeting in the middle to complete the circum-œsophageal vessel. Along their whole length they are suspended in the prolongations of the cœlome already described. From the mid-dorsal region of the circum-œsophageal vessel a dorsal bloodvessel is given off, travelling down the middle of the proboscis surrounded by a tissue which, as already stated, appears to be nervous. This dorsal vessel breaks up into capillaries in the vicinity of the œsophagus.

Anal trees.—The anal glands or posterior nephridia are represented by two small, tuft-like masses situated one on each side of the posterior end of the intestine (Plate ix., fig.7). Each consists of a mass of very delicate, simple, cylindrical tubes opening separately into the rectum, whose walls in this region are thickened, while rather prominent ridges of tissue project into its lumen, giving the tube a star-like appearance in section. This is perhaps due to the presence of well-marked circular (sphincter) and longitudinal bundles of muscle fibres. The tubules are approximately circular in section with an irregular lumen. They consist of a single layer of elongate epithelial cells. Near its free end each tubule becomes narrowed before opening into the cœlome by a slightly dilated funnel fringed with long cilia (Plate x., figs. 13, 14, 15). The nephridia thus differ from those described in various species of *Bonellia*, in that the funnels are simple, unbranched tubes which open directly into the rectum, instead of into a large vesicle on each side.

The Ovary. - The mesenteric strands of muscular tissue which maintain the posterior portion of the rectum in position are very well developed and form the basis of the ovary (Plate ix., fig.2), whilst from the peritoneum lining them the ova are developed. The organ is slightly elongate transversely, and lies ventrally and laterally from the rectum. It thus has a position different from that described for *Bonellia*, where its main axis is longitudinal.

Spengel (1897, pp.360-373) gave a detailed account of the early development of the ova of *B. viridis*. We were not able to observe the early stages, while the later ones are different from those described by him. He gave an account of characteristic cell masses developing from the peritoneum lining the ventral bloodvessel, and forming each a spherical mass consisting of a relatively large central cell (which degenerates later) surrounded by a layer of small peripheral cells. It is from one of the latter that, according to him, the ovum develops at the expense of the remainder.

In our specimens the earliest stage observable shows this cell mass in its nine-celled condition, there being a slightly differentiated central cell present (Plate x., fig.16*a*). It is this latter cell that develops into the ovum. The cell mass grows quickly, the central cell outstripping the others, which become cubical and form a membrane, at first thick and closely fitting, but later thin and far separated from the central cell (Plate x., figs.16*b-e*). In these later stages, the central egg-cell can be seen to be actually connected by a stalk to the mesenteric strands. As the egg grows larger, it fills the space within the ring of accessory cells; and, continuing to grow, stretches this layer, which eventually comes to lie as a delicate membrane around the egg. The latter is now fully developed. At this stage the stalk evidently ruptures and the egg escapes. Within the cœlome, eggs may be seen with the small peripheral cell nuclei on their surface.

The ova pass forward and are received into the uteri. The peripheral egg membrane has by this time disappeared. In *Bonellia*, according to Spengel, it bursts before reaching the uterus. The eggs in the uteri are large cells, each with a prominent nucleus. They measure about 0·11 mm. in diameter, while the nuclei are about 0·037 mm. across. The latter contain large numbers of nucleoli. The egg cytoplasm is faintly granular, containing an outer clearer portion which is sometimes slightly and sometimes very highly vacuolated.

Anterior nephridia (*uteri*). There is a pair of uteri which, in the mature state, when laden with ova, are very prominent, projecting upwards and backwards from the anterior end of the ventral body wall (Plate ix., figs.2, 4). They are about 6 mm. in length, cylindrical in the middle, but tapering to a blunt point at the extremities. Each communicates with the cœlome by a nephrostome, borne at the end of a relatively thick tube which opens into the uterus ventrally, close to the posterior end (Plate x., fig.12). The rim of each nephrostome is prominent and is distinctly crenate. The proximal end of the tube projects slightly into the uterine cavity (Plate x., fig.9). Perhaps this arrangement serves as a means for preventing the return of eggs to the cœlome. In Plate x., fig.9, one may see this proximal invaginated portion in section lying within the uterine cavity.

Uteri from which eggs are absent are cylindrical; and in cross-section the lumen can be seen to be occupied by a meshwork of connective tissue trabeculæ which almost obliterate it in places. It is in this connective tissue that the eggs come to lie imbedded singly (Plate x., fig.9). Each uterus consists of an outer mass of tough connective tissue containing longitudinal muscle fibres. Internal to this is a highly developed, readily staining, glandular layer. The external uterine openings are close to one another on the ventral body wall, about 3 mm. behind the mouth.

Male tube (*andrœcium*).—As in *Bonellia* and *Hamingia*, the male is very degenerate. It is not, however, lodged in the œsophagus, uterus, or body cavity, as in these genera, but lives within a definite blindly-ending tube projecting into the cœlome, and opening on the ventral body wall between the two uterine apertures by a narrow muscular canal whose walls contain strong sphincter fibres. This remarkable structure we propose to call the *male tube* or *andrœcium*. Internally it is lined by a cubical epithelium, continuous through the aperture with the columnar epithelium of the body wall. The walls of the organ consist chiefly of the invaginated dermis and epidermis, but there is also a slight development of an inner circular and an outer longitudinal muscle layer, continuous with the corresponding muscle layers of the body wall. The oblique muscle layer is absent.

Male.—The male is an extremely degenerate, elongated organism which in transverse section may appear almost circular or nearly semi-circular. It is about 0·6 mm. in length and 0·12 to 0·16 mm. in maximum breadth. The anterior end appears more or less spherical, this portion being followed by a somewhat constricted region, the remainder of the worm being cylindrical, with a diameter approximately equal to that of the anterior portion. There are no ventral setæ. The epidermis on the anterior portion of the male is cubical; but posteriorly its cells are very elongated to form a prominent structure. In the mid-region of the body the cells are of an intermediate character.

Below the epidermis lies a thick mass of dermis ("trabecular layer" of Ikeda; "parenchyma" of Spengel) of a rather loose texture, surrounding the cœlome. It contains abundant lacunæ. In the posterior portion of the organism there is a definite system of longitudinal muscle fibres (subperitoneal musculature of Ikeda, 1907) lying in the dermis, close to the cœlome. They can be best distinguished in longitudinal section. In immature males the cœlome is practically obliterated, but in mature forms it is well developed, and may be divided into a small but almost spherical portion at the anterior end of the organism, joined by a very narrow canal with an elongated but not so dilated posterior part. No peritoneum could be detected lining the body cavity except the anterior dilatation.

The anterior portion of the cœlome lodges the sexual organs, alimentary canal and nerve. The last-named is very ill-defined, occurring as a slight prominence mid-ventrally, projecting into the cœlome from the ventral body wall. Nothing could be made out regarding its structure. It appears to be absent from the posterior part of the animal.

The alimentary canal is also extremely rudimentary, mouth and anus being absent. It lies in the front portion of the anterior dilatation of the cœlome, being recognisable as a short, vesicular, rudimentary structure with a rather definite lumen, and about 0·03 mm. in length. Its wall consists of comparatively large, clear cells, having pseudopodial processes projecting into the lumen in a manner somewhat like that figured by Ikeda (1907, p.10, Pl.2, fig.17). The digestive tract in *Pseudobonellia* appears to be the most degenerate so far known to occur in *Bonelliidæ*, as it consists of a minute spheroidal body, reminding us of one of the fragments figured by Ikeda (1907) in the male of *B. miyajimai*, in which there occur a large number of separate closed vesicles floating in the body cavity.

A few, highly-refracting, rounded cells are constantly present in the cœlome, and are probably to be regarded as representing chlorophyllous cells such as are described from the male of *B. viridis*. The posterior nephridia could not be detected, owing, at least in part, to the extremely small size of the organism.

The greater part of the remainder of the anterior part of the body cavity is filled with sexual elements. Two vesiculæ seminales occur. These are very short, prominent vesicles, or rather spheres, usually so dilated with mature sperms that it is impossible to make out the structure of their extremely thin walls. From the inner side of each of these vesiculæ, a very delicate short vas deferens is given off, travelling forwards and outwards to open independently to the exterior ventro-laterally at a little distance behind the anterior extremity.

The sperms are minute, tailed cells, with rod-like heads. Their formation is different from that of the ova; similar masses of central ("spermatophores") and peripheral cells are formed, but they lie in the anterior dilatation of the body cavity. Sperms do not arise directly from the central cell, but by modification of the peripheral cells. The central cell does not grow very large. When the sperms are fully developed, they separate from it. Numerous "sperm spheres" can be seen within the anterior cœlomic dilatation.

It has already been mentioned that the epidermis of the posterior third or half of the male is greatly modified. The cells, instead of being small and more or less cubical, become long and irregular, with spaces between them (Plate xi., figs.23, 24). Some appear to be branched at the extremity, but this effect is probably given by the irregularities of shape of adjacent cells. The whole of this region of the male is wedged into the end of the andrœcium in such a way that there appears to be a very intimate relationship between the two, amounting practically to a fusion. The epithelial cells lining the andrœcium are squames of about one-half the thickness of those lining the male body. These squames at the line of junction of the male and its tube become reflected over the male for a little distance, so that in section one sees a layer of cells of female origin, *i.e.*, those from the wall of the andrœcium, actually lying outside of, and closely adjacent to, the epithelium of the male. This is well shown in the oblique section figured on Plate xi., fig.23, where one part of the male is seen to be imbedded in the dermis of the andrœcium, while the remainder is enveloped by the epithelium of the latter, enclosing a part of the cavity of the male tube. Short finger-like prolongations of this cavity are also seen in section.

Here, then, is a most remarkable association between the sexes. Not only is the male a parasite as it is in *Bonellia*, but it lives in a special compartment lying between the two uteri. In *Bonellia* it is, moreover, a freely motile organism, while in *Pseudobonellia* the posterior half of the male becomes actually surrounded by female tissues so that the parasitism is of a very much more pronounced type. The whole of the male apparatus is lodged in the cœlome of the tiny, spherical, anterior quarter of the animal. This part is connected with the attached region by a zone whose cœlome is very narrow. The posterior region reminds us of a placenta by means of which, no doubt, the male is nourished by the female. Associated with this apparently sessile existence, there is a very poorly developed musculature, and the alimentary system is almost obliterated, while the nervous system is extremely rudimentary.

If our interpretation be correct (and it is based on a study of a number of males, both mature and immature, in whole mounts as well as in transverse and longitudinal sections), then the male of *Pseudobonellia* is an extraordinarily degenerate organism. How it performs its sexual functions is not known. Perhaps the sperms may be liberated into the cavity of the andrœcium whence they reach the exterior through its canal and enter either of the adjacent uterine openings. It is, however, quite likely that the male may be protruded through the canal of the andrœcium and actually liberate sperms into the female apertures.

W. Kellicott, in his Textbook of General Embryology (1914, pp.106-7), drew attention to a series of organisms showing various grades between fully developed males and females on the one hand, and a fully developed animal of only one sex, with its partner more or less parasitic on, or in it, on the other hand; the final stage being reached in hermaphrodite self-fertilising flatworms; in other words, the sex relationship may be followed through successive stages of symbiosis and parasitism, and, perhaps, incorporation of one sex in the other (hermaphroditism). The series mentioned by Kellicott includes the following:— Certain Cirripede species in which there is a diminutive complementary male living parasitically on the hermaphrodite form; *Bilharzia*, in which the elongate female lives in a canal on the ventral surface of the male which is wrapped partly round it; the permanent fusion of two hermaphrodites (*e.g.*, *Diplozoon*) in such a way that the female duct of each becomes continuous with the male canal of its partner; or the fusion of a male and a female, *e.g.*, the gape worm of poultry, *Syngamus;* while an extreme type is to be found in another parasitic nematode, *Trichosomoides crassicauda* where the female harbours one or more males in its uterus. He goes on to state that one might say that the true climax is reached in self-fertilising hermaphrodites.

We think that two stages between the conditions found in the last-mentioned two worms can be exemplified by *Bonellia* and *Pseudobonellia*. In *Trichosomoides*, the males, though somewhat degenerate, are provided with a definite alimentary canal extending from the anterior end to the anus. In *Bonellia*, however, the male is a ciliate, planarian-like parasite frequenting the œsophagus or uterus (or, in one case, the cœlome) of the female; but it has neither mouth nor anus, and its alimentary canal exhibits various degrees of atrophy. In other words, parasitism has gone further than in the case of the nematode. In *Pseudobonellia*, as we have already seen, degeneracy has proceeded still further, and the male is little more than a sperm-producing apparatus partly incorporated in the female tissues. Complete fusion would produce a hermaphrodite condition, but we do not think it likely that hermaphroditism would arise in that way, since the male system would require to retain at least a part of its own nerve system for its innervation.

The outstanding features of the remarkable species now described may thus be summarised :—*Female:* Bonellia-like form; the presence of two to four setæ; two well developed and functional uteri; simple anal glands opening directly into the rectum, *i.e.*, there are no definite anal vesicles; posterior transverse position of ovary; a siphon associated with the intestine; presence of an invagination (andrœcium or male tube) within which only one male is lodged. *Male:* extremely degenerate and apparently partly fused with the female; possessing two functional vesiculæ seminales; hooks absent. Such features are of sufficient importance to justify the erection of a new genus, *Pseudobonellia*, within the family *Bonelliidæ*, with generic characters as above stated. Type species, *P. biuterina* Johnston and Tiegs, 1919.

The form of the body and proboscis, as well as many of its internal characters, separate the genus from *Thalassema* and *Hamingia*, but relate it to *Bonellia*; while the presence of two uteri, a male tube and a siphon in the female, and two vesiculæ in the male separate it from the last-named. The absence of hooks or ventral setæ in the male has been noted in the case of some species of *Bonellia*, while the presence of more than two in the female has been recorded in the case of one species, viz., *B. miyajimai*, by Ikeda (1907, p.3, Pl.2, fig.6), who reported the occurrence of no less than twenty-nine small ones.

Typical specimens of *P. biuterina* are being deposited in the Australian Museum, Sydney, and the Queensland Museum, Brisbane.

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a.g., anal glands (posterior nephridial tubes); *b.w.m.*, body wall of male; *c*, cœlome; *c.c.*, central cell; *ci*, cilia; *c.corp.*, cœlomic corpuscle; *c.m.*, circular muscles; *c.p.*, cœlomic prolongations into proboscis; *c.u.*, cœlomic opening of uterus; *d.*, dermis; *d.b.v.*, dorsal bloodvessel; *e.*, egg; *e.m.*, epithelium of male; *e.m.m.*, modified epithelium of male; *e.m.t.*, epithelium of male tube; *ep.*, epithelium; *g.c.*, gland cells; *g.l.*, glandular layer; *i.*, intestine; *i.l.*, intestinal lumen; *i.w.*, intestinal wall; *l.*, lacunæ in body wall; *l.b.v.*, lateral bloodvessel of proboscis; *l.m.*, *l.m.*1., *l.m.*2., longitudinal muscle; *l.n.*, lateral nerve of proboscis; *m.*, male; *m.a.*, one of the male apertures; *m.c.*, cœlome of male; *mes.*, "mesentery"; *m.m.*, modified body wall musculature in vicinity of a uterine aperture; *m.t.*, male tube (andrœcium); *m.t.c.*, cavity of male tube; *m.t.o.*, opening of male tube to exterior; *m.t.w.*, wall of male tube; *n.*, nerve; *neph.*, nephrostome of anal tubule; *o.*, ovum; *œs.*, œsophagus (pharynx); *o.m.*, oblique (inner circular) muscle; *ov.*, ovary; *p.*, papilla; *p.c.*, peripheral cell; *per.*, peritoneum; *r.*, rectum; *s.*, setæ; *s.b.*, sperm ball; *s.f.*, siphonal folds; *s.t.*, siphonal tube;

u.c., uterine cavity; *ut.*, uterus; *u.i.*, inner part of uterus; *u.o.*, outer part of uterus; *u.n.*, funnel (nephrostome) of uterus, communicating with the coelome; *v.b.v.*, ventral blood vessel; *v.d.*, vas deferens; *v.g.p.*, ventral groove of proboscis; *v.n.c.*, ventral nerve cord; *v.s.*, vesicula seminalis; *x.*, nervous(?) tissue associated with dorsal blood vessel of proboscis; *y.*, pit surrounding uterine openings.

EXPLANATION OF PLATES IX.-XI.

Plate ix.

Fig.1.—Female of *Pseudobonellia biuterina:* ventral view (slightly magnified).

Fig.2.—Female, showing anatomy (× about 3). The uteri were empty in the specimen figured.

Fig.3.—Setae.

Fig.4.—Sketch showing relations of uteri, male tube, oesophagus and nerve cord.

Fig.5.—Portion of proboscis (diagrammatic).

Fig.6.—T.S. proboscis.

Fig.7.—Rectum and anal funnels.

Plate x.

Fig.8.—T.S. body wall of female.

Fig.9.—Body showing male tube, two parts of a uterus, two intestinal loops, and the siphon.

Fig.10.—Part of intestinal wall with associated siphonal folds with which the siphon becomes subsequently connected.

Fig.11.—As in Fig.10, but showing the siphon in process of fusion with the siphonal folds.

Fig.12.—Uterus, side view, diagrammatic.

Figs.13, 14.—Two views of posterior nephridial tubes.

Fig.15.—Two sections across such tubes.

Fig.16*a*, *b*, *c*, *d*, *e*.—Successive stages in the development of the ovum: *c* shows section through stage *b*.

Fig.17.—Developing sperms.

Plate xi.

Fig.18.—T.S. androecium and associated structures (female body wall, uterus, nerve).

Fig.19.—T.S. androecium and male.

Fig.20.—Oblique longitudinal section of body wall, androecium and male, showing mode of attachment of the posterior end of the male to the distal portion of the male tube.

Fig. 21.—Anterior end of male in oblique longitudinal section.

Fig. 22.—View of male in andrœcium, showing relation to body wall of female.

Fig. 23.—T.S. distal portion of male showing intimate relationship between that portion and the surrounding tissues of the andrœcium (oil immersion).

Fig. 24.—L.S. ditto (oil immersion).

Figs. 18 and 20 have been drawn to the same magnification; 19 and 21; 23 and 24.

A FOSSIL INSECT WING BELONGING TO THE NEW ORDER PARAMECOPTERA, ANCESTRAL TO THE TRICHOPTERA AND LEPIDOPTERA, FROM THE UPPER COAL-MEASURES OF NEWCASTLE, N.S.W.

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

(Plates xii.-xiii., and eight Text-figures).

The working out of Mr. John Mitchell's Collection of Fossil Insects from the Upper Coal-Measures of Newcastle, New South Wales(**4**), proved the existence of Holometabolous Insects in Palæozoic times, the genus *Permochorista* from Belmont being an undoubted Mecopteron, closely allied to, and almost certainly directly ancestral to, the genus *Tæniochorista* found in Australia at the present day. That being so, the great importance of these fossils to science became at once evident; since further discoveries would almost certainly throw new light upon the all-important problem of the origin of the Holometabola. I therefore arranged with Mr. Mitchell to visit the Belmont Beds, in order to see for myself the place where he had found the fossils.

In my previous paper (**4**, p.723), I gave a figure of a vertical section through the Upper Coal-Measures, showing the exact position of the Belmont Beds within them. As there stated, they lie about 600 feet below the top of the Upper Coal-Measures, and may therefore be regarded as of Upper Permian age. I can now add a few impressions of the Beds themselves as I saw them.

Some two miles back along the Newcastle Road from Belmont, there has been quarried out from the top of a low, wooded hill a quantity of hard, cherty shale. This was made use of for a time for mending the road, but was found unsuitable, so that the quarry was soon abandoned. The band of cherty shale is nowhere more than a yard thick, and is only uncovered in an irregular manner for some fifty yards or more; so that the amount of material at present available for fossil-hunting is very small. Mr. Mitchell, a friend, and myself worked through a large quantity of it in one day, the only result being the discovery of another wing of *Permofulgor* in excellent condition; this fell to Mr. Mitchell's hammer. The rock splits sometimes with a plane, and sometimes with a conchoidal fracture. The plant-remains consist chiefly of *Glossopteris* in an excellent state of preservation. Occasional specimens of the small Crustacean *Leaia mitchelli* Eth., are also found. The fronds of *Glossopteris* are never closely crowded together; usually not more than one or two will be found within a large hand-specimen of rock. Thus the conditions are ideal for the preservation of insect wings; for these, when they occur, likewise lie quite free from plant-remains, and the impressions that they have made on the hard rock are almost as good as one could hope for. Against this it has to be borne in mind that insect-remains are very rare indeed at Belmont, and one is indeed fortunate if, as the result of a hard day's work, a single wing falls to one's lot.

My visit to Belmont took place in June, 1918. While staying with Mr. Mitchell at Waratah, he very kindly looked over some old material from Belmont and Glenlee, with the result that several insect wings were found and handed to me to describe. These will be dealt with in a separate paper later on.

Mr. Mitchell again visited the Belmont Beds in February of this year. As a result of two days' work, a single wing was found, very beautifully preserved, and almost perfect. This was sent at once to me, Mr. Mitchell being unable to determine it, and thinking that it might turn out to be something good. It is this wing that forms the subject of this paper. It is indeed a wonderful discovery, and one upon which Mr. Mitchell is greatly to be congratulated. For it solves, as it were at a single stroke, the long-vexed question of the origin of the Trichoptera and Lepidoptera: while at the same time throwing a flood of light upon the probable origins of the other Panorpoid Orders.

As this wing is of such great scientific interest, it was decided that it should be dealt with in a separate paper, while the remaining Belmont fossils might reasonably be postponed to a later date, although they were discovered earlier than the one here dealt with.

The characters of the wing are such that it cannot be placed in any known Order, either fossil or recent It is undoubtedly allied to the Mecoptera and Protomecoptera, on the one hand, and to the Trichoptera and Lepidoptera on the other. Its relationships with the first two Orders mentioned are *collateral*, as will be clearly seen when we come to compare it with *Permochorista* from the same Beds. With the Trichoptera and Lepidoptera, on the other hand, its relationships are definitely *ancestral;* a comparison of the fossil wing with *Rhyacophila* and *Micropteryx* will show quite clearly that both these types can be directly derived from the fossil by reduction, without a single discordant character. That being so, we are now able to state definitely, not only that the Mecoptera (and, of course, the Triassic Protomecoptera also, though not yet found in Palæozoic strata) were in existence in Upper Permian times, but that the Trichoptera and Lepidoptera were not then differentiated, being represented by a common ancestral type closely allied to the Mecoptera, such as we find in this fossil.

The above relationships have suggested to me the name Paramecoptera for the new Order. Not only does this name indicate the collateral evolution of the new type alongside the Mecoptera, but it also allows future entomologists, should they so desire, to merge the new Order into the Mecoptera, together with the Protomecoptera; so that a single Order Mecoptera, with its characters defined on a wider basis, may one day be made to include the three Suborders Paramecoptera (Permian), Protomecoptera (Triassic), and Eumecoptera (fossil and recent), these last being the true Mecoptera, or Scorpion-flies, as at present understood. For the present, however, the difficult task of the Phylogenist in these groups can only be undertaken with clearness if these new types, about which we know so little, are given distinct ordinal rank, thus marking out clearly, and without any ambiguity, the venational characters of each separate type within the complex of the Panorpoid Orders. That being so, I propose to define at once the new Order, and to describe the fossil wing placed within it. A full discussion of its relationships will follow this description.

Order **PARAMECOPTERA**, ordo nova.

Fossil insects belonging to the Subclass Panorpoidea, and having the same general venational scheme as those of the older existing types within the Trichoptera and Lepidoptera, but with a larger number of branches to both Rs and M. The *posterior arculus* well developed, its connection with the cubitus being of the same nature as in the *Rhyacophilidæ* and the Homoneurous Lepidoptera. No separate costal vein. Rs dichotomously branched, with at least seven separate branches on the wing-margin. M dichotomously branched, with five separate branches on the wing-margin. Cu three-branched (as in Megaloptera, Trichoptera, and Lepidoptera). Cu_1 having an apical fork, while Cu_2 is a weak, concave, simple vein. Anal veins simple. System of cross-veins the same as that of the older Trichoptera, with a few additions; no development of regularly spaced cross-veins at intervals, as in the true Mecoptera.

Family BELMONTIIDÆ, fam.nov.

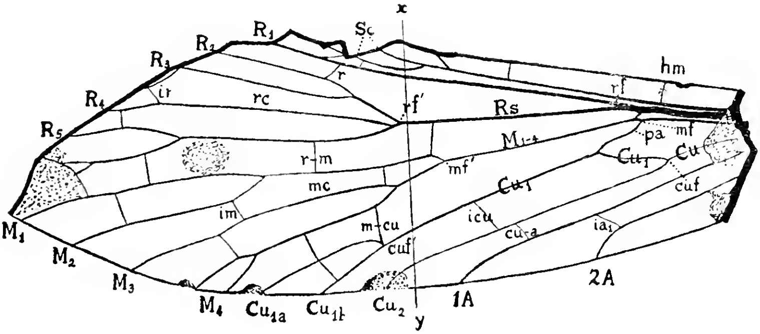
Moderate-sized insects with fairly long and narrow wings. Costal space narrow, with humeral cross-vein present. Both radial and median cells closed. The dichotomy of R_{4+5} into R_4 and R_5 takes place very close to the first dichotomy of Rs into R_{2+3} and R_{4+5}. Median fork at about two-fifths from base of wing; three cross-veins between Rs and M_{1+2} or M_1, also a short basal cross-vein from R to M, just distad from origin of posterior arculus.

Genus BELMONTIA, n.g.

(Plates xii.-xiii.; Text-figs.1-3).

Forewing:—Subcosta forked distally, ending up at about half the wing-length; costal space with two extra veinlets between the humeral cross-vein and Sc_1. R_1 connected with Rs by a single cross-vein below end of Sc_2. Radial cell irregular, elongate, six-sided, the two most distal sides being the basal portion of R_{3}, and the inter-radial cross-vein respectively. R$_3$ and R$_5$ both forked, the posterior portion of R$_5$ (*i.e.*, R$_{5b}$) again forked distally. R$_4$ connected with R$_{5a}$ by a single cross-vein. Median cell narrow, elongated, six-sided, closed distally by the inter-median cross-vein, and crossed internally by an extra cross-vein at its basal third. Apical fork between M$_1$ and M$_2$ crossed by an extra cross-vein; the same is true of the apical fork between M$_3$ and M$_4$, but the cross-vein descends upon the upper branch of a small fork made by the bifurcation of M$_4$ into two veins distally. Cu$_1$ forks at a level about half-way along the wing, the fork being supported by a cross-vein from M$_4$ directly upon it. Apical fork between Cu$_{1a}$ and Cu$_{1b}$ crossed by an extra cross-vein, which is continued above to M$_4$. Single cross-veins, as usual, connect the branches of Cu and the anal veins. (Third anal vein and jugal lobe missing in the fossil, also a portion of the apical area of the wing).

Genotype, *Belmontia mitchelli*, n.g. et sp. (Upper Coal-Measures of Newcastle, N.S.W.).



Text-fig. 1.

Belmontia mitchelli, n.g. et sp., forewing (× 6). Upper Permian of Belmont, N.S.W. *xy* indicates the line along which the rock was broken in two. For rest of lettering, see Text-fig. 2, p. 238.

BELMONTIA MITCHELLI, n.sp. (Plates xii.-xiii.; Text-figs. 1-3).

This species is represented by a single forewing, as shown in Plate xii. and Text-fig. 1. The extreme base is covered over by a small piece of rock which, owing to its conchoidal fracture, cannot be removed without serious risk of damaging the specimen. The rock has also broken away obliquely at the opposite end of the wing, so that an apical portion carrying the distal ends of all the branches of R and Rs is missing. Besides this, Mr. Mitchell informs me that, in trying to clear the base of the wing, he unfortunately broke the rock in two, transversely across the middle of the wing; the two parts have, however, been carefully glued together, so that the break is barely noticeable. This break is indicated by the line *xy* in Text-fig.1.

Total length of preserved portion of wing, 16 mm.; *greatest breadth*, 5·5 mm. Approximate total length of complete wing, 20 mm. The impression is that of a forewing, and is the *mould*, not the cast; this is proved by the fact that the strongly convex veins R and Cu_1 appear as deep grooves instead of raised ridges. Consequently, although the apex of the wing lies to the left in the fossil, the wing itself was the *right* forewing.

The venational characters have all been included in the generic definition given above. Besides these, it may be added that the main veins mostly show, under a good oblique light, the bases of macrotrichia; but these cannot be seen on the cross-veins. The membrane was evidently very thin, as usual also in Trichoptera and many Lepidoptera, and shows the peculiar oblique rucking and stretching usual in fossils of these Orders and also in the Diptera. A very careful examination reveals slight traces of an archedictyon in places, apparently with some rather small macrotrichia upon it; but these indications are scarcely more than would be seen if the meshwork were in the last stage of aphantoneurism.

In Text-fig.1, the base of the wing is represented as cut off in the conventional manner; but as a matter of fact the wing disappears along the basal break *underneath* a portion of rock some 1½ mm. higher than the level of the wing itself.

Type in Mr. John Mitchell's Collection. *Label*, "No. 40, Wing. Loc. Belmont. Coll. J. Mitchell," on back.

Locality, Belmont Beds, Upper Coal-Measures, near Newcastle, N.S.W. (Upper Permian).

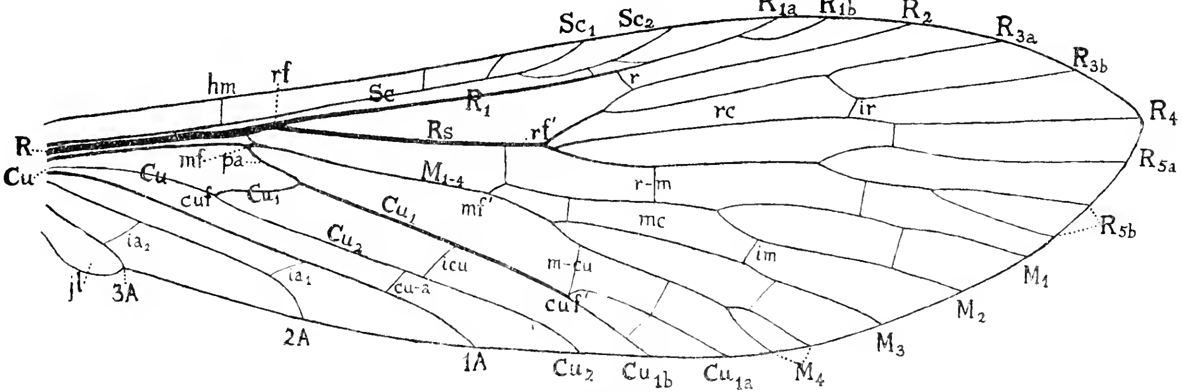
Restoration of the Fossil Wing. (Text-fig.2).

It will be seen at once, from Text-fig.1, that practically all the essential parts of this wing have been preserved. This makes the task of restoring it an easy one. Most of the wings of Holometabolous insects so far found have been incomplete, or obscure, as regards the venation of the basal part of the wing. Hence it is a particular piece of good fortune that the posterior arculus and its surroundings have been perfectly preserved in this fossil. The only vein missing is the short 3A, with the jugal lobe lying basad from it. In restoring this part, I have assumed a simple 3A, connected with 2A by a single cross-vein, in the same way that 2A is itself connected with 1A The jugal lobe has been restored on the primitive plan, as in *Chorista*, and I have omitted the jugal bristles, since these are not known to be present outside the true Mecoptera. Mr. Mitchell hopes later on to make another attempt to remove the rock covering this part of the wing; but the risks attaching to such an attempt are so great, that it is necessary to describe the fossil as it stands first of all, in case of damage later on.

In restoring the apical part of the wing, I have introduced no more forkings to the branches of Rs than can already be seen in the fossil, *i.e.*, each vein has just been produced to the apical margin. The spacings between them show that this is almost certainly correct. In the case of R_1, however, there is a wide space to be filled up between Sc_2 and R_2, so that I have introduced a distal forking to this vein. The apex itself I have made slightly pointed, as this type of wing is much more representative of the older types of Trichoptera and Lepidoptera than is the rounded wing, which predominates in the true Mecoptera. Whether there were any extra apical cross-veins it is impossible to say; but I think it very unlikely. The restored right forewing is shown complete in Text-fig.2.

Affinities of the Fossil. (Text-figs.3-8).

In his recent work upon the Wings of Insects(**1**), Professor Comstock rightly insists upon the importance of the presence of the *posterior arculus* in the forewings of the more archaic Tri-



Text-fig.2.

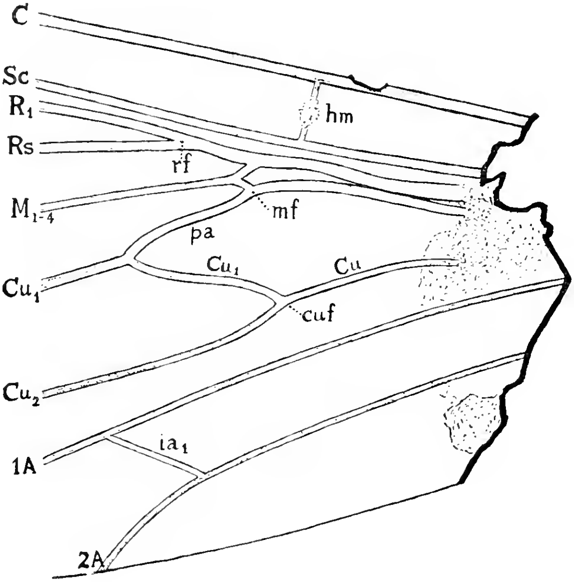
Belmontia mitchelli, n.g. et sp., forewing, restored, (×7½). Upper Permian of Belmont, N.S.W.

1A, 2A, 3A, the three anal veins; Cu, cubitus; Cu_1, Cu_2, its two primary branches, separating at the primary cubital fork, *cuf;* Cu_{1a}, Cu_{1b}, the two branches of Cu_1, separating at the secondary cubital fork, *cuf'*: *cu-a*, cubito-anal cross-vein; *hm*, humeral veinlet; ia_1, ia_2, inter-anal cross-veins; *icu*, inter-cubital cross-vein; *im*, intermedian cross-vein, closing the median cell, *mc*; *ir*, inter-radial cross-vein, closing the radial cell, *rc*; *jl*, jugal lobe; M, media; M_{1-4}, M_5 (=*pa*) its primary branches, separating at the primary median fork, *mf;* M_{1+2}, M_{3+4}, secondary branches of M_{1-4}, separating at the secondary median fork, *mf'* (sometimes called the *thyridium*); *m-cu*, medio-cubital cross-vein; *mc*, median cell, closed by *im; pa*, the so-called posterior arculus, $=M_5$; R, radius; R_1, Rs, its primary branches, separating at the primary radial fork, *rf;* the posterior branch, Rs, is called the *radial sector:* R_{1a}, R_{1b}, branches of R_1; R_{2+3}, R_{4+5}, the two principal branches of Rs, separating at the secondary radial fork, *rf'*; R_2, R_3, R_4, R_5, the four secondary branches of Rs; R_{3a}, R_{3b}, branches of R_3; R_{5a}, R_{5b}, branches of R_5; *r*, radial cross-vein, from R_1 to Rs; *r-m*, radio-median cross-vein; *rc*, radial or discoidal cell, closed by *ir;* Sc, subcosta; Sc_1, Sc_2, its two distal branches.

choptera and in the *Micropterygidæ*. This character is also to be found in the *Hepialidæ*. In studying the pupal wings of Lepidoptera, the same condition can be seen to exist throughout the Order, the bend of Cu_1 being distinctly shown, with the posterior arculus, usually devoid of a trachea, above it. In the imagines of the more advanced types of both Trichoptera and Lepidoptera, the posterior arculus cannot usually be recognised, as it becomes obliterated by further specialisation in this region of the wing.

In naming this formation the *posterior arculus*, Comstock assumes that it is the homologue of the posterior portion of the complete arculus found in the Odonata, *i.e.*, that it is formed from a cross-vein descending from M to Cu, which later on becomes specialised as a strong oblique connection carrying Cu_1 back basally to join M. Another possibility is that the posterior arculus is really the remnant of the posterior branch of the first dichotomy of M; in other words, that it is the homologue of M_4 in the Odonata. If this be so, then this branch of M must very early have united with Cu_1 not far from its origin, in the same manner that M_4 united with Cu_{1a} later on in the Lepidoptera, and M_{3+4} with Cu_1 in the Planipennia. If this latter supposition be true, then the correspondence between the media in Zygopterous Odonata and in the Trichoptera and Lepidoptera is exact, both having five branches similarly placed, and the primitive dichotomic branching being still preserved in the *Synlestinæ*. Only the notation is different, the branches in the Zygoptera being called M_1, M_2, Ms, M_3, and M_4 respectively; whereas, in the other Orders, they are M_1, M_2, M_3, M_4, and M_5, the latter being the posterior arculus.

The evidence as to whether the posterior arculus is really a branch of M, or only a specialised cross-vein, has hitherto been inconclusive. On the one hand, we find that, in the freshly turned pupæ of *Hepialidæ*, *Cossidæ*, and other archaic Lepidoptera, the posterior arculus is marked by a very distinct pale band, not traversed by any trachea; on the other, a distinct trachea can generally be seen to have grown out into it from near the base of M, in pupæ of more advanced age. This trachea sometimes increases in length, and may be seen traversing the cubitus in the imaginal wing. Again, in most species of *Rhyacophila* (rightly regarded as being one of the most archaic of existing Trichopterous genera), the posterior arculus is well developed; but other species exist in which it is reduced to a short cross-vein, or even obliterated by complete fusion of M with Cu_1. Which of these conditions is the most archaic?



Text-fig. 3.

Belmontia mitchelli, n.g. et sp., to show the preserved portion of base of forewing, enlarged, (× 17). Upper Permian of Belmont, N.S.W. For lettering, see Text-fig. 2, p. 238.

In our new fossil, as can be seen from Plate xiii. and Text-fig. 3, the posterior arculus appears as a very strongly formed convex vein. If it is a cross-vein, then it is very different from any other cross-vein in the wing, since all the others are much more weakly chitinised. Now I have already shown, in a previous paper (5), that, in all archaic Panorpoid types, macrotrichia are present upon the main veins and their branches, but are absent from the true cross-veins. We have, then, a test in this fossil: does the posterior arculus carry macrotrichia or not? The basal two-fifths of this vein are unfortunately not very well preserved, but the remainder is in excellent preservation, and *the bases of at least two macrotrichia can be seen upon it.* One of these is very beautifully preserved, and is indicated by the large arrow placed just below it in Plate xiii., fig.3. The other can just be made out, a little higher up, in the same Plate, but is not very distinct. Similar bases of macrotrichia can be seen upon the other main veins of the wing; a particularly good one can be picked up on Cu_1 by following the main stem of the same arrow in Plate xiii., fig.3, backwards. These bases are more abundant and better preserved in the apical part of the wing, where the veins are, on the whole, more clearly defined.

It seems evident, therefore, that the posterior arculus must be rightly considered as having been originally M_5, and the exact homologue of M_4 in the Zygopterous Odonata. If so, then the vein that we now call Cu_1 may well be actually $M_5 + Cu_1$, and its distal forkings may be due to incomplete fusion of the two veins M_5 and Cu distally, Cu_{1a} being really the distal portion of M_5, and Cu_{1b} the distal portion of Cu_1. It should be noted that the term *posterior arculus* is a misnomer, if this be really the case; for it is the *anterior* part of the arculus in Odonata that is formed from M, the posterior part being a cross-vein. Also the point of origin of M_5 should be rightly designated the *primary median fork* (*mf*), while the point at which M_{1-4} divides into M_{1+2} and M_{3+4}, hitherto designated *mf* (sometimes called the *thyridium*), must be regarded as the *secondary median fork* (*mf'*).

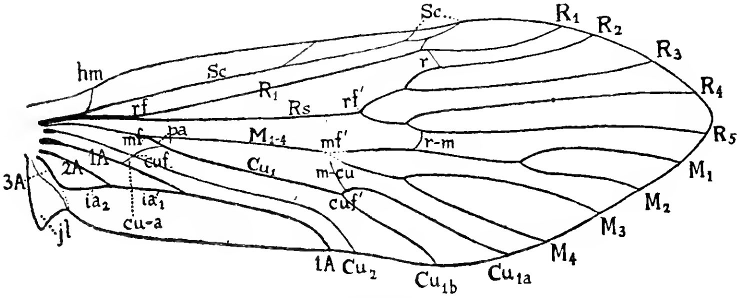
I would suggest that the term posterior arculus should be no longer used for the vein in question, and that it be simply designated the *arculus*, with the notation *arc* or M_5.

An examination of the arculus in the Caddis-fly *Rhyacophila dorsalis* Curtis, reveals the fact that, in this insect also, this vein carries macrotrichia. This is in agreement with the evidence from the fossil, so that there can really be little doubt that we are dealing with a true branch of the media.

But, whatever view we may take as regards the true nature of the vein forming the arculus, we have to face the fact that it is present in our new fossil, and more strongly formed than in any other known type within the Panorpoid Orders, either fossil or recent. Now the arculus, in the form in which we find it in this fossil, is typical of the oldest existing Trichoptera and Lepidoptera. It does not occur in the Mecoptera, with the single exception of the Triassic fossil *Stereochorista*(7). In the Diptera, the arculus is present, but of different form from that in the fossil; in the Megaloptera and Planipennia, it has not yet been shown to occur at all. The conclusion, then, is obvious, that *our fossil must be closely related to the archaic types of existing Trichoptera and Lepidoptera.*

(i.) *Affinity with the Trichoptera.*

We may take the forewing of *Rhyacophila dorsalis* Curtis, (Text-fig.4) as a good example of the wing of an archaic Caddis-fly. Comparing this closely with the wing of *Belmontia*, it will readily be seen that the wing of the Caddis-fly can be directly derived from that of the fossil, simply by reduction of certain parts.



Text-fig.4.

Rhyacophila dorsalis Curtis, forewing, (× 8). Scotland, recent; Order Trichoptera. For lettering, see Text-fig.2, p.238.

The resemblance between the subcostal veins of the two wings is very striking. Both have the humeral cross-vein, the distal dichotomy, and an oblique vein towards the distal end of the costal space. Only in *Belmontia* there is an extra veinlet not present in *Rhyacophila*, and the subcosta of the latter extends to about three-fifths of the length of the wing, as against one-half in *Belmontia*. This difference could easily be removed in the course of evolution, either by actual growth of Sc, or by a reduction in the length of the apical portion of the wing.

In spite of the extra veins present in the radial area of *Belmontia*, the resemblance of this part of the wing to that of *Rhyacophila* is very striking. In both, R_1 is connected with Sc_2 above, and with R_2 below, by cross-veins in closely similar positions. The form and manner of origin of R_{2+3} is practically the same in both; but *Belmontia* possesses an extra vein, R_{3b}, which has been completely eliminated from *Rhyacophila* and all other Trichoptera. The common stalk R_{4+5} is exceptionally short in *Belmontia*. But the tendency of such stalks throughout the whole of the Orders Trichoptera and Lepidoptera is to lengthen; so that the condition found in *Rhyacophila* is a natural derivative from this, as part of the same process by which the extra branches of R_5 have also been eliminated. Cross-veins are absent from this part of the wing in *Rhyacophila*; but there are many other existing genera of Trichoptera in which the interradial cross-vein (*ir*) is present, closing the radial or discoidal cell distally.

In *Belmontia* there are four cross-veins between R, or Rs, and M. One of these lies just above the origin of the arculus, and is absent from *Rhyacophila*. The other three connect Rs or its most posterior branches with M_{1+2} or M_1. Only the middle of these three (*r-m*) remains in *Rhyacophila*.

The media itself is very similar in *Belmontia* and in *Rhyacophila*, the only difference being the extra distal forking of M_4 in *Belmontia*. The position of the median fork (*mf*), not far from the middle of the wing, and the relative positions of the distal forkings, are much the same in both. In *Belmontia*, as in numerous existing genera of Trichoptera, though not in *Rhyacophila*, the median cell (*mc*) is closed by the inter-median cross-vein (*im*); there is also a cross-vein within this cell itself, and cross-veins connecting M_1 with M_2, and M_3 with M_4, respectively, which are absent from all recent Trichoptera.

Of the cross-veins connecting M_4 with Cu, *m-cu* is present in

Rhyacophila, but has moved slightly basad, to take up a more advantageous position at the actual forking of M_{3+4} into M_3 and M_4. The more distal cross-vein, with its continuation across Cu_{1a} to Cu_{1b}, is missing in *Rhyacophila*, as in all existing Trichoptera.

The general scheme of the cubitus is the same in *Belmontia* and in *Rhyacophila*. The cubital fork (*cuf*) lies at a level slightly basad from the origin of *pa*, and the bent portion of Cu_1 arising from the fork is similar in both. The course of the strong, straight, convex vein Cu_1 beyond its junction with *pa* is the same in both; but the apical fork of this vein is larger in *Rhyacophila* than in *Belmontia*. It is quite clear that a slight movement of the median fork distad, with reduction of the fourth apical fork (between M_3 and M_4), correlated with a slight movement of the secondary cubital fork (*cuf'*) basad, and consequent change in the position of *m-cu*, would account for the changes in this region, and could easily have taken place during the period of time elapsing between the Upper Permian and the first appearance of *Rhyacophila* and its allies.

The intercubital cross-vein (*icu*) is absent from *Rhyacophila*, but present in *Belmontia*; the cubito-anal cross-vein (*cu-a*) is present in both, but has moved much further basad in *Rhyacophila*.

Finally, in *Rhyacophila*, as in all existing Trichoptera, the anal area of the forewing has undergone very high specialisation, the three anal veins having become linked up with one another by loss of the distal ends of 2A and 3A, and incorporation of the cross-veins ia_1, ia_2 in the complex trifurcate vein that is found universally in this region of the forewing of all true Trichoptera. The condition of the anal area in *Belmontia* is the typical archaic condition, from which it has long been clearly evident that such a type of specialisation must have been originally derived.

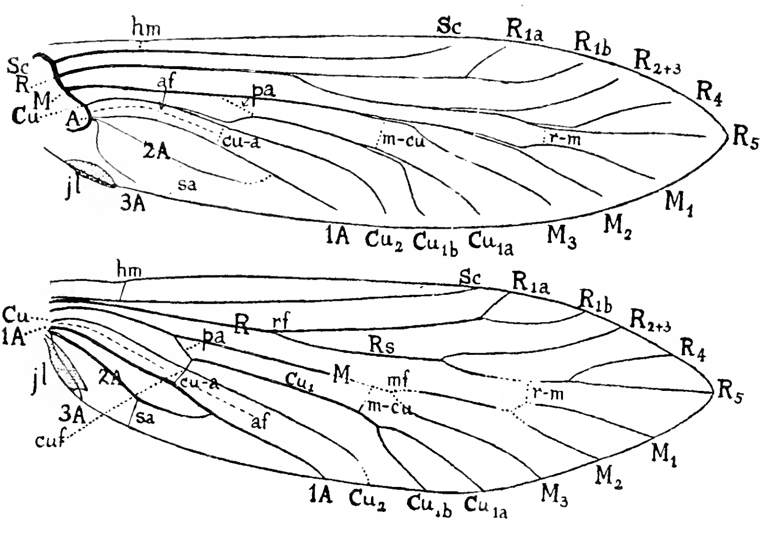
Unfortunately the area of the jugal lobe, if such exists, is covered over in the fossil; so that we cannot say definitely whether it was triangular, as in *Rhyacophila*, or rounded and less prominent, as in *Chorista* and allies.

Summing up the above evidence, it is quite clear that there is not a single character in the venation of *Belmontia* which precludes its being accepted as the actual ancestor of *Rhyacophila*, and of the whole Order Trichoptera, as now constituted. I do not wish, however, to claim that this newly discovered genus *Belmontia* is itself the *actual ancestor* of that Order; it is quite sufficient to state that *it is the first known representative of a new Order Paramecoptera from which the Trichoptera are undoubtedly derived.* I do not think that the Trichoptera originated in or near Australia; most certainly the *Rhyacophilidæ* themselves did not. That being so, we must think of the Paramecoptera either as having existed in other parts of the world also, in Upper Permian times, or as having spread thither from Australia during the Lower Trias. It would then be from some more specialised and reduced type, within the Order, that the true Trichoptera must have been actually derived.

(ii.) *Affinity with the Lepidoptera.*

Let us now turn our attention to the Lepidoptera Homoneura, and compare *Belmontia* with one of the *Micropterygidæ*. For this purpose, I shall figure the *pupal wing-tracheation* as well as the *imaginal venation* of the forewing of the genus *Eriocrania*. (Owing to the reduction of the pupal wing-tracheation in all Trichoptera, this comparison could not be made in the case of *Rhyacophila*). This shows that the condition of the cubitus and anal veins, together with the position of the arculus, is closely similar in this pupal wing and in the fossil. In the region of M, of course, *Eriocrania*, like all other Lepidoptera, lacks a separate M_4, and is thus more highly reduced than *Rhyacophila*. The loss of one of the four usual branches of Rs is peculiar to *Eriocrania*; the missing branch is present in its ally *Mnemonica*, as well as in *Sabatinca* and *Micropteryx*. The forking of Sc into Sc_1 and Sc_2 is retained in *Sabatinca*, *Micropteryx*, and *Mnemonica*, while R_1 also is forked in the first and last of these three genera. The radial cell is closed distally by the cross-vein *ir* in *Sabatinca* and *Micropteryx*, and the primitive dichotomic branching of Rs is preserved in both these genera. In the other genera of the family, the radial cell is open, and the primitive dichotomy is generally lost.

It will scarcely be necessary to pursue this comparison any further, seeing how closely comparable the general venational schemes of archaic Trichoptera and Lepidoptera admittedly are. For those who wish to make detailed comparison of the venation of *Micropterygidæ* with that of *Belmontia*, reference may be made to the figures in my paper on this family (**6**); the same paper indicates the connection between the venational type of the *Micropterygidæ* and that of the *Hepialidæ*, and so with all Lepidoptera.



Text-fig. 5.

Eriocrania semipurpurella Steph., forewing, pupal tracheation (above, × 54) and imaginal venation (below, × 18). England, recent; Order Lepidoptera, family *Micropterygidæ*. For lettering, see Text-fig. 2, p. 238.

Summing up the above evidence, then, it is clear that there is not a single character in the venation of *Belmontia* which precludes it being accepted as the actual ancestor of the *Micropterygidæ*, unless it can be shown that R_1 in the fossil is not distally forked. As this part is missing, we cannot decide the point; but, even if it were so, it might legitimately be argued, I think, that the forking of R_1 could have been secondarily acquired, in those genera that possess it, either by splitting of the tip into two (as in Planipennia) or by a veinlet taking on the character of a branch vein during evolution of the pterostigmatic region. The fact that the hindwing has a simple R_1 in all genera of the family, might be held to support this; but I think the question is not of sufficient importance to warrant any prolonged argument. If we agree to overlook it, then we may say that *Belmontia is the first known representative of a new Order from which the Micropterygidæ, and likewise all other existing Lepidoptera, are undoubtedly derived.* Bearing in mind the present distribution of the Lepidoptera Homoneura, it seems quite likely that they did originate somewhere in the Southern Hemisphere; and the fact that Australia is the headquarters for the *Hepialidæ*, while New Zealand is the head-quarters of the *Micropterygidæ*, might suggest that this place of origin was not far removed from Australia. That being so, there is, perhaps, a greater chance of *Belmontia* itself having been actually in the ancestral line of the Lepidoptera than in that of the Trichoptera. The point of importance, however, is that the Lepidoptera must in any case have been derived from some type intermediate between *Belmontia* and the Homoneura.

We may, then, legitimately claim that *both the Trichoptera and the Lepidoptera are directly descended from the Paramecoptera.* The archetypes of the Trichoptera and the Lepidoptera, as at present constituted, contain certain archaic characters not shared by both. For instance, in the Trichoptera, there is the retention of M_4 in the forewing, and the non-development of scales; in the Lepidoptera, the abdominal prolegs of the larva, the retention of the complete pupal tracheation of the wing, the presence of a frenulum in the hindwing, the small but functional mandibles, and the normal maxillæ (*Micropterygidæ*). It is quite clear, therefore, that neither of these Orders can be derived from the other, as Handlirsch plainly showed some years ago (**2**, p.1253). Handlirsch, however, derived them both from the older Mecoptera. We are now able to correct that statement, and to say that *the Trichoptera and Lepidoptera were undoubtedly derived* *from a common ancestor which was itself derived from the Paramecoptera.* It is quite clear, of course, that if we had the whole fossil record before us, we could not say definitely where the Paramecoptera ended and the Trichoptera and Lepidoptera began. It is also quite clear that *Belmontia* itself could undergo considerable further reduction, and still be legitimately regarded as the true ancestral type from which both these Orders have been derived. Our chief satisfaction in the discovery of the new fossil should be, I think, that we have found a type far enough back in point of evolution, as well as in point of time, to indicate not only the true line of descent of these two Orders, but also their true relationship with the much older Order Mecoptera and its other near allies.

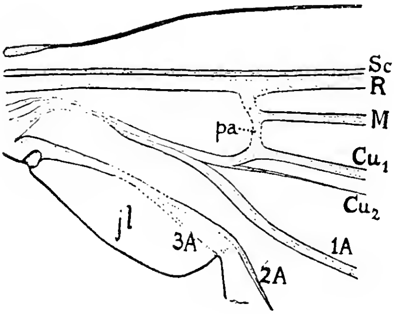
(iii.) *Affinity with the Paratrichoptera.*

We may now turn from the consideration of the Lepidoptera, and examine the relationship of *Belmontia* with the group of Trichopterous-like fossil insects which I have termed Paratrichoptera(**7**), from the Upper Trias of Ipswich. We do not know the condition of the arculus in any of the four known genera of this Order, the basal part of the wing being not clearly enough preserved for this purpose, even in the beautiful wing of *Aristopsyche.* The vein that I have called Cu_1 in that genus appears to come off directly from near the base of M. Hence it is either the true Cu_1, attached to M as in most Mecoptera; or it may be attached by means of a very specialised arculus, whose junction with the true basal piece of Cu_1 is not clearly visible in the fossil; or it may even be not Cu_1 at all, but the vein M_5 complete, before its fusion with Cu_1 is accomplished. Until a more perfect representative of this Order is forthcoming, it is useless to argue as to whether the Paratrichoptera can be derived from the Paramecoptera. But we should note that *Aristopsyche* has the remains of a true costal vein, separate from the costal border of the wing, and that it has more veinlets in the costal space than are to be found in the same area of *Belmontia.* In these characters, *Aristopsyche* is more archaic than *Belmontia*; while in the lack of the distal forking of the supposed Cu_1, it is less so.

On the whole, then, we are unable to establish a direct connection between *Belmontia* and the Triassic Paratrichoptera. The latter may possibly be derived rather from the Protomecoptera, which, though only so far known from the Ipswich Trias, must certainly also have existed in the Permian.

(iv.) *Affinity with the Diptera.*

Concerning the arculus in the Diptera, Comstock (1, p.358) has remarked that "owing to the reduced condition of the tracheation in this Order, the elements that enter into its formation cannot be definitely determined." Nevertheless, it seems to me that the condition of this part of the wing in the *Stratiomyiidæ* (Text-fig.6), as well as in some archaic genera of other families, points definitely to the conclusion that it is formed on the same plan as in the Trichoptera and Lepidoptera. The close affinity of the Diptera with the Trichoptera in many other respects is generally recognised, and there can be little doubt also of the close general resemblance of the venational schemes in the two Orders. It is, however, necessary to point out that the usually accepted limits of Cu in this Order are incorrect. The vein usually designated Cu_1 is undoubtedly M_4; this can be proved by reference to the trichiation in the genus *Rhyphus*, as I have already pointed out in a previous paper (5, p.642, note), and by the fact that it actually comes off from the median cell itself in some archaic genera of *Tipulidæ*, such as the Australian *Gynoplistia*. Consequently, the true Cu_1 is a strong, usually straight, convex vein, without any distal forking, and the part usually labelled Cu_2 is really the distal continuation



Text-fig.6.*

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* Basal portion of wing of an undetermined Stratiomyiid fly, (× 18). Hornsby, N.S.W.; recent. For lettering, see Text-fig.2, p.238.

of Cu_1 itself. The true Cu_2 arises, as always, close to the base of the wing, but is either a very weakly formed vein (as in Text-fig.6) or entirely lost

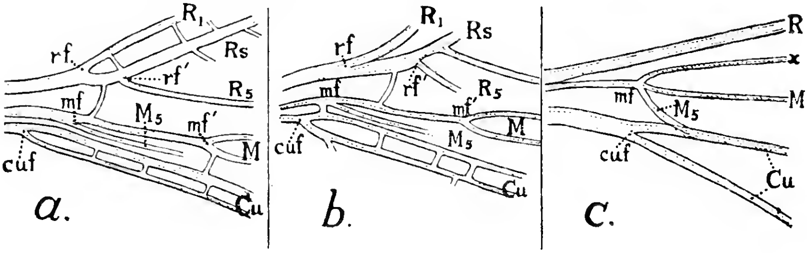
Thus we see that, although the Diptera may well be directly derived from the Paramecoptera, as regards their arculus-formation and most other points in their venation, yet we have to explain how it is that they have Cu_1 unbranched, as in the Mecoptera. Either they originally had this vein distally forked, which does not seem likely; or they are descended, not from the Paramecoptera, but from one of the Orders in which Cu_1 is simple, viz., the Mecoptera or the Paratrichoptera.

We are bound, then, to conclude that the descent of the Diptera from the Paramecoptera cannot be proved with certainty. That there is a close affinity of some kind between the two Orders appears certain; but the probability is that it is not a directly ancestral one.

(v.) *Affinities with the Megaloptera and Planipennia.*

A remarkable feature in the wing of *Belmontia* is the position of the fork of R_{4+5}, quite close up to the first forking of Rs into R_{2+3} and R_{4+5} respectively. Now Comstock (**1**, pp.95, 147) has shown very convincingly how the pectinate type of branching found in the Megaloptera and Planipennia can be simply derived from the older dichotomic type, by the recession of the origin of R_4 from its original position on R_{4+5} across to R_{2+3} The condition shown in *Belmontia* is intermediate between what are usually regarded as the typical dichotomic and pectinate types of branching; *i.e.*, though definitely dichotomic, the origin of R_4 is so close to R_{2+3} that a very little change would produce the pectinate type. Thus we see that, on this character, *Belmontia* could well be the ancestor of both the Megaloptera and the Planipennia.

But, in order to establish this suggestion on a much firmer basis, we must ask for evidence of the presence of the arculus in the two Orders in question. For, if they do not possess this distinctive venational structure, they cannot certainly be descended from the Paramecoptera. Now, in a previous paper (**7**), I pointed out a peculiarity in the structure of the media of the Triassic Prohemerobiid *Archepsychops* (Order Planipennia). In this fossil, it is possible to make out a weak posterior branch of M arising quite close to the base, and running parallel to and between M_{1-4} and Cu_1 almost up to the first dichotomy of M_{1-4}. This vein can also be seen in some recent *Psychopsidæ*, as may be seen from Text-fig.7, *a*, *b*. I also figure an interesting formation from the hindwing of the archaic Megalopteron *Archichauliodes* (Text-fig.7, *c*). Provided that we are agreed that the arculus is really M_5, then it is clear that it is the homologue of the vein shown in Text-fig.7. Only, in the *Prohemerobiidæ* and *Psychopsidæ*, M_5 is in process of degeneration, being crowded out between M_{1-4} and Cu_1; whereas, in *Archichauliodes*, it has succeeded in taking on a form not at all unlike that found in Paramecoptera, Trichoptera, and Lepidoptera. Whether the condition of M_5 in the *Prohemerobiidæ* and *Psychopsidæ* is more primitive than that found in *Belmontia*, it is not very easy to determine But we should note that, in *Psychopsis elegans*, R_5 is frequently found degenerating also, being crowded out between R_4 and M, as in Text-fig.7, *b*. This seems to point clearly enough to the fact that the condition of M_5, in those few Planipennia in which it still exists, represents the last stage of degradation, and



Text-fig.7.

Portion of base of wing, to show vestige of M_5 or posterior arculus in the Orders Planipennia and Megaloptera. (*a*) forewing of *Megapsychops illidgei* (Frogg.); (*b*) forewing of *Psychopsis elegans* (Guér.); (*c*) hindwing of *Archichauliodes guttiferus* (Walk.); *x* specialised elongated cross-vein from M to Rs. (All figures × 12). For rest of lettering, see Text-fig.2, p.238.

is due to the crowding out of this vein, during the rapid proliferation of the branches of Rs that took place during the first formation of the Prohemerobiid type of wing-venation.

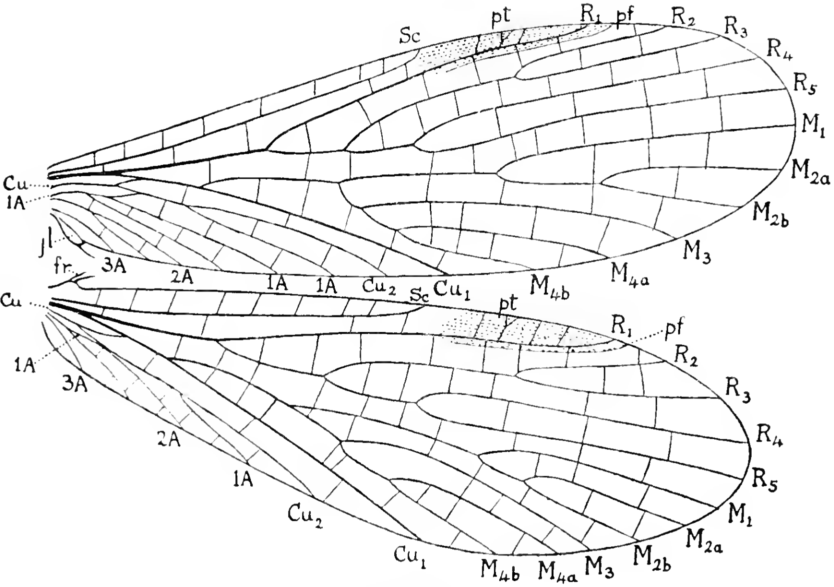
The family of Planipennia whose venation most closely resembles that of *Belmontia* is certainly the *Sisyridæ*, already recognised as one of the most archaic types within the Order. The pupal tracheation of this family has not yet been studied. Until this can be done, we cannot say definitely that the Planipennia are descended from the Paramecoptera; but enough will have already been said to show that there is quite a fair probability of this being so.

With respect to the Megaloptera, the forewings of this Order either have Cu_1 actually fused with M for a short distance, or the two are connected by what is apparently a cross-vein in the position of the arculus. Both conditions can easily be derived from the more archaic state seen in *Belmontia*, by means of a gradual shortening of the arculus, leading to its final elimination, and the consequent fusion mentioned. We should be careful to remember that, within the single family *Rhyacophilidæ* of the Order Trichoptera, all stages may be found from the primitive arrangement, closely resembling that of *Belmontia*, through forms in which *pa* becomes a short, transverse vein, to others in which Cu_1 is actually fused with M. Within this family, the arculus in the genera *Glossosoma*, *Mystrophora*, *Agapetus*, and *Catagapetus* resembles that of *Belmontia* even more closely than it does in *Rhyacophila dorsalis* (Text-fig.4). If, then, all stages from the original type to the most complete reduction can be seen within the limits of a single archaic family, how much more easily may the same series of evolutionary stages be accomplished during the passage from one Order to another?

Thus, though we cannot prove certainly that the Planipennia and Megaloptera are descended from the Paramecoptera, it will be seen that there is quite a fair probability of this being the case. If, when the Belmont Beds have been further worked, no wings of the types associated definitely with these two Orders can be found, then it will become more than ever probable that they did not evolve until later on in geological time; and the chance that they arose from the older Paramecoptera will become greater still.

(vi.) *Affinities with the Mecoptera and Protomecoptera.*

The affinities of the Paramecoptera with these two Orders are clearly evident; but they are definitely *collateral* relationships, not ancestral. For the Mecoptera already exist alongside the Paramecoptera in the Belmont Beds; while the Triassic Protomecoptera, being more archaic in many respects than the known Mecoptera from Belmont, must also have existed in the Permian, though not yet discovered there.



Text-fig.8.

Restoration of forewing in the genus *Permochorista* Tillyard (1919), Order Mecoptera. Upper Permian of Belmont, N.S.W. For lettering, see Text-fig.2, p.238.

All three Orders agree in having the original dichotomous branchings of Rs and M_{1-4} preserved. Comparing *Belmontia* with the forewing of *Permochorista* (Text-fig.8) from the same

Beds, we see the obvious differences of the more complete system of cross-veins in the latter (these were, however, very weakly chitinised), the more symmetrically arched and regularly arranged dichotomies of the veins, the absence of the arculus (as in almost all Mecoptera, owing to the partial fusion of Cu_1 with the main stem of M), and the unbranched condition of the very typically Mecopterous Cu_1. M_{1-4} is six-branched in the forewing of *Permochorista*, but only five-branched in *Belmontia*, as also in the existing genus *Tæniochorista*, which stands very close to *Permochorista* in its general scheme of venation. On the other hand, Rs is only four-branched in *Permochorista*, while in *Belmontia* it is seven-branched

Thus it is quite clear, apart from the question of *time*, that neither of the two Orders Mecoptera and Paramecoptera can be derived from the other. For the Mecoptera are the older in possessing the more regular dichotomies, the more regular system of cross-veins, the more numerous veinlets in the costal space, and the larger number of branches of M; whereas the latter have the more archaic type of arculus, the forked Cu_1, and the larger number of branches of Rs. We must, therefore, postulate, as common ancestor to both Orders, an even more archaic type of Holometabolon, which possessed the archaic features of both.

Turning next to the Protomecoptera, we must compare *Belmontia* with *Archipanorpa* (**3**, p.188, Pls. viii.-ix.), the only known genus of that Order, from the Upper Trias of Ipswich. The system of cross-veins in this genus is intermediate in completeness between that of the Mecoptera and of *Belmontia*, and the same may be said to be true of the regularity and symmetry of the dichotomous branchings of its veins. *Archipanorpa* is definitely more archaic than *Belmontia* in possessing a well-developed costal vein, distinct from the costal border of the wing, and in having a larger number of branches of Rs and M. It possesses a forked Cu, but the anterior branch Cu_{1a} is partially fused with M_4; in this, it is clearly more specialised than *Belmontia*. The region of the arculus is not preserved in either wing of *Archipanorpa*: and hence we cannot complete the comparison.

Thus it is clear again that, apart from the question of *time*, neither of the two Orders Protomecoptera and Paramecoptera can be derived from the other. A more archaic type of Holometabolon must have existed, somewhere in the Permian, which possessed the archaic characters of both; and this insect would also have possessed the archaic characters of the Mecoptera. In other words, the three Orders Mecoptera, Paramecoptera, and Protomecoptera are to be regarded as being *collaterally related*, all three being separately derived from a single, more primitive, Holometabolous stock. In constituting three separate Orders for these three types, I have followed the wise precedent of Handlirsch in similar cases; since only by this method can the essential differences between them be sufficiently emphasised. Further discoveries at Belmont or Ipswich may perhaps enable us to place all these types definitely within a single enlarged Order Mecoptera, from which all the other Orders within the Panorpoid Complex have probably been derived.

We may sum up the evidence as to the affinities of this interesting new fossil Order by saying that it has now been shown to be *definitely ancestral* to the Trichoptera and Lepidoptera, but *of collateral descent* with the Mecoptera and Protomecoptera. It may very possibly be ancestral also to the Megaloptera and Planipennia. With the Paratrichoptera and the Diptera it is not possible, so far, to determine the nature of its affinity, though there is no doubt of a relationship of some kind between them, probably through the Mecoptera. If the only types of Holometabola existing at Belmont be Mecoptera and Paramecoptera, then the probability that all other Orders within the Panorpoid Complex are descended from one or other of these two, or from the Protomecoptera of the Trias, would be very great. Thus we leave this interesting problem, in the hope that further discoveries from the Belmont Beds may yet clear the whole matter up, and settle the descent of all these Orders without any doubt.

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EXPLANATION OF PLATES XII.-XIII.

Plate xii.

Fig.1.—*Belmontia mitchelli*, n.g. et sp. (Upper Permian of Belmont, N.S.W.). The fossil wing *in situ*, (× 8¼).

Plate xiii.

Fig.2.—*Belmontia mitchelli*, n.g. et sp. Base of wing, more highly magnified, to show the region of the arculus and the cubital fork, (× 19).

Fig.3.—*Belmontia mitchelli*, n.g. et sp. Arculus and cubital fork still more highly magnified, to show bases of insertion of macrotrichia, (× 42½). The arrow points to a clearly marked base of insertion on the arculus itself, while an equally well marked one can be seen on Cu_1 by following the main stem of the arrow backwards. Other similar bases are to be seen on the remaining veins. (The true cross-veins do not carry macrotrichia).

(Fig.1 enlarged from a photograph taken with a triple-extension camera, magnified × 4½; Figs.2-3 reproduced from a photomicrograph taken with Reichert's photomicrographic apparatus; Fig.3 an enlargement from the negative of Fig.2).

ORDINARY MONTHLY MEETING.

25th June, 1919.

Mr J. J. Fletcher, M.A., B Sc., President, in the Chair.

Mr. George Vance Scammell, 18 Middle Head Road, Mosman, was elected an Ordinary Member of the Society.

It was resolved that the congratulations of Members be tendered to Professor A. A. Lawson on the award to him of the Makdougall-Brisbane Prize, by the Royal Society of Edinburgh.

The Donations and Exchanges received since the previous Monthly Meeting (28th May, 1919), amounting to 8 Vols., 67 Parts or Nos., 2 Bulletins, 3 Reports, and 3 Pamphlets, received from 35 Societies and Institutions, and one private donor, were laid upon the table.

EXHIBIT.

Mr. A. A. Hamilton exhibited specimens of *Synaphea* illustrating Professor Merrill's paper on *Polypodium spinulosum.*

REVISION OF AUSTRALIAN LEPIDOPTERA, vi.*

By A. Jefferis Turner, M.D., F.E.S.

Gen. 38. Eugnesia.

Eugnesia, Warr., Nov. Zool., 1897, p.76.

Frons flat, with a slight frontal tuft. Tongue well-developed. Palpi long, porrect or slightly ascending; basal joint very long, shortly rough-haired beneath; second joint smooth; terminal joint about second tolerably acute. Antennæ long (about $\frac{4}{5}$): in ♂ simple. Thorax not crested, slightly hairy beneath. Forewings with 6 from angle of cell; 7, 8, 9, 10 stalked from well before angle, 11 from cell, anastomosing with 12. Hindwings normal.

Type, *E. correspondens* Warr., from Philippines. I have only seen one ♀ of the following species, which was described by Warren from a single ♀. The genus belongs to the *Deilinia* group.

129. Eugnesia aurantiaca.

Eugnesia aurantiaca, Warr., Nov. Zool., 1897, p.77.

♀. 29 mm. Head orange; upper and lower margins of face yellow. Palpi $1\frac{1}{2}$: orange, base of first joint, and apices of first and second joints yellow. Antennæ ochreous. Thorax and abdomen yellow. Legs whitish-ochreous. Forewings triangular, costa gently arched, apex rounded, termen gently rounded, oblique; pale yellow with numerous irregularly scattered orange dots; a small orange discal spot before middle; a broad, orange, sinuate, denticulate, postmedian line from $\frac{2}{3}$ costa to $\frac{3}{4}$ dorsum; basal $\frac{3}{4}$ of costa broadly strigulated with fuscous; a terminal series of fuscous dots; cilia yellow. Hindwings with termen

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* Continued from Vol. xlii., 1917, Part 2, p.390.

strongly rounded, wavy: colour and markings as forewings. Underside ochreous.

N.Q : Cairns; Innisfail.

Gen. 39. HYPERYTHRA.

Hyperythra, Gn., Lep., ix., p.99; Hmps., Moths Ind., iii., p.218. *Callipona*, Turn., Tr. R.S.S.A., 1904, p.236.

Face with projecting tuft of scales. Tongue well-developed. Palpi long, porrect; second joint very long, densely clothed with long, rough hairs: terminal joint moderate, smooth, acute. Antennæ of ♂ bipectinate, towards apex simple. Thorax not crested; beneath hairy. Femora smooth; posterior tibiæ of ♂ not dilated. Forewings in ♂ with fovea; 10 out of 9, 11 from cell, free. Hindwings with cell extremely short (about $\frac{1}{6}$).

Evidently one of the *Casbia* group with extreme shortening of cell, of hindwings. The fovea is nearly always absent in this group, but I think it may have been originally present but lost in most of the species and genera.

130. HYPERYTHRA RUBRICATA.

Hyperythra lutea rubricata, Warr., Nov. Zool., 1898, p.35. *Hyperythra rubricata*, Swin., Tr. E.S., 1902, p.612. *Callipona metabolis*, Turn., Tr. R.S.S.A., 1904, p.236.

The ♂ of this species does not possess the tuft of hairs on underside of forewings present in *H. lutea* Cram. Forewings with 10 and 11 as above without variation (4 ♂, 3 ♀).

N.Q.: Claremont Island, Innisfail, Townsville.

Gen. 40. CHROSTOBAPTA.

Chrostobapta, Warr., Nov. Zool., 1909, p.127.

Frons flat. Tongue developed. Palpi rather short (not over 1), slender, porrect; terminal joint acute. Antennæ of ♂ simple, with very long ciliations. Thorax not crested, beneath not hairy. Femora glabrous. Posterior tibiæ with all spurs present; in ♂ strongly dilated. Forewings in ♂ without fovea, 10 absent, 11 from cell, not anastomosing. Hindwings normal.

Type, *C. deletaria* Moore, from India. Probably vein 10 is coincident with 9, in which case this genus, like *Lomographa*, must be regarded as a derivative of *Casbia*.

131. CHROSTOBAPTA INSULATA.

Heterostegane insulata, Warr., Nov. Zool., 1898, p.429; *Chrysocraspeda galinaria*, Swin., Tr. E.S., 1902, p.662; *Lipomelia kuehni*, Warr., Nov. Zool., 1902, p.357; *Chrostobapta deludens*, Warr., Nov. Zool., 1907, p.164.

♂. 22 mm. Head ochreous-whitish; face and palpi brown. Antennæ ochreous-whitish; ciliations 3. Thorax whitish-ochreous, two transverse bars and some irroration reddish-brown. Abdomen reddish-brown, apices of segments, tuft, and underside whitish-ochreous. Legs whitish-ochreous; anterior pair fuscous anteriorly. Forewings triangular, costa rather strongly arched, apex rounded, termen gently rounded, oblique; suffused over most of disc with brown, leaving base, a costal strip, and an apical blotch whitish-ochreous; markings dark reddish brown; a short median basal bar; a line from $\frac{1}{4}$ costa obliquely outwards but nearly obsolete beneath costa, then sharply angled inwards to dorsum near base; a straight line from mid-costa to $\frac{2}{5}$ dorsum, with two short projections posteriorly above middle; a doubly sinuate and finely dentate line from $\frac{2}{3}$ costa to $\frac{2}{3}$ dorsum, doubly outlined with whitish-ochreous; a subterminal line from $\frac{5}{6}$ costa, angled outwards beneath apex, and then angled inwards, ending on dorsum, posteriorly outlined with whitish-ochreous; a fuscous terminal line; cilia whitish-ochreous. Hindwings with termen rounded, slightly bent on vein 4; wholly suffused with brown; markings nearly as forewings. Underside ochreous-whitish.

♀. 22 mm. Differs in wings being whitish-ochreous without any brown suffusion, the lines in consequence much more distinct, a reddish-brown spot on mid-termen, and a fuscous and reddish-brown spot on tornus of forewing.

N.Q: Kuranda, near Cairns, in October (F. P. Dodd). Also from Key Islands and New Guinea.

Gen. 41. LOMOGRAPHA.

Lomographa, Hb., Verz., p.311; Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.633.

Face smooth. Tongue present. Palpi short, porrect, rough-scaled; terminal joint very short. Antennæ in ♂ bipectinated, apex simple. Thorax and abdomen not crested; thorax slightly hairy beneath. Femora glabrous; posterior tibiæ in ♂ rarely dilated. Forewings without fovea; 10 absent (coincident with 9), 11 anastomosing with 12 and 9.

A small European genus. The species are small and obscure.

1. Wings grey, not ochreous-tinged......	2.
Wings ochreous-tinged	4.
2. Hindwings with termen nearly straight........................	*odontocrossa.*
Hindwings with termen rounded................................	3.
3. Posterior tibiæ of ♂ dilated with basal tuft.................	*icasta.*
Posterior tibiæ of ♂ not dilated and without tuft	*spodina.*
4. Wings pale ochreous with whitish, and deeper ochreous or fuscous irroration	*isocyma.*
Wings brownish with whitish irroration	*sabulicolor.*

132. LOMOGRAPHA ODONTOCROSSA, n.sp.

Deilinia odontocrossa, Turn., Tr. R.S.S.A., 1906, p.134.

Very similar to *L. spodina*: best distinguished by the nearly straight, dentate termen of hindwings

Tas.: Strahan.

133. LOMOGRAPHA ICASTA, n.sp.

εικαστος, like.

♂. 25 mm. Head, thorax, and abdomen grey. Palpi $1\frac{1}{4}$; grey. Antennæ grey; pectinations of ♂ 6, apical $\frac{1}{10}$ simple. Legs grey; posterior tibiæ of ♂ strongly dilated, with a pencil of long hairs from inner side of base. Forewings triangular, costa slightly arched, apex acute, termen slightly bowed, slightly crenulate, oblique; grey with slight fuscous irroration; costa strigulated with fuscous; a very fine fuscous line from $\frac{1}{4}$ costa, bent inwards beneath costa, and thence oblique to $\frac{1}{4}$ dorsum; a dark fuscous, median, discal dot; a fine, fuscous, oblique line with darker points on veins from $\frac{3}{4}$ costa to $\frac{3}{4}$ dorsum; a very fine, pale, dentate, subterminal line; a terminal series of fuscous dots; cilia grey. Hindwings with termen rounded, crenulate; as forewings but discal dot at $\frac{1}{3}$. Underside similar but even more obscure.

Very like *L. spodina*; the wing-margins are more crenulate, but its distinctness rests mainly on the posterior tibiæ of the ♂

N.S.W.: Blackheath, near Katoomba; one specimen.

134. LOMOGRAPHA SPODINA.

Lomographa spodina, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.633; *Laophila fokia*, Swin., Tr. E.S., 1902, p.628.

N.S.W.: Sydney.—S.A.: Mt. Lofty.

135. †LOMOGRAPHA ISOCYMA.

Lomographa isocyma, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.634.

Q.: Duaringa.

136. LOMOGRAPHA SABULICOLOR, n.sp.

Sabulicolor, sand-coloured.

♂♀. 20-23 mm. Head brown-whitish; face brownish. Palpi short in both sexes (1¼); brown-whitish. Antennæ grey-whitish; pectinations in ♂ 8, apical ⅕ simple. Thorax and abdomen brown-whitish; in ♀ whitish. Legs brown-whitish; in ♀ whitish. Forewings triangular, costa almost straight, apex round-pointed, termen slightly bowed, slightly oblique; 11 from cell anastomosing strongly with 12 (2 ♂, 2 ♀), and sometimes connected at a point with 9 (1 ♂, 1 ♀); brown-whitish, in ♀ whitish; markings exceedingly obscure or almost wholly obsolete; in ♂ a whitish, dentate, subterminal line; costa whitish, with some darker strigulations; no discal nor terminal dots; cilia whitish. Hindwings with termen rounded; as forewings. Underside whitish

A very obscure little species. Type in Coll. Turner.

N.A.: Port Darwin in September, October, and November; four specimens received from Mr. F. P. Dodd. Also from Melville Island.

Gen. 42. PETELIA.

Petelia, H.-Sch., Ausser. Schmet., p.84 (1854); Hmps., Moths Ind., iii., p.216.

Frons with anterior rounded tuft of hairs. Tongue well-developed. Palpi long, ascending; second joint very long, thickened with appressed scales; terminal joint moderate, depressed. Antennæ of ♂ bipectinate, apical portion simple. Forewings of ♂ without fovea; 10 out of 9. Hindwings with cell considerably less than $\frac{1}{2}$, discocellulars straight, nearly obsolete, 8 approximated to cell at base, diverging before middle.

Allied to *Casbia*, but very distinct by the long palpi and shorter cell of hindwings.

137. PETELIA MEDARDARIA.

Petelia medardaria, H.-Sch., Ausser. Schmet., p.534, Hmps., Moths Ind., iii., p.216.

Antennæ of ♂ with apical $\frac{2}{5}$ simple. Forewings with 7, 8, 9, 10 stalked, 11 from cell not anastomosing (4 ♂, 4 ♀).

N.A.: Port Darwin in December.—N.Q.: Kuranda, near Cairns, in October, March, and June. Also from Ceylon and India.

Gen. 43. POLYCRASTA.

Polycrasta, Warr., Nov. Zool, 1896, p.301.

Frons with rounded tuft. Tongue well-developed. Palpi rather long, ascending: terminal joint moderate, depressed. Antennæ of ♂ bipectinate, apex simple. Forewing of ♂ without fovea; 10 out of 9. Hindwings with cell much less than $\frac{1}{2}$, discocellulars straight, 7 from near middle of cell, 8 approximated to cell near base, soon diverging.

Certainly near the preceding, best distinguished by the origin of vein 7 of hindwings. In *Petelia* this arises from just before angle of cell.

138. POLYCRASTA OCELLATA.

Polycrasta ocellata, Warr., Nov. Zool., 1896, p.302.

Antennæ of ♂ with apical $\frac{1}{5}$ simple. Forewings with 7, 8, 9, 10 stalked, 11 from cell, anastomosing with 12.

N.Q.: Kuranda, near Cairns, in August, November, and April; Dunk Island. Also from Louisiades.

Gen. 44. PERIDELIAS, nov.

περιδηλος, conspicuous.

Frons smooth. Tongue well-developed. Palpi moderate, porrect, thickened with appressed scales; terminal joint small, depressed. Antennæ of ♂ pectinated, apex simple. Thorax not crested; very slightly hairy beneath. Abdomen without crests. Posterior tibiæ with two pairs of spurs, the inner spurs longer

Forewings in ♂ without fovea; 2 from $\frac{4}{5}$, 3 from near angle, 7, 8, 9, 10 stalked from $\frac{4}{5}$, 11 connate, anastomosing with 12 shortly, and then connected with common stalk of preceding veins. Hindwings elongate, rounded-rhombiform; cell rather less than $\frac{1}{2}$, discocellulars angled, the dorsal very oblique, 7 from before angle, 8 approximated to cell to near $\frac{1}{2}$, then diverging.

The form of the hindwings should be sufficient to distinguish this from *Casbia* even if the neuration proved insufficient.

139. PERIDELIAS APROSITA, n.sp.

ἀπροσιτος, unapproachable.

♂. 22 mm. Head yellowish; face dark red, lower edge and a median transverse bar orange. Palpi $1\frac{1}{4}$; yellow with two oblique red bars. Antennæ whitish-grey; basal joint red with yellow apex; pectinations in ♂ 12, apical $\frac{1}{8}$ simple. Thorax yellow with dark red irroration; tegulæ and patagia dark red. Abdomen bright yellow with irregular dark red irroration most dense on apices of segments. Legs whitish-ochreous; anterior femora and tibiæ crimson internally; first joint of anterior tarsi and middle tibiæ fuscous internally. Forewings triangular, costa strongly arched at base, then nearly straight to apex, apex rounded, termen strongly bowed, slightly oblique; dark red strigulated with orange-yellow; markings yellow; a sinuate line from $\frac{1}{3}$ costa expanding above dorsum into a quadrangular blotch with its angles produced, connected with dorsum at middle and $\frac{3}{4}$, and also with a smaller tornal blotch: these blotches are paler yellow and by contrast appear greenish: a second irregular line from $\frac{2}{3}$ costa to termen above tornus; an irregular spot on termen midway between this and apex; cilia yellow with several dark red bars. Hindwings rounded-rhombiform, bright red, strigulated with yellow and dark red; a small yellow spot in disc before middle; a postmedian dentate and strongly projecting yellow line; succeeded by a broad, dark red, terminal band; several yellow terminal spots; cilia as forewings. Underside fuscous with lines and spots reproduced in whitish.

"A remarkable species not resembling anything else."

N.Q.: Evelyn Scrub, near Herberton, in January; one specimen received from Mr. F. P. Dodd.

Gen. 45. ŒNOPTILA.

Œnoptila, Warr., Nov. Zool., 1897, p.475.

Frons with a slight triangular projection. Tongue well-developed. Palpi moderate, ascending, appressed to frons: second joint rather long, shortly rough-haired beneath; terminal joint very short, obtuse Antennæ of ♂ simple, minutely ciliated. Thorax not crested, beneath slightly hairy. Femora glabrous. Posterior tibiæ of ♂ not dilated, all spurs present Forewings in ♂ without fovea, 7, 8, 9, 10 stalked, 10 anastomosing with 11 and 9, 11 anastomosing with 12 and 10.

Type, *Oxydia mixtata* Gn., from South America. Closely allied to *Casbia*, but with simple ♂ antennæ. In the following species the basal joint of each antenna is dilated.

140. ŒNOPTILA VULPINA.

Œnoptila vulpina, Warr., Nov. Zool., 1902, p.369; *Perutostega pallidicosta*, Warr., Nov. Zool., 1903, p.269; ?*Œnoptila flavirupta*, Warr., Nov. Zool., 1903, p.402.

♂. 38-40 mm. Head, face, and palpi reddish-brown; fillet whitish. Antennæ grey, towards base whitish; ciliations in ♂ $\frac{1}{5}$. Thorax and abdomen reddish-brown, beneath ochreous. Legs ochreous; anterior tibiæ and tarsi ochreous-fuseous. Forewings triangular, costa nearly straight, apex round-pointed, termen gently rounded, slightly oblique; reddish-brown sparsely strigulated with fuscous; sometimes with extensive ochreous-whitish suffusion, especially posteriorly; costal edge whitish-ochreous, sometimes forming an uninterrupted streak, sometimes thickly strigulated; a fuscous discal dot beneath mid-costa; a fuscous transverse median shade just beyond this, sometimes obsolete; cilia reddish-brown. Hindwings with termen rounded; colour and markings as forewings. Underside ochreous, markings as above but without whitish blotches.

Mr. Prout informs me that this is a very variable species. I have seen only two examples, which differ considerably.

N.Q.: Kuranda, near Cairns, in October; Evelyn Scrub, near Herberton, in January (F. P. Dodd). Also from New Guinea and Solomon Islands.

Gen. 46. CASBIA.

Casbia, Wlk., Cat. Brit. Mus., xxxv., p.1667 (1866); *Deilinia*, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.634, *nec* Hb.; *Trochistis*, Meyr., Tr. E.S., 1892, p.110.

Face smooth, or with short, rough scales, or with a small projecting tuft of hairs. Tongue well-developed. Palpi moderate, porrect or ascending, rough-scaled: terminal joint very short. Antennæ in ♂ bipectinate, towards apex simple. Thorax not crested, beneath somewhat hairy. Femora smooth, not hairy; posterior tibiæ in ♂ not dilated. Forewings in ♂ without fovea (except in *rectaria*, in which a moderate fovea with small central gland is present); 10 out of 9, 11 from cell or out of 9, usually anastomosing with 12 but sometimes free; or rarely, 11 apparently out of 12. Hindwings normal; 8 approximated to cell to about middle.

Type, *C. rectaria* Wlk. I agree with Mr. Meyrick in restricting the genus *Deilinia* Hb. (for which, however, I think *Cabera* Treit., may have to be substituted). The type of these genera is *pusaria* Lin., in which there is a fovea at base of hindwing on underside, and vein 8 diverges from cell at about $\frac{1}{4}$. But I must differ from him in not referring *rectaria* to that genus, for this has a fovea in the forewing, not in the hindwing. On the other hand, *impressaria* has the base of the hindwing in ♂ roughly hairy beneath, but with no fovea. Vein 11 usually anastomoses with 12, but appears to be always free in *rectaria* and *albinotata*, and occasionally so in some other species. *Rectaria* and *impressaria* are so closely allied to each other, and to other species of the genus, that they should not be generically separated.

Idæa farinalis Rosen., Ann. Mag. Nat. Hist., 1885, p.402, probably belongs to this genus: the type is a wasted ♀, which I was unable to identify.

1.	Wings with red fasciæ	*fasciata.*
	Wings without fasciæ	2.
2.	Wings pinkish-tinged	3.
	Wings not pinkish-tinged	4.
3.	Thorax with a white transverse bar	*rhodoptila.*
	Thorax without a white transverse bar	*rhodina.*

4.	Forewings brown or brownish-grey	5.
	Forewings grey without brownish tinge	11.
5.	Forewings with an ochreous costal streak	6.
	Forewings without an ochreous costal streak	7.
6.	Head with a white band on vertex	*anias.*
	Head without a white band on vertex	*impressaria.*
7.	Head with a white band on vertex	*ochthadia.*
	Head without a white band on vertex	8.
8.	Wings with silvery discal dots	*scardamiata.*
	Wings without silvery discal dots	9.
9.	Hindwings with termen dentate	*catharodes.*
	Hindwings with termen not dentate	10.
10.	Wings with subterminal white spots	*calliorma.*
	Wings with fuscous strigulations	*resinacea.*
11.	Forewings with a thick postmedian line from dorsum	*sciagrapha.*
	Forewings without a thick postmedian line from dorsum	12.
12.	Forewings with a small basal fovea in ♂	*rectaria.*
	Forewings without a small basal fovea in ♂	13.
13.	Forewings with posterior ochreous spots	14.
	Forewings without posterior ochreous spots	17.
14.	Face whitish	*lithodora.*
	Face not whitish	15.
15.	Hindwings brownish-grey	*anisochroa.*
	Hindwings without brownish tinge	16.
16.	Forewings grey-whitish	*alphitopis.*
	Forewings grey with fuscous irroration	*synempora.*
17.	Head irrorated with whitish	*cremnias.*
	Head not irrorated with whitish	*eccentritis.*

141. CASBIA RECTARIA.

Casbia rectaria, Wlk., Cat. Brit. Mus., xxxv., p.1667: *Casbia irrorata*, Butl., Tr. E.S., 1886, p.438; *Deilinia rectaria*, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p 636.

Forewings with 11 arising from cell and free (21 ♂, 8 ♀).

N.Q.: Thursday Island, Cairns, Atherton, Herberton, Stannary Hills, Townsville —Q.: Rockhampton, Duaringa, Eidsvold, Nambour, Brisbane, Blackbutt, Rosewood, Toowoomba.

I have also three ♀ from Herberton and Townsville differing from *rectaria* in the pinkish colouring and some other points, which have also vein 11 separate and free. These probably represent an undescribed species in which the ♂ is unknown.

Very similar to these are two ♀ from Kuranda, with postmedian, whitish-brown blotches and vein 11 separate and free; these may be varietal forms of the same species.

142. CASBIA IMPRESSARIA.

Tephrina impressaria, Wlk., Cat. Brit. Mus., xxiii., p.966; *Deilinia impressaria*, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p 636.

Forewings with 11 from cell anastomosing with 12 (4 ♂, 1 ♀).

Q.: Duaringa, Brisbane.—N.S.W.: Sydney.

143.† CASBIA ŒNIAS.

Deilinia œnias, Meyr., Proc. Linn. Soc. N.S. Wales, 1891, p.637.

Tas.: George's Bay.

144. CASBIA SYNEMPORA, n.sp.

συνεμπορος, a fellow-wayfarer.

♂♀. 29-31 mm. Head brownish-grey, face brownish. Palpi in ♂ $1\frac{1}{2}$, in ♀ 2; brownish. Antennæ grey: in ♂ with long pectinations (10), [apices broken]. Thorax brownish-grey Abdomen brown-whitish. Legs ochreous-whitish; anterior tibiæ and tarsi pale fuscous. Forewings triangular, costa gently arched, apex rounded, termen slightly bowed, oblique; vein 11 from cell and separate (1 ♂, 5 ♀) or shortly anastomosing with 12 (2♀); brownish-grey more or less irrorated with dark fuscous, which forms fine strigulæ towards costa; lines reddish-brown, faintly indicated; first at $\frac{1}{5}$, transverse, nearly obsolete; second before middle, sometimes dentate: on it beneath costa is a dark fuscous discal dot; third at $\frac{2}{3}$, dentate, nearly parallel to termen: a reddish-fuscous, pale-centred, subapical spot, and a similar but double median spot posterior to third line; a terminal series of dark fuscous dots; cilia brown-whitish. Hindwings with termen rounded; as forewings but without first line and subapical spot, double spot often nearly obsolete. Underside as upper but paler and without lines and spots.

Ab.♀. Subterminal spots rather large and fuscous.

Very similar to *D. rectaria* but slightly larger and darker, the ♂ without fovea and gland, and both sexes with longer palpi.

N.Q.: Herberton, in October, November, January, and February: eight specimens received from Mr. F. P. Dodd.

145. CASBIA RHODINA, n.sp.

ῥοδινος, rosy.

♂♀ 25-29 mm. Head reddish; anterior part of crown snow-white. Palpi 1½; whitish-ochreous tinged with reddish. Antennæ grey, towards base whitish; pectinations in ♂ very long (10), apical ⅛ simple. Thorax rosy. Abdomen whitish with some dark fuscous scales. Legs whitish; anterior pair pale fuscous except coxæ, which are reddish. Forewings triangular, costa gently arched, apex round-pointed, termen bowed, oblique; 11 from cell anastomosing with 12 (7 ♂, 4 ♀); rosy with some sparse dark fuscous irroration; lines nearly obsolete; a dark fuscous discal dot beneath mid-costa; a small blotch on middle of subterminal line variably developed, consisting typically of a short, tridentate, fuscous line, edged anteriorly by reddish, posteriorly by whitish; a terminal series of dark fuscous dots; cilia pale rosy. Hindwings with termen rounded; colour and markings as forewings. Underside whitish with fuscous irroration; costa of forewings ochreous; fuscous discal and terminal dots. Type in Coll. Lyell.

N.S.W.: Ebor (4,000 ft.), in January and February; four specimens.—Vic: Beaconsfield and Monbulk, from September to March; seven specimens.

146. CASBIA ALPHITOPIS, n.sp.

ἀλφιτωπις, floury.

♂♀. 28-32 mm. Head whitish; face fuscous. Palpi 1; pale fuscous. Antennæ whitish; ciliations in ♂ 8, apical ⅛ simple. Thorax and abdomen whitish. Legs whitish; anterior and middle tibiæ and tarsi pale fuscous Forewings triangular, costa moderately arched, apex round-pointed, termen bowed, oblique; 11 from cell anastomosing with 12 (2 ♂, 3 ♀): whitish sparsely irrorated with grey; a grey discal dot beneath mid-costa; in ♂ a small, ferruginous, ill-defined subterminal spot below middle; a terminal series of dark fuscous dots; cilia whitish. Hindwings with termen rounded; as forewings. Underside similar but rather more greyish. Type in Coll. Lyell.

Vic.: Macedon, near Gisborne, in February and March; Lorne, in February and March.—Tas.: Mt. Wellington, in October. Mr. Lyell writes that this species frequents the fallen timber of densely-wooded gullies at the head of fern gullies, and is exceedingly difficult to catch on account of the surroundings.

147. CASBIA ECCENTRITIS.

Deilinia eccentritis, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.635.

Forewings with 11 arising separately from cell and anastomosing with 12 (1 ♂, 1 ♀), or 11 out of 9 and anastomosing with 12 (3 ♀).

Q.: Blackbutt.—N.S.W.: Sydney.—Vic.: Warragul, Beaconsfield, Mt. Macedon, near Gisborne.

148 CASBIA LITHODORA.

Deilinia lithodora, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.637.

Forewings with 11 arising separately from cell and anastomosing with 12 (13 ♂, 4 ♀).

N.Q.: Herberton.—Q.: Eidsvold, Stanthorpe.—N.S.W.: Ebor (4,000 ft.), Sydney.—Vic.: Warragul.—S.A.: Mt. Lofty.—W.A.: Perth, Kelmscott, Waroona, Geraldton.

149. †CASBIA CREMNIAS.

Deilinia cremnias, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.638.

W.A.: Geraldton.

150. †CASBIA OCHTHADIA.

Deilinia ochthadia, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.639.

N.S.W.: Mt. Kosciusko (2,700 ft.).

151. CASBIA RHODOPTILA, n.sp.

ῥοδοπτιλος, rosy-winged.

♂. 23 mm. Head reddish. Palpi $1\frac{1}{2}$; brown-whitish. Antennæ grey-whitish; pectinations in ♂ 8, apical $\frac{1}{10}$ simple. Thorax whitish; tegulæ reddish. Abdomen whitish, towards base rosy-tinged. Legs whitish. Forewings triangular, costa nearly straight, apex round-pointed, termen slightly bowed, slightly oblique; 11 from cell anastomosing shortly with 12 (1♂): pale rosy; a suffused whitish streak along costa; a reddish discal dot beneath mid-costa; a very faint, reddish, postmedian line at $\frac{2}{3}$; an ill-defined, reddish-fuscous spot in middle of disc beyond this; a series of inconspicuous reddish terminal dots; cilia pale rosy, apices whitish. Hindwings with termen rounded: colour and markings as forewings, but subterminal spot nearly obsolete. Underside grey-whitish with a few pale fuscous strigulæ: small fuscous discal and terminal dots.

N.A.: Port Darwin, in September; one specimen, received from Mr. F. P. Dodd.

152. CASBIA SCIAGRAPHA, n.sp.

σκιαγραφος, with shaded marking.

♂♀. 25-28 mm. Head white, posterior edge of crown and face, except margins, brownish. Palpi in both sexes 2½; brownish, towards base white. Antennæ grey-whitish; pectinations in ♂ long (10), apical $\frac{1}{8}$ simple. Thorax grey-whitish; tegulæ brown. Abdomen ochreous-whitish. Legs whitish with some fuscous irroration; anterior tibiæ and tarsi pale fuscous. Forewings rather elongate-triangular, costa slightly arched at base, then straight nearly to apex, apex round-pointed, termen bowed, slightly oblique; 11 arising from a point with 9, anastomosing with 12 (2♂, 2♀), from 9 near base anastomosing with 12 (2♂), arising apparently from 12 (2♂, 1♀); grey-whitish, sometimes with pale fuscous strigulæ; costal edge ochreous with pale fuscous strigulæ; sometimes a pale fuscous dot above fold at $\frac{1}{5}$ representing first line; a dark fuscous median discal dot; a rather broad, sinuate, pale fuscous line, edged posteriorly with whitish, from $\frac{2}{3}$ dorsum towards, but not reaching $\frac{4}{5}$ costa; a fine fuscous terminal line: cilia grey. Hindwings with termen obtusely dentate, slightly rounded; as forewings but without postmedian shade, and with terminal line more distinct. Underside grey.

The brown tegulæ should be noted. When 11 appears to arise from 12, its basal portion is not developed.

N.S.W.: Glen Innes (3,500 ft.), in April, one ♀; Mt. Kosciusko (3,000-3,500 ft.), in March; eight specimens.

153. CASBIA ALBINOTATA.

Casbia albinotata, Warr., Nov. Zool., 1903, p.401: *Deilinia acrocosma*, Turn., Tr. R.S.S.A., 1904, p.236.

Forewings with 11 from cell, not anastomosing (2♂, 5♀).

N.Q.: Kuranda, near Cairns.—Q.: Brisbane, Stradbroke Island. Also from New Guinea.

154. CASBIA GLAUCOCHROA.

Deilinia glaucochroa, Turn., Tr. R.S.S.A., 1906, p.134.

Forewings with 11 from cell anastomosing with 12 (1♂).

N.Q.: Townsville.

155. CASBIA FASCIATA.

Scardamia fasciata, Warr., Nov. Zool., 1896, p.296.

Antennæ of ♂ with long pectinations (10), apical $\frac{2}{5}$ simple. Forewings with 11 from cell anastomosing with 12 (1♂), or free (1♀). Very conspicuous by its crimson-red and orange coloration. It deserves a better name.

N.Q.: Kuranda, near Cairns, in May and June; two specimens received from Mr. F. P. Dodd. Also from Louisiades.

156. CASBIA SCARDAMIATA

Casbia scardamiata, Warr., Nov. Zool., 1898, p.431.

Antennæ of ♂ with long pectinations (8), apical $\frac{1}{3}$ simple. Forewings with 11 from cell, anastomosing with 12 (2♂, 3♀).

N.Q.: Kuranda, near Cairns, in April, May, June, and August; five specimens received from Mr. F. P. Dodd. Also from New Guinea and Key Island.

157. CASBIA RESINACEA, n.sp.

Resinaceus, like resin, resin-coloured.

♂. 28-30 mm. Head brown. Palpi $1\frac{3}{4}$; brown. Antennæ fuscous; pectinations in ♂ 8, apical $\frac{1}{3}$ simple. Abdomen brown, sometimes with one or two white median dorsal dots. Legs pale ochreous; anterior tibiæ and tarsi pale fuscous. Forewings triangular, costa gently arched, apex rounded, termen bowed, oblique; 11 from cell, anastomosing first with 12, then with 9 (2♂); deep reddish-brown with sparse, transverse, fuscous strigulations; costa more densely strigulated, sometimes a white dot edged with fuscous beneath costa at $\frac{2}{3}$, sometimes two dots placed transversely close together; cilia brown, apices grey. Hindwings with termen rounded; a dark fuscous discal dot before middle; otherwise as forewings. Underside as upper, but more obscure.

Evidently variable. One example has a single white dot on one forewing, two dots on the other; in the second specimen there is no trace of either. The femora are hairy, and perhaps this may justify its generic separation.

N.Q.: Evelyn Scrub, near Herberton, in December; Kuranda, near Cairns, in May; two specimens, of which one is in Coll. Lyell, received from Mr. F. P. Dodd.

158. CASBIA CALLIORMA, n.sp.

καλλιορμος, with beautiful chain or necklace.

♂. 30 mm. Head and thorax brown. Palpi 1¼; brownish. Antennæ grey; pectinations in ♂ 10, apical ⅕ simple. Abdomen brown with a few fuscous scales, dorsum of apical segment fuscous; tuft whitish-ochreous. Legs whitish-ochreous; anterior tibiæ and tarsi pale fuscous. Forewings triangular, costa moderately arched, apex round pointed, termen bowed, oblique; 11 from cell, not anastomosing (1♂): brown with a few fuscous strigulæ; costa densely strigulated with fuscous; a dark fuscous discal dot; a subterminal series of white spots suffusedly outlined with dark fuscous scales; a terminal series of dark fuscous dots; cilia brown. Hindwings with termen rounded; as forewings, but costa not strigulated. Underside ochreous-whitish with some fuscous strigulæ; dark fuscous discal and terminal dots.

The white spots are probably variable. Type in Coll. Lyell.

N.Q.: Kuranda, near Cairns, in August; one specimen received from Mr. F. P. Dodd.

Gen. 17. RHINODIA.

Rhinodia, Gn., Lep., x., p.125; Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.640.

Face with strong projecting tuft of hairs. Tongue well-developed. Palpi very long, porrect, clothed with long rough hairs; terminal joint rather long. Antennæ of ♂ bipectinate to apex. Thorax not crested; nearly smooth or slightly hairy beneath. Femora smooth; posterior tibiæ of ♂ not dilated. Forewings in

♂ without fovea; 10 out of 9 anastomosing with 11, but basal part of 10 may be obsolete so that 10 appears to rise from 11, 11 from cell, connected or anastomosing with 12, but sometimes 11 apparently from 12. Hindwings normal.

An endemic derivative from the *Casbia* stem. Monotypical.

159. RHINODIA ROSTRARIA.

Rhinodia rostraria, Gn., Lep., x., p.125; Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.640. *Panagra undiferaria*, Wlk., Cat. Brit. Mus., xxxv., 1663. *Panagra jucundaria*, Wlk., Cat. Brit. Mus, xxxv., 1663. *Stegania allogata*, Feld., Reise Nov., Pl.131, f.15.

Forewings with 10 out of 9 anastomosing with 11, 11 previously connected (1♂, 1♀) or anastomosing (1♂) with 12; or 11 anastomosing with 12 and 10 apparently out of 11 (2♂, 3♀); or 11 apparently out of 12, 10 out of 9 anastomosing with 11 (1♀), or 11 apparently out of 12, 10 apparently from cell (1♀). The neuration is so variable that it is impossible to understand it without examining a series of specimens. It will then be seen that 10 arises normally from 9, but its basal portion is more often obsolete than developed. The basal portion of 11 may also be obsolete, and in the last example both anomalies occur, so that the true relationships are altogether obscured.

Q.: Duaringa, Gayndah, Brisbane, Blackbutt.—N.S.W.: Sydney.—Vic.: Melbourne, Fernshaw.—W.A.: York.

Gen. 48. COELOCROSSA, nov.

κοιλοκροσσος, with hollowed margin.

Frons flat. Tongue well-developed. Palpi moderate, porrect; second joint shortly rough-haired; terminal joint short. Antennæ of ♂ simple, minutely ciliated. Thorax not crested, beneath slightly hairy. Femora not hairy. Posterior tibiæ of ♂ dilated, with a basal tuft of hairs. Forewings rather elongate, termen very strongly bowed, in ♂ without fovea, 7, 8, 9, 10 stalked, 10 anastomosing with 9, 11 anastomosing with 12 and 10. Hindwings with 8 connected with cell near base, thence gradually diverging.

Type, *C. drepanucha*.

160. Coelocrossa drepanucha, n.sp.

δρεπανουχος. bearing a sickle.

♂. 22 mm. Head fuscous-whitish ; face brownish-fuscous, lower edge ochreous. Palpi moderate ($1\frac{1}{2}$), ochreous-brown. Antennæ fuscous-whitish; ciliations in ♂ $\frac{1}{4}$. Thorax and abdomen fuscous-whitish, the latter with a few fuscous scales. Legs whitish-ochreous; anterior pair, except coxæ, pale fuscous. Forewings elongate-triangular, costa straight to near apex, apex rounded, strongly produced, termen excavated beneath apex, strongly bowed and almost angled beneath vein 4, fuscous-whitish, with some brownish suffusion; markings and some scattered scales dark fuscous; several minute dots on costa near base; a subcostal dot near base; a quadrangular costal spot at $\frac{1}{3}$ representing first line; another on middle, and a smaller costal spot at $\frac{5}{6}$; a crescentic or sickle-shaped mark parallel to subapical concavity of termen; cilia fuscous-whitish. Hindwings with termen sinuate, fuscous-whitish with some brownish suffusion and a few dark fuscous scales; dark fuscous dots on dorsum at $\frac{2}{5}$ and $\frac{4}{5}$; cilia fuscous-whitish. Underside pale fuscous, with patchy orange-ochreous suffusion, especially towards costa of forewings. Type in Coll. Lyell.

N.Q : Evelyn Scrub, near Herberton: one specimen received from Mr. F. P. Dodd.

161. Coelocrossa hypocrocea, n.sp

ὑποκροκεος, saffron beneath.

♂. 24 mm. Head and thorax fuscous-whitish; face dark fuscous, lower edge ochreous. Palpi moderate ($1\frac{1}{2}$); ochreous mixed with brownish. Antennæ fuscous-whitish; ciliations in ♂ $\frac{1}{4}$. Legs ochreous; apical part of tibiæ and tarsi fuscous; [posterior pair broken]. Forewings triangular, costa sinuate, apex rounded, produced, termen excavated beneath apex, angled beneath vein 4 ; fuscous-whitish irrorated and strigulated with fuscous, a fuscous spot on costa at $\frac{2}{5}$, from which a fine fuscous line is traceable to dorsum at $\frac{1}{3}$; another spot on costa beyond middle, and a third at $\frac{4}{5}$; cilia fuscous-brown, on apex and angle of termen whitish. Hindwings with termen slightly rounded, as forewings but with fuscous dots on dorsum at middle and $\frac{3}{4}$. Underside orange-ochreous with patchy fuscous suffusion which on forewings forms a subterminal band. Broader winged than the preceding and without crescentic mark on forewing, but with general fuscous strigulation. Type in Coll. Lyell.

N.Q.: Kuranda, near Cairns, in December; one specimen received from Mr. F. P. Dodd.

162. COELOCROSSA LEPTOXANTHA, n.sp.

λεπτοξανθος, pale yellowish.

♂. 42 mm. Head pale ochreous. Palpi fuscous. Antennæ grey; ciliations in ♂ very minute. Thorax pale ochreous, with a few fuscous scales. Abdomen whitish-ochreous. Legs fuscous, barred with ochreous-whitish; middle and posterior tarsi ochreous-whitish. Forewings triangular, costa strongly arched, apex obtusely angled, deeply semicircularly incised between veins 6 and 4, thence sinuate to tornus; whitish-ochreous, costa strigulated and disc sparsely but coarsely irrorated with brownish-fuscous; markings dark fuscous edged with brownish; a slightly outwardly curved line from $\frac{1}{6}$ costa to $\frac{1}{4}$ dorsum; a pale-centered discal spot beneath mid-costa; a gently sinuate line from $\frac{5}{6}$ costa to $\frac{3}{4}$ dorsum; a line from this along dorsum to tornus; cilia brownish-ochreous. Hindwings with termen obtusely angled on vein 4; whitish-ochreous, with very scanty fuscous irroration; a fuscous median discal spot; a fuscous line at $\frac{4}{5}$ parallel to termen; cilia whitish-ochreous. Underside similar, but with discal dots more distinct and not pale-centred on forewing.

I think this is best included here for the present, although it differs in shape of wings and some details of neuration. In the forewing, 10 arises from 9 and is again connected with 9 by a bar beyond 7, 11 anastomoses with 12 but not with 10; in the hindwing, 8 is approximated as far as middle of cell. Type in Coll. Lyell.

N.S.W.: Dorrigo, in November; one specimen taken by Dr. R. J. Tillyard.

Gen. 19. PICROMORPHA, nov.

πικρομορφος. acutely shaped.

Frons rounded and somewhat projecting, smooth-scaled. Tongue well-developed. Palpi short, porrect; with short, rough scales beneath; terminal joint short. Antennæ of ♂ simple, thickened, minutely ciliated. Thorax and abdomen smooth above; thorax beneath slightly hairy. Femora smooth. Posterior tibiæ with two pairs of spurs, the inner longer. Forewings with acute, shortly projecting apex; in ♂ with a large basal fovea; 11 from cell, 10 from stalk of 7, 8, 9, anastomosing with 11 and then closely approximated to 8, 9 beyond 7. Hindwings with cell about ½, discocellulars nearly straight, 7 from just above angle of cell, nearly connate with 6.

163. PICROMORPHA PYRRHOPA.

Idiodes(?) pyrrhopa, Low., Proc. Linn. Soc. N. S. Wales, 1897, p.264.

♂. 24-26 mm. Head orange; face orange with a pair of yellow spots above middle and another at lower edge. Palpi 1¼; orange, towards base pale yellow. Antennæ pale yellow. Thorax grey, with a pale yellow, transverse, anterior band. Abdomen grey; beneath pale yellow with a few fuscous scales Legs pale yellow, sparsely irrorated, and tarsi annulated with fuscous. Forewings triangular, costa nearly straight, apex pointed, slightly produced, termen sinuate beneath apex, strongly bowed, oblique, grey; veins in disc more or less streaked with orange; a pale yellow costal streak, edged by a fine orange line, from base almost to apex; first line obsolete, represented by an obscure, fuscous, subcostal dot; median line by a similar dot; postmedian line very fine and obscure, fuscous, dentate; cilia orange, apices yellowish. Hindwings with termen rounded; as forewings, but without transverse lines and costal streak.

Neuration as in generic definition (3♂), but in one the basal part of vein 10 is very indistinct, so that 10 and 11 appear long-stalked from cell.

N.S.W.: Sydney; two specimens received from Dr. R. Riches.

Gen. 50. APLOCHLORA.

Aplochlora, Warr., P.Z.S., 1893, p.386; Hmps., Moths Ind., iii., p.156.

Face smooth. Tongue well developed. Palpi moderate; second joint rather long, ascending, rough-scaled; terminal joint short, porrect. Antennæ of ♂ simple, minutely ciliated. Thorax not crested; smooth beneath; posterior tibiæ of ♂ not dilated. Forewings in ♂ without fovea: 10 and 11 long-stalked from near base of 9, their stalk anastomosing strongly with 12, 10 anastomosing strongly with 9. Hindwings with 8 closely approximated to cell to $\frac{1}{3}$; otherwise normal.

Type, *A. virilaca* Wlk.

164. APLOCHLORA VIVILACA.

Iodis(?) virilaca, Wlk., Cat. Brit. Mus., xxii., p.544; *Aplochlora virilaca*, Hmps., Moths Ind., iii., p.157; *Aplochlora subflava*, Warr., Nov. Zool., 1896, p.392; *Euchloris pisochroa*, Turn., Tr. R.S.S.A., 1906, p.128.

Forewings with neuration as above, without variation (3♂).

N.Q.: Kuranda, near Cairns, in September and November; three specimens received from Mr. F. P. Dodd. Also from New Guinea, Ceylon, and India.

Gen. 51. PARAMETRODES.

Parametrodes, Warr., Nov. Zool., 1897, p.250.

Head shortly rough-scaled, face smooth with a slight tuft at lower edge. Tongue well-developed. Palpi moderate, porrect: second joint thickened with appressed hairs above and beneath, slightly ascending; terminal joint short, obtuse, bent downwards. Antennæ in ♂ bipectinate, apex simple. Thorax and abdomen not crested; thorax hairy beneath. Femora glabrous. Posterior tibiæ of ♂ not dilated. Forewings in ♂ without fovea; 10 and 11 stalked, their common stalk anastomosing with 12, 10 anastomosing with 9. Hindwings normal.

Type, *P. dispar* Warr. Superficially this resembles a *Cashia*, but the neuration approaches *Aplochlora*.

165. PARAMETRODES DISPAR.

Parametrodes dispar, Warr., Nov. Zool., 1897, p.250.

♂♀. 25-30 mm. Head brown. Palpi $1\frac{1}{2}$; brown. Antennæ grey; pectinations in ♂ 8, apical $\frac{1}{10}$ simple. Thorax brown. Abdomen brown, sometimes with two or three median dorsal white dots on basal segments. Legs pale ochreous; anterior pair more or less fuscous anteriorly. Forewings triangular, costa moderately arched, apex round-pointed, termen bowed, oblique; reddish-brown, with sparse, fuscous, transverse strigulations; a variably darker costal streak, with denser strigulations; first line from $\frac{1}{4}$ costa to $\frac{1}{3}$ dorsum, sometimes indicated by white dots; basal area sometimes ochreous-reddish except towards costa; second line usually ill-defined, from $\frac{3}{4}$ costa to $\frac{2}{3}$ dorsum, angled outwards in disc, sometimes marked towards costa with white or whitish-ochreous spots; median area occasionally suffused with fuscous, except in centre; sometimes a dark fuscous discal dot; sometimes a reddish-ochreous subapical blotch; cilia brown. Hindwings with termen rounded; as forewings. A very variable species.

N.Q.: Cooktown, Kuranda, near Cairns, in June; Evelyn Scrub, near Herberton, in November, December, and February (F. P. Dodd).

Gen. 52. SCARDAMIA.

Scardamia, Gn., Lep., ix., p.89; Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.639.

Face smooth, with short, conical projection. Tongue well-developed. Palpi moderate, ascending, with appressed hairs; terminal joint very short. Antennæ of ♂ bipectinate, towards apex simple. Thorax not crested, smooth or slightly hairy beneath. Abdomen with a small dorsal crest near base. Femora smooth; posterior tibiæ in ♂ not dilated. Forewings in ♂ without fovea; 10 and 11 long-stalked, their stalk anastomosing or connected with 12, or 11 apparently from 12, not connected with 10. Hindwings normal.

In this instance, I imagine the separation of veins 10 and 11 has occurred in the same way as in the genus *Boarmia*, and not in the usual way by obsolescence of the basal part of vein 11. I have seen no example in which 11 arises out of 10 and anastomoses with 12, as stated by Meyrick and Hampson (Moths Ind., iii., p.163).

Type, *S. metallaria* Gn.

1. Wings with postmedian line curved or sinuate..... .... 2.
Wings with postmedian line straight .... *ithyzona*.
2. Wings with fine, streak-like, blackish strigulæ.. .... *metallaria*.
Wings with fuscous irroration, but without strigulæ ..... *chrysolina*.

166. SCARDAMIA METALLARIA.

Scardamia metallaria, Gn., Lep., ix., p.89; Hmps., Moths Ind., iii., p.163.

Very similar to *S. chrysolina*, but in addition to the character given above, the antemedian line appears to be obsolete in the hindwings. Forewings with 11 apparently from 12, 10 from cell, free (1♀).

N.A.: Port Darwin, in December; one specimen received from Mr. F. P. Dodd.—Also from Java, Formosa, Ceylon, and India.

167. SCARDAMIA CHRYSOLINA.

Scardamia chrysolina, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.640.

Antennal pectinations of ♂ 8, apical $\frac{1}{3}$ simple. Forewings with 11 apparently from 12, 10 from cell, free (2♂, 1♀).

Q.: Brisbane, in October and May.—N.S.W.: Newcastle.

168. SCARDAMIA ITHYZONA, n.sp.

ἰθυζωνος, straight-girdled.

♀. 26-29 mm. Head orange, posteriorly dull purple: face reddish. Palpi 1$\frac{1}{4}$; reddish. Antennæ dull purple. Thorax orange. Abdomen, base, and dorsum orange, sides dull reddish; a rounded, metallic, dorsal crest on first segment. Legs whitish, tinged with reddish. Forewings triangular, costa rather strongly arched, apex round-pointed, termen bowed, oblique; 10 and 11 long-stalked, their stalk anastomosing shortly with 12 (3♀), or connected by a short bar (1♀); orange, rather densely strigulated with pale purple-fuscous; a dull purple costal streak; a fuscous line edged posteriorly by a fine metallic line from $\frac{1}{3}$ costa to $\frac{1}{3}$

dorsum, slightly angled outwardly in disc: a slender, oblique, discal mark beneath midcosta; a straight fuscous line edged anteriorly by a fine metallic line from $\frac{3}{4}$ costa to $\frac{3}{4}$ dorsum; cilia orange, mixed with dull purple. Hindwings with termen rounded; as forewings, but without first line, and with dark fuscous discal dot before middle. Underside paler; lines dull purple and more suffused.

This species appears to be similar to *S. rectilinea* Warr. (Nov. Zool., 1896, p.127), which has, however, metallic markings on termen.

N.Q.: Evelyn Scrub, near Herberton; four specimens received from Mr. F. P. Dodd.

Gen. 53. NADAGARODES.

Nadagarodes, Warr., Nov. Zool., 1895, p.133.

Face smooth. Tongue well-developed. Palpi moderate, ascending; second joint thickened with short, rough scales; terminal joint short, obtuse. Antennæ of ♂ shortly bipectinate, extreme apex simple. Thorax not crested, hairy beneath. Femora smooth; posterior tibiæ of ♂ dilated, with two pairs of spurs, the outer much shorter. Forewings of ♂ without fovea; 10 and 11 long-stalked or coincident, their stalk connected or anastomosing with 12. Hindwings with cell very short ($\frac{1}{4}$ or $\frac{1}{3}$), otherwise normal.

Type, *N. mysolata* Walk.

1. Underside of wings orange-ochreous .... *mysolata*.
Underside of wings whitish .... *ochrophara*.

169. NADAGARODES MYSOLATA.

Nadagara mysolata, Wlk., Cat. Brit. Mus., xxxv., p.1665.

♂♀. 36-40 mm. Head brownish-grey; face brown, lower edge ochreous. Palpi $1\frac{3}{4}$ to 2; brown, towards base ochreous. Antennæ dark grey, towards base whitish-grey; pectinations of ♂ $2\frac{1}{2}$, apical $\frac{1}{8}$ simple. Thorax pale grey, sometimes brownish-tinged. Abdomen pale grey, beneath pale ochreous. Legs grey; all femora and posterior tibiæ ochreous with a few grey scales. Forewings triangular, costa nearly straight, but strongly arched towards apex, apex in ♂ round-pointed, in ♀ acute and slightly produced, termen nearly straight, oblique; 10 and 11 long-stalked, their stalk anastomosing with 12 (1♂), 10 and 11 coincident (4♀), anastomosing strongly with 12 (1♀), or connected by a bar (3♀); pale grey, with some brownish tinge, sometimes wholly brown, sometimes whitish, densely strigulated with grey; usually with some fuscous irroration, first line obsolete; median from mid-costa to ¼ dorsum, angled beneath costa, usually very indistinct; postmedian from ¾ costa, strongly bent in upper part, thence straight to ⅔ dorsum, slightly dentate, fuscous, sometimes followed by a suffused grey band; cilia brown, apices sometimes whitish. Hindwings rather long, termen somewhat angled on vein 4; as forewings. Underside orange-ochreous, with fuscous strigulæ and lines; often a subapical white spot. Variable, but easily recognised by the underside.

N.Q.: Cape York, Cairns, Herberton. Also from Mysol.

170. NADAGARODES OCHROPHARA, n.sp.

ὠχροφαρος, pale-robed.

♀. 32 mm. Head brown-whitish; face, except lower edge, fuscous-brown. Palpi brown-whitish, towards apex brown. Antennæ grey, towards base grey-whitish. Abdomen brown-whitish with a few brown scales. Legs brown-whitish; anterior pair slightly infuscated. Forewings triangular, costa straight, but strongly arched near base and again before apex, apex acute, termen slightly sinuate, oblique, wavy; 10 and 11 coincident, arising from cell, connected at a point with 12 (1♀); whitish with slight brownish tinge and some brown irroration and markings; first line absent; a faint median line; a finely dentate line at ¾, straight, obsolete towards costa; beyond this are two broadish, wavy, grey lines, best defined towards dorsum, each edged posteriorly by a fine whitish line, a terminal series of dark fuscous dots; cilia whitish. Hindwings long, termen rounded, dentate, tornus slightly projecting and angled; as forewings; a linear discal mark before median line. Underside similar, but markings brown and more distinct; a linear discal mark on forewings also.

N.Q.: Evelyn Scrub, near Herberton, in December; one specimen received from Mr. F. P. Dodd.

Gen. 54. BURSADA.

Bursada, Wlk., Cat. Brit. Mus., xxxi., p.187.

Face smooth, not projecting. Tongue well-developed. Palpi moderate, or rather short, ascending, rather slender, smooth, without rough projecting hairs except at base; terminal joint very short. Antennæ of both sexes bipectinate, near apex simple. Thorax not crested; smooth-scaled beneath. Femora smooth; posterior tibiæ of ♂ not dilated. Forewings in ♂ without fovea; 10 from cell, connected with 9, 11 out of 10 near base, anastomosing with 12, or 11 apparently out of 12 (owing to obsolescence of its basal part), discocellulars weakly developed. Hindwings with cell $\frac{3}{5}$, 8 approximated to cell at about $\frac{1}{4}$; otherwise normal.

Ctimene Bdv., would be an older name for this genus if it is anything more than a *nomen nudum*.

171. BURSADA SYNESTIA.

Ctimene synestia, Meyr., Proc. Linn. Soc. N. S. Wales, 1886, p.242.

Antennal pectinations in ♂ 8, in ♀ 4, apical $\frac{1}{8}$ simple. Forewings with 11 out of 10 near base, anastomosing with 12 (1♂), 11 apparently out of 12 (1♀).

N.A.: Port Darwin, Daly River.—N.Q.: Cape York.—Also from New Guinea and Loyalty Islands.

Gen. 55. BULONGA.

Bulonga, Wlk., Cat. Brit. Mus., xx., p.276.

Face with a small anterior tuft of hairs. Tongue well-developed. Palpi rather long, porrect; second joint rough-scaled; terminal joint long, with appressed scales, obtuse. Antennæ of ♂ (not recorded). Thorax not crested; beneath hairy. Femora smooth. Forewings with 10 and 11 long-stalked, their stalk anastomosing with 12, 10 anastomosing with 9. Hindwings with cell short ($\frac{1}{3}$).

Allied to *Nadagarodes*, to which the neuration nearly corresponds, but the peculiar palpi alone are sufficient for distinction. I have no ♂ for examination.

Type, *B. schistacearia* Wlk., from the Malay Peninsula.

172. BULONGA SUBCINEREA.

Antibadistes subcinerea, Warr., Nov. Zool., 1896, p. 142. *Bulonga subcinerea distans*, Warr., Nov. Zool., 1896, p.408.

♀. 34-40 mm. Head ochreous-whitish; face pale brownish. Palpi 2, terminal joint $\frac{1}{3}$ second: pale brownish, barred with ochreous-whitish. Antennæ pale grey. Thorax and abdomen grey-whitish. Legs whitish: anterior pair ochreous-tinged. Forewings triangular, costa straight except near base and apex, apex obtusely pointed, termen straight, oblique, 10 and 11 long-stalked, their stalk anastomosing with 12, 10 anastomosing with 9 (3♀); grey-whitish with grey markings; costa finely strigulated with grey; faintly suffused transverse lines at $\frac{1}{4}$ and middle; a more distinct line from $\frac{2}{3}$ costa to $\frac{4}{5}$ dorsum, nearly straight, edged posteriorly with whitish; a transverse discal mark beneath costa at $\frac{1}{3}$; a faint terminal line; cilia white. Hindwings with termen angled on vein 4, wavy; as forewings, but without first line. Underside grey-whitish with discal marks and a terminal band on hindwings.

N.Q.: Cape York, Cooktown, Cairns.—Also from Amboyna and Java.

Gen. 56. NADAGARA.

Nadagara, Wlk., Cat. Brit. Mus., xxiv., p.1093; Hmps., Moths Ind., iii., p.193.

Face with well-marked anterior tuft. Tongue well-developed. Palpi rather long; second joint ascending, thickened with short, rough scales; terminal joint rather long, depressed, obtuse. Antennæ of ♂ simple. Posterior tibiæ of ♂ not dilated; with two pairs of spurs, inner spurs longer. Forewings with 11 from cell, anastomosing with 12, 10 out of 11 beyond anastomosis, sometimes anastomosing with 8, 9. Hindwings with cell about $\frac{2}{5}$, 8 approximated to cell near base, diverging before middle.

As I have only ♀ examples, I am indebted to Hampson for the ♂ characters.

Type. *N. rigaia* Wlk., from India.

1. Wings grey-whitish .... *irretracta*.
   Wings grey-brown .... *argyrosticha*.

173. NADAGARA IRRETRACTA.

Nadagara irretracta, Warr., Nov. Zool., 1899, p.356.

♀. 34 mm. Head brown; face with a whitish median transverse bar, its extremities produced upwards along edges. Palpi 3; pale fuscous. Antennæ brown. Thorax grey-whitish, tegulæ pale fuscous. Abdomen grey-whitish. Legs whitish irrorated with grey. Forewings triangular, costa nearly straight almost to apex, apex acute, slightly produced, termen bowed, oblique, wavy; 10 and 11 long-stalked, their stalk anastomosing with 12 (1♀); whitish irrorated and finely strigulated with pale grey; a blackish discal dot before middle; an oblique line from costa near apex to ¾ dorsum, brownish-grey, its anterior edge suffused, posterior distinct; an obscure whitish subterminal line; a grey terminal line; cilia whitish-grey. Hindwings with termen rounded, wavy; as forewings. Underside similar, but lines and strigulæ more distinct.

N.Q.: Kuranda, near Cairns, in April; one specimen received from Mr. F. P. Dodd. Also from Solomon Islands.

174. NADAGARA ARGYROSTICHA, n.sp.

ἀργυροστιχος, silver lined.

♀. 38 mm. Head purple-reddish. Palpi 2½; purple-reddish, mixed with ochreous. Antennæ purple-reddish. Thorax purple-whitish; tegulæ purple-reddish. Abdomen pale purplish; underside and apices of segments ochreous-whitish. Legs brown, purplish-tinged; posterior pair whitish-ochreous. Forewings triangular, costa straight, except close to base and apex, apex tolerably acute, termen strongly bowed, slightly oblique, wavy; 10 and 11 long-stalked, their stalk anastomosing strongly with 12, 10 anastomosing with 9 (1♀); pale ochreous-brown closely strigulated with purple-fuscous; first line from ¼ dorsum obliquely outwards towards ⅓ costa, edged anteriorly with some whitish scales; a dark fuscous median discal dot; a distinct line from ⅚ costa to ⅔ dorsum, evenly curved, edged posteriorly with silvery-white scales; a similar but slightly dentate parallel line from costa before apex to ⅚ dorsum; a faint submarginal line; cilia purple-fuscous. Hindwings with termen slightly rounded; as forewings, but without first line. Underside similar but less distinct.

N.Q.: Kuranda, near Cairns, in July; one specimen.

Gen. 57. IRIDOBAPTA.

Iridobapta, Warr., Nov. Zool., 1903, p.120.

Frons smooth, rounded, not projecting. Tongue well-developed. Palpi short, curved upwards; second joint thickened with appressed scales; terminal joint short. Antennæ in ♂ (unknown)- Thorax not crested, hairy beneath. Femora not hairy. Forewings with 2 from ⅔, 3 from near angle, 6 from upper angle, 7, 8, 9, 10, 11 by a common stalk from well before angle, 11 long-stalked with 10, connected with 12 soon after separation. Hindwings with cell about ⅓, otherwise normal.

175. IRIDOBAPTA ARGOSTOLA.

ἀργοστολος, white-robed.

♀. 32-34 mm. Head white; face ochreous-brown. Palpi ochreous-brown, paler towards base. Antennæ grey, towards base whitish. Thorax and abdomen white, on dorsum with sparse grey irroration. Legs whitish; anterior pair pale grey. Forewings triangular, costa straight, slightly arched towards base and apex, apex tolerably pointed, termen bowed, oblique; white, with general sparse grey irroration; a fuscous discal dot beneath costa before middle; a suffused grey line from ⅔ costa to ⅔ dorsum, nearly straight; a similar, but faint, subterminal line; cilia white. Hindwings rather long, termen gently rounded; colour and markings as forewings. Underside whitish.

N.Q.: Cairns, Atherton; three specimens.

Gen. 58. ORSONOBA.

Orsonoba, Wlk., Cat. Brit. Mus., xx., p.218; Hmps., Moths Ind., iii., p.211.

Face smooth. Tongue well-developed. Palpi moderate or rather long, porrect or ascending; densely rough-scaled; terminal joint short. Antennæ in ♂ bipectinate, towards apex simple. Thorax not crested; hairy beneath. Femora smooth or hairy. Forewings with apex somewhat falcate; 10 and 11 arising separately from cell, or stalked, 10 sometimes connected with 9. Hindwings with costa excised towards apex, termen acutely angled on vein 7: neuration normal.

I have no ♂ to examine, but the fovea is probably absent.

Type, *O. clelia* Cram.

176. Orsonoba clelia.

Orsonoba clelia, Cram., Pap. Exot., iii., p.172, Pl. 288, f. B,C; Hmps., Moths Ind., iii., p.212.

Forewings with 10 and 11 separate, 10 connected with 9 (1♀), or 10 and 11 long-stalked (1♀).

N.Q.: Kuranda, near Cairns.—Q.: Gympie.

177. Orsonoba zapluta.

Orsonoba zapluta, Turn., Tr. R.S.S.A., 1904, p.234.

Forewings with 10 and 11 separate, and free (2♀), or 10 connected with 9 (1♀).

Q.: Brisbane.

Gen. 59. Proboloptera.

Proboloptera, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.641.

Face smooth, with a rounded or conical, corneous projection. Tongue well-developed. Palpi moderate, porrect, rough-haired; terminal joint very short. Antennæ of ♂ bipectinate to apex. Thorax not crested; hairy beneath. Femora hairy; posterior tibiæ of ♂ not dilated. Forewings in ♂ without fovea; 10 and 11 arising separately from cell and free, 10 sometimes connected with 9. Hindwings normal.

I do not know the type species, *P. embolias* Meyr., in which no mention is made of the frontal projection, and the neuration is more variable, 10 sometimes arising from 9, 11 anastomosing with 12, and 10 with 11.

1.	Wings with white blotches	*leucoprepes.*
	Wings without white blotches	2.
2.	Wings pale ochreous	*luteola.*
	Wings purplish-grey	*embolias.*

178. †PROBOLOPTERA EMBOLIAS.

Proboloptera embolias, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.641.

N.S.W.: Katoomba.

179. PROBOLOPTERA LUTEOLA.

Orsonoba luteola, Turn., Tr. R.S.S.A., 1904, p.234.

Owing to a printer's error, part of my description has been omitted; the missing lines should read, "Forewings elongate-triangular, costa straight to near apex, apex rounded, termen bowed, oblique; pale yellowish, with a very few dark fuscous strigulæ." Forewing with 10 and 11 arising separately from cell and free (1♂).

Q.: Brisbane, in September.

180. PROBOLOPTERA LEUCOPREPES.

Orsonoba leucoprepes, Turn., Tr. R.S.S.A., 1904, p.235.

Forewings with 10 and 11 arising separately from cell and free (1♂), similar but 10 connected with 9 on one side only (1♂).

Q.: Gayndah, Dalby.

Gen. 60. TESSAROTIS.

Tessarotis, Warr., Nov. Zool., 1903, p.269.

Face smooth, not projecting. Tongue well-developed. Palpi rather long and slender, porrect, smooth-scaled; terminal joint moderate. Thorax not crested, hairy beneath. Femora smooth. Forewings with 10 and 11 arising separately from cell, 10 anastomosing strongly with 11 (to form an areole), and anastomosing or connected with 9. Hindwings with costa excised towards apex, termen acutely angled on vein 7; neuration normal.

Allied to *Orsonoba*, but with peculiar neuration. The anastomosis of 11 with 10 instead of with 12 is unusual in this subfamily.

Type, *T. rubra* Warr.

I have not seen a ♂, but according to Warren the antennæ in this sex are lamellate, and there is a fovea in the forewing.

181. Tessarotis rubra.

Tessarotis rubra, Wlk., Cat. Brit. Mus., 1903, p.270.

♀. 29-32 mm. Head whitish, suffused with rosy purple and mixed with dark fuscous on crown. Palpi $1\frac{1}{2}$; rosy-purple. Antennæ fuscous. Thorax whitish-rosy; apices of patagia and a posterior spot dark brown. Abdomen dark brown, with a median white line crossing five transverse lines on apices of segments. Legs dark fuscous; tibiæ annulated with ochreous-whitish. Forewings with costa straight, arched shortly before apex, apex rectangular, termen obtusely angled on vein 4, straight on costal side of angle, slightly concave on tornal side, dorsum much shorter than termen; 10 and 11 arising separately, 10 anastomosing with 11 and 9 (1♀), or connected with 9 (1♀); dark brown, toward apex paler; a broad, whitish-rosy, costal streak from base to $\frac{5}{6}$, gradually attenuated; a fine white line from beneath $\frac{2}{5}$ costa to $\frac{2}{5}$ dorsum; a short, transverse, dark fuscous discal mark; a second white line from beneath $\frac{2}{3}$ costa to $\frac{4}{5}$ dorsum, strongly bowed outwards; a third similar line from $\frac{5}{6}$ costa, roughly parallel, but approximated as it nears dorsum; longitudinal white streaks on veins 3 and 4 crossing last two lines; the first of these ends in a small white blotch connected with a white streak on termen from beneath angle nearly to tornus; two short rows of dark fuscous dots before upper part of termen; cilia dark brown, apices whitish. Hindwings with termen acutely angled and produced on vein 7, thence straight to tornus; grey-brown with dark fuscous irroration; a basal whitish suffusion to $\frac{1}{4}$; a whitish line from apex of suffusion to $\frac{2}{3}$ dorsum; a clear white discal dot before middle; an imperfect double row of dark fuscous subterminal dots; cilia dark brown, apices whitish except on angle. Underside grey with postmedian and subterminal fuscous lines and a white discal dot on hindwings.

N.Q.: Mackay.—Q.: Brisbane, in November and March; two specimens.

Gen. 61. IDIODES.

Idiodes, Gn., Lep., ix., p.39; Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.643.

Face with projecting tuft of hairs. Tongue well-developed. Palpi moderately long, ascending, clothed with dense rough hairs; terminal joint very short. Antennæ of ♂ stout, simple, ciliations extremely minute. Thorax not crested; beneath hairy. Femora hairy; posterior tibiæ of ♂ usually strongly dilated with internal groove containing a large tuft of long hairs from base. Forewings in ♂ without fovea; 10 and 11 arising separately from cell, very rarely 10 out of 9 or 11 near base, 10 anastomosing with 11 and usually also with 9, occasionally 11 anastomosing with 12 before 9. Hindwings normal.

An isolated genus in the Australian fauna.

Type, *I. apicata* Gn.

1.	Forewings with distinct, pale, antemedian line	*ceramopis.*
	Forewings without distinct antemedian line	2.
2.	Posterior tibiæ of ♂ dilated	3.
	Posterior tibiæ of ♂ not dilated	*fictilis.*
3.	Wings uniformly fuscous	*homophaea.*
	Wings not uniformly fuscous	4.
4.	Thorax slender	5.
	Thorax stout	*apicata.*
5.	Forewings with a dentate subterminal shade following postmedian line	*prionosema.*
	Forewings without such marking	*ischnora.*

182. IDIODES APICATA.

Idiodes apicata, Gn., Lep., ix., p.40; Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.643. *Idiodes mitigata*, Gn., Lep., ix., p.40, Pl. xiii., f.1. *Idiodes inspirata*, Gn., Lep., ix., p.40; Feld., Reise Nov., Pl.124, f.3. *Idiodes rinata*, Gn., Lep., ix., p.40. *Idiodes introducta*, Wlk., Cat. Brit. Mus., xx., p.30. *Tacparia zalissaria*, Wlk., Cat. Brit. Mus., xx., p.234. *Choara siculoides*, Wlk., Cat. Brit. Mus., xxi., p.291. *Phallaria conductaria*, Wlk., Cat. Brit. Mus., xxvi., p.1525. *Phallaria inductaria*, Wlk., Cat. Brit. Mus., xxvi., p.1526. *Acidalia primaria*, Wlk., Cat. Brit. Mus., xxvi., p.1610. *Idiodes inornata*, Wlk., Char. Undesc. Lep., p.74. *Idiodes punctiger*, Feld., Reise Nov., Pl.124, f.4.

Forewings with 10 and 11 arising separately from cell anastomosing, and 10 anastomosing with 9 (26 examples), similar, but 10 out of 9 (one example), similar, but 10 out of 11 near base (one example).

N.Q.: Cairns, Atherton, Herberton.—Q.: Nambour, Caloundra, Brisbane, Mt. Tambourine, Stradbroke I., Coolangatta.—N.S.W.: Sydney, Bathurst.—Vic.: Melbourne.—Tas.: George's Bay,—S.A.: Mt. Lofty.

183. Idiodes ischnora, n.sp.

ἰσχνορος, thin, narrow.

Idiodes primaria, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.642, *nec* Wlk.

Mr. Meyrick has sufficiently described this species. Forewings with 10 and 11 arising separately from cell and anastomosing, 10 approximated to 9, but not connected with it (six examples).

Q.: Mt. Tambourine, in December.—N.S.W.: Dorrigo, Stanwell Park, near Bulli, in February and March.—Vic.: Melbourne.

184. Idiodes prionosema, n.sp.

πριονοσημος, saw-marked.

♂. 37-38 mm. Head pale brown. Palpi 1½; pale brown. Antennæ ochreous-whitish. Thorax brown-whitish, tegulæ pale brown. Abdomen brown-whitish. Legs brown-whitish, irrorated with fuscous; posterior tibiæ of ♂ dilated with internal groove and tuft. Forewings triangular, costa gently arched, apex acute, slightly produced, termen bowed, oblique, slightly crenulate; 10 and 11 arising separately from cell and strongly anastomosing with each other, 10 closely approximated to 9 but not connected (2♂); very pale reddish-brown with fine fuscous strigulæ; markings fuscous; first line represented by three or four spots with intermediate strigulæ, from ¼ costa to ⅓ dorsum, outwardly curved; a median discal dot; a line from ⅚ costa to ⅔ dorsum, nearly straight, interrupted by whitish dots on veins, each of which is edged anteriorly by a fuscous dot; occasionally some pale fuscous suffusion between discal dot and dorsum; an interrupted line or shade posterior and parallel to postmedian line, with sharp dentations on posterior edge; some blackish dots on termen between veins; cilia concolorous. Hindwings with termen rounded, slightly crenulate; whitish, with sparse fuscous irroration; a fuscous discal dot; a straight transverse line from $\frac{2}{3}$ dorsum, not reaching costa; cilia whitish. Underside similar, markings less distinct on forewings, more distinct on hindwings.

N.S.W.: Ebor Scrub (4,500 ft.), in January; two specimens beaten from dead fronds of treeferns in 1916. They were taken in company with *Planolocha autoptis*, and I have previously mistaken them for a varietal form of that species.

185. Idiodes homophæa.

Idiodes homophæa, Turn., Tr. R.S.S.A., 1906, p.135.

The type is a ♂ (not ♀ as stated) with posterior tibiæ dilated. Forewings with 10 and 11 arising separately from cell and anastomosing, 10 connected with 9.

Q.: Nambour.

186. Idiodes ceramopis, n.sp.

κεραμωπις, like earthenware.

♀. 33 mm. Head, palpi, antennæ, thorax, and abdomen pale ochreous-brown. Legs brown-whitish, rather densely irrorated with fuscous-brown. Forewings triangular, costa straight almost to apex, apex round-pointed, termen bowed, oblique; 10 and 11 arising separately from cell, 11 anastomosing first with 12 and then with 10, 10 anastomosing with 9 (1♀); ochreous-brown; lines whitish-ochreous: first from $\frac{1}{3}$ costa to $\frac{1}{3}$ dorsum, straight, posteriorly dark-edged; a faintly darker discal mark; second line from $\frac{5}{6}$ costa to $\frac{2}{3}$ dorsum, sinuate, anteriorly dark-edged; a subterminal series of faintly marked fuscous dots; some terminal fuscous dots; cilia ochreous-brown. Hindwings with termen rounded; as forewings, but without first line.

Q.: Brisbane.

187. Idiodes fictilis, n.sp.

Fictilis, made of clay.

♂. 38 mm. Head and thorax brown; face dark brown. Palpi brown. Antennæ grey; in ♂ thickened, with extremely minute ciliations. (Abdomen broken). Legs brown-whitish, posterior tibiæ in ♂ not dilated, and without tuft of hair. Forewings triangular, costa gently arched, apex round-pointed, termen slightly bowed, slightly oblique; brown with sparsely scattered fuscous strigulations; a well-marked, round, fuscous, discal dot beneath mid-costa; cilia brown. Hindwings as forewings, but with discal dot very inconspicuous. Underside similar.

I regard this, as well as the preceding, as true *Idiodes*, though in addition to the differences in the ♂ tibiæ there is a small difference in the neuration of the forewing, 11 anastomosing first with 12, then with 10, 10 out of 9, anastomosing first with 11, then with 9. Type in Coll. Lyell.

N.S.W.: Gosford, in November.

Gen. 62. EPICAMPYLA, nov.

ἐπικαμπυλος, bent; in allusion to forewings.

Frons flat. Tongue well-developed. Palpi short, porrect; basal and second joints rough-scaled beneath; terminal joint short, obtuse. Antennæ of ♂ (unknown); in ♀ shortly bipectinate to near apex. Thorax not crested; somewhat hairy beneath. Femora not hairy. Forewings with termen strongly bowed and twice angled, first on vein 6 and secondly just below vein 4; 10 and 11 from cell, 11 anastomosing first with 12, then with 10, 10 connected with 9. Hindwings normal.

Of peculiar neuration and uncertain affinities; superficially the type resembles *Anisographe*, but it is more probably allied to *Idiodes*.

188. EPICAMPYLA SUBLÆTA, n.sp.

Sublætus, gay beneath.

♀. 44 mm. Head ochreous-whitish; face and palpi orange-brown. Antennæ ochreous-whitish. Thorax brown-whitish. Abdomen brown-whitish with a few dark fuscous scales. Legs ochreous-yellow irrorated with reddish; anterior tibiæ and all tarsi suffused with grey. Forewings elongate-triangular, costa twice sinuate, apex acute, produced, termen excavated beneath apex, strongly bowed, and angled on vein 6 and just below vein 4; whitish-ochreous with numerous brownish strigulations; an oblique whitish mark from costa before apex, preceded by a pale fuscous shade which reaches middle of disc; cilia brownish, mixed with pale ochreous. Hindwings with termen rounded, towards apex wavy; colour as in forewings; a darker-shaded, transverse line at $\frac{3}{4}$. Underside similar, but much more brightly coloured. Type in Coll. Goldfinch.

N.S.W.: Port Macquarie, in October; one specimen.

Gen. 63. PLANOLOCHA.

Planolocha, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.645.

Face smooth, or with projecting tuft of hairs. Tongue well-developed. Palpi moderately long, porrect, or somewhat ascending, thickened with rough hairs, terminal joint short. Antennæ of ♂ thickened, slightly laminate, minutely ciliated. Thorax not crested: slightly hairy beneath. Femora smooth; posterior tibiæ of ♂ sometimes dilated, with internal groove and tuft. Forewings of ♂ without fovea; 10 and 11 arising separately from cell, 10 sometimes connected with 9. Hindwings normal.

I have extended the scope of Meyrick's genus to include *obliquata* Luc., in which the face is smooth, and the ♂ without abdominal tufts and dilated posterior tibiæ.

189. PLANOLOCHA AUTOPTIS.

Planolocha autoptis, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.646.

Forewings with 10 and 11 arising separately from cell and free (2♂, 3♀), or 10 connected with 9 (3♂, 3♀). Abdomen of ♂ with dense tuft of hairs on each side beneath at base.

N.Q.: Herberton.—Q.: Nambour, Brisbane, Mt. Tambourine, Killarney.—N.S.W.: Ebor, Jenolan.—Vic.: Melbourne, Lorne.

190. PLANOLOCHA OBLIQUATA.

Aspilates obliquata, Luc., P.R.S.Q., 1892, p.80.

Forewings with 10 and 11 arising separately from cell and free (4♂, 1♀), or 10 connected with 9 (2♂, 3♀).

Q.: Nambour, Brisbane, Mt. Tambourine.—N.S.W.: Jenolan, Ourimbah.

Gen. 64. UROSTOLA.

Urostola, Meyr., Tr. R.S.S.A., 1891, p.198.

Face smooth, not projecting. Tongue well-developed. Palpi rather long, porrect, densely rough-haired; terminal joint short, concealed, tolerably acute. Antennæ in ♂ simple, shortly ciliated. Thorax not crested; beneath smooth-scaled. Femora smooth; posterior femora of ♂ short, with apical tuft of hairs; posterior tibiæ of ♂ dilated, with internal groove and tuft. Forewings in ♂ without fovea; 6 from upper angle of cell, 7, 8, 9, 10 stalked from well before angle, 11 from cell anastomosing first with 12, then with 10, 10 subsequently anastomosing with 9, so forming a double areole. Hindwing with neuration normal in ♀, but in ♂ 7 arises considerably before angle of cell, and is arched so as to approach closely or even anastomose shortly with 8 beyond cell.

I have examined seven examples (5♂, 2♀), and find no variation in the neuration of the forewing. I can offer no explanation for the curious neuration of the hindwings in the ♂, but the fact that it is confined to that sex deprives it of most of the importance originally attributed to it by Mr. Meyrick. The genus is peculiar and isolated, but belongs to the *Casbia* section of the subfamily.

191. UROSTOLA MAGICA.

Urostola magica, Meyr., Tr. R.S.S.A., 1891, p.199. *Loxographe fulva*, Warr., Nov. Zool., 1898, p.252.

N.Q.: Atherton, Herberton.—Q.: Brisbane, Mt. Tambourine.—N.S.W.: Richmond River, Ourimbah, Dorrigo, Manning River.

Gen. 65. NERITODES.

Neritodes, Gn., Lep., x., p.118; Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.651.

Face smooth, forming a moderate conical projection. Tongue well-developed. Palpi moderate, porrect, densely rough-haired; terminal joint concealed. Antennæ of ♂ slightly dentate, minutely ciliated. Thorax not crested; beneath smooth-scaled. Femora smooth; posterior tibiæ of ♂ somewhat dilated. Forewings of ♂ with a large glandular swelling between cell and vein 1 on undersurface; 10 and 11 coincident, anastomosing first with 12 and then with 9. Hindwings normal.

The glandular swelling does not appear to be homologous with the fovea.

192. NERITODES VERRUCATA.

Neritodes verrucata, Gn., Lep., x., p.119, Pl. 22, f.8; Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.652.

Forewings with neuration as described, without variation (5♂, 3♀).

Q.: Caloundra, Brisbane, Stradbroke I.—N.S.W.: Glen Innes, Ben Lomond (4,500 ft.), Sydney, Bathurst.—Vic.: Melbourne.—Tas.: Hobart, Strahan.—S.A.: Mt. Lofty, Pt. Lincoln.

Gen. 66. PARAMELORA.

Paramelora, Low., Tr. R.S.S.A., 1903, p.195.

Frons flat. Tongue well-developed. Palpi moderate, porrect: second joint roughly hairy; terminal joint minute. Antennæ of ♂ with long pectinations not extending to apex. Forewings in ♂ with basal fovea; 10 absent; 11 from cell, anastomosing at a point with 12, and again at a point with 9. Hindwings normal.

A development of *Amelora*, differing in the absence of vein 10 and in the ♂ antennal pectinations not reaching apex.

193. PARAMELORA ZOPHODESMA.

Paramelora zophodesma, Low., Tr. R.S.S.A., 1903, p.195.

♂ antennæ with pectinations 8, apical $\frac{1}{8}$ simple.

N.S.W.: Broken Hill.

Gen. 67. AUTHAEMON, nov.

αὐθαιμων, akin.

Frons with well-marked anterior tuft. Tongue well-developed. Palpi long, porrect; second joint very long, smooth-scaled; terminal joint moderately long in ♂, short in ♀, stout, obtuse. Antennæ of ♂ simple, minutely ciliated. Thorax with a small anterior subtriangular crest; rather hairy beneath. Femora somewhat hairy. Posterior tibiæ with two pairs of spurs. Forewings with 10 and 11 stalked and connected by a bar with 12, 10 anastomosing with 9: in ♂ with a small basal fovea. Hind wings normal.

Closely allied to *Amelora*, from which it is distinguished by the long smooth palpi and simple ♂ antennæ.

Type, *A. poliophara*.

194. AUTHAEMON POLIOPHARA, n.sp.

πολιοφαρος, grey-robed.

♂♀. 28-33 mm. Head whitish; face grey. Palpi in ♂ 3, in ♀ $2\frac{1}{2}$: terminal joint in ♂ $\frac{1}{4}$, in ♀ $\frac{1}{8}$: whitish, with a few blackish scales: terminal joint fuscous. Antennæ grey. Thorax pale ochreous-grey. Abdomen whitish with slight fuscous irroration. Legs whitish, irrorated with dark fuscous: tarsi fuscous, with whitish annulations. Forewings triangular, costa arched at base, thence straight, apex acute, termen scarcely bowed, slightly oblique: pale ochreous-grey, sparsely strigulated with fuscous; costal edge whitish, with some dark fuscous strigulations towards base; first line obsolete, or represented by three fuscous dots: discal spot obsolete: a line of fuscous dots from $\frac{5}{6}$ costa to $\frac{2}{3}$ dorsum, each edged posteriorly by a few white scales; a fine, white, costal streak not reaching apex, towards base strigulated with dark fuscous: cilia fuscous, apices white. Hindwings with termen rounded, slightly wavy; dark grey: cilia as forewings. Underside whitish, with dark fuscous irroration: dorsal area of forewings grey: hindwings with dark fuscous discal dot and postmedian row of dots.

Vic.: Birchip, in April and June; three specimens received from Mr D. Goudie.

195. AUTHAEMON STENONIPHA, n.sp.

στενονιφος, narrowly snowy.

♂. 29 mm. Head fuscous. Palpi in ♂ 4, terminal joint $\frac{1}{4}$: fuscous mixed with whitish, apex of terminal joint white. Antennæ dark grey: abdomen whitish, irrorated with fuscous. Legs dark fuscous, irrorated with whitish: tarsi dark fuscous, with whitish annulations. Forewings triangular, costa gently arched, more strongly at base, apex acute, termen strongly bowed, scarcely oblique; ochreous-brown, closely strigulated with fuscous; a white costal streak from $\frac{1}{6}$ to $\frac{5}{6}$; first line represented by three fuscous dots, each edged anteriorly with white: an obscure discal spot; a curved line of fuscous dots, each edged posteriorly with white, from $\frac{5}{6}$ costa to $\frac{3}{4}$ dorsum; cilia ochreous-brown barred with fuscous. Hindwings with termen rounded, slightly wavy; pale grey; a postmedian line of dots like those of forewings, but faintly marked; cilia pale grey tinged with ochreous. Underside whitish, with fuscous irrorated discal dot, and postmedian line of dots; dorsal area of forewings grey.

Differs from preceding by the longer palpi, darker forewings with strongly bowed termen, apices of cilia not white, etc. Type in Coll. Lyell.

Vic.: Lorne, in March, one specimen.

Gen. 68. ANGELIA.

Angelia, Low., Tr. R.S.S.A., 1903, p.193.

Frons with a horizontal, corneous, spathulate process. Tongue well-developed. Palpi moderate or rather short; second joint roughly hairy; terminal joint minute. Antennæ of ♂ pectinate to apex. Thorax sometimes with a small, anterior, triangular crest. Posterior tibiæ with two pairs of spurs; in ♂ dilated. Forewings in ♂ with a basal fovea; 10 and 11 arising from cell by a common stalk, which is connected by a bar with 12, 10 anastomosing with 9. Hindwings with 6 and 7 separate, connate, or short-stalked.

Type, *A. tephrochroa* Low.

A very natural genus distinguished from *Amelora* by the characteristic frontal process. The stalking of 6 and 7 of the hindwings I have noticed only in *A. heteropa* Low.

196. ANGELIA HETEROPA.

Amelora heteropa, Low., Tr. R.S.S.A., 1901, p.64.

N.S.W.: Broken Hill.

197. ANGELIA CAPNOSTICTA, n.sp.

καπνοστικτος, smoke-spotted.

♂. 30 mm. Head whitish-grey; face and palpi fuscous. (Antennæ broken). Thorax whitish-grey. Abdomen brown-whitish with some fuscous scales. Legs fuscous; tarsi annulated with whitish; middle femora, posterior femora, and tibiæ whitish with fuscous irroration. Forewings triangular, costa arched at base, thence straight to near apex, apex rounded, termen slightly bowed, slightly oblique; whitish-grey with numerous discrete fuscous dots; a roundish, ill-defined, discal spot beneath midcosta; an obscure, fuscous, dentate line from ⅚ costa, parallel to termen, not reaching dorsum: cilia grey-whitish. Hindwings with termen rounded; pale fuscous, with some darker irroration; cilia fuscous-whitish. Underside similar: forewings more obscure and without discal spot: hindwings grey-whitish, with dark fuscous irroration, discal, and line of postmedian dots. Type in Coll. Lyell.

Vic.: Birchip, in April; one specimen received from Mr. D. Goudie.

198. ANGELIA MESOPHAEA, n.sp.

μεσοφαιος, dusky in the middle.

♂. 25-29 mm. Head grey-whitish; face and palpi fuscous. Antennæ fuscous: pectinations in ♂ 8. Thorax grey-whitish. Abdomen grey-whitish, sometimes ochreous-tinged, with a few pale fuscous scales. Legs fuscous; tarsi with whitish annulations: femora and posterior tibiæ whitish, irrorated with fuscous. Forewings triangular, costa arched at base, thence straight to near apex, apex rounded, termen slightly bowed, slightly oblique; grey-whitish; a very broad median band, densely irrorated with dark fuscous and brownish, not reaching costa, from which it is separated by a grey-whitish streak, containing some fuscous strigulæ; anterior edge of band from ⅓ costa to ¼ dorsum, strongly outwardly curved, posterior edge from ⅚ costa to ⅓ dorsum, irregularly dentate; a blackish median discal spot; cilia grey-whitish. Hindwings with termen rounded; whitish-grey with some fuscous suffusion posteriorly; a faint discal dot; cilia grey-whitish. Underside of forewings pale grey, with fuscous discal spot and indistinct postmedian line; of hindwings, whitish with fuscous irroration, discal spot, and postmedian line.

Vic.: Sea Lake, in March; three specimens received from Mr. D. Goudie.

199. ANGELIA MELANCROCA, n.sp.

μελαγκροκος, woven with black.

♂. 26 mm. Head ochreous-whitish; face and palpi fuscous. Antennæ grey, towards base whitish, pectinations in ♂ 6. Thorax and abdomen ochreous-whitish. Legs pale fuscous; posterior pair, except tarsi, whitish, with fuscous irroration. Forewings triangular, costa strongly arched at base, thence straight, apex round-pointed, termen nearly straight, slightly oblique; ochreous-whitish, markings blackish; a short streak from costa at $\frac{1}{5}$, strongly outwardly oblique; a transversely oval discal spot; a subdentate line, parallel to termen at $\frac{5}{6}$, strongly marked on costa, thence pale and slender; cilia ochreous-whitish. Hindwings with termen rounded; fuscous, towards base ochreous-whitish; a dark fuscous postmedian line at $\frac{4}{5}$, cilia whitish. Underside pale grey, with fuscous discal spot and postmedian line on each wing. Type in West Australian Museum.

W.A.: Perth, in May, one specimen received from Mr. W. B. Alexander.

Gen. 69. AMELORA.

Amelora, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.646.

Head rounded, usually somewhat projecting, sometimes strongly, smooth or rough-scaled, sometimes with a short projecting tuft. Tongue well-developed. Palpi moderately long, porrect, rough-scaled; terminal joint short or moderate. Antennæ in ♂ bipectinate to apex. Thorax often with a slight, rounded, anterior crest; beneath more or less hairy. Femora smooth or somewhat hairy; posterior tibiæ of ♂ often dilated with internal groove and tuft. Forewings of ♂ sometimes with fovea, usually without, 10 and 11 long-stalked, their stalk connected or anastomosing with 12, 10 connected or anastomosing with 9. Hindwings normal.

Variable in several details of structure, but surprisingly constant in neuration, this is becoming a large genus. What is of more interest is that it is the centre of a small group of distinctively Australian genera, two of which, *Anthaemon* and *Angelia*, agree with it absolutely in neuration, while *Paramelora* is but slightly different. All the species of this group are southern, only one so far being recorded north of Sydney, and they are well represented in the interior and in the western half of the continent. A basal fovea in the forewing of the ♂ appears to have been originally present in this group, though it is not developed in most species of *Amelora*, but in two at least, which cannot be generically separate from that genus, it is still present.

200. †AMELORA GONIOTA.

Amelora goniota, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.647.

S.A.: Mt. Lofty.

201. AMELORA SPARSULARIA.

Panagra sparsularia, Gn., Lep., x., p.131, Pl.12, f.4. *Amelora sparsularia*, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.648.

Q.: Brisbane.—N.S.W.: Sydney, Bathurst.—Vic.: Blackrock, near Melbourne.—S.A.: Mt. Lofty.

202. AMELORA DEMISTIS.

Amelora demistis, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.648.

N.S.W.: Sydney.—Vic.: Gisborne, Lorne.—S.A.: Mt. Lofty.

203. AMELORA AMBLOPA.

Amelora amblopa, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.649.

This species, if I have identified it correctly, has a small basal fovea in the ♂ forewing.

N.S.W.: Bathurst, Mt. Kosciusko (5,000 ft.).—Vic.: Birchip, Sea Lake.—S.A.: Mt. Lofty.

204. AMELORA ZOPHOPASTA, n.sp.

ζοφόπαστος, dark-sprinkled.

♂. 34mm. Head, palpi, and thorax grey-whitish, with blackish irroration. Antennæ grey, towards base grey-whitish; pectinations in ♂ 6. Abdomen whitish, with blackish irroration on undersurface. Legs whitish, with dark fuscous irroration; anterior pair dark fuscous. Forewings triangular, costa arched at base, thence nearly straight, apex rounded, termen rather bowed, slightly oblique; ♂ with a small basal fovea; grey-whitish, finely irrorated with blackish; an oval, pale-centred, fuscous, median, discal spot; cilia grey-whitish, irrorated with blackish. Hindwings with termen rounded, wavy; whitish, with some fuscous irroration; a median discal dot and broad terminal band fuscous; cilia whitish, with some fuscous irroration. Underside of forewings fuscous; of hindwings as on upper surface, but with discal dot and irroration more pronounced.

This appears to be a true *Amelora*, agreeing in all respects except in the presence of the fovea. Type in Coll. Lyell.

Vic.: Blackrock, near Melbourne, in February; one specimen.

205. AMELORA MESOCAPNA, n.sp.

μεσοκαπνος, smoky in the middle.

♂. 29 mm. Head and thorax pale grey. Palpi pale grey, with some blackish irroration. Antennæ pale grey; pectinations in ♂ 8. Abdomen pale grey, with some fuscous scales. Legs whitish; anterior pair irrorated with dark fuscous. Forewings triangular, costa nearly straight, apex acute, termen bowed, slightly oblique, crenulate; pale grey; markings fuscous; a basal costal spot; some fine costal strigulations, a broad median band not reaching costa, from which it is separated by a broad streak of groundcolour, bounded anteriorly by an outwardly curved crenulate edge from $\frac{1}{6}$ costa to $\frac{1}{3}$ dorsum, and posteriorly by an acutely, but irregularly dentate edge from $\frac{7}{8}$ costa to $\frac{2}{3}$ dorsum; a fine terminal line; cilia fuscous, at tornus pale grey. Hindwings with termen rounded, crenulate; pale grey; a faintly darker discal dot and dentate postmedian line; cilia grey-whitish. Underside grey; forewings with a faint median line; hindwings paler, with fuscous irroration, discal dot and postmedian line. Type in Coll. Lyell.

N.S.W.: Hornsby, near Sydney, in March; one specimen.

206. AMELORA ONCERODES, n.sp.

ὀγκηρωδης, large, bulky.

♂. 40-42 mm. Head, thorax, and palpi grey. Antennæ grey; pectinations in ♂ 5. Abdomen grey-whitish. Legs grey-whitish; anterior pair grey. Forewings triangular, costa arched at base, thence nearly straight, apex rounded, termen bowed, slightly oblique: grey, with a few dark fuscous scales: postmedian line represented by a series of dark fuscous dots from $\frac{5}{6}$ costa to $\frac{2}{3}$ dorsum: cilia dark grey. Hindwings with termen rounded, slightly wavy; as forewings. Underside pale grey, without markings; a small, fuscous, discal dot on hindwings. Type in Coll. Lyell.

Vic.: Gisborne, in January; two specimens.

207. Amelora pachyspila, n.sp.

παχυσπιλος, thick-spotted.

♂. 33 mm. Head grey. Palpi dark fuscous. Antennæ grey; pectinations in ♂ 8. Thorax grey. Abdomen grey-whitish. Legs whitish, with fuscous irroration; anterior pair fuscous; all tarsi fuscous, with whitish annulations. Forewings triangular, costa arched at base, thence nearly straight, apex round-pointed, termen bowed, oblique: grey; markings blackish; a thick transverse line from $\frac{1}{5}$ costa, becoming slender and dentate beneath middle; a rather large, oval, discal spot; a very fine, irregularly dentate line from $\frac{4}{5}$ costa to $\frac{1}{5}$ dorsum, better marked at costal end; cilia grey. Hindwings with termen rounded; grey-whitish; a fuscous discal spot and broad terminal band: the latter preceded by a series of minute fuscous dots on veins; cilia grey-whitish. Underside of forewings without sub-basal line, and with postmedian line indistinct; of hindwings, whitish with dark fuscous irroration, discal and postmedian series of dots dark fuscous and very distinct. Type in Coll. Lyell.

W.A.: Waterloo, in May; one specimen received from Mr. G. A. Berthoud.

208. Amelora pentheres, n.sp.

πενθηρης, mournful.

♂. 29 mm. Head fuscous-brown; face prominent, grey-whitish. Palpi fuscous. Antennæ fuscous (broken off near base). Thorax fuscous-brown. Abdomen grey-whitish, towards apex grey. Legs dark fuscous, femora irrorated and tibiæ and tarsi annulated with whitish. Forewings triangular, costa strongly arched at base, thence straight to near apex, apex rounded, termen slightly bowed, oblique; fuscous-brown, suffused towards margins with fuscous, with a few, scattered, blackish scales: a transverse, linear, dark fuscous, discal mark; cilia fuscous. Hindwings with termen rounded: grey-whitish: a broad, ill-defined, fuscous, terminal band; cilia grey. Underside of forewings fuscous; of hindwings as upper side. Type in Coll. Lyell.

W.A.: Waterloo, in May: one specimen received from Mr. G. F. Berthoud.

209. AMELORA CRYPHIA, n.sp.

κρυφιος, hidden.

♂. 26 mm. Head whitish-grey; face and palpi fuscous. Antennæ grey, towards base whitish; pectinations in ♂ 5. Thorax ochreous fuscous. Abdomen whitish, irrorated with fuscous. Legs whitish, irrorated with dark fuscous; anterior pair dark fuscous, with whitish tarsal annulations. Forewings triangular, costa slightly arched, apex pointed, termen slightly bowed, slightly oblique; pale ochreous-grey irrorated with fuscous, central area suffused with reddish-brown; a faintly marked outwardly curved line from $\frac{1}{4}$ costa to $\frac{1}{3}$ dorsum, suffused posteriorly with reddish-brown; a very faint, dark, discal spot; a fine, dentate, fuscous line from costa before apex to $\frac{2}{3}$ dorsum, suffused anteriorly with reddish-brown; cilia pale ochreous-grey, irrorated with fuscous. Hindwings with termen rounded; fuscous-grey, towards base paler; cilia whitish-ochreous mixed with fuscous. Underside of forewings fuscous; of hindwings whitish with fuscous irroration, and a very broad, fuscous, terminal band. Type in Coll. Lyell.

Vic.: Birchip, in April: one specimen received from Mr. D. Goudie.

210. AMELORA CAMPTODES, n.sp.

καμπτωδης, bent.

♀. 34 mm. Head whitish, mixed with dark fuscous: face and palpi fuscous. Antennæ fuscous, towards base whitish. Thorax fuscous. Abdomen whitish, irrorated with fuscous. Legs fuscous with whitish annulations; posterior pair whitish. Forewings broadly triangular, costa strongly arched at base, thence straight, apex acute, termen sinuate beneath apex, strongly bowed and bent on vein 4, scarcely oblique; fuscous-whitish, with dark fuscous strigulations; a broad, fuscous, median band, containing a darker discal spot, and edged by ochreous-whitish lines; first line from $\frac{1}{10}$ costa very obliquely outwards, sharply angled in disc, then inwardly oblique to $\frac{1}{4}$ dorsum, second line from costa before apex to $\frac{3}{4}$ dorsum, straight but slightly wavy; cilia fuscous, apices whitish. Hindwings with termen only slightly rounded, slightly wavy; grey, towards base grey-whitish; cilia whitish-grey. Underside grey-whitish, strigulated with fuscous; dorsal area of forewings uniformly grey; a fuscous postmedian line, obsolete towards dorsum of forewings; a fuscous discal spot on hindwings. Type in Coll. Lyell.

Vic.: Woodford, in March; one specimen.

211. AMELORA AUSTRALIS.

Odontoptera australis, Rosen., A.M.N.H., 1885, p.428, Pl.11, f.9. *Amelora australis*, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.649.

Vic.: Melbourne, Lorne.—Tas.: Hobart.

212. AMELORA SYNCLERA, n.sp.

συγκληρος, neighbouring.

♂. 33 mm. Head and thorax dark fuscous with some whitish irroration. Palpi brown-whitish with some dark fuscous scales towards base. Antennæ grey-whitish; pectinations in ♂ 7. Abdomen grey-whitish, with a few fuscous scales. Legs ochreous-whitish, irrorated with dark fuscous; anterior pair mostly dark fuscous. Forewings triangular, costa slightly arched at base, thence straight to near apex, apex pointed, termen slightly bowed, slightly oblique, evenly crenulate; grey-whitish, unevenly suffused with dark fuscous; lines darker; first from $\frac{1}{4}$ costa to $\frac{1}{3}$ dorsum, slightly outwardly curved, suffused; second from $\frac{4}{5}$ costa to $\frac{2}{3}$ dorsum, acutely dentate, partly obscured by dark fuscous suffusion; a transverse, median, discal mark; a terminal series of dark fuscous dots between veins; cilia grey-whitish. Hindwings with termen rounded, slightly waved: grey-whitish, suffused with fuscous; cilia grey-whitish. Underside of hindwings with discal dot and postmedian line.

Similar to *A. australis*, which may be distinguished by the peculiarly toothed termen of forewing. Type in Coll. Lyell.

N.S.W.: Hornsby, near Sydney, in April; one specimen.

213. †AMELORA MILVARIA.

Scodiona milvaria, Gn., Lep., x., p.140, Pl. 8, f. 8. *Amelora milvaria*, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.650.

S.A.: Mt. Lofty.

214. AMELORA CATACRIS.

Amelora catacris, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.650.

N.S.W.: Mt. Kosciusko (6,000 ft.).—Tas.: Strahan.

215. AMELORA OENOBRECHES, n.sp.

οἰνοβρεχης, wine-sprinkled.

♂. 33-36 mm. Head and thorax purple-grey; face and palpi dark fuscous; palpi rather short (1¼). Antennæ grey; pectinations in ♂ 6. Abdomen grey. Legs whitish-grey, with fuscous irroration; anterior pair grey. Forewings broadly triangular, costa slightly arched at base, thence straight, apex acute, slightly produced, termen bowed, scarcely oblique; ochreous-grey; a broad costal streak and narrow streaks on veins purple; costal edge ferruginous; first line represented by two fuscous-purple dots, one on median and one on internal vein; a large, suffused, fuscous, discal spot; second line slightly sinuate, represented by fuscous-purple dots on veins; cilia purple. Hindwings with termen scarcely rounded, slightly wavy; grey; a large, suffused, fuscous, median spot; an obscure postmedian line of fuscous dots; cilia purple. Underside of forewings grey, with obscure, darker, discal dot and postmedian line; of hindwings, whitish irrorated with grey, with large, fuscous, median spot, and broad, grey, terminal band.

Ab. Broad, antemedian, curved line on forewings, and broad postmedian lines on both wings, the latter sharply defined and dentate posteriorly. Apparently equally common with the typical form. Type in Coll. Wyld.

N.S.W.: Sydney, in April; five specimens received from Mr. G. H. Wyld, who has a series.

216. AMELORA CRYPSIGRAMMA.

Amelora crypsigramma, Low., Proc. Linn. Soc. N. S. Wales, 1899, p.87.

N.S.W.: Broken Hill.—Vic.: Birchip.

217. AMELORA MACARTA, n.sp.

μακαρτος, happy.

♂. 36 mm. Head and thorax whitish-grey; face whitish, with two pairs of lateral blackish dots. Palpi moderate (1½): whitish, apices blackish. Abdomen grey-whitish, with a few blackish scales. Legs whitish, irrorated and annulated with blackish. Forewings triangular, costa straight nearly to apex, apex pointed, termen bowed, oblique: whitish-ochreous-grey, with a few, scattered, blackish scales, and numerous, minute, paler strigulations; a basal spot of black and white scales mixed; an ill-defined, basal, pale ochreous patch, bordered by some blackish dots; a sinuate line from costa near apex to ¾ dorsum, consisting of a row of blackish white-edged dots with a posterior pale ochreous suffusion: cilia grey, apices white. Hindwings with termen slightly rounded, slightly wavy; whitish, with grey strigulations, towards termen grey; a grey discal dot before middle; a dentate fuscous line at ¾; cilia grey, apices white, except at apex, on dorsum whitish. Type in Coll. Wyld.

N.S.W.: Sydney, in May; one specimen received from Mr. G. H. Wyld.

218. AMELORA FUCOSA, n.sp.

Fucosus, reddish.

♂. 32 mm. Head dull reddish-brown; face and palpi dark fuscous. Antennæ grey; pectinations in ♂ 5. Thorax dull reddish-brown. Abdomen ochreous-whitish. Legs whitish, with fuscous irroration, tarsi and spurs, except apices, fuscous; anterior pair dark fuscous, tarsi with whitish annulations. Forewings triangular, costa slightly arched at base, thence straight, apex round-pointed, termen scarcely bowed, slightly oblique; dull reddish-brown; first line represented by three darker dots, discal spot similar; a series of darker dots each edged posteriorly by ochreous-whitish, from costa before apex in a wavy line to ⅔ dorsum: cilia fuscous-purple. Hindwings with termen but slightly rounded: dark grey, with faintly darker discal and postmedian series of dots; cilia fuscous-purple. Underside of forewings fuscous; of hindwings, whitish with dark fuscous irroration, discal spot, and broad terminal band. Type in West Australian Museum.

W.A.: Perth, in April: one specimen received from Mr. W. B. Alexander.

219. AMELORA AROTRAEA.

Amelora arotraea, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.651.

N.S.W.: Mt. Kosciusko (5,000 ft.).—Vic.: Melbourne.—Tas.: Hobart.

220. AMELORA LEUCANIATA.

Liodes leucaniata, Gn., Lep., x., p.120, Pl.18, f.3. *Chlenias vittaligera*, Wlk., Cat. Brit. Mus., xxiv., p.1153. *Amelora leucaniata*, Meyr., Proc. Linn. Soc. N.S.W., 1891, p.651.

N.S.W.: Sydney.—Vic.: Melbourne.—S.A.: Mt. Lofty.

221. AMELORA ORITROPHA, n.sp.

ὀρειτροφος, mountain-bred.

♂. 31-32 mm.; ♀. 28-29 mm. Head whitish-brown; face in ♂ fuscous. Palpi 3; second joint much elongate, rough-haired; terminal joint smooth, slender, acute. Antennæ dark fuscous, sharply annulated with white; pectinations in ♂ 8, dark fuscous. Thorax in ♂ fuscous, patagia whitish-ochreous; in ♀ wholly whitish-ochreous. Abdomen whitish. Legs fuscous; posterior pair ochreous-whitish. Forewings elongate-triangular, costa gently arched at base, thence straight, apex round-pointed, termen bowed, oblique; ochreous-fuscous, in ♀ paler, with broad, white, longitudinal streaks, finely edged with fuscous; a narrow streak along dorsum; a subdorsal streak from base to termen just above tornus; a median streak commencing in a fine point near base, gradually broadening and bifurcating shortly before termen; two streaks between these, the upper from $\frac{2}{3}$ to termen, the lower from middle to termen; a streak above median from middle to termen, and a short subcostal streak from $\frac{2}{3}$ to termen; cilia whitish-grey, becoming grey towards apex. Hindwings narrower in ♀; termen rounded, in ♀ wavy; whitish; cilia whitish. Underside fuscous-whitish, with a fuscous discal dot in each wing.

The ♀ is uniformly smaller and narrower-winged than the ♂. Allied to *A. leucaniata*, the two forming a distinct section of the genus.

N.S.W.: Mt. Kosciusko (5,000-6,000 ft.), in February, abundant in the moist peaty valleys. My examples (2♂, 6♀) taken in the end of February and beginning of March are wasted, especially the males.

222. AMELORA RHYNCHOPHORA.

Chlenias(?) *rhynchophora*, Low., Tr. R.S.S.A., 1893, p.163.

♂. 35-36 mm. Head grey mixed with whitish; face with long frontal tuft. Palpi long ($3\frac{1}{2}$); grey. Antennæ grey; pectinations in ♂ 7. Thorax grey. Abdomen whitish, irrorated with purple-grey. Legs dark fuscous, irrorated with whitish and purple; posterior pair mostly whitish; posterior tibiæ in ♂ not dilated. Forewings elongate-triangular, costa moderately arched at base, thence straight, apex round-pointed, termen bowed, oblique; whitish-grey, partly suffused with purple grey; lines dark fuscous; a line from $\frac{1}{4}$ costa very obliquely outwards, then obtusely angled, and again with an obtuse tooth outwards above dorsum; a longitudinal streak traverses each of these teeth, the subdorsal streak being connected with second line; second line from apex to $\frac{2}{3}$ dorsum, sharply and strongly serrate; cilia whitish, barred with fuscous, and with a purplish line before apices. Hindwings with termen rounded; whitish-grey; cilia whitish-grey, bases barred with fuscous. Underside grey, with some fuscous and purple irroration.

The unusually long palpi are exceptional in this genus. In one of the two examples the bar connecting veins 11 and 12 is absent. The species shows distinct relationship to *Mictodoca.*

N.S.W.: Hornsby, near Sydney, in May: two specimens.—S.A.: Mt. Lofty (Lower).

223. AMELORA BELOPHORA, n.sp.

βελοφορος, dart-bearing.

♂. 34 mm. Head pale ochreous-fuscous; face and palpi fuscous. Antennæ pale grey; pectinations in ♂ very long (10). Thorax pale ochreous-fuscous. Abdomen ochreous-whitish. Legs fuscous irrorated, and tarsi annulated with ochreous-whitish Forewings elongate-triangular, costa gently arched at base, thence straight to near apex, apex rounded, termen bowed, oblique: ochreous-whitish, suffused with pale fuscous: a broad, fuscous, median streak from $\frac{1}{4}$ to $\frac{3}{4}$; a line of fuscous dots at $\frac{3}{4}$, first outwardly curved, then sinuate to dorsum; some fine, interneural, fuscous streaks towards termen; a terminal series of dark fuscous dots; cilia pale fuscous, obscurely barred with ochreous-whitish. Hindwings with termen rounded; fuscous-whitish; cilia fuscous-whitish. Underside fuscous-whitish, with faintly darker discal dot and terminal line on each wing.

In the forewing, the neuration is abnormal, 10 and 11 are short-stalked, 10 connected with 9, but 11 not connected with 12; but it seems best to refer the species here, at least for the present. Type in Coll. Lyell.

Vic.: Beaconsfield, in April; one specimen.

THE GERMICIDAL ACTIVITY OF THE EUCALYPTUS OILS.

PART ii. THE ACTION OF THE OILS IN AQUEOUS DILUTIONS.

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(With seven Text-figures).

In Part i. of this contribution, I dealt with the germicidal activity of the Eucalyptus oils when dissolved in a neutral oil such as olive oil, and it was shown that under such conditions they were poor disinfectants. The phenol-coefficients, against *B. coli communis* at 20° for two hours, ranged from 0·4 with the oils of *E. linearis*, *E. cinerea*, rect., and *E. australiana*, crude, 3rd hour, down to 0·07 with cineol and the oil of *E. polybractea*.

In this paper, an examination has been made of their germicidal powers when in aqueous dilution.

It is a difficult matter to determine the real, hygienic or economic value of a disinfectant, for so much depends upon the material in which the bacteria are contained. They may be suspended in blood, pus, sputum, urine, sewage, water, trade waste, etc., all of which have variable influences in absorbing or rendering inert the disinfectant. The proteids and fat are among the most active destroyers of the disinfectants, and in considering their virtues the nature of the bacterial menstruum or, as it is called, their environment, has to be taken into account. The coal tar products, for example, have their powers seriously reduced by fat, in which they are more soluble than in water, while the metallic disinfectants, such as mercuric chloride, are weakened by proteids with which they form compounds. The oxidising disinfectants are more or less used up in oxidising the organic matter of the environment. It is, therefore, evident that a common medium must be employed when a comparison is desired, and the Rideal-Walker test is that which is generally used. In it, the activity of the disinfectant is not interfered with, and although the test has its weaknesses, it has been very useful in giving us some idea of the value of disinfectants in the absence of organic matter. The test is easy to do, and it should give approximately similar results when made by different workers.

The Eucalyptus oils are partly soluble in water and partly emulsified, much depending upon the oil and upon the quantity of water. Cineol or Eucalyptol, the chief constituent of many of the oils, is soluble in about 300 parts of water, while the other constituents are so insoluble that many give opalescent dilutions with 2,000 parts of water. Their power of forming emulsions is probably of value, for, as I think Martin has pointed out, the adsorption by bacteria from emulsions is greater* than from solutions, and the adsorption is the first step in the destruction of bacteria by disinfectants.

In preparing the dilutions of the oils, two methods were employed—the mass and the droplet methods. In the first, a certain weight of oil was shaken with a calculated quantity of water, usually 199 times the weight of the oil, and from this strong emulsion the weaker dilutions were made by adding the requisite quantities of water. In working with the oils, one is struck with the tenacity with which they adhere to the glass of the flasks and pipettes, and with the idea of minimising any irregularity rising from this phenomenon, the droplet method was used as an alternative. One point in favour of the droplet method is that, when only small quantities of the oil are available, there is very little waste. A capillary pipette was made and kept for dropping. Each oil under examination was tested daily or weekly, according to the laboratory temperature, by

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* "Adsorption undoubtedly plays a large part in many forms of disinfection, and confers upon emulsions, as contrasted with solutions, considerable advantages." Somerville, Cantor Lectures, 1913. Roy. Soc. of Arts.

weighing 30 drops discharged from the pipette while held vertically. Three weighings were made, and as these never varied from a milligram or two, the weight of an average droplet was obtained. The volume of water necessary to make about 10 c.c. of the required dilution was pipetted into a wide-mouthed ounce bottle, and the requisite number of drops of oil were added. The bottle was corked and shaken 300 times at intervals and finally before the abstraction of 2 c.c. This quantity was pipetted into a small tube, $5 \times \frac{5}{8}$ inches, a drop* of a 20 hours' broth culture of *B. coli communis* was added, and the tube was put into a water-bath at 20° for the allotted time.

At certain intervals the dilutions were shaken and a small quantity withdrawn from each by means of a platinum spiral,† and put into a test tube containing 3 c.c. of Lemco broth. The infected Lemco tubes were incubated at 37° for two days.

The dilutions were generally made in steps of 100 up to 1,000, then by 200 up to 2,000, but in certain cases this was departed from and the steps made smaller, as in the case of cineol and phenol.

When the oils are diluted with water, they are more or less opalescent, depending upon the relative amounts of oil and water. The oil slowly dissolves, and the faintly opalescent dilutions become clear.

The question arose as to when the dilutions should be tested, that is to say, at what time, after their preparation, were they most potent? To answer this question, cineol was tested, and it was found to be as effective in twenty minutes as in four hours, but that it became less and less germicidal as the time extended from one to twelve days. This is in keeping with the idea that an emulsion of a disinfectant is more effective than a solution, and, with cineol, the potency seemed to keep pace with the solubility. Those dilutions which just became bright at 12°

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* From a capillary pipette discharging 40 drops of broth per gram.

† Made by rolling an ordinary platinum needle wire five times round a No.18 wire. It withdrew 7 milligrams of broth. Several spirals were used, so that one was always cold. They were consistent in picking up the same weight of liquid.

were just germicidal to *B. coli communis* at 20° in 15 minutes. It was decided that the dilutions should be tested within an hour after their preparation.

Some further preliminary work was done to determine which were the best strengths of some oils to employ, and in how far we might expect to get consistent results. The lethal dilutions vary more or less in each experiment, and it is sometimes difficult to determine what is the real efficiency of the oil under examination. At one time, it was considered that the lowest of all the dilutions germicidal with a certain exposure would indicate the efficiency, but the curve of these dilutions was often too irregular,* and did not bear out the idea given by the curves of the individual tests. Consequently the germicidal dilutions of each test were plotted, and the probable dilution curve drawn through at least three exposures. From this curve the dilutions were corrected for the other exposures. The average lethal dilution for each exposure was calculated from the corrected lethal dilutions, and the curve of these numbers was taken as passing through the probable effective dilution.

Cineol and Phenol.—The cineol was obtained from Mr. G. I. Hudson, and had been obtained by freezing the rectified oils of *E. polybractea* or of *E. sideroxylon*. The phenol was obtained as crystals of phenol absolute which in the preliminary experiment solidified at 38·5°,† and in the others at 40°.

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* Lee and Gilbert (Abs. Journ. Soc Chem. Ind., 1918, 439A) find that disinfection is an orderly time process analogous to a chemical reaction. A definite relationship exists between the velocity of the reaction and the concentration of the disinfectant. Chick (Journ. Hyg., 1910, 237) found the same analogy and found that the velocity of disinfection at any moment was proportional to the number of surviving bacteria. Disinfection proceeded in accordance with a logarithmic law of the first order, *i.e.*, like a chemical reaction.

† Noted in Part i. as being crystalline at 28°.

TABLE i. Preliminary Experiment. *B. coli communis.*

Exposure in minutes.		15	30	60	120	180	240
Cineol, *a.* ...	1 :	260	—	300	—	380	—
b. ...	1 :	260	—	340	360	420	420
c. ...	1 :	240	—	320	340	360	380
d. ...	1 :	260	280	300	—	—	—
Probable effective dilution	1 :	255	280	315	355	385	410
Phenol, *a.* ...	1 :	90	100	120	120	120	140
b. ...	1 :	70	80	90	110	120	140
c. ...	1 :	—	90	110	120	140	140
Probable effective dilution	1 :	80	92	107	123	132	137
Phenol coefficient of cineol	1 :	3·2	3·1	3·0	2·9	2·9	2·9

These preliminary tests were made in October: in the following March, the activity was again determined, with the new lot of phenol.

TABLE ii. *B. coli communis.*

Exposure in minutes.		15	30	45	60	120	180	240
Cineol. 19/3 ...	1 :	300	350	—	425	425	425	425
20/3 ...	1 :	275	275	—	375	450	450	450
21/3	1 :	275	275	300	375	375	375	375
26/3 ...	1 :	275	375	400	425	450	450	450
27/3 ...	1 :	250	325	350	350	350	400	425
Probable effective dilution	1 :	275	350	375	392	415	420	425
Phenol. 14/3 ...	1 :	100	100	—	120	130	150	—
18/3 ...	1 :	100	100	—	110	130	130	140
19/3 ...	1 :	90	110	—	120	130	150	160
20/3 ...	1 :	90	110	—	120	130	140	160
28/3 ...	1 :	90	100	120	120	140	140	150
Probable effective dilution	1 :	90	104	111	118	135	145	152
Cineol. Second lot, freshly prepared 25/3	1 :	225	325	350	350	400	—	—
26/3	1 :	250	300	325	375	375	425	425
27/3	1 :	225	275	375	375	400	400	400
28/3	1 :	275	275	325	325	350	350	350
1/4	1 :	275	325	350	400	400	450	450
Probable effective dilution	1 :	245	325	355	375	400	405	410
Phenol coefficient of cineol		3·1	3·4	3·4	3·3	3·1	2·9	2·8
cineol. Second lot		2·7	3·1	3·2	3·2	3·0	2·8	2·7

Stronger dilutions were tested at shorter intervals, but as the tube method, on account of the apparent necessity for keeping the oil emulsified, was considered impracticable, wide-mouthed ounce-bottles containing 10 c.c. of emulsion were cooled to 20°, and each was treated with five drops of a 20-hour broth culture and shaken repeatedly during the period of exposure. The results were very irregular, much more so than with more dilute emulsions, and the reason for this was not at once elucidated. One test showed that a greater amount of shaking lessened the lethal exposures, but when the shaking was regulated, the results were no more uniform. Differences in the reaction of the broth, which is claimed by J. H. Wright* to cause discrepancies in the results obtained in testing disinfectants, did not account for those obtained by me, for tests were made with dilutions of cineol, 1 : 100, which after exposures of 2, 4, 6, 8, and 10 minutes, were seeded into tubes of broth varying in reaction from + 3° through 6°, 8, 10° to + 12°, and all showed no growth in 6 minutes.

The phenol tests were always fairly constant; in fact the broth cultures used for infecting the tests were controlled by the bacteria being destroyed in 6 minutes by a 1 : 80 solution of phenol at 20°. If a shorter or a longer time was taken to destroy the bacteria, the experiment was rejected, and the cultures examined to obtain a mixture of races capable of being destroyed under the conditions in six minutes.

In considering the uniformity of the phenol tests and the comparative regularity of the tests with the weaker dilutions of cineol, it would appear that an irregularity of result is to be expected in dealing with strong emulsions which separate so readily as do mixtures of cineol and distilled water. I have, therefore, recorded the results of the tests, irregular as they are, and have calculated the general average which enabled a curve of probable efficiency to be made.

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* Through Abs. of Bact., 1918, 78.

TABLE iii. *B. coli communis*.—Cineol with short Exposures.

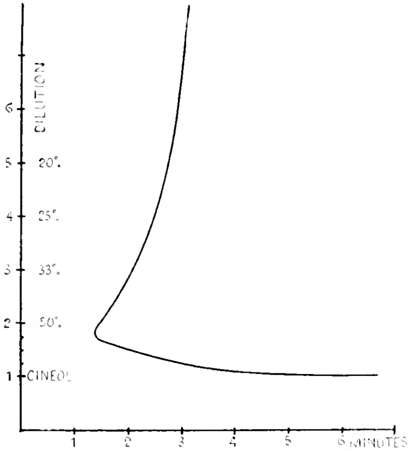
Dilutions... ... ... 1 :	1	1¼	1½	2	5	10	25	30	50	75	100	150	200	225	250	275	300
Cineol, 1st lot	10	—	—	½	2½	2½	4½	—	4½	—	5	6	5	—	—	—	
	—	—	—	½	2	2½	—	—	4	—		—	—	—	—		
	—	—	—	—	1½	3½	6	—	6	—		—	—	—	—		
		—	—	1½	4	—	5	—	4½	5	4				—		
	—	—	—	1½	2½	—	3	—	4½	—	—	5	5	—			—
	—	—	—	1½	3½	—	3	—	3	—	2½	4½	7	—	—		
	—	—	—	—	3	—	—	—	3	—	6	—		—	—		
	—	—	—	2	4½	—	5	—	4	3½	—			—			
	—	—	—	1½	2½		3	—	4	—	3½	—					—
2nd lot	—	—	—	2	3	5	—	4	8	—	8	10	8	10	10	10	—
	—	—	—	2	4	4	—	5	6	—	5	7	5	—	9	—	—
	—	—	—	2	3	—	—	6	9	—	6	6	4	6	15	15	15
	—	—	—	2	3	2	—	—	4	—	4	6	4	6	6	10	15
	30	3	2	2	—	—	—	—	4	—	4	4	4	—	10	15	
	—	—	—	2	3	3	—	4	3	—	5	—	10	—		—	—
	—	—	—	1	3	2	—	2	2	—	5	—	8	—		—	
	—	—	—	—	—		—	—	4	4	4	5	6	—	—	12	
	—	—	—	—	—	—	—	—	3	4	6	5	8	—		10	—
	—	—	—	—	—	—	—	—	6	5	4	6	6			12	—
	—	—	—	—	—	—	—	—	6	6	5	6	10	—	10	20	—
	5	2	—	2	3	4	—	3	5	—	5	4	10	—	10		
	5	3	2	2	3	3	—	3	4	—	—	—		—	—	—	—
General average	—	3	2	1½	3	3	4	4	4½	4½	5	6	6½	7	10	13	15
Probable effective exposures ...	5+	3	2	1½	2¾	3¼	4	4	4½	4¾	5	5¾	7	8	10	12½	17

Table iii.*a*. *B. coli communis.*
Phenol with short Exposures.

Dilutions 1 :	60	70	80	90
	½	1½	5	—
	—	1	6*	10
	½	1½	6	15
Probable effective exposure ...	½	1½	6	15

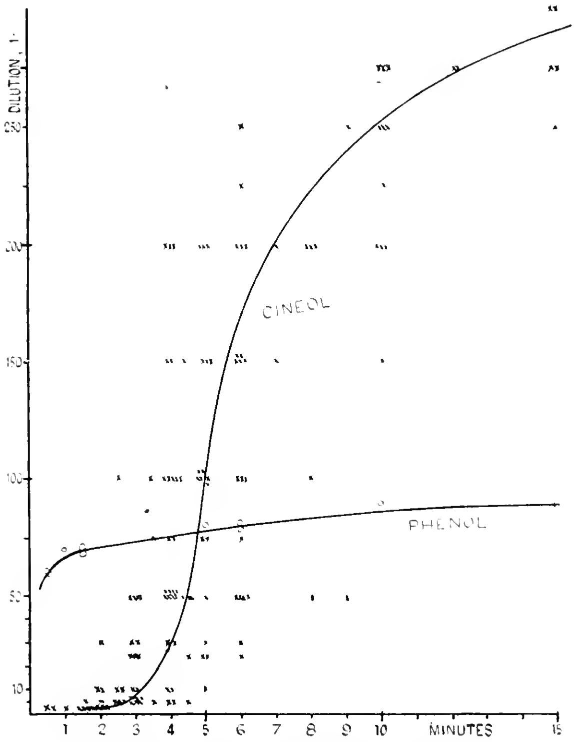
* Many times.

As determined from the results on Table iii., the probable effective exposures for cineol at 15 and 30 minutes are slightly higher than those as determined from Table ii., but this difference is the result of the methods, the bottle giving a speedier distribution than the tube, and consequently a higher efficiency.



Text-fig. i.—Cineol with Small Quantities of Water.

The necessity for the presence of a sufficiency of water in accelerating the action of cineol is shown by the fact, as determined by Cuthbert Hall, that when comparatively dry bacteria, such as are taken from an agar culture, are added to pure cineol, the lethal exposure may vary up to eight hours. With the small quantity of water contained in a few drops of a broth culture, the disinfecting time varied from 5 to 30 minutes. An 80% emulsion, that is, four parts by weight of cineol to one of water,* had a lethal period of 3 minutes, a 66% emulsion had 2 minutes, and a 50% had 1½ minutes. Then the period began to lengthen as the cineol percentage became smaller. The expressions 1 : 2, 1 : 5, and so on, which occur in the tabulated results, mean 1 in 2 and 1 in 5 by weight of oil and water.



Text-fig. ii.—Cineol with Short Exposures.

The curve of cineol rises slowly from the turning point at one and a half minutes to the three minute interval before rising very rapidly. This lag or period of quiescence is met with in many disinfectants. The rapidity of the rise from the three

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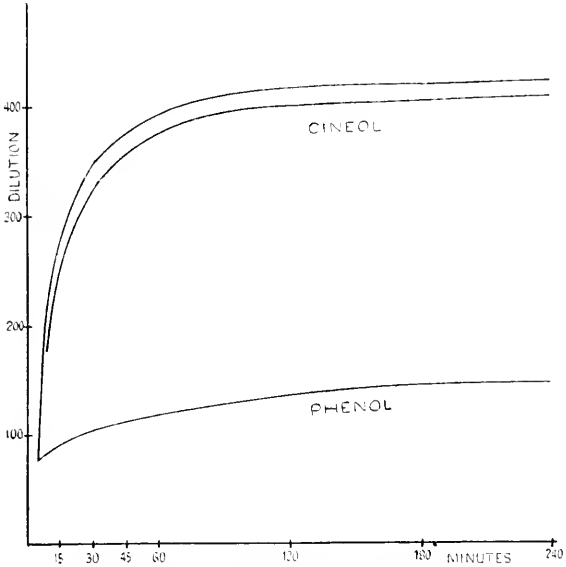
* Tabulated as 1 : 1¼.

minute to the eight minute interval explains much of the great irregularity in the tests. Concordant results can scarcely be expected during an interval of rapidly altering activity. The same gross irregularity was not noted with the weaker dilutions of Table ii., or with phenol which furnishes a true solution in dilutions over 1 : 5.



Text-fig. iii.—The Cineol and Phenol Curves.

By combining the results of Tables ii. and iii., we are able to obtain the complete curves of cineol and phenol. Both are of the same nature, inasmuch as they show a sharp rise followed by a slowing down to a straight line rising slightly from the horizontal. Indeed, if we were to enlarge the phenol area, we would find that it had much the same shape as the cineol area. The phenol curve reaches the approximately horizontal level in $1\frac{1}{2}$ minutes, while cineol takes half-an-hour. Although more powerful as a disinfectant than phenol, it is slower in its action and overtakes the quickly acting phenol at the five-minute interval when each has a dilution of 1 : 75.

It is customary, when comparing the germicidal properties of some disinfectants, to refer to them in terms of phenol, which for many reasons is taken as a standard. The phenol-coefficient is obtained by dividing the weakest dilution of a disinfectant which destroys a bacterium in a certain time and at a certain temperature by the weakest dilution of phenol lethal in the same time and at the same temperature. In Table ii. the coefficients have been obtained by dividing the probable effective dilutions of cineol by those of phenol.

The coefficiency curve is comparatively high and reaches a maximum of 3·4 in thirty minutes, and slowly falls to 2·8 in four hours. As Delepine* reminded us, the ratio between the lethal doses of two disinfectants is not the same for exposures of different durations.

There is no definite rule as to the exposure which should be taken in calculating the phenol coefficient of any disinfectant. The method suggested by Rideal and Walker is to withdraw portions of the tests every two and a half minutes up to fifteen, and to take the dilutions of the disinfectants which are lethal at any one exposure. Thus the coefficient might be calculated from any $2\frac{1}{2}$ minute period up to 15 minutes. Sims Woodhead† determined the coefficients at $2\frac{1}{2}$ and at 30 minutes and took the average. Blyth‡ used the $12\frac{1}{2}$ minute interval. Delepine§ preferred exposures of not less than 20 minutes for bacteria such as *B. coli communis*, and took 20 or 30 minutes as the proper exposure, but he recognised that half-hourly and hourly exposures had the advantage of giving more steady results. Chick and Martin|| considered that 30 minutes was best. A study of the coefficients of cineol leads one to the same conclusion. It would clearly be unwise to take a time during the rapid rise in the cineol curve. It should rather be taken when the curve has begun to assume its nearly horizontal position. The curves for

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* Journ. Soc. Chem. Ind., 1910, 1344.

† Lancet, 1909, 1454.

‡ Journ. Soc. Chem. Ind., 1906, 1183.

§ *Idem*, 1911, 334.

|| Journ. Hyg., 1908, 654.

aromadendral and piperitone are like cineol in this respect, but the Eucalyptus oils generally are different, their curves usually showing a more sustained rise. While theoretically the real coefficient should be the highest, practically we want to know the maximum efficiency in the shortest time so that there might be a minimum of risk in the disinfection of infectious material. The half-hour interval is clearly indicated for cineol and, as we shall see later, for aromadendral and piperitone, as well as for the pinene and sesquiterpene oils.

The question of the choice of cineol as a disinfectant will depend upon circumstances. While phenol forms clear solutions with water in dilutions of 1 : 20 and weaker, cineol, according to the data of Earle,* would at 20° give a clear solution with 1:270. The strongest clear solution of cineol destroys *B. coli communis* in 15 minutes at 20°, while the strongest clear solution of phenol kills it instantly. On the other hand, a 1 : 270 dilution of phenol would not destroy the bacillus within a reasonable time. In dilutions stronger than 1 : 270, cineol forms milky emulsions which throw oil globules to the surface upon standing for a few minutes, and on this account it does not give what is termed an elegant preparation.

The oil of E. cinerea.—The crude oil of *E. cinerea* usually contains over 50% of cineol, the remainder being pinene, with a comparatively large amount of esters and some sesquiterpene. The first specimen to be examined was that which gave the high toxicity numbers when tested in oil. It had an acidity of 95°, and, judging by this, some time, probably some years, had passed since its preparation. Two and a half months after the first set of tests, the oil was treated with dry sodium carbonate for two days and dilutions were made by two methods, the mass and the droplet. The idea was to test the two methods, and at the same time to slightly vary the conditions of the experiment. So far as the method is concerned, it appears to be immaterial which is used, as *a*, *b*, *c*, and *e* were made by the droplet and *d* by preparing a bulk dilution of 1 : 200 and making the other dilutions from that.

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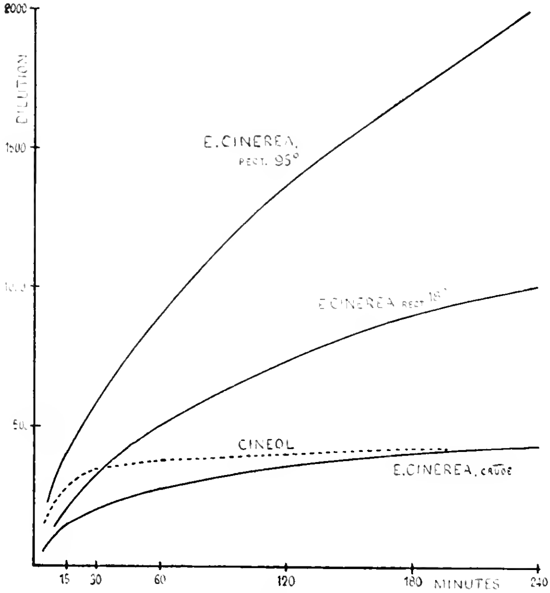
* Journ. Soc. Chem. Ind., 1918, 274T.

TABLE IV. *B. coli communis.*

			Dilutions bactericidal at 20°.										
Exposure in minutes ...		...	15	30	45	60	90	120	150	180	210	240	300
E. cinerea, rect., acidity = 9·5°	*a.*	1 :	500	600	700	900	1200	*1200†	—	*1200†	—	—	—
	b.	1 :	400	800	900	900	1000	1000	1400	1400	2000*	2000*	—
	c.	1 :	400	500	700	1000	1000	1400	1600	1600	2400	2400	—
Probable effective dilution		1 :	400	600	800	900	1150	1350	1500	1700	1850	2000	—
The same treated with Na_2CO_3	*d.*	1 :	300	600	—	1000	—	1400	—	1600	—	2400	—
	e.	1 :	400	500	—	1000	—	1400	—	1600	—	1800	—
E. cinerea, rect., acidity = 18·5°	*f.*	1 :	200	—	—	400	—	—	—	800	—	—	1000
	g.	1 :	200	—	—	500	—	800	—	1000	—	—	1400
	h.	1 :	200	—	—	500	—	600	—	700	—	1200	1200
	k.	1 :	200	—	—	700	—	700	—	900	—	1100	1100
Probable effective dilution		1 :	200	330	—	500	—	725	—	900	—	1000	1100

* = or weaker, † = but stronger than 1 : 2000.

The older oil is undoubtedly the stronger germicide, and this is not on account of the great amount of acid which it contained, because the neutralisation of the acid did not appreciably alter the efficiency. The crude oil of *E. cinerea* has, compared with many other oils, a high saponification number, 14·4 to 24,* which indicates a preponderance of esters. These apparently become hydrolysed in course of time, producing acids and alcohols, and it is either to the alcohols or to their oxidation products that the increased germicidal effect is to be traced, for, as we shall see later, the aldehydes are the most bactericidal components of the oils.



Text-fig. iv.

It had been suggested that as the crude oils in most cases contain substances of a phenolic nature, they would probably be more germicidal than the rectified oils. When the crude oil of

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* Baker and Smith. The Eucalypts and their Essential Oils.

E. cinerea was tested, the results did not bear out the contention. Two specimens were tested.

TABLE V. *B. coli communis.*

			Dilutions bactericidal at 20°.						
Exposure in minutes ...		...	15	30	60	120	180	240	300
E. cinerea, crude, acidity = 81	*a.*	1 :	150	—	250	400	400	400	400
	b.	1 :	150	175	250	350	350	350	350
Probable effective dilution		1 :	150	175	250	350	390	400	400
E. cinerea, crude, acidity = 12°	*a.*	1 :	150	200	300	400	500	—	—
	b.	1 :	150	—	200	350	350	400	500
	c.	1 :	175	—	350	350	350	450	450
Probable effective dilution		1 :	150	200	275	350	400	425	450

Compared with the rectified oils, they have a low germicidal value. Furthermore, while the rectified oil with the higher acid content was the better, the crude oil with 81° of acidity was rather less germicidal than that with 12°. The acidity cannot therefore be depended upon as an index of the disinfecting value of the oil. It would almost seem as if the act of distilling the oil with steam had brought about the production of germicidal substances from the components of the oil. So far, these specimens of oil, both rectified and crude, had not been directly related one with the other, and, therefore, one could only guess at what might be the reason for their different behaviours. But Mr. H. G. Smith had two specimens, one a rectified oil, another the crude oil from which it was obtained, and it was thought that an examination of these might throw some light upon the matter.

Table vi. *B. coli communis.*

			Dilutions bactericidal at 20°.					
Exposure in minutes ...		...	15	30	60	120	180	240
E. cinerea, crude, acidity 86°	*a.*	1 :	300	300	400	400	400	600
	b.	1 :	200	200	300	300	300	400
	c.	1 :	200	300	400	500	500	500
Probable effective dilution		1 :	230	300	370	440	470	500
E. cinerea, rect., acidity = 26°	*a.*	1 :	100	300	400	400	500	900
	b.	1 :	100	200	300	400	400	700
Probable effective dilution		1 :	150	250	340	430	450	—

The relative activities of the two oils were very much the same. One must believe that distillation had no influence upon the hitherto observed higher efficiency of the steam-rectified oils.

Superheated steam has likewise no action, as was shown by an experiment in which the crude oil of *E. cinerea* (acidity = 12°) was, with the addition of a few drops of water, sealed in glass tubes and heated at 180° for an hour. Control tubes were sealed at the same time. Six weeks afterwards, the tubes were opened and the oils centrifugalised and examined. The heated oil was found to be slightly more germicidal, but not sufficiently so to warrant the idea that any tangible increase had actually been obtained.

It may be remembered that, when testing the activity of the oils in solution of olive oil, *E. cinerea* was found, after the addition of acetic acid, to become more and more germicidal in course of time. Small quantities of the treated oils remained, and that to which the least quantity of acetic acid had been added, was tested in aqueous dilution.

TABLE vii. *B. coli communis.*

		Dilutions bactericidal at 20 .					
Exposure in minutes		15	30	60	120	180	240
E. cinerea, crude. Acidity 12 , increased to 93	1 :	200	400	600	800	800	1000
Control as previously determined	1 :	150	200	300	350	400	400

It is clear that a considerable elevation of the germicidal activity had, in course of time, resulted from the acidification. It was tested on the 108th day after acidification. The acidity of the oil would have little effect in acidifying the dilutions, for at 1 : 400 the acidity would be less than 0·25°. The experiment therefore shows that acidification does, in time, cause the oil of *E. cinerea* to become more germicidal, and since storage of the oil results in the natural development of acidity, it follows that storage of the oil, by reason of the formation of acids, will lead to the production of germicidal substances. It will in progress of time become more and more bactericidal.

The Oils of E. australiana.—The oils of this member of the Peppermint group of Eucalypts differ according to whether the trees grow on the high ridges of the Main Dividing Range or at lower elevations. The oil from the latter is termed *E. australiana*, and that from the ridges is named *E. australiana*, Braidwood. *E. australiana* contains some 70% of cineol, while the Braidwood oil has about half this amount replaced by phellandrene. Otherwise the constituents are much the same. Besides the cineol, the oil of *E. australiana* contains a little piperitone, occasionally a little phellandrene, a phenol (Tasmanol), a small amount of esters, and some of an unknown alcohol. The oil is not generally rectified, but, in distilling the leaves, the oil that comes over during the first hour is sufficiently pure to enable it to be sold for medicinal purposes. It is known as "First Hour Oil," and contains over 70% of cineol and usually but a trace of phellandrene and a minimum amount of volatile aldehydes.*

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* Proc. Roy. Soc. N. S. Wales, 1915, 514.

TABLE viii. *B. coli communis.*

			Dilutions bactericidal at 20°.						
Exposure in minutes ...		...	15	30	60	120	180	240	300
E. australiana, 1st hour oil, acidity = 5°	*a*.	1 :	400	500	500	600	600	600	600
	b.	1 :	200	400	600	700	700	700	700
	c.	1 :	200	200	400	400	500	500	—
	d.	1 :	200	300	400	500	500	500	—
	e.	1 :	300	300	300	400	500	500	—
Probable effective dilution		1 :	225	350	450	525	550	550	—

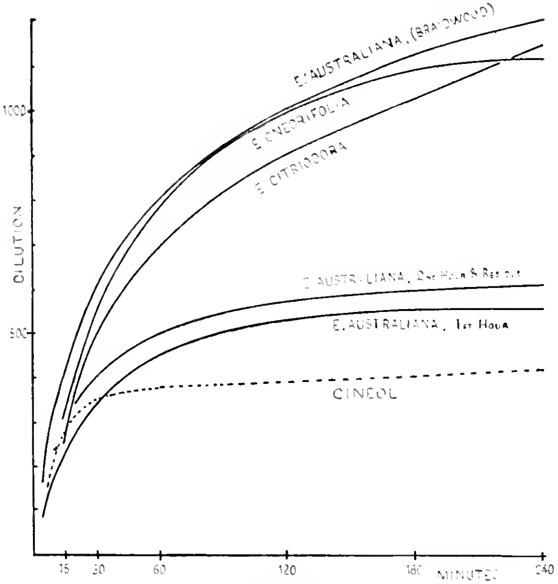
A second specimen of the First Hour Oil was obtained, and it was tested with the second hour oil and the commercial residue.

TABLE ix. *B. coli communis.*

			Dilutions bactericidal at 20°.					
Exposure in minutes		...	15	30	60	120	180	240
E. australiana, 1st hour, acidity = 10°	*a*.	1 :	200	200	200	400	400	400
	b.	1 :	300	300	400	500	600	700
	c.	1 :	300	300	400	500	500	500
	d.	1 :	300	400	500	500	700	700 (race 7)
Probable effective dilution		1 :	250	325	400	480	520	550
E. australiana, crude, 2nd hour, acidity = 150°	*a*.	1 :	200	300	300	400	400	500
	b.	1 :	400	400	400	400	600	600
	c.	1 :	300	—	500	550	600	600
	d.	1 :	400	400	500	600	600	800
Probable effective dilution		1 :	300	400	500	570	590	600
E. australiana, commercial residue		1 :	300	400	500	600	600	600

From a germicidal point of view, these oils of *E. australiana* are all the same, and it would appear that the bactericidal constituents are distilled in constant proportions.

The high acidity of the 2nd hour oils will cause the stronger dilutions to be pronouncedly acid; a dilution of 1 : 300 will have an acidity of 0·5° which, by increasing the lethal power, might raise the germicidal dilution considerably (see p.339).



Text-fig.5.

The oil of the Braidwood variety of *E. australiana* was tested to complete the information respecting the oil, and incidentally to see how the replacement of the cineol by phellandrene would affect the germicidal value of the oil.

Table x. *B. coli communis.*

			Dilutions bactericidal at 20° and 22°.					
Exposure in minutes		...	15	30	60	120	180	240
E. australiana (Braidwood).								
acidity = 7	*a.* (20°)	1 :	400	600	600	900	900	1000
	b. (20°)	1 :	500	600	800	1000	1100	1200
	c. (20°)	1 :	400	500	600	1000	1100	1200(race 6)
	d. (22°)	1 :	500	700	900	1000	1400	—
Probable effective dilution		1 :	400	600	800	1000	1120	1200

It is apparent that phellandrene is more efficient than cineol as a germicide, if the only difference between the two oils lies in the cineol and phellandrene. The low acidity of the Braidwood oil shows that it had been recently distilled, as it had been given out to be. It is one of the most efficient of the oils that have been examined, the only stronger oil being the old specimen of *E. cinerea*, rect.

The Phellandrene Oil of E. dives.—In the absence of pure phellandrene, use was made of the oil of *E. dives*, which consists largely of this constituent. There is also in it a quantity of piperitone, the strongly smelling peppermint substance of the Eucalypts. The oil of *E. dives* is not usually rectified, and is extensively used in the flotation of minerals.*

TABLE xi. *B. coli communis.*

		Dilutions bactericidal at 20°, 21°, and 22°.					
Exposure in minutes		15	30	60	120	180	240
E. dives, crude, acidity = 52°	*a.* (20°) 1 :	200	400	500	600	600	—
	b. (20°) 1 :	300	400	600	600	600	700
	c. (21°) 1 :	200	300	600	700	700	800
	d. (22°) 1 :	400	500	700	800	1000†	1000†
Probable effective dilution at 20°	1 :	300	400	500	600	660	700

† = or weaker.

* The use of this oil as a disinfectant for clothing was tested. It is a sticky oil, and about the worst that could be employed for such purposes, on account of its rather difficult removal with soap and water. This consideration, however, did not occur to the writer until later. A suspension of *M. aureus* in serum was absorbed on cotton mending and dried at 37° for an hour. The infected twists were then inserted in dilutions of *E. dives* and withdrawn at stated intervals (the excess dilution being removed on porous gypsum strips) and inserted into broth. The lethal dilutions were as follows:

	5	10	15	30	60	120	180	240 minutes.
1 :	less than 5		20	20	30	60	80	80

The results indicate that while phellandrene, as exemplified by this oil, is certainly more germicidal than cineol, it is less bactericidal than the phellandrene oil of *E. australiana*, Braidwood. The bactericidal dilutions are somewhat akin to those of the normal variety of *E. australiana*, so that there is something in the oil of the Braidwood variety more potent than phellandrene, possibly the oxidation products of the unknown alcohol.

The Oil of E. Smithii.—This oil contains over 70% of cineol. The other constituents are pinene, with small quantities of a phenol, volatile aldehydes, eudesmol, esters containing butyl-butyrate and a sesquiterpene. It contains neither phellandrene, piperitone, nor aromadendral.

Table xii. *B. coli communis.*

		Dilutions bactericidal at 20° and 22°.						
Exposure in minutes	..	15	30	60	120	180	240	300
E. Smithii, rect. Acidity=37°	*a.* (20°) 1 :	300	400	400	500	800	900	—
	b. (20°) 1 :	300	400	500	700	700	900	—
	c. (20°) 1 :	300	300	600	700	800	1000	1000
	d. (22°) 1 ;	400	500	700	900	1000	—	—
Probable effect. dilution at 20°,	1 :	300	400	550	700	800	900	1000
E. Smithii, crude. Acidity=35°	*a.* (20°) 1 :	300	300	400	600	600	600	—
	b. (20°) 1 :	200	300	450	600	600	700	800
Probable effective dilution	1 :	200	300	450	600	660	700	—

This is another case in which we have the rectified oil having a stronger disinfecting action than the crude. It is not quite so pronounced as with *E. cinerea*, but there is less room for the formation of substances of an aldehydic nature; the saponification number varies from 2·4 to 3·0 as against 14·4 to 24 in the case of *E. cinerea*.

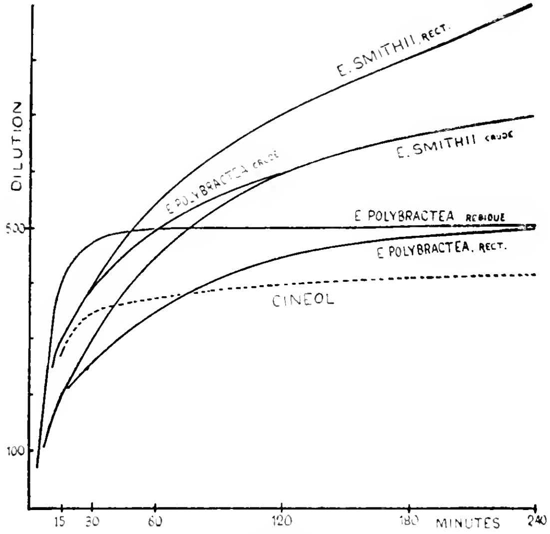
The Oil of E. polybractea.—*E. polybractea*, or "Blue Mallee," is one of the chief sources of the medicinal oil at the present time. The crude oil contains over 70% of cineol, besides pinene and aromadendral. The rectified and crude oils were tested, while a residual oil was included in order to see in how far the presence of aromadendral would influence the germicidal activity.

TABLE xiii. *B. coli communis.*

			Dilutions bactericidal at 20°.					
Exposure in minutes ...			15	30	60	120	180	240
E. polybractea, rect.								
Acidity = 10°	*a.*	1 :	200	200	200	500	500	500
	b.	1 :	200	200	300	300	400	400
	c.	1 :	200	200	300	400	500	500
	*d.**	1 :	200	300	300	400	400	500
Probable effective dilution		1 :	200	260	350	450	480	500
E. polybractea, crude.								
Acidity = 4°	*a.*	1 :	400	400	500	600	800	800
	b.	1 :	300	400	500	600	600	700
	c.	1 :	300	300	400	500	500	600
Probable effective dilution		1 :	300	400	500	600	650	700
E. polybractea, residue	*a.*	1 :	400	600	600	—	—	—
	b.	1 :	500	500	500	500	500	600
	c.	1 :	400	400	500	500	500	500
Probable effective dilution		1 :	400	480	500	500	500	500

* This test was made after the paper was written with the idea of testing the validity of the earlier tests.

This is an instance where the crude oil is more germicidal than the rectified. The residual oil, the dilutions of which had the odour of aromadendral, has a curve suggestive of a mixture of aromadendral with an almost inert oil such as sesquiterpene.



Text-fig. 6.

Some Constituents of the Oils.

Cuthbert Hall showed that of all the undiluted constituents of the oils, aromadendral was the most active germicide. In view of this, it seemed advisable to test the aldehyde in aqueous dilutions. Aromadendral has a high boiling point (210°-215°), and largely remains behind when the crude oils of the "Mallees" —*E. polybractea* for example and of the "Box" group of Eucalypts are rectified by steam distillation. At the present time there is no market for these residuals containing the aromadendral, and they are usually thrown away. However, Mr. H. G. Smith was able to obtain a small quantity of the residues, and prepared for me about five c.c. of the aldehyde, which was sufficient to test its properties.

Piperitone, the ketone of the "Peppermint" group of Eucalypts, was tested about the same time, and I included the oils of *E. nova-anglica*, the chief constituent of which is a sesquiterpene, of *E. dextropinea*, and of *E. lævopinea*, both of which consist very largely of pinene.

TABLE XIV. *B. coli communis.*

	Dilutions bactericidal at 20, 21, and 22°.					
Exposure in minutes ...	15	30	60	120	180	240
Aromadendral *a.* (20°) 1 :	1600	—	2400	2800	2800	2800
b. (20°) 1 :	1800	2200	2600	2600	3000	--
c. (21°) 1 :	1600	2600	2800	2800	3000	3000
d. (22°) 1 :	—	2800	2800	2800	2800	—
Prob'le effect, dilution at 20° 1 :	1700	2200	2600	2800	2900	3000
Aromadendral and cineol, equal parts (20°) 1 :	800	—	1400	1400	—	1400
Piperitone (20°) 1 :	400	--	450	500	500	500
E. nova-anglica. Acidity = 33° (20°) 1 :	40	—	60	—	60	—
E. dextropinea. Acidity = 68·5° (20°) 1 :	40*	80	100	120	130	140
E. lævopinea. Acidity = 94° (20°) 1 :	40	100	140	200	200	200

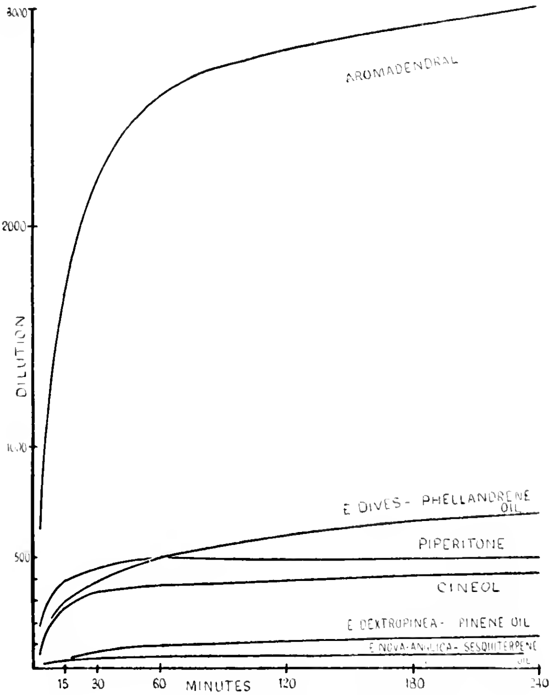
* = or stronger.

There can be no doubt that of all the oils and their constituents that have so far been tested in aqueous dilutions, aromadendral is by far the most efficient germicide. It is about seven times stronger than cineol. Its bactericidal power does not appear to be reduced to any great extent beyond the expected proportion when it is mixed with cineol, so that its presence in any oil should raise the efficiency of that oil.

Previous experiments with the sesquiterpene oil of *E. nova-anglica* showed that, when dissolved in olive oil, it was the most inert towards *B. coli communis*. This was borne out by its behaviour in aqueous dilutions; its germicidal power is very feeble.

Piperitone is stronger than cineol, but not to any great extent.

Pinene, as represented by the oils of *E. dextropinea* and *E. lævopinea*, has a comparatively feeble action, although slightly better than sesquiterpene.



Text-fig. 7. The Constituents of the Eucalyptus Oils.

The Oils of E. cneorifolia and E. citriodora.—The oil of *E. cneorifolia*, one of the "Mallee" group from Kangaroo Island, contains cineol and aromadendral with a small amount of sesquiterpene. It should give high dilution numbers, and the expectation was fulfilled. The oil of *E. citriodora* contains 91% of the aldehyde citronellal and a small amount of pinene, but no cineol.

TABLE XV. *B. coli communis.*

	Dilutions bactericidal at 20°.						
Exposure in minutes...	15	30	60	120	180	240	300
E. cneorifolia, crude.							
Acidity = ·1° *a.* 1 :	300	500	800	900	1000*	1000*	—
b. 1 :	300	500	800	800	1100	1100	1100
Probable effective dilution 1 :	300	500	800	1000	1080	1100	1100
E. citriodora, crude.							
Acidity = 140° *a.* 1 :	300	300	600	1000	1000	1200	1200
b. 1 :	400	400	600	800	1100	1200	—
c. 1 :	400	400	800	1000	1200	1200	1200
Probable effective dilution 1 :	330	500	700	900	1020	1140	1200

* or weaker.

Both these oils are good disinfectants; they are the best of the crude oils that have been examined; the reason for their excellence is to be found in the presence of the aldehydes, aromadendral and citronellal. Indeed, from the work that has been done, it is clear that a comparatively high germicidal activity can only be expected in those oils containing substances of an aldehydic nature. The pinenes and sesquiterpene are, inferentially, poor disinfectants; cineol is moderate, phellandrene and the ketone piperitone are better, and the aldehydes are the best.

SUBSIDIARY NOTES.

a. The races in the stock culture.—During the research, the stock culture of *B. coli communis* was plated to see if it had retained its purity. The plates showed a pure culture. One of the colonies was picked out and used. As it appeared to be much more sensitive to the action of the Eucalyptus oils than the stock culture, a direct test was made, using the 2nd hour oil of *E. australiana.*

TABLE XVI. Races of *B. coli communis.*

Exposure in minutes ...		15	30	60	120	180	240
Stock culture (mixed races)	1 :	400	400	400	400	600	600
New culture (race 1)	1 :	600	900	900	1000	1000	1200

The new culture was almost twice as sensitive to the action of the disinfectant as the stock culture with which the work had been done.

The result of the test led to the trying of nine colonies, picked out at random from a plate containing about fifty colonies, and, in order to economise labour and material, the time test with single dilutions was employed. A spiral loop of broth culture (7 milligrams) was put into 2 c.c. of diluted disinfectant and portions were withdrawn at intervals of 5, 10, 15, and 30 minutes. Longer exposures were all negative.

TABLE XVII. Minutes required to destroy *B. coli communis.*

	E. australiana, 2nd hour. 1 : 600.	*E. australiana,* rect. 1 : 400.
Stock culture	15	15
Race 1	10	10
Race 2	15	30
Race 3	30	10
Race 4	15	10
Races 5, 8, and 9	15	15
Race 6	30	30
Race 7	30	15

Race 1, the behaviour of which had led to the test, proved to be the most sensitive of all the races. Race 7 which, from its resistance to the 2nd hour oil of *E. australiana*, promised to be hardy, did not justify the promise either in the second part of the test or in Table ix., where test *c.* was made with the stock culture and test *d.* with race 7 upon the same day and at the same time. Race 6 appeared to be the most resistant of all the races, and it was tried with *E. australiana* (Braidwood) upon the same day and at the same time. The result showed that it had the same resistance as the stock culture. In Table x., test *b.* was made with the stock culture and test *c.* with race 6.

The stock culture clearly contained a mixture of races, the most resistant of which have played their part in the recorded experiments. The germicidal dilutions are those which destroy all the bacteria in certain times, and naturally the most resistant bacteria will be the last to succumb.

b. The Effect of Mass Infection.—The lethal dilutions for the stock culture in the previous test with the races of *B. coli communis* are not in agreement with the results tabulated elsewhere. This is explained by the fact that the infected broth added to the 2 c.c. of disinfectant weighed 7 milligrams, while elsewhere the infecting material weighed 25 milligrams (the droplet from a standard pipette). The proof of this is found in the following:

TABLE xviii. *B. coli communis.*

Exposure in minutes ...		15	30	60	120	180	240
E. australiana, 2nd hour.							
Infection, 25 mgrms.	1 :	400	400	500	600	600	800
7 mgrms.	1 :	600	600	700	700	1000	1000

It confirms the well known rule of mass infection, *i.e.*, the greater the number of bacteria, the stronger must be the disinfectant to destroy them. It emphasises the importance of keeping to one method of technique in doing a set of experiments.

c. The Effect of Acidity.—In a preliminary test, it was found that when the oil of *E. cinerea* was diluted with water containing 1° of alkalinity as sodium bicarbonate, it was less germicidal than when neutral distilled water was employed. It is possible that the converse of this holds, and that slightly acid water would increase the germicidal power. There is also the possibility that an acid oil may be more toxic on account of the acidity conferred upon the diluting water by the acid of the oil. The elucidation of these two points was attempted.

The chief and probably the most active free acid in the oils is acetic, and accordingly this acid was tested to see if it had any bactericidal power of its own. A solution was prepared by taking 1 c.c. of glacial acetic acid and diluting it to 50 c.c. This was found to be equivalent to $\frac{N}{2{\cdot}77}$. It was diluted progressively from 5 to 500 times, and tested with *B. coli communis* in the usual manner. All the tests were positive with exposures from one to four hours. Acetic acid is, therefore, inactive in dilutions ranging from zero up to $\frac{N}{13{\cdot}8}$, that is, up to 72° of acidity. It follows that any assistance given by the acid in the dilutions of the oils cannot be due to the acid directly, but to a condition that the acid brings about.

The next experiment was made with cineol which was acidified with acetic acid so that it contained 92·5° of acidity. This is close to the acidity of the specimen of the rectified oil of *E. cinerea* which had been previously tested (Table iv.).

The acidified oil was a little more toxic, but the differences were comparatively slight, due possibly to the fact that, when the oil is diluted 300 or 350 times, the original acidity is reduced to 0·26° (= a quarter of a c.c. of normal acid per litre) which is a comparatively slight acidity.

The effect of using acidified water in place of neutral distilled water was then investigated. A supply of recently distilled oil of *E. polybractea* with a natural acidity of 10° was used. Dilutions were made with water acidified with acetic acid and containing varying degrees of acidity.

TABLE xix. *B. coli communis.*

	E. polybractea, rect. Dilutions bactericidal at 20°.				
Acidity of water.	30 min.	60 min.	120 min.	180 min.	240 min.
b. neutral	200	300	400	600	600
1°	300	500	700	1000	1000
a. 1°	400	500	800*	800*	800*
5°	400	500	600	800	1400
15°	500	600	800	800	1800

* = or weaker.

The results are somewhat irregular, but as a whole they show that an acid condition increases the potency of the oil in aqueous dilutions. For this reason, it would be a mistake to employ ordinary tap-water when making dilutions, as its slight alkalinity would tend to reduce the germicidal efficiency.

Since phenol behaves as a weak acid, it is likely that its activity will be enhanced in the presence of dilute acid. A preliminary test showed that this was so, for with 10° of acidity, as acetic acid, dilutions up to 1 : 200 were germicidal in 30 minutes. A test made at the same time with 11° (corrected) of alkalinity as sodium bicarbonate gave normal numbers up to an hour, and at four hours the lethal dilution was 1 : 180, as against 1 : 140 with neutral water. Alkali itself has no action when used in small amounts, for a control test showed that water with 22° of alkalinity as sodium bicarbonate was inactive in four hours.

Thus the addition of alkali or of acid to the water used for dissolving the phenol, increases the efficiency, and of these, the acid is the more powerful.

The effect of acidity upon the action of phenol was confirmed in the following experiment. Solutions of acetic acid were prepared to give 1° and 10° of acidity, but when the pipette was checked it was found that the number of drops per gram differed with the strength of the acid. Solutions of $\frac{N}{7\cdot5}$ strength gave 72 drops per gram, while those of $\frac{N}{0\cdot75}$ gave 90 drops. The actual acidity was therefore weaker.

TABLE XX. *B. coli communis.*

			Phenol, acidified dilutions bactericidal at 20°.			
Exposure in minutes		...	15	60	180	300
Acidity of water						
a.	0·96°	1 :	120	160	220	260
	7·26°	1 :	140	220	300	340*
b.	10°	1 :	140	220	340	380
neutral as previously determined		1 :	90	120	145	150

* = or weaker.

There is nothing new in this example of the influence of acidity in increasing the activity of phenol, for Delepine* quotes an experiment showing that the presence of acetic acid in a solution of phenol in the ratio of 1 : 400 (= 41° of acidity) increased the activity of the disinfectant by 140/70 in five minutes at 17°. Hydrochloric acid in the ratio of 1 : 8000 (= 3·4°) increased it by 80/70 in the same time. Hailer† says that acids increase the disinfecting power of phenols in the order oxalic, sulphuric, acetic, tartaric, citric, boric: the last has scarcely any action. As having a bearing upon the matter, it is known that a faint acidity causes a medium to be easily sterilised by heat. Currie, for example, added 4 c.c. of seminormal hydrochloric acid per litre to obtain the sterilisation of a saccharose medium in one steaming.

d. Water increases the efficiency of the oils.—The value of water in enhancing the germicidal effect of cineol and reasonably of Eucalyptus oils, is shown by the fact that *B. coli communis*, when suspended in serum, was destroyed by a 50 % dilution of cineol in olive oil where the only water present was contained in the serum. When an aqueous dilution of cineol was given the same time to act, the bacteria were destroyed in a dilution of 1 : 415, *i.e.*, 50 %, with a trace of water and 0·24 % with much water.

An experiment was designed to see in how far bacteria impregnated on cotton could survive the vapour of cineol at ordinary temperatures (23° to 26° C.), the idea being to determine if cotton masks such as were worn during the pneumonic influenza epidemic would be sterilised when enclosed in a vessel containing cineol vapour. Some strands of cotton were infected with seven milligrams of *coli*-infected broth, and immediately suspended in cineol vapour (see p.91); others were dried in the air for an hour before being suspended in the same manner. The moist strands were found to be sterile in 60 minutes, while the dry strands were sterile in three but not in two days. Obviously, if

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* Journ. Soc. Chem. Ind., 1910, 1344.

† Abstr. Journ. Soc. Chem. Ind., 1910, 514.

the masks were slightly damped, they could be depended upon as being sterile after a night's exposure to the vapour.

Conclusions.

The germicidal value of the Eucalyptus oils varies with the kind of oil and also with the particular specimen. While Baker and Smith have shown that the major chemical constituents are wonderfully uniform, so much so that from a consideration of the oil they are able to recognise the affinities of species of the Eucalypts, the minor constituents may vary considerably, and these seem to have a pronounced influence upon the germicidal power. To realise this, one has only to consider the variations in the bactericidal power of the oil of *E. cinerea*. The rectified oils were germicidal in an hour with dilutions of 1 : 900, 1 : 500, and 1 : 340 according to the individual specimen. These were not all of the same age. The most potent was the oldest, and it was the most acid. From this we infer that the degree of acidity is to a certain extent an index of the age and, to some extent, an index of the disinfecting power. At any rate, with an oil having a high saponification number such as that of *E. cinerea*, it is to be expected that, as time goes on, the oil becomes oxidised and the constituents decomposed, yielding oxidation products such as aldehydes and acids. The aldehydes seem to possess high germicidal values, one of them, aromadendral for example, is a very powerful disinfectant.

But the acidity is only a rough index, for the three specimens had their acidities in the ratio, 95 : 18 : 26, from which we see that, when the acidity is low, there is no indication given as to the disinfecting action. Possibly the original acidity of the oil should be taken into account.

It is customary in dealing with the germicidal activities of disinfectants to refer to them in terms of a standard disinfectant such as phenol, and accordingly the phenol-coefficients of these oils that have been tested, were calculated and appear in the following Table in which the rectified oils have been grouped in the approximate order of their efficiency. The same applies to the crude oils and to the oil constituents.

TABLE XXI. *B. coli communis.*

Acidity in degrees.	Iodine number in seconds.	Exposure in minutes	Phenol-coefficients at 20°.					
			15	30	60	120	180	240
95	5	*E. cinerea*, rect.	4·4	5·8	7·6	10·0	11·7	13·2
18	25	,, ,, ,, ...	2·2	3·2	4·2	5·4	6·2	6·6
26	90	,, ,, ,, ...	1·7	2·4	2·9	3·2	3·1	—
37	14	*E. Smithii*, rect.	3·3	3·9	5·0	5·2	5·5	5·9
10	000*	*E. polybractea*, rect.	2·2	2·5	3·0	3.3	3·3	3·3
7	12	*E. australiana* (Braidwood), crude ...	4·4	5·8	6·8	7·4	7·7	7·9
41	75	*E. cneorifolia*, crude	3·3	4·8	6·8	7·4	7·4	7·2
140	000	*E. citriodora*	3·7	4·8	5·9	6·7	7·0	7·5
5	15	*E. australiana*, 1st hour	2·5	3·4	3·9	3·9	3·8	3·6
10	11	,, ,, ,, ,, ...	2·8	3·1	3·4	3·6	3·6	3·6
150	12	,, ,, 2nd hour	3·3	3·9	4·2	4·2	4·1	3·9
52	34	*E. dives*, crude	3·3	3·9	4·2	4·4	4·5	4·6
4	30	*E. polybractea*, crude	3·3	3·9	4·2	4·4	4·5	4·6
35	32	*E. Smithii*, crude	2·2	2·9	3·9	4·4	4·5	4·6
86	30	*E. cinerea*, crude	2·5	2·9	3·1	3·2	3·3	3·2
12	150	,, ,, ,, ...	1·7	1·9	2·3	2·6	2·7	2·8
81	000	,, ,, ,, ...	1·7	1·7	2·1	2·6	2·7	2·6
—	000	Aromadendral	18·9	21·1	21·1	20·7	20·0	19·7
—	55	Piperitone	4·4	4·1	3·9	3·7	3·4	3·3
2	000	Cineol†	3·1	3·4	3·3	3·1	2·9	2·8
52	34	Phellandrene oil (*E. dives*)	3·3	3·9	4·2	4·4	4·5	4·6
68	000	Pinene oil (*E. dextropinea*)...	0·4	0·8	0·9	0·9	0·9	0·9
33	75	Sesquiterpene oil (*E. nova-anglica*) ...	0·4	0·5	0·5	0·4	0·4	0·4
		Phenol...	1·0	1·0	1·0	1·0	1·0	1·0

*000 = over 180 seconds. †Cineol at 2½ minutes = 0·07, at 5 minutes = 1·0, at 7½ minutes = 2·6 and at 10 minutes = 3·0.

Certain text-books give the coefficient of the oil of *E. globulus* as about 4. Martindale* emulsified the oils of *E. globulus* and of *E. amygdalina* in a solution of soap, and, taking the average of the coefficients at two and at thirty minutes, found them to be 3·55 and 4·35 respectively. As soap, however, is itself a disinfectant, it is probable that these numbers are high. Cavel*, working with the bacteria from a septic cyst, determined the maximum doses of essential oils, dissolved in acetone or alcohol, necessary to prohibit growth in infected media. Essence of Eucalyptus was lethal in 2·75 parts per 1,000, and phenol in 5·6 parts. This gives a phenol-coefficient of about 2.

According to Baker and Smith, *E. globulus* belongs to the same group of Eucalypts as *E. cinerea* and *E. Smithii*, the rectified oils of which have high coefficients. It is curious that, while the rectified oils of these trees are among the most efficient, the crude oils are among the least, judging by the coefficients at the end of the first hour. Even at the end of 30 minutes, which is, I think, a fair period for purposes of comparison, the same holds.

We are led to believe that the rectification of an oil, such as those that were tested, gives us a product containing a higher proportion of cineol. It is, therefore, strange to find that one of the samples of *E. cinerea* and one of *E. polybractea* have a lower coefficient than cineol. In the case of *E. polybractea*, rectification appears to have removed the high boiling aromadendral from the lower boiling cineol and pinene; the sample gave the coefficient of a mixture of 50% of cineol and 50% of pinene.

Cuthbert Hall, from his observations upon the behaviour of the oils towards iodide of starch paper, considered that the ozone content of the oils was an index of their germicidal power. I showed that this did not hold for the Eucalyptus oils when they were dissolved in olive oil. With regard to the iodide of starch reaction and the activity of the oils when emulsified in water, there does appear to be some relation when individual oils are considered. The three specimens of rectified oil of *E. cinerea*, and

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* Abstr. Journ. Soc. Chem. Ind., 1910, 1470.

† Compt. Rend., (20), 21/5/18, p.827.

the three crude oils of the same species have their phenol-coefficients inversely as their iodide of starch times. The acidities do not show any such order. But when we take the oils as a whole, we find that there is no relation, indeed in view of the high germicidal power of aromadendral, we are driven to the conclusion that the chemical constituents of the oils, exclusive of any oxidising body, are the sources of the germicidal substances, and determine the disinfecting efficiency. The hydrolysis of the esters and the oxidation of the resulting alcohols is undoubtedly the reason for the enhanced efficiency of the older oils.

As disinfectants, the rectified oils do not appear very promising. The older oils of *E. cinerea* are certainly good, but those recently distilled are not. The rectified oil of *E. polybractea* is comparatively poor, while *E. Smithii* is good.

With regard to the crude oils, the question of the price comes in. Mr. H. G. Smith informed me that at the end of the year 1918, the oils of *E. cneorifolia*, *E. polybractea*, and *E. cinerea* cost from 1s. to 1s. 3d. per lb. at the still. The oil of *E. australiana*, 1st hour, cost 1s. to 1s. 2d., and of *E. dives* and *E. australiana* (Braidwood), 7d. to 8d. Rectification would add about 2d. per lb. to these figures. Thus the two most effective crude oils, *E. cneorifolia* and *E. australiana* (Braidwood) cost about 1s. 3d. and 7½d. each per lb. respectively. *E. australiana* (Braidwood) is thus the cheaper, and, at the same time, the better disinfectant. It is quite a pleasant oil to work with, and, although containing phellandrene, it has not the sticky character of the oil of *E. dives*.

On account of the difficulty of maintaining an emulsion with water, these oils will probably not displace the tar-products, which are more easily emulsified when in strong dilutions. But there are situations in which the use of the Eucalyptus oils would be preferable. The disinfection of the walls of a room, for example, by spraying, is a case in which a Eucalyptus oil, such as *E. australiana* (Braidwood) could be recommended. The oil has a phenol-coefficient of 5·8, and a dilution of 1:600, destroys *B. coli communis* in half-an hour. An emulsion of, say, 1:400 does not separate readily, and it is more efficient than a 1:80 solution of phenol. As it is at least five times more effective than phenol, and very much cheaper, it should find considerable use in spraying rooms and in disinfecting clothing or such materials as are free from oils or fatty substances, in which the Eucalyptus oil is more soluble than in water. The necessity for the use of water in conjunction with the undiluted oils has already been emphasised.

Summary.—The Eucalyptus oils are irregular in their action upon *B. coli communis*, and duplicate experiments may show a considerable amount of variation.

Cineol begins to act in about a minute and a half; phenol acts instantly.

The curves of cineol and phenol cross in five minutes with a dilution of 1:75 at 20°.

The phenol coefficient of cineol in 15 minutes at 20° is 3·1; it rises to 3·4 in 30 minutes, and then slowly declines to 2·8 in 4 hours.

Aromadendral is the most active of the constituents of the oils. The phenol-coefficient is 21·1 in 30 minutes.

The next most active is piperitone (4·1), and possibly phellandrene.

Pinene and sesquiterpene are low (0·8 to 0·5).

The rectified oils of *E. cinerea* and *E. Smithii* are more efficient than the crude oils.

In the case of the oil of *E. cinerea*, this appears to be due to the hydrolysis of the esters and the subsequent oxidation of the alcohols to aldehydes.

Treatment with alkali did not reduce the efficiency of the acid, rectified oil.

The addition of acetic acid to the crude oil doubled the germicidal power in the course of $3\frac{1}{2}$ months.

The germicidal activity of the rectified and crude oils of *E. cinerea* is proportional to the starch-iodide reaction, and not to the acidity, but this does not hold for the oils as a class.

The rectified oil of *E. polybractea* is less efficient than the crude oil.

This may be due to the elimination of aromadendral during rectification.

The oil of the Braidwood variety of *E. australiana* is the best and cheapest disinfecting oil (phenol-coefficient = 5·8 in 30 minutes.)

The oil of *E. eucorifolia* was the second best crude oil tested (phenol-coefficient = 1·8 in 30 minutes); its activity is probably due to its aromadendral content.

As in the case of phenol, the addition of acid to the water used in emulsifying the oils greatly increases the germicidal activity.

I have to acknowledge the kindness of Messrs. Baker and Smith, of the Technological Museum, in supplying me with specimens of the oils, of Mr. H. G. Smith in giving details connected with the oils, and of Mr. W. W. L'Estrange in giving much valuable assistance.

ON WATER FROM THE ROOTS OF THE RED MALLEE *(EUCALYPTUS OLEOSA).*

By Thos. Steel, F.L.S.

The use for drinking purposes of the water or sap which can be obtained from the roots and stems of plants, has been described by many observers. Eyre[*] mentions how dependent he was on this source of supply obtained by the aboriginals of his party, in the course of his famous journey along the Great Australian Bight, in 1841. Mueller[†] refers to the copious store of water in the roots of the Mallee. Cairns[‡] has some very interesting observations on the same subject. In the course of a lengthy paper, "Effects of Forest Vegetation on Climate,"[§] Rev. W. B. Clarke mentions the occurrence of such water and its use by aboriginals and others. Magarey,[‖] in a valuable paper in which a great deal of information is gathered, details a large number of Australian plants which are of value in this connection, and which, in parts of the interior where water is scarce or absent, enable the aboriginals to exist.

In numerous other works mention is made of this source of supply of drinking water, but I have been unable to find any adequate report of a chemical examination. Doherty[¶] gives a partial analysis of a sample from a species of *Vitis* growing at Tweed River, New South Wales, in which he found 39 grains total solids per gallon, of which 11 grains were inorganic, and 28 grains organic, chiefly tannin. This is equivalent to 55·8 parts total solids, of which 15·7 are inorganic, and 40·0 tannin per 100,000.

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[*] Central Expeditions into Australia, i., p.350.

[†] Fragments, ii., p.57.

[‡] Trans. Phil. Inst. Vict., iii.

[§] Journ. Roy. Soc. N. S. Wales, x., pp.179-235.

[‖] Rep. Aust. Assn. Adv. Science, vi., p.647.

[¶] Rep. Aust. Assn. Adv. Science, vii., p.335.

At the meeting of this Society in September, 1918, Mr. Fletcher exhibited specimens of the water-storing roots of the Red Mallee (*Eucalyptus oleosa*), and of the water obtained therefrom, which had been sent to him from Fowler's Bay, South Australia, through the good offices of Messrs. G. Murray, T. Gill, C.M.G., and H. S. Crummer. Mr. Fletcher kindly gave me the water for chemical examination, and I desire to thank him and the gentlemen named for the opportunity of conducting so interesting an investigation.

When the water is freshly extracted, it is stated to be colourless and practically without taste, and furnishes a cool refreshing drink. It is obtained by cutting lengths of the roots, and allowing them to drain into a vessel. When the tightly-corked sample reached me, it had been in the bottles several months, and had a pale brown colour, which darkened considerably soon after the bottles were opened. When I examined the sample it had a slight flavour, resembling that of water in which leaves had been soaked or that from a peaty source, but was quite palatable. It was neutral to litmus. The figures below give the results of the analysis. For comparison, I have put in the average of a number of representative analyses of soil waters obtained by Morgan at Michigan Agricultural College, U.S.A.*

These samples were obtained by packing the soil firmly into an iron cylinder, screwing on a tightly-closing lid, and pumping kerosene in on top. The kerosene displaced the soil solution, which was collected through a small pipe at the bottom. Morgan states his results on a different scale and system, but for purposes of comparison I have calculated them to the basis used by me.

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* Michigan Agricult. Coll. Tech. Bull. No.28, Oct. 1916

Results of analyses of Red Mallee root-water and of soil-solution, in parts per 100,000:—

	Root water.	Soil Solution (American).
Potash (K_2O)	4·25	5·66
Soda (Na_2O)	7·03	
Lime (CaO)	4·48	11·45
Magnesia (MgO)	1·44	11·97
Chlorine (Cl)	5·88	
Sulphuric anhydride (SO_3)	1·79	
Phosphoric oxide (P_2O_5)	0·43	0·69
Undetermined and loss	0·22	13·03
	25·52	42·80
Less oxygen equivalent to chlorine ...	1·32	
Total salts	24·20	
Organic matter	42·40*	32·90
Total solids	66·60	75·70
Specific gravity...	1.0003	1·0007

* Chiefly tannin.

In the root-water analysis, the carbon dioxide present in the ash, being produced during incineration, is extraneous, and has been deducted. The chlorine was determined in the water direct. The sample was insufficient to enable me to investigate the nature of the tannin, of which the organic matter mainly consisted.

Unfortunately, the American report does not take cognisance of soda, chlorine or sulphuric anhydride. The organic matter in the soil water would probably consist principally of humus. Taking the figures for soil solution as being representative, it is interesting to note how the plant has selected the substances absorbed. Thus potash and lime are taken up in greater relative proportion than magnesia. This selective action is well known. A striking illustration is furnished by marine plants, which, though bathed in a medium containing enormous relative proportions of soda and magnesia, take up very little of these substances, but select the much less abundant potash. Although land-plants do possess a very decided power of selection, we have evidence that this is to some extent overcome by the osmotic pressure of substances in the soil solution, and a plant may be compelled to take up a larger amount of substances like soda or magnesia than it requires, and which may be decidedly harmful. Such a case is furnished in my own experience by the growth of sugar-cane on soil infiltrated with brackish water, on certain parts of the Clarence River, New South Wales, and on what is known as Tiri land in Fiji—low-lying land subject to inundation with sea-water. In such cases, quite excessive amounts of chlorides are found in the juice when the cane is crushed.

Another interesting point which requires bearing in mind in case of further investigation of the water from plants, is that brought out by Professor H. H. Dixon*, as to the variation in concentration in different parts of the plant. Dixon finds that the concentration of solids is greatest in the sap from the roots, and becomes less in the upper parts of the plant. This was determined by the electrical conductivity and freezing-point methods in samples of sap obtained by centrifuging pieces of the roots and stems. The figures obtained by both methods are proportional to the amount of dissolved substance present, and are in close agreement. It was found in the case, for instance, of *Acer pseudoplatanus*, that the sap in the branches at a height of 30 feet had only two-thirds the amount of dissolved substances as that in the roots. In another plant, *Colocasia antiquorum*, a similar distribution was observed, and it is interesting to note that the droplets of liquid transpired from the tips of the leaves consisted not of sap, but of practically pure water.

These results, as regards the greater concentration of the sap in the roots, are certainly contrary to what I would have expected, but Professor Dixon's experiments are most lucidly described, bear evidence of careful execution, and seem to me quite convincing The Rev. W. B. Clarke,† without giving his authority, states his belief that it had been ascertained that the specific gravity of

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* Transpiration and ascent of Sap in Plants, 1914, p.11.

† *Loc. cit.*, p.187.

the sap is least in the roots. This would be a most interesting subject for further observation. It will be noticed that, in the Red Mallee water, the proportions of soda and of chlorine are high relative to the other ingredients. In a series of analyses of Mallee soils published many years ago by the Agricultural Chemist of Victoria,† the amounts of soda and of chlorine vary within wide limits, the chlorine in one case rising as high as 0·20 per cent. of the soil. This corresponds to about 0.33 per cent. of sodium chloride, which is a high percentage for a soil, and is quite sufficient to account for the large proportion of soda and chlorine in the Mallee root-water.

Not all samples of sap obtained in the manner of the Mallee root-water are so dilute; Smith, for instance,‡ found enormously greater amounts of both mineral and organic solids in the sap from the timber of *Grevillea robusta*, while the juices of such plants as the sugar-cane and sugar-maple, carry large percentages of sugar, though not of mineral constituents; it must, however, be remembered that in the case of these latter plants the sweet sap is contained in special cells or vessels, and is not the ordinary circulating sap, but apparently functions as a food reserve. In the specimen of these roots exhibited by Mr. Fletcher, the cut ends showed a remarkable assemblage of open vascular tubes, reminding one strongly of a section of cane. From a consideration of the circumstances, I am inclined to think that the Mallee root-water may be a reserve supply for the use of the plant during droughty conditions stored in special vessels.

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† Report Dept. of Agriculture. Victoria. 1875.

‡ Proc. Roy. Soc. N. S. Wales. 1896. p.194.

ON THE IDENTITY OF *POLYPODIUM SPINULOSUM* Burm.f.

By E. D. Merrill, M.S., Bureau of Science, Manila, P.I.

(*Communicated by J. H. Maiden, I.S.O., F.R.S.*)

In making a preliminary examination of the species figured and described by the younger Burman in his Flora Indica,* my attention was directed to the rather excellent figure illustrating *Polypodium spinulosum* Burm.f., which no pteridologist has succeeded in identifying with any other described species, it having long been considered as one of entirely doubtful status. The figure clearly represents no fern, but a leafy branch of some dicotyledonous plant.

The original description is short and imperfect, and from it alone it is impossible to gain any true conception of what Burman intended. It is as follows:—

Polypodium (*spinulosum*) caulescens, frondibus petiolatis pinnatifido trifidis, apice bifida spinosa. Polypodium indicum, foliis vario modo laciniatis, apice spiniferis ex Java. *Tab.* 67, *f.* 1.

Being fairly familiar with the Javan flora, I first attempted to refer the figure to some Javan species, but soon found that it did not agree with any species in any family known from Java, nor, for that matter, with any species known from the entire Indo-Malayan region. It seems to be evident that Burman was in error in citing Java as the origin of his species. From the figure I suspected the species to be some proteaceous plant, and an examination of the Australian material available to me shows that it unquestionably represents the West Australian species currently known as *Synaphea polymorpha* R.Br. An adjustment of the synonymy follows.

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* Burman, N. L., Flora Indica, 1768. pp.1-242.

PROTEACEÆ.

SYNAPHEA R. Brown.

SYNAPHEA SPINULOSA (Burm.f.).

Polypodium spinulosum, Burm. f., Fl. Ind., 1768, p. 233, t. 67, f. 1. *Synaphea polymorpha*, R.Br., in Trans. Linn. Soc., 10, 1810, 156; Prodr., 1810, p. 370; Benth. Fl. Austral., 5, 1870, p. 360. *Synaphea brachystachya*, Lindl., in Swan Riv., App., 1840, p. 32; Meissn. in DC. Prodr., 14, 1857, p. 316.

The species is apparently one of wide distribution in West Australia, my specimens from Swan River and from Perth, collected by Maiden and by Morrison, agreeing in all respects with Burman's short description, and with his excellent figure.

ORDINARY MONTHLY MEETING.

30th July, 1919.

Mr. J. J. Fletcher, M.A., B.Sc., President, in the chair.

Before proceeding with the formal business of the Meeting, the President referred briefly to the Signing of Peace, which had taken place since last Meeting, and moved the following resolution, which was carried unanimously, the Members rising:—"Peace having been signed, the Members present, especially keeping in mind the memory of those who have fallen, desire to reaffirm the sentiments of the resolution passed on the 27th November, 1918, expressive of loyalty, gratitude and sympathy."

The President offered a hearty welcome to Captain L. Harrison, who was present, on his safe return, and also announced that four other Members—Dr. E. W. Ferguson, Messrs. C. O. Hamblin, M. Henry, and D. S. North—had returned since last Meeting.

The Donations and Exchanges received since the previous Monthly Meeting (25th June, 1919), amounting to 4 Vols., 43 Parts or Nos., 7 Bulletins, 4 Reports, and 10 Pamphlets, received from 41 Societies and Institutions, and one private donor, were laid upon the table.

NOTES AND EXHIBITS.

Mr. Froggatt exhibited specimens of the green tomato and bean bug, *Nezara viridula*, from Florida, U.S.A., infested with the eggs of a Tactonid fly, *Trichopoda pennipes*, which destroys this bug in the southern State; also an enlarged photo. of the egg-infested bug, taken by Professor Carl J. Drake, of Syracuse University, New York, U.S.A. This cosmopolitan bug is a serious pest in New South Wales on tomatoes, potatoes, and french beans, and has also been found upon citrus trees.

Mr. A. A. Hamilton exhibited, from the National Herbarium, (*a*) specimens of the "Potato," *Solanum tuberosum*, showing adventitious tubers in the axils of the stem-leaves (Coll. Miss M. Flockton); (*b*) an example of increased bulb production in the "Snow-flake," *Leucojum vernum* (Coll. H. Selkirk). Worsdell (Principles of Plant Teratology, i., p. 156) and Goebel (Organography of Plants, Part i., p. 215) attribute the growth of these aerial tubers to interference with underground tuber formation, though the former admits that the phenomenon is occasional when the underground tubers have not been disturbed. In an investigation of this habit in the common "Yam," *Dioscorea sativa*, in which aerial tuber formation occurs normally, Elizabeth Dale (Ann. of Bot., xv., p. 491), suggests that the occurrence is due to the supercession of sexual production by the vegetative method, owing to inability to readily produce seeds. This view is also maintained by C. A. Barker (Ann. of Bot., iv., p. 105) in a paper dealing with a monstrous form of *Nymphaea lotus*, which produces tubers in the place of flowers. The excessive growth in the snow-flake has probably been stimulated by over-nutrition.

Mr. E. Cheel exhibited living seedling plants of the following species of *Rutaceae*, which are all more or less of economic importance, and require to be further studied, as there seems to be several Australian forms or varieties imperfectly described, and comparatively rare: (a) *Triphasia trifoliata* Dc. (*T. aurantiola* Lour.). The plants exhibited were raised from seeds obtained from a plant in the Botanic Gardens of Suva, in August, 1918. It is commonly known as "Lime Berry," and the plant was loaded with berries about the size of fruits of the Port Jackson Fig; they were of a reddish-brown or dark orange-red colour, and of an acidulous flavour. (*b*) *Eremocitrus glauca* Swingle, Journ. Agric. Research, Dept. Agric., Washington, 1914, 85; (*Triphasia glauca* Lindl.; *Atalantia glauca* Hook fil., in Benth). Swingle has conducted a series of experiments with this and other species of the Citratae group, and regards it as distinct from *Triphasia* and *Atalantia*, and has accordingly created a new genus as above. It is commonly known as "Native Kumquat," "Desert Lemon," and Swingle has added the name "Australian Desert Kumquat." Bailey (Queensl. Agric. Journal, January, 1915, p. 29) has proposed the name *inermis* for some apparently spineless forms of this species. It is interesting to note that no spines are present in the seedling-stage. (*c*) *Poncirus trifoliata* (L.) Raf. (*Citrus trifoliata* L.). Seedling raised from fruits taken from a plant cultivated in the Botanic Gardens, Sydney. This species is a native of China, and very subject to "Citrus-canker" (*Pseudomonas citri*). (*d*) *Microcitrus australasica* Swingle (*Citrus australasica* F.v.M.). "Australian Finger Lime."

Dr. Tillyard drew attention to a paper by Mr. D. A. Herbert, Government Botanist of Western Australia, on the Parasitism of the Western Australian Christmas tree (*Nuytsia floribunda*) in the Proceedings of the Royal Society of Western Australia.

MESOZOIC INSECTS OF QUEENSLAND.

No. 6. BLATTOIDEA.

By R. J. TILLYARD, M.A., D.Sc., F.L.S., F.E.S., LINNEAN MACLEAY FELLOW OF THE SOCIETY IN ZOOLOGY.

(Text-figs. 29-40).

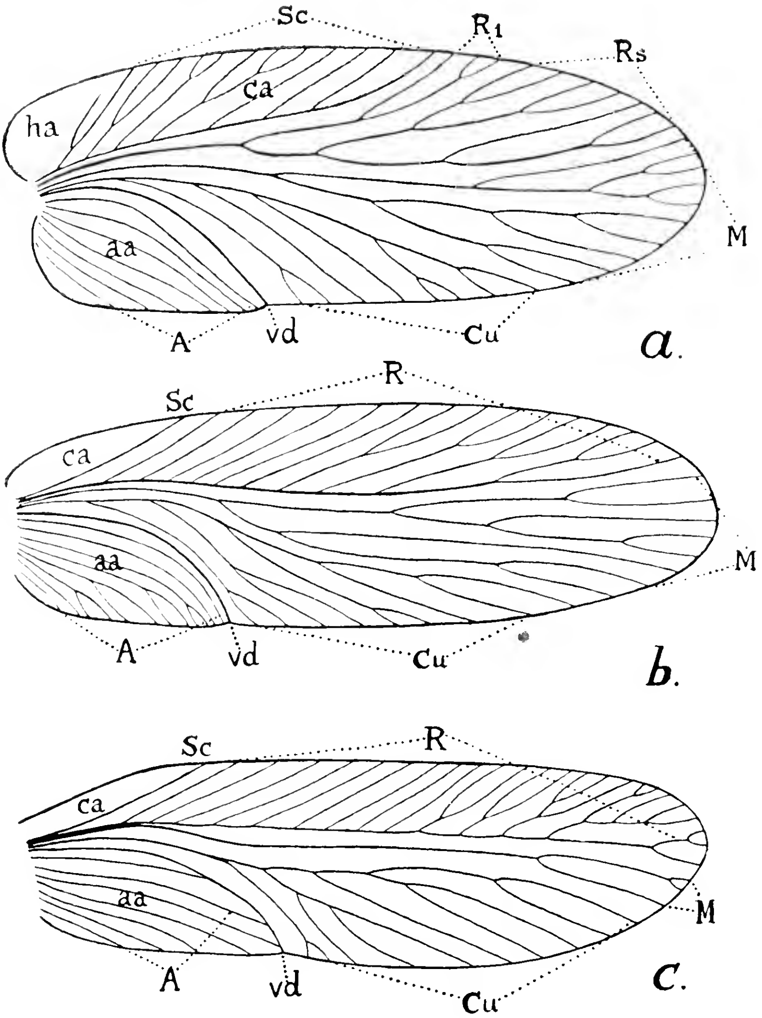
Although regarded by many entomologists as forming only a single family, or at most a Suborder, within the Order Orthoptera, the Cockroaches comprise the vast majority of the known fossil insects of Palæozoic times, and were evidently the dominant group during the Upper Carboniferous and Permian of the Northern Hemisphere. Consequently, they have come to be studied apart from the rest of the Orthoptera; and many attempts have been made to indicate for them characters of ordinal value, which should set them completely apart from the rest of that Order. Such characters are to be found in the oval, much flattened body; the large oval pronotum, beneath which the head is almost wholly concealed; the huge coxæ; the similarity in the structure of all three pairs of legs; and especially in the shape and venation of the tegmina or forewings. I must confess my inability, at present, to see anything of more than subordinal value in all these characters. The Cockroaches appear to me to be essentially the most generalised of Orthoptera; and I propose to use the group-term Blattoidea as indicating a distinct, archaic Suborder within the Order Orthoptera.

The great majority of fossil cockroaches are represented either by a single tegmen, or part of it, or at most by the two tegmina *in situ*, folded down the back of the insect. Hindwings are comparatively rare, owing to their much greater delicacy of texture, and the slight chance of their being preserved intact, or, if preserved, of leaving any reasonably clear impression upon the rock in which they become imbedded.

The study of fossil cockroach tegmina is almost a special branch of Entomology by itself, and has been brought to considerable perfection by Scudder, Brongniart, Handlirsch, and others. For the purpose of dealing adequately with the fossil Blattoidea so far found at Ipswich, it would appear sufficient if we indicated the typical venational scheme of a cockroach tegmen, and pointed out the main lines of specialisation which are shown in the evolution of this type of forewing, from its first occurrence in the Upper Carboniferous, down to the present day.

Text-fig.29 shows three very typical cockroach tegmina, one from the Upper Carboniferous of Europe, another from the Lias of Europe, and a third from a still existing genus of Australian cockroaches All three agree in the general shape of the tegmen, though it may be said that the average breadth, in comparison with the length, is greatest in the oldest forms, and decreases as we pass up through the Mesozoic forms to those of the present day. All three likewise agree in the very definite marking off of a somewhat cultriform *anal area* or *clavus*. This character is one of the most distinctive of the true cockroach tegmen, and the area in question is generally excellently preserved in fossils.

The differences between the three types are fairly obvious. In the Carboniferous fossil, the subcostal vein (Sc) was well developed, sending many branches to the anterior border of the wing, and occupying at least half of that border. The only space devoid of branch-veins is a small portion of the costal area, at its extreme base, which we may term the *humeral area* (Text fig.29*a*, *ha*). The space lying between the anterior border of the tegmen and the main stem of the subcosta, and including, therefore, not only the humeral area proper, but also the whole area supplied by branches of Sc, is the true *costal area* (Text-fig. 29, *ca*). In the Mesozoic and recent types figured, the subcosta becomes reduced to a simple vein, which borders the costal area distally; and the latter becomes, like the humeral area of the older type, free of branch-veins. There are, of course, many Carboniferous types that show stages in this reduction; but they are not dominant types for that period. Thus the *Poroblattinidæ*



Text-fig.29.

Venation of Blattoid tegmina. *a.* Genus *Phyloblatta*, family *Archimylacridae* (diagrammatic). Upper Carboniferous of Commentry, France. *b. Rhipidoblatta geikiei* Scudder, family *Mesoblattinidae* (enlarged from Handlirsch). Lias of Moreton Bagot, England. *c. Escala circumducta* (Walker), family *Blattidae*, recent. Australia (× 7½).

show the subcosta reduced to a few veins—an intermediate stage between *Phyloblatta* (Text-fig.29*a*) and *Rhipidoblattina* (Text-fig. 29*b*). This latter genus belongs to the *Mesoblattinidæ*, which, represented by only three genera in the Upper Carboniferous, become more important in the Permian, and finally reach the dominant position among Mesozoic Blattoids.

Let us next consider the radius (R) In the type exhibited by *Phyloblatta*, we can usually indicate the boundaries of the main stem of R (R_1) and the radial sector (Rs) respectively. Thus these cockroaches fall into line with almost all other insects in this respect. But when the radius supplants the subcosta, as in the Mesozoic and recent forms, it tends more and more to take on the original character of that vein, viz., a single, gently curving main stem, giving off only anterior branches to the wing-border. There are many forms in which this process can be seen uncompleted; yet, in general, we may say that the limits of R_1 and Rs become no longer clearly evident, and it is best to consider the radius, for purposes of description, as a single main stem with many anterior branches.

The media (M) tends to alter very little throughout all Palæozoic and Mesozoic forms. It always supplies about the same area of the wing, viz., a more or less triangular area covering the middle line of the tegmen, including the apex and portion of the wing-border below it. In the recent form figured (Text-fig.29*c*), the media is shown much reduced, and fused basally with the radius. A reduced media is found in a few Mesozoic forms, but its basal portion is never fused with R in these fossils. There are also many genera still existing in which the media remains free and many-branched.

The cubitus (Cu) also tends to alter very little. In the great majority of forms it supplies the broadly triangular area lying below the middle line, sending branches to the posterior border, from below the most posterior branch of M to near the anal area. The manner and number of these branches is very variable in all forms.

The most characteristic structure in all Blattoid tegmina is the sharply marked-off *anal area* or *clavus* (Text-fig.29, *aa*). This somewhat cultriform area is separated from the rest of the tegmen by a deeply impressed vein, called the *vena dividens* (*vd*). This vein, in the Comstock-Needham system, must be either Cu_2 or 1A; but, as it does not seem to be quite clear, as yet, which of these it really is, it is best to keep to the non-committal name still in use with students of the Blattoidea. The anal area itself is more or less convex, and hence it is usually very well preserved in fossils, making a deep impression on the rock, much as a Coleopterous elytron does.

The veins supplying the anal area are termed either *anal veins* or *axillaries* (Text-fig.29, A); we shall adopt the former term. In the Palæozoic fossils, they all spring from the base, and take a more or less oblique course towards the posterior border; none of them ends upon the *vena dividens*. The same is true of most Mesozoic fossils, though occasionally one, or perhaps two, of the more anterior ones may be found to end up on the *vena dividens*, just above the apex of the anal area. Recent forms with the same condition still exist; but there are also many forms in which, as in the one figured in Text-fig.29*c*, the anal veins distribute themselves alike equally to the *vena dividens* and the posterior border, or even run mostly longitudinally to the former only.

We may add to this account that, in the great majority of Carboniferous fossils, there is a delicate close network of cross-veins all over the tegmen; this is apparently a specialisation from the older and more irregular palæodictyopterous meshwork, or *archedictyon*, found in the Palæodictyoptera, Protorthoptera, and Protoblattoidea. Intercalated veins are very rarely developed In the Mesozoic fossils, on the other hand, intercalated veins are often well developed, while the close network of cross-veins is more rarely found. Most recent forms have the intercalated veins well developed; and there still exist a number with the cross-venation persisting, though it is seldom of so close a type as in the Carboniferous forms.

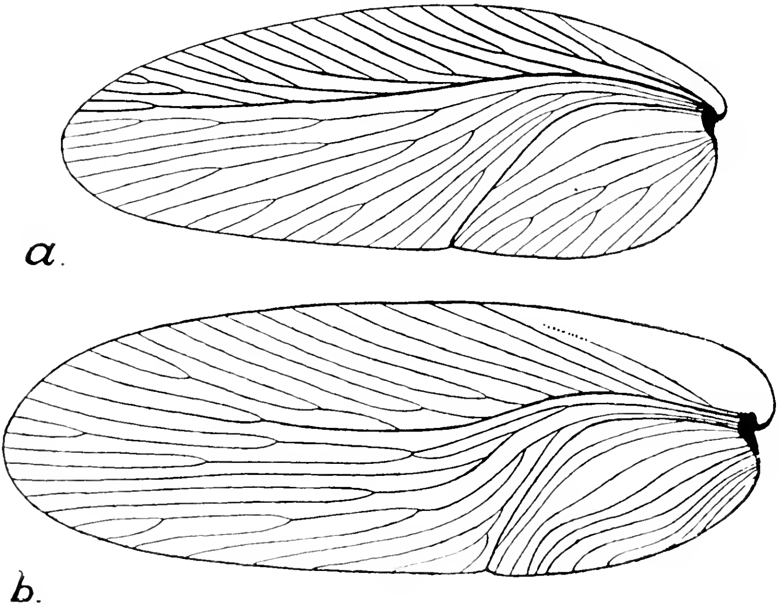
Thus, although the Blattoid type of tegmen has remained remarkably stable through many millions of years, we are yet able to see the general trend of evolution, as shown by the changes in the dominant types at each period. We may sum up these tendencies as follows :—

(1) Tendency towards narrowing of the tegmen.

(2) Tendency towards reduction of Sc, and invasion of the anterior border of the wing by branches from R.

(3) A correlated early tendency towards loss of the clear distinction between R_1 and Rs.

(4) Tendency for the anal veins to migrate distally from their original endings on the posterior margin of the wing, and to end instead upon the *vena dividens.*



Text-fig.30.

Restoration of the tegmen in *a. Triassoblatta typica*, n.g. et sp., and *b. Samaroblatta reticulata*, n.g. et sp. Both from Upper Trias of Ipswich, Q. (× 7½). In *b*, the intercalated ridges and cross-venation are omitted.

We are now in a position to study our new Ipswich fossil Cockroaches with advantage. Text-fig.30 shows the restoration of the tegmina of the two principal genera described in this Part.

Of these two, we must select *Triassoblatta* as the older type; because in it, Sc remains still not reduced to its full limit of a single vein bounding the costal space distally. The radius in this genus shows no strong double curving. This genus might reasonably be put into the *Poroblattinidæ* on the character of its subcosta; but in other respects it comes closer to the *Mesoblattinidæ*, so that a slight extension of the definition, as given by Handlirsch, will enable us to include it as the most archaic member of that family. The other genus, *Samaroblatta*, agrees with *Rhipidoblattina* (Text-fig.29*b*) in its completely reduced Sc, but differs from it in the strong double-curving of R, and in the absence of branchings on the anal veins. It goes naturally into the *Mesoblattinidæ*. The same may be said of the third genus *Austroblattula*, of which it does not seem necessary to give a restoration.

The assemblage of forms described in this paper, then, is just such as we might expect to find in beds of Upper Triassic age. We may note, however, the existence of a much more archaic type in these same beds, in the genus *Austromylacrites* Tillyard, described in a former paper (**2**, p.13).

Before proceeding to enter upon the descriptions of the new fossils, I desire to express my grateful thanks to Dr. A. Eland Shaw, M.R.C.S., F.E.S., of Wynnum, South Queensland, for his valuable help and criticism upon this Part. The manuscript and Text-figures were sent to Dr. Shaw, who studied them carefully, and was able, owing to his great experience in the group, to suggest a number of useful alterations. My chief discussions with Dr. Shaw centred upon two points, viz., the method of counting the branches of R, and the correct naming of the wing-areas. Both these really depend upon the application of the Comstock-Needham system of venational nomenclature to the Blattoidea, which Dr. Shaw is as anxious to see established as I am, though by long use he has accustomed himself to the different notation in vogue amongst Blattidists. As regards the branches of R, it seems to me, after a study of the known fossil types, that it is quite impossible to say what are the limits of R_1 and Rs in Mesozoic and recent forms. I have, therefore, expressly stated that I regard R as a single elongated main stem, from which a series of primary branches comes off anteriorly, meeting the costal border. In counting these branches, I do *not* include the small fork or forks that may be present near the tip of this main stem, because I consider these to be only secondary forkings, of the same nature as the branches of some of the forkings of the primary branches themselves. To take an example:—by reference to Text-fig.29*c*, I should say that *Escala circumducta* had a radius with thirteen primary anterior branches, the first nine of which are simple, the next four themselves branched or forked. The last primary branch arises just above the forking of M. To make this quite clear, I should add the phrase "excluding the distal forked end of the main stem," which, as will be seen from the figure, divides into three very short veins. This method of description has been followed throughout the paper, and I trust that it will be quite plain.

As regards the naming of the wing-areas, the rule in the Comstock-Needham System is that *each area should be named from the vein that bounds it anteriorly.* This is awkward for the Blattoidea, since it makes the area in which all the branches of R lie, the *subcostal area.* But it is better to put up with this than to make one rule for the Blattoidea and another for those insects in which the branches of R are posteriorly placed. As regards the area served by the branches of Sc, the rule makes it quite clear that the whole area between the costal border and the main stem of Sc must be the true *costal area*, and will contain within itself all the branches of Sc. Hence a new name is needed for the clear basal portion of the costal area which is of such value as a generic character. This I propose to term, in full, *the humeral portion of the costal area*, a term which may conveniently be shortened to *humeral area,* provided it is understood that it is always part of the costal area proper. When Sc becomes a single straight vein, then the humeral area and the costal area coincide, as in *Samaroblatta*, n.g. In some cases, as in *Triassoblatta insignita*, n.g. et sp. (Text-fig.32), the humeral area has its costal border strengthened, and this strong border is continued beyond the first branch of Sc.

Family MESOBLATTINIDÆ Handl.

Subcosta much reduced. Radial area extensive and strongly developed, sending numerous branches towards the anterior border, and reaching nearly to apex. Media free, dividing into a variable large number of branches directed towards the apical border. Cubitus also free, branching variably, the branches directed towards the posterior border. Anal field large, well-defined, usually somewhat cultriform, with more or less curved veins running chiefly towards the posterior border. Intercalated veins and reticulation or cross-venation may or may not be present. Mostly small to medium-sized forms.

The above definition of the family is a slight modification of that given by Handlirsch (**1**, pp.290, 378, 427), the alterations having been made with a view to the inclusion of one of the new genera from Ipswich, which does not seem to me sufficiently distinct from the described types of the Northern Hemisphere to warrant the formation of a new family for its reception. Besides, the family, as recognised by Handlirsch, already comprises forms from the Upper Carboniferous, the Permian, and the Lias; so that the new forms from the Upper Trias fall naturally into the family, with respect to their geological age, as well as with respect to their characters. The alterations allow forms in which Sc is not reduced to its full extent, and the branches of Cu do not all come off posteriorly, to be retained within the family, and also indicate that the presence of cross-venation is not as exceptional as Handlirsch imagined it to be.

Handlirsch regards the family as directly derivable from the older *Poroblattinidæ*. From the Upper Carboniferous of North America and Saxony he lists three genera, with five species. From the Lower Permian of North America, he gives three genera, with four species (one of these genera, *Nearoblatta*, occurs in both formations). From the Lias of England, Switzerland, and Mecklenburg, he defines no less than ten genera, comprising twenty-four species. Thus the family contains a total of fifteen genera and thirty-three species. Handlirsch also remarks that the family is only poorly represented in the Upper Carboniferous, but becomes more important in the Permian, finally reaching the dominant position within the Blattoidea during the Lias. We should, therefore, not be at all surprised to find that the cockroaches from Ipswich, with the single exception of the fine genus *Austromylacrites* Tillyard, previously described (**2**, p.13), fall naturally into this family.

Of the eleven specimens here dealt with, only two (Specimens 121*a-b* and 152) are not named, the former being too poorly preserved, the latter too fragmentary. Of the remaining nine, two cannot be placed with certainty in their correct genera; these are Specimens 216 and 262, the former being a nearly perfect clavus or anal area only, while the latter has neither humeral area nor anal area clearly preserved. The remaining species may be arranged within three genera, on well-defined characters, as shown in the following key:—

(1) Length of humeral area, from base to apex, distinctly less than that of anal area .... TRIASSOBLATTA, n.g.
Length of humeral area, from base to apex, at least equal to that of anal area .... 2.

(2) Medium-sized tegmina (about 13 mm. long) with the main stem of R fairly strongly double-curved, so that its lowest point of dip reaches almost to the middle line of the tegmen .... SAMAROBLATTA, n.g.
Small tegmina (less than 10 mm. long), with the main stem of R very slightly curved, its lowest point of dip lying well above the middle line of the tegmen.......... AUSTROBLATTULA, n.g.

Genus TRIASSOBLATTA, n.g. (Text-figs.30*a*, 31-33).

Medium-sized to large tegmina from 12 to 21 mm. in length. Humeral area narrow to moderately wide; distinctly less in length, from base to apex, than is the anal area. Sc consisting of a group of sectors, one of which borders the costal area distally, with or without extra branches on that area, but always with at least one branching sector placed distad from it. Main stem of R with very weak double-curving, so that its lowest point of dip lies well above the middle line of the tegmen, and the most distal branch of R reaches almost to the apex. Anal area somewhat cultriform, well-defined, with some at least of the anal veins forking well before their distal ends.

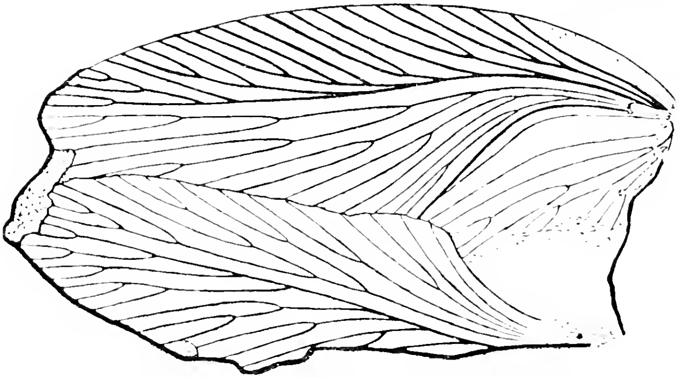
Genotype, *Triassoblatta typica*, n.sp. (Upper Triassic, Ipswich, Q.).

This genus is closely related to *Rhipidoblattina* Handl., from the English Lias, but may be at once distinguished from it by the greater breadth of the tegmen in comparison with its length, and by the absence of intercalated veins and cross-veins.

The two species that can be placed with certainty in this genus may be distinguished as follows:—

Large tegmen (more than 20 mm. long) with definitely strengthened margin to humeral area. Sc with eight branches to border. Anal area with an irregular archedictyon .... *T. insignita*, n.sp.

Medium-sized tegmen (about 12 mm. long) with humeral area normal, much narrower than in the above. Sc with only four branches to border. Anal area without any reticulation .... *T. typica* n.sp.



Text-fig.31.

Triassoblatta typica, n.g. et sp. (× 7½). Left and right tegmina *in situ*. Upper Trias of Ipswich, Q. Drawn from Specimen No.180*a*.

TRIASSOBLATTA TYPICA, n.sp. (Text-figs.30*a*, 31).

This specimen is a *mould** of both tegmina *in situ*, the right one almost complete, the left with portions of the costal and

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* The impression is a very flat one, but the *vena dividens* lies upon a ridge, thus proving that the fossil is a *mould*, not a *cast*. Consequently left and right sides are interchanged, as in the figure. Dr. Shaw writes:—"Almost invariably in Cockroaches the left tegmen overlaps the right."

posterior borders missing. The apices of both tegmina are also missing. The left tegmen overlaps the right; but, in process of delamination, its extreme posterior border has broken away, leaving somewhat more of the corresponding border of the right tegmen exposed than would otherwise have been the case. Most of the anal area of the right tegmen is well preserved, but the posterior border is missing, as well as, apparently, the whole of this same area in the left tegmen.

Judging from the form of the impression, the insect must have been of considerably broader build than is usually found in existing winged forms amongst Australian cockroaches, even if we allow something for flattening down during fossilisation.

Greatest length of fossil, 11·5 mm., representing a tegmen whose *total length* was about 12 mm. *Greatest breadth*, 5·8 mm., representing a total breadth across the two tegmina *in situ* of about 7 mm., and a probable greatest width for a single tegmen of 4·5 mm.

Humeral area narrow, 3·4 mm. long from base to apex, bounded distally by a simple, nearly straight branch of Sc. Distad from this, Sc gives off another sector, which branches into three. Sc, R and its branches are strongly formed, moderately thick veins. R sends in all seven primary branches towards the anterior border, excluding the distal forked end of the main stem; of these, the first is a forked vein, the second simple, the third forked, the fourth a long vein with four branches, the fifth also a long vein with three branches, the sixth simple, the seventh short with three branches. (This description applies to the right tegmen only; the distribution of the branches in the left tegmen, as far as these are preserved, is somewhat different). Media a moderately strong vein, branching dichotomously again and again, and sending at least nine branches to the wing border at and below the apex. Cubitus also a moderately strong vein, dichotomously branched, sending six veins to the posterior border. *Vena dividens* strongly arched, deeply impressed. Anal area just over 5 mm. long from base to apex, greatest breadth about 3 mm. Of the anal veins the first (most anterior) lies close to the *vena dividens*, and ends up distally upon it; all the rest apparently end upon the posterior margin of the wing. Second and third anal veins simple, the fourth forking about midway, with an extra distal fork on the anterior branch. The other anal veins not fully preserved, but some of them are evidently forked. Distance between first and second anal veins much greater than that between the others.

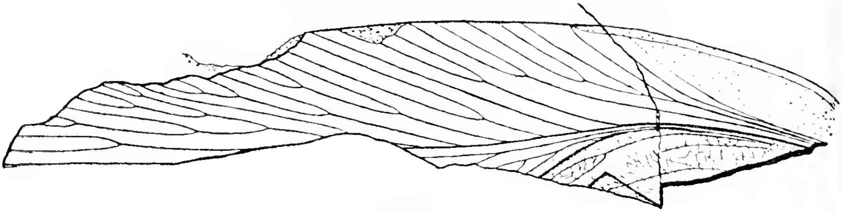
Type, Specimen No.180*a*, with its counterpart No.180*b* (the latter shows only about the basal two-fifths of the tegmina). (Coll. Queensland Geological Survey).

Horizon: Upper Triassic, Ipswich, Q.

TRIASSOBLATTA INSIGNITA, n.sp. (Text-fig.32).

A fragment of a single left tegmen, including almost the whole of the anterior portion from base to apex, with humeral area, Sc and most of R, also the bases of M and Cu, more than half of the *vena dividens*, and the upper portion of the anal area.

Greatest length, 19·5 mm., representing a total length for the tegmen of about 21 mm. *Greatest breadth* of fragment, 4 mm., representing an estimated total width of tegmen about 8·5 mm.



Text-fig.32.

Triassoblatta insignita, n.g. et sp. (×5·4). Fragment of left tegmen. Upper Trias of Ipswich, Q. Drawn from Specimen No.124.

Humeral area 6 mm. long from base to apex, moderately wide, and having its anterior or costal border strongly thickened; this thickening extends as far as the *third* branch of Sc. First two branches of Sc simple; distad from these follows a long sector giving off four branches; beyond this is another forked sector, so that the total number of branches sent by Sc to the wing-border is eight. Radius apparently gives off six primary branches to the anterior border, exclusive of the forked end of the main stem. Of these, the first is a forked vein, the second simple, the third again forked, the fourth with three branches, the fifth with four, and the sixth a many-branched vein sending altogether no less than eight branches to the margin of the wing. M and Cu are forked near their bases. *Vena dividens* strongly marked. Anal area, as far as preserved, covered with an archedictyon or primitive palæodictyopterous meshwork of weak, irregular veinlets; the first anal vein lies close to the *vena dividens*, and probably meets it distally; this vein also forks at about half-way; second and third anal veins, as far as preserved, appear to be simple and moderately wide apart.

Type, Specimen No.124. (Coll. Queensland Geological Survey).

Horizon: Upper Trias, Ipswich, Q.

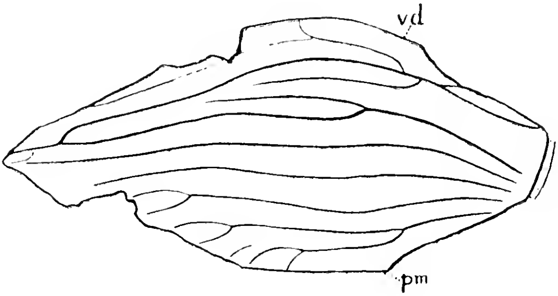
In spite of the fragmentary nature of this fossil, there can be little doubt that it belongs to the genus *Triassoblatta*, since the characters of the costal area, subcosta, and radius agree with the definition, while enough of the anal area is preserved to show that it must have been of considerably greater length, from base to apex, than the completely preserved humeral area.

TRIASSOBLATTA(?) INTERMEDIA, n.sp. (Text-fig.33).

This species is represented only by the anal area of a left tegmen, which is almost complete. It may be placed provisionally in this genus, on account of the forking of some of the anal veins, a character shared in common with the two species already described, but absent from the other genera defined in this paper.

Total length of anal area, 7·3 mm. *Greatest breadth*, 3·3 mm.

Most of the *vena dividens* missing, but the more anterior part of it (*vd*) preserved. The first anal vein appears to be the weakly formed vein lying just below the *vena dividens*, and connected both with it and with the second anal vein. The latter is a very strong vein, much curved, giving off a posterior branch which does not connect up with any other vein, and anastomosing, near its distal end, with the third anal. The third anal is also a strong vein, giving off an anterior branch which, like the very similar posterior branch of the second anal vein, does not connect up with any other vein. The fourth and fifth anals are unbranched and nearly straight; the sixth a weaker vein, slightly curved, and with a short distal fork. The seventh is a weak vein, branching into two not far from its base; each branch forks again near its distal end. The fused distal ends of the second and third anal veins appear to end up almost exactly upon the apex of the area; all the veins below these end upon the posterior margin (*pm*). Traces of a true archedictyon are evident in this fossil, but have been omitted from the drawing in Text-fig.33.



Text-fig.33.
Triassoblatta(?) *intermedia*, n.sp. (×11). Left tegmen, anal area. Upper Trias of Ipswich, Q. Drawn from Specimen No.216.

Type, Specimen No. 216. (Coll. Queensland Geological Survey).

Horizon: Upper Trias, Ipswich, Q.

The anal area described above is intermediate in size between those of *T. typica*, n.sp., and *T. insignita*, n.sp., and probably belonged to a tegmen about 18 mm. in length. In showing traces of an archedictyon, it comes closest to the anal area of *T. insignita*. The arrangement and branching of the anal veins is very distinct, and should alone enable us to recognise the species again, if by any chance a more completely preserved specimen be one day found.

Genus Samaroblatta, n.g. (Text-figs. 30*b*, 34-38).

Medium-sized tegmina (about 13 or 14 mm. in length). Humeral area moderately wide, of about the same length, from base to apex, as the anal area. Sc a single, strong, and nearly straight vein bounding the humeral area distally, with or without a weaker, incomplete branch vein proceeding from it on to the humeral area. Main stem of R with fairly strong double-curving, so that its lowest point of dip lies almost upon the middle line of the tegmen, and the most distal portion of R reaches the border well before the apex. Anal area somewhat cultriform, well-defined: forkings of anal veins, if any, confined to small twigs near their distal ends.

Genotype, *Samaroblatta reticulata*, n.sp. (Upper Trias, Ipswich, Q.).

Closely related, by the character of the strong double-curving of R, to *Mesoblattula* Handl., from the Lias of Dobbertin, Mecklenburg; but at once distinguished from it by its much greater size and larger number of veins. The generic name is derived from the word *samara* (Lat. *samera* or *samara*, the seed of the ash), a botanical term indicating the winged mericarp found in the Natural Order Aceraceæ, such as the seed of the maple, sycamore, etc. The appearance of these fossil tegmina, with their strongly impressed basal anal area, is strongly suggestive of this type of winged seed. Parenthetically, it may be mentioned that the venation of quite a number of plant-remains is deceptively like that of the cockroach tegmen, necessitating some care on the part of the investigator of these fossils.

This genus differs from *Triassoblatta*, n.g., not only in the greater comparative length of its humeral area (as given in the key), but also by the simplification of Sc, the much greater double-curving of R, and the absence of any but small distal forkings from the anal veins.

The five species here described may be separated by the following key:—

(1) { Sc, R and its branches strongly thickened veins; M and Cu moderate .... *S. blabelloïdes*, n.sp.
All the veins slender .... 2.

(2) All the veins, except those of the anal area, separated from one another by broad, strongly developed ridges, resembling thickened veins, but distinguished by not being joined to one another basally.. 3.
M, Cu and their branches separated by delicate intercalated veins...... .... *S. intercalata*, n.sp.

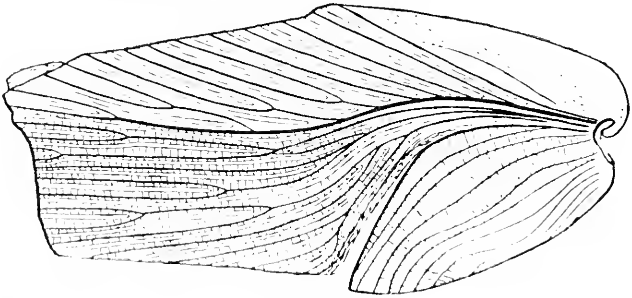
(3) Delicate cross-venation indicated on M, Cu and anal areas... .... *S. reticulata*, n.sp.
No cross-venation on these areas 4

(4) Anal veins distinct, the third, fourth, and fifth with small distal forkings; delicate cross-venation indicated in region of branches of R .... *S. triassica*, n.sp.
Anal area with only vestiges of veins; no cross-venation indicated anywhere on the tegmen .... *S. jonesi*, n.sp.

SAMAROBLATTA RETICULATA, n.sp. (Text-figs.30*b*, 34).

A beautifully preserved left tegmen, complete except for a narrow portion missing from the anterior border, and the whole of the apical portion. Anal area complete, but slightly torn away from the rest of the tegmen along the *vena dividens*.

Greatest length, nearly 10·5 mm. *Greatest width*, 4·5 mm. Probable *total length* of tegmen, nearly 14 mm.



Text-fig.34.

Samaroblatta reticulata, n.g. et sp. (× 7½). Left tegmen. Upper Trias of Ipswich, Q. Drawn from Specimen No.155*a*.

Extreme base of tegmen well preserved, showing the typical Blattoid humeral border, strongly convex. Humeral area 5·5 mm. long, sharply pointed at apex, and carrying a single weakly indicated branch from Sc. Main stem of R giving off seven primary branches to the anterior border, excluding the forked distal end; of these, the first four are simple veins, the fifth, sixth, and seventh forked. M sends at least seven branches to the apex and below it. Cu sends also at least seven branches to the posterior border; of these the more anterior ones extend far out below the apex, parallel with the lower branches of M. In the area covered by M and Cu, there are strong indications of a somewhat irregular cross-venation.

Raised ridges of considerable breadth separate all the veins, except those on the anal area. These ridges appear at first sight to be the veins themselves; but a closer examination shows that they do not join up basally with one another, whereas the finer veins lying between them do all so join up. Thus these latter must be the true veins, the ridges being probably some specialised development of a series of intercalated veins. The cross-venation, where it is well enough preserved to be studied with advantage, can be seen to lie on either side of each true vein, being interrupted more or less by the intercalated ridges.

Anal area complete, with *vena dividens* strongly marked. Anal veins weakly indicated anteriorly, more strongly posteriorly. A fairly regular cross-venation present almost all over the anal area. First anal vein both arising from and ending upon the *vena dividens*; the second lying close below the first, but ending just below the apex; the third and fourth wide apart, the latter much waved; the fifth close under the fourth, much less curved; below this are five more veins, the first two of which are considerably waved.

Type, Specimen No.155*a*. (Coll. Queensland Geological Survey).

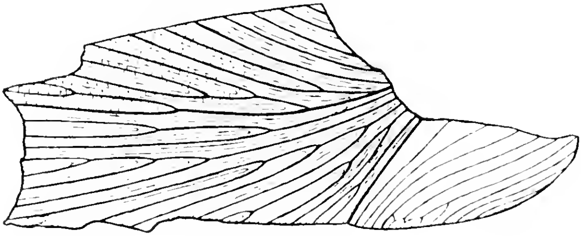
Horizon: Upper Triassic, Ipswich, Q.

SAMAROBLATTA TRIASSICA, n.sp. (Text-fig.35).

A well preserved fragment of a left tegmen, with the greater portion of the base missing, also the apex and a narrow piece along the posterior border.

Greatest length, 10·5 mm., representing a tegmen whose total length was about 13 mm. *Greatest breadth*, 4·5 mm.

Closely similar to *S. reticulata*, from which it differs as follows:—Branchings of R, M, and Cu differently arranged, as may be seen by comparing Text-figs. 34 and 35. (Not much stress can be laid on this character, however, since not only different individuals of the same species of Cockroach, but also even the right and left tegmina of the same individual, show considerable differences in this respect). Cross-venation indicated upon the area served by the branches of R, but not upon M, Cu, or the anal area. Anal area with nine anal veins, all ending upon the posterior border; the fourth, fifth, and sixth with small distal forkings, which anastomose with one another; the other anal veins simple.



Text-fig.35.

Samaroblatta triassica, n.g. et sp. (×7½). Left tegmen. Upper Trias of Ipswich, Q. Drawn from Specimen No.156.

Type, Specimen No. 156. (Coll. Queensland Geological Survey).

Horizon: Upper Triassic, Ipswich, Q.

Though the costal area is missing, the structure of R shows that this species belongs to the genus *Samaroblatta*.

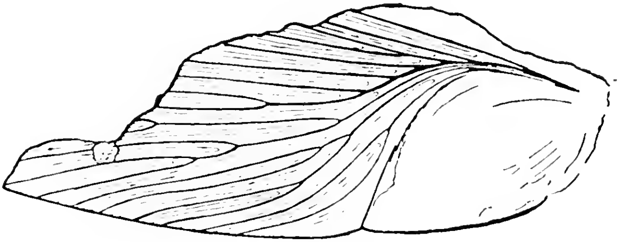
SAMAROBLATTA JONESI, n.sp. (Text-fig.36).

A fairly well preserved fragment of a left tegmen, with the costal border and apical area missing, most of the posterior border and anal area complete.

Greatest length, 11 mm., indicating a tegmen of total length about 13 mm. *Greatest breadth*, 4 mm.

Closely related to the above two species, but distinguished from them as follows:—No cross-venation anywhere indicated;

anal area with only vestiges of anal veins. The veins and intercalated ridges are well preserved, and the form of branching of R, M, and Cu is not unlike that of *S. reticulata*, n.sp. But M had certainly less than seven branches, while Cu, which is completely preserved in this fossil, shows only six.



Text-fig.36.
Samaroblatta jonesi, n.g. et sp. (×7½). Left tegmen. Upper Trias of Ipswich, Q. Drawn from Specimen No.157*a*.

Type, Specimens No. 157*a*, 157*b* (part and counterpart). (Coll. Queensland Geological Survey).

Horizon: Upper Triassic, Ipswich, Q.

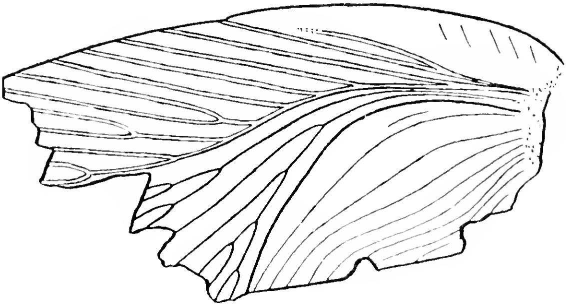
Dedicated to Mr. A. J. Jones, the present Minister for Mines in Queensland.

SAMAROBLATTA BLABELLOIDES, n.sp. (Text-fig.37).

A well preserved fragment of a left tegmen, with the apical third missing, broken off along a very irregular line. There are also small portions missing from the anal area and extreme base.

Greatest length of fragment, 9·3 mm., indicating a tegmen of total length 13 mm. *Greatest breadth*, 5 mm., being the total breadth of the tegmen.

Costal area fairly wide, sharply pointed at apex, 6 mm in length from base to apex; bounded distally by the straight vein Sc, from which a less distinct branch comes off within the area; slight signs of a series of oblique costal veinlets towards the base. Sc, R and its branches consisting of very thick veins; M and Cu only moderate. Primary branches of R seven, excluding the forked end of the main stem; the first four straight, simple veins, the fifth forked near its base, the sixth forked further distad, the seventh only partly preserved. So far as preserved, M shows four branches, Cu six. No signs of intercalated veins or cross-veins. Anal area well defined, with strongly marked *vena dividens*, and anal veins unbranched. What is probably the first anal vein is only just indicated by a slight impression near the top of the area; then follow two widely spaced veins, corresponding exactly with the second and third anal veins of *S. reticulata*, n.sp.; below these are about six more veins, closer together, and not quite so irregularly curved as in *S. reticulata.*



Text-fig.37.

Samaroblatta blabelloïdes, n.g. et sp. (×7½). Left tegmen. Upper Trias of Ipswich, Q. Drawn from Specimen No.131*b*.

Type, Specimen No. 131*b*. (Coll. Queensland Geological Survey).

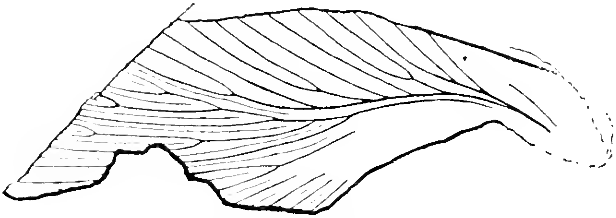
Horizon: Upper Triassic, Ipswich, Q.

In spite of the difference in the structure of the veins in the region of Sc and R, and the absence of intercalated veins and cross-veins, this species would appear to be closely allied to *S. reticulata.* As far as it is preserved, the branching of R is closely similar in the two species, while the arrangement of the anal veins shows also a very close parallelism.

The specific name has been given on account of the thickened veins in the anterior region of the tegmen, reminding one of the similar condition in the well known genus of recent cockroaches, *Blabella* Caudell (= *Phyllodromia* Serville, preoccupied), of which the common *B. germanica* (Linn.) is the genotype. A similar condition also exists in the very fragmentary Mesozoic fossil *Pachyneuroblattina rigida* Handl. (**1**, p.433), in which also the primary branches of R, as far as preserved, exactly correspond with those of our new species. It seems a pity that Handlirsch should have founded a new genus on such a fragmentary type as this, especially as the thickening of the veins may not really be of generic value at all, any more than it is in *Samaroblatta*. Until a more complete specimen is found, it would not be possible to decide the amount of relationship between *Pachyneuroblattina* and *Samaroblatta*.

SAMAROBLATTA INTERCALATA, n.sp. (Text-fig.38).

Greatest length of fragment, 10 mm.; *greatest breadth*, 3·3 mm. A fragment of a left tegmen of probably about the average size of those already described in this genus.



Text-fig.38.

Samaroblatta intercalata, n.sp. (×$7\frac{1}{2}$). Left tegmen. Upper Trias of Ipswich, Q. Drawn from Specimen No.262.

The anal area is missing, and the costal area not clearly preserved, except for a small portion of the costal border. The double-curving of R is strong, and is the one definite character that allows of the species being placed in the genus *Samaroblatta*. The limits of Sc and R basally are not clear; what appears to be the first primary branch of R is itself three-branched, a very unusual condition for *Samaroblatta*. The next branch of R is forked, then follow in order two simple branches, a forked branch, another simple branch and a final branch making a very definite fork with the main stem; thus there are seven primary branches of R in all, as far as preserved. The veins below R appear at first sight to be very well preserved, but it is not possible to determine the more basal portions of M and Cu with certainty. Intercalated veins are quite absent in the region of R, but are present between every pair of veins in the regions of M and Cu, and are very clearly marked. This character has suggested the specific name.

Type, Specimen No. 262. (Coll. Queensland Geological Survey).

Horizon: Upper Triassic, Ipswich, Q.

Genus AUSTROBLATTULA, n.g. (Text-fig.39).

Small tegmina (less than 10 mm. long), with the humeral area, if anything, slightly longer from base to apex than is the anal area. Sc apparently fused with R basally, and consisting of a single, straight vein bordering the humeral area distally. R bent near base, then almost straight for most of its length, curving slightly upwards towards the apex. Anal area somewhat cultriform, more than usually broad; the anal veins apparently unforked (indistinctly preserved).

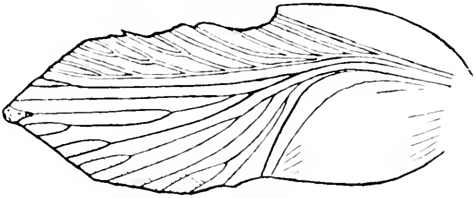
Genotype, *Austroblattula ipsviciensis*, n.sp. (Upper Trias of Ipswich, Q).

This genus comes fairly close to *Mesoblattina* Geinitz, from the Lias of Dobbertin, Mecklenburg, but may be distinguished from it by its larger humeral area, not crossed by any branch of Sc, by its broader anal area, and by the absence of intercalated veins. From *Mesoblattula* Handl., another genus of small cockroaches from the same beds, it can be at once separated by the absence of the strong double-curving of R, as well as by its larger humeral and anal areas, and by the absence of intercalated veins. It agrees with *Triassoblatta* in lacking this strong double-curving of R, but differs from that genus in its much larger humeral area (in comparison with its size), its strongly reduced Sc, its much more strongly curved *vena dividens*, and its much smaller size. The differences between it and *Samaroblatta*, apart from its size, are indicated in the generic key already given.

AUSTROBLATTULA IPSVICIENSIS, n.sp. (Text fig.38).

A small left tegmen with the whole of the basal portion preserved, but parts of the anterior, apical, and posterior margins missing.

Greatest length of fragment, 7·5 mm., indicating a tegmen of total length about 9 mm. *Greatest breadth*, 3·3 mm.



Text-fig.39.
Austroblattula ipsviciensis, n.g. et sp. (×7½). Left tegmen. Upper Trias of Ipswich, Q. Drawn from Specimen No.105*a*.

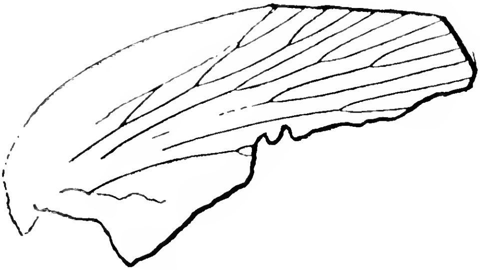
Humeral area of moderate width, without veins or markings of any kind. Sc a straight, simple vein, bounding the humeral area distally. Main stem of R giving off eight primary branches, exclusive of its apical continuation; of these the first two are simple veins, the third forked near its base, the fourth simple, the fifth forked, the sixth three-branched, the seventh and eighth simple (as far as preserved). Sc, R and its branches are formed of strong, thick veins, as in *Samaroblatta blabelloïdes*, n.sp.; M and Cu are only moderately strong veins, each of which gives off seven branches to the wing-border. *Vena dividens* very strongly arched; the first anal vein complete, simple, ending on the posterior border just below the apex of the area; the other anal veins only partially indicated towards their bases and apices.

Type, Specimens No. 105*a*, 105*b* (part and counterpart). (Coll. Queensland Geological Survey).

Horizon: Upper Triassic, Ipswich, Q.

BLATTOIDEA INCERTÆ SEDIS.

Specimen No.152 (Text-fig.40). A fragment of a cockroach tegmen, about 8 mm. long, and showing very clearly a number of branching veins, and apparently also the outline of the costal border of the humeral area above them. If the most anterior of the preserved veins be Sc, as appears very likely, then this fossil must belong to a more archaic group than the *Mesoblattinidæ*, seeing that Sc appears to have retained its primitive branched condition and has remained of considerable length. The affinities of this specimen are quite uncertain, and it does not seem to me to be complete enough to merit a name.



Text-fig.40.
Specimen No.152 (× 7½).

Specimens No.121a, 121b (part and counterpart). These represent fragments of a cockroach tegmen, very indistinctly preserved, and not well enough characterised to merit a name. The basal half or more of the tegmen is shown, with most of the anal area. The venation is indistinct, except for Sc and some of the branches of R, which appear to be thick, strongly formed veins. Length, 6 mm.; greatest breadth, 3 mm.

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REVISION OF AUSTRALIAN LEPIDOPTERA, vi.*

By A. Jefferis Turner, M.D., F.E.S.

Gen. 70. Synzeuxis, nov.

συνζευξις, a connection.

Face smooth, not projecting. Tongue well-developed. Palpi rather short, porrect, much thickened with rough scales beneath; terminal joint short. Antennæ in ♀ dentate (in ♂ unknown, but probably bipectinate to apex). Thorax with a small, rounded, anterior crest; beneath slightly hairy. Forewings with 10 and 11 arising separately from cell, 10 connected with 9. Hindwings normal.

An interesting link having the neuration of *Chlenias*, but in all other respects resembling *Amelora*.

224. Synzeuxis penthina, n.sp.

πενθινος, mournful.

♀. 40 mm. Head and thorax fuscous. Palpi $1\frac{1}{4}$; fuscous. Antennæ ochreous-whitish. Abdomen ochreous-whitish, with some fuscous irroration. Legs fuscous; tarsi with ochreous-whitish annulations; posterior pair ochreous-whitish annulated with fuscous. Forewings broadly triangular, costa moderately arched, apex round-pointed, termen bowed, oblique, crenulate; brown-whitish, closely strigulated with grey, with scattered ochreous-whitish and dark fuscous scales; an ochreous-whitish mark on costa at $\frac{4}{5}$; from this proceeds a faintly darker dentate line, irrorated with ochreous-whitish, to $\frac{4}{5}$ dorsum; cilia fuscous with whitish apices. Hindwings with termen rounded, crenulate; ochreous-whitish, irrorated with grey; a grey discal dot; cilia grey. Underside similar. Type in Coll. Lyell.

N.S.W.: Hornsby, near Sydney, in April; one specimen.

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* Continued from page 310.

Gen. 71. PAUROCOMA.

Paurocoma, Low., Tr. R.S.S.A., 1902, p.230.

Frons with strong, rounded, anterior protuberance. Tongue present. Palpi moderate, porrect; second joint roughly hairy; terminal joint minute Antennæ of ♂ thickened, slightly dentate, minutely ciliated. Forewings of ♂ without fovea; 10 and 11 arising separately from cell, 10 anastomosing strongly with 11 and then approximated to 9 (perhaps sometimes anastomosing), 12 free. Hindwings normal.

Perhaps allied to the *Amelora* group, but its exact affinities are not clear.

225. PAUROCOMA MOLYBDINA.

Paurocoma molybdina, Low., Tr. R.S.S.A., 1902, p.230.

N.S.W.: Broken Hill.

Gen. 72. ENCRYPHODES, nov.

ἐγκρυφωδης, hidden.

Frons flat. Tongue well-developed. Palpi short, porrect; second joint thickened with rough scales beneath; terminal joint minute. Antennæ of ♂ laminate, shortly ciliated. Thorax not crested(?); beneath slightly hairy. Femora not hairy. Posterior tibiæ of ♂ not dilated. Forewings with 10 and 11 arising separately from cell and strongly anastomosing, 10 sometimes anastomosing with 9; in ♂ without fovea. Hindwings normal. Closely allied to *Paurocoma*, which differs in the strongly projecting frons.

Type, *E. melanochorda*.

226. ENCRYPHODES MELANOCHORDA, n.sp.

μελανοχορδος, with black strings.

♂. 30 mm. Head fuscous. Palpi 1¼; fuscous. Antennæ in ♂ shortly laminate, ciliations ¼; fuscous. Thorax fuscous. Abdomen fuscous-whitish. Legs fuscous-whitish ; anterior and middle tarsi fuscous. Forewings triangular, costa gently arched, apex acute, termen bowed, oblique; pale fuscous; with two oblique, slightly dentate, blackish lines; first from ⅓ dorsum towards but not reaching mid-costa: second from ⅔ dorsum to costa before apex; cilia fuscous-whitish. Hindwings with termen gently rounded; as forewings, but without first line; a minute discal dot; second line transverse at $\frac{2}{3}$. Underside similar, but without first line of forewings. Type in Coll. Lyell.

Tas.: Hobart, in April; one specimen.

227. ENCRYPHODES SYSCIA, n.sp.

συσκιος, shaded.

♂. 28 mm. Head and thorax brown-whitish. Palpi 1; brown-whitish. Antennæ whitish; in ♂ shortly laminate, ciliations $\frac{1}{2}$. Abdomen whitish. Legs pale fuscous; posterior pair whitish. Forewings triangular, costa gently arched, apex pointed, termen bowed, oblique; brown-whitish with a few fuscous scales; a broad fuscous shade below cell; a fuscous discal dot below mid-costa, succeeded and followed by a fuscous shade, the latter giving off a fine line to costa before apex; a terminal series of blackish dots; cilia brown-whitish. Hindwings with termen rounded; whitish, with a few grey scales; some fuscous dots on termen; cilia whitish. Underside of forewings pale fuscous; of hindwings like upper side, but with a blackish discal dot. Type in Coll. Lyell.

N.S.W.: Moruya, in June; one specimen.

Gen. 73. EPICOMPSA.

Epicompsa, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.585.

Face smooth. Tongue developed. Palpi moderate, porrect, slender, shortly rough-scaled, terminal joint short. Antennæ in ♂ bipectinate, towards apex simple. Thorax smooth; beneath nearly glabrous. Femora glabrous; posterior tibiæ in ♂ not dilated. Forewings in ♂ without fovea; veins 10 and 11 separate. Hindwings normal.

This genus is unknown to me, and I have copied Mr. Meyrick's description.

228. †EPICOMPSA XANTHOCROSSA.

Epicompsa xanthocrossa, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.585.

S.A.: Mt. Lofty.

Gen. 74. THALAINODES.

Thalainodes, Low., Tr. R.S.S.A., 1902, p.231.

Frons with a broad, flattened, corneous process. Tongue well-developed. Palpi moderate, porrect, second joint shortly rough-haired beneath; terminal joint short, obtuse. Antennæ of ♂ shortly bipectinated to apex. Thorax and abdomen not crested; thorax hairy beneath. Femora glabrous. Posterior tibiæ in ♂ slightly dilated. Forewings in ♂ without fovea; 10 out of 9, 11 anastomosing with 12. Hindwings with cell rather long ($\frac{3}{5}$), otherwise normal.

Allied to *Thalaina*, differing in the frontal process and the pectinated antennæ of ♂.

Type, *T. tetraclada* Low.

This genus appears to be confined to the dry country of the interior. I have not seen either *tetraclada* Low., or *paronycha* Low., but both are so clearly closely allied to the new species *nessostoma* that I have no hesitation in including them.

1\. Forewings silvery-white, with ochreous or fuscous lines ...... 2.
Forewings grey, without markings .... *allochroa*.
2\. Forewings with a median bifurcating line . . .. 3.
Forewings without a median bifurcating line .... *tetraclada*.
3\. Forewings with bifurcating line arising from base of costa... *nessostoma*.
Forewings with bifurcating line arising from costa at $\frac{1}{3}$ ...... *paronycha*.

229. †THALAINODES TETRACLADA.

Amelora tetraclada, Low., Proc. Linn. Soc. N. S. Wales, 1900, p.406.

N.S.W.: Broken Hill.

230. †THALAINODES PARONYCHA.

Amelora paronycha, Low., Proc. Linn. Soc. N. S. Wales, 1900, p.407.

N.S.W.: Broken Hill.

231. THALAINODES NESSOSTOMA, n.sp.

νησσοστομος, duck-billed.

♀. 42 mm. Head orange-ochreous; face with a long, plate-like, corneous process, bent downwards at the edges and rounded at the end, of the shape of the upper half of a duck's bill. Palpi white. Antennæ grey-whitish. Thorax orange-ochreous; lateral parts and edges of patagia white. Abdomen whitish-ochreous. Legs whitish; anterior pair except coxæ pale fuscous. Forewings triangular, costa nearly straight, apex rectangular, termen bowed, oblique; silvery white, with thick orange-ochreous lines; a line on costa from middle to apex; a line from base of costa through disc, bifurcating at $\frac{1}{4}$; the two limbs diverging and ending on termen above and below middle; a line along dorsum from base to apex; cilia orange-ochreous. Hindwings with termen rounded, wavy; white; a broad, dark fuscous band close to termen, leaving termen narrowly white, its posterior margin dentate; cilia white. Type in Coll. Goldfinch.

N.S.W.: Bourke; one specimen from the collection of the late Mr. Helms, without locality label, but probably taken at this locality.

232. THALAINODES ALLOCHROA.

Thalainodes allochroa, Low., Tr. R.S.S.A., 1902, p.232.

Corneal process thick, truncate, square-ended, beneath it a much less prominent but wider corneal ridge. ♂.36 mm. Antennal pectinations $2\frac{1}{2}$.

N.S.W.: Broken Hill, Bourke; two examples, ♂,♀, from the same source as the preceding and also without locality labels.

Gen. 75. THALAINA.

Thalaina, Wlk., Cat. Brit. Mus., iii., p.659; Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.652.

Face smooth, rounded, slightly projecting. Tongue well-developed. Palpi short, porrect, rough-haired; terminal joint very short Antennæ of ♂ shortly laminate, minutely ciliated. Thorax not crested; beneath hairy. Femora smooth; posterior tibiæ of ♂ somewhat dilated. Forewing in ♂ without fovea: 7, 8, 9, 10 stalked from before angle of cell, 11 from cell anastomosing or connected with 12, and sometimes also with 10. Hindwings normal.

233. THALAINA SELENÆA.

Callimorpha selenæa, Dbld., Eyre's Disc. Austr., i., p.437, Pl. v., f.3. *Absyrtes magnificaria*, Chen., Hist. Nat. Pap., p.5; Gn., Lep., x., p.226. *Thalaina klenæa*, Wlk., Cat. Brit. Mus., iii., p.660. *Thalaina australiaria*, H.-Sch., Exot. Lep., p. 333. *Thalaina punctilinea*, Wlk., Cat. Brit. Mus., xxxi., p.288.

Mr. Lyell assures me that he has bred both forms of this species from the same batch of larvæ. *Punctilinea* differs only in the absence of the fascia on forewings; there are no intermediates, and the difference is not sexual.

Q: Mt. Tambourine —N.S.W.: Sydney.—Vic.: Melbourne, Oakleigh, Gisborne.—Tas.: ——.

234. THALAINA CLARA.

Thalaina clara, Wlk., Cat Brit. Mus., iii., p.660; Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.654.

Q.: Blackbutt.—N.S.W.: Sydney, Bathurst.—Vic.: Melbourne, Gisborne.

235. THALAINA ANGULOSA.

Thalaina angulosa, Wlk., Cat. Brit. Mus , xxxi., p.289; Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.655.

Vic.: Birchip.—S.A.: Adelaide.

236. THALAINA INSCRIPTA.

Thalaina inscripta, Wlk., Cat. Brit. Mus., iii., p.661. *Thalaina principaria*, H.-Sch., Lep. Exot., p.446; Gn., Lep., x., p.227.

N.S.W.: Bathurst.—Vic.: Melbourne, Gisborne.—Tas.: ——.

Gen. 76. MNESAMPELA.

Mnesampela, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.656.

Face with a more or less developed conical protuberance clothed with short, projecting scales. Tongue well-developed. Palpi moderate, porrect, densely rough-scaled; terminal joint very short. Antennæ of ♂ shortly bipectinate, or simple. Thorax not crested; beneath hairy. Femora hairy; posterior tibiæ of ♂ dilated. Forewings in ♂ without fovea; 7, 8, 9, 10 stalked, 11 from cell, free. Hindwings normal.

237. †MNESAMPELA COMARCHA.

Mnesampela comarcha, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.656.

Vic.: Melbourne, Warragul.

238. MNESAMPELA LENÆA.

Mnesampela lenæa, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.657.

N.S.W.: Sydney, Bathurst, Mt. Kosciusko (5,000 ft.).—Vic.: Beaconsfield, Gisborne.—Tas.: Launceston.—S.A.: Mt. Lofty.

239. MNESAMPELA PRIVATA.

Idiodes privata, Gn., Lep., ix., p.41, Pl. xiv., f.4; *Mnesampela privata*, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.658.

N.S.W.: Sydney.—Vic.: Melbourne. S.A.: Mt. Lofty.—W.A.: Perth, Bridgetown.

240. MNESAMPELA FUCATA.

Chlenias fucata, Feld., Reise Nov., Pl.121, f.11. *Mnesampela fucata*, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.658.

N.S.W.: Sydney.—Vic.: Melbourne.—Tas.: Zeehan.—S.A.: Mt. Lofty.

Gen. 77. FISERA.

Fisera, Wlk., Cat. Brit. Mus., xxi., p.291. *Criomacha*, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.659.

Face with strong, truncate or flattened and acute conical projection, shortly rough-scaled. Tongue well-developed. Palpi moderate or rather long, subascending, densely rough-haired; terminal joint short or moderate, obtuse. Antennæ in ♂ bipectinate to apex. Thorax with a central keel-like crest; beneath densely hairy. Femora hairy; anterior tibiæ with an anterior, apical, corneous hook; posterior tibiæ in ♂ not dilated. Forewings in ♂ without fovea; 7, 8, 9, 10 stalked, 11 from cell, usually connected with 12, sometimes free.

Type, *F. perplexata* Wlk.

1. Hindwings whitish at base .... 2.
   Hindwings not whitish at base .... 3.
2. Forewings grey-whitish .... *phricotypa.*
   Forewings purple-fuscous .... *dictyodes.*
3. Both wings purplish-tinged .... *halurga.*
   Wings without purple tinge .... 4.
4. Hindwings reddish-ochreous .... *bradymorpha.*
   Hindwings not reddish-ochreous .... *perplexata.*

241. FISERA PERPLEXATA.

Fisera perplexata, Wlk., Cat. Brit. Mus., xxi., p.292. *Chlenias belidearia*, Feld., Reise Nov., Pl.124, f.9. *Criomacha belidearia*, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.659.

Palpi $1\frac{1}{2}$, terminal joint $\frac{1}{4}$ second. Antennal pectinations of ♂ 5. Forewings with 11 connected (1♂) or anastomosing (2♂) with 12.

Vic.: Melbourne, Gisborne, Birchip, Brentwood.—Tas.: ——.—S.A.: Mt. Lofty.

242. FISERA HALURGA, n.sp.

ἁλουργος, purple.

♂. 50 mm. Head purple-grey; face with a strong conical projection ending in a flattened corneous ridge. Palpi 2; terminal joint $\frac{1}{2}$ second; purple-grey. Antennæ purple-grey: pectinations of ♂ 5. Thorax purple-grey. Abdomen pale grey. Legs whitish with purple-grey irroration: anterior pair purple-grey. Forewings elongate-triangular, costa nearly straight, (apex broken), termen bowed, oblique; purple-grey with a few fuscous scales; cilia purple-grey. Hindwings with termen rounded: purple-fuscous, becoming paler towards base; cilia purple-fuscous, on tornus and dorsum whitish. Underside paler, hindwings whitish with defined, fuscous, terminal band.

Q.: Gayndah, in May; one specimen received from Dr. Hamilton Kenny.

243 FISERA DICTYODES.

Mnesampela(?) dictyodes, Low., Tr. R.S.S.A., 1893, p.291.

This is a very distinct species certainly referable here. In the only specimen I have examined (♀) vein 11 is free.

244. FISERA PHRICOTYPA, n.sp.

φρικοτυπος, ripple-marked.

♂♀. 40-43 mm. Head and thorax ochreous-grey-whitish. Palpi ochreous grey-whitish with a few, dark, fuscous scales. Antennæ ochreous-whitish, pectinations in ♂ 6. Abdomen ochreous-whitish. Legs ochreous-whitish: tibiæ and tarsi densely irrorated with fuscous. Forewings triangular, costa gently arched, apex rectangular, termen bowed, scarcely oblique: 11 anastomosing with 12 (one ♂, one ♀) or free (one ♂): ochreous-grey-whitish, with some dark fuscous irroration; a dark fuscous discal dot beyond middle, sometimes obsolete; a dark fuscous line from beneath costa near apex to $\frac{2}{3}$ dorsum, more or less developed, sometimes strongly dentate; cilia ochreous-grey-whitish. Hindwings broad, termen rounded; whitish, suffused with fuscous towards termen; cilia fuscous, apices whitish, on dorsum whitish. Type in Coll. Lyell.

Vic.: Birchip and Brentwood, in April; three specimens.

245. Fisera bradymorpha, n.sp.

βραδύμορφος, heavily made.

♂♀ 48-50 mm. Head, palpi, and thorax greyish-ochreous. Antennæ greyish-ochreous; pectinations in ♂ 3. Abdomen and legs whitish-ochreous. Forewings elongate-oblong, posteriorly dilated, costa strongly arched, apex acute, slightly produced, termen bowed, sinuate beneath apex, scarcely oblique; 11 connected by a bar with 12; pale greyish-ochreous with some minute pale fuscous strigulæ; a fuscous dot on median vein at $\frac{1}{5}$, and another on internal vein beneath this; a faint discal dot: a sinuate line of fuscous dots on veins at $\frac{3}{4}$; in ♀ all these dots are obsolete; cilia greyish-ochreous. Hindwings with termen rounded, sinuate; pale reddish-ochreous, becoming whitish-ochreous at base; a line of dark fuscous dots on veins at $\frac{3}{4}$; cilia pale reddish-ochreous, apices whitish. Underside similar, but forewings without markings; hindwings with a large, median, subterminal, fuscous blotch with narrower extensions towards costa and dorsum. Type in Coll. Wyld.

N.S.W.: Sydney, in April and May; four specimens received from Mr. G. H. Wyld.

Gen. 78. Stathmorrhopa.

Stathmorrhopa, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.659.

Face with an obtuse, rounded, conical projection, shortly rough-scaled. Tongue well-developed. Palpi moderate, porrect, densely rough-haired; terminal joint moderate, obtuse. Antennæ of ♂ bipectinate to apex. Thorax with sharp central crest; beneath densely hairy. Femora hairy; posterior tibiæ in ♂ not dilated. Forewings in ♂ without fovea; 7, 8, 9, 10 stalked, 11 from cell, anastomosing first with 12 and then with 10.

Closely allied to ***Fisera***. Type, *S. beggaria* Gn.

1. Forewings oblong .... *beggaria*.
   Forewings triangular .... 2.
2. Hindwings ochreous .... *hypsilopha*.
   Hindwings fuscous .... *hypoleuca*.

246. STATHMORRHOPA BEGGARIA.

Chlenias beggaria, Gn., Lep., x., p.238, Pl. xiv., f.2. ?*Chlenias porphyrinaria*, Gn., Lep., x., p.237. *Stathmorrhopa beggaria*, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.660.

N.S.W.: Sydney.—Vic.: Warragul, Beaconsfield, Gisborne.—Tas.: Hobart.—S.A.: Mt. Lofty.

247. STATHMORRHOPA HYPSILOPHA, n.sp.

ὑψιλοφος, high-crested.

♂. 48 mm. Head pale ochreous-brown; face with strong rounded prominence. Palpi pale ochreous-brown, towards base whitish. Antennæ pale ochreous-brown; pectinations in ♂ 2. Thorax pale ochreous-brown; with a high, narrow, keel-like, median crest. Abdomen whitish-ochreous. Legs ochreous-whitish; anterior pair pale ochreous-brown. Forewings elongate-triangular, costa rather strongly arched, apex pointed, slightly produced, termen bowed, scarcely oblique; pale ochreous-brown, with a few pale fuscous strigulæ; cilia brown, apices whitish. Hindwings with termen rounded, slightly wavy; ochreous; postmedian line represented by two or three minute fuscous dots on veins; cilia ochreous, apices whitish-ochreous. Underside pale brownish; hindwings with a large, dark fuscous, postmedian blotch, not reaching margins, and a few fuscous strigulæ near apex.

This and the following species have the forewings proportionately broader and more triangular than in *S. beggaria*. Type in Coll. Lyell.

N.S.W.: Hornsby, near Sydney, in March; one specimen.

248. STATHMORRHOPA HYPOLEUCA, n.sp.

ὑπολευκος, white beneath.

♂. 48-52 mm. Head reddish-brown; face with a rounded prominence excavated at apex into a shallow cavity filled with pale ochreous and rimmed with dark fuscous. Palpi brown. Antennæ pale grey; pectinations in ♂ 6. Thorax reddish-brown; with a narrow median crest. (Abdomen broken). Legs fuscous; posterior femora and tibiæ, and outer surface of middle tibiæ whitish. Forewings elongate-triangular, costa arched towards base, thence straight, apex round-pointed, termen bowed, oblique; pale reddish-brown with sparsely scattered fuscous strigulæ; a small, round, pale fuscous, median, discal spot; a faintly marked or obsolete line of fuscous strigulæ from $\frac{2}{3}$ dorsum obliquely outwards; cilia brown. Hindwings with termen slightly rounded, slightly wavy; fuscous; base white over a restricted area, or to beyond middle; cilia fuscous, apices white. Underside white, with broad, suffused, fuscous, terminal band on each wing. Type in Coll. Lyell.

Vic.: Gisborne, in April and May (Lyell); Birchip, in April (Goudie): three specimens.

Gen. 79. NYCTEREPHES.

Nycterephes, Turn., Tr. R.S.S.A., 1906, p 135.

Face with strong rounded prominence, smooth-scaled. Tongue well-developed. Palpi moderate, porrect, densely rough-scaled; terminal joint very short Antennæ of ♂ bipectinate nearly to apex. Thorax with a posterior crest; beneath hairy. Abdomen not crested. Femora smooth. Forewings in ♂ without fovea; 10 and 11 long stalked, their stalk connected by a bar with 12, 10 anastomosing with 9. Hindwings with 6 and 7 connate or approximated at base; otherwise normal.

Type, *N. coracopa* Turn. The neuration of the forewings as originally given is, I think, incorrect: that now given is taken from a second ♀ example. Probably it is related to *Smyriodes*.

249. NYCTEREPHES CORACOPA.

Nycterephes coracopa, Turn., Tr. R.S.S.A., 1906, p.136.

Antennæ in ♂ with apical $\frac{1}{10}$ simple.

W.A.: Bridgetown, Beverley.

Gen. 80. SMYRIODES.

Smyriodes, Gn., Lep., ix., p.223: Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.666.

Face not projecting, shortly rough-haired. Tongue well-developed. Palpi moderate, porrect, densely rough-haired; terminal joint moderate, obtuse. Antennæ in both sexes bipectinate to apex. Thorax with rounded anterior and bifid posterior crests; beneath densely hairy. Femora densely hairy. Forewings in ♂ without fovea; 10 and 11 long-stalked, their stalk connected by a bar with 12, 10 connected with 9. Hindwings normal.

A development of the *Chlenias* stem important as illustrating its relationship to *Amelora*. With the latter it agrees in neuration, differing in stouter build, general hairiness, posterior thoracic crest, and other details.

Type, *S. aplectaria* Gn.

250. SMYRIODES APLECTARIA.

Smyriodes aplectaria, Gn., Lep., ix., p.223, Pl. xx., f 1: Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.667. *Nisista notodontaria*, Wlk., Cat. Brit. Mus., xxi., p.294. *Vunga delineata*, Wlk., Cat. Brit. Mus., xxxii., p 453.

Antennal pectinations in ♂ 8, in ♀ 2½.

N.S.W.: Sydney.—Vic.: Melbourne.—Tas.: ——.—S.A.: Mt. Lofty.

251. †SMYRIODES CARBURARIA.

Chlenias carburaria, Gn., Lep., x., p.238. *Smyriodes carburaria*, Low., Tr. R.S.S.A., p.164.

S.A.: Mt. Lofty.

Gen. 81. SYMMIGES, nov.

συμμιγης, mixed up with, confused.

Frons flat. Tongue well-developed. Palpi moderate, porrect. Antennæ of ♂ pectinated to apex. Thorax with a triangular anterior crest; beneath densely hairy. Femora hairy. Forewings of ♂ without fovea; 10 and 11 rising from cell by a long common stalk, not anastomosing. Hindwings normal.

A development of *Chlenias*, differing only in the stalking of veins 10 and 11. From *Smyriodes* it differs by these veins being without anastomoses, and by the absence of a posterior thoracic crest.

252. SYMMIGES GALEARIA.

Chlenias galearia, Gn., Lep., x., p.238. *Smyriodes aphronesa*, Low., Tr. R.S.S.A., 1902, p.250.

Vic.: Melbourne, Birchip.

Gen. 82. GASTRINA.

Gastrina, Gn., Lep., ix., p.224: Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.667.

Face with slightly projecting scales. Tongue developed. Palpi moderate, subascending, rough-sealed; terminal joint short. Antennæ in ♂ bipectinate, apex simple. Thorax with posterior crest, densely hairy beneath. Abdomen with strong dorsal crests. Femora glabrous; posterior tibiæ in ♂ strongly dilated, containing tuft, outer apical spur very short, thick. Forewings in ♂ without fovea; 10 out of 9, connected again with 9. Hindwings normal.

I have taken this description from Mr. Meyrick, as I have no specimen before me, though I have seen one.

253. GASTRINA CRISTARIA.

Gastrina cristaria, Gn., Lep., ix., p.224, Pl.5, f.4; Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.668. *Praxis illapsa*, Wlk., Cat. Brit. Mus., xiii., p.1088. *Hypochroma velutinata*, Wlk., Cat. Brit. Mus., xxi., p.442. *Passa latifasciata*, Wlk., Cat. Brit Mus., xxxv., p.1563.

N.S.W.: Sydney.—Vic.: Gisborne.—Tas : ——.

Gen. 83. MICTODOCA.

Mictodoca, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.661.

Face shortly rough-haired, not tufted. Tongue well-developed. Palpi very long, porrect, with long dense hairs above and beneath; terminal joint moderate, partly concealed. Antennæ in ♂ bipectinate to apex. Thorax with a bifid posterior crest; beneath hairy. Femora hairy; posterior tibiæ in ♂ not dilated. Forewings in ♂ without fovea; 10 and 11 arising separately from cell, 10 anastomosing first with 11 and then with 9. Hindwings with cell rather long, otherwise normal.

Nearly related to *Conosara*.

254. MICTODOCA TOXEUTA.

Mictodoca toxeuta, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.661.

Palpi 1. Forewings with neuration as given, without variation (4 examples).

N.S.W.: Newcastle, Sydney, in April and May.—Tas.: Kelso.

Gen. 84. CONOSARA.

Conosara, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.660.

Face with projecting cone of scales. Tongue well-developed. Palpi long, porrect, densely rough-haired; terminal joint moderately long, smooth. Antennæ of ♂ bipectinate to apex. Thorax with a posterior crest; beneath hairy. Femora smooth; posterior tibiæ of ♂ moderately dilated, with internal groove and tuft. Forewings in ♂ without fovea; 10 and 11 arising separately from cell and free, or rarely 10 out of 9 near base (Meyrick). Hindwings normal.

Probably allied to *Chlenias*.

255. CONOSARA CASTANEATA.

Conosara castaneata, Meyr., Proc. Linn. Soc. N.S. Wales, 1891, p.660.

Palpi 4; second joint very long, densely rough-haired above and beneath; terminal joint $\frac{1}{4}$, tolerably acute. Forewings with 10 and 11 arising separately from cell and free (2♂).

Tas.: Hobart.

256. CONOSARA PAMMICTA, n.sp.

παμμικτος, all-blended.

♂. 34 mm. Head dark fuscous. Palpi 2, terminal joint $\frac{1}{2}$, obtuse; dark fuscous. Antennæ dark grey; pectinations in ♂ 3. Thorax dark fuscous. Abdomen grey. Legs dark fuscous; tibiæ and tarsi annulated with whitish; posterior pair mostly whitish. Forewings triangular, costa gently arched, apex round-pointed, termen bowed, oblique; 10 and 11 arising separately from cell, 10 connected by a bar with 9 (1♂); pale brown, closely strigulated with dark fuscous, in places irrorated with whitish; markings dark fuscous: dentate transverse lines at $\frac{1}{4}$ and middle, preceded and followed by some whitish irroration; a discal spot closely following median line, a dentate sinuate postmedian line approximated on dorsum to median line, its posterior edge irrorated with whitish; an imperfect, dentate, whitish, subterminal line, anteriorly partly edged with dark fuscous; a terminal series of dots: cilia fuscous, barred with dark fuscous and partly irrorated with whitish. Hindwings with termen rounded, slightly wavy; grey, towards costa whitish; two fuscous dentate lines from middle and $\frac{3}{4}$ of dorsum; cilia whitish, barred with fuscous. Underside fuscous; hindwings with darker discal dot and antemedian and postmedian lines. Type in Coll. Lyell.

N.S.W.: Wentworth Falls, near Katoomba, in April; one specimen.

Gen. 85. HARPAGOCNEMA.

Harpagocnema, Turn., Tr. R.S.S.A., 1915, p.802.

Face with strong rounded prominence, shortly rough-scaled. Tongue well-developed. Palpi moderately long, porrect, rough-scaled beneath; terminal joint moderate, obtuse. Antennæ of ♂ bipectinate, extreme apex simple. Thorax with an acute anterior crest; beneath hairy. Femora smooth; anterior tibiæ with two, stout, horny, apical hooks, the inner longer: posterior tibiæ of ♂ not dilated. Forewings of ♂ without fovea; 10 and 11 long-stalked, free. Hindwings much broader than forewings; cell long ($\frac{2}{3}$); otherwise normal.

Allied to *Capusa* and *Chlenias*, differing from the former in the stalking of veins 10 and 11 and from the latter in the hooked anterior tibiæ.

257. HARPAGOCNEMA EREMOPLANA.

Harpagocnema eremoplana, Turn., Tr. R.S.S.A., 1915, p.802.

S.A.: Musgrave and Everard Ranges.

Gen. 86. CAPUSA.

Capusa, Wlk., Cat. Brit. Mus., xi., p.620.

Frons flat. Tongue well-developed. Palpi moderate, porrect; second joint rough-scaled; terminal joint short. Antennæ of ♂ simple or dentate. Thorax with a rounded anterior crest; beneath hairy. Femora smooth; anterior tibiæ with a strong, curved, apical hook; posterior tibiæ in ♂ dilated. Forewings long and narrow; in ♂ without fovea; 10 and 11 from cell, not anastomosing. Hindwings broader than forewings; cell long ($\frac{2}{3}$); otherwise normal.

Allied to *Chlenias*, but differs in vein 10 not being connected with 9, in the non-pectinate antennæ, differently shaped thoracic crest, and in the apical hook of anterior tibiæ.

Type, *C. senilis* Wlk.

258. CAPUSA SENILIS.

Capusa senilis, Wlk., Cat. Brit. Mus., xi., p.621. *Teinocladia cucculloides*, Feld., Reise Nov., Pl.96, f.9.

♂♀. 43-62 mm. Head, palpi, and thorax grey. Antennæ grey; in ♂ simple, with minute ciliations. Abdomen grey-whitish. Legs white irrorated with grey; tarsi and anterior tibiæ grey; tibial hook from inner side of apex ferruginous. Forewings narrow, elongate-triangular, costa straight to $\frac{2}{3}$, thence gently arched, apex rounded, termen oblique; dark grey with whitish irroration; a whitish suffusion in disc posteriorly with an anterior projection, usually well-marked, beneath cell; first and median lines obsolete; a roundish, fuscous, discal dot at $\frac{3}{5}$; a fine, fuscous, acutely dentate line traversing whitish area from costa at $\frac{3}{5}$ very obliquely outwards, then acutely angled on a long projecting tooth, and ending on $\frac{3}{4}$ dorsum; a very obscure whitish terminal line; cilia whitish, more or less mixed with grey. Hindwings twice as broad as forewings, termen somewhat wavy; white; a fuscous apical blotch; cilia white. Underside similar.

N.Q.: Kuranda, near Cairns, in June. Q.: Brisbane, in July, September, March, and May. Vic.: ——(?)

259. CAPUSA GRAODES, n.sp.

γραωδης, like an old woman.

♀. 44 mm. Head, palpi, and thorax grey with some fine whitish irroration. Antennæ grey. Abdomen dark grey. Legs grey, irrorated with whitish; tibial hook from inner side of apex, fuscous. Forewings narrow, elongate-triangular, costa straight to $\frac{2}{3}$, thence gently arched, apex rounded, termen oblique, rounded towards tornus; grey, uniformly irrorated with whitish:

markings dark grey; a suffused, outwardly-curved line from costa at $\frac{1}{4}$ to dorsum at $\frac{1}{3}$; a similar line from $\frac{2}{3}$ costa to mid dorsum; a subcostal discal spot beyond middle; a dentate line from $\frac{2}{3}$ costa acutely angled on a long projecting tooth and ending on $\frac{3}{4}$ dorsum; cilia whitish mixed with grey. Hindwings nearly twice as broad as forewings, termen slightly waved; whitish, towards termen suffused with grey; cilia whitish. Underside similar.

Very near the preceding; best distinguished by absence of apical blotch on hindwings.

Vic.: Birchip, in April; one specimen received from Mr. D. Goudie.

260. Capusa stenophara, n.sp.

στενοφαρος, narrow-cloaked.

♂. 50 mm. Head, palpi, and thorax grey. Antennæ grey; in ♂ dentate and moderately ciliated. Abdomen grey. Legs whitish, irrorated with grey; tibial hook from outer side of apex, fuscous. Forewings very narrow, elongate-triangular, costa gently arched, apex round-pointed, termen strongly oblique, subdentate; whitish-grey; a broad, grey, median area, sharply limited by an anterior line, preceded by a whitish suffusion, from $\frac{1}{3}$ costa to $\frac{1}{3}$ dorsum, and a finely dentate posterior line from $\frac{2}{3}$ costa obliquely outwards, sharply bent in disc and continued to $\frac{3}{4}$ dorsum; some fine blackish streaks on veins; cilia white mixed with grey. Hindwings broader than, but not twice as broad as forewings, termen slightly waved; pale grey; cilia whitish. Underside of forewings dark grey; of hindwings whitish, with some fuscous suffusion at apex. Type in Coll. Lyell.

Vic.: Gisborne, in June; one specimen.

Gen. 87. Ceratucha, nov.

κερατουχος, horned.

Frons with a horny process. Tongue developed. Palpi short or moderate, porrect; second joint rough-scaled. Antennæ in ♂ pectinated to apex, in ♀ serrate. Thorax with a triangular anterior crest; hairy beneath. Femora hairy. Forewings in ♂ without fovea; 10 from cell, connected with 9, 11 free. Hindwings normal.

Differs from *Chlenias* only by the horny frontal process, but this seems sufficient.

Type, *Chlenias arietaria* Gn.

261. CERATUCHA ARIETARIA

Chlenias arietaria, Gn., Lep., x., p.239: Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.663. *Chemerina cuneifera*, Wlk., Cat. Brit. Mus., xxiv., p.1155. *Ciampa defixella*, Wlk., Cat. Brit. Mus., xxvii., p.180. *Chlenias crambaria*, Feld., Reise Nov., Pl. 133, f.12.

N.S.W.: Newcastle, Sydney, Bathurst, Brewarrina.—Vic.: Melbourne, Castlemaine, Gisborne, Birchip.—S.A.: Adelaide.—W.A.: Perth.

262. CERATUCHA HETEROMORPHA.

Chlenias heteromorpha, Low., Tr. R.S.S.A., 1901, p.65.

N.S.W.: Broken Hill.—Vic.: Birchip.

Gen. 88. CHLENIAS.

Chlenias, Gn., Lep., x., p.236: Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.662.

Face rounded, sometimes projecting, smooth, or shortly rough-haired. Tongue well-developed. Palpi moderately long, porrect, densely rough-haired; terminal joint moderate, obtuse. Antennæ bipectinate to apex in both sexes, pectinations in ♀ short. Thorax with a triangular anterior crest; beneath densely hairy. Femora hairy; posterior tibiæ in ♂ not dilated. Forewings in ♂ without fovea, 10 and 11 arising separately from cell, 10 connected by a short bar with 9 or anastomosing. Hindwings with cell rather long, 8 closely approximated to cell beyond middle, otherwise normal.

Type, *C. banksiaria* Le Guil. Mr. Meyrick has so restricted Guenée's genus, though without indicating the type.

263. †CHLENIAS MELANOXYSTA.

Chlenias melanoxysta, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.663.

S.A.: Balaclava.

264. CHLENIAS UMBRATICARIA.

Chlenias umbraticaria, Gn., Lep., x., p.240; Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.664.

N.S.W.: Sydney.—Vic.: Melbourne.—S.A.: Mt. Lofty.—W.A.: Perth.

265. CHLENIAS BANKSIARIA.

Chlenias banksiaria, Le Guil., Rev. Zool., 1841, p.257; Gn., Lep., x., p.239; Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.664. *C. auctaria*, Gn., Lep., x., p.239, Pl.14, f.1. *C. indecisata*, Wlk., Cat. Brit. Mus., xxiv., p.1153.

N.S.W.: Sydney.—Vic.: Melbourne.—S.A.: Mt. Lofty.—W.A.: Perth.

266. CHLENIAS ZONÆA.

Chlenias zonæa, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.665.

N.S.W.: Sydney.—Vic.: Melbourne, Lorne.—Tas.: Launceston, Hobart.—S.A.: Adelaide, Mt. Lofty.

267. CHLENIAS SEMINIGRA.

Chlenias seminigra, Rosen., A.M.N.H., 1885, p.430; Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.666.

Vic.: Warragul, Beaconsfield.—Tas.: Hobart.

268. CHLENIAS SERINA.

Chlenias serina, Low., Tr. R.S.S.A., 1900, p.36.

N.S.W.: Broken Hill.

269. CHLENIAS PSOLINA, n.sp.

ψολινος, sooty.

♀. 42-48 mm. Head, palpi, and thorax dark fuscous. Antennæ dark fuscous; bipectinated in both sexes, pectinations of ♂ (unknown), of ♀ 1. Abdomen pale grey. Legs fuscous. Forewings narrow, oblong-oval, costa rather strongly arched, apex rounded, termen bowed, oblique; dark fuscous, sometimes with some brownish suffusion; a terminal series of blackish dots; cilia fuscous, apices and a slender median line whitish. Hindwings with termen slightly rounded; grey-whitish, darker towards termen; cilia grey. Underside fuscous.

A true *Chlenias*, but exceptional in vein 10 anastomosing strongly with 9, not merely connected with it by a short bar. Type in Coll. Lyell.

Vic.: Beaconsfield, in May, June, and July; Sale, in August.—Tas.: Sheffield, in November. Five specimens.

270. CHLENIAS STENOSTICHA, n.sp.

στενοστιχος, with narrow streaks.

♂. 45 mm. Head fuscous, finely irrorated with white; face rounded, prominent, shortly rough-haired. Palpi $1\frac{3}{4}$, grey, lower edge and base white. Antennæ whitish-grey; pectinations in ♂ 5. Thorax fuscous with fine white irroration, so as to appear grey. Abdomen brown-whitish. Legs grey; posterior pair, except tarsi, whitish. Forewings elongate-triangular, costa very slightly arched, apex round-pointed, termen bowed, oblique, whitish-grey; markings blackish; a subdorsal line from base to $\frac{4}{5}$, slightly dorsally bent before middle; a short oblique streak from $\frac{1}{5}$ costa, with several fine longitudinal streaks on veins between it and dorsum; a long, fine streak in cell, and another on fold; a series of short streaks representing postmedian line; in terminal area a series of long, fine, inter-neural streaks running into termen; cilia grey-whitish. Hindwings with termen rounded, wavy; fuscous, becoming whitish towards base; cilia whitish. Underside of forewing fuscous; of hindwing, whitish with dark fuscous terminal band. Type in Coll. Lyell.

Vic.: Blackrock, near Melbourne, in March; one specimen.

271. CHLENIAS MESOSTICHA, n.sp.

μεσοστιχος, with central streak.

♂. 35 mm., ♀. 42 mm. Head, palpi, and thorax fuscous, finely irrorated with whitish. Antennæ grey; pectinations in ♂ 5. Abdomen whitish with pale fuscous irroration. Legs whitish with fuscous irroration; tarsi fuscous, annulated with whitish; anterior pair dark fuscous. Forewings narrow elongate-triangular, costa moderately arched, apex rounded, termen bowed, oblique; whitish-grey; costa more or less suffused with fuscous; a dark fuscous (in ♀ blackish) streak along median vein from base, giving off finer streaks along veins 2, 3, and 4; a short streak on vein 6; a whitish, wavy, subterminal line; an interrupted, dark fuscous, terminal line (in ♀ a continuous blackish line); cilia fuscous mixed with whitish. Hindwings much broader than forewings, termen bowed in middle, wavy; whitish; a fuscous discal dot and broad terminal band obsolete towards tornus; cilia white. Underside whitish with fuscous discal dot and terminal band, more or less obsolete towards costa in each wing. Type in Coll. Lyell

Vic.: Birchip, in April.—W.A.: Perth; a ♀ in West Australian Museum, differing slightly from type, but I think the same species.

272. Chilenias basichorda, n.sp.

βασιχορδος, with basal stripe.

♂. 40 mm. Head grey-whitish; face with upper margin fuscous. Palpi grey-whitish mixed with fuscous. Antennæ grey-whitish; pectinations in ♂ 6. Thorax grey-whitish with an anterior fuscous spot. Abdomen whitish. Legs whitish; anterior pair fuscous-whitish. Forewings triangular, costa moderately arched near base, thence straight to near apex, apex pointed, termen bowed, oblique, crenulate; grey-whitish; markings blackish: a broad, subdorsal, basal streak not reaching first line; first line from $\frac{1}{5}$ costa to $\frac{1}{3}$ dorsum, slender, outwardly curved; a fine, dentate, transverse line before middle; a transverse discal mark slightly beyond middle; postmedian line represented indistinctly by fine dots on veins; three interneural streaks beneath apex running into termen, and two more above tornus; a fine terminal line; cilia grey-whitish. Hindwings with termen rounded, dentate opposite veins 3, 4, 6, and 7; whitish; a faint grey discal mark; a small, dark fuscous, median, terminal suffusion; cilia whitish. Underside grey-whitish with a median grey discal mark on each wing. Type in West Australian Museum.

W A.: Perth, in June; one specimen received from Mr. W. B. Alexander.

273. Chilenias macrochorda, n.sp.

μακροχορδος, with long streak,

♀. 44 mm. Head and thorax grey-whitish; upper margin of face fuscous. Palpi fuscous above, whitish beneath. Antennæ whitish. Abdomen ochreous-whitish. Legs whitish-grey: posterior pair whitish. Forewings elongate-oval, costa strongly and evenly arched, apex round-pointed, termen bowed, oblique, slightly wavy; grey-whitish with dark fuscous streaks: a subdorsal streak from base nearly to tornus; a fine longitudinal streak in cell; a short, oblique streak from $\frac{1}{4}$ costa: a series of fine interneural streaks running into termen; cilia whitish. Hindwings much broader than forewings, with termen rounded, irregularly waved; whitish, towards termen grey; cilia whitish. Underside of forewings pale grey; of hindwings whitish, with a fuscous terminal band obsolete towards costa. Type in West Australian Museum.

W.A.: Perth, in April; one specimen received from Mr. W. B. Alexander.

Gen. 89. STIBAROMA.

Stibaroma, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.669.

Face smooth, somewhat projecting, rounded. Tongue well developed. Palpi moderately long, porrect, densely rough-scaled; terminal joint short, obtuse. Antennæ in ♂ bipectinate, apex simple. Thorax with slight central crest: beneath densely hairy. Femora hairy; posterior tibiæ in ♂ not dilated. Forewings in ♂ without fovea; 10 and 11 arising separately from cell, 10 sometimes connected with 9. Hindwings with cell rather long; 3 and 4 sometimes connate: 8 closely approximated to cell beyond middle.

Type, *S. melanotoxa* Meyr. The connection of vein 10 with 9 is inconstant; in fact I have not observed it in any of the few examples I have been able to examine. The genus is closely allied to *Chlenias*, differing only in the scaling of the thorax and in some minor points.

274. STIBAROMA MELANOTOXA.

Stibaroma melanotoxa, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.669.

N.S.W.: Sydney.—Vic.: Melbourne, Gisborne, Wimmera.—S.A.: Mt. Lofty.

Mr. Lyell has a fine aberration taken at Hornsby, near Sydney. It has white patagia, and white blotches on forewing, one at base of dorsum, one on dorsum following postmedian line, and a third subcostal, also following postmedian line.

275. Stibaroma trigramma.

Stibaroma trigramma, Low., Tr. R.S.S.A., 1892, p.9.

S.A : Mt. Lofty.

276. Stibaroma triphasia.

τριφασιος, threefold.

♂. 40 mm. Head, palpi, and thorax fuscous, irrorated with whitish. Antennæ grey; pectinations in ♂ 5, extreme apex simple. Abdomen whitish, bases of segments fuscous. Legs dark fuscous, irrorated and tarsi annulated, with whitish. Forewings elongate-triangular, costa gently arched, more strongly towards apex, apex rounded, termen slightly bowed, oblique; pale fuscous, mixed with whitish and irrorated with dark fuscous: markings dark fuscous; a transverse line near base; an oblique wavy line from $\frac{1}{5}$ costa to $\frac{1}{3}$ dorsum; a line from $\frac{2}{5}$ costa to $\frac{2}{5}$ dorsum, angulated outwards above middle; a median, transverse, discal mark; a line from costa at $\frac{3}{5}$ at first straight, then sinuate to $\frac{3}{5}$ dorsum; an obscure, whitish, dentate, subterminal line; an interrupted, dark fuscous, terminal line; cilia whitish, barred with fuscous. Hindwings with termen rounded, slightly wavy; whitish; a fuscous discal dot, postmedian line, and broad suffused terminal band; a dark fuscous terminal line; cilia as forewings. Underside of forewings whitish with fuscous irroration along costa and at apex, and fuscous discal dot; of hindwings whitish, with dark fuscous irroration, discal mark, postmedian line, and large apical blotch. Type in Coll. Lyell.

Vic.: Gisborne, in April; two specimens.

Gen. 90. PROSOTERA, nov.

προσωτερος, further off.

Frons flat. Tongue well-developed. Palpi moderately long, porrect; second joint rough-haired beneath; terminal joint short. Antennæ of ♂ shortly laminated, minutely ciliated. Thorax with a posterior crest; hairy beneath. Femora hairy. Posterior tibiæ of ♂ not dilated. Forewings in ♂ without fovea; 10 and

11 arising separately from cell, not anastomosing. Hindwings normal.

This genus differs from the two preceding only in the ♂ antennæ, and the posterior thoracic crest.

277. PROSOTERA METOPORA, n.sp.

μετοπωρος, autumnal.

♂. 34 mm. Head brown; face and palpi dark fuscous. Antennæ fuscous; in ♂ slightly laminate and minutely ciliated ($\frac{1}{5}$). Thorax brown; tegulæ fuscous. Legs fuscous; posterior pair, except tarsi, whitish-ochreous; all tarsi annulated with whitish-ochreous. Forewings triangular, costa moderately arched, apex rounded, termen bowed, oblique, slightly wavy; fuscous-brown, towards base and costa strigulated with dark fuscous; lines dark fuscous; first line from $\frac{1}{4}$ costa to $\frac{1}{3}$ dorsum, outwardly curved, rather broad, but not sharply defined; median similar from midcosta to $\frac{2}{3}$ dorsum; postmedian from $\frac{3}{4}$ costa, commencing by a thick costal mark, then attenuated and interrupted, and towards dorsum closely applied to median line, subterminal represented by a few dark fuscous points outlined posteriorly with white; cilia fuscous-brown. Hindwings with termen rounded, wavy; grey becoming whitish at base; a faint discal spot and slightly dentate median line; cilia grey. Type in Coll. Wyld.

N.S.W.: Sydney, in May; one specimen received from Mr. G. H. Wyld.

Gen. 91. CORULA.

Corula, Wlk., Cat. Brit. Mus., ix., p.11.

Face with smooth, rounded prominence. Tongue well-developed. Palpi moderate, porrect, densely rough-scaled, terminal joint very short. Antennæ in ♂ pectinate (?). Thorax with a posterior crest; beneath hairy. Femora smooth; posterior tibiæ in ♂ not dilated. Forewings in ♂ without fovea; cell unusually broad at apex, 2 from shortly before angle, 4 widely separated from 3 and closely approximated to 5, running close to it for some distance, 10 and 11 arising separately from cell and free. Hindwings with cell long ($\frac{2}{3}$), otherwise normal.

Type, *C. geometroides* Wlk. The distorted neuration of the forewing is probably confined to the ♂. In my only example the antennæ are unfortunately broken off short.

278. CORULA GEOMETROIDES.

Corula geometroides, Wlk., Cat. Brit. Mus., ix., p.11.

♂. 30 mm. Head and thorax fuscous, finely irrorated with white Palpi 2; fuscous mixed with white. Abdomen ochreous-grey-whitish. Legs whitish with some fuscous irroration. Forewings elongate-triangular, costa rather strongly arched, apex round-pointed, termen bowed, oblique; grey with whitish irroration; lines fuscous; first line from $\frac{1}{5}$ costa to $\frac{1}{4}$ dorsum, at first outwardly oblique, then bent strongly inwards, and again outwards; median line faintly indicated, sharply dentate; postmedian from $\frac{3}{4}$ costa to $\frac{4}{5}$ dorsum, sharply dentate; an indistinct, wavy, whitish, subterminal line; a continuous terminal line; cilia grey-whitish. Hindwings broad, termen slightly sinuate; whitish; with a pale grey terminal band; cilia whitish.

N.S.W.: Sydney (Walker).—Vic.: Sea Lake, in November; one specimen received from Mr. D. Goudie.

Gen. 92. LOPHOSTICHA.

Lophosticha, Low., Tr. R.S.S.A., 1902, p.232.

Face with rough projecting scales. Tongue well-developed. Palpi moderate, porrect, rough-scaled; terminal joint short. Antennæ of ♂ bipectinate, near apex simple. Thorax rough-scaled, with small anterior and larger posterior crests; beneath densely hairy. Femora hairy; posterior tibiæ of ♂ not dilated. Forewings with numerous tufts of raised scales; in ♂ without fovea. 10 and 11 arising separately from cell, 10 anastomosing with 9. Hindwings with cell long ($\frac{2}{3}$), otherwise normal.

Type, *L. psorallodes* Low.

279. LOPHOSTICHA PSORALLODES.

Lophosticha psorallodes, Low., Tr. R.S.S.A., 1902, p.232.

Vic.: Birchip, in April; two specimens received from Mr. D. Goudie.

Gen. 93. DRYMOPTILA.

Drymoptila, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.670.

Face smooth, not projecting. Tongue well-developed. Palpi moderate, porrect, rough-scaled; terminal joint short. Antennæ in ♂ simple, minutely ciliated. Thorax with strong posterior crest: beneath slightly hairy. Femora smooth; posterior tibiæ of ♂ slightly dilated, with internal groove and tuft. Forewings in ♂ without fovea: 10 and 11 arising separately, 10 sometimes connate with 9. Hindwings with cell rather long, otherwise normal.

280. DRYMOPTILA TEMENITIS.

Drymoptila temenitis, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.670.

Tas.: Hobart.—S.A.: Mt. Lofty.

Gen. 94. NEOTERISTIS.

Neoteristis, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.672.

Face with projecting tuft of scales. Tongue well-developed. Palpi very long, porrect, rough-haired; terminal joint moderate. Antennæ in ♂ dentate, ciliated. Thorax not crested; beneath hairy. Femora smooth. Forewings in ♂ without fovea; 10 and 11 arising separately from cell and free. Hindwings normal.

281. NEOTERISTIS PARAPHANES.

Neoteristis paraphanes, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.672.

N.S.W.: Sydney, in June and July (G. H. Wyld).—Tas.: Deloraine, in November.

Gen. 95. MOCHLOTONA.

Mochlotona, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.672.

Face smooth. Tongue well-developed. Palpi moderate, somewhat ascending, rough-haired: terminal joint rather short. Antennæ of ♂ simple, thickened, ciliations very minute. Thorax not crested; hairy beneath. Forewings in ♂ without fovea; 10 and 11 arising separately from cell, 11 connected with 12 and 10, 10 connected with 9. Hindwings normal.

282. MOCHLOTONA PHASMATIAS.

Mochlotona phasmatias, Meyr., Proc. Linn. Soc. N. S. Wales, 1891, p.673.

Vic.: Warragul, Thorpdale (J. A. Kershaw).

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STUDIES IN AUSTRALIAN *NEUROPTERA*.

No.8. Revision of the Family *Ithonidæ*, with Descriptions of a new Genus and two new Species.

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

(With six Text-figures.)

In No.4 of this Series of Studies(**9**), I dealt, among other families of the Planipennia, with the *Ithonidæ*, and described a new species, *Ithone fulva* Till., from Stradbroke Island, Queensland. Since that time, I have done a large amount of work on this interesting family, with the result that it is now possible to give a thorough revision of it, together with a complete account of the extraordinary life-history of the original species, *Ithone fusca* Newman, described as long ago as 1838(**6**). In this paper, I propose to confine myself to the revision of the family, reserving the account of the life-history of *I. fusca* for a succeeding paper.

In 1853(**7**), Newman first proposed the separation of *Ithone fusca* as the type of a new family *Ithonesidæ*, a name which I subsequently changed to *Ithonidæ*(**9**) in conformity with the rules governing zoological nomenclature. The classification adopted by Newman in this paper was very remarkable, considering the early date at which it was attempted, and was certainly worthy of greater attention than it has received from later entomologists. Briefly, he proposed to divide the old Linnean Order Neuroptera into two Orders: the Neuroptera, containing only those having no true pupal stage; and the Stegoptera, containing those with a true pupal stage. Thus he was the first to recognise the seriousness of the error by which both hemimetabolous and holometabolous insects had been placed within the confines of a single Order; an error that is by now universally admitted by all thinking entomologists. In his Order Stegoptera he included the Caddis-flies, Alder-flies, Snake-flies, and Lacewings; in other words, his single Order comprised the insects which we now distribute between the three Orders Trichoptera, Megaloptera, and Planipennia. His Order was divided into four groups, Phryganeina, Myrmeleonina, Hemerobiina, and Corydalina. The latter was again divided into four families, according to the following key (**7**, p. cci.):—

Ocelli 3:—
Body clothed with hair .... *Ithonesidæ* Newm.
Body naked:—
Antennæ simple.................................. *Corydalidæ* Newm.
Antennæ pectinated.............................. *Chauliodesidæ* Newm.
Ocelli 0 .... *Sialidæ* Leach.

Thus it will be seen that the *Ithonidæ* were associated with the Megaloptera, instead of with the Planipennia, though it is now generally agreed that they belong to the latter Order.

Inadequate as we now know Newman's classification to have been, yet there is no denying the fact that the *Ithonidæ* are, amongst all Planipennia, the most closely related to the Megaloptera. In my previous paper, I gave reasons why it appeared very likely that the larva of *Ithone* might be aquatic (**9**, p.281). If such had proved to be the case, and if, as might further have been expected, the larval type of the *Ithonidæ* had shown close affinity with that of the Megaloptera, and its pupa had proved to lie free in the earth, without forming any cocoon, then the separation of the two Orders Megaloptera and Planipennia could no longer have been maintained. There are, indeed, many present-day entomologists who refuse to recognise these two Orders, on the ground that the imagines cannot be separated by any characters of sufficient importance. Such authors, of whom we may take Comstock (**1**) as an example, treat these two groups as Suborders within a single Order Neuroptera. Their position is quite logical. The Planipennia, however, are so distinct from all other Neuropteroid insects in possessing their unique suctorial larva, in which the mandibles and maxillæ are developed together to form a pair of sucking-jaws, that it is, from the point of view of the Phylogenist, unwise to merge them with any other group: and

I propose to continue to treat them as a separate Order for the present. This point of view, I may now say, has been justified by the discovery that the larva of *Ithone* does actually possess the typical suctorial jaws of the Planipennia, although its pupa lies free in the earth, without a cocoon.

If, then, we are agreed that the *Ithonidæ* are an archaic group of insects, deserving of family rank within the Order Planipennia, we have next to enquire into the composition of that family. Comstock (**1**, p.177) has recently suggested the inclusion in it provisionally of the remarkable Oriental genus *Rapisma.* I agree with Comstock that "the limits and distinguishing characteristics of the *Ithonidæ* must be determined by a study of other characters as well as those presented by the wings"; but, until this can be done for *Rapisma* as well as for *Ithone*, I cannot accept the inclusion of that genus within the family. Hence I propose to omit it from consideration in this paper, and to confine my attention to the purely Australian insects belonging to the genus *Ithone* and its close allies.

We are now faced with an initial difficulty as to the identity of Newman's original type of *Ithone fusca.* In 1853 (**7**), Newman wrote:—"The *Ithonesidæ* appear to be a numerous group, confined to New Holland. *Ithone* is the only genus described, but there are many species, and these very dissimilar, and likely to be generically subdivided when we become better acquainted with the entomological productions of the wonderful country in which they are found." Thus he must have known of the existence of other species besides his *I. fusca* at this date, though he did not describe any, and did not attempt to indicate more fully the distinguishing characteristics of the single species he had described. The next species described was *Varnia perloides* Walker, from Western Australia, in 1860. The types of this insect and of *I. fusca* are both in the British Museum. The only other *Ithonidæ* so far described are *Nespra implexa* Navás, from Central Australia, in 1914, and *Ithone fulva* Tillyard, from Queensland, in 1916. The type of the former is in the British Museum, that of the latter in my collection.

Thus, at the present time, the family *Ithonidæ* contains four described species, allotted to three genera. Most fortunately for future studies, the types of three of these species are located in the British Museum.

When I wrote my previous paper on this family(**9**), my collection contained only the two males of *I. fulva* from Stradbroke Island, together with two specimens of a much larger and darker species, taken at light at Hornsby, N.S.W. One of these latter insects had been sent to Mr. P. Esben Petersen, the well-known Neuropterist, of Silkeborg, Denmark, and had been determined by him as belonging to *I. fusca* Newman. It was on this determination that I figured the male appendages of this species (**9**, Pl. xii., figs. 7-9) for comparison with those of *I. fulva.*

From 1916 onwards, I was most anxious to discover the larva of *Ithone.* For this purpose, I showed my insects to Mr. Luke Gallard, to whom the family was at that time unknown, and told him of my experiences with them on Stradbroke Island. He became very interested in them, and promised to keep a sharp look-out for further specimens. In October, 1917, while he and his family were staying in a cottage near the Ocean Beach, Woy Woy, Mrs. Gallard discovered, about 6 o'clock one evening, a specimen of *Ithone* sitting on a post. This led to further finds, and Mr. Gallard returned at the end of a week with about two dozen specimens, most of which had been found hiding in an old outhouse near the cottage. Last year I spent a week with Mr. Gallard in the same cottage, at the beginning of November, with the result that we not only obtained about two hundred of the imagines, but also discovered the larva and pupa, and obtained many hundreds of fertile eggs. The full account of these interesting discoveries will be given in a later paper.

Now the extraordinary thing was that this abundant species, which agreed well enough with Newman's description of *I. fusca*, was most certainly not the same species as the one I already had in my collection, and which Petersen had already determined as the true *I. fusca.* It was not even congeneric with it; for the Woy Woy species has constantly only a single radial sector in the forewing, whereas the Hornsby species, like *I. fulva*, has either two or three separate radial sectors in the forewing. The appendages of the males are also quite different, those of the Woy Woy species being of normal size and of simple forcipate shape like those of *I. fulva*, whereas those of the Hornsby species are immense claspers of a very specialised broad shape. Referring to Newman's description of *I. fusca*, in order to solve this problem, I was disappointed to find that he makes mention neither of the condition of Rs in the forewing, nor of the form of the appendages, although his type specimen was a male.

Thus it was impossible, on the evidence at hand, to determine whether the Woy Woy or the Hornsby species was the true *I. fusca* of Newman. There was only one method of solving the problem, viz., to have specimens of both insects compared with Newman's type in the British Museum. With this purpose, I wrote to my friend Mr. Herbert Campion, and sent him one of my Hornsby specimens, together with a series of the Woy Woy insects, and a specimen of a very distinct paler species from Tasmania and Victoria. His reply to my request has now reached me, and definitely clears up all doubts, not only about the identity of *I. fusca*, but also about the other species represented in the British Museum. For this help, without which a revision of this family could not possibly have been attempted, I now desire to offer him my most cordial thanks. He writes as follows :—

"I think there can be no doubt that two remarkably similar, but nevertheless distinct, species have been going under the name of *Ithone fusca*. Newman's species is represented in your collection by the specimens from Woy Woy, while the other (which, so far as I am aware, stands without a name) is represented by the insect from Hornsby. I distinguish the two insects thus:—

Larger species; 2 Rs in forewing; anal appendages of ♂ expanded dorso-ventrally, excavated at apex ... . Gen. et sp. incert.
Smaller species; 1 Rs in forewing; anal appendages of ♂ not expanded dorso-ventrally, pointed at apex .. . . *Ithone fusca* Newm.

"In addition to Newman's type, the B.M. has two other males of *Ithone fusca*, while a female of the large species is registered thus, under the year 1845:—'Australia (Harrington); purch. of Argent.'

"As to your *Ithone pallida* (this was the MS. name under which I sent the Tasmanian species to Mr. Campion—R.J.T.), I do not see how it can have very much to do either with *Varnia perloides* or with *Nespra implexa*. For one thing, the wings are unspotted, instead of being marked with blotches along the veins. For another thing, the costal veinlets in the forewing are for the most part simple and regular, whereas in *V. perloides* they are either forked anteriorly or anastomosed and irregular. In *N. implexa* the costal space is filled with an intricate meshwork of little veins, recalling the condition prevailing in the elytra of Acridiid Orthoptera.

"I do not know how Navás distinguishes *Nespra* from *Varnia*, as he compares his genus with *Ithone* alone. There is a good deal of resemblance between the two types, although there is a great disparity in size, and *V. perloides* is more heavily spotted, especially on the hindwings. But of course I am comparing a single male with a single female, and I do not know enough of the group to say how far sexual differences extend, neither can I tell what, if any, colour-changes take place during life. . . . . I cannot understand why Walker's genus *Varnia* should have been allowed to lapse, and its contents transferred to *Ithone*, for it seems to me that species having two Rs in the forewing must be generically distinct from forms possessing only one Rs."

Thanks, then, to Mr. Campion's careful comparison of the species in the British Museum with those in my own collection, it is now possible to make the following assertions:—

(1) The species determined by Petersen from my own collection, and by Navás in the British Museum Collection, as being *Ithone fusca* Newm., is not that species, but a species that so far has no distinctive name.

(2) The true *Ithone fusca* Newm., is the same species that is so common at Woy Woy, and possesses only one Rs in forewings.

(3) *Ithone fulva* Tillyard, possessing either two or three Rs in forewings, is not congeneric with *Ithone fusca* Newm., and must form the type of a new genus.

(4) The unnamed species mentioned in (1), in that it also possesses two or three Rs in forewing, should be placed in the same genus as *I. fulva* Till.

(5) The Tasmanian and Victorian species, *I. pallida* Till. MS., which also has a variable number of Rs, two or more, in the forewings, should also go into this genus. It will be described in this paper under its MS. specific name.

(6) Walker's genus *Varnia* is a valid one, and should not have been suppressed by McLachlan.

(7) Navás' genus *Nespra* is not sufficiently distinct from *Varnia* Walker; and it is quite possible, seeing that the females in this family are normally much larger and darker than the males, that his *N. implexa* is only the male of *V. perloides*. This is the more likely, when one recalls the fact that the sand-dwelling insects of Western Australia mostly extend unchanged right into Central Australia, many of them reaching to the limit of the dry belt in Western Queensland.

It remains to be added that Comstock (**1**, p.175, fig.170) has correctly figured the wings of *Ithone fusca* Newm., with a single Rs in forewing, and has correctly inferred that my *I. fulva* is not congeneric with it. But he is quite in error in stating that, in the hindwings of *I. fulva*, "veins Sc and R coalesce throughout the distal half of their length." This statement clearly shows that he studied my figure without troubling to read my paper, in which (**9**, p.280) I clearly stated that "in Plate xii., fig. 1, the radius and subcosta appear to be fused, but actually R stands on a high ridge, with Sc sunk far beneath it, so that the two come into line when viewed from above." This fact, of course, made it inevitable that the two should *appear* fused in the figure.

We may now proceed to redefine the characters of the family, in the light of our latest knowledge, and to give keys and descriptions of the genera and species.

Family ITHONIDÆ.

Large, stout-bodied lacewings of superficially moth like appearance, the females larger than the males.

Head:—*Antennæ* filiform, tapering, the basal joint stout, the rest formed of from 40-50 short cylindrical joints, increasing in length gradually from base to tip; length from two fifths to three-fifths of that of forewing; bases fairly close together. *Ocelli* absent, or at the most vestigial.* *Eyes* button-like, prominent, occupying almost the whole of the two sides of the very short but rather wide head. *Mandibles* well developed; without internal teeth. *Maxillary palpi* five-jointed; *labial palpi* three-jointed (Text-fig.6).

Thorax (Text-fig.5):—*Prothorax* strongly built, with the head sessile upon it; much wider than long. *Meso-* and *metathorax* both well developed, quite separate; their coxæ apparently in two separate pieces (the true coxa, and an attached piece from the epimerum). *Legs* moderately stout and long, the tibiæ with a pair of strong apical spurs, the tarsi five-jointed, the most basal joint being the longest, the next three decreasing in length, the last joint longer again; tarsal claws and a bilobed empodium well developed. Large *spiracles* present between prothorax and mesothorax, and also between meso- and metathorax (Text-fig. 5, sp_2, sp_3).

Wings:—Forewings of tougher consistency than hind, somewhat leathery. Both pairs of wings fairly wide, held roof-like over the body when at rest. Costa of forewing slightly arched near base, so that the costal space is slightly widened; a humeral recurrent vein present; costal veinlets numerous, sometimes branched or connected by cross-veinlets. Sc and R_1 close together, connected only by a single cross-vein near base, and by one or more towards apex. Apparent radial sectors one or more, with a moderate number of pectinate branches; frequently the original dichotomic branching of R_{4+5} is retained. R_1 markedly bent concavely to the costa in the pterostigmatic region, with a number of closely-set branches. M two-branched, connected

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* Newman says "Ocelli 3," but this is surely an error!

basally with R in forewing. Cu with its strong anterior branch (Cu_1) carrying pectinate posterior branches only distally; the weaker Cu_2 dichotomously branched. The three anal veins distinct, all branched. Cross-veins weakly formed, only moderately numerous, scattered irregularly about on the disc. Main veins and their branches hairy; cross-veins without hairs. Jugal lobe and humeral process present, but no definite frenulum.

Abdomen stout, cylindrical, shorter than the wings; formed of eight complete segments, with reduced ninth and tenth also present, the latter in the form of a small *proctiger* carrying the anus. Eight pairs of spiracles, on segs. 1-8 respectively; the first pair very large, the others small (Text-fig.5, asp_1, asp_2). *Anal appendages of male* consisting of a pair of large superior appendages of forcipate shape, and a single, broad, valve-like, inferior appendage or *hypandrium*; between these lies the penis, with its projecting penis-hooks or *penunci*. In the female, the abdomen ends in a peculiar *psammarotrum* or sand-plough, from which depend two tactile appendages; the *anus* lies dorsally above and anterior to this organ, apparently upon seg. 8, but actually on the reduced tenth segment. The genital opening lies in a slit at the posterior end of the sand-plough, which is part of seg. 9.

Eggs large, oval, soft, deposited in the sand, which adheres to them, owing to a sticky secretion with which they are covered.

Larva a soft, whitish, burrowing, blind, melolonthoid grub, with small mandibles and maxillæ fashioned for sucking.

Pupa a *pupa libera*, not enclosed in a cocoon; lying free in the sand. (*See* postscript, p.437).

Distribution: Confined to Australia and Tasmania, so far as known. Inhabitants of sandy places, including the central desert region, as well as the coast-line.

(A full account of the life history will be given in a later paper of this Series).

The *Ithonidæ* differ so much from all other Planipennia, that I have no hesitation in proposing to separate them from the rest as a new Suborder ITHONOIDEA, distinguished by their remarkable larva, the pupa free in the earth, without a cocoon, and the imago stout-bodied and moth-like in appearance, with large mandibles and generalised Prohemerobiid type of wing-venation.

Key to the Genera of *Ithonidae*.

(1) Forewing with only a single radial sector........... ITHONE, Newm.
Forewing with two or more apparent radial sectors 2.

(2) Wings unicolorous; the costal veinlets of the forewing with little or no tendency to branching, and with few or no cross-veinlets connecting them. Eastern Australia only .... HETERITHONE, n.g. (Type. *Ithone fulva* Till.).
Wings with the veins marked with black or fuscous: the costal veinlets of the forewing frequently branched, and frequently connected together by cross-veinlets. Western and Central Australia only .... VARNIA Walk.

Genus ITHONE Newm. (Text-figs. 1*a*, *b*, 2, 3, 5, 6).

Newman, Ent. Mag., 1838, v., p.181; Zool., 1853, xi., Appendix, Art. xxix., p. cci.

Characters as for the family, with the addition that the fore wing has only a single radial sector.

Genotype, *Ithone fusca* Newm.

Habitat: Sandy places along the coast-line of New South Wales.

The genus, as now restricted, contains only the type-species, which appears to be abundant enough, if looked for at the right season and in the right places.

ITHONE FUSCA Newm. (Text-figs. 1*a*, *b*, 2, 3, 5, 6).

Newman, Ent. Mag., 1838, v., p.181.

As Newman's description is far too general, and does not distinguish the species definitely from its near neighbours, it is redescribed here, with special attention to the anal appendages, which are of great value in the determination of the various species.

♂. *Total length* (dried), 16-20 mm.; *abdomen* (dried), 10-14 mm.; *forewing*, 19-24 mm.; *hindwing*, 17-22 mm.; *expanse*, 40-52 mm.

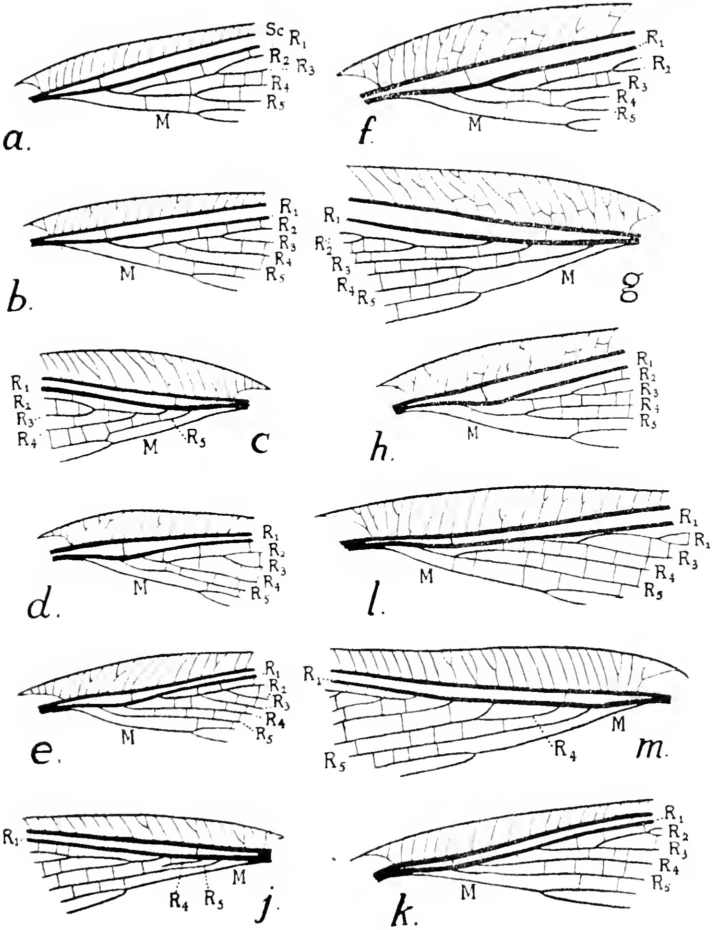
Head blackish-brown above, the *eyes* grey-black; *antennæ* dark brown, with two conspicuous creamy areas at their bases, forming a kind of inverted V-mark between them on the frons; below this a conspicuous, black, transverse band from eye to eye; *clypeus* and *mouth-parts* a medium brown.

Thorax hairy above, brownish, paler on sides; legs brown.

Wings:—Forewings fuscous, semi-transparent; hindwings somewhat paler. Costal space of forewing not very much broadened; its veinlets set close together, and very few of them branched; humeral recurrent vein short, usually with only a single anterior branch to it. The single radial sector of the forewing may be either completely pectinately branched, or R_{4+5} may retain its original dichotomic branching; these two formations are figured in Text-fig. 1, *a* and *b*. An analysis of nearly two hundred specimens of both sexes shows that about 40 per cent. of the specimens have the dichotomic branching of R_{4+5} in both forewings, only 20 per cent. the complete pectinate branching in both, and about 40 per cent. have one forewing with one condition and the other with the other condition. Thus 60 per cent. of the total number of forewings have the dichotomic condition present, and only 40 per cent. the pectinate. The total number of branches descending from Rs before the region of the pterostigma varies from three to six.

Abdomen fuscous above, brown beneath; segs. 1-2 hairy; seg. 1 paler above. Each segment has a pair of oblique pale marks dorsally, placed well apart on either side of the middle line, and laterally a pale curved band.

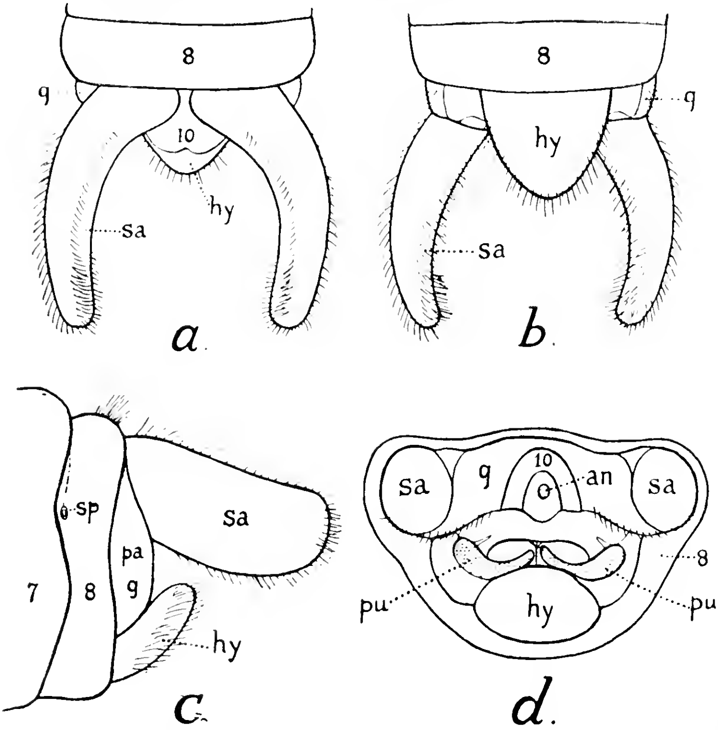
Appendages pale brownish; the *superior* in the form of a pair of strong forceps about 2·4 mm. long, of moderate width viewed dorsally or ventrally, but much wider when viewed laterally (see Text-fig. 2, *sa*); the *inferior* a single, broad, valve-like hypandrium (Text-fig. 2, *hy*) lying beneath the penis, whose hard, brown, chitinous hooks or penunci (Text-fig. 2, *d*, *pu*) can be seen above its base. The anus lies on the reduced tenth segment or *proctiger*, midway between the two superior appendages (Text-fig. 2, *d*, *an*) (See also Crampton, **3**, fig. 14).



Text-fig. 1.

Structure of the costal space and radial sectors in the forewings of various *Ithonidæ* (all × 6). *a*, *Ithone fusca* Newm., ♂, to show the dichotomic branching of the single Rs. *b*, the same, with Rs pectinately branched. *c-d*, *Heterithone fulva* (Till.), ♂ paratype, left and right forewings. *e*, *H. fulva* (Till.), ♂ holotype, right forewing. *f-g*, *H. megacerca*, n.sp., ♂ holotype, right and left forewings. *h*, *H. megacerca*, n.sp., ♂ paratype, right forewing. *j-k*, *H. pallida*, n.sp., ♂ holotype, left and right forewings. *l-m*, *H. pallida*, n.sp., ♀ allotype, right and left forewings. (Compare Text-fig.4*c*).

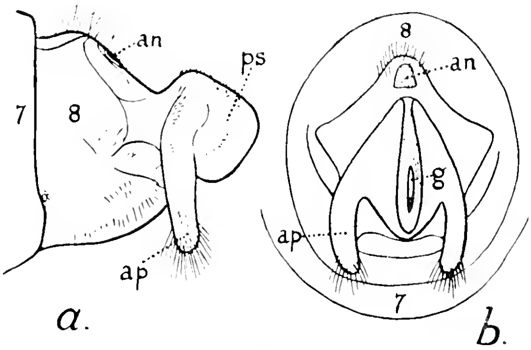
♂. *Total length*, 20-26 mm.; *abdomen*, 13-18 mm.; *forewing*, 25-28 mm.; *hindwing*, 22-24 mm.; *expanse*, 52-60 mm.



Text-fig.2.

Ithone fusca Newm., ♂. Abdominal appendages. *a*, dorsal view; *b*, ventral view; *c*, lateral view; *d*, posterior view; *an*, anus; *hy*, hypandrium or inferior appendage; *pa*, paraproct; *pu*, penunci or penis-hooks; *sa*, superior appendages or surgonopods; *sp*, spiracle; 8, 9, 10, abdominal segments. (× 12). (Compare Text-fig.4, *a*, *b*).

Generally similar in appearance and colouration to ♂, but with somewhat darker and broader wings, and darker abdomen. There may be as many as seven descending branches from Rs, and the humeral recurrent vein of the forewing may have two or three anterior branches. The end of the abdomen is peculiarly modified, with a view to the laying of the eggs in the loose sand. The eighth, ninth, and tenth segments are more or less fused together, forming the projecting end of the abdomen; of these, the ninth segment is terminal, the reduced tenth being situated more dorsally upon the eighth, and carrying the anus, as in Text-fig.3, *an*. The ninth segment is flattened from side to side to form the unique *psammarotrum* or sand-plough, with which the insect ploughs the loose sand while ovipositing. From the base of this segment, on either side, there projects downwards an unjointed appendage, ending in a rounded tip with numerous hairs; these, though very like cerci in appearance, must be true gonapophyses or gonopods, from their position; they clearly act as feelers during oviposition, and must be homologous with the more elongated but otherwise similar organs in the females of *Berothidae*.



Text-fig.3.

Ithone fusca Newm., ♀. End of abdomen. *a*, Lateral view; *b*, posterior view; *an*, anus; *ap*, tactile appendage or gonopod; *g*, gonopore or genital opening; *ps*, psammarotrum or sand-plough; 7, 8, abdominal segments. (× 12).

Types: Holotype of ♂ in British Museum Coll., from New Holland; presented by the Entomological Club; described by Newman in 1838(6). Allotype ♀ in Coll. Tillyard; this sex not having been previously described, I have selected a fine specimen, with the largest measurements given in the above description, as allotype; loc. Woy Woy, N.S.W., Nov. 6th, 1918.

Besides these, there are two other males in the British Museum Collection, one in the Collection at Cornell Univ. (venation figured by Comstock, **1**, fig.170), a number in Mr. Luke Gallard's collection, and thirty males and six females in my own collection, all from Woy Woy. I have also a large number in alcohol, and have distributed set males to many correspondents.

Habitat: Sandy places along the coast of New South Wales. Woy Woy, abundant during first half of November in the bush near the Ocean Beach. Jervis Bay, abundant at same date around the Naval College.* The males, which are much more abundant than the females, assemble around the latter at dusk, on tree-trunks or fence-posts, running actively about like Cockroaches, or flying wildly round like Hepialid Moths. In the air, both sexes appear of a very pale, almost whitish colour.

Genus HETERITHONE, n.g. (Text-fig.1, *c-m*).

Differs from *Ithone* only in the possession of two or more apparent radial sectors in the forewing.

Genotype, *Ithone fulva* Till.

Habitat: Sandy places in Eastern Australia.

This genus contains three species, which may be separated by the following key:—

(1) Dark, fuscous species of large size, with the appendages of the male of enormous size, pointed apically, and almost as broad as long when viewed laterally .... *H. megacerca*, n.sp.
Paler species, with males of smaller size, and their appendages of normal forcipate type...... .... 2.

(2) Abdomen dull fulvous; the wings with a tinge of mauve. Stradbroke Island, Queensland .... *H. fulva* (Till.).
Abdomen pale ochreous, the wings very pale, not tinged with mauve. Victoria and Tasmania .... *H. pallida*, n.sp.

HETERITHONE FULVA (Till.). (Text-fig.1, *c-e*).

Ithone fulva Till., These Proceedings, 1916, xli., Part 2, p.279, Pl. xii., figs.1-6.

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* I have to thank my friend Lt. Commdr. Paymaster L. H. Mosse-Robinson for this observation.

To the description and figures given, it is only necessary to add that, although the type male has *three* apparent radial sectors on each forewing, the second male in my collection shows only *two*; while, in the left forewing, one of these (R_5) becomes attached to M near the forking of the latter.

Type: Holotype ♂, Coll. Tillyard; Stradbroke Island, Q. A second male in my collection, from the same locality.

♀ unknown.

Habitat: Apparently confined to Stradbroke Island, Q.

HETERITHONE PALLIDA, n.sp. (Text-fig.1, *j-m*).

♂. *Total length*, 23 mm.; *abdomen*, 11 mm.; *forewing*, 21 mm.; *hindwing*, 18 mm.; *expanse*, 47 mm.

Very close to *H. fulva* (Till.), from which it differs in the following points:—General colour pale ochreous, with a black line behind the eyes in the suture between head and prothorax. Wings very transparent, almost colourless, the veins very pale; no tinge of mauve on them at all. Antennæ with the basal joints pale yellowish-brown, the rest gradually darkening to dark brown towards tip (those of *H. fulva* are of a uniform rich orange-brown). Appendages rather short, of normal forcipate type, but somewhat broader than those of *H. fulva* when viewed laterally.

♀. *Total length*, 25 mm.; *abdomen*, 18 mm.; *forewing*, 30 mm.; *hindwing*, 27 mm.; *expanse*, 66 mm.

Closely resembles the male, but much larger and stouter. No dark band between head and prothorax. Wings very broad, with 7-8 descending branches from Rs, instead of 5-6, as in the male. *Sand-plough* strongly cultriform in shape, the angle being placed dorsally; the two gonopods very short and inconspicuous.

Types: Holotype ♂ in Coll. Tillyard; Point Lonsdale, Victoria, taken at light by Mr. J. A. Kershaw. Allotype ♀ in Coll. Tillyard, loc. Victoria, received in exchange from Mr. G. F. Hill.

A second male in my collection, also received from Mr. Kershaw, is somewhat smaller than the type, the expanse being 44 mm.

Habitat: Sandy places in Victoria and Tasmania. I have in my collection also two males, closely resembling the type, from Ulverstone, Tas., taken by Mr. A. M. Lea, and received in exchange from Mr. G. H. Hardy.

This species may have anything from two to four apparent radial sectors in forewing. The type male has only two in each forewing. Text-fig.1, *j-k*, show the interesting conditions of the radial sectors in the two forewings of the second male from Victoria; while Text-fig-1, *l-m*, show the even more striking conditions in the allotype female.

HETERITHONE MEGACERCA, n.sp. (Text-fig.1, *f-h*).

Ithone fusca Till. (*nec* Newm.), These Proceedings, 1916, xli., Part 2, p.279, Pl. xii., figs.7-9.

♂. *Total length*, 25 mm.; *abdomen*, 17 mm.; *forewing*, 25 mm.; *hindwing*, 22·5 mm.; *expanse*, 53 mm.

This very striking species has a close general resemblance to *Ithone fusca* Newm., with which it has hitherto been confounded. The principal differences are as follows:—

The general build is more robust, the abdomen stouter and longer, apparently without any definite pattern, the antennæ shorter and somewhat stouter, the wings very distinctly wider and more broadly rounded at the tips. In the forewings, besides the presence of more than one apparent radial sector, the costal margin is thickened and darkened, and both R_1 and Cu_1 are very strong, darkened veins, much more prominently convex than in *I. fusca*. Also the costal space is much wider, and its veinlets tend to fork considerably, while a few of them are actually connected by cross-veinlets, as in the genus *Varnia* (*see* Text-fig. 1, *f-h*). The appendages of the male, which are of great size and extraordinary shape, have been already described and figured by me as belonging to *I. fusca*, and it is only here necessary to refer to those figures (9, Pl. xii., figs.7-9).

The male of *H. megacerca* has the size and build of a female of *I. fusca*. The female is unknown to me, but should be correspondingly larger and more heavily built than the male. Mr. Campion (*antea*, p.419) states that there is a female of this species in the British Museum Collection; but, at the time he wrote this, I am not sure that he knew of the great difference in size between the two sexes in this family. It is, therefore, possible that this specimen is really a large female of *I. fusca.* I should estimate that the expanse of the average female of *H. megacerca* would be about 70 mm., while the difference in the shape of the wings, especially the greater breadth towards the apex of the forewing, ought to be even more strongly marked than in the male.

Type: Holotype ♂ in Coll. Tillyard, taken at light at Hornsby, N.S.W., in November, 1913. A second male, slightly smaller than the type (length, 24 mm.: expanse, 52·5 mm.) is also in my collection; it was taken at light at Hornsby in Nov., 1909.

Genus VARNIA Walker. (Text-fig.4).

Walker, Trans. Ent. Soc. London, 1860, v., p.197. (Suppressed by McLachlan, 1870, Ent. Mo. Mag., 1869-70, p.26:—"Genus *Varnia* Walker = *Ithone* Newman. *V. perloides* is an interesting second species of this curious genus." No reason at all is offered for the suppression). *Nespra* Navás, Rev. Real Acad., Madrid, 1914, p.478.

Characters as given in the key on p.423.

Genotype, *Varnia perloides* Walker (Western Australia).

Habitat: Sandy places in Western and Central Australia.

The only specimens known of this genus, apparently, are the type ♀ of *V. perloides* Walker, from Western Australia, and the type of *Nespra implexa* Navás, from Central Australia, both in the British Museum Collection. I have not seen these insects, but it is quite clear, from Mr. Campion's study of them, that they must be regarded as congeneric, seeing that they agree in the three important characters of having the veins of the wings marked with fuscous or black, the possession of more than one apparent radial sector in the forewing, and the costal veinlets in that wing much forked and connected together by means of cross-veinlets. The only difference is that of size, which we now know to be a characteristic difference between the sexes in this family. I therefore have no hesitation, firstly in restoring the genus *Varnia* Walker, with its type *V. perloides*, and secondly in suppressing the genus *Nespra* Navás, as a synonym of *Varnia* Walker. It should be noted that Navás only compared his new genus with *Ithone* Newman, thus showing that he was either ignorant of the existence of Walker's genus, or, at any rate, not cognisant with its characters, which were those of his new genus itself.

VARNIA PERLOIDES Walker.

Walker, Trans. Ent. Soc. London, 1860, v., p.197.

The length of body in this insect is 21 mm., the expanse of wing 55 mm. (Walker gives the measurements in lines).

Type: Holotype ♀ in British Museum Collection.

Habitat: Western Australia.

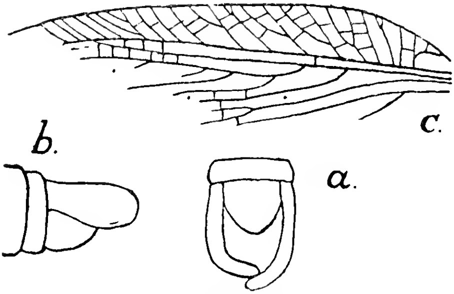
VARNIA IMPLEXA (Navás). (Text-fig.4).

Nespra implexa Navás, Rev. Real Acad., Madrid, 1914, p.478.

Length of body, 15 mm.; forewing, 19 mm., implying an expanse of wing of about 43 mm.

Type: Holotype ♂ in British Museum Collection.

Habitat: Central Australia (Hermannsburg, H. J. Hillier, 1911).

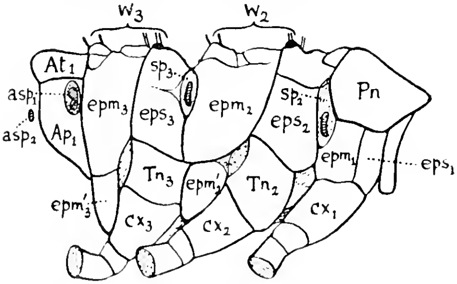


Text-fig.4.

Varnia implexa (Navás), male. *a*, dorsal and *b*, lateral view of appendages; *c*, costal space and radial sectors of forewings, for comparison with Text-figs.1-2. (After Navás).

The measurements and description show that this insect may perhaps be the male of *V. perloides* Walker. I have copied herewith the figures given by Navás of the venation and appendages, for comparison with those of other genera and species of the families figured in this paper (Text-fig. 4). It is to be hoped that the discovery of further specimens of both sexes of either this species or *V. perloides* may soon settle the question of whether one or two species are represented by the two known specimens.

In suggesting the vernacular name "Moth-Lacewings" for the insects of this family, I do so with a desire to emphasise not only their superficial resemblance, in structure and habits, to certain archaic moths, such as, for instance, the smaller and duller *Hepialidae*, but also because, being one of the very oldest existing types of Planipennia, they do show actually a closer morphological approach to the Lepidoptera than do most other insects of their Order. Quite apart from the moth-like form of the head and body, the greatly reduced labium with its long three-jointed palpi, and the very typically Hepialid-like position of rest and manner of flight, we can see, by a study of the thoracic exoskeleton, how very close this ancient type really comes to the Lepidoptera. Text-fig. 5 shows the thorax of



Text-fig. 5.

Ithone fusca Newm. Thorax of male, lateral view, (× 6). Ap_1, pleurum of first abdominal segment; *asp*, abdominal spiracle; At_1, tergum of first abdominal segment; *cx*, coxa; *epm*, epimerum; *eps*, episternum; *Pn*, pronotum; *sp*, thoracic spiracle; *Tn*, trochantin; *w*, attachments of wing. The suffixes 1-3 indicate the parts belonging to pro-, meso-, and meta-thorax respectively.

Ithone fusca, viewed from the side. It will be seen that the structure of the coxæ of the middle and hind legs is the same as in the older Lepidoptera, a special piece of the epimerum (*epm'*) being separated off from the principal part of the sclerite, and attached posteriorly to the coxa in question. The position and shape of the two large thoracic spiracles also resemble those of the older Lepidoptera. The prothorax is more primitive than in any known Lepidoptera, the pronotum being well developed, and the pleurum definitely divided into two parts.

Snodgrass(**8**) and Crampton and Hasey(**2**) have shown that the character of the specialised coxæ is common to the Mecoptera, Trichoptera, Megaloptera, Planipennia, and Lepidoptera; but *Ithone* appears to show this more clearly than other Lacewings, possibly because of its greater robustness.

The *Ithonidæ* might also very appropriately be named the "Cockroach-Lacewings," since they exhibit certain superficial resemblances to Cockroaches. Their quick powers of running, the peculiar texture and "feel" of their wings and bodies, their fondness for running over one in the field, and their aptitude at hiding away in dark places, are all characters that suggest a resemblance to these insects. Moreover, as I hope to show later, their internal morphology shows that they are more closely related to the Cockroaches than these superficial resemblances would suggest.

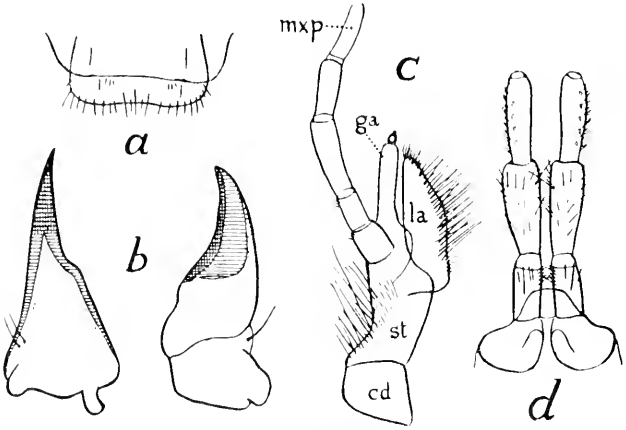
In conclusion, I should like to remark that the very specialised life-history of this family proves it to be a very early side-branch of the Planipennia, lying well off the main line of descent of present-day groups from the original Prohemerobiid types of the Trias and Lias. As this life-history is by now almost completely worked out, I shall hope to give a full account of it in a future paper.

Note on the mouth-parts of the Ithonidæ. (Text-fig.6).

Text fig.6 shows the mouth-parts of the male of *Ithone fusca* Newm., for comparison with those of other archaic Planipennia, such as *Psychopsis* (**10**, p.812, Text-fig.12).

The *labrum* (Text-fig.6*a*) is closely similar to that of *Psychopsis*, but there is a delicate lobe attached to it on the inner side, which appears to represent the epipharynx. As the figures for *Psychopsis* were not made from fresh specimens, it is possible that the epipharynx may have been shrivelled in these, and was thus overlooked.

The *mandibles* (Text-fig.6*b*) are of the primitive Panorpoid type, elongated, pointed, and without internal teeth. Those of the male are longer and sharper than those of the female. They differ from those of *Psychopsis* in not possessing any inner broad lobe. The difference may be correlated with the absence of a cocoon in the pupal stage of the *Ithonidæ*; if so, then the form of mandible found in the imagines of *Psychopsidæ* is partially due to specialisation in the pupal stage, in which, as I have previously shown (**10**, p.808, Text-fig.10) the mandibles are more strongly formed than in the imago, and are used for cutting open the cocoon. Of what use the mandibles are to the *Ithonidæ* I do not know, as these insects appear to live only a few days; I



Text-fig.6.

Ithone fusca Newm. Mouth-parts of male. *a*, labrum and epipharynx; *b*, left and right mandibles; *c*, left maxilla, with *cd*, cardo, *ga*, galea, *la*, lacinia, *mxp*, maxillary palpus, and *st*, stipes; *d*, labium. (All × 30).

should doubt whether they take any food at all that requires the use of mandibles, and I have never found anything except air inside the alimentary canal of a number of specimens that I dissected. It is possible that they are only of use to the males for fighting one another when assembling around a female for pairing: but I have not observed any actual combats; only a disposition to drive one another away.

The *maxillæ* (Text-fig.6,*c*) closely resemble those of the *Psychopsidæ*, having the primitive five-jointed palpus, a well developed *galea* with a small terminal knob, which may be the vestige of a distal joint, and a somewhat flat, blade-like *lacinia*, more pointed than in *Psychopsis*, and with its outer margin carrying numerous closely-set stiff hairs. The *stipes* is elongated, as in *Psychopsis*, but much narrower, and carries a large number of stiff hairs, some of them of considerable length, on its outer margin. The *cardo* is short, as in the *Psychopsidæ*.

The *labium* (Text-fig.6,*d*) differs from that of *Psychopsis* in showing considerable reduction of all parts except the *palpi*, which are well developed, three-jointed, and set close together at their bases, as in the Lepidoptera. The first or basal joint is short, the second longer and wider, the third slightly shorter than the second, and much narrower; this joint carries a row of five sensory pits or depressions, with sets of minute hairs close to them, and its tip is bluntly rounded and transparent, probably carrying another sense-organ. There are larger hairs on the first and second joints, of which a set of five stiff ones, close together, projects from the inner side of the basal joint, while one or two large, stiff bristles cross one another on the inner sides of the second joints. The mentum, submentum, and inner lobe of the labium are much reduced, and there does not appear to be any definite hypopharynx as in the *Psychopsidæ*.

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Postscript, added 10th September, 1919: Since the above was written, both Mr. Gallard and myself have discovered, almost simultaneously, the *cocoon* of *Ithone*. Thus the discovery of the pupa and pupal skin free in the earth, last year, led to an erroneous conclusion, and is only to be explained on the supposition that the pupa was found while on its way up through the sand. All statements in the present paper about the pupa lying free in the earth should be deleted. The cocoon and pupa will be fully described in a future paper.—R. J. Tillyard.

ORDINARY MONTHLY MEETING.

27th AUGUST, 1919.

Mr. J. J. Fletcher, M.A., B.Sc., President, in the Chair.

The President offered a hearty welcome to Captain Aurousseau and Lieut. Goldfinch, who were present, on their safe return from active service.

The President made regretful reference to the death of Mr. Harry Stephens, B.Sc Ag., "killed in action," and it was resolved that a letter of sympathy be sent, on behalf of members, to Miss Stephens.

It was resolved that a letter expressing the congratulations of members on the award of the Clarke Memorial Medal by the Royal Society of New South Wales, be sent to Professor David.

The attention of members was called to circulars regarding (*a*) Proposed Imperial Botanical Congress to be held in London, 1920; and (*b*) R. M. Johnston Memorial.

The Donations and Exchanges received since the previous Monthly Meeting (30th July, 1919), amounting to 5 Vols., 48 Parts or Nos., 14 Bulletins, and 5 Pamphlets, received from 37 Societies and Institutions, and two private donors, were laid upon the table.

NOTES AND EXHIBITS.

Mr. E. Cheel exhibited a specimen of a skull of a flying fox impaled on a twig of the Lombardy Poplar.

Mr. Fred Turner made some remarks condemning the use of *Citrus trifoliata* as a stock for citrus trees.

A NEW SPECIES OF WAX SCALE *(CEROPLASTES MURRAYI)* FROM NEW GUINEA.

By Walter W. Froggatt, F.L.S., Government Entomologist.

(Plate xiv.)

The members of the genus *Ceroplastes* are chiefly confined to the Tropics, and of the sixty-five species recorded in Mrs. Fernald's Catalogue of the Coccidæ of the World, fifty-three are described from the West Indies, Mexico, and Brazil; one is a native of Australia; and one, the "Indian Wax Scale," has become cosmopolitan, and, accidentally introduced into Australia, is a troublesome garden and orchard pest. These curious coccids have the power of producing a quantity of waxy secretion, forming a protective covering over the otherwise soft and naked female coccid. The secretion used by the cosmopolitan "Indian Wax Scale (*Ceroplastes ceriferus*) is soft and watery; that of the "Red Wax Scale" (*Ceroplastes rubens*) forms a hard crystalline box over the coccid; while the "Wild Mango Wax Scale" (*Ceroplastes murrayi*) produces a solid mass of hard, white, wax-like secretion, forming a rounded dome over the resting gravid female coccid.

I am indebted to my valued friend, Mr. George H. Murray, for a fine series of these wonderful coccids, which, he states, are very common on the branches of the wild mango growing in the forests fringing the Kikori River, Delta Division, British New Guinea. My thanks are due to the Under-Secretary of Agriculture (Mr. Geo. Valder) for permission to use the beautiful plate drawn by Mr. E. H. Zeck, of the Artists' Branch, at the Government Printing Office.

Ceroplastes murrayi, n.sp. (Plate xiv.).

First stage, ♀ *test*. Flattened star-shaped, slightly convex in centre, composed of crystalline plates, an oval one covering the back of the coccid, with encircling plates fitting round it. From this centre there are usually seven, but sometimes eight, flattened plates, broad at the base, but each terminating in a fine point standing out like the rays of a star. Width across, 4 mm.

First stage, ♀. Light brown with yellowish tints; dorsum slightly convex; general form oval, with two well-defined arcuate impressions on each side between the cephalic, thoracic and abdominal regions; rounded at the apex, with a deep anal cleft. At the base of cephalic region are three stigmatic spines with a group of small tubercles; at the base of the thoracic are three large projecting spines, with smaller ones on either side, and a much larger stigmatic spine on the dorsum; on either side of the anal cleft, a long stout spine and two small ones. Antennæ tapering, apparently composed of six joints, third longest. Legs long, femora thickened, tibia long, slender, tarsal claw pointed, digitules spatulate at tips. Length, 3 mm.

Second stage, ♀ *test*. Composed of white wax; the basal portion produced on the outer margin into seven, raised, rounded ribs, tapering to the extremities; a central rounded mass slightly constricted at the base, and depressed on the apex with a central keyhole-like pit directly over the back of the enclosed coccid. Height, 8 mm.

Test of adult ♀. A rounded bell-shaped mass of white wax. Height, $\frac{1}{2}$ inch; diameter, $\frac{3}{4}$ inch. The ribs or rays of the earlier stages, indicated by slight ridges down the sides, extending to short fingers on the basal margin.

Adult ♀. Chocolate-brown, probably dull red when alive; general form hemispherical, with the basal marginal fold fitting close against the bark; ventral surface contracted, forming a large cavity packed with eggs. The cephalic lobe densely chitinous. Derm with small, oval, translucent, glandular pores; anal process very prominent, apparently contracted at the extremity; stigmatic spines on the marginal fold projecting through the enveloping wax with filaments. Height, $\frac{1}{4}$ inch.

♂ unknown.

ON TWO NEW TRILOBITES FROM BOWNING.

By John Mitchell, late Principal, Technical College, Newcastle, N.S.W.

(Plates xv.-xvi.)

Dalmanites (Hausmannia) loomesi, n.sp.

(Pl. xv., figs. 1, 2; Pl. xvi., figs. 3, 4, 5).

Hausmannia meridianus, Eth. and Mitchell (in part), Proc. Linn. Soc. N. S. Wales, 1895, pp.504-509.

Complete form oval.

Cephalon subsemicircular, smooth, moderately convex, greatest length, 25mm., width, 58 mm. between the genal angles.

Glabella subpyriform, very gently tumid, depressed; anterior glabellar furrows wide, shallow, oblique and do not meet medially; second pair slit-like, do not communicate with the axial grooves, nor are they continuous transversely; third pair similar to second pair, but nearly reach the axial furrows; front glabellar lobe subellipsoidal, anterior pair subtriangular, second and third pairs more or less rectangular, the latter pair being rounded at the postero-lateral angles by the neck furrow; neck furrow deep and narrow towards the axial grooves, but faint medially, and has an anterior direction centrally and basally; its lateral extensions are wide and fairly deep, especially along their anterior boundary, thus giving to the portions of the fixed cheeks abutting them prominent faces; neck ring moderately arched, its lateral extensions narrow and prominent. Axial grooves wide and shallow. Fixed cheeks large, the portions between the posterior branches of the facial sutures and posterior furrows delicately wrinkled; genal lobe large, mildly convex, subpyriform, and separated from the palpebral lobes by a shallow furrow; genal angles bear spines reaching to the sixth and seventh thoracic somite. Free cheeks small, continuous, depressed, lateral furrows narrow and deep, borders very gently convex and diminish in width as they pass around the front of the glabella. Facial sutures follow the courses characteristic of the genus.

Thorax: greatest width, 57 mm., length, 30 mm., smooth or microscopically granular, mildly inflated; axis subspindle-shaped, the fifth and sixth rings being the widest, and from these the width gradually diminishes posteriorly, mildly convex, greatest width 12 mm., or about half as wide as the width of one side lobe, bases of rings very slightly swollen. Side lobes very mildly convex, medial furrows of somites wide and deep, the ridges of these, too, are strong, the posterior ones being thickened at the ends abutting the axial grooves, so as to appear mildly tuberculate; their terminals are claw-like.

Pygidium: triangular and smooth axis consists of 16 to 20 rings (dependent on the state of maturity), of which the last two or three are faintly outlined; only mildly convex, its width diminishes gradually posteriorly and terminates with less than one-third of the anterior spread inconspicuously, at the border; the six or more anterior rings have their bases gently thickened, those posterior to these very gradually become fainter, and towards the end annulations frequently seem to obsolesce; its greatest spread is approximately half as great as one side lobe. Side lobes mildly inflated, gradually sloping from near the axial grooves to the periphery; the pairs of segments number from eleven to fourteen according to the state of maturity reached by the individuals examined, and are very similar in structure to the thoracic somites, their ridges, furrows and articulating sutures crossing the border to the narrow, very gently thickened edge; each preceding pair has an increasing backward bend, so that the last pair is parallel with the axis line. Border wide, similar in convexity with the pleura; inwardly its boundary is indicated by a succession of fine linear ridges in the furrow of each pleuron; the under surface is finely and beautifully punctate; behind the axis it is continued into a short deltoid spine, that is not in any way connected with the pygidial axis, for at the inner boundary of the border the axis vanishes.

Obs.—When describing *Hausmannia meridianus* (These Proceedings, x., 1895, Pl. xxxviii., figs. 1-3, etc.) Mr. Etheridge, Junr., and myself joined with it the present form, under the impression that the differences in their pygidial mucros, etc., were insufficient reason for their separation, and were perhaps merely sexual variations. That this latter part of our conclusion is erroneous still remains to be shown, but the acquirement of much additional material of both varieties has proven that the differences between them are greater than was at first recognised by us; and that in one fairly important assumption made by us, we were in error, viz., that when the pygidial border was removed and bore the spine with it, the spinal or mucronal impression left was identical in both varieties. Further, a careful revision of a very large number of specimens of the two varieties now in my collection, goes to show that they differ from each other in so many respects, that their specific separation is, from my point of view, justified on scientific grounds. The differences between these two Australian forms seem to be quite as numerous and important, as are those between *Dalmanites caudatus* and *D. longicaudatus*, and, therefore, the two local forms present equally strong claims for separate specific distinction. The following is a tabulation of the differences between specimens represented on Plate xv., figs. 1 and 3:—

Tabulation of differences between *D. meridianus* and *D. loomesi* in the case of an almost perfect specimen of each, that of *D. meridianus* being the nearer to maturity. The measurements are in millimetres in every case.

Parts of the fossils contrasted.	Character of the parts in *D. meridianus.*	Character of the parts in *D. loomesi.*
i. Complete form—		
(*a*) Outline	Elongate oval.	Broadly oval.
Length and width		
(*b*) Length from front margin to outer edge of tail border	93 mm.	83 mm.
(*c*) Greatest width ... (at the genal angles)	53 mm.	57 mm.

Parts of the fossils contrasted.	Character of the parts in *D. meridianus.*	Character of the parts in *D. loomesi.*
ii. Cephalon—		
(*a*) Length	26·5 mm.	25 mm.
(*b*) Width	53 mm.	57 mm.
(*c*) Glabella	No marked difference.	
(*d*) Fixed cheeks ...	Slightly smaller.	Slightly larger.
(*e*) Genal lobes... ...	Slightly smaller.	Slightly larger.
(*f*) Extreme width between eyes ...	30 mm.	39 mm.
(*g*) Length of eye ...	10 mm.	11 mm.
iii. Thorax—		
(*a*) Length	37 mm.	31 mm.
(*b*) Width	50 mm.	58 mm,
(*c*) Axis	Fairly prominent.	Less prominent.
(*d*) Bases of axial rings ...	Strongly tuberculate	Very mildly tuberculate
(*e*) Proportionate width of axis to one side of lobe	14 : 20.	14 : 25
iv. Pygidium—		
(*a*) Length exclusive of mucro	30 mm.	28 mm.
(*b*) Width (greatest) ...	40 mm.	47 mm.
(*c*) Axial rings... ...	17.	16
(*d*) Axis	Terminally prominent.	Terminally not prominent.
(*e*) Pleural segments (pairs of)	10 to 12.	13
(*f*) Mucro	Continuous with the axis.	Not continuous with axis
(*g*) Impression of spine left after removal of the border ...	Long and acicular.	Short, triangular.

It appears that the generic term *Hausmannia,* proposed by Mr. Etheridge, Junr., and Mitchell (These Proceedings, 2nd Ser., x., 1895, p. 502) to take the place of *Dalmanites* Barr., and which had been previously suggested for a subgenus of *Dalmanites* by Hall and Clarke (Palæont. New York, Vol. lxxxi.), has been rejected by palæontologists; and for this rejection I am willing to admit there is very good reason, if there were no other than that *Dalmanites* has been so long in use and generally accepted; acting in compliance with this view the fossil above described is placed in the *Dalmanites* group, although it in some minor features differs from the genotype *D. caudatus* Brunn. For instance, in the present form there is a partial fusion of the first, second and third pairs of glabellar lobes by the partial or complete obsolescence of the second and third pairs of glabellar furrows as they approach the axial grooves; but this obsolescence has not sufficiently progressed to affect the pentamerous character of the glabella. It further differs from the genotype by the interruption, centrally, of the first pair of glabellar furrows, which, therefore, do not detach the frontal lobe from the rest of the glabella, as occurs in the case of *D. caudatus.* In these two modifications it shows the first steps of the specialisation developed so fully in the true *Phacops* group, but it is remarkable that, in the Australian Palæozoic seas, as far as research has yet revealed, a group represented by the species now under discussion, and by *D.* (*Hausmannia*) *meridianus* E. and M., exhibiting only a small degree of specialisation, should make its sudden appearance, associated with such highly specialised forms as *Phacops crossleii* E. & M., and *P. latigenalis* E. & M., and by the very highly specialised form described further on, unaccompanied by intermediate forms.

Besides the specialisation of the glabellæ noted above, the pygidia of our members of the *Dalmanites* branch, show transition towards the pygidial segmentation of the Devonian species of the branch, but do not exceed the segmentation allowed to be the limit for Silurian species by F. R. Cowper Reed (Geol. Mag., N.S., Dec. v., Vol. ii., 1905, pp.172-178 and 224-228), viz., 12-16. In the present species the pleural segments of the pygidium in individuals nearing maturity range from twelve to fourteen, and in *D.* (*Hausmannia*) *meridianus* ten to twelve. The largest pygidium of the species now described possesses twenty axial rings and fourteen pairs of pleural segments. In *D. meridianus* these similar divisions are seventeen and twelve respectively for the largest known specimens. Mr. Reed (*loc. cit.*) refers to the absence of the Silurian forms of *Dalmanites* from Bohemia, and particularly from the typical Silurian horizon, Barrande's étage E. It is somewhat interesting to note that the lower Trilobite Beds of our Bowning Series, judging by the trilobite fauna they have yielded, are homotaxial with the beds forming Barrande's étage E.

and that from these Bowning Beds the Silurian *Dalmanites* group of trilobites is absent, just as it is from étage E of the Bohemian rocks. Recent study of the Bowning Series reveals a great break in the sedimentary continuity between the Lower and Middle Trilobite Beds of the Bowning Series, which when properly investigated, may greatly affect our conclusion respecting the age of the Middle Trilobite and succeeding Beds. Until the Family *Phacopidae* was dealt with by Etheridge, Junr., and Mitchell, the trilobite now under review was generally considered to be *Dalmanites caudatus*, but when the forms are contrasted it is seen they differ very much from each other. As far as I have been able to ascertain, *D. perce-ensis* Clarke (New York State Mus., Bull. 107, 1907, pp. 157-158) is one of the most closely related to our species; but it differs from ours in possessing from fifteen to seventeen pleural segments in the pygidium, etc. Dedicated to Mr. F. Loomes, of Bowning, who obtained the fine specimen represented on Plate xv., fig. 1.

Loc. and hor.: Near Bowning Railway Station, Parish of Bowning, County Harden; Yass-Burrowa Road, Lime Stone Creek, Parish of Derrengullen, County King, etc. Upper and Middle Trilobite Beds, Bowning and Yass Series, Upper Silurian, and perhaps in the upper zone of its occurrence, Lower Devonian.

On examining my trilobite specimens recently I came across one so different to any other known to me that I have thought it necessary to make of it the type of a new genus.

Order **PROPARIA.**

Family PHACOPIDÆ.

Subfamily PHACOPINÆ (Reed).

Genus ADASTOCEPHALUM,* g.n.

Gen. chars.—Glabella subquadrate, mildly rounded in front, sides straight, only gently converging to the neck ring; lateral glabellar furrows and lobes absent.

The outstanding features of this new type are the complete

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* *αδαστος*, undivided.

absence of glabellar furrows and lobes; the small convergence of the axial furrows posteriorly, squat condition of the eyes and mild convexity of the cephalon.

ADASTOCEPHALUM TELEOTYPICUM, g. et sp.n.

(Plate xvi., figs. 1 and 2).

Sp. chars.—*Cephalon* mildly convex, finely granular, and subsemicircular. Glabella only moderately convex, gently rounded in front, sides rather straight. Neck furrow deep, neck ring moderately arched, bases strongly directed forward, and interrupting the continuity of the neck furrow laterally. Limb very narrow. Axial grooves deep, and only converging moderately, posteriorly. Cheeks relatively small, gently convex, genal and palpebral lobes ill-defined; posterior furrows narrow, deep, and with the lateral furrows, which are shallow, form almost a semicircle; posterior ridges narrow, strongly directed anteriorly and merging into the depressed lateral borders in such a way as to obliterate the genal angles. Eyes not prominent, rather squat, and they and the palpebral lobes are indistinctly separated from the genal lobes; in th central rows of eye facets there appear to have been four individuals in each row.

Obs.—The subject of this description is a headshield, of which the left cheek is much damaged, but the rest is fairly perfect, except that the right eye is somewhat distorted. This form is just such as could reasonably have been expected to make its appearance before the close of, say, the lower Devonian period, and apparently marks the limit of specialisation in the glabellæ of the true Phacops group. Perhaps the nearest relatives of the form now under consideration are *Ph. logani* Hall, *Ph. rana* Green, and *Ph. hylanderi* Clark, for in each of these species the first and second pairs of gabellar furrows are obsolesced. It is also worth noting that our highly specialised type occurs associated with *Ph. crossleii* and *Ph. serratus*, which possessed the normal glabellar furrows, though faintly defined. The limb or front lobe of the glabella in each of these two species is obsolete, but in the new form this limb is present, but indistinctly outlined. For purposes of comparison and contrast photos of the above two Bowning species will be found on the plates illustrating this paper. Other associates are *Ceratocephala longispinosa* Mitchell, *Odontopleura* (*Acidaspis*) *jenkinsi*, and *O. rattei*, and a coral which is thought to be *Pleurodictyum megastomum* McCoy. The occurrence of the latter fossil, together with many lamellibranchs not yet determined, but which, if not actually Devonian species, are closely allied to them, indicates that it is more than likely that the upper beds of the Bowning stratified rocks will prove to belong to the lower Devonian horizon, although up to the present Mr. Etheridge and myself have considered these beds to be Upper Silurian or passage beds between these two formations.

Loc. and hor.—Near the railway station, Bowning township. Parish of Bowning, County Harden, N.S.W. Upper Trilobite Bed. Probably Lower Devonian.

(*Note.*—In my paper "The Carboniferous Trilobites of Australia" (Proc. Linn. Soc., N.S.Wales, xliii., 1918, pp. 437-494, Pls. 46-53), a few omissions and errors occurred. These I wish to have the privilege to correct.)

Explanation of Plates.

Plate xliii., fig.9.—*Read*—Medial portion of a cephalon much weathered (Coll. Queensland Mus., No.707).

Plate xlix , figs. 1, 2, 3, 4, and 6 are photos of wax impressions of casts; fig. 6 is the counterpart of fig. 5. Figs. 3 and 4 are from Malchi Creek, near Rockhampton, Queensland.

Plate lii., fig.2 represents specimen F1031 and not F1017 of the Queensland Geol. Surv.

Plate liii., fig 9, represents Pl. vii., fig.11, Geol. and Pal. Queensland and New Guinea.

Page 465, last line—*for* figs.5-6, *read* fig.5.

EXPLANATION OF PLATES.

Plate xv.

Dalmanites loomesi Mitchell.

Fig. 1.—An almost perfect individual, slightly enlarged

Fig. 2.—A fine pygidium showing about 20 rings in the axis and 14 segments in the pleura, and the absence of connection between the axis and tail spine, etc. The pygidium belonged to an individual that had a length approximately of four and a half inches. ($\times \frac{5}{3}$). (Coll. Mitchell).

Hausmannia (Dalmanites) meridianus E. & M.

Fig. 3.—The photo of the original type specimen of *Hausmannia meridianus* E. & M.; contrasting this with fig. 1 of this Plate, the differences between the two species will be very evident. (× ½ nearly).

Fig. 4.—A pygidium showing 12 pleural segments and the extension of the axis into the spine. (× ⅔). (Coll. Mitchell).

Phacops crossleii E. & M.

Fig. 5.—An almost perfect specimen for comparison and contrast with *Adastocephalum teleotypicum*. (× about 2). (Coll. Mitchell).

Phacops serratus E. & M.

Fig. 6.—A very fine specimen of a young individual given to compare and contrast with *Adastocephalum teleotypicum*. (× about 2). (Coll. Mitchell).

Plate xvi.

Adastocephalum teleotypicum Mitchell.

Fig. 1.—Photo of the only portion of the glabella known; shows the generic and specific features fairly well. (× about 2). (Coll. Mitchell).

Fig. 2.—The same with outline restored.

Dalmanites loomesi Mitchell.

Fig. 3.—Photo representing portion of a thorax, and complete pygidium, except for the removal of a part of the border. Shows the imperceptible mergence of the thoracic axis into the pygidial axis, etc. (Coll. Mitchell).

Fig. 4.—Another photo of the same specimen shown on Plate xv., fig. 1, with the defective part restored (Reduced). (Coll. Mitchell).

Fig. 5.—Side view of an eye; (× about 3). (Coll. Mitchell).

Hausmannia (Dalmanites) meridianus.

Fig. 6.—Photo from a squeeze of the counterpart of a pygidium showing the long acicular spine or telson; (× 2). (Coll. Mitchell).

Fig. 7.—Pygidium of a mature individual showing twelve pleural segments and their characters clearly.

AUSTRALIAN *STRATIOMYIDÆ (DIPTERA)*, WITH DESCRIPTION OF NEW SPECIES.

By Gerald F. Hill, F.E.S., Entomologist, Australian Institute of Tropical Medicine, Townsville, N.Q.

In his revision of the Australian *Stratiomyidæ*, White* lists 30 species belonging to 18 genera. In the following paper the writer proposes six new species, belonging to five genera, of which two genera have not been recognised hitherto in Australia. The apparently rare fly *Negritomyia albitarsis* Bigot, previously known from Papua and Queensland, is recorded from the Northern Territory.

The specimens are all in a perfect state of preservation. Their examination for the purpose of description was made in daylight, with No. 4 ocular and 2 inch objective. Measurements are given in millimeters. The figures were outlined with camera lucida.

Family STRATIOMYIDÆ.

Subfamily BERINÆ.

Actina victoriæ, n.sp. (Figs. 1*a*, 1*b*, 1*c*).

♂. Total length, 6·0; wing, 4·7.

Frons, vertex and thorax dark bronze-green; antennæ black; abdomen dark brown, with brownish yellow areas on segments three, four and five.

Head wide (1·55), wider than prescutum (1·30); eyes separated by a space (the frons) of ·15, widening to ·30 at the vertex; vertex, upper part of frons, and clypeus clothed with long black hairs; lower part of frons and sides of face covered with silvery tomentum, genæ clothed with long white hairs; antennæ inserted slightly above the middle of the head in profile, ·90 long, first and

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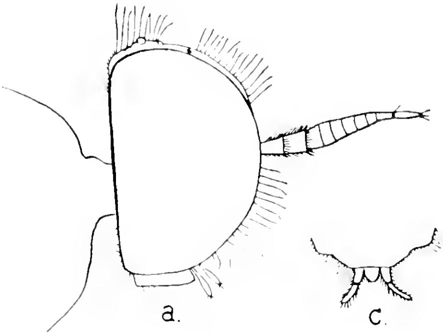
* These Proceedings, Vol. xli., 1916, Pt. 1, p. 71.

second joints about equal (·15), both covered with stiff black hairs, third joint longest (·45) with seven indistinct segments and a terminal style (·15 in length) bearing three or four long hairs at the apex; palpi black; mouth parts stramineous; eyes only moderately hairy, clypeus and lower part of frons not projecting, and the ocellar plate projecting only very slightly in front of the eyes (Fig. 1*a*).



Text-fig. 1.

Actina victoriae, n.sp.; *a*, male; *c*, female.

Thorax densely covered with long black and short pale hairs; scutellar spines long, bases dark like scutellum, the remainder pale yellow; halteres pale stramineous.

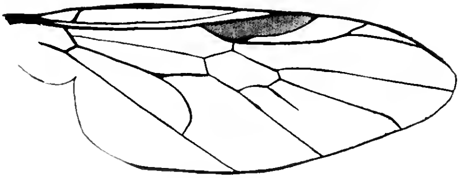
Legs: fore- and mid-legs dark ochraceous, with second-fifth tarsals brown; hind legs similar, but with distal half of femora and tibiæ dark brown or suffused with brown.

Wings light smoky, veins and pterostigma brown, third posterior vein extending one-third of the distance to the wing border (Fig. 1*b*).

Abdomen long and narrow (3·75 long by 1·35 wide), the sides clothed with long pale hairs; the greater part of the dorsum of the third, fourth, and fifth segments occupied by a brownish yellow area, roughly triangular in shape, the apex directed posteriorly.

♀. Total length, 5·0; wing, 4·40.

Frons, vertex and thorax dark bronze-green; antennæ rusty red shading into black beyond the second joint; abdomen bright orange brown with brownish-black segmentations, the first and seventh segments entirely brownish-black; genitalia prominent, bright orange brown (Fig. 1*c*).



Text-fig. 1*b*.
Actina victoriæ, n.sp., male.

Head (1·30 wide), narrower than in male, wider than prescutum (1·15); eyes (·30 apart) parallel on their inner margins, no long black hairs on vertex and frons and very few on clypeus; genæ as in male, mouth parts yellowish; palpi dark ochraceous; eyes almost hairless; antennæ about ·85 long, first and second joints rusty red and clothed with short stout black hairs, third joint entirely black, or shading from rusty into black towards its apex; style black.

Thorax without long black hairs. Legs dark ochraceous, second and fifth tarsals of each leg and the apices of the femora and tibia of the hind legs shaded brown.

Hab.—Vic.: Ararat, April 1917.

Described from two females and nine males taken on the wing from a small flight at Native Cherry Tree (*Exocarpus*).

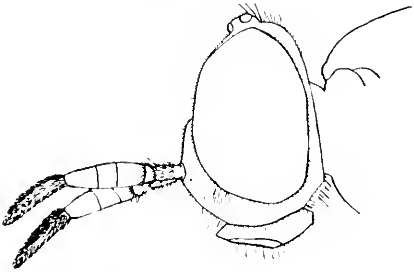
Subfamily CLITELLARINÆ.

NEGRITOMYIA ALBITARSIS Bigot. (Fig. 2).

♀. Total length, 10-11: wing, 9·5.

Clypeus, head, thorax and abdomen black, covered with silvery pubescence; dorsum of thorax, scutellum and scutellar spines with black hairs

Head: eyes nearly parallel along the inner margins, densely clothed with short silvery pubescence; ocellar triangle prominent, hairy; frons wide (·70), sides clothed with silvery pubescence; clypeus densely pubescent; mouth parts dark brown. Antennæ dark buff, the first and second joints clothed with stout black hairs, third joint bare, with three fairly distinct segments, the first longest, the second longer than the third; style black, densely clothed with black hairs (Fig. 2).



Text-fig.2.
Negritomyia albitarsis, Bigot, female.

Thorax narrower than abdomen, prescutum slightly wider than head, scutum (3·5) wider than prescutum; side spines stout, black, shining; scutellar spines long, black at base, yellowish brown at tip.

Wings dark smoky with clearer areas towards middle and base.

Legs: femora and tibiæ black, knees and first tarsi light yellowish brown remaining tarsi darker.

Abdomen (6 long and 4 wide) black with silvery pubescence chiefly on sides and median line of segments 3, 4 and 5. Genitalia rather prominent, yellowish.

Hab.—Northern Territory: Darwin, October, 1916.

Three females taken on foliage of garden plants.

(*Note.*—Bigot's specimen (female) is from Papua*. The male is unknown to me. White† describes a male from Mackay, Queensland, in Froggatt's collection.)

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* Ann. Ent. Soc. Fr., 1879, p.207.

† These Proceedings, Vol. xli., 1916, Pt.1, p.83.

HERMETIA PALLIDIPES, n.sp. (Figs.3*a*, 3*b*).

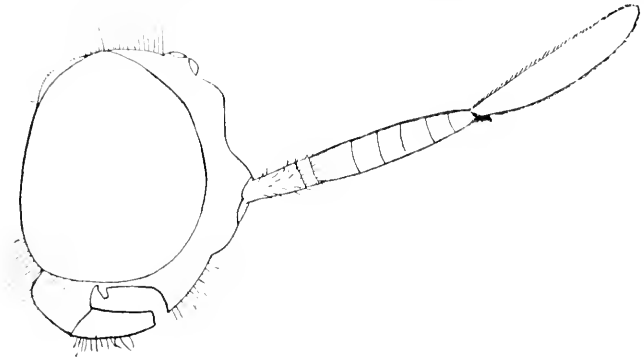
♂. Total length, 13; wings, 11·5.

Clypeus, frons, vertex, humeral calli, a small area at the posterior angles of the prescutum, another at the posterior angles of the scutum, the apex of the scutellum, the pronotum, and the episternum pale horn colour; the knob of the halteres and two large spots on the anterior margin of the second abdominal segment pale greenish fading to yellowish after death; thorax black; abdomen black with silvery reflections on second, third, and fourth segments; mouth parts creamy buff; antennæ rusty red.

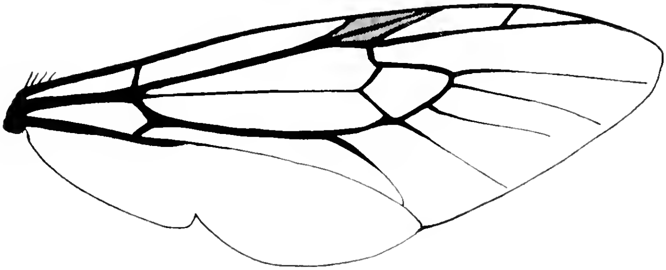
Head wide (♂, 4·5, ♀, 3·80), wider than long (♂, 2·75, ♀, 2·50); eyes densely pubescent, widely separated; clypeus wide (♂, 2·05, ♀, 1·75), projecting well in front of head, clothed with moderately long white hairs; genæ clothed with long white hairs; frons wide, projecting, the sides converging slightly towards the vertex, an oval, dark area, as long as the frons is wide, occupying the middle of the frons; ocellar tubercle small (·40 wide), black, with a few dark hairs, a small area above it dark; vertex wide (♂, 2·0, ♀, 1·25) with numerous long white hairs. Antennæ 5 mm. in length, first joint (·55) nearly four times as long as second, proximal half black, the remainder rusty red like the second, both joints widest at apex and clothed with short, stout, black hairs; third joint clothed with golden pubescence, long (2·0), tapering gradually to the apex, with six indistinct segments, the first three rusty, the others shading into dark brown; style as long as third joint, dark brownish black, convex and densely clothed with short stiff black hairs on one side, concave and bare on the other. (Fig. 3*a*).

Thorax finely punctate; prothorax small, narrow (1·35), inconspicuous, glabrous; prescutum (2·85) much narrower than head, clothed with white hairs (longest on sides), and a few black hairs; scutum (3·5) wider than prescutum; scutellum not spined (generic character), rounded at the apex, clothed with short hairs above and longer hairs on the sides.

Legs: femora black, fore- and mid-tibiæ with proximal half creamy, remainder suffused with light brown, densely clothed with short white hairs; tarsi creamy buff, hind tibiæ with apical two-fifths dark brown, otherwise like fore- and mid-tibiæ. Wings smoky brown, lighter near base, nervures darker; base of large nervures setose, surface of wing clothed with minute hairs, those on the anal lobe longest, pterostigma small, as dark as nervures. Venation as shown in Fig. 3*b*.



Text-fig.3*a*.
Hermetia pallidipes, n.sp., male.



Text-fig.3*b*.
Hermetia pallidipes, n.sp., male.

Abdomen at widest part, *i.e.*, the second segment, as wide as scutum, tapered gradually to the truncate apex; first segment with short dusky and long white hairs; second, third and fourth segments broadly margined posteriorly with silvery pubescence, the remainder of each segment clothed with short black pubescence, fifth segment black.

♀. Similar to ♂. Antennæ about 4 mm. long, first and second joints dark buff, the former (·40) twice as long as the latter; vertex less hairy than in male, abdomen relatively shorter and broader; silvery pubescence on abdomen less conspicuous.

Hab.—Northern Territory: Darwin, 13th Feb., 1915.

Described from one male and one female, taken on foliage of garden plants.

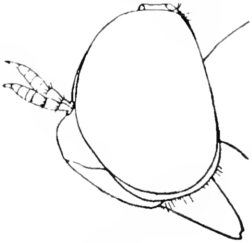
(*Note.*—This genus has not been recorded previously from Australia.)

Subfamily STRATIOMYINÆ.

ODONTOMYIA PALLIDA, n.sp. (Figs.4*a*, 4*b*).

♂. Total length, 7; wing, 5·75.

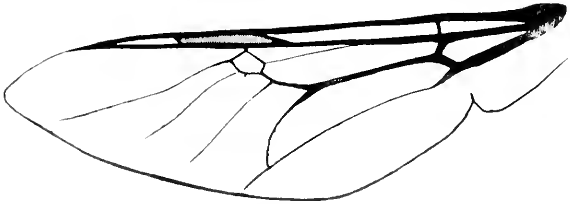
Head wider than long (2·55 by 1·90); eyes: upper half lighter-coloured and more coarsely facetted than lower, widely separated below, converging immediately above the insertion of the antennæ; antennæ dark ochraceous, arising about the middle of the head in profile, ·90 in length, first and second joints equal in length, fringed with a few short stiff hairs at apex, third joint long with four indistinct segments and a short terminal style; clypeus light stramineous, prominent, triangular, bare; genæ light stramineous, with a few short hairs, parafacials prominent; proboscis brownish black; ocellar plate black, longer than wide, with a few short golden hairs and broad scales (Fig. 4*a*).



Text-fig.4*a*.
Odontomyia pallida, n.sp., male.

Thorax blackish, completely covered with short golden yellow hairs and broad scales, producing a brassy appearance, apex of scutellum dark ochraceous, rounded and armed with two very small spines, humeral calli and pleura dark stramineous, sternum blackish. Halteres pale greenish yellow. Legs uniform dark stramineous.

Wings hyaline, veins and pterostigma pale yellowish; the posterior veins, excepting the base of the first and fourth, very indistinct, only a vestige of the third, the fourth issuing from the second basal cell (generic character), none reaching the wing border. (Fig. 4*b*.)



Text-fig.4*b*.
Odontomyia pallida, n.sp., male.

Abdomen pale stramineous, anterior half of first segment dark brown medially, this area becoming narrower and obscure posteriorly, scarcely visible in the anterior border of the second segment, but darker and wider posteriorly, widening and occupying nearly the whole of the third and the entire fourth segments.

10 ♀. Unknown.

Hab.—Northern Territory: Darwin, July, 1918. Type unique.

ODONTOMYIA OBSCURA, n.sp. (Figs.5*a*, 5*b*).

♀. Total length, 12; wing, 9.

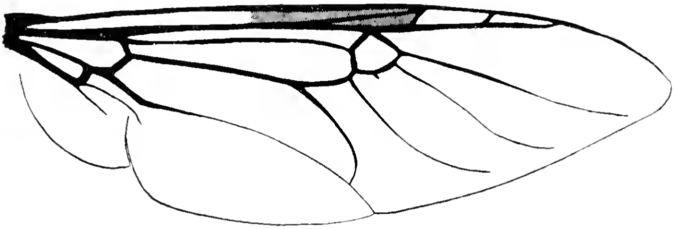
Head: eyes finely facetted throughout, widely separated, converging from 2 mm. about the middle of the frons to 1·45 mm. at the vertex. Vertex, ocellar plate, and upper part of frons black, with a few short golden hairs; lower part of frons, the clypeus and genæ dark stramineous; proboscis black; frons with a deep median suture extending from the ocellar plate to the insertion of the antennæ; antennæ arising slightly above the middle of the head in profile, 1·5 in length, rusty red freckled with white, bare excepting for a few short stout hairs at apex of second joint; first and second joints equal in length (·20), third joint nearly five times as long (·95), style short (Fig. 5*a*).

Thorax black, clothed with short golden hairs, longer towards the sides; posterior border of scutellum rounded, dark stramineous, with two moderately long spines and some long golden hairs; pleura and halteres pale stramineous; sternum blackish.

Legs dark ochraceous, tarsi of hind legs rusty.

Text-fig.5*a*.
Odontomyia obscura, n.sp , female.

Wings hyaline, costa and sub-costa dark ochraceous, other veins and the pterostigma brown: third posterior vein reduced to a short spur, none of them quite complete (Fig. 5*b*).



Text-fig.5*b*.
Odontomyia obscura, n.sp., female.

Abdomen: first segment dark brownish black with greenish yellow spot at each side; second segment with triangular brownish black mark occupying about half the segment, the remainder brownish, with obscure greenish blotches; third segment similar; fourth segment chiefly dark brownish black, sides similar to segments 2 and 3; fifth segment chiefly dark brownish black, remainder mottled with brown and greenish; on the ventral side the first segment greenish yellow, the remaining segments dark brown.

♂. Unknown.

Hab.—Northern Territory: Darwin, 4th June, 1916. Type unique.

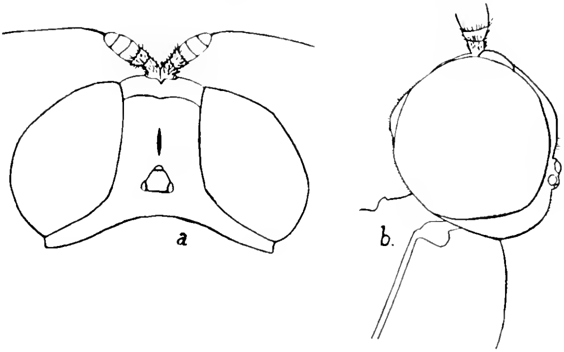
Subfamily SARGINÆ.

SARGUS GSELLI, n.sp. (Figs. 6*a*, 6*b*, 6*c*).

♀. Total length, 7·5; wing, 6·0.

Head, thorax and abdomen metallic peacock blue to metallic cyanine blue, lower part of frons silvery, clypeus black, mouth parts yellowish.

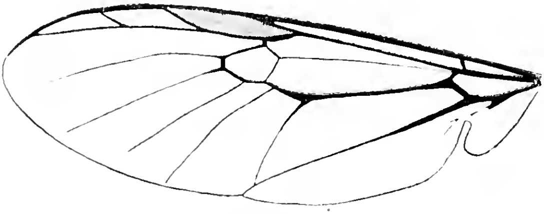
Head wide (2·40), wider than presentum (1·60); eyes bare; antennæ pale rusty, arising from about the middle of the head in profile; first and second joints about equal in length (·10), clothed with short stout hairs; third joint three times as long as the first with two long hairs at apex; arista long (·90), terminal; frons convex, ·65 wide, increasing to ·80 at vertex, almost hairless, a cleft-like suture down median line from ocellar triangle to near the insertion of the antennæ. Ocellar triangle prominent, occupying about one-third of the width of the vertex; clypeus black, almost hairless; proboscis stramineous. (Figs. 6*a* and 6*b*).



Text-figs. 6*a*, 6*b*.
Sargus gselli, n.sp., female.

Thorax with fairly prominent humeral calli, nearly parallel along the sides, 1·75 wide; scutellum bluntly rounded behind, the whole thorax lightly clothed with short pale hairs.

Legs: fore legs with coxæ, trochanters and tarsi pale stramineous, distal half of femora and proximal half of tibiæ suffused with brown, the remainder pale stramineous, mid legs similar, with entire tibiæ blackish; hind legs, coxæ and distal half of femora blackish; tibiæ and tarsi pale stramineous suffused with brown. Wings pale smoky, veins and pterostigma dark brown; venation as shown in Fig. 6*c*.



Text-fig. 6*c*.
Sargus gselli, n.sp., female.

Abdomen about as wide as head, parallel on the sides, posterior margin of segments bordered with short white hairs. Genitalia prominent.

Hab.—Northern Territory: Bathurst Island, October, 1916. Type unique.

Named in honour of Reverend Father Gsell, whose hospitality and cordial assistance are freely extended to visitors to this locality.

The intense colouring of this species renders it a conspicuous object. Hitherto the genus has been known in Australia by only one described species, *S. meridionalis* White. There are one or two additional species in the Australian Institute of Tropical Medicine, Townsville, from North Queensland (Kuranda).

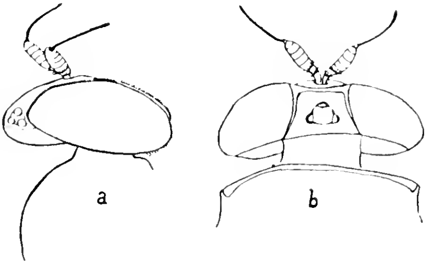
Subfamily PACHYGASTRINÆ.

WALLACEA DARWINI, n.sp. (Figs. 7*a*, 7*b*, 7*c*).

♀. Total length, 4·25; wing, 4.

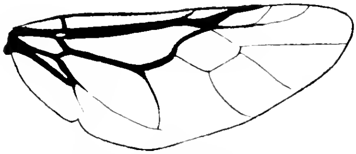
Head, thorax, abdomen, femora, tibiæ black; tarsi, wing, veins, pterostigma, antennæ ochraceous; wings hyaline.

Head wide (1·65), as wide as prescutum, eyes finely facetted, nearly parallel on inner margins, with scattered, fine, whitish hairs; clypeus glossy black, convex, depressed in the median line, with a few short, silvery and black hairs, bordered laterally by a narrow fringe of silvery pubescence; genæ greatly reduced, clothed with blackish hairs; antennæ inserted above the middle of the head in profile, pale rusty, covered with short hairs, first joint short (·048), as wide as long, second joint about as long as first, widest at apex, apices of first and second joints fringed with short, stiff hairs, third joint long (·304), widest in the middle, with five fairly distinct annulations, arista long (·60) arising from a raised tubercle, densely clothed with short white hairs; frons wide (·45), glossy black, a few hair-like whitish scales near the depressed median line; ocellar plate prominent, occupying more than half the width of the vertex, black, rugose, with a few black hairs; vertex as wide as frons, with a few black hairs. (Figs. 7*a* and 7*b*.)



Text-fig. 7*a*, 7*b*.
Wallacea darwini, n.sp., female.

Thorax widest at insertion of wings (1·85); humeral calli prominent, on either side of the scutellum there is a prominent disc-like process (prealar callus) projecting (·15) horizontally from the thorax; scutellum large, (·75 long), triangular, armed with two long (·30), stout, apical spines (generic character), and about seven somewhat irregular and smaller stout spines on either side, a patch of silvery scales near apex. The whole upper surface of thorax and the pleura clothed with moderately short, stout, black hairs and narrow silvery scales, the latter giving the appearance of silvery dusting; sternum clothed with silvery hairs; the entire thorax and abdomen minutely punctured. Wings hyaline, principal veins thickened, the three posterior veins all reaching the wing border. Halteres with brownish stem and stramineous knob (Fig. 7c).



Text-fig. 7c.
Wallacea darwini, n.sp., female.

Legs: forelegs black, excepting joints and proximal ends of tibiæ, which are brownish, tarsi densely clothed with short, stout, black hairs; mid-legs black, excepting apices of femora and the first four joints of the tarsi, which are ochraceous, fifth joint and claws dark, tarsi clothed with short, stout, black hairs; hind-legs similar to mid-legs. Pulvelli and empodia large.

Abdomen wide (2·75), wider than long, clothed with black hairs (silvery in some lights), a conspicuous patch of silvery scales on the dorsum of the fifth segment, except in the median line, similar but fewer scales on dorsum of fourth segment, nearly absent from third segment, a smooth bare patch in the middle of the anterior margin of the fourth segment, wider and occupying the whole of the middle of the fifth segment. Genitalia conspicuous.

♂. Similar to ♀. Total length, 3; wing, 3.

Head wide (1·25), wider than presentum (1·15), frons wide (·320).

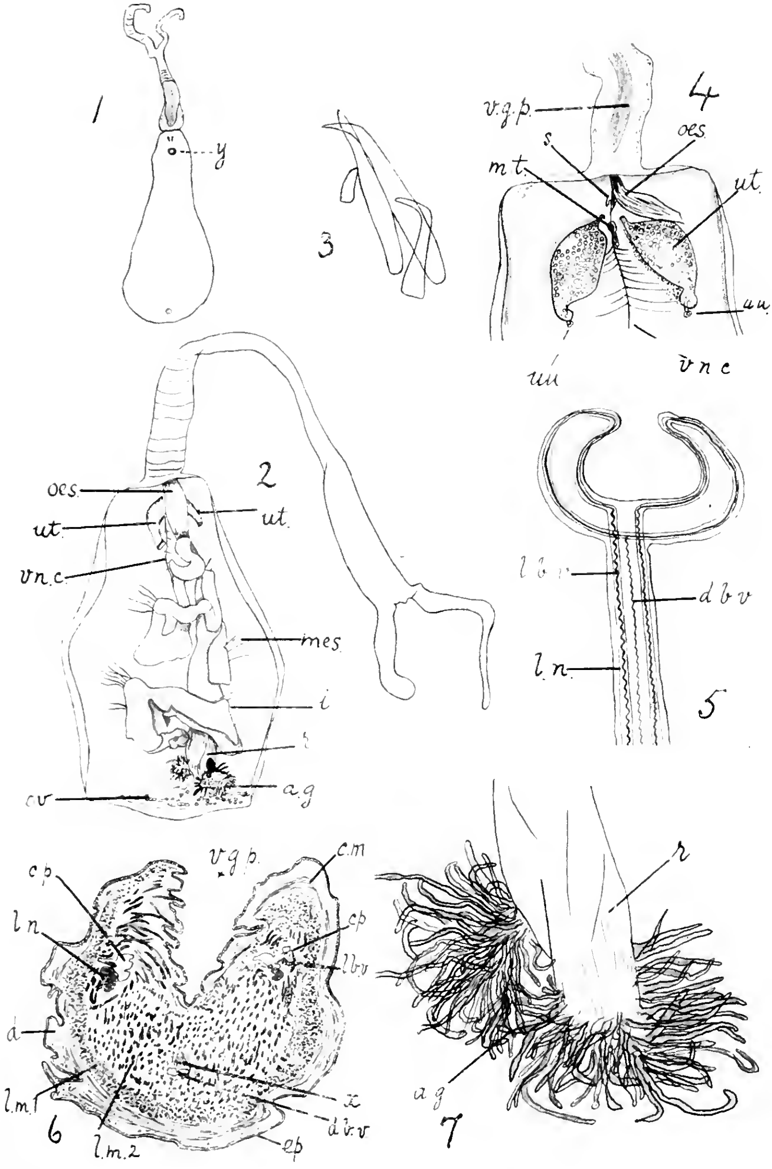
Thorax 1·30 at insertion of wings.

Legs similar to ♀, excepting that the tarsi of mid-legs are ochraceous. Halteres brownish, knob white.

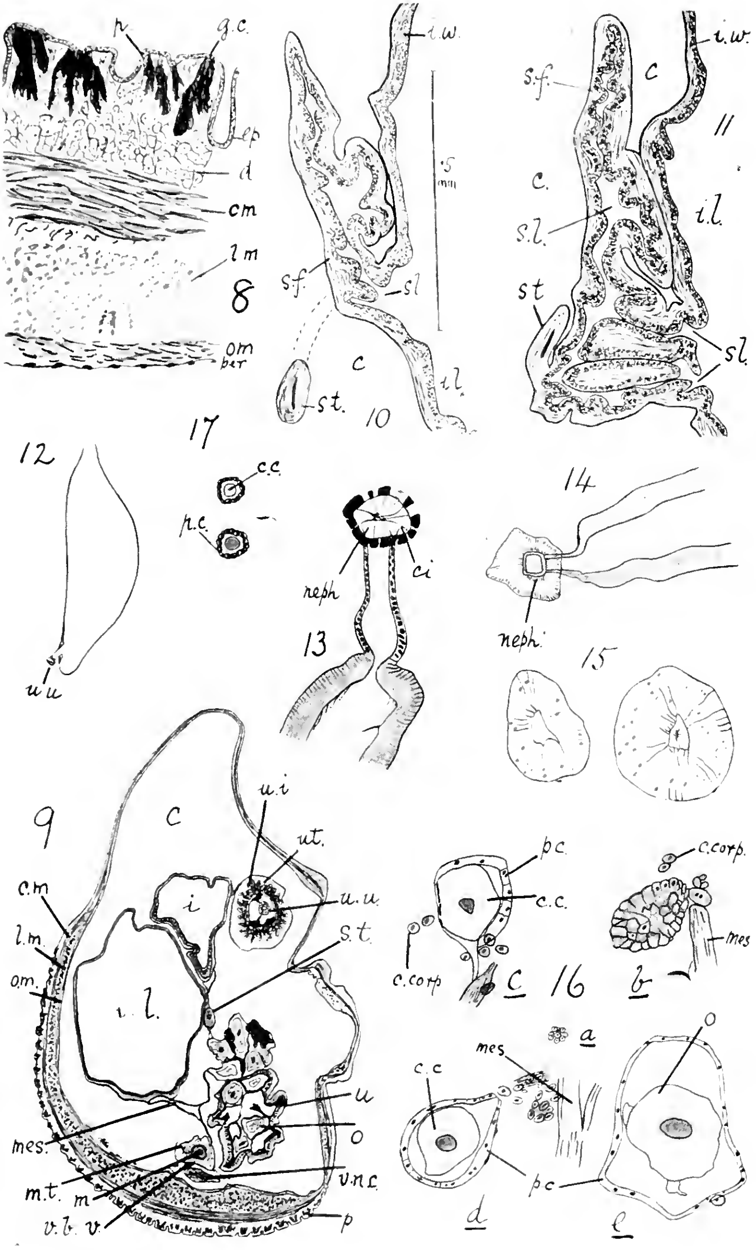
Hab.—Northern Territory: Darwin, June, 1918. Both species were taken on a citrus leaf.

(*Note.*—This genus has not been recognised hitherto in Australia.)

[Printed off, 27th September, 1919.]



Pseudobonellia biuterina, n. gen. et sp.



Pseudobonellia biuterina, n. gen. et sp.

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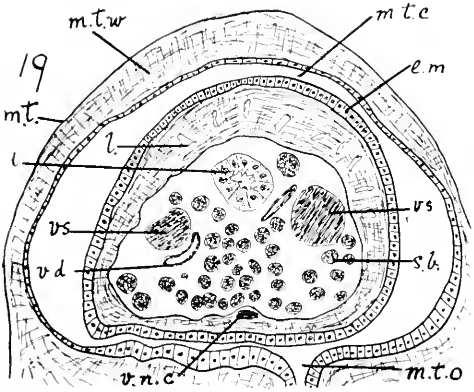

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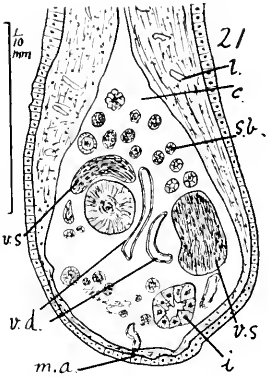

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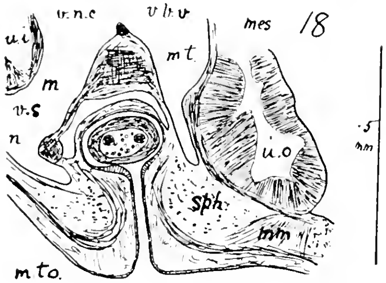

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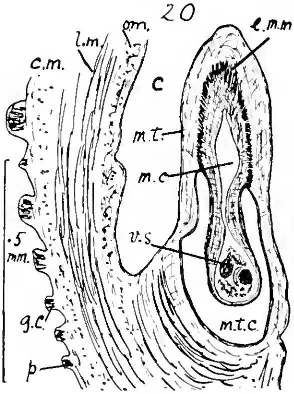

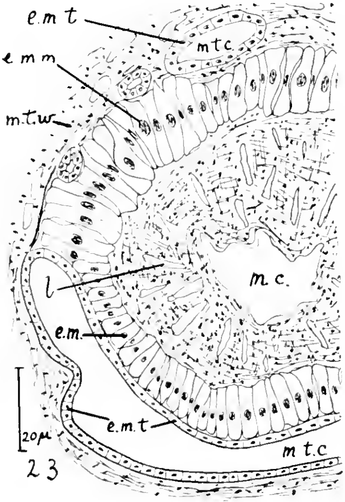

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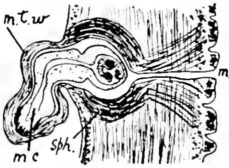

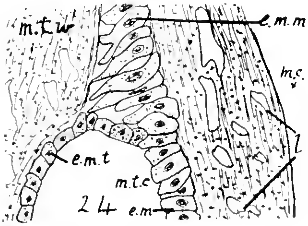

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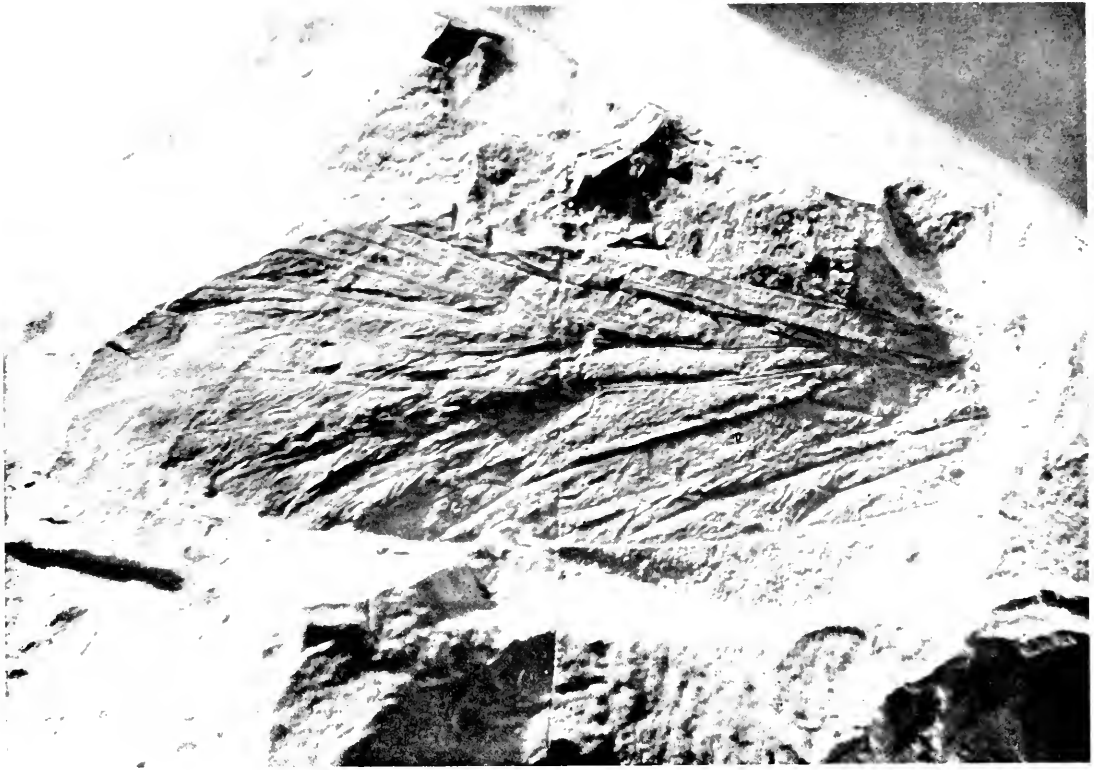
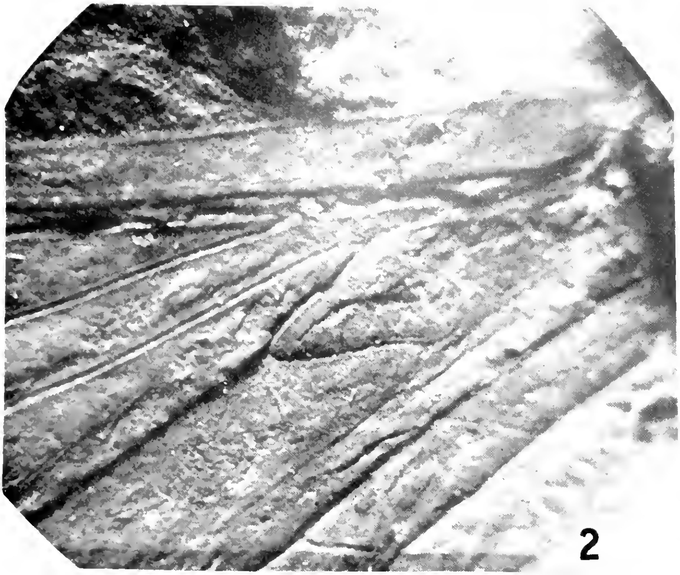
Pseudobonellia biuterina, n. gen. et sp.



Belmontia mitchelli, n. gen. et sp.



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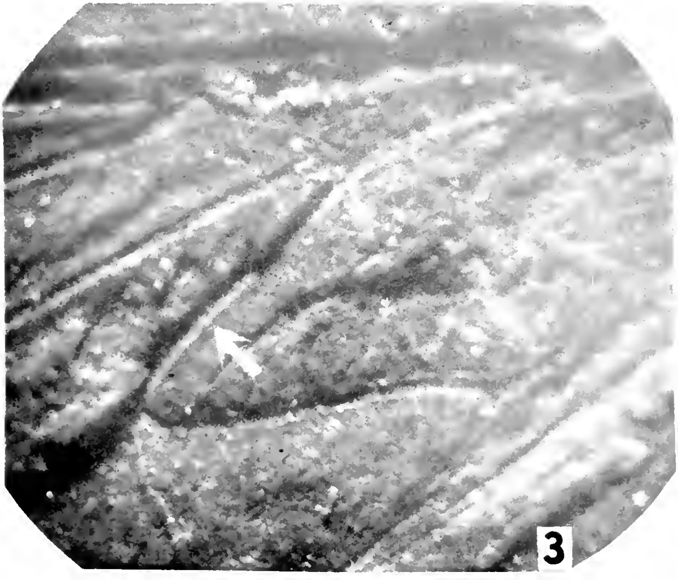

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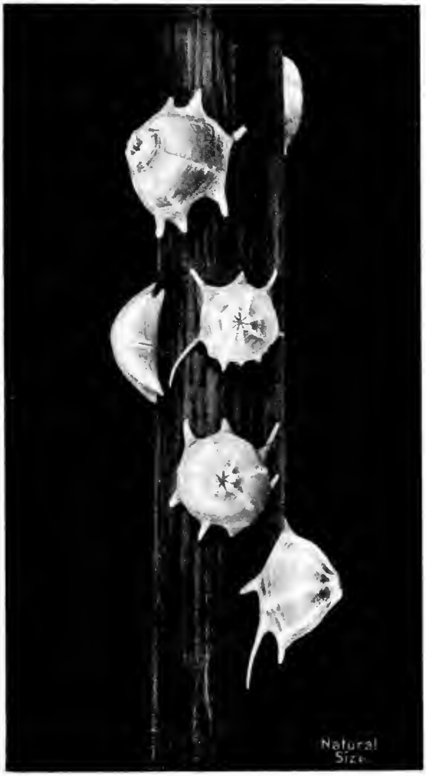
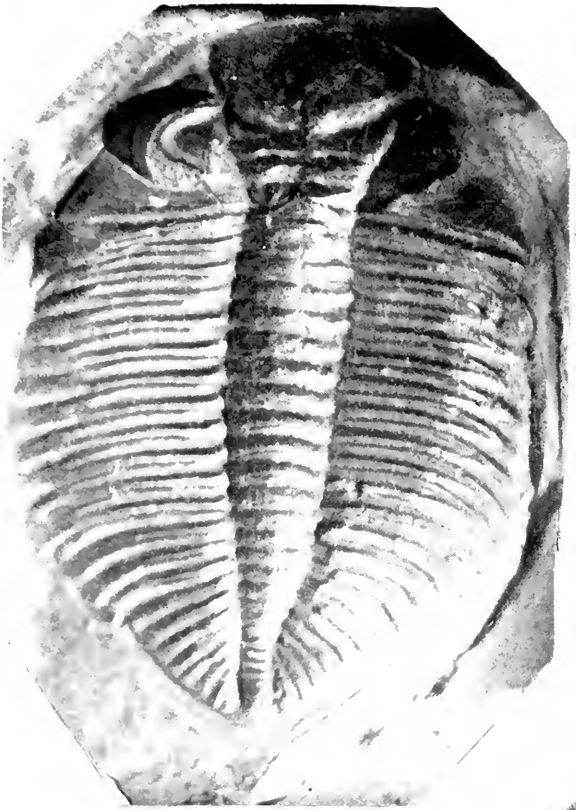
Belmontia mitchelli, n. gen. et sp.



Ceroplastes murrayi, n. sp.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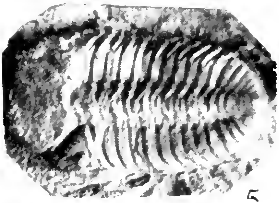
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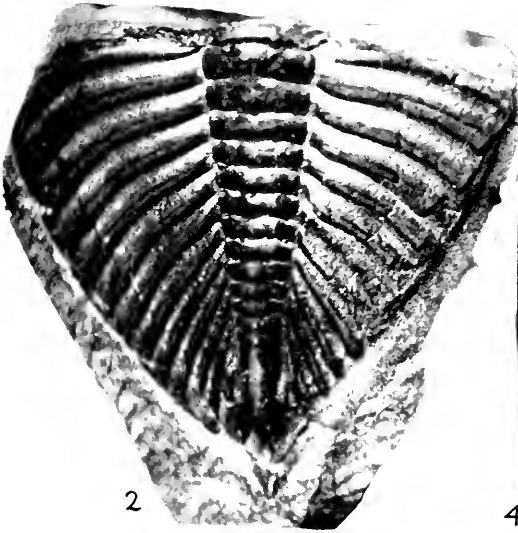
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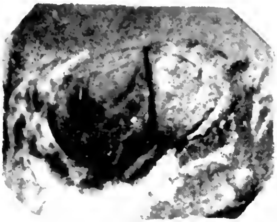
Trilobites from Bowning (*Dalmanites*, *Hausmannia* and *Phacops*)



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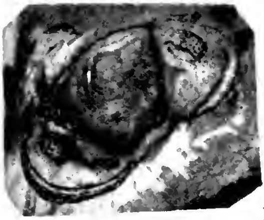

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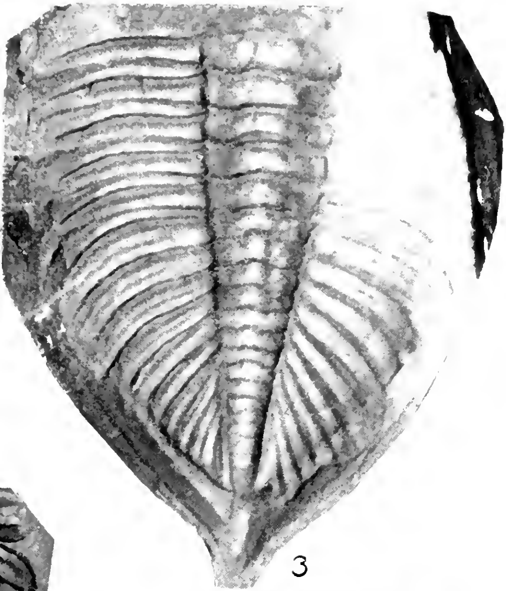

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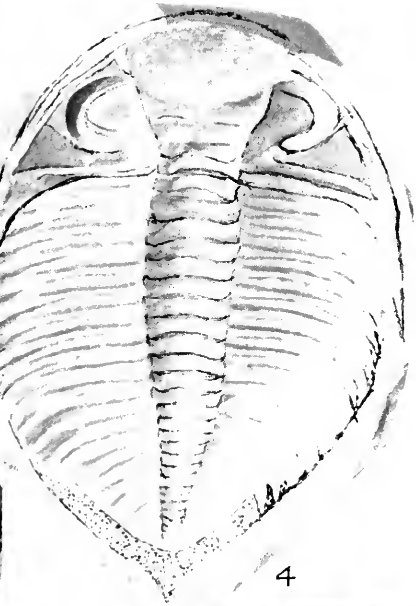

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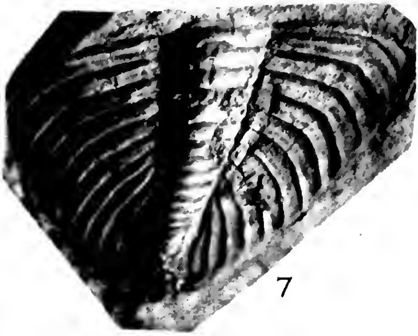

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Trilobites from Bowning (*Adastocephalum*, *Dalmanites* and *Hausmannia*).

AN ECOLOGICAL STUDY OF THE SALTMARSH VEGETATION IN THE PORT JACKSON DISTRICT.

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(Plates xvii.—xxx.)

Introductory.

Plant ecology embraces the environmental conditions relative to plant distribution and adaptation throughout the world. Such a study can only deal with broad generalisations, hence the necessity for the critical survey of small areas in which detailed observations of the behaviour of the vegetation may be conducted. The results of these investigations, though primarily of purely scientific interest, should provide much valuable economic information. Forestry has already been termed applied ecology, our native fodder plants are under consideration from an ecological standpoint by local workers, and all branches of agriculture must eventually benefit by the knowledge thus acquired of both plant and habitat. To the systematic botanist a knowledge of the structural modifications imposed upon plants by environmental conditions is of extreme importance.

Factors and Response.

The most potent factors affecting plant life in the local marshes are the presence, in quantity, of sodium chloride in the soil, intense insolation, imperfect drainage, tidal and stream movement. The dominance of these agencies has resulted in the production of a flora specially organised to resist their injurious influence, plants with xerophytic structures attaining the maximum of success. *Salicornia australis* Sol., the largest local herbaceous formation, has adopted the protective device of succulence; the Grey Mangrove, *Avicennia officinalis* L., deflects the light and minimises the effects of extreme insolation by presenting a glossy leaf surface to the solar rays; the Swamp Oak, *Casuarina glauca* Sieb., is practically leafless, and the vertically arranged, highly cutinised, cylindrical stems of the reeds are well adapted to withstand the deleterious factors operating in the marsh. The common vegetative response to bad drainage is shallow rooting; the Grey Mangrove also reacts to imperfect oxidation by the production of special breathing organs (1). Massed assemblages, with a rhizomatic connection and tolerance of the deposit of considerable quantities of silt on their formations, are characteristic adaptations of our marsh plants to resist tidal and stream invasion.

The Habitat.

The local marshes are the result of hydrodynamic action, stream and tide each bearing its quota of soil particles to form a mud bank at the head of the estuary. When the alluvium, usually a clayey deposit, has attained an altitude upon which vegetation may exist, floating seeds of the Grey Mangrove settle on the mud and the surface is eventually covered with a forest of these trees. By obstructing the tide and stream flow they compel each in turn to deposit a portion of its burden of silt in their immediate vicinity, thereby accelerating the uplift of the marsh. The landward margin of the marsh is built up by stream deposit and as the banks advance upon the plain, the halophytic vegetation is driven seawards, until it reaches the region where the tidal scour is sufficiently energetic to preclude further encroachment. In many local marshes the littoral margin is moulded into a crescent by the sweep of the tide, and frequently bisected by a channel flowing inland and connected more or less directly with the stream formed by the drainage collected in the adjacent country.

The littoral soil consists of loose black mud, whose stabilisation is largely the work of Algæ which form a filamentous network on the surface, and eventually provide a modicum of humus for the succeeding herbs. This muddy area is frequented by a crab, of which Mr. C. Hedley (18, p. 46) writes: "Between the falling and the rising tide, it burrows and builds with such energy that the whole field is covered with little pits and heaps of mud pellets like worm eastings on a lawn." The analogy may be advanced a step further, as the crabs perform a similar beneficent service in the aeration of the marsh mud to that undertaken by the earthworms in ordinary garden soil. The various formations, by collecting soil and debris, finally raise the marsh until it becomes unfitted for their further occupation and are eventually destroyed by the conditions in whose production they have played such a prominent part.

Zonation.

The zonal system in our marshes is largely regulated by the edaphic conditions, in which soil salinity and the degree of submergence play a prominent part. The muddy, tide-flooded area on the marsh littoral, followed by a barren stretch of saltplain, with its detritus heaps and shallow pools and channels, and the marginal zone, with a reduced soil salinity consequent upon the spread of the fluvial stream over the surface, each form distinctive stations occupied by selective formations. The dominant arboreal species, the Grey Mangrove and the Swamp Oak, occupy, respectively, the seaboard of the marsh and its landward margin, herbaceous formations clothing more or less effectively the intervening area. The curvature of the marsh on its littoral front has necessitated the adoption of a semicircular, or horseshoe-shaped, zonal arrangement by the various formations, each in succession forming a border, more or less regular, on its neighbour's boundary. The formations in the centre of the marsh expand radially, those on the landward side narrowing into elongated bands and extending bilaterally. The detrital uplift of the landward bank and its forward movement on the plain dislodge the marginal formations, either suppressing them, or driving them towards the centre of the marsh, and replacing them with the series next in the line of succession.

The creeping, or carpet-forming, perennial herbs—grasses, etc.,—which constitute the major portion of the vegetation in the marginal zone, are annually intruded by ephemeral ruderals, which consummate their life-history during the resting period of their hosts, the cycle closing contemporaneously with the arrival of the season of activity of the permanent plants. Monocarpic herbs of longer than annual growth also enter these formations, their (usually) vertical roots operating in a sphere complementary to those of the perennial rhizomatic species.

Special Features.

The distinctive note in the saltmarsh proper is uniformity, the vegetation covering large areas of our marshes maintaining a strikingly symmetrical arrangement, the principal formations displaying an even contour level and a decided zonal boundary, though, in sections where the physical factors operate irregularly, salients of greater or lesser depth are formed on their lines of division, and the shapeless detritus heaps on the salt plain are occupied by variform assemblages. The landscape of the marsh is the joint production of the mangrove forest and the *Salicornia* meadow, the latter, with its monotonous stretch of dull-green, stunted herbage, framing the mangroves with a sombre border. The lack of diversity is due to the harsh conditions obtaining in this exclusive station, which have limited the vegetation to a few species. The portion of the plain lying between the *Salicornia* and the marginal formations is broken by scattered detritus hummocks and ridges, and intersected by water channels and occasional pools which harbour a weak scanty herbage, the remnants of several communities. Large stretches of this inhospitable station are bare of vegetation, except where clothed with a filamentous algal deposit, the surface, in the lengthy intervals between tidal visitations, becoming sun-cracked and flaked (Plate xxiii.,fig. 13) or, in places, encrusted with a glistening coat of salt (Plate xxiii., fig. 14). The marsh plain is frequently fringed by reed formations which extend along its margin in elongated bands (Plate xvii., fig. 1), their tall, closely-ranked stems providing a pleasing alternative to the degenerate herbage of the salt plain.

In several local marshes the Swamp Oak occupies a position on the plain boundary, lining its banks in a belted avenue, or spreading into a forest on the fluvial mud flats at the head of the marsh. This quaint tree lends a picturesque character to the scenery, with its ascending tufts of ashen grey branchlets, encircled at their joints by toothed whorls of rudimentary leaves and the rough corrugated bark usually draped with varicoloured lichens. Tea-trees, *Melaleuca* spp., form the bulk of the shrubby undergrowth in the *Casuarina* forest (Plate xxvi., fig. 19) their heath-like foliage blending harmoniously with the narrow cylindrical branchlets of their taller associate. The loose, smooth, papery bark of the Tea-trees presents a marked contrast to the wrinkled compact cortex of the Swamp Oak.

The outlying formations are less regular in outline and volume than the central groups. The scarcity of mosses, noted by ecologists as exceptionally halophobus, was observed in the local marshes. The lichen flora on the contrary is well represented, chiefly on the *Casuarina* trunks. Though occasional on the mangroves exposed to the light at the fringe of the forest, the lichens are unable to penetrate its heavily canopied interior. Rosette-forming species are rare in the tide-flooded zone and on the salt plain, though the detritus heaps occasionally harbour the introduced 'Rib-herb,' *Plantago lanceolata* L. or *P. coronopus* L. The endemic rosetted *Droseras* and *Goodenias,* common in swamps and peat bogs, are absentees from the saline stations in the marsh. Bulbous plants, crown-forming species, and herbs with a tuberous root-stock are also infrequent in these stations. The absence from the local marshes of the vines and varied shrubby vegetation common in tropical estuarine marshes is conspicuous. In the marsh proper the indigenous flora predominates, but in the fluvial zone on its boundary the foreign element is more evident.

Floristic.

The floral element is unobtrusive, the absence of bright colours emphasising the distinction between the xerophytic marsh plants and the ericoid xerophytes of the neighbouring sandstone hills, with their wealth of gay blossoms, the prominent species in the marsh displaying small or neutral-tinted flowers. The inflorescence of the Grey Mangrove is dull and inconspicuous, consisting of sprays (cymes) of flowers with yellowish-red petals frequently hidden in the luxuriant foliage. The River Mangrove, *Aegiceras majus* Gaertn., which makes a more presentable display, is not well represented in the local marshes. The flowers of the *Salicornia* are immersed in the succulent fertile stems, the anthers when ripe protruding from the narrow foliar collar surrounding the joints. The floral envelopes of the Seablite, *Suaeda maritima* Dumort., and other chenopods are green, the minute flowers clustered round the stem, or half hidden in the axils of the leaves. The dingy yellow flowers of the New Zealand Spinach, *Tetragonia expansa* Murr., are also inconspicuously disposed. The horizontally arranged flowers of *Selliera radicans* Cav. are streaked with drab-coloured splashes, and the Spurrey, *Spergularia rubra* Camb., *Lobelia anceps* Thunb., and *Wilsonia Backhousii* Hook. f. have small unattractive flowers. *Samolus repens* Pers., a species with a minor representation in the marsh, has bright starry flowers, but they are usually hidden among the taller herbage through which the plants creep. *Cotula coronopifolia* L., a lowly herb which attains its optimum at the junction of the fluvial and saline stations, makes a display of bright button-like flowers, which arrest attention by their disparity with the prevailing lack of colour rather than their intrinsic beauty. A large proportion of the marsh plants are wind-pollinated, and the paucity of species with bright coloured flowers is complementary to the absence of insects. The rarity of coloured fruits is also notable.

A feature of the colour scheme in the marsh remarked by numerous writers is the occurrence of chromatism in the stems or leaves of certain plants, more particularly *Salicornia*. The red colouration is generally attributed to the presence of anthocyanin, and various hypotheses have been advanced in explanation of the phenomenon, *e.g.* environmental—extreme salinity (3. p. 337), a dry station (4, p. 350); phenological—red in autumn (39, vol. 16, p. 189), red in winter (24); heredity—transmission from parent to offspring (22, vol. 8, p. 102). Tufts of *Salicornia* were noted by the writer bearing both red and green stems in all stations in the marsh and at all seasons of the year. The percentage of red stems was lowest in summer and reached the maximum at midwinter. In June the marsh plain at Homebush Bay had acquired a purplish tint owing to the prevalence of coloured stems of the *Salicornia*. The Sea-blite, which was also affected, showed a slight increase only in the proportion of coloured herbage during the winter season. Other plants in the local marshes which have developed chromatism are—*Spergularia rubra*, *Atriplex patula* L., *Mesembryanthemum aequilaterale* Haw., *Polycarpon tetraphyllum* Loefl., *Rottbellia compressa* L. f., *Haloragis micrantha* R. Br., *Rumex acetosella* L. The latter is noted as " Often turning red."*

Taxonomic.

In systematic botany the floral structure is important, but in ecology the growth form is the consequential character. The rôle of ecology in systematic botany has been considered by various writers, and numerous instances of species and varieties whose morphology has been affected by the formative factors dominating their environment have been recorded. Of *Atriplex patula*, Miss Cross (7, p. 550) says, "In the dried parts of the meadow the leaves are smaller and very rarely hastate; sometimes they are almost sessile. In the marshes the leaves reach their greatest size, and have the typical hastate shape."

The extremely diverse factors operating in contiguous stations in the marsh have left their impress on this exceptionally plastic species, which is well represented locally. Its behaviour in our marshes is similar to that noted by Miss Cross, the leaves ranging from narrow ovate to rhombic and hastate, in the passage of

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* Fl. Austr., v., p. 265.

the plants from a dry station on the marsh margin to the muddy zone, their habit also gradually developing from a prostrate to an erect stature. Several forms of *A. patula* have been described as species, sub-species or varieties, but the evidence obtainable in the local marshes points to a common origin, though the resultant forms are dissimilar in leaf structure and habit of growth. Further taxonomic references to halophytic plants will be found in (3), (5), (14), (20).

Seed Dispersal.

Of the three principal agencies—apart from man—engaged in seed distribution, viz., currents, birds, and winds, the former plays the most important part in the local marshes, the newly-formed mud-bank—the future saltmarsh—depending exclusively upon water carriage for its afforestation by the mangroves. Plants also occur whose fruits are embedded in the stems which disintegrate and float on tide or current disseminating the seeds. The capacity to germinate in salt water and float for a period in the seedling stage—a special feature of the tropical mangroves—is also characteristic of the seeds of several local species. The large fruits with buoyant fibrous tissue, common in tropical estuaries, are not found in the local marshes, the majority of the plants producing small fruits or seeds with a brief flotation. The albuminous seeds of the grasses and sedges are probably the most tempting diet offered to visiting birds, fleshy baccate fruits being conspicuously absent from our marshes; the insignificant berries of the Sea-blite provide the best example of succulence among the indigenous species. Plants were noted whose seeds emitted a sticky mucus when wet, which would cause them to adhere to the feathers of birds and facilitate their dispersal.

Typical wind-dispersed seeds are the dust-like spores of the lichens clothing the trunks of the Swamp Oak, which are launched on their aerial flight from elevated positions. None of the indigenous marsh Composites are provided with wind-disseminating pappus, but several introduced members of this family are dependent on their parachute of bristles for distribution. Though the wind is less responsible for seed dispersal in our marshes than either birds or currents, it enacts a beneficent role in pollination in this station, where insect life is infrequent, the reeds and grasses, among herbs, and the swamp Oak, representing the arboreal species, relying upon the wind for this indispensable office. Numerous references to the flotation and germination of the seeds of plants represented in the local marshes will be found in (13), (14), (15), while viability tests of seeds of plants herein noted are tabulated by Ewart (11) and Rees (35).

The Formations.

1. *The Tide-flooded Zone.*

The vegetation of the tidal zone is furnished chiefly by the Grey Mangrove and the *Salicornia,* supported by a series of low succulents and salt-grasses, with a background of closely-regimented reeds. In the marsh, this zone is bounded by the barren salt plain, but on the landward margin the tidal formations follow the bank inland until they reach the fluvial zone. The Grey Mangrove, an umbrageous tree which forms dense forests on its seaboard, is the pioneer colonist of the saltmarsh. In many of the local estuarine marshes the mangroves spread outwards across the tideway, following inland, in belted formation, the banks of the customary drainage channel flowing through the centre of the marsh. The extension of the Mangrove forest is strictly limited by the depth of the tidal waters, its entry into the bay usually taking the shape of a crescent encircling the area at the head of the muddy basin lying behind the permanently flooded expanse of the bay, which is exposed at low tide. Inland, the trees which have followed the course of the channel to its broken headwaters, display, in a marked manner, loss of size and vigour as they approach the shoals. Typical examples of this graduated dwarfing occur in the marshes at Homebush Bay (Plate xxii., fig. 12) and Cronulla, the reduction in stature commencing where the dilution of the tidal water by the fresh water from the inland drainage channels becomes effective.

The root system of the adult Mangroves is shallow, radiating horizontally and beset with the characteristic asparagoid pneumatophores, which indicate the course traversed by the roots from which they arise. In addition to fulfilling their well known function of aeration, the breathing roots afford a powerful stay to the Mangroves, their partially embedded stems offering a stout resistance to the wash of the tide. Incidentally they collect a considerable quantity of detritus and play a prominent part in the uplift of the marsh.

The deepening of an arm of Cook's River, which traverses the sewage farm near Arncliffe, has isolated a group of Mangroves from their normal habitat, and left them stranded on a part of the marsh now drained by the channel. The Mangroves have responded to the aeration of the soil, rendered possible through the damming back of the tide, by dispensing with their pneumatophores, a few only of the breathing roots remaining, in a debilitated condition, at the base of their trunks. The sweetening of the soil has encouraged the invasion of the Mangroves by a grass and ruderal pasture (Plate xxvi., fig. 20).

The Mangrove is dependent on currents for distribution, a mode of conveyance for which it is admirably equipped, the fruit, with the seed in a more or less advanced stage of germination, falling within the range of tidal movement which promotes its dispersal. When deposited on a mudbank the fleshy cotyledons swell rapidly and rupture the leathery pericarp which is then discarded, the roots simultaneously sprouting from the quickly elongating hypocotyl and securing the young seedling in position. The advanced stage of vivipary (40, p. 236) and the extensive flotation of the seedlings (13, p. 76) attributed to tropical members of the genus, do not occur in the local marshes. In the Port Jackson district, *Avicennia officinalis* flowers in June and its fallen fruits were seen in profusion on the mud-flats in December.

The Mangrove formation is surrounded on the landward side by a carpet of *Salicornia* which extends to the dry salt plain. Of certain Molluscs found in the local marshes Hedley (18, p. 46) writes:—" These range from the fringe of glass wort, locally called 'samphire,' *Salicornia australis,* along the high-tide mark downwards as far as the *Avicennia* grows." The association of Mangrove and *Salicornia* is of frequent occurrence throughout their geographical range, each occupying relatively similar positions on the marsh.

The adaptable *Salicornias* are represented in all climatic zones, but the Mangroves are largely restricted to tropical and subtropical regions, only the hardier species venturing into colder temperatures. Under normal conditions the boundaries of the *Salicornia* meadow and the *Avicennia* arboretum are strictly maintained, the dense thicket of pneumatophores presenting a formidable barrier to intruders. On the banks of Duck River, a few hundred yards below the dam separating the fresh and tidal waters at Clyde, a belt of Mangroves is bordered by a sward of *Salicornia,* the line of demarcation between the formations showing a cleavage as sharply defined as the verge of an artificial lawn bordering a footpath. The invasion of the Mangrove forest is initiated on its landward boundary, where the uplift of the marsh by the accumulated debris has stabilised the muddy surface and created a situation favourable to the *Salicornia.* Isolated plants of the latter, and its occasional rival but more frequent ally, *Suaeda maritima,* evade the defending pneumatophores and gain a precarious foothold among the dwarfed shrubby Mangroves on the fringe of the forest. Their presence assists the factors already operating to render the position untenable to the Mangroves and, as they retreat, the *Salicornia* which in this station outstrips its shorter-lived associate, occupies the vacated area. At the head of Iron Cove, the formation of a road through the marsh has made a clearing in the Mangrove forest, and the first to enter the breach were the *Salicornia* and *Suaeda.* A similar occurrence was noted at Homebush Bay, a third herb, *Atriplex patula,* also obtaining a footing in the broken Mangrove formation.

Near the mouth of Cook's River a group of Mangroves has been felled and the area is overrun by *Salicornia.* Several young Mangroves have sprung up, but are unable to attain an arboreal development, the close carpet of *Salicornia,* favoured by the collection of soil and detritus, placing them at a disadvantage. On an open reach of the Parramatta River at Meadowbank, the *Salicornia* exhibits antipathy for a sandy habitat, its formation breaking up while in transit from the marsh mud to the sandy shore upon which its further progress is arrested.

On the tide-flooded plain the *Salicornia* is an almost pure culture with a remarkably even compact carpet rarely exceeding a few inches in height, the stems developing the short internodal growth attributed by most writers to the effects of intense insolation. Where it ascends the drainage channels, it is frequently built up, in shoal water, into hummocky patches, the stems attaining a length of 1½—2 feet. On the marsh plain, individual plants are usually arranged in spreading radial tufts, the closely-knitted, shortly-rhizomatic, procumbent stems buried under the silt to a depth equal to the emerged portion. As the stem disappears beneath the soil it loses its succulence and develops a tough wiry rhizome, which produces adventitious roots plentifully supplied with root hairs, an exceptional provision in the saltmarsh plants.

The faculty of excreting hygroscopic salts by means of salt glands is ascribed to certain saltmarsh and desert plants by various investigators who are not, however, in agreement as to the role of this function. A theory which finds some acceptance is, that the excreted salt crystals absorb water from the atmosphere and deliquesce, the plant absorbing the moisture through stem or leaves. It has also been maintained that the plant is merely ridding itself of an accumulation of injurious salts.

When drying specimens of *S. australis* for mounting, the writer observed that salt crystals, formed in the stems, had ruptured the epidermis in several places, and were protruding through the apertures. The turgidity of the *Salicornia* varies with the salt content of the soil, numerous experiments showing that the plants lose much of their succulence when grown in ordinary garden soil. The halophytic tendency of the genus is exemplified by its world-wide distribution in saline stations. Of the 9 species of Australian *Salicornia* 7 are shrubby; 1 is an annual, and 1 a perennial herb; 5 are exclusively interior species and 3, including *S. australis*, are coastal; 1 species, *S. arbuscula* R. Br., is coastal in Victoria, and an interior species in New South Wales. The *Salicornia* is distributed by currents; the fruiting spikes fall at maturity with the seeds *in situ* and float away on the tide. (This character is not so well developed in *S. australis* as in some other members of the genus.) Discussing the dispersal of *S. australis*, Miss Cooke (4, p. 361) says, "When the seed is ripe the fleshy perianth persists, the cell-contents disappear, and the cell-walls become thickened by regular bands which run in different directions in different cells, and the cells are filled with air. This is evidently an adaptation for dispersal; for by means of this persistent perianth the seeds float on the top of the water for a long time. Seeds were placed in fresh water, and at the end of a week only 3 per cent. of them had sunk." [Seeds of this species with the perianth removed sank in a few hours in fresh water.—A. A. H.] Guppy (13, p. 545) notes that the seeds of *S. herbacea* germinate in sea water more readily than fresh, and the sea water seedling is much the more vigorous and healthy of the two; he remarks: "The floating seedlings can evidently disperse the species."

The Sea-blite, *Suaeda maritima,* a cosmopolitan species and a member of the same family as the *Salicornia,* (Chenopodiaceæ), is usually associated with the latter either as a competitor—in the tidal zone—or as a colleague in the work of clothing the intermediate barren plain. In the tide-flooded area, the somewhat woody stem of the Seablite is early decumbent and reclines on the soft mud, producing an abundance of lateral adventitious roots which spread horizontally on the surface of the slimy ooze (Plate xxvii., fig. 22). The extremity of the stem is curved upwards and plentifully furnished with divaricate branches thickly clothed with succulent, semi-terete leaves. The ramification of the interlaced branches with their heavy canopy of foliage, in combination with the close network of surface-spreading, matted roots, constitutes its defensive system. In the numerous conflicts in which the Seablite and the *Salicornia* are engaged, the latter generally emerges victorious, its vegetative reproductive system and perennial growth enabling it to overcome its shorter-lived opponent, which is entirely dependent upon sexual reproduction for colonisation. Seedlings of the *Salicornia* attempting to obtain a footing in the Seablite formation are promptly suppressed by their taller antagonist, which deprives them of the necessary light by interposing its leafy curtain, and prevents their lateral growth by the density of its own superficial root system. Invasion of the *Salicornia* by the Seablite is equally futile, seedlings of the latter obtaining a temporary footing in the *Salicornia* carpet finding it too compact to penetrate, the inability of the adventitious roots to reach the surface of the marsh resulting in the collapse of the intruders. The frequent breaches in the *Salicornia* carpet, due to unfavourable conditions arising in the habitat, afford the Seablite numerous opportunities for encroachment. Its quickly germinating seeds, of which large quantities are shed in contiguity to the *Salicornia,* are swept by the wash of the tide into the denuded gap, which is invested with a sturdy growth of the Seablite before its slower moving antagonist is able to enter the breach. When the latter arrives at the margin of the Seablite formation, its wiry rhizomes are insinuated under the shallower root system of its opponent, and, as the shorter-lived Seablite disintegrates, the rhizomes of the *Salicornia,* rising obliquely, occupy the ground before a new crop of Seablite seedlings can secure a footing. The invasion continues until the Seablite is either driven out or a change in the conditions again weakens the *Salicornia*, and permits its opponent to reassert a temporary supremacy. A typical example of this intrusion was noted at Hen and Chickens Bay, where the *Salicornia* carpet surrounding the Mangroves is exceptionally compact. Near the boundary of St. Luke's Park, a weak salient in the *Salicornia* has been occupied by the Seablite, which has entered its carpet in a wedge-shaped formation, whose apex has reached the Mangroves, completely bisecting the *Salicornia* sward. The boundary of the joint formations on the northern side runs along the fence of the Rifle Butts with a well-defined line of demarcation, the intrusive Seablite, pallid, and taller than its rival, attracting the attention of the observer from the marsh bank. At Homebush Bay a dyke has been thrown up along the bank of the tidal channel running through the centre of the marsh to protect the plain from floods. The Seablite has taken advantage of the resultant alteration in the habitat and obtained possession of the station on the banks of the tidal channel intermediate between the dyke and the Mangroves, fringing them with a narrow border (Plate xxii., fig. 11). In the artificial habitat created by the stoppage of the tide flow, the Seablite has its opponent at a disadvantage, as the *Salicornia* is unable, under the supervening dry conditions, to construct a carpet, its formation breaking up into small patches or individual tufts. The narrow margin of superiority held by the *Salicornia* over the Seablite is well demonstrated on the broad expanse of plain affected, where neither species is capable of maintaining a massed carpet, both breaking up into small patches or individual tufts and frequently intermingling (Plate xxiii., fig. 13), the *Salicornia* by virtue of its perennial habit eventually supplying the major portion of the plain vegetation. On a section of the marsh at a point opposite the Concord West railway station, the plain is traversed by two almost parallel branches of the central tidal channel, which extend for a considerable distance in the direction of the marsh bank enclosing a strip some 30ft. wide. The banks of the shallow waterways are lined with Mangroves which display a graduated reduction in development as the channels merge into the plain, the attenuated bushes at the extremities, where the tide flow ceases, limiting their foliage to a few scattered leaves (Plate xxii., fig. 12). This natural avenue lends a unique feature to the landscape, the enclosed space, which is slightly raised above the level of the plain, carrying an almost pure sward of Seablite which conveys the impression of a strip of lawn enclosed by hedges.

On the drier parts of the plain the Seablite gradually loses its decumbent habit and discards its lateral surface roots. A similar alteration in the habit of the northern *Suaeda fruticosa* growing on a shingle beach is noted by Oliver and Salisbury (31, p. 260). The Seablite was not observed by the writer on the ocean shore-line, but Bentham* notes it as abundant on shingle beaches close to high water mark in Tasmania.

The formation of salt crystals in the stems and their extrusion from the epidermis as in *Salicornia,* was also noted in dried specimens of the Seablite.

In typical local estuarine bays the tide-flooded area on the littoral boundary extends to the marsh banks, a series of irregular formations, chiefly low, carpet-forming succulents, occupying the space between the *Salicornia* and the reeds. In this station the former is intruded by occasional patches of *Wilsonia Backhousii* Hook. f., a creeping, stoloniferous perennial with a flat carpet. There are three species of *Wilsonia,* none of which is admitted by Bentham into the flora of New South Wales,† but they are all recorded in local publications, and there are specimens in the National Herbarium of *W. rotundifolia* Hook. from Lake Cudgellico and Lake Bathurst, and of *W. Backhousii* from the local marshes. The genus is endemic in the Commonwealth, New South Wales and Tasmania representing respectively its northern and southern limits.

Where the tidal detritus has extended the base of the bank into a terrace, the *Wilsonia* creeps over it, consolidating the drift, its compact formation of crass fleshy leaves, closely appressed to the soil, narrowing with the deposit into a band, or, where the bank rises abruptly from the marsh, into a mere fringe. At Homebush Bay, a *Wilsonia* formation an acre or more in extent was noted on a comparatively dry peaty stretch of the salt-plain, where, under the drier conditions and loose soil, it is unable to maintain a continuous carpet, breaking up into small mats or stools. The *Wilsonia* is essentially halophytic and does not extend to the fluvial zone. The genus is a degenerate offshoot of the *Convolvulaceae,* a family largely constituted of climbers

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* Flora Austr., v., p. 206.

† Flora Austr., iv., 439.

with showy trumpet-like flowers, *e.g.*, the "Morning Glory," *Ipomoea purpurea* Roth. The inadaptability of the *Wilsonia* for dispersal is accountable for its limited range, neither the small fruited capsules, nor their seed contents possessing an equipment for lengthy flotation.

Mesembryanthemum tegens F. v. M., which is also a creeping succulent perennial with the trigonus leaves common in the genus, was noted at Homebush Bay and other saltmarshes in the vicinity in the same zone as the *Wilsonia.* This plant was described* from specimens growing in a similar habitat in Victoria. "In pratis depressis paulo salinis urbi Melbourne adjacentibus," where it is probably endemic. It forms a compact carpet, studded with a profusion of bright rose-pink flowers, and is commonly grown as an ornamental garden plant, the name figuring in the catalogue of plants growing in the Sydney Botanic Gardens, published in 1895 (p. 42). The grounds of Miss Eadith Walker at Yaralla and those of the Walker Hospital are probable sources from which the plants may have been disseminated, as the boundaries of both establishments extend to the neighbouring saltmarshes. The carpets of *Mesembryanthemum* and *Wilsonia* are for the greater part distinct, each clothing a section of the marsh bank, or a flattened ridge among the shallow water channels, but in places they run in parallel lines along the bank, the *Wilsonia* occupying the inner—more frequently flooded—zone. Their growth is usually complementary, their root systems ramifying in different directions, the roots of the *Wilsonia* descending to a greater depth than those of its associate. The root system of the *Wilsonia* is rhizomatic, *Mesembryanthemum,* which is a surface creeper, emitting tufts of vertical roots from the nodes. When growing side by side, an occasional rampant runner from the *Mesembryanthemum* overlaps and, finding an opening in its neighbour's carpet, promptly descends and roots, eventually—where favoured by the habitat—overrunning the plants in its vicinity and establishing a patch in the invaded territory. A sandy soil is favourable to the *Mesembryanthemum*, the *Wilsonia* displaying a preference for the black mud of the marsh. It is remarkable that *M. tegens* is not more widely dispersed, as the crustaceous coat of the seeds is sufficiently protective to preserve their germinative power

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* Phrag. Phyto. Austr., v., 157.

when eaten by birds. The small seeds, which are freed from the capsule (dehiscent) when ripe, sink almost immediately when immersed in water.

Selliera radicans, another perennial carpet-forming species, is occasionally present in the tide-flooded zone, the largest local formation noted extending along the marsh margin at Iron Cove. This formation stretches for a considerable distance in a broad band, occasionally interrupted by unfavourable edaphic intrusions. On the saline mud at the base of the marsh bank its heavy succulent leaves are closely appressed to the ground, overlapping in several layers, the resultant carpet presenting a dense barrier to encroachment by the surrounding herbage. On the landward boundary, the *Selliera* has attempted the ascent of the sloping bank, but the Salt-grass, *Sporobolus virginicus* Humb. & Kunth., which is firmly established in this station, has obstructed its passage, its strong, wiry framework forcing the soft fleshy stems of the *Selliera* to rise obliquely from the ground. When the stems of the *Selliera* lose their grip on the surface they trail over the Saltgrass sward, and as they are unable to again descend to root their further progress is arrested.

On the muddy flat the struggle for existence in the *Selliera* carpet is very severe and has resulted in the production of short crass leaves, sessile and crowded. The harsh conditions are also responsible for a prolific growth of flowers, which are closely appressed to the stems and almost cover the surface of this section of the carpet. The flaccid aerial stems trailing over the salt-grass are not subject to this competition and have responded by the adoption of a lax growth habit, broadening the leaf blades and raising them on stalks, reducing their turgid succulence, and spacing them distantly along the branches (Plate xxix. fig. 25). A further response to the removal of the stress of competition is the cessation of sexual reproduction, the well-favoured stems either declining to produce flowers or reducing the output to a negligible quantity. In the muddy station the *Selliera* meets outlying tufts, or occasional patches, of *Juncus maritimus* var., and surrounds them, closely investing the spaces between the tufts. The association of *Selliera* and *Juncus* is noted by Guppy (13) among coast plants in Southern Chile.

The fruit, which is slightly succulent, retains the seeds when it falls (indehiscent), but its weakly constructed walls are readily permeable and soon collapse in water, releasing the seeds.

Dried capsules floated for a week, a thin glutinous coating keeping them dry for several days. Of a number of seeds tested the majority sank in a few hours, none remaining afloat 24 hours. The seeds are compressed and when young are encircled by a membraneous wing which is extremely fugacious, the mature seeds rarely retaining more than a ragged fringe on their border. The fugitive nature of the wing renders it valueless for flight, and the flat, creeping growth-form of the plant, and its customary domicile, are also opposed to this means of dispersal. This species has been omitted by Bentham from the flora of New South Wales,* though it is very common in our local saltmarshes.

Samolus repens, a slender floriferous perennial which extends to New Zealand and New Caledonia, finds a refuge in depressions in this zone which are too frequently submerged to permit of their occupation by the *Selliera* and other carpet-forming species. It spreads superficially by means of runners which root at intervals and produce tufts of short stems, its rhizomatic system connecting the mature clumps subterraneously. The small plants are somewhat frutescent and have thin, hard (sclerophyllous) leaves, lustrous on the upper surface, an unusual occurrence in this station. The extensive ramification of its root system is a valuable provision for securing an anchorage in the mobile mud. The *Samolus,* though exceptionally well equipped for such a habitat, is a fugitive in this station and is only permitted to occupy the spaces edaphically repugnant to the surrounding succulents. The largest colonies of this species noted were established in a *Salicornia* meadow at Buffalo Creek on the Lane Cove River.

On the ocean headlands it is frequently associated with *Lobelia anceps* clothing a rock ledge or invading a crevice, their weak straggling stems, drawn and flaccid, appressed against the face of the cliff, seeking shelter and support. The *Lobelia* is also occasional in the saltmarsh but is unable to tolerate the harsh conditions obtaining in the station occupied by its confrere, and cannot advance further than the detritus heaps on the plain, its frequent presence and sturdy growth in freshwater swamps indicating the excessive soil salinity as the deterrent factor. The *Samolus* is more partial to a muddy than a sandy soil and can-

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* Flora Austr., iv., p. 82.

not ascend the dry marsh banks. Its numerous small seeds only float for a few hours, the protective crustaceous seed-coat pointing to its dispersal by birds.

The outermost series in the zonal succession on the flooded marsh littoral is a *Juncus* association, which introduces a taller type of vegetation with a cylindrical growth form. The stems of these rushes are strongly built, the epidermis forming a cylinder of bast, highly cutinised, and the walls of the air cavities are arranged in a stout network binding the frame both longitudinally and transversely. The lacunar tissue so well developed in the *Juncus* is disadvantageous, as it increases transpiration, but offers a modicum of compensation by storing a supply of oxygen and lightening the stem structure. The firm texture of the rushes enables them to advance into the weaker formations of the succulents in their vicinity, wherever a change in the edaphic conditions favours a forward movement.

The dominant species in the local marshes is *Juncus maritimus* Lam. var. *australiensis* Buchen., a tufted, shortly rhizomatic herb. Its supremacy in this zone is rarely challenged, though a Cyperaceous rush, *Cladium junceum*, R. Br., which extends from Queensland south to New Zealand is an occasional competitor in stations where the saline conditions operate in its favour. At Buffalo Creek on the Lane Cove River, near the bisection of the marsh by the Pittwater Road, the *Cladium* and *Juncus* run side by side along the marsh margin in parallel bands (Plate xvii., fig. 2). At intervals the drainage, collected into short gullies, enters the marsh, forming shallow bays on its margin. The soil salinity in the bays is considerably reduced, the dilution of the marsh water acting unfavourably upon the *Juncus* formation. The more plastic *Cladium*, preferably a lacustrine habitue, is not prejudicially affected by the influx of fresh water and in these stations advances into the *Juncus* formation, occasionally pressing through its ranks and occupying a frontal position (Plate xviii., fig. 4). An extensive formation of *Cladium junceum* was noted on the margin of a lake in the Centennial Park. In this habitat the conditions which confine it to a narrow band on the marsh margin or the bank of a tidal stream, *i.e.*, the severe competition of the *Juncus* on its aquatic boundary, and the abrupt transition to a dry station on the landward bank, are absent, and the *Cladium* spreads from the shallow waters of the lake, in an irregular formation, into the adjoining swamp, its movements limited only by the degree of soil saturation. The regularity of the zonation of these frequently associated rushes is exemplified on the banks of George's River, at Como, where their several ranks extend in parallel lines forming an even band, 6-8 feet wide, for a distance of several hundred yards, the *Juncus* keeping the front line along the river margin. The slightly reduced height of the *Cladium*, its pale green stems, and insignificant inflorescence are sufficiently distinctive to enable the observer to follow the lines of their respective boundaries throughout their association. The fruits of *Cladium junceum* have no flotation, seeds 5 years old, which resemble a leaden pellet in size and colour, sinking at once.

In a shallow basin on a saltmarsh at Clyde, the cosmopolitan Reed-mace, *Typha angustifolia* L., has established a colony, an irregular formation of *Juncus maritimus* occupying a position on the border of the depression, a vacant space several yards wide dividing them. The factor limiting the boundaries of their respective formations is the decreased salinity of the water in the basin, which is fed by a sluggish seepage from the marsh bank, rendering it prohibitive to the *Juncus*, though congenial to the Reed-mace, the ridge on the border of the basin remaining inaccessible to either. The ovaries of the flowers of the Reed-mace are surrounded by tufts of hairs affixed to the stipes which fall off with the fruit, simulating the pappus of a Composite.

The saltmarsh at the head of Woolooware Bay, Cronulla, is merged into a swamp in which tidal and fluvial waters intermingle. A forest of *Casuarina glauca* has spread over the swampy area from the verge of the tidal zone to the dry landward slopes. In this station *Juncus maritimus* has relinquished its banded formation and, adopting a massed disposition, has invaded the forest to the boundary of the fluvial zone. Its frequent associate, *Cladium junceum*, is also represented by a series of diffused patches, and two reed-like Sedges, *Scirpus littoralis* Schrad., a species common in the Mediterranean, which is tolerant of a lacustrine habitat, though much better developed under estuarine conditions, and *Cyperus laevigatus* L., common in most warm regions, noted only by the writer in estuarine stations, have also established small colonies in the *Juncus* formation. The seeds of these two Sedges have a brief flotation, dried seeds of both species sinking within 24 hours. Discussing New Zealand halophytes, Miss Cross (7, p. 547) remarks:—

"In the neighbourhood of one lagoon . . . only one small tuft of *J. maritimus* was collected. This, perhaps, may be accounted for by the fact that there are no mud-flats, the soil being of a rather sandy nature." The choice of a muddy rather than a sandy station is characteristic of this *Juncus* in the Port Jackson district also.

At Cook's River *Juncus pallidus* R. Br., a species endemic within the Commonwealth, has established its tufts—slightly taller and stouter—among those of *J. maritimus* var., on the drier parts of the marsh plain, but its dominance on the margin of a slightly brackish pool—a station into which *J. maritimus* cannot enter—demonstrates its preference for the less saline habitat. *J. maritimus* extends from the tide-flooded zone to the boundary of the fluvial station, invading the plain *en route* where the soil is sufficiently saturated to permit its growth, *Cladium junceum* declining to accompany it beyond the tidal zone. In its passage across the salt plain, *J. maritimus* has again discarded its banded formation, the dry conditions causing it to separate into small patches or isolated tufts. [At Swansea, Lake Macquarie, hundreds of acres of the marshes are covered with a lax growth of this rush, the individual tufts remaining sufficiently distinct to be non-competitive.] The sequence of the rushes in the ascent of the marsh banks is continued by *J. effusus* L., a cosmopolitan species, and followed on a higher level by the Australian *J. polyanthemus,* a slender stemmed form separated from *J. effusus* by Fr. Buchenau. Of the seeds of *J. maritimus* var., *J. pallidus, J. effusus,* and *J. polyanthemus,* none have more than 24 hours' flotation. The seeds of each of these species emitted a slight coating of mucus when immersed. The position on the margin of the marsh plain, which, owing to its infrequent submergence has become prohibitive to *Cladium junceum,* is occupied by the Salt-grass, *Sporobolus virginicus* Humb. & Kunth., a creeping perennial represented in most warm regions, which develops a lax growth, 1--3 inches high, on the verge of the plain, its sward rising and becoming more compact and rigid as it extends inland. In occasional depressions where seepage from the marsh banks has collected, the Coast Couch, *Zoysia pungens* Willd., also a salt-loving grass, but less halophytic than the Salt-grass, forms irregular patches in the sward of the latter, but on the saline plain ranges behind it in interrupted bands. The *Zoysia* is also of perennial duration and very similar in structure and habit of growth to its associate—both have the convolute leaves of the xerophyte, and a spike-like inflorescence—and their boundaries, though usually very decided, are not readily discernible, especially when they are not in flower, the height of the *Sporobolus* sward where the formations meet approximating that of the *Zoysia* and accentuating the homoplasy. The two grasses are frequently associated both in the saltmarsh and on the seashore, occupying relatively similar positions in either station, the *Zoysia* forming the larger colony on the dune and the *Sporobolus* dominant in the marsh.

In their coastal traverse the *Zoysia* is frequently found intruding a lawn of Common Couch, *Cynodon dactylon* Rich., several miles inland, but the *Sporobolus* rarely leaves the vicinity of tidal waters. The *Zoysia* ranges from the maritime sands of Eastern Asia to New Zealand, where according to Cheeseman* it ascends to 2000ft. at Lake Taupo and in Canterbury and Otago. The *Sporobolus,* which is common in saltmarshes in the interior, reaches its optimum growth in the local marshes on the infrequently tide-flooded plain, slightly uplifted, and with a fresh water seepage reducing the soil salinity (Plate xix., fig. 5). The small, hard, mature grains of the *Sporobolus* are naked when ejected from the glumes and hang for some time on the outside of the spikelets before falling.

2. *The Dry Salt Plain.*

The stretch of dry salt plain extending from the tide-flooded area to the fluvial zone is for the greater part bare, the detritus heaps and ridges usually formed round the decaying stumps and roots of the dead Mangroves or other obstructions, and the pools, channels, and moist depressions, harbouring a few hardy pioneers, chiefly fugitives from the adjoining formations, which eventually prepare the habitat for the advent of the fluvial vegetation. The detritus heaps are frequently coated with a sward of *Sporobolus virginicus* and outlined with an edging of *Salicornia,* the latter seated on the plain (Plate xx., fig. 8). The severity of the conditions prevailing in this station is exemplified by the efforts of the *Sporobolus* to invade the salt plain. An outlying stem from the sward creeps down the side of the mound and pushes out on to the bare plain. Flattened and closely appressed to the surface, it proceeds for a short distance when its

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* Manual Fl. N.Z., p. 844.

progress is arrested and it sickens, turns black, and dies. On the demise of the premier shoot, a series of laterals issues from the inner joints and advances *en masse,* but is compelled to either turn aside or meet the fate of the leader (Plate xix., fig. 6). The *Sporobolus* lawn on the detritus mounds provides a refuge for a series of miniature colonies, small groups of a species, or individual plants, chiefly ruderals of annual or biennial growth, and a root system usually vertical descending below that of the *Sporobolus.* The Orache, *Atriplex patula* L., a weedy annual introduced from Europe, is occasional on these mounds though the bulk of its herbage is disposed in the vacant spaces of the Seablite-*Salicornia* formations, isolated plants occasionally reaching the verge of the Mangroves. In areas where the conditions are exceptionally favourable it frequently grows in dense patches, reaching a height of 3 feet and temporarily excluding the lower growths by overshadowing them with its close fleshy foliage. A luxuriant growth of the Orache was noted on the marsh plain at Homebush Bay, and a ribbon-like colony was seen at Hen and Chickens Bay crowning a low bank on the margin of a drainage channel. The colony at Hen and Chickens Bay was interspersed, in December, with young plants of the New Zealand Spinach, *Tetragonia expansa* Murr. In the following June this locality was again visited and the *Atriplex* had ripened its fruits and was rapidly dying; the *Tetragonia*—also an annual—having developed the bulk of its heavy foliage, dominated the position. These plants were noted, in several of the estuaries visited, in mutual occupation of an area under a similar phenological arrangement. The invasion of the salt plain by the Orache is ephemeral, its brief existence passing and permitting the reappearance of the lowly marsh herbs. Its leaves are encrusted with an excretion of salt which, in addition to relieving the plants of an injurious deposit, affords the leaves a measure of protection from the intense insolation prevalent in this station. The Orache is widely distributed in temperate regions and owes its dispersal to the agency of both currents and birds. Guppy (13, p. 537) lists the fruits as floating for six months. [Seeds, released from the calyx in which they are enclosed and stripped of their membraneous coat, sank at once —A. A. H.] The capsules of the New Zealand Spinach floated for a week, the dried epicarp supporting the weight of the bony endocarp until saturated.

Two annual grasses, *Calamagrostis aemula* Steud., found in all the Australian States and New Zealand, and the curly, tufted *Lepturus incurvatus* Trin., common on the Mediterranean littoral and extending from India to Australia and New Zealand, are frequently present on the detritus mounds, and scattered generally throughout the various formations bordering the salt plain. The *Calamagrostis* is less halophytic than the *Lepturus*, extending to the fluvial formations and the moist meadow on the marsh slopes, and frequently occurs among the rushes and sedges in a freshwater swamp. Both grasses establish colonies in the formations of the permanent herbage, neither forming an independent sward: a few tufts occasionally occupy a vacancy in a suitable habitat. Their vertical roots do not compete with the horizontal root systems of the grasses or other herbs with which they are usually associated. The *Lepturus* frequently forms extensive banded colonies in a sward of *Sporobolus*, *Zoysia*, or *Cynodon* on the marsh margin, completing its life cycle before the demand for space created by the spring activities of its hosts becomes insistent, the disintegration of its colony providing a mulch of humus for the permanent pasture which has given it sanctuary. It is rarely taller than the herbage with which it consorts and has to contend for aerial space and access to the light. To obviate the danger of being overrun, the outer stems of the *Lepturus* tufts curve laterally from the base, pressing back the more yielding superstructure of its associates and securing space for expansion and admission of the essential illumination. The fruits of the *Lepturus* are embedded in cavities in the rachis of the flower spike and the joints, which separate at maturity, are floated by the tide into the surrounding formations.

The *Calamagrostis*, which rarely assembles in large patches, has a weak growth and is unable to spread among its associates. The plants are compressed, their soft basal leaves yielding to the pressure of the surrounding herbage, folding vertically around the stem, and threading their way through the interstices to the light. The stem rises above the sward to mature its plumed floral panicle which bends when weighted with grain, resting on the sward. Finally, the fruit-laden branches are snapped off by the wind and collected into a ball which is blown over the meadow or salt plain, scattering its seeds, simulating the Tumble Weed of the Western Plains. The broad soft leaves of the

Calamagrostis are aberrant in the saltmarsh, as they are essentially mesophytic, but the demand for moisture is more insistent than distaste for the salinity of the marsh or the acidity of the swamp.

The Spurrey, *Spergularia rubra* Camb., supports a fluctuating growth on the salt plain among the detritus heaps, occasionally forming a limited sward on the more habitable parts of the plain. This cosmopolitan species, a low procumbent succulent herb with varicolored flowers (red to white) of a dull hue, is of annual duration in cold regions but attains a biennial growth in our local marshes. It is joined in this station by a yellow Marsh Daisy, *Cotula coronopifolia* L., a shortly rhizomatic perennial with a wide range, chiefly maritime, in both the Old and New World, whose bright flowers are conspicuous among the dull surroundings. In the area in which they are associated, these herbs are not competitive, the conditions precluding a strong growth in either formation, and their diverse root systems seek nutrition at different levels. The *Cotula* does not venture as far on the dry plain as its associate, its larger and more luxuriant colony in the vicinity of the pools and soaks (Plate xxiv., fig 15) disclosing its partiality for moisture, and its more rank growth in the fluvial mud on the side of the drainage channel presents *prima facie* evidence of its inclination for a less saline habitat. The Spurrey requires less moisture and is more strictly halophytic. The *Cotula* was present in all the marshes visited, but the *Spergularia* was not so well represented, the stretches of salt plain at Cook's River in the neighbourhood of Tempe railway station carrying the largest colonies noted.

Guppy (13, p. 540) notes little or no floating capacity in the seeds of the maritime forms of *Spergularia rubra*, with or without winged seeds, even after prolonged drying. [Seeds of saltmarsh plants, one year old, tested by the writer, sank at once.]

During the testing of the buoyancy of the achenes of *Cotula coronopifolia*, a quantity of a gelatinous adherent mucus was emitted when the seeds were immersed. The presence of this species in extra tropical South America, New Zealand, and South Africa, and its capacity for dispersal by gulls and other sea-birds owing to the adherence of its sticky fruits to their feathers, gives it a measure of significance in relation to the Antarctic problem discussed by Guppy (15) and Hedley.*

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* The Palaegeographic Relations of Antarctica.

The *Sporobolus* sward covering a typical detritus mound on the salt plain at Cook's River is intruded by a lax colony of *Lobelia anceps*, also an extratropical inhabitant of S. Africa, S. America, and New Zealand. It is a straggling perennial with succulent leaves and stems, and a shortly rhizomatic root system which finds ample room for development in the open network of the debilitated subterranean growth of the *Sporobolus*. On its margin, a congener, *L. debilis* L. f., a weak annual indigenous in South Africa, but an alien weed in most temperate countries, has established a compact colony in which the fraternal struggle for space is keenly contested. The individual plants which, under normal conditions are branched and spreading, are so closely packed that their stems are unbranched and leafless almost to the summit which is crowned with a short tuft of leaves. Both species have small flowers, those of *L. anceps* being light blue and of its congener a dull reddish colour. The small seeds of both species sank within 24 hours.

Several plants of *Cyperus polystachyus* Rottb., a perennial sedge confined to Australia, with a range from Port Jackson to Queensland, are scattered through the *Sporobolus* sward. In the flattened growth of *Sporobolus* on the detritus mounds, the *Cyperus* has space in which to develop, but in the erect swards of either *Sporobolus* or *Zoysia* on the marsh margin it is speedily suppressed, the taller grasses closing round the short, flaccid, basal leaves of the *Cyperus*, spreading over them, and depriving them of the light. This sedge occasionally occupies a narrow strip on the margin of the plain between the bands of reeds and the customary lawn on the marsh banks—a habitat too dry for the reeds and too salt for the grass. A ribbon-like colony of *C. polystachyus* was noted ranging behind a band of *Cladium junceum* in this exclusive station on the banks of George's River at Como.

A small scattered colony of *Plantago coronopus* L., the only rosette-forming species observed in the saltmarsh proper, occupied an elevated position on the mound. This *Plantago*, an annual in cold climates, is a biennial in the local marshes. It is common in most temperate countries in the northern hemisphere, chiefly maritime, and probably an introduction into Australia. This is the only station on the salt plain open to *P.*

coronopus, as it requires a permeable soil, usually frequenting a sandy habitat, and is intolerant of the salinity of the plain either in the dry or flooded areas.

Discussing the dispersal of seeds by Gulls, Guppy (15, p. 421) says: . . . "*Plantago coronopus*, which grows on the rock ledges where these birds nest. Here the seeds emit mucus and become sticky when wetted, and they would adhere firmly to a bird's plumage when dry." This species was noted by the writer growing on the rock ledges of the ocean escarpment at Coogee (17, p. 339).

One of the Cudweeds, *Gnaphalium purpureum* L., a cosmopolitan weed of annual growth was represented on the mounds in small patches. It is more frequent in a moist meadow or the sparse sward of an open forest (Savannah), its lax frame and flaccid mesophytic foliage indicating its anomalous position in the saltmarsh. The xerophytic equipment of the Cudweed consists of a coating of cottony hairs but this provision is insufficient for a prolonged resistance to the harsh conditions obtaining in this station, and it frequently collapses before it has reached the flowering stage. The distribution of this widespread herb, apart from man,—it is a horticultural and ruderal weed—is the work of birds. Though the minute achenes are crowned by a comparatively large parachute-like pappus, they are not wind dispersed, as the ring of hairs, united by their bases into a short tube, is detached at maturity and drifts away on the breeze, the small solid seeds falling in the vicinity of the parent plant. The membraneous seed-coat would resist erosion when eaten by birds. The seeds have little flotation, sinking within 24 hours.

On the dry salt plain at the head of Homebush Bay, the slender *Apium leptophyllum* F. v. M., a succulent annual with finely dissected foliage, was sparsely represented among the salt-grasses. This weedy herb is indigenous in tropical Africa and America and has a coastal range throughout Eastern Australia. Though its presence in the saltmarsh and on the seaboard would denote a tolerance of saline conditions, it is not as exclusively halophytic as its coastal congener, *A. prostratum* Labill., which, however, does not favour the saltmarsh, owing to its objection to a sour and muddy soil. The structure of *A. leptophyllum* is largely xerophytic, but it is frequently located in a moist shady sward.

Several plants of the Half-berried Salt-bush, *Atriplex semibaccata*, R. Br., a prostrate twiggy perennial with an extensive range, coastal and interior, within Australia—one of our best natural fodder plants—were also noted in this station. In common with most members of the family *(Chenopodiaceae)* it is a halophyte, but is apparently able to procure a sufficient quantity of salt from soils not classed as saline to satisfy its craving for this condiment. At Hen and Chickens Bay it has migrated a considerable distance across the dry plain, reaching the station occupied by its relative *Atriplex patula.*

Two alien Composites are established on the margin of the salt plain at Homebush Bay. The Bushy Starwort, *Aster subulatus* Mich., a tough-stemmed herbaceous perennial indigenous in the North American saltmarshes, has founded a colony among the broken *Salicornia* tufts, its tall dense growth excluding the surrounding herbage. Its confrere the Stinkwort, *Inula graveolens* Desf., a somewhat woody stemmed annual from the Mediterranean which has shown an extraordinary aptitude for aggressive colonisation in Australia, is unable to accompany the Starwort on to the salt plain, the soil salinity acting as a barrier to its progress. The parachute crowned fruits of the Starwort are held aloft on tall waving stems, the slender achenes are extremely light, and the pappus, which clings tenaciously, is relatively large, a series of factors favourable to wind transport. The fruits of both Composites sank within 24 hours, those of the Stinkwort emitting a slight mucus.

In the pools and shallow channels on the salt plain *Ruppia maritima* L., common in most temperate and subtropical regions, spreads a filamentous network, frequently occupying the whole of the space in which the water is sufficiently deep to permit the flotation of its thread-like stems. The occurrence of a *Ruppia* lagoon at Deewhy is noted by Hedley (18, p. 53) who presents a photo of the lagoon and offers some interesting observations on the range of heat and salinity imposed upon its occupants. The *Ruppia* prefers still water, usually occupying isolated pools and disconnected channels, but can withstand a moderate tidal invasion. [A series of *Salicornia*-encircled *Ruppia* pools occurs on the barren salt plain at Homebush Bay near Concord West railway station (Plate xx., fig. 7).] At Cook's River, near Tempe, a dense growth of *Ruppia* (Plate xxi., fig. 10) permeates the waters of a channel connected with the river, bordering Unwin's Bridge Road. In exceptionally low tides the upper reaches of the channel are emptied and the *Ruppia* lies exposed on the mud (Plate xxi., fig. 9). The banks of the channel are lined on either side with a formation of *Triglochin striata* Ruiz. et Pav., a stoloniferous perennial with a wide extratropical range. The *Triglochin* is arranged in narrow bands at the mouth of the channel where the tide flow is strong and deep. broadening as the stream is ascended, the bands on either bank finally becoming confluent in the shallow headwaters. The zonal boundaries of the *Ruppia* and *Triglochin* are regulated by the facilities for submergence, the formation of the latter projecting at intervals into the stream, indicating, beacon-like, the shoals of the channel.

The Thatch-reed, *Phragmites communis* Trin., a cosmopolitan cane-like grass with an elastic growth form, has established a reed-bed in the saltmarsh on the banks of Cook's River at Undercliffe. The section of the marsh selected by the Thatch-reed receives a slight influx of drainage from the surrounding hills, and in this station the formation—a pure culture—reaches its optimum. In the tidal river it is restricted to a narrow band along the bank, rarely descending into water more than 2--3 feet in depth. Of this species Warming (40, p. 189) writes:—"It can grow in water 3 metres in depth." As shown above the Thatch-reed does not invade tidal waters in the Port Jackson district to the depth noted by Warming.

In an article on the mitigation of floods by forestry operations J. H. Maiden (29, vi., 1917, p. 130) recommends *Phragmites communis* as a useful grass for the protection of river banks from erosion. A small patch of the *Phragmites* detached from the reed-bed at Undercliffe, lying between the banks of the river and the dry salt plain which is not affected by the fresh water drainage, has developed a weak open growth into which a formation of *Triglochin striata* has intruded, filling the spaces between the thinly-ranked stems of the Thatch-reed with a compact sward (Plate xxv., fig. 18).* Owing to the greater depth of the rhizomes of the Thatch-reed their formations are noncompetitive, and, sheltered and stayed by the stout culms of its tall associate, *Triglochin striata*—more tolerant of salinity than the *Phragmites*—here attains its full stature, 1--1½

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* This photo was taken in August when the haulm-leaves of the *Phragmites* were withered.

feet. On the dry salt plain, the *Triglochin* cannot maintain a connected sward, breaking up into small mats or isolated tufts which reach maturity and produce flowers and fruits when but 1--2 inches high (Plate xxviii., fig. 23).

On the opposite side of the river the scour sets in the direction of the bank which is deeply eroded. A long strip of Thatch-reed is here bisected by a band of *Scirpus littoralis*, each species maintaining in a large measure the integrity of its formation, an occasional rhizome of either species intruding its neighbour's colony and signifying its presence by raising a solitary stem (Plate xxv., fig. 17). The struggle for supremacy between the reed formations in this station is exceptionally severe, as their root systems descend to an equal depth and compete for sustenance and space on the same plane. The Thatch-reed maintains a large aerial growth, its tall culms carrying a quantity of broad flag which places it at a disadvantage with its competitor, whose narrow cylindrical leaves do not make a heavy demand on the roots for support, but the compact rhizomatic system of the Thatch-reed enables it to keep its more straggling opponent at bay. In the deeper water the Thatch-reed is reproduced vegetatively, but the plants growing in the shallow marsh mud frequently flower and fruit.

Triglochin procera R. Br., a flaccid-leaved, tuberous-rooted, aquatic herb, endemic within the Commonwealth, occasionally intrudes the open spaces of the formations of both Thatch-reed and *Scirpus*, occupying in the deeper water a position similar to that held by its smaller relative *T. striata* in the shallower habitat on the marsh. *T. procera* is not as communal as its congener and is one of the few perennial herbs frequenting the estuary which has not connected its members either epigeally or hypogeally by means of runners or rhizomes. The fruits of *T. procera* have a brief flotation, the soft corky coat of the carpels, though buoyant, is soon saturated, none floating longer than 48 hours; the cylindrical seeds stripped of the coat sink immediately.

In a narrow tidal channel on the southern bank of Cook's River which enters the marsh on the eastern side of Cook's River Road, a ribbonlike formation of *Azolla filiculoides* Lam., var. *rubra* Diels., was observed lining the muddy bank on either side of the watercourse at high water mark. When visited in November (it is an æstival monocarp) the plants were resting on the mud but would be awash at high tide. The *Azolla* is usually found in fresh water pools and was not noted elsewhere in the Port Jackson district in a saline habitat. Though the plants were vigorous, they had not collected into the close layer which they form in a pool, the thinness of the sheet reflecting the disturbing tidal influence. The diminutive fern-like plants float on the surface and are dispersed by currents.

3. *The Fluvial Zone.*

The line of demarcation between the dry salt plain and the fluvial zone is frequently indicated in the local marshes by the Swamp-Oak, *Casuarina glauca* Sieb., which follows the boundary of the plain in belted formation or spreads into an irregular forest in the fluvial swamp frequently formed at the head of the bay, or on the swampy river flats. Its movements are restricted to the vicinity of the tidal waters owing to its partiality for a saline environment and its objection to a dry station. In exceptional cases a grove of these trees has ascended the hillside to a distance of 1000 yards from the waters of the estuary, *e.g.*, the clump near the Mitchell Library, and a straggling colony which has reached the Pittwater road at Deewhy. A forest formation of *Casuarina glauca* on the Parramatta River is depicted in a photo by R. H. Cambage.* Belts of these pine-like trees line the banks of the Curl Curl lagoon on the Manly-Narrabeen Road and ornament long stretches of the banks of Cook's River at Undercliffe and Duck River at Clyde with shady avenues. The *Casuarina* is exceptionally well equipped to withstand the xerophytic conditions obtaining in the estuary, its vertically held cylindrical branchlets, arranged in switch-like tufts and practically aphyllous, offering a minimum surface for subjection to direct insolation.

The equisetoid branchlets are laxly jointed, and consequent upon the advent of a sudden dessicating factor such as the passage of a hot wind over the forest, they are easily dismembered and fall (simulating the leaf-fall of a mesophytic tree under a like provocation), affording the root system a speedy measure of relief from the strain of the accelerated evaporation.

The bedding of fallen branchlets under the trees has been compared by several writers to the carpet of Pine-needles in a

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* in Maiden, J. H., The Forest Flora of N.S.W., ii., 1907, p. 96.

Pine-forest. In a *Casuarina* forest at Bray's Bay on the Parramatta River, a carpet of branchlets was found several inches thick, which had rendered the habitat almost untenable for herbaceous vegetation. A sward of Salt-grass established on the verge of the salt-plain had forced a passage some yards into the forest by mechanical pressure, where the deposit was thin, but its further progress was arrested by the accumulation of dead branchlets. A few tufts of *Juncus maritimus* which had entered the forest were able to develop in its precincts, their strong, sharp-pointed leaves and stems pushing upwards through the debris to secure the necessary illumination. The cylindrical elongated branches of the *Casuarina*, held vertically and regularly-spaced, break the light in a manner suited to the requirements of the numerous epiphytes to which its protection is extended. On the banks of Tuggerah Lakes and the tidal channel entering the Tom Thumb lagoon near Wollongong, the trunks of the *Casuarinas* harbour dense masses of the Pencil Orchid, *Dendrobium teretifolium* R. Br., in addition to the Lichens which are invariably present. These trees are also exceptionally subject to infestation by parasitic *Loranths* which frequently reward their host by accomplishing its destruction. It is doubtless more than a coincidence that the leaves of the Pencil-Orchid, and its associate *Loranthus linophyllus* Fenzl., (probably the var. *b*. of Bentham* which has a coastal range from Brisbane to the Illawarra), both of which have chosen *C. glauca* as a host, should simulate the cylindrical growth form of its branchlets.

The seed-like nutlets of the Swamp-Oak are surmounted by a membraneous wing and have a highly polished coat. The wing is larger than the nut and would carry it a short distance from the parent plant in a strong breeze, but is not adapted for a lengthy flight. The nutlets of *C. glauca* floated for a week, the varnished coat, though not ruptured, developing permeability at an early stage of immersion. Nutlets of *Casuarina distyla* Vent., which is not a halophytic species, sank within 48 hours The influence of the wing on buoyancy is inconsequential, fruits from which the wings had been removed sinking in a like period to those upon which it was retained, though it was noted that the nutlets of *C. glauca* floated wing upwards, and those of *C. distyla* with the wing downwards.

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* Flora Austr., iii., 394.

Several Tea-trees, *Melaleucas,* all of which are confined to Australia, constitute the major portion of the ligneus vegetation in the *Casuarina* forest (Plate xxvi., fig. 19). They have xerophytic leaves ranging from the prickly foliage of *M. nodosa* Sm., the less harsh and smaller cylindrical leaves of *M. ericifolia* Sm., the broader and frequently twisted leaf blade of *M. styphelioides* Sm., to the somewhat flattened elongated leaves of *M. linariifolia* Sm. *M. ericifolia,* a shrub of 3--6 feet, less plastic than its congeners, is confined to a moist soil frequently extending its colony on to the tide-flooded mud-banks projecting into the stream and covering them with a dense exclusive growth. Though tolerant of periodical tide-flooding, this species is not strictly halophytic, as it forms comparatively large colonies in the fluvial mud at the head of the marsh. *M. styphelioides,* and *M. linariifolia,* do not reach their optimum growth in the *Casuarina* forest, as they are dominated by the latter which outgrows them, but on the Wianamatta Shale flats in the Bankstown-Cabramatta districts these Tea-trees attain an arboreal growth equal to that of the *Casuarina.* Both *Melaleucas* are occasional on the local sandstone in swampy places but neither can maintain more than a shrubby growth on the dry sandstone hillsides. *M. nodosa* attains its individual optimum in the *Casuarina* forest where the canopy formed by its taller associate compels it to ascend to obtain light, but its maximum communal growth is reached on the shale flats where, though inferior in height, it spreads laterally, covering areas several acres in extent with an exclusive thicket. It is also capable of maintaining a vigorous but less compact colony on the Hawkesbury Series, both on the rocky ocean escarpment and the landward sandhills *M. ericifolia* is unable to accompany its swamp associates to the dry shale flats but a reddish-purple flowered variety, var. *erubescens* Benth., mingles with the other *Melaleucas* in the Clyde-Auburn district at a distance from the marsh. Of the Tea-trees noted, mature seeds sank within 12 hours.

The Blackthorn, *Bursaria spinosa* Cav., a spiny shrub endemic within the Commonwealth, has a sparse representation in the *Casuarina* forest and occurs in company with *Melaleuca nodosa* on the shale flats, where it congregates in large colonies. These shrubs are also frequently associated on the sandstone hills. The *Bursaria* is exceptionally rigid in its habit of growth which varies but slightly under widely differing conditions of soil and moisture. Another xerophytic shrub with a coastal range in southern New South Wales, Victoria and Tasmania, occasional in this habitat, is the heath-leaved *Kunzea corifolia* Reichb., but its preference for a more brightly illuminated station is shown by its greater frequency and larger colony in an open situation. The *Kunzea* maintains its association with the *Bursaria* and *Melaleuca nodosa* throughout their several habitats and reaches its maximum communal growth on the shale flats.

In a *Casuarina* forest at Cook's River on a clayey alluvium flat on the western side of the Illawarra Road, the trees on the landward side have been felled, the undergrowth cleared, and the land laid down in pasture. The soil nearest the river is too salt for the Couch and Buffalo grasses, of which the sward is composed, and a broad band of *Sporobolus virginicus* is established along the river margin, extending inland until the drier conditions and reduced soil salinity become sufficiently favourable to the pasture grasses to enable them to resist further encroachment. The original vegetation is reappearing, and already some of the shrubby species have recaptured small areas and are driving back the introduced vegetation, especially on the river front where the trees were not disturbed. In the habitat subject to the clearing operations several aliens have established colonies, temporarily replacing the natural undergrowth. The Lantana, *Lantana camara* L., an introduction from South America, whose usefulness as a producer of humus on large areas of unoccupied land in Northern New South Wales and Queensland has been somewhat dubiously championed, has here invaded the forest with a weak growth. An aggressive coloniser in poor but well-drained land, it is unable in this swampy soil to form its customary thicket, breaking up into small clumps or individual bushes as it advances towards the river, and offering little resistance to the oncoming shrubby indigenous vegetation. The Lantana is indebted to birds for its distribution, its fleshy fruits affording them a tempting bait.

The Poke-weed of North America, *Phytolacca octandra* L., a succulent herbaceous perennial with broad mesophytic leaves, which has a wide range as a ruderal weed in most tropical and subtropical regions, has established a colony on the flank of the Lantana. The factors of shade and moisture obtaining in the habitat favour the development of the Poke-weed and it is not detrimentally affected by soil salinity, but its soft yielding frame offers no obstruction to the shrubs which are driving it back as they advance. This is one of the first weeds to appear on newly-cleared land, especially in places where the previous vegetation has been destroyed by fire. It soon becomes exhausted in a habitat and dies out, a phenomenon not infrequently noted among herbaceous weeds. The fruits of the Poke-weed were found in the stomachs of the following Australian birds (38)· Peaceful Dove, *Geopelia placida,* Yellow-throated Scrub-Wren, *Sericornis barbara,* Silver Eye, *Zosterops coerulescens,* Yellow eared Honey-eater, *Ptilotis chrusotis.*

Solanum auriculatum Ait., a tropical American herbaceous perennial with several vernacular names each obtaining a more or less wide acceptance, is represented by a few individuals whose behaviour is somewhat similar to that of the Poke-weed, though it is not so widespread. The Wild Cotton-plant *Gomphocarpus fruticosus* R. Br., introduced from South Africa, which has also secured a footing in the forest will be more difficult to displace than the two preceding species, its tough fibrous stems and compact formation presenting a formidable line of defence. As it advances, the shrubby *Melaleuca ericifolia* is overcoming the *Gomphocarpus* in the swamp but cannot follow it on to the dry hillside. A coma of silky hairs is appended to the seeds of the *Gomphocarpus,* but their attachment is weak and they are of no value for flight. The seeds sink within a few hours.

In a *Casuarina* forest at the head of the saltmarsh at Wooloo-ware Bay (Cronulla), the Bramble, *Rubus fruticosus* L., has established a thicket and initiated the invasion of a slightly raised, comparatively dry flat, exterminating all except the arboreal vegetation in its onward march. The Bramble is advancing in the direction of a colony of *Melaleuca ericifolia* which has entered the flat from the swamp. When the two formations come into contact, the Bramble, with its effective offensive equipment, will dominate the *Melaleuca.* Its firm but supple canes, furnished with broad horizontally-arranged leaves, will run over the tops of the *Melaleuca* bushes, building a thick screen and depriving them of light, its powerful rhizomes meanwhile forcing a passage among the shallow roots of its opponent, competing with them for nutrition and sapping their vitality. Attacked both above and below ground, the *Melaleuca* will be compelled to retreat until the habitat becomes too moist for the

Bramble. When this station is reached their respective boundaries will be regulated by the fluctuating water supply. The Bramble is incapable of building a thicket sufficiently high for the suppression of the taller *Melaleucas*, but if left undisturbed, will eventually displace them, its close investment preventing sexual reproduction—their only means of renewal—as no seedlings could survive in the Bramble thicket. The investment by the Bramble also operates unfavourably to the *Casuarina*, whose seeds, though provided with a wing, are not, as previously shown, adapted for a lengthy flight.

The Chinese Box-thorn, *Lycium chinese* Mill., is represented in the *Casuarina* forest by a scattered colony, discarding in this station its customary chapparal growth. At Lady Robinson's Beach, the Box-thorn has demonstrated its halophytic tendencies and exposure-resistant capacity, by extending in belted formation along the verge of the frontal embankment of the dune. Its hardy growth and divaricate habit have encouraged its cultivation as a hedge plant, but its adaptability has, in many places, destroyed its usefulness as it has spread over the pastures and is difficult to eradicate.

The undergrowth in the muddy fluvial station in the *Casuarina* forest is largely herbaceous, the dominant species responding to the xerophytic conditions, lack of aeration and acidity, by the production of leaves and stems with a fibrous or leathery texture. The keenest competition in this station occurs among the low growths in the flooded depressions, the taller plants usually forming loose clumps, or occurring as isolated individuals, on the slightly elevated ground surrounding the depressions. Several species have developed a trunk-forming habit with the object of raising the crown of the rootstock—from which the tender young shoots emerge—above the level of the occasional flood-waters. Of these the most prominent is a giant Tussock-forming Sedge, *Gahnia psittacorum* Labill., endemic in the Commonwealth, which erects a mound at its base, its bulky rhizomes, whose twisted arms arise and project in every direction, obstructing and retaining debris from the passing flood. These mounds form a special habitat and are occupied by a few selective minor herbs whose requirements are a rich permeable soil with a constant supply of moisture. The distribution of *G. psittacorum* is the work of birds, chiefly Parrots, as the specific name indicates, though other birds are in some measure responsible for its dispersal, the seeds of this Sedge forming part of the stomach contents of *Corcorax melanorhamphus,* the White-winged Chough (38, p. 94). The seeds in an early stage of maturity are bright red, changing when fully ripened to a dull brown. They are shed from the glumes while still highly coloured and hang temptingly suspended by the elongated staminal filaments. As the colour fades, the shrinking filaments draw the seeds inwards to the rachis. The red (unripe) seeds sank directly, the dry, brown, fully-ripened seeds floating for several days. This giant Sedge is present in the fluvial station in the saltmarshes and in swamps and watercourses throughout the district.

The only local species of either *Gahnia* or *Cladium* whose fruits have more than a few days' flotation is *Cladium jamaicense* Crantz, *(Cladium (Gahnia) mariscus* (F. v. M.) R. Br.), a cosmopolitan species listed by Guppy (13, 537) as having a flotation of several months. Seeds tested by the writer were immersed 26th August, 1918, and are still afloat (28th June, 1919). Though its fruits have every facility for dispersal by water, this widely ranging species is indifferently represented in the Port Jackson district. It is well established on the mudbanks in the fresh waters of the upper reaches of Duck River and in the broken headwaters of several arms of George's River at Oatley, etc., and was collected at Cook's River by Mr. A. H. S. Lucas. Its inadaptability is disclosed by its failure to spread along the course of these rivers and colonise the numerous freshwater swamps and lagoons with which they are more or less connected.

Blechnum serrulatum Rich., a hardy fern which extends from tropical America to the Malayan Archipelago, is frequently associated with *Gahnia psittacorum,* erecting a limited brake on the mounds at its base and raising its fronds above the flood-waters on short rhizomatic trunks. When growing in a peaty bog, the *Blechnum* usually chooses a station near the margin where the surface is only occasionally flooded. In this habitat the necessity for uplift is removed and the trunk formation is discarded, the young fronds springing directly from the crown of the tuft at the ground level. In some of the local bogs the *Blechnum* has taken possession of this zone and extended along the peaty margin in a broad band, restricted on the landward side by the dry bank and regulated in the swamp by the depth of water. An example of this banded formation occurs at Maroubra Bay in the margin of the swampy lagoon at the rear of the beach.

The Bead-fern, *Gleichenia dicarpa* R. Br., an Indo-Malayan species which extends to Tasmania, is occasional in this station, frequently associated with *Dryopteris punctata* (Thunb) C. Chr., a tropical species which reaches extra tropical latitudes in southern regions. Both ferns are limited to small clumps in this station but in the peat-bog, their preferential habitat, their formations are more extensive, the Bead-fern in some of the local swamps building a tangled brake 2--3 feet high, and several acres in extent, overrunning the smaller Cyperaceous and other herbaceous growths. In the frequent encounters between these ferns the *Gleichenia* prevails in the flooded areas, its wiry trailing stems sprawling over the rigid frondage of the *Dryopteris* and smothering it. As it advances to the drier station it weakens and is unable to support a heavy aerial growth. The rhizomatic system of *Dryopteris* is stouter than that of the *Gleichenia* and when the formations meet it is able to hold its slender but sinewy opponent at bay by arresting the further progress of its rhizomes. These ferns may be observed engaged in such a competition in a peaty swamp in Centennial Park.

The Bracken, *Pteridium aquilinum* (L.) Kuhn., is less tolerant of a wet soil than its confreres and does not proceed far into the fluvial zone. Though frequently found in close proximity to tidal waters, the Bracken is not a halophyte, its most vigorous colonies occurring in non-saline soils, and it especially favours a permeable, sandy, well-drained soil. Its avoidance of a calcareous soil has been noted by many writers. *Goodenia ovata* Sm., a shade and moisture loving species—endemic in the Commonwealth—forms tangled patches on the margins of the depressions, the weak stems of the plants interlacing their branches for mutual support. Though tolerant of a degree of salinity, the *Goodenia* is equally suited in a freshwater station. Seeds of *G. ovata* sank within 24 hours.

The Tall Corn Flag, *Gladiolus cuspidatus* Jacq., whose station in its native country (South Africa) is the coastal sand-dunes, was noted in the tidal zone in the saltmarshes at Tempe and Buffalo Creek. It is one of the few bulbous plants found in saline stations and is well established in both marshes. The rootstock, a globose corm protected by a tunic of matted fibre, produces a cluster of bulbels which aid in the distribution of the plants. The winged discoid seeds floated for six days. A succulent-flowered Orchid, *Cryptostylis longifolia* R. Br., which also has a tuberous rootstock, is occasionally associated with the *Gladiolus*, and they were noted in close proximity in a peaty swamp in Centennial Park.

The Fox-tail Grass, *Polypogon monspeliensis* Desf., an immigrant from the Mediterranean, enters the various herbaceous associations on the border of the salt plain, the flaccid tufts accommodating their growth to the pressure of their hosts by a vertical uplift. In a close sward of Couch or Buffalo this short-lived grass makes a weak growth a few inches high, but in an open formation of *Cotula coronopifolia* in the fluvial mud or on the mounds at the base of the *Casuarina* trunks, it reaches a height of 1½--2 feet. An Australian Composite, *Epaltes australis* Less., a fleshy prostrate perennial with dull brown rayless (discoid) flowers, forms a scattered colony on the margins of the depressions in the vicinity of the salt plain. This weedy herb is rarely subjected to competition as it is tolerant of a sour soil and usually occupies a habitat shunned by other herbage. It has established numerous colonies on the ill-drained Wianamatta Shale flats in the Fairfield-Canley Vale district. The achenes of this species sank within 24 hours.

Jussieua repens L., a cosmopolitan perennial, creeps in the mud or builds up a mass of matted herbage in the shallow pools. When growing on the mud or in shallow water the *Jussieua* develops breathing roots on the submerged rhizomatic stems in the interstices between the joints from which the true roots emerge. When floating in deeper water the plants are frequently beset with small bladder-like cavities (vesicles) around the base of the leaves, which are occasionally present in sufficient numbers to sustain the stems. *Paspalum distichum* L., a cosmopolitan grass with a creeping habit, builds up a thick sward in the shallow depressions. Bailey* separates this species into two distinct varieties, *normale* and *littorale*. The former he describes as a broad-leaved grass which grows in fresh water and the latter a narrow-leaved form confined to brackish swamps. This distinction was noted locally, the plants growing in fresh water showing a broad lush (mesophytic) flag, and those in the brackish station the tough wiry leaves of the xerophyte. In his Manual of the Grasses of New South Wales, J. H. Maiden gives some interesting ecological references, climatic and edaphic,

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* Queensland Flora, vi., 1902, p. 1814.

to this grass, together with valuable economic notes. Various common names have been given to this species but the var. *normale* is perhaps best known as Water-Couch, and the var. *littorale* as Sea-side Millet. During its active growing stage—it is an æstival grass—it banks up a mass of divaricately-branched herbage which overruns the intrusive annuals that have taken advantage of its resting period to enter its sward. The supremacy of the *Paspalum* in the brackish pools is frequently disputed by *Juncus prismatocarpus* R. Br., a perennial rush which adopts a similar arrangement of its colony. The formations of the grass and rush are evenly matched in height, density of formation, and mechanical structure, their respective rhizomes, which feed on the same plane, maintaining the equality of their competitive equipment. When colonising a new habitat, which may have arisen through a favourable alteration in the depth of water—the shallowing of a deep pool, or the flooding of a dry station—primary possession determines their relative boundaries. Their joint occurrence in a pool is most frequent in the zone between the fresh and brackish waters, the *Juncus* exhibiting a greater partiality for salinity than its associate, though equally capable of forming a sward in fresh water.

The Mat-grass, *Rotbellia compressa* L. f., an Asiatic species which has spread along the coast of Australia and reached Tasmania, is a decumbent perennial with weak culms, which elongate and assume a straggling habit when growing among rushes or the taller Cyperaceous plants. Normally a swamp-dweller, the Mat-grass can adapt itself to comparatively dry conditions and is not averse to a degree of salinity. At Buffalo Creek (Lane Cove), a vigorous growth of this grass has ranged behind a band of *Cladium junceum* on the border of the marsh. In this station it is able to maintain the integrity of its formation, but in a dry habitat its density is broken and intruded by the Common Couch and other lawn grasses.

Two flaccid perennial Sedges, *Scirpus inundatus* Poir., and a close relation, *S. prolifer* Rottb., occasionally join forces in the invasion of a shallow pool in the fluvial station, their weak stems mingled in a ramifying growth. They are preferably freshwater plants and do not proceed far into the brackish zone. *S. prolifer* frequently produces a proliferous growth on the tips of its stems—simulating vivipary—which roots when it reaches the ground, affording the plants some assistance in the extension of the colony. The seeds of both species sank within 24 hours.

Philydrum lanuginosum Bks., a succulent perennial which ranges from China to Victoria, is common in the brackish pools. It is also well represented in freshwater pools and swamps and shows no appreciable alteration in either station. In the shallows its growth is dwarfed, the tufts attaining their tallest growth in permanent water 2--3 feet deep. The small seeds sank within 12 hours. The Australian Violet, *Viola hederacea* Labill., creeps on the banks of the pools or occupies the mounds at the base of the *Gahnia* and *Casuarina; Commelina cyanea* R. Br. trails over the low sedges and other herbaceous growths; *Goodenia paniculata* has also a limited representation in this station. The three above-mentioned species are preferably freshwater habitues. The Creeping Monkey Flower, *Mimulus repens* R. Br., spreads a small mat of one to a few individuals on the ridges in the saline area, occasionally invading the salt plain in moist places. It was noted on the tide-flooded mud-banks in Cook's River—an exclusive habitat—forming small patches. In both stations the *Mimulus* is associated with *Cotula reptans,* also a mud-creeper with a meagre representation. *C. reptans* establishes its largest formations in the coastal lagoons, Curl Curl, etc., and is less tolerant of a freshwater station than its associate. *Limnanthemum geminatum* Griseb., has a similar range of salinity to *Cotula reptans* and is also common in the coastal lagoons, a banded formation of this species occupying a distinct zone on the shallow margin of the Narrabeen lagoon. A broken colony was also noted in the less saline mud of a *Casuarina* forest at Cronulla, its disintegrated membership evincing its antipathy to the semi-aquatic habitat. That the reduced salinity is not the cause of its weak growth is shown by the flourishing colonies it forms in freshwater creeks and pools.

Two species of *Hydrocotyle, H. hirta* R. Br. and *H. asiatica* L., frequent the muddy depressions, but do not reach the salt plain. *H. hirta* requires more moisture than its congener, displaying a preference for a muddy habitat, the latter making a more robust growth in a turfy lawn. Both are preferably freshwater habitues. The Mullumbimby Couch, *Kyllingia monocephala* Rottb., forms a close sward on the verge of the pasture on the marsh boundary slopes where it is frequently associated with *H. asiatica;* both species spread into the lawn, the *Kyllingia* weakening as the saturation decreases. The latter is a tropical species, reaching its southern limit in New South Wales. Its luxuriant growth on the rich alluvial flats on the northern rivers has gained it an unenviable notoriety among the dairy farmers, who are responsible for its vernacular name.

The Small Loosestrife, *Lythrum hyssopifolium* L., a weedy annual with a cosmopolitan range, chiefly maritime, reaches its optimum in a ditch or shallow pool, but attains a fair growth in the pasture of the *Casuarina* forest. *Haloragis micrantha* R. Br., a twiggy, depressed undershrub, indigenous in Japan and New Zealand and extending northwards along the Australian coast to Queensland, is occasional in the fluvial mud, its short stems appressed to the moist soil with the flowering branches held erect, raising the inflorescence above the water line.

Two small rushes, *Juncus bufonius* L., a cosmopolitan annual, and *J. plebius* R. Br., a perennial confined to Australia, are represented in the pasture. *J. bufonius* requires more moisture than its associate and can tolerate a greater degree of salinity, frequently intruding the herbals in the brackish station, and developing a broken, short-lived sward. *J. plebius* has a scattered formation with rarely more than a few individuals in each tuft. It is occasional in the sour clayey soils in the Bankstown-Cabramatta district where it is joined by a diminutive Sedge, *Cyperus tenellus* L., an annual with the growth habit of *J. bufonius*, a native of South Africa with a southerly range along the Australian coast from New South Wales and extending to New Zealand.

A Malvaceous perennial introduced from South America, *Modiola multifida* Moench., creeps through the pasture, rooting at short intervals and starving out any weak herbs in the vicinity of its closely-knitted carpet. In the Couch lawn, its creeping stems are forced upwards and it is unable to form a mat, the long runners trailing over the sward.

Solira sessilis Ruiz & Pav., a flaccid annual with finely dissected leaves and a low decumbent growth, dominates during its active season large patches of the Couch lawn on the marsh boundary. The creeping stems root freely, forming an intricate mat and suppressing the Couch, a few blades only of the grass struggling through to the light. In St. Luke's Park, at the head of the saltmarsh in Hen and Chickens Bay, a Couch lawn was invaded by this weed which took possession of a portion of the lawn on the marsh front about an acre in extent. Its optimum was reached in midsummer when hardly a blade of grass could be seen in its carpet, but when again visited in midwinter not a vestige of the *Soliva* was visible and the Couch dominated the recently invaded area. A congener, *Soliva anthemifolia* R. Br., also of annual duration and with similar foliage is less aggressive, rarely spreading over more than one or two feet of turf during its period of activity. *S. sessilis* succeeds best in a sandy soil and is tolerant of moderately dry conditions, its congener displaying a preference for a moist clayey alluvium, neither advancing into the brackish station on the margin of the salt-plain. *S. sessilis* was first recorded for Australia by Maiden and Betche* and was figured and described by Maiden†. It is not known when *S. anthemifolia* appeared in Australia, but it is viewed as a doubtful member of the native vegetation. Both species are indigenous in South America. The distribution of the seeds of *S. sessilis* is probably carried out by animals, the pointed dart at the apex of the achenes piercing their skins, or the marginal irregularities becoming entangled in their coats. The achenes of *S. anthemifolia* emit mucus when wet and would adhere to the plumage of birds. In both species the achenes have but a few hours' flotation.

Two Buttercups, *Ranunculus muricatus* L., a tufted annual introduced from the Mediterranean region, and *R. rivularis* Bks. and Sol., a stoloniferous perennial, a native of Australia which extends to New Zealand, meet in the boundary pasture. Both species find a limiting factor in this station, insufficient moisture retarding the progress inland of *R. rivularis*—normally an aquatic, with finely dissected leaves—which reaches its highest stage of development when submerged. *R. muricatus* is precluded from advancing towards the salt plain by the salinity of the station. The latter clears a space for its tufts by spreading its stiff basal leaves in the form of a rosette and overlying the grass in its vicinity. Its associate, on the contrary, is pressed by the stouter herbage into an upright growth, its weak foliage reclining on the sward. Large colonies of *R. rivularis* occur in the muddy flats on the banks of Cook's River, *R. muricatus*, in its season, spreading over the inland Couch sward. The

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* These Proceedings, xxiv., 1899, p. 646.

† Agric. Gazette N.S.W., 1917, p. 183.

evidence points to the distribution of the Buttercups by birds. The protuberances which cover the flattened sides of the fruits of *R. muricatus,* and endow it with a specific name, impart a rough surface to the achenes when dry, which would cause them to catch in the plumage of birds, or to adhere to their muddy feet. The achenes of this species sank within 12 hours.

The Rib-herb, *Plantago lanceolata* L., a tufted perennial with a wide distribution in temperate countries, is frequent in the station selected by *R. muricatus*, and behaves in a similar manner. Hooker (24, p. 271) notes that the seeds of this species have a mucilaginous testa.

Several Docks of which the Curled Dock, *Rumex crispus* L. and the Clustered Dock, *R. conglomeratus* Murr., are the most frequent, form tufted colonies in the boundary pasture. These aliens have a perennial rootstock and a fusiform tuberous tap-root which descends to a considerable depth in the sour soil where no competition is encountered. During their resting period the tap-roots accumulate a large supply of food which is greedily absorbed by the plants in the growing season. When the active growth commences the tufts enlarge—the Docks employ the same method as that practised by *R. muricatus* to secure expansion—and stout leafy stems arise from the crown of the rootstock upon which the inflorescence is elevated. After fruiting, the aerial portion of the plant dies and the tuft is reduced to a small rosette. The Sheep's Sorrel, *Rumex acetosella* L., is occasional in this station where, though not mechanically aggressive, it maintains a position owing to exceptional tolerance of soil acidity. Its antipathy to a calcareous soil has been frequently noted. The Sorrel has replaced the deep tap-root of its congeners the Docks with the shallow rhizomatic growth adopted by most of the marsh herbs. Seeds of the Sorrel either enclosed in the perianth or separated from it sank within 24 hours.

Melilotus parviflorus Desf., the Scented Melilot of Europe, an adaptable annual with an erect growth habit, has no difficulty in securing a footing among the pasture herbs, its deep taproot descending to feed below their root systems and its aerial growth ascending above them. In moist, permeable, non-saline soil the plants may rise to a height of 3 feet, but at Cook's River a small colony was noted on the margin of the salt plain, debilitated by the excessive salinity, flowering and fruiting at a height of 1 to a few inches (Plate xxviii., fig. 24). *Polycarpon tetraphyllum* Loefl., a diminutive mat-forming cosmopolitan annual, common in sandy maritime stations, can only maintain a position in the sward of a resting species or on a vacant space, its weak growth offering no resistance to the pressure of its stronger associates. On a newly reclaimed area at Cook's River it was the only vegetation present, dotting the ground with isolated mats some of which extended to 1 foot in diameter. The persistent bracts and sepals of the closely-packed flowers, which turn red in fruit, presented a striking contrast to the pale rain-leached sand.

The Petty Spurge, *Euphorbia peplus* L., an introduced annual with an upright habit, is forced into a rank growth by the damp shady conditions obtaining in the lax pasture of the *Casuarina* forest, its weak lanky stems supported by the surrounding herbs. In common with many of its congeners, the Spurge secretes a milky latex. The Pimpernel, *Anagalis arvensis* L., another cosmopolitan shade and moisture loving annual, with a decumbent growth, also frequents the *Casuarina* forest, both the blue and scarlet flowered varieties trailing succulent stems through the pasture. *Fimbristylis diphylla* Vahl., a tufted perennial sedge common in most warm regions, is occasional in the pasture where it is non-competitive, its flaccid basal leaves folding vertically round the stem when pressed by the grasses which it intrudes. *Chenopodium album* L., the White Goose-foot of Britain, an adaptable weed with a cosmopolitan range, enters most of the formations from the boundary of the salt plain inland. Its lengthy taproot penetrates the marsh mud undeterred by either acidity or salinity, and can develop an equally vigorous growth in a comparatively dry station if the soil is permeable. The plants maintain their positions in the formations which they intrude, by building a tall, spreading, leafy screen which acts as a deterrent to approaching competitors. Seeds of *Chenopodium* spp. were frequently identified in the stomach contents of Australian birds (38).

The slopes on the boundary of the marsh are usually clothed with a Couch lawn which is intruded by numerous ruderals, chiefly Clovers, Medicks, Grasses and Thistles. The Clovers, *Trifolium* spp. and Medicks, *Medicago* spp., are chiefly creeping or procumbent herbs and make their maximum growth in the moist meadow at the base of the slope, gradually weakening as they ascend the dry hillside. These plants make a close matted growth in the lawn, several species frequently associating, subduing the Couch, and taking possession of small areas during their active growing season. After fruiting, the annuals disintegrate and the perennials reduce their mat, the Couch resuming the vacated area. The ruderal grasses are chiefly annuals and range from the meadow at its base to the crown of the slope. They are mostly shallow rooting and scantily tufted and do not interfere to an appreciable extent with the Couch. An exception is provided by the Barley-grass, *Hordeum murinum* L., which develops a powerful offensive mechanism, its elbow-shaped stems forcing back and depressing the weaker stems of the Couch and forming a radial patch in the lawn.

In addition to the introduced grasses several indigenous species of perennial growth are represented on the slopes and where undisturbed soon re-establish their supremacy. The Kangaroo-grass, *Themeda Forskalii* Hack. var. *imberbis*, a tufted grass, maintains a comparatively large colony, its thick tussocky growth smothering the adjoining herbs. The Blady-grass, *Imperata arundinacea* Cyr., a rhizomatic species, also covers considerable areas, its aggressive underground stems and tall broad aerial flag forming a strong offensive and defensive combination. The Blady-grass is frequently associated in this station with the Bracken Fern, *Pteridium aquilinum* (L.) Kuhn. The Thistles range throughout the slopes, their strong, rough, fibrous stems defending the colony from aggression by the taller herbs and their heavy basal rosettes suppressing the lower growths. *Scirpus nodosus* Rottb., a tall slender-stemmed rush common on the shore-line, has a limited representation on the hillside. A series of smaller and weaker herbs in the Couch lawn includes the Common Chick-weed, *Stellaria media* L., and the Mouse-eared Chick-weed, *Cerastium vulgatum* L., both introduced weedy annuals, and *Cotula australis* J. Hook., an Australian perennial. The members of this group do not form large colonies nor enter into competition with the Couch, their flaccid stems and leaves trailing over the grass which they are not firm enough to displace nor sufficiently close to overshadow.

Of the arboreal vegetation on the slopes the White Honeysuckle, *Banksia integrifolia* L. f. descends into the fluvial zone on the boundary of the *Casuarina* forest. In their customary habitat on the exposed shore line these trees are compressed into a narrow conical growth but in this moist sheltered station they develop an umbrageous habit. At Hen and Chickens Bay a group of Turpentine trees, *Syncarpia laurifolia* Ten.—symptomatic of the shale—was noted on the hillside at no great distance from the marsh. The River Mangrove, *Aegiceras majus* Gaertn., is indifferently represented in the local marshes, the largest formation observed occurring in a marsh on the southern bank of Port Hacking River, near the entrance. This species is more frequent locally on the banks of tidal rivers than in the marsh proper, several clumps occurring on the banks of Cook's River, and on the banks of George's River at Como, always ranging behind the Grey Mangrove. In the latter locality several trees of the Grey Gum, *Eucalyptus punctata* DC., were noted in a formation of *Juncus maritimus* on the muddy river bank. The halophytic tendency of the Grey Gum is shown in a record of its habitat by J. H. Maiden,* "Kuring-gai Chase, at edge of salt-water, near house-boat. W. F. Blakely." A bush of *Viminaria denudata* Sm. had also penetrated the ranks of the *Juncus* formation a considerable distance into the tideway.

In the vicinity *Polygala myrtifolia* L., an aggressive, soft-wooded shrub introduced from South Africa as an ornamental garden plant, has escaped from cultivation and spread round the sides of an amphitheatre-shaped gap in the river bank which had been cleared and grassed. The original indigenous vegetation is already reasserting itself, the Native Grapes, *Vitis Baudiniana* F. v. M., and *V. hypoglauca* F. v. M., climbing over the *Polygala* bushes and enveloping them.

On the rock benches overhanging the river a series of succulent epiphytes form small clustered colonies. Of these, the somewhat rare *Calandrinia Pickeringi* A. Gray, and *Peperomia leptostachya* Hk. et Arn., are occasional, their associate *Plectranthus parviflorus* Henck., occurring more frequently and forming larger colonies. Though these herbs are usually found in shady situations, they can flourish under strong illumination, occasionally growing on rock ledges exposed to direct sunlight for the greater part of the day. The two former species rarely depart from the epiphytal habit of growth but the *Plectranthus* is more adaptable and on occasion becomes a troublesome weed in cultivated land.

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* Critical Revision of the Genus *Eucalyptus*, iii., p. 197.

Along the river banks several trees and shrubs were noted which, though found in situations far removed from tidal waters, exhibit a measure of partiality for a saline environment. *Acacia falcata* Willd., has lined the banks of Bray's Bay on the Parramatta River with a belted shrubbery. The soft-wooded *Clerodendron tomentosum* R. Br., grows almost to the water's edge at Cook's River and was also noted on the banks of George's River near Como. *Glochidion Ferdinandii* J. Muell., has formed an extensive grove in the vicinity of the bridge over George's River at Como, and a smaller colony near the tideway at Fig-tree, Lane Cove River.

Of the plants noted in the marsh proper the following are found in the saltmarshes of the interior:—*Samolus repens, Suaeda maritima, Spergularia rubra, Triglochin striata, Juncus maritimus,* var. *australiensis, Sporobolus virginicus, Mesembryanthemum aequilaterale, Tetragonia expansa, Wilsonia Backhousii.*

The specimens mounted to illustrate this paper will be presented to the Sydney National Herbarium.

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EXPLANATION OF PLATES.

Plate xvii.

Fig. 1.—Saltmarsh fringed by a band of reeds *(Cladium junceum* and *Juncus maritimus* var*)*. *Salicornia* meadow in the middle distance. Buffalo Creek, Lane Cove River.

Fig. 2.—Parallel bands of *Juncus* and *Cladium* lining the marsh. *Juncus* in the tidal zone. Buffalo Creek.

Plate xviii.

Fig. 3.—*Juncus* (drooping tufts) in tidal zone. *Cladium* (erect) on bank in swampy soil with reduced salinity. Buffalo Creek, Lane Cove River.

Fig. 4.—Intrusion of a *Juncus* formation by the *Cladium* along the course of a fresh water drainage channel. Buffalo Creek.

Plate xix.

Fig. 5.—Salt-grass *(Sporobolus virginicus)* showing luxuriant growth in response to reduced soil salinity. Buffalo Creek, Lane Cove River.

Fig. 6.—Debilitated culms of the Salt-grass prostrate on the sterile plain, the result of extreme soil salinity. Cook's River.

Plate xx.

Fig. 7.—*Salicornia australis* encircling a *Ruppia* pool on the salt plain at Homebush Bay.

Fig. 8.—Tuft of *Salicornia* bordering a detritus mound crowned with Salt-grass on a salt plain at Cook's River.

Plate xxi.

Fig. 9.—*Ruppia maritima* L. lying on the mud at low tide. Band of *Triglochin striata* lining the bank of the channel, Cook's River.

Fig. 10.—Dense growth of *Ruppia maritima* awash at high tide, Cook's River near Tempe.

Plate xxii.

Fig. 11.—Artificial environment created by the formation of a dyke at Homebush Bay permits encroachment by Seablite *(Suaeda maritima)*.

Fig. 12.—Pure culture of Seablite at Homebush Bay. Debilitated mangroves in foreground.

Plate xxiii.

Fig. 13.—Intermingled patches of *Salicornia* and Seablite clothing the salt plain at Homebush Bay. Suncracked surface in the foreground.

Fig. 14.—Stretch of barren salt-encrusted plain at Cook's River. *Juncus maritimus* on margin.

Plate xxiv.

Fig. 15.—Meadow of *Cotula coronopifolia* (inundated) bordering a Thatch-reed formation at Undercliffe, Cook's River. *Juncus maritimus* in foreground.

Fig. 16.—Dense sward of *Salicornia* in tidal zone breaking up into mats in an attempt to invade the dry salt plain at Cook's River.

Plate xxv.

Fig. 17.—Band of Thatch-reed *(Phragmites communis)* bisected by a band of *Scirpus littoralis* on the bank of Cook's River at Undercliffe.

Fig. 18.—Weak growth of Thatch-reed invaded by *Triglochin striata*. Salt plain, Undercliffe.

Plate xxvi.

Fig. 19.—Forest of Swamp Oak *(Casuarina glauca)* with undergrowth of Tea-trees *(Melaleuca spp.)* at Bray's Bay, Parramatta River.

Fig. 20.—Stranded Mangroves *(Avicennia officinalis)* invaded by a grass and ruderal pasture. Cook's River.

Plate xxvii.

Fig. 21.—*Wilsonia Backhousii* Hook. f. Stems elongating and rooting *pari passu* with the silt deposit.

Fig. 22.—Seablite *(Suaeda maritima* Dumort). Lateral roots spreading horizontally on the marsh mud.

Plate xxviii.

Fig.23.—*Triglochin striata* Ruiz. et Pav. Variation in height represented by relative degree of submergence.

Fig.24.—*Melilotus parviflora* Desf. Stunted plants on salt plain 1-1½ in. high. Normal height 3-4 ft.

Plate xxix.

Fig.25.—*Selliera radicans* Cav. 1. Growth luxuriant, few flowered. 2. Growth densely appressed, floriferous.

Fig.26.—Swamp Oak (*Casuarina glauca* Sieb.).

Plate xxx.

Fig.27.—*Juncus maritimus* Lam. var. *australiensis.* Rhizome short. Inflorescence clustered.

Fig.28.—*Cladium junceum* R. Br. Rhizome elongated. Inflorescence few flowered.

THE VENOUS OXYGEN CONTENT AND THE ALKALINE RESERVE OF THE BLOOD IN PNEUMONIC INFLUENZA.

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The skin of persons suffering from pneumonic influenza often assumes a distinctly bluish or plum-coloured tinge. This colouration was at first described as a cyanosis, and was attributed to the most likely cause of such a condition: a deficient oxygenation of the blood in the lungs. Such an assumption is the most natural one to make to explain a condition of this kind accompanying a disease of the respiratory system. It was observed, however, that many of the persons whose skins became coloured in this way did not show any marked signs of respiratory distress.

The question therefore arose, whether this colouring of the skin really was a cyanosis in the generally accepted sense of the word, that is to say, whether the colour actually was due to an abnormally large proportion of reduced hæmoglobin in the blood. An excess of hæmoglobin would be the result of deficient oxygenation of the blood, and under ordinary conditions of acidity, would lead to marked dyspnœa.

To explain the absence of obvious respiratory distress in the case of the "cyanosis" accompanying pneumonic influenza several hypotheses have been put forward. It has been suggested that the nerve centre governing respiration may be poisoned; that its sensitiveness may thus be dulled, and that the accumulation of products due to insufficient oxidation may no longer produce its customary response in increased ventilation of the lungs.

Another suggestion is that the colouring matter of the blood may itself be altered somehow. It may no longer be capable of taking up its normal amount of oxygen in the lungs, and a condition of anoxaemia which Haldane (1918) has described may result. Such a condition might be produced by a conversion of the oxyhæmoglobin of the blood into its isomer methæmoglobin. If in addition, there were decreased sensitiveness of the respiratory centre, such a condition might give rise to an appearance resembling cyanosis, but to no dyspnœa.

A third suggestion is that the colouration of the skin of influenza patients has nothing to do with the degree of oxygenation of the blood, but that it is a direct pigmentation. In this case, no respiratory disturbance would accompany the appearance of the colour.

If, as is supposed in the first hypothesis, the so-called cyanosis is due to deficient aeration of the blood, then the oxygen content of the arterial blood, and also of the venous blood, will be lower than normal, provided that the rate of the circulation does not increase out of all proportion to the metabolism. The amount of carbonic and other acids in this blood, on the other hand, will be abnormally high. Such blood will possess a normal capacity for oxygen; its degree of saturation with oxygen, however, will be abnormally low. The reaction or hydrogen ion concentration of this blood will probably also be normal, since only an extreme degree of acidosis affects the reaction. The reactivity of this blood, however, or its power of neutralising added acid will be abnormally low.

On the second hypothesis the oxygen capacity of the blood as well as its oxygen content will be altered. A given amount of hæmoglobin will not be able to take up its usual charge of oxygen. The reactivity of this blood toward alkali will also be diminished owing to the accumulation of acid products of metabolism.

On the third hypothesis the blood will differ neither as regards its degree of oxygen saturation nor its oxygen capacity from normal, and its reactivity toward alkali will also lie within normal limits.

An investigation which has been carried out by Harrop (1919) supports this last hypothesis. This worker found that the venous oxygen content and the oxygen capacity of the blood of influenza patients remained normal until the final stages of the pneumonic complications were reached. The oxygen capacity and the degree of saturation then began to diminish, and some cases reached very low values before death took place. Harrop concluded that the apparent cyanosis observed was really a pigmentation of the skin, and was no indication of a disturbed respiratory function during the earlier stages of the disease.

In the present investigation, determinations have been made of the oxygen capacity and the degree of oxygen saturation of the venous blood of persons suffering from pneumonic influenza. In some of the specimens the acidity and the reactivity were determined by means of the hydrogen electrode. The presence of bands due to pigments other than oxyhæmoglobin was looked for in the absorption spectrum of the blood, but the method adopted was not found to be sensitive enough to detect the presence of small quantities of abnormal pigments in the presence of a large proportion of oxyhæmoglobin.

If the determinations of oxygen content could have been made upon arterial instead of venous blood, the results would doubtless have been of greater value. Venous blood passes through the capillary circulation after leaving the lungs, and before it reaches the veins undergoes changes, the extent of which must remain largely a matter of assumption. And these considerations must be of greater weight in conditions in which there is an enhanced metabolism due to fever. With all these reservations, however, it seems clear that, under similar pathological conditions, pronounced variations of the oxygen content of venous blood must be associated with variations in the same direction of the oxygen content of the arterial blood, and some recent work by Stadie (1919) has shown this to be the case. Further, there is the practical aspect of the matter; the obtaining of arterial blood is an operation likely to cause considerable discomfort to a person who is already seriously ill, while the obtaining of a sample of venous blood requires only a few moments, and subjects the patient to a minimum of inconvenience.

The above reservations with regard to venous blood do not hold for the determinations of acidity and reactivity. The methods adopted in the present investigation aimed at the determination of decrease of available alkali or of excess of acids other than carbonic acid, and as this acid is the only acid whose concentration is altered by the conversion of venous into arterial blood, it is a matter of indifference whether the remaining acids are determined in the blood before or after arterialisation.

The samples of blood were collected in the manner described by Cullen (1917). The blood was taken from a vein in the arm with a hypodermic syringe. The syringe was first washed with liquid paraffin to hinder clotting during the withdrawal of the sample. The sample was then ejected under a layer of liquid paraffin on to a quantity of solid, finely ground potassium oxalate equal to about 0.4 per cent. of the amount of blood taken. The blood was then gently agitated to dissolve the potassium oxalate. In this way the samples are obtained in an unclotted condition without the addition of a liquid, which would alter their dilution, and are exposed to a minimum of risk of coming into contact with the air. It was sometimes necessary to compress the arms of the subjects to render the veins turgid and to facilitate the insertion of the needle, but the compression was removed, and the circulation allowed to resume its course before the sample was withdrawn. The cases of pneumonic influenza from which the samples of blood were obtained were all very serious, and many of them terminated fatally: all showed distinct colouration of the skin.

The following are particulars of cases from which samples of blood were obtained:—

2. A. S., male, 26, single, bricklayer. Admitted 2/4/19, died 18/4/19. Sample taken 16/4/19 (22nd day of disease), temperature 97.7°, pulse 110, respiration 40.

4. D. M. B., male, 21, single, collector. Admitted 16/4/19, died 22/4/19. Sample taken 22/4/19 (8th day of disease), temperature 103°, pulse 136, respiration 36.

6. H. F., female, 11, scholar. Admitted 16/4/19, discharged 1/5/19. Sample taken 25/4/19 (10th day of disease), temperature 98.1°, pulse 92, respiration 25.

7. W. R., male, 24, single, labourer. Admitted 26/4/19, died 6/5/19. Sample taken 1/5/19 (7th day of disease), temperature 102.8°, pulse 84, respiration 25.

8. P. U., male, 24, single. Admitted 26/4/19, discharged 10/5/19. Sample taken 2/5/19, (9th day of disease), temperature 98.2°, pulse 77, respiration 29.

9. A. C., male, 29, single, fitter. Admitted 2/5/19, discharged 30/5/19. Sample taken 5/5/19 (11th day of disease), temperature 98.6°, pulse 90, respiration 26.

11. H. B., male, 27, married, carpenter. Admitted 6/5/19, discharged 16/5/19. Sample taken 12/5/19 (11th day of disease), temperature 99.3°, pulse 70, respiration 24.

The particulars of cases 1, 3, 5, and 10 were not obtainable.

The oxygen capacity and oxygen saturation of the samples of blood were determined by Haldane's (1897) ferricyanide method in Barcroft's (1908) differential apparatus. The principle of the method is as follows: Blood is laked with dilute ammonium hydroxide. Its oxygen is then liberated by the addition of potassium ferricyanide. These operations are performed in closed vessels connected with a clove oil manometer. The difference of pressure observed in the manometer multiplied by the constant of the instrument gives the volume of oxygen liberated. The volume is then corrected for temperature, barometric pressure, and moisture, the final volume given being that of the dry gas at normal temperature and pressure. In the case of unsaturated blood, oxygen is absorbed during the process of laking, and the negative pressure produced in the manometer is similarly a measure of the volume of oxygen absorbed.

For samples 1—6 Barcroft's small apparatus, which takes 0.1 cc. of blood was used; for samples 7—11 the large apparatus, which requires 1.0 cc. of blood was used. The small apparatus was calibrated by liberating in it the oxygen from a known volume of standard hydrogen peroxide (Barcroft and Burn, 1913). The large apparatus was calibrated by measuring the diameters of the limbs of the manometer and the volumes of the vessels in which the gas was liberated (Barcroft and Higgins, 1911), the constants so found being increased by 2 % to allow for the difference existing between this and the former method of calibration.

The sample of blood for the determination of oxygen capacity was saturated with oxygen by spreading 2 cc. in a thin layer over the inner surface of a 200 cc. flask. The flask was corked to prevent evaporation of the blood, and was kept rotating so as to expose the greatest surface to the air for about 15 minutes. Such blood took up no more oxygen on being laked in the differential apparatus. The samples for the determination of oxygen content were cautiously introduced into the apparatus. under a layer of the dilute ammonium hydroxide used for laking, and did not come into contact with the air during the transference except at the narrow upper meniscus of the pipette, and momentarily at its tip. As the pipette was not completely emptied in delivering the sample, the upper portion of the sample, which came into contact with the air was not used in the analysis. The pipettes used were calibrated by weighing the amounts of blood delivered by them. Care was taken, by thorough mixing, to ensure a uniform distribution of the corpuscles in a sample of blood before withdrawing a portion for analysis.

The percentages of oxyhæmoglobin were determined in two ways: (1) By calculation from the oxygen capacity, taking as 100 per cent. the amount of hæmoglobin in blood which combines with 18.5 volumes of oxygen (at normal temperature and pressure) per 100 cc.; (2) colorimetrically, by comparison of solutions of known dilution with standard tinted glass in the Miescher—von Fleischl haemoglobinometer. The scale of the hæmoglobinometer was calibrated by determination of the oxygen capacity of samples of blood corresponding to different readings. Five series of determinations showed a maximum range of variation of 5 per cent. from the values obtained by the chemical method for a dilution of blood of 1 in 200.

Attempts were made to detect the presence of pigments other than oxyhæmoglobin by examination of the absorption spectrum of the blood. Methæmoglobin was especially looked for. It was not found possible, however, to detect the small proportions of this pigment in the presence of a large proportion of oxyhæmoglobin by means of the spectroscope, as already stated. The effect of various proportions of methæmoglobin on the colorimetric estimation of hæmoglobin in the blood was then determined. It was found that the presence of 5 per cent. of methæmoglobin could be detected with certainty by this method. For a particular sample of blood, this proportion of methæmoglobin altered the reading of the hæmoglobinometer from 40.8 to 30.3, that is, caused an error of 25 per cent in the determination of hæmoglobin, and gave rise to an appreciable change in the tint of the diluted blood. Percentages of methæmoglobin well within the range of variation between the results of the chemical and colorimetric methods of determining hæmoglobin, would therefore be detected by this means.

The acidity and reactivity of the samples of blood were determined by the method described by Cullen *(loc. cit.)*. The corpuscles of the blood were separated from the plasma in a centrifuge. The dissolved carbon dioxide was then removed from the plasma by exposing it in a thin layer for several minutes to a pressure of about 6 cm. of Hg. In this way, uncertainties due to the escape of varying amounts of carbon dioxide during the measurement were avoided. The electromotive force of a cell made up of a hydrogen electrode dipping into this plasma and a decinormal calomel electrode was then measured as described by Michaelis (1911). The plasma was connected with the calomel electrode by means of a siphon containing saturated ammonium nitrate. A capillary electrometer was used as the null instrument; the readings were made on a Wolff's potentiometer to the nearest millivolt. The acidity or concentration of hydrogen ions ($C^{\cdot}_{H}$) is calculated from the observed electromotive force by the equation:

$$\log \frac{1}{C_H} = pH = (E-0.337)/k.$$

where E is the observed E.M.F., and k a factor which varies slightly with the temperature.

The reactivity of the plasma towards acid may be determined in two ways: (1) by measuring the amount of acid required to alter the reaction by an arbitrary extent, or (2) by measuring the change of reaction produced by an arbitrary amount of acid. In practice the latter method is much the simpler and more convenient. Cullen *(loc. cit.)* showed that it was convenient to add an amount of acid sufficient to liberate all the combined carbon dioxide in the plasma, the liberated gas being got rid of by exposure to a reduced pressure, as described above. In the present work, the change of acidity produced by adding 2 volumes of 0.0196N HCl was measured after pumping off the liberated carbon dioxide.

In the following table are shown the oxygen content and capacity of a number of samples of venous blood from cases of pneumonic influenza. The percentages of hæmoglobin as determined colorimetrically in the von Fleischl hæmoglobinometer, and as calculated from the oxygen capacity, are also shown.

TABLE I.

Oxygen capacity, oxygen content, and percentage of hæmoglobin of venous blood in pneumonic influenza.

Sample.	Oxygen capacity.	Oxygen content.	Per cent. Hæmoglobin	
			Chem.	Colorim.
1	13·25	71·7	71·5	86·5
2	19·7	68·4	106·5	96
3	20·2	37·9	109	112
4	23·2	72·2	125	125
5	20·8	62·0	105	104
6	17·7	47·9	95·5	109
7	21·7	82·7	117	116
8	19·2	50·8	104	108
9	21·2	57·7	112	110
10	16·4	82·9	88·5	100
11	18·9	38.7	102	99
Average	19·1	61·2	103	106

The above table shows that there is considerable variation, both in the oxygen content and the oxygen capacity of these samples. The oxygen capacity varies between 13.25 and 23.2 cc. of oxygen, at 0°C. and 760 mm. Hg. per 100 cc. of blood. The corresponding percentages of oxyhæmoglobin are 71.5 and 125. These values, therefore, vary over a range of about 25 % of the average, but it is doubtful whether any significance can be attached to this degree of variation. Even in normal individuals the number of red corpuscles in the blood varies over a range at least as wide as this (from 3.5 to 6.0 million per cubic mm.). From the figures available as to the normal range over which the percentage of oxyhæmoglobin or oxygen capacity of blood varies, but there is no reason to doubt that it is approximately the same as that of the number of red corpuscles.

The percentage saturation of the samples with oxygen varies over a slightly wider range, from 37.9 % to 82.9 %. Here again, however, the figures show no general tendency to which any significance may be attached; there is certainly no tendency for the percentage saturation to be low. As many figures lie above the average, which has the normal value, as lie below it And although 60 % is taken as the average normal oxygen saturation of venous blood, this number is likely to be subject to even greater variations than that of the oxygen capacity. Under conditions of disease, in which the metabolism is abnormal, these variations may be still greater, without introducing the necessity of postulating any alterations of the aeration of the blood itself. The few figures available for the oxygen saturation of normal venous blood confirm this supposition [Twort and Hill (1915), Lundsgaard (1918)]. No conclusions, therefore, can be drawn from a variation of the oxygen content of 30 % in either direction from the normal average.

The figures in this table, therefore, give no evidence of any general decrease, either in the oxygen capacity or in the oxygen content of the blood in pneumonic influenza. The averages of the values given are within 5 % of the averages of normal figures: oxygen capacity, 19.1 % (normal 18.5 %); oxygen saturation, 61.2 % (normal 60 %); percentage of oxyhæmoglobin, 103 (normal 100).

It will be noticed that, although the majority of the values obtained for the percentages of oxyhæmoglobin by the colorimetric method agree well with those calculated from the oxygen capacity of the blood, certain of the results show differences greater than the error of the method (5 %). The results obtained by the mixtures of small percentages of methæmoglobin show that deviations of the magnitude observed might be due to the presence of very small amounts of abnormal pigments, amounts considerably lower than 5 %. Such amounts could not be detected by variations of the oxygen capacity, as the normal variations of this, as has been mentioned, are greater than the variations under consideration. Until further information is obtained however, these variations cannot be definitely attributed to the presence of abnormal pigments in the blood.

The following table shows the concentration of hydrogen ions in the CO_2 free plasma of venous blood from cases of pneumonic influenza, before and after the addition of twice their volume of 0.0196N HCl. The concentrations are expressed both as equivalents of acid per litre (C_H), and in Sörensen's notation in which $pH = \frac{1}{\log C_H}$ The difference of pH and the corresponding increase of C_H, i.e. $\left(\frac{C''_H}{C'_H}\right)$, due to the addition of the acid are also shown. The figures in the columns headed E.M.F. are the values in volts of the potential differences between the plasma and the hydrogen electrode. They are obtained by subtracting 0.377 volts, the potential of the 0.1N calomel electrode, from the observed potential.

TABLE II.

Change of reaction produced by addition of 2 volumes of 0·0196N HCl to 1 volume of CO_2 free oxalate plasma from blood in pneumonic influenza.

Sample	Before Acid.			After Acid.			Diff. pH	$\frac{C''_H}{C'_H}$
	E.M.F.	pH	C'_H	E.M.F.	pH	C''_H		
			10^{-9}X			10^{-6}X		10^{3}X
1	0·418	8·25	5·62	0·294	5·04	9·10	3·21	1·62
2	0·520	8·92	1·20	0·317	5·44	3·63	3·48	3·02
3	0.503	8·62	2·40	0·286	4·90	12·6	3·72	5·25
4	0·521	8·93	1·17	0·289	4·96	11·0	3·97	9·40
5	0·465	7·98	10·5	0·292	5·01	9·77	2·97	0·93
Mean		8·54	3·47		5·09	7·66	3·45	4·04

The above figures show that in the samples examined the acidity of the CO_2 free oxalate plasma ranged from pH 8.93 to pH 7.98 (1.17×10^{-9} N to 10.5×10^{-9}N). After the addition of HCl, the acidity ranged from pH 5.44 to pH 4.90 (3.63×10^{-6} N to 12.6×10^{-6} N). The change of reaction caused by the addition of the acid varied from pH 3.97 to pH 2.97, that is, the acidity was increased from approximately 1000 to 10,000 times by the addition of the hydrochloric acid. The averages of the values for pH in the table before and after the addition of acid are 8.54 and 5.09 respectively. The variations of the individual results from these averages lie between the limits within which the results for normal plasma vary according to the figures given by Cullen *(loc. cit.)*. These figures, therefore, show no abnormalities from which any conclusion may be drawn. In particular, they give no indication of a decreased alkaline reserve; the degree of acidity produced by the addition of a given amount of hydrochloric acid is not definitely greater than would be produced in normal plasma, and no evidence exists for the presence of acid products of intermediate metabolism (acidosis) which would be the result of a deficient oxygenation of the blood. These results are what would be expected from the values obtained for the oxygen capacity and saturation of these samples of blood. Here again, however, attention must be called to the paucity of normal figures for comparison.

SUMMARY.

Samples of venous blood from cases of pneumonic influenza showed no indication of decreased oxygen capacity nor of deficient oxygenation.

The concentration of hydrogen ion produced by the addition of a measured quantity of acid showed no indication of acidosis: the alkaline reserve was not reduced.

In conclusion, I wish to express my indebtedness to Professor Sir Thomas Anderson Stuart, in whose laboratory this work was done, and to Dr. A. H. Tebbutt and Dr. Mona Ross, Honorary and Chief Resident Pathologists respectively of the Royal Prince Alfred Hospital, who placed at my disposal the material upon which this investigation was carried out. I also express my thanks for the assistance received from Miss Myrtle S. Bromley, M.A., in carrying out the colorimetric estimations of hæmoglobin.

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ORDINARY MONTHLY MEETING.

24th September, 1919.

Mr. J. J. Fletcher, M.A., B.Sc., President, in the Chair.

The President offered a hearty welcome to Professor David and Mr. C. O. Hamblin, who were present, on their safe return from active service.

It was resolved that letters of welcome be sent to Messrs. W. M. Carne, and W. R. B. Oliver on their safe return from active service.

A letter was read from Professor David, returning thanks for congratulations on the award of the Clarke Memorial Medal by the Royal Society of New South Wales.

The President made regretful reference to the sudden death of Dr. F. M. Gellatly, Director of the Commonwealth Institute of Science and Industry.

The Donations and Exchanges received since the previous Monthly Meeting (27th August, 1919), amounting to 8 Vols., 48 Parts or Nos., 2 Bulletins, 2 Reports and 1 Pamphlet, received from 28 Societies and Institutions and two private donors, were laid upon the table.

NOTES AND EXHIBITS.

Mr. E. Cheel exhibited (i.) Specimens of the common broad bean (*Vicia faba* L.), with the leaves badly infested with a "Rust-fungus" (*Uromyces fabae* (Pers.) De Bary). The specimens were taken from plants cultivated in a garden at Ashfield and although this disease has been reported as having been found in New South Wales, no specimens are available for confirmation, and the record quoted by McAlpine ("The Rusts of Australia," 1906, p. 93), is *Uromyces phaseoli* which attacks "French Beans" (*Phaseolus vulgaris*) which is quite distinct from that on the common broad bean. The disease has, however, been found at Gladfield, Queensland, as quoted by McAlpine, *l. c.* (ii.) Fresh specimens of *Oxalis corniculata*, collected in the Botanic Gardens, Sydney, which is also quite common in plantations of the Experiment Station at Nasina in Fiji, having purplish or bronze coloured leaves. At the May Meeting of this Society in 1918, two forms were exhibited (These Proc., 1918, p. 235), so that the specimens now exhibited prove that we have at least three distinct forms in this State.

Mr. A. A. Hamilton exhibited specimens from the National Herbarium, Sydney, showing fasciation and spiral torsion. *Dipsacus sylvestris torsus* De Vries, "Teasel," Botanic Gardens, Amsterdam (Hugo De Vries, 1902). In a series of experiments with the teasel Professor De Vries succeeded in producing from 30 % to 45 % of plants with contorted stems. *Echium* Hort., var., Botanic Gardens, Sydney (J. L. Boorman, November, 1916). Plants of several species of *Echium* grown from seeds supplied by Dr. G. V. Perez of Teneriffe have developed this abnormality. Mr. Boorman states that selfsown seeds from the normal plants have reproduced abnormal examples for several years. The occurrence of selfsown seeds of the "Snapdragon" producing fasciated plants four years in succession was noted in these Proceedings, 1914, p. 647. Three factors are recognised by investigators as the principal agents in the production of plant abnormalities, viz., heredity, mutilation—mechanical or insectival—and superabundant nourishment. Heredity in certain malformations has been demonstrated by De Vries (Species and Varieties, Their Origin by Mutation, Hugo De Vries, 1905) who refers to races poor or rich in the production of an abnormality. Fasciation is noted as the result of insectival attack by Miss Knox (The Induction, Development, and Heritability of Fasciations. Alice A. Knox, Carnegie Institute of Washington, 1908) in the "Evening Primrose," and other species of *Oenothera*. Reed produced fasciation by mechanical injury (Some Points in the Morphology and Physiology of Fasciated Seedlings. T. Reed, Ann. of Botany, xxvi., p. 389). He obtained this result by cutting out the apical bud of the plumule of seedling Peas and Beans. The effects of a rich diet on the production of fasciation in the "Cocks-comb," *Celosia cristata*, was demonstrated a century ago by Knight (On the Cultivation of the Cockscomb. T. A. Knight, Trans. Horti. Soc. Lond., iv., 1820, p. 321) who used the most nutritive and stimulating compost available to secure breadth of "comb." It is conceded by most authorities that a considerable quantity of elaborated sap must be present in the plant to supply the demands of the increased growth.

Dr. R. J. Tillyard gave a short account of his visit to Jervis Bay in search of the larvæ and pupæ of the Moth-Lacewings or *Ithonidae*, and exhibited the following interesting specimens collected there: (1). Two living larvæ of *Ithone fusca* Newm., burrowing in sandy soil in a large tube. These larvæ prey on beetle grubs of the family *Scarabaeidae,* which they suck dry. They should therefore be of great economic value, especially in helping to prevent the destruction of golf-courses etc., now so prevalent in New South Wales, and due to the abundance of Scarabæid grubs in the sandy soil. (2). A number of the same larvæ in alcohol. (3). Fresh cocoons of the same insect, containing living pupæ, due to emerge as imagines early next November. (4). Cocoons of *Thynnus variabilis* Kirby, dug out from sandy soil. Two males were bred out last week, while another cocoon was found to contain a larva carrying an extraordinary parasitic Hymenopterous larva upon it, which it is hoped will be bred out later on. (5). Living Pupæ of species of Dipterous flies belonging to the family *Bombyliidae,* also dug from the sandy soil. (6). Living larvæ of the Limacodid Moth *Apoda xylomeli* Scott, found feeding upon a dwarf *Banksia.* This extraordinary larva also feeds upon the Native Pear and the Waratah.

Dr. Tillyard also mentioned that Dr. C. P. Alexander, one of the leading Dipterists of the United States, had written to him requesting his help in obtaining a portrait of the late Mr. F. Skuse, of the Australian Museum, for a gallery of famous Dipterists, together with authentic records of his life and works, the latter being regarded at the present day as some of the finest ever published upon systematic Dipterology.

Mr. J. J. Fletcher re-exhibited specimens of *Grevillea buxifolia* R. Br., with bipistillate flowers, in order to point out that, as he had quite accidentally found out recently, the late Baron von Mueller had recorded the occurrence of bipistillate and tripistillate flowers in *G. Renwickiana.* In his description of the latter species [These Proceedings, 1886, p. 1105] the Baron says—"The majority of the flowers on the transmitted specimens, as well as numerous others sent subsequently at my desire by Mr. Bauerlen, are bipistillate, two ovaries developing on distinct stipites, each with its own style and stigma, or occasionally two of the pistils still from the same flower are connate into one; rarely even a third pistil is developed. This tendency to floral duplication extends partly to the petals, which sometimes become augmented in number also, while the often scattered stalklets may appear solitary through the concrescence of two. Analagous teratological states of flowers seem not to have been noted before in the vast order of *Proteaceae.*" With the object of keeping the records together, in addition to the above the following may be noted:—E. Cheel, exhibit of bipistillate flowers of *G. punicea* R. Br., These Proceedings, 1911, p. 158; J. J. Fletcher, exhibit of bipistillate flowers of *G. buxifolia, op. cit.*, 1917, p. 247; Ewart and Davies, "Flora of the Northern Territory" (1917), reference to, and figure of, bipistillate flowers of *Hakea digyna;* H. A. Longman and C. T. White, "Mutation in a Proteaceous Tree" *(Buckinghamia celsissima* F. v. M.), Proc. R. Soc. Queensland, xxx., p. 162 (1918), description and figures of abnormal flowers.—Mr. Fletcher showed, also, two examples of fasciated phylloclades of *Bossiaea scolopendria* bearing leaves; and fasciated flowering branches of *Phyllota phylicoides.*

NOTES ON THE AUSTRALIAN GENUS *CESTRINUS* Er. (FAM. TENEBRIONIDÆ) AND SOME ALLIED GENERA.

By K. G. Blair, British Museum.

(Communicated by H. J. Carter, B.A., F.E.S.)

The genus *Cestrinus* was characterised by Erichson in 1842 for the reception of two species, *C. obscurus* and *C. trivialis*, both from Tasmania. Of these the latter is well known in collections, while the identity of the former seems to have been practically lost. The description is, nevertheless, quite a good one, and evidently applies to the insect described by Hope in the same year as *Asida serricollis* (= *Opatrum denticolle* Blanch.) For this a new genus, *Prionotus*, was proposed by Mulsant and Rey, but this name, being already preoccupied, is invalid. Pascoe later, independently proposed the genus *Achora* for the same insect. Gebien, in his recent Catalogue of the Tenebrionidæ, (1910), sinks *Achora* Pasc. as a synonym of *Prionotus* Muls. and Rey, which he condemns as invalid, and proposes a new name *Priothorax*. The latter name is quite redundant, and *Achora* Pasc. should be retained as the name of the genus. *Cestrinus tuberculatus* Carter, if I am right in my determination of two insects from Champion Bay, is also an *Achora*. *C. trivialis* Er. thus remains the type species of *Cestrinus*.

Isopteron Hope (type, *opatroides* Hope) has been correctly recognised as synonymous with *Cestrinus* Er., but though Hope's name antedates that of Erichson by two years, Champion has already put forward certain objections to its use*, and these have been maintained by later workers.

By the courtesy of Professor Poulton I have been enabled to examine the types of *Isopteron opatroides* Hope and *Opatrum piceitarsis* Hope. The former is slightly the broader insect, with a more transverse thorax and redder antennæ; there are also

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*Trans. Ent. Soc., 1894, p.355.

certain differences in sculpture, e.g., the thorax is closely set with large pits, each of which has a small setigerous tubercle near its anterior edge, leaving as it were a raised network between them. In *I. opatroides* this raised network is broader, more even in elevation, and its surface is minutely areolated; in *O. piceitarsis* it is narrower, i.e., the pits are placed closer together, rather uneven, or lumpy, in elevation, and the surface nitid, scarcely visibly areolated. The elytral interstices of *I. opatroides* are also a little more sharply granulate. These differences I do not believe to be of specific value, as, though sufficiently well defined in the two types, they occur in varying degree in specimens from widely different localities. Both of them I believe to be merely forms of *C. trivialis* Er., a common and variable species ranging from Queensland to South Australia. The type of *I. opatroides* is marked West Australia.

C. angustior Blackbn. is very similar to *C. opatroides,* but has the thorax narrower, with straighter sides. The raised network of the thorax is broad and even, the pits even wider apart than in *opatroides,* but the spaces between them are not or scarcely visibly areolated. This also I believe to be merely a form of *C. trivialis.*

"Apatelus" squamosus Macl. has been stated by Carter to be the same species.

C. championi Blackb. and *C. eremicola* Blackb. present certain points of difference analogous to those between the types of *I. opatroides* Hope and *O. piceitarsis* Hope. Unfortunately there are only a few other specimens in the collection, two from Western Australia and one labelled *C. trivialis* Er. from Tasmania, all of which more closely approximate to *C. eremicola* than to *C. championi.* I am inclined to think that these species also are not really distinct, and they may even prove to be merely huge specimens of *C. trivialis. C. zietzi* Blackb. is evidently closely allied; the type should be in the S. Australian Museum.

C. aversus Pasc. and *C. posticus* Blackb. (the latter a purely individual malformation) are both abraded specimens of *C punctatissimus* Pasc. In spite of page priority in favour of *aversus* the name *punctatissimus* should be retained for the species.

Whether *C. minor* Blackb., the type of which remains unique in the British Museum Collection, is really distinct from *C. punctatissimus* is, I think, very doubtful.

C. brevis Champ., *C. aspersus* Blackb. and *C. puellus* Geb. form another little group of very closely allied forms, much shorter and stouter than those previously considered, with the prosternal process somewhat prominent behind, widened and emarginate or bilobed at the apex. The type of *C. brevis* has the punctures of the elytral striæ plainly separated, while that of *C. aspersus* has them practically contiguous. *C. puellus,* if I am right in my identification, has the punctures of the striæ almost as in *C. brevis,* with the intervals more distinctly granulate. *C. aspersus* is described from S. Australia, but I have a specimen agreeing well with the type from the Swan River. Again I doubt whether these forms can be maintained as good species.

C. costatus Geb. Specimens from Fremantle and King George's Sound that I identify with this species cannot well be confused with any of the above. They resemble *C. brevis* in shape but are readily distinguished by the fine elytral costæ with double rows of punctures between them. There are eight of these costæ, as stated by Gebien, as well as a partial 9th, in addition to the epipleural margin; Carter in his comparison of *C. tuberculatus* with this species gives the number as six.

Adelodemus Haag (type, *asperulus* Haag, = *Cestrinus squalidus* Macl.) is placed in Gebien's Catalogue as a synonym of *Cestrinus.* It presents many points of difference, notably the deeply emarginate clypeus, and the wide explanate margins of the thorax, amply sufficient to warrant its retention as a distinct genus.

A. excisicollis Carter is unknown to me, but appears to be correctly placed. It is probably by a slip that it is compared with *A. squamosus* Macl., *A. squalidus* being intended.

Apostethus Pasc. (type, *terreus* Pasc.) is allied to *Adelodemus* from which it differs in having the front of the head short and rounded anteriorly, the thorax convex, uneven, widely-rounded at the sides, without explanate margins; the elytra are more convex, but with similar broad epipleura, the interstices even, each with a single median row of rather widely spaced granules; legs much as in *Adelodemus;* the prosternal process is of the same character, but much exaggerated in degree, projecting backwards as two large horizontal lobes.

Mitua Hope (type, *bidwelli* Hope) placed both in Gemminger and Harold's and in Gebien's Catalogues as a synonym of

Cestrinus Er., is a totally different insect and must be removed from the Australian list. It is in fact the New Zealand species *Pseudopatrum tuberculicostatum* White. *Mitua* Hope has precedence over *Pseudopatrum* (Sharp) but *bidwelli* must sink to White's name. That this synonymy was known to Miedel about 40 years ago is proved by specimens in Bates's collection bearing labels "*Mitua tuberculicostatum* White (*Bidwelli* Hope)" in his handwriting, but the fact has never been published.

Apatelus hopei Muls. is unknown to me except by description. It is probably a *Cestrinus;* it is described as having the alternate intervals of the elytra a little raised.

THE PANORPOID COMPLEX.

Part 3:—The Wing-Venation.

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

(Plates xxxi.—xxxv. and Text-figures 35-112.)

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LETTERING OF PLATES AND TEXT-FIGURES.

A, anal veins; 1A, 2A, 3A, first, second and third anals; 1A-2A, fused first and second anals, forming a Y-vein; *acl*, areocel; *af*, anal furrow; Af_1, Af_2, Af_3, Af_4, Af_5, the five apical forks in Trichoptera; *arc* arculus; *bc*, basal cell in Lepidoptera; C, costal trachea or vein; Cu, cubitus; Cu_1, Cu_2, its two primary branches, separating at *cuf*, the primary cubital fork; Cu_{1a}, Cu_{1b}, the secondary branches of Cu_1, separating at *cuf′*, the secondary cubital fork; Cu_2-1A, fused second cubitus and first analis, forming an incomplete Y-vein; *Cut*, cubital trachea, in Text-fig.92.; *cu-a*, cubito-anal cross-vein (but not in Text-fig.37); *dcv*, distal costal veinlet; *fr*, frenulum; *hm*, humeral cross-vein; ia_1, ia_2, first and second inter-anal cross-vein; *icu*, inter-cubital cross-vein; *icv*, intermediate costal veinlet; *im*, intermedian cross-vein; *ir*, inter-radial cross-vein closing radial cell; *ir′*, upper inter-radial cross-vein, between R_1 and R_2; *jb*, jugal bristles; *jg*, jugum; *jl*, jugal lobe; M, media; M_{1-4}, M_5, its primary branches, separating at *mf*, the primary median fork; M_{1-2}, M_{3-4}, the secondary branches of M_{1-4}, separating at *mf′*, the secondary median fork; M_1, M_2, M_3, M_4, branches of M_{1-4} (further branches are indicated by using the suffixes *a*, *b*,); M_4 — Cu_{1a}, the fused stem of the distal Y-vein in Lepidoptera; M_5 — Cu_1, the fused stem of the cubito-median Y-vein; Mt, median trachea in Text-fig.92; *m-cu*, medio-cubital cross-vein; *mc*, median cell, closed distally by cross-vein *im*; *pl*, pterostigma; *ptf*, pterostigmatic furrow; R, radius; R_1, Rs, its primary branches, separating at *rf*, the primary radial fork; R_{1a} R_{1b}, distal branches of R_1; R_{2-3}, R_{4-5}, secondary branches of Rs, separating at *rf′*, the secondary radial fork; R_2, R_3, R_4, R_5, branches of Rs, (further branches are indicated by using the suffixes *a*, *b*,); *r-m*, radio-median cross-vein; *rc*, radial cell (areole in Lepidoptera), closed distally by cross-vein *ir*; *rt*, subcostal retinaculum; *rt′*, subdorsal retinaculum; *sa*, subanal cross-vein; Sc, subcosta; Sc′, its upper basal branch; Sc_1, Sc_2, its distal branches; Sc-R, fused subcosta and radius in Text-fig.43; Sc-R_1, fused subcosta and first radius; *sc-r*, subcosto-radial cross-vein; *sh*, subhumeral cross-vein; *sm*, submedian cross-vein; *sp*, wingspot in Trichoptera, between R_4 and R_5; *x*, true cross-vein in Text-fig.57, (without macrotrichia).

INTRODUCTION.

(Text-fig. 35.)

The study of the Wing-Venations of the Orders comprising the Panorpoid Complex has proved a difficult and protracted task; and the results, even with the greatest possible amount of condensation, will occupy quite as much space as can be fairly allotted to a single part of this work. That being so, I have decided to dispense with the usual introductory remarks upon the general scheme of wing-venation, and to embark upon the details of the actual research with the briefest possible indication of the premises on which they are founded. For those who have not yet mastered the Comstock-Needham system, either the earlier work of these authors (14*), or the excellent later book by Comstock (15), will be found to contain all that is necessary for the complete understanding of the venational notation; while Text-fig. 37 reproduces Comstock's original diagram showing this notation applied to his hypothetical venational type.

As a basis for my study, I have not been content to accept merely the reference to the precedent pupal tracheation, valuable as it is. It must be recalled that, in three of the Orders with which we have to deal, this pupal tracheation is greatly reduced, and of little value in the determination of homologies. Moreover, since Part 2 was written, two new fossil Orders belonging to the Complex have come to light (28, 29); so that, besides the three recent Orders just mentioned, there are also three fossil Orders, now extinct, to which this method is not applicable. We may put the position thus:—

(1) *Orders only known as fossils*:—Protomecoptera, Paramecoptera, Paratrichoptera.

(2) *Recent Orders with reduced pupal tracheation*:—Mecoptera, Trichoptera, Diptera.

(3) *Recent Orders with complete pupal tracheation*:—Megaloptera, Planipennia, Lepidoptera.

The presence of the complete pupal tracheation is an archaic character; so that the last three Orders named must be regarded as more archaic than the three in (2), for the character mentioned. It will be at once obvious that no Order in (2) can be ancestral to any one of the Orders in (3). Those wings, in which the pupal tracheation remains complete, I propose to term *holotracheate;* those in which it is reduced, *merotracheate.*

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*The numbers in brackets refer to the Bibliography at the end of the paper.

Comstock and Needham applied the test of the pupal or nymphal tracheation to those Orders in which the wings were holotracheate. In the case of merotracheate types, they were content to obtain results simply by comparative studies of the imaginal wing-venations. Consequently, excellent as is that part of their work which is based upon tracheational studies, their results in the Orders placed in (2) above, as well as in the Hymenoptera, do not carry the same conviction, and errors have unfortunately crept in which might have been avoided by more complete methods.

After having spent a very large amount of time, during the past three years, upon this research, I have found the following methods yield good results —

(A) *Study of the Pupal Tracheation.* This is the essential basis of the study of the wing-venation in the Megaloptera, Planipennia and Lepidoptera. But I soon found, in the course of my researches, that not enough attention had been paid to the *age* of the pupa studied. In the Megaloptera and Planipennia, unless the pupa is taken fairly early, the wing becomes folded in its sheath, and the courses of the tracheæ cannot be followed at all. But, in the Lepidoptera, the wings of older pupæ can be withdrawn from their sheaths without damage to the tracheation. Thus it frequently happens that results in this Order have been obtained from a study of advanced pupæ; yet nobody, so far as I know, has noticed that the tracheation in the advanced pupa may differ very materially from that of the freshly-turned pupa, and may lead to erroneous conclusions. The rule which I followed, and which seems to have only one exception, was this:—*Study the pupal tracheation as soon after the formation of the pupa as possible; in any case, remember that it is the freshly-turned pupa that exhibits the most archaic arrangement of the tracheae, while older pupae very often show specialisations towards the type of tracheation preserved in the imago.* The exception to be noted is, that, sometimes, in the case of a fusion of veins, *both* the tracheæ underlying the two fused veins do not develop in the pupa, but only one; and that one, as a rule, is *the trachea which underlies the more convex of the two veins in question.* The other trachea, however, frequently develops late in pupal life, or is to be found in the fused vein of the imago directly after metamorphosis; so that the double nature of the vein is indicated by its carrying two tracheæ.

The variations in the tracheation of the wings of Lepidoptera during pupal life appear to me to be of such importance that I have paid special attention to them in dealing with the venation of this Order in Section xiv.

In the case of wings of merotracheate type, the pupa should always be examined, when obtainable; for some evidence of value may be gained in this way. Moreover, such wings may also show a progressive change in their venational scheme, as the pupa ages, and these changes must be noted.

(B) *Study of the Wing-Trichiation.* The distribution of the macrotrichia upon the wing-veins in the Panorpoid Complex is of the greatest value in determining homologies in difficult cases. The rule, which I have already proved much more fully in Part 2 of this work (25) may be briefly stated as follows:—*In the more archaic types of every Order within the Complex, the main veins and their branches carry macrotrichia, while the cross-veins do not.* The specialised groups, in which the cross-veins, as well as the main veins, carry macrotrichia, are the Raphidioidea, and the higher families of the Planipennia. These will scarcely be needed at all in our search for the Archetypic Venational Schemes of the separate Orders.
latter case, there are many examples of the retention of the base of the wing, in a number of types, where the chitinisation of the basal parts of certain veins, particularly M and Cu, may be so weakened as not to carry macrotrichia; or *(b)* where the basal portion of the weaker (more concave) of two veins taking part in a fusion becomes more or less transverse in direction, and begins to take on the character of a cross-vein. But, even in this latter case, there are many examples of the retention of the macrotrichia.

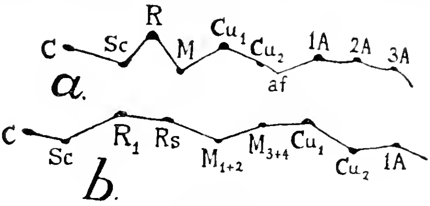
It should also be borne in mind that true cross-veins are not preceded by tracheæ. A main vein, or part of it, may occasionally lose its trachea; but true cross-veins never possess tracheæ in the freshly-turned pupal wing, though they may sometimes gain them as special outgrowths from the main tracheæ, either later in pupal life, or at metamorphosis.

(C) *The Palaeontological Evidence.* This is of the utmost importance, but needs to be used with great care. The tracheation test cannot be used in the case of fossils; but it frequently happens that the sockets of the macrotrichia are preserved, and their presence or absence may decide a point of great value.

Fossil types must be carefully compared with recent types showing closely similar venations; but wide generalisations, based for the most part upon the study of many types lying outside the bounds of the Complex, must be avoided, as tending to give very misleading results. As an example of this, we may cite Comstock's insistence on a single primitive venational type (15 Chap. iv.), which he constructed largely with the aid of the Carboniferous Palæodictyoptera, and then applied to the Lepidoptera and other Orders within the Panorpoid Complex. The primitive type to be considered in this paper will not be the one constructed by Comstock, but one constructed on the evidence obtainable *within the Complex only;* and it will be found to differ in certain very important respects from that type which, whether it was the primitive type for the Pterygote Insects or not, was certainly not, in some of its essential characters, the primitive type from which the Panorpoid Orders were derived.

As an instance of the value of the palæontological data, let anyone after reading this paper, cut right out of it all the evidence afforded by the three fossil Orders Protomecoptera, Paramecoptera and Paratrichoptera, and then consider what chance there would have been of a correct conclusion on the remaining evidence alone! Let him also consider what the result might have been, if not only this evidence, but also that afforded by the fossil representatives of still existing Orders, had not been available? It is not always difficult to construct a simple theory that will fit all the known facts; the chances that Nature, in the course of Evolution, followed the direct path that such a theory is sure to lay down, are actually very small indeed.

(D) *Convex and Concave Veins.* It is easy to demonstrate that the more archaic types within every Order of the Panorpoid Complex show the same arrangement of Convex and Concave



Text-fig.35.

Two sections across a wing of Panorpoid type, to show alternation of convex and concave veins. *a*, close to base; *b*, beyond *rf* and *mf'*. Lettering as on p.535. (Cf. Text-fig-16. corrected, on p.713).

Veins. Text-fig. 35 shows, diagrammatically, the condition of the veins when viewed by a cut taken somewhat obliquely across the wing, *(a)* not far from the base, so as to include only the main stems of the main veins, and *(b)* beyond the first forkings of R and M_{1-4}.. Rs, like R_1, is convex near its origin. Further distad, there is a tendency for the branches of M and R to arrange themselves at very much the same levels on a plane surface, so that the part of the wing lying between the two very strongly convex veins R_1 and Cu_1 is often nearly flat. However, in many types, it can be seen that there are actual differences of level, as in Text-fig. 35 *b*, right to the apex of the wing.

The general rule for the insect wing is that *concave and convex veins follow one another alternately.* Consequently, if two convex veins are seen next to one another, a strong presumption arises that a concave vein has become suppressed between them. Thus, for example, in the higher Lepidoptera, two very strong convex veins (Rs and Cu_1) form the anterior and posterior borders of the closed *basal cell.* This fact should at once suggest that the concave vein M has been suppressed between them; and an examination of the pupal tracheation proves this to be the case.

A more difficult problem, of which no solution has been attempted before, lies in the fact that, in the Panorpoid type of wing, veins M_{3+4} and Cu_1 are both convex, yet lie next to one another. There is thus a strong antecedent probability that a missing branch of M, viz. M_5 has been suppressed between them. The working out of this problem is shown in this paper, and offers a very interesting example of how the four types of evidence here arranged under the headings A to D may be used together, to furnish a satisfactory proof, which could not be supplied by anything less than all four of them.

There is also the question of the anal veins, which, as shown in Text-fig. 35 *a*, are all convex, though sometimes separated by depressions or furrows. The suggestion that they may be, after all, only so many branches of a single convex vein, as in the Odonata, is worth consideration, and has been studied in this paper, in the light of the evidence afforded by the pupal tracheation.

(E) *Atavisms, or Reversions to Type.* It sometimes happens that a single individual of a species, here and there, reproduces a more archaic condition in its venation than is usual for the species. This is an *atavism*, or reversion to type. All such occurrences need to be carefully noted; and the changes that occur should be carefully compared with known archaic conditions. Comstock (15) has recorded quite a number of instances of this in the Planipennia and Megaloptera, particularly with respect to the retention of the primitive dichotomic forking of R_{4+5}. In the Lepidoptera, the family *Hepialidae* is occasionally subject to atavisms, which are of special interest, owing to the very archaic position of this family within the Order at the present day. Thus Comstock (15, fig. 335) has recorded a specimen of *Pielus labyrinthicus*, in the forewing of which R_5 is itself forked, and I have myself seen a specimen with a very similar forking. We know from the venation of ***Belmontia*** (Text-fig. 63) that the Permian Paramecoptera had this vein forked. Thus the atavism serves to strengthen our belief that the *Hepialidae* are descended from ancestors which possessed the Paramecopterous forking of R_5. Comstock (15, fig. 337) also mentions the famous specimen of *Sthenopis*, in which the hindwing had M_4 and Cu_{1a} only partially fused. This is the same condition which we find in the Triassic fossil *Archipanorpa;* and there can be no doubt that the ancestors of the Lepidoptera must at one time have passed through a stage in which the two originally separate veins M_4 and Cu_{1a} were only partially fused, as in this atavistic individual of *Sthenopis*.

As it is impossible to say definitely that the condition shown in an atavistic individual actually belonged to the Order in question, seeing that it may just as well be an atavistic reproduction of a character preserved in the ancestral Order only, and not in the Order descended from it, to which the specimen now belongs, I have not admitted the evidence of these atavisms as sufficient, *per se*, to govern the character of the Archetype of an Order. Only when their evidence is supported also by evidence under one of the four headings A-D above, have I deemed it permissible to use it in the construction of the Archetype. Thus, in forming the Archetype of the Order Lepidoptera, I have admitted only four branches to Rs, and have kept M_4 fused with Cu_{1a} right to their tips; since there is no evidence, apart from the atavistic specimens themselves, to show that these characters ever really belonged to the true Lepidoptera; whereas there *is* distinct evidence, in the form of the fossil record, to show that they did belong to Orders ancestral to the Lepidoptera.

Before entering upon the detailed researches that form the main portion of this paper, I desire to offer my very best thanks to all those kind friends who have made the work possible, by helping to supply the immense amount of material studied. Much of this material finds no mention in this paper, seeing that the limitations of space only permit of the use of the most telling arguments, which are reinforced, in the author's mind, by the results attained in many other directions, and with many other genera than those here mentioned. Thus I would ask those who supplied material, not to think that, because their particular specimens do not appear to fill any place in the argument, they were not of value. The number of dissections of pupæ in the Lepidoptera alone has approached two hundred, representing practically every family obtainable within a reasonable distance of Sydney, and not a few from distant localities. Let me, then, thank the following gentlemen for the supply of valuable material, mentioning here only the Orders involved; and let me make further special acknowledgments of those particular consignments, each in its proper place, which have proved of special value in this work:—Drs. T. A. Chapman, F.R.S., L. Peringuey and A. J. Turner (Lepidoptera), Messrs. Herbert Campion (Megaloptera), F. W. Carpenter (Planipennia, Trichoptera, and general help in the field), E. J. Dumigan (Lepidoptera), Luke Gallard (Planipennia, Lepidoptera, Diptera), G. H. Hardy (Diptera), G. Howes (Megaloptera, Trichoptera), G. Lyell (Lepidoptera, Mecoptera), E. Meyrick, F.R.S., (Lepidoptera), K. J. Morton (Trichoptera, Lepidoptera), A. Philpott (Lepidoptera), and the discoverers of the fine new types of three fossil Orders, Messrs. B. Dunstan and J. Mitchell.

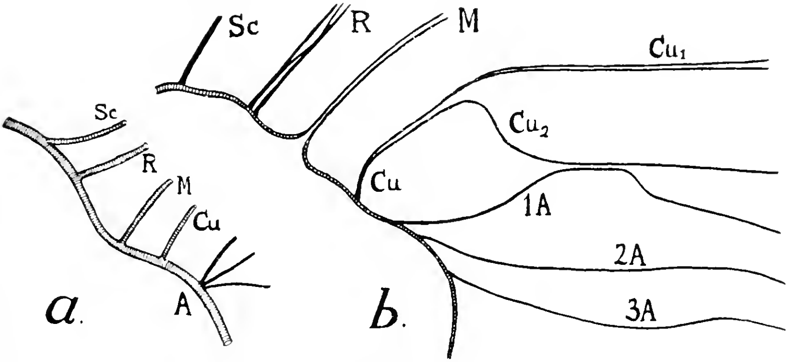
Section i.—The Basal Tracheation of the Pupal Wing.

(Text-fig. 36.)

Comstock and Needham (14) have shown how, in the most primitive types of wings, the tracheal supply arises from two sources. An anterior trachea, called the *costo-radial trachea,* arises either from the dorsal trunk, or from the anterior branch of the Y-shaped leg-trachea, and enters the wing anteriorly. From this, the costal (if present), subcostal and radial tracheæ are derived, as well as, originally, the median trachea. A posterior trachea, called the *cubito-anal trachea,* arises either from further back along the dorsal trunk, or from the posterior branch of the Y-shaped leg-trachea, and enters the wing posteriorly. From this, the cubital and anal tracheæ are derived. Originally there was no connection between the two groups of tracheæ; and this primitive condition is still preserved in the Perlaria and certain Cockroaches. But, in most other insects, the two groups are linked up by a short connecting-loop, so that a complete trachea, in the form of an arch, which I have called the *alar trunk* (18), lies at the base of the growing wing, and sends the main wing-tracheæ into it.

In the more archaic of those insects in which the alar trunk is complete, the median trachea may still belong to the costo-radial group. But, as specialisation proceeds, the base of the median trachea tends to move along the alar trunk posteriad, towards the cubito-anal group, and finally becomes incorporated in that group of tracheæ.

In the Panorpoid Complex, we have, as already stated, three Orders only in which the wings are holotracheate, and three in which they are merotracheate. Let us examine the holotracheate types first.



Text-Fig.36.

Basal Tracheation of the pupal wing in the Panorpoid Complex. *a*, in Megaloptera and Planipennia; *b*, in a hindwing of *Charagia splendens* Scott, (Order Lepidoptera, fam. *Hepialidae*), to show the double origin of trachea M. Lettering on p.535. (See also Plate xxxiii., fig. 20).

The condition to be found in both Megaloptera and Planipennia is that in which (Text-fig. 36, *a*) the alar trunk trachea is complete, and M stands about half-way between the costo-radial and cubito-anal groups of tracheæ.

The condition found in the higher Lepidoptera is well illustrated by Chapman, in Comstock's latest work (15, fig. 21). The genus figured is *Antheraea* (family *Saturniidae)*, one of the most highly specialised of all Lepidoptera. In this type, as might have been expected, the alar trunk is complete, and the median trachea has migrated completely across to the cubito-anal group.

It seems obvious that the archetypic condition of the bases of the main tracheæ for the Lepidoptera ought not to be determined by the selection of such a highly specialised type as *Antheraea*. The *Hepialidae* and *Cossidae*, at any rate, might reasonably be expected to show a more primitive condition. Moreover, it is not yet really known by what means the connecting piece between the two main groups of tracheæ has been developed, nor by what exact method the media has migrated across it. I therefore paid careful attention to these points, when dissecting pupæ of the more archaic Lepidoptera.

In the *Cossidae*, I found, within the single genus *Xyleutes*, much variation in the position of M. Sometimes it was close to the costo-radial group; sometimes close to the cubito-anal group; and less frequently it lay about half-way between them, much as in the Planipennia. In all cases, the alar trunk was complete.

In the *Hepialidae* (Text-fig. 36 *b)*, I met with a very great surprise. In many pupal wings the alar trunk is not complete; but the two groups of tracheæ are brought together by the approximation of two large tracheæ, viz., the most posterior of the costo-radial group (this trachea should be M) and the most anterior of the cubito-anal group. These two tracheæ pass into the wing alongside one another, and together supply the branches of M.

Several pupæ of *Charagia* showed this condition, and I began to think that it might be the normal one for the family. However, further dissections showed that the condition was very variable. In some pupæ, the cubito-anal branch to M was very weakly formed, while the principal supply to M consisted of a huge trachea connected with the costo-radial group. This, I think, is probably the most archaic condition. The tendency towards the splitting-back of tracheæ towards their bases is very strong in all Lepidoptera. If then, we grant that the alar trunk was not completed in the ancestor of the Lepidoptera, it is easy to see how, when the tracheal connection from the cubito-anal group grew out towards the base of the true median trachea (still united with the costo-radial group), it might have become connected, not with the single base of this trachea, but with the posterior half only, split back almost to its very base. This connection, once established, would give rise to the condition described above, in which M is supplied apparently by two strong tracheæ, one from each group.

Further dissections of pupæ of *Hepialidae* also revealed a number of instances in which the alar trunk was complete, although its middle portion is never strongly formed. In these cases, M was sometimes still closely connected with the costo-radial group, sometimes just as closely connected with the cubito-anal group.

The conclusion we must come to from this evidence is that, in the ancestor of the Lepidoptera, the alar trunk was not fully formed as a completed arch at the base of the wing. There was probably present a small tracheal outgrowth from the cubito-anal group, which, owing to the already strongly developed tendency of the main tracheæ to split back to their bases, did not always make the same connection with M; and so the various formations met with at the bases of Hepialid pupal wings must have been arrived at.

In so far as they have attained a moderate degree of specialisation, the alar trunk being complete, and the median trachea placed about half-way between the costo-radial and cubito-anal groups, both the Megaloptera and Planipennia must be considered as more specialised in this respect than the *Hepialidae*, and, therefore, than the archetype of the Lepidoptera. But the lines of evolution of these two Orders and of the Lepidoptera, for this character, are not the same. The tendency towards the splitting back of the trachea, which is in itself a specialisation in a different direction, is only developed to any great extent in the Lepidoptera; and, as we have seen, it was probably this line of specialisation that prevented the complete formation of the alar trunk in the earliest Lepidoptera. We might note, in this connection, that, in the *Jugo-frenata* (27), in which this splitting is not so strongly developed as in most Lepidoptera, the alar trunk is completed, though its middle portion is of small calibre.

Turning next to the Orders with merotracheate wings, we may take first of all the Diptera, in the older members of which

(Text-fig. 50) the reduction of the tracheation has only gone so far as to eliminate M and the anal tracheæ. In this Order, so far as known, the alar trunk is complete, but the middle portion of it is of very small calibre. The costo-radial group of tracheæ remains well developed except for the loss of M, and there is in most cases a definite *costal trachea* (C) present, running close up to the anterior border of the wing.

Much more specialised by the reduction of their pupal wing-tracheation, and, through this character, therefore, not ancestral to any other existing Order, are the Mecoptera and Trichoptera. In the former Order, the anal trunk is incomplete; the costo-radial group sends only one trachea into the wing, viz., R; and the cubito-anal group likewise only sends one, viz., M. If this latter trachea is the original M, then it would suggest that there must once have been a time when the alar trunk was complete, so that M might have migrated along it to the cubito-anal group, with which it is now connected. On the other hand, the basal portion of the cubital vein is much weakened in this Order; and it may be that the trachea grows out into the wing after the venational scheme is laid down. Hence, if the natural course along Cu is closed up, the trachea might be expected to penetrate the media instead. In whatever light we look at it, the condition of the pupal tracheation in this Order must be regarded as highly specialised.

The most specialised Order of all, as regards the condition of its pupal tracheation, is the Trichoptera. The alar trunk is incomplete, but, even in so old a group as the *Rhyacophilidae,* the costo-radial group sends only one trachea into the wing, usually along R, but sometimes apparently quite aimlessly, as if it were content to penetrate anywhere within the sheath; and the cubito-anal group is greatly reduced, sending only one weak trachea into the wing either along Cu or 1A, or aimlessly into the sheath, without any relationship to the venation.

Owing to the great reduction of the tracheation in these two last Orders, we cannot be sure that they may not have passed through a stage of development, in times past, in which the alar trunk was complete, though weakly formed. All we can assert with confidence is that their present condition is a very highly specialised one, and indicates a line of evolution, for this character, quite different from that of the three Orders with holotracheate wings.

We may sum up the above results as follows:—

(1) *Orders in which the pupal wings are holotracheate:—*

(A) Alar trunk not always quite complete; position of trachea M upon it variable; very strong tendency towards splitting back of all tracheæ. ....LEPIDOPTERA.

(B) Alar trunk complete; position of trachea M about midway along it between the costo-radial and cubito-anal groups; little or no tendency towards the splitting back of the tracheæ............MEGALOPTERA and PLANIPENNIA.

(2) *Orders in which the pupal wings are merotracheate:—*

(C) Alar trunk complete; more than two tracheæ enter the wing; a true costal trachea frequently present. ....DIPTERA.

(D) Alar trunk incomplete; only two tracheæ enter the wing, one from the costo-radial and one from the cubito-anal group; generally no costal trachea.*

(a) The anterior trachea is R, the posterior M. ....MECOPTERA.

(b) The anterior trachea is R, the posterior Cu or 1A; or both may penetrate aimlessly into the wing-sheath. ....TRICHOPTERA.

It will be clear, from the characters studied in this section alone, that the Trichoptera, as the most highly specialised of all the Orders in the evolution of its pupal tracheation, cannot be regarded as ancestral to any other Order now existing. Nor can the Mecoptera possibly be ancestral to any Order except the Trichoptera; and this only by supposing that the Trichopterous condition could be naturally derived from the Mecopterous, as a further specialisation. As we shall see in the sequel, there is at least one venational character in which the Trichoptera are more archaic than the Mecoptera; and thus they cannot be derived from these latter.

Section ii. THE MAIN VEINS AND THEIR BRANCHES.

(Text-figs. 37-40.)

In their hypothetical ancestral type of tracheation for the Insect Wing, and consequently also for the venation (which originally coincided with the tracheation in so far as the main veins were concerned), Comstock and Needham (14) indicated the following conditions for the tracheæ and veins:—

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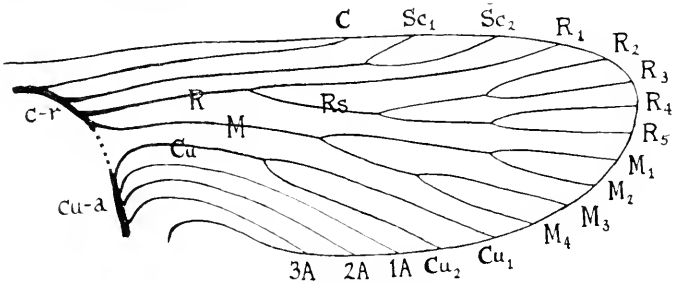
*I have seen a costal trachea in *imaginal wings* of some Trichoptera, but never in the pupal wings.

C (rarely present), simple; Sc, forked distally; R1, simple; Rs, four-branched; M, four-branched; Cu, two-branched; 1A, 2A, 3A, all simple.



Text-Fig.37.

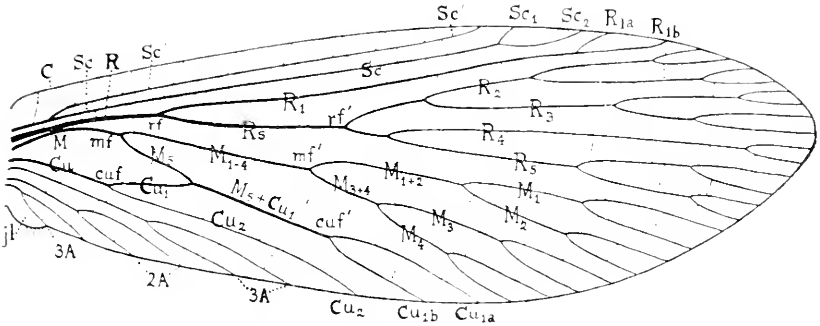
Hypothetical Type of Wing-venation, according to Comstock and Needham. (From Comstock). *c-r*, costo-radial basal trachea; *cu-a*, cubito-anal basal trachea. Other lettering as on p.535.

This hypothetical type is shown in Text-fig. 37.

My attempt to apply this type of venation as archetypic for the Orders of the Panorpoid Complex did not meet with success! and I was soon forced to conclude that this hypothetical type needs considerable alteration, before it can be accepted as typical for the original scheme of the wing-venation in these Orders. There is no doubt whatever about the correctness of the hypothetical arrangement of the tracheæ as having been originally in two groups entering the base of the wing separately, as will be seen from Section i. Nor can I find any flaw in Comstock's argument (15) as to the original *dichotomic* manner of arrangement of the branches of R and M. These points are accepted in this paper. But, with regard to the *number of branches of the main veins*, I am quite unable to accept Comstock's conclusions. In this Section, I propose to review briefly the evidence concerning the condition of branching of each main vein, in the Archetype of the Complex. Text-fig. 38 shows the venation of this Archetype, as worked out in full in this Part.

The Costa and the Subcosta.

A separate costal trachea is sometimes present in the pupal wing, as, for instance, in the Megaloptera (15, fig. 166) and in the Diptera (Text-fig. 50). In the fossil genus *Archipanorpa*,



Text-Fig.38.

Venation of forewing of Archetype of the Panorpoid Complex as worked out in this Part. (See also Text-fig.111). Lettering as on p.535. Note especially the fusion of M_5 with Cu_1 to form the cubito-median Y-vein.

belonging to the Order Protomecoptera, I described a well-developed costal vein (5), and, in the fossil genus *Aristopsyche* of the Order Paratrichoptera (28), I also described a much-shortened costal vein near the base of the wing. Besides these, a strongly developed costal trachea may be found running along the anterior marginal vein in the imaginal wings of many Trichoptera and Diptera.

Further study of the fossils above mentioned has convinced me that the veins which I originally described as the costa are, in reality, only branches of Sc. In *Archipanorpa* (Text-fig. 64), the origin of this vein is missing. But it is *strongly concave,* like Sc below it; whereas a true costal vein should certainly be convex. In *Aristopsyche*, I have succeeded in tracing the supposed vein C back to a definite origin on Sc; so that this vein also must be considered as a shortened basal branch of the latter.

As it seems very likely that the marginal vein of Trichoptera and Diptera may be a secondary development, due to strengthening of the anterior border of the wing, I have decided to omit the question of the presence or absence of a true costal vein from the evidence used in constructing the Archetype. It seems, however, very unlikely that any true costal vein, distinct from the anterior border of the wing, was ever present in any Panorpoid type, seeing that such a vein is absent from almost all known insect wings.

It follows, from the above, that the subcosta may be branched either basally or distally. The basal branching is complete in *Archipanorpa*, where Sc consists of two long concave veins, running side by side between R_1 and the anterior border of the wing. If this condition be altered, by reduction of the upper branch, we arrive at the stage shown in *Aristopsyche,* in which this branch is clearly becoming reduced to a mere veinlet. A comparison of Text-figs. 65, 85, will show clearly that the final fate of this branch is that it becomes the humeral veinlet *(hm).*

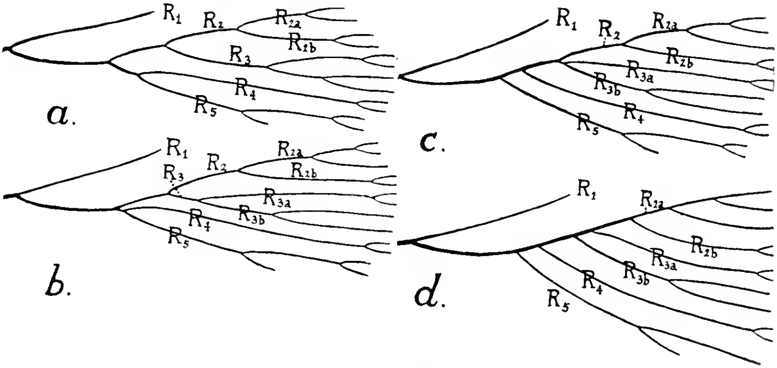
Besides this basal branch, Sc is frequently forked distally, as in Text-figs. 63, 76. This is certainly an archaic condition, and I have accepted it as such. As the usual notation for the distal forking is Sc_1 and Sc_2, I have suggested the use of Sc' for the more anterior basal branch in *Archipanorpa* (Text-fig. 64) and in the Archetype of the Complex (Text-fig. 38). The archetypic condition, in which both Sc' and the distal forking are present together, has not been found so far in any single known type; but the condition in which the distal forking remains, while the basal branch is reduced to the humeral veinlet, is quite common.

The Radius and Radial Sector.

The main stem of the radius (R) divides, in all archaic types, not far from the base of the wing, into a fairly simple upper branch (R_1) and a more complexly branched lower branch, called the *radial sector* (Rs). The point at which this division takes place is the *primary radial fork (rf).*

The most archaic condition of R_I is clearly that in which it is a straight vein, with a definite distal forking into R_{1a} and R_{1b}, as seen in Text-figs. 63, 76. By loss of this terminal fork, it usually becomes a simple, straight vein.

Comstock has clearly shown (15) that the original condition of branching of Rs was dichotomic. His diagram showing how the pectinate type of branching of this vein can be derived from the older dichotomic type (15, fig. 138) unfortunately assumes that Rs was originally only four-branched. This is not borne out by the palæontological evidence, at any rate as far as the Panorpoid Complex is concerned. The number of branches of Rs in the more archaic representatives of each Order is fully worked out in those Sections devoted to the venations of the separate Orders (Sections viii.-xvi.) which should be referred to for details. It will suffice to state here that the evidence is overwhelmingly in favour of Rs having had more than four branches originally in the Orders Mecoptera, Paramecoptera, Protomecoptera, Megaloptera and Planipennia; whereas, in the more specialised Orders Diptera, Trichoptera, and Lepidoptera, it is reduced to the four-branched condition. It will, of course, be perfectly obvious that the pectinate type of branching, which



Text-Fig.39.

Stages in the evolution of the pectinate type of radial sector from original dichotomic type, shown in *a*. Lettering as on p.535.

distinguishes Handlirsch's Sub-class Neuropteroidea from his Panorpoidea, is just as easily derived from a dichotomic condition with *more* than four branches, as it is from one with only four branches. Text-fig. 39 shows us how this could be brought about, starting with a dichotomic type in which the branches of Rs are arranged as in the Archetype of the Complex (Text-fig. 38). In this connection, I wish especially to draw attention to the position of the dichotomic forkings in the fossil genus *Belmontia* (Text-fig. 63), and to emphasise the obvious fact that a very little movement of the point of origin of R_4 from its original position on R_{4+5} across to R_{2+3} would at once produce the pectinate type of branching.

The fossil *Belmontia* (Text-fig. 63) may not, however, be taken as the starting point of the Neuropteroid Orders, for two reasons. Firstly, *Belmontia* is clearly more specialised than the older Megaloptera in the reduction of the series of costal veinlets and the arrangement of its cross-veins, as well as, probably, in its simplified anal veins, and possibly also in the very complete formation of the cubito-median Y-vein (see Section iii.).

Secondly, a study of the Orders Megaloptera and Planipennia (Section xv., xvi.) shows us that the evolution of the pectinate type of branching of Rs was probably at first confined to R_{2+3}, the dichotomic condition of R_{4+5} remaining in these insects long after the rest of Rs had become pectinately branched.* Thus we are driven back to examine R_{2+3} only, and to try to discover what its original condition was, before it became pectinate.

A study of the wings of archaic Megaloptera and Planipennia must convince us that there were *more than two* original dichotomic branches of R_{2+3} concerned in the formation of the pectinate type. All the fossil Planipennia show a considerable number of pectinate branches in this region, and the same is true of most of the *Corydalidae*, all the *Ithonidae* and *Psychopsidae*, and most other archaic types. Even in the very reduced *Sisyridae* (Text-fig. 110), it must be clear that at least three branches of R_{2+3} took part in this formation. Probably the actual number of branches varied according to the size of the species affected. As an illustration of the manner in which pectination of Rs could be brought about, without loss of the original dichotomy of R_{4+5}, from a many-branched type, we have selected the actual type of branching found in *Archipanorpa* (Text-fig. 39), and have shown how, by very simple changes, the original dichotomies of R_{2+3} can be altered to the pectinate arrangement.

As the point at which Rs first forks is of great importance, we have called it the *secondary radial fork*, with the notation *rf'*.

The Media.

The original first dichotomy of this vein was clearly that into M_{1-4} and M_5 (Section iii.). This has hitherto been overlooked. The point at which this forking takes place is the true *primary median fork*, and should carry the notation *mf*. The point at which M_{1-4} divides into M_{1+2} and M_{3+4}, hitherto known as *mf*, must now be called the *secondary median fork*, and must take the notation *mf'*.

The evidence is clear that, in the three Orders Mecoptera,

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*Note, however, that, if R_5 itself were originally branched, as in Text-fig.38, R_4 might migrate across to R_{2+3} and still leave a branched vein in the original position of R_{4+5}. It is thus impossible to decide this point definitely.

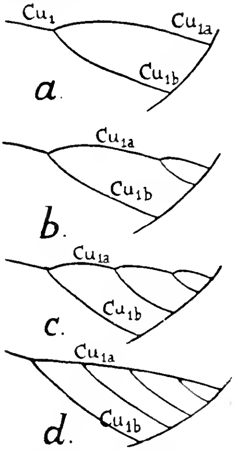
Paramecoptera and Protomecoptera, M_{1-4} had more than four dichotomic branches originally. It is equally clear that, in the more specialised Orders Diptera, Trichoptera and Lepidoptera, this number was reduced to four. As regards the Megaloptera and Planipennia, the evidence is not conclusive one way or another. For, although the great majority of forms in these Orders have this vein reduced to four branches or less, yet the fossil *Kalligrammatidae* show it with from five to nine branches, while six branches can be counted in the hindwing of the recent *Megapsychops*. But these types are both of them Planipennian, and exceptionally abundantly veined. I have therefore assumed that the Orders Megaloptera and Planipennia had archetypically M_{1-4} with only four branches, though I think that more definite evidence on this point may be forthcoming later on from the fossil record.

As regards the condition of M_5, it is clear that the complete fusion of that vein with Cu_1 to form the cubito-median Y-vein, as in *Belmontia* (Text-fig. 63), is a very primitive condition. We are still in doubt, however, as to whether the state of this vein shown in certain primitive Megaloptera and Planipennia (Text-figs. 44, 45) is to be regarded as derivable from the condition seen in *Belmontia*, or whether it is a reduction from a more primitive formation, in which M_5 has not succeeded in becoming fused with Cu_1. Until we have further evidence on that point, we cannot fix the geological age at which these Orders arose. This question is fully discussed in Section iii.

The Cubitus.

A special Section (Section iv.) has been devoted to this vein, as the condition of its branching is of the utmost importance in this research. The conclusions reached are that Cu was originally three-branched, Cu_1 having a distal forking into Cu_{1a} and Cu_{1b}, while Cu_2 was a weak concave vein. It is possible that the distal branching of Cu_1 may have been originally due to incomplete fusion of M_5 distally with that vein; but this point cannot be decided with certainty, in the absence of fossil evidence.

The *primary cubital fork (cuf)* is situated near the base of the wing, and is the point at which Cu divides into Cu_1 and Cu_2. The *secondary cubital fork (cuf')* is the point at which Cu_1 divides into Cu_{1a} and Cu_{1b}. This latter forking is present in all the Orders of the Complex, except only in the Mecoptera, Paratrichoptera and Diptera, in which Cu_1 is a strong, straight vein, without any branches.



Text-Fig. 40.
Stages in the evolution of the pectinate type of first cubitus, from original dichotomic type shown in *a*.

In many Planipennia, and some Megaloptera, the original dichotomic forking of Cu_1 is replaced by a pectinate type of branching, due to additions from the tip inwards. The manner of evolution of this type is shown in Text-fig. 40.

The Anal Veins.

These also are dealt with in a special Section (Section v.). I have, however, omitted from that discussion any reference to the probable number of branches of these three veins. A study of the known venational types within the Complex fails to offer us any clear decision on the point, seeing that the branched condition of these veins seen in so many Megaloptera and Planipennia may be secondarily derived from the simple condition found in the Panorpoidea. I have, therefore, left this question in abeyance, though I have figured these veins in the Archetype of the Complex (Text-fig. 38) as branched, as I think that this is most likely to have been their primitive condition.

Section iii. THE ARCULUS AND CUBITO-MEDIAN Y-VEIN.

(Plate xxxi., figs. 15-16, and Text-figs. 41-45.)

The term *arculus* was originally applied, by writers on the Order Odonata, to the remarkable formation shown near the base of the wings in that Order, R and M being fused basally, and then diverging further distad, so that M approaches Cu. The curve thus formed is completed by a strong cross-vein descending from M to Cu. The *arculus* consists of the curved portion of M, from the point at which it leaves R, to the top of this cross-vein, *plus* the cross-vein itself. The portion formed from M has been called the *anterior arculus,* that from the cross-vein the *posterior arculus* (Text-fig. 41*a*).

Comstock has extended the use of the term to other Orders also, in which somewhat similar formations are to be met with (15, p. 78). In the Trichoptera and Lepidoptera, in particular, he has applied the name *posterior arculus* to the supposed cross-vein that descends upon Cu_1 not far distad from the cubital fork.

The discovery of the fossil Order Paramecoptera (29) has shown us very clearly that this supposed cross-vein is not a cross-vein at all, but a true branch of M, whose existence might otherwise have passed unsuspected. As this discovery is of the utmost importance, for the right understanding of the Phylogeny of the Complex, it is necessary here to undertake a careful analysis of the region of the arculus, and to give the full proof of the true nature of this basal posterior branch of M, which has hitherto been regarded as a cross-vein.

In order to follow this argument clearly, it will be necessary to go back, first of all, to the Odonata, in which the arculus still exists in a more primitive condition than it does in any Order of the Panorpoid Complex. In the Zygopterous Odonata, which preserve the most archaic condition of the venation as regards the media and its branches, there are actually *five* branches of M represented. But, owing to the fact that the venational scheme was worked out from the more specialised Anisoptera, in which Rs has crossed over M_1 and M_2, and has captured the third branch (leaving its basal portion as the so-called *bridge-vein*), the notation originally applied to these five branches, beginning with the most anterior, was M_1, M_2, Rs, M_3 and M_4 respectively. When I pointed out that, in the Zygoptera, the supposed Rs was really a branch of M, I adopted the name Zygopterid Sector for it, with the notation Ms (19). Hence the notation for the five branches now stands at M_1, M_2, Ms, M_3 and M_4 respectively, the last three being actually the *third, fourth* and *fifth* of these branches, in order. The correct notation, of course, would be M_3, M_4 and M_5 respectively for these three branches; and, as this is not an Odonatological research, I propose to use these terms in this paper.

A careful analysis of the Odonate arculus shows that it is really divisible into *three* parts, viz.:—

(i.) the uppermost part, from the point where M leaves R to the point where M_{1-4} diverges from M_5.

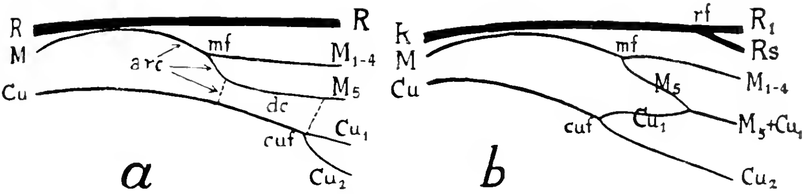
(ii.) the middle part, consisting of a short basal piece of M_5, from its divergence from M_{1-4} to the top of the cross-vein.

(iii.) the lowest part, formed from the cross-vein, called the *posterior arculus*.

The middle portion (ii.) is apt to be overlooked, since, in the majority of recent Odonata, M_{1-4} and M_5 come off together from the same point on the arculus; or, in other words, the cross-vein forming the lowest portion has moved up to the point of origin of M_5, thus obliterating (ii.) altogether. But in some fossils this portion is the longest of the three, as, for instance, in *Aeschnidiopsis* (22). This middle part is of the greatest importance in the present discussion, and must not for one moment be lost sight of.

Lying distad from the posterior arculus, in the Zygoptera, is the discoidal cell, or quadrilateral, whose upper and lower sides are portions of M_5 and Cu respectively. The condition that this cell can be formed was laid down by me in a former work (21, p. 57), viz. that the bifurcation or forking of Cu must take place at some point distad from the level of the arculus. If the cubital fork were placed at some point closer to the base than the arculus is, no discoidal cell could be formed, and the evolution of the arculus would have to proceed along different lines.

Now, in all archaic types within the Panorpoid Complex, the cubital fork lies very close to the base, and the arculus lies at a level somewhat distad from it. Hence it was not possible for a discoidal cell of the Odonate type to be formed, and the evolution of the arculus has proceeded upon different lines. Instead of remaining separated by a definite area, out of which in the Odonata, the discoidal cell and the area distad from it are formed, M_5 and Cu_1 have become more and more approximated, and very early became fused, for at least a considerable portion of their lengths, as we find them already in the Permian Paramecoptera. This condition is shown in Text-fig. 41, *b*. The



Text-Fig-41.

Diagrams to show the structure of the arculus and cubito-median Y-vein. *a*, arculus in Odonata, with the discoidal cell or quadrilateral *(dc)* formed between two cross-veins; *b*, cubito-median Y-vein in the Panorpoid Complex, formed by fusion of M5 with Cu1. Lettering as on p.535.

resulting formation may be called the *cubito-median Y-vein*. Its relationship with the Odonate arculus will now be quite clear. Part (i.) of that arculus, defined above as the part of M from its divergence from R to the origin of M_5, takes no part in it at all. Part (ii.) corresponds with the upper arm of the Y, in so far as it is the basal portion of M_5; it is not, however, terminated below by a cross-vein, but by the point of junction of Cu_1 with M_5. Part (iii.), the cross-vein, is absent; if it were ever present, as is very probable, then it has been entirely eliminated by the fusion of M_5 with Cu_1. The lower arm of the Y is the basal portion of Cu_1, and corresponds with the same portion of the same vein in the Odonata, which, as we can see from Text-fig. 41*a*, lies distad from the discoidal cell.

The *cubito-median Y-vein*, then, in the Orders of the Panorpoid Complex, is a specialisation akin to the arculus in the Odonata, and serving the same purpose of strengthening the venation at a point of stress near the base. It is, however, only partially homologous with it; and the condition necessary to its formation is the opposite of the condition for the formation of the Odonate quadrilateral, viz. that the cubital fork should lie at a level *nearer to* the base than does the distal part of the arculus itself.

The proof that the upper arm of the Y-vein in the Paramecoptera is actually a main vein, i.e. M_5, and not a cross-vein, may be given briefly as follows (*see* Plate xxxi., and Text-fig. 63):—

(a) As regards its *structure*, an examination of the fossil

shows that it is very strongly formed, and exactly resembles the other main veins near the base of the wing. All the true cross-veins are very weakly formed, and their impressions in the fossil are of quite a different type and intensity.

(b) As regards its *direction*, this is oblique, and concave to the base of the wing, i.e. exactly similar to that of the lower arm of the Y-vein, but on the other side of the axis of symmetry of the Y. We know for certain that the lower arm of the Y is Cu_1, and not a cross-vein; there can, therefore, be no reason (outside of a bias present from a previous belief that the vein corresponding to the upper arm of the Y in other Orders is a cross-vein) why it could possibly be regarded as such in the Paramecoptera. In other words, if the wing of *Belmontia* had been an absolutely new type, with no close relatives amongst existing Orders, nobody would have suggested that the upper arm of the Y was a cross-vein.

(c) As regards its *connection* with the main stem of the Y-vein, this is even more direct and complete than is that of Cu_1. This can be well seen from the photograph in Plate xxxi., fig. 15. Anybody who might be asked, with an unbiassed mind, to say which of the two arms of the Y-vein is most likely to be a cross-vein, assuming that one or the other of them must be such, would certainly indicate the lower arm, i.e. Cu_1, from a study of its method of connection with the main stem.

(d) As regards the *presence or absence of macrotrichia*, this vein is most certainly part of a main vein. An examination of any one of the main veins in this fossil will show the sockets of macrotrichia clearly present, whereas no such structures can be seen upon any of the cross-veins. Several of these can be seen upon the lower arm of the Y, i.e. Cu_1. Although the upper two-fifths of the upper arm of the Y is somewhat damaged, and not well preserved, yet two sockets can be clearly seen upon the lower three-fifths, thus proving that it carried macrotrichia, and must therefore have been a portion of a main vein. In Plate xxxi., fig. 16, the arrow points to one of the sockets on M_5, while another on Cu_1 can be seen by following the stem of the arrow backwards.

(e) As regards the *alternate convexity and concavity* of the main veins, the fossil shows quite clearly that R and Cu are convex, M concave. Further distad, as in all Panorpoid wings in which the levels of these veins differ appreciably, M_{1+2}

remains concave, while M_{3+4} becomes slightly convex. Meanwhile, Cu_1 remains convex for its whole length, and thus we have two adjacent main veins, M_{3+4} and Cu_1 both of them convex. This points to the fact that a concave vein must have been suppressed between them. If the upper arm of the Y-vein be truly M_5, then this interpretation fits in exactly with the present convexity and concavity of the veins; for M_5 is a concave vein, and must be the basal portion of the concave vein missing further distally between M_{3+4} and Cu_1.

Thus we see that, on all five counts, the upper arm of the Y-vein is shown to be M_5, and not a true cross-vein.

It is impossible to decide whether the distal forking of Cu_1 is due to incomplete fusion of this vein with M_5 or not. The latter being a concave vein, it may well be that it had already become too weak distally, before the basal fusion was accomplished, to be able to take any part in the more distal formation. An examination of the distal forking of Cu_1 shows that both branches are more or less convex; this evidence, then, so far as it goes, would indicate that both belonged originally to Cu_1. I propose, therefore, to continue the notation Cu_{1a} and Cu_{1b} for these two branches, while leaving it quite open for anybody to consider the upper branch as the distal end of M_5, not completely fused with Cu_1, if he prefers that interpretation. That M_5 took some part in the formation of the main stem of the Y-vein there can be no doubt whatever, seeing how strongly formed this vein is at the fork of the Y. Consequently the correct notation for this vein is M_5+Cu_1 in this fossil. If this be borne in mind, there does not seem to be any reason why the notation Cu_1 for the corresponding vein in recent Orders should not be maintained, seeing that the influence of M_5 in its formation has undoubtedly gradually decreased; until, at the present day, the only trachea supplying it in most pupal wings is that of Cu_1 itself.

We may now sum up the above evidence as follows:—

In the Permian fossil Order Paramecoptera, the cubito-median Y-vein is strongly formed, and consists of an upper arm, M_5, *a lower arm,* Cu_1, *and a distal main stem* M_5+Cu_1, *which does not extend to the wing-border, but forks again distally into* Cu_{1a} *and* Cu_{1b}.

The further discussion of the evolution of the distal forking of Cu_1 will be found in Section iv., dealing with the cubitus.

Having now analysed the complete Y-vein formation in the Order Paramecoptera, let us trace its evolution through the other Orders of the Complex.

(1) *The Mecoptera.*

These may be taken first, as they are the only Order known to have existed alongside the Paramecoptera in Palæozoic times. Three stages in the evolution of the Y-vein are to be found within this Order:—

(a) In the pupal wing of *Chorista* (23), the Y-vein is complete, though the upper branch, M_5, is shortened. It is very important to notice that, in spite of the fact that this Order has merotracheate wings, yet tracheæ R and M still exist, and from the latter trachea a small branch penetrates down the upper branch of the Y-vein. This seems to me to be very significant of the true nature of this vein. At the time that I described this pupal wing first (23), I had not studied the arculus-formation outside of the Odonata, and knew nothing of the Paramecoptera; hence I regarded this vein as a cross-vein, in spite of its trachea. The new evidence has compelled me to alter my opinion.

In the fossil genus *Stereochorista* (Upper Triassic, 28), the Y-vein may be seen completely formed.*

(b) In the forewing of the genus *Panorpa,* the upper branch of the Y becomes transverse, and takes on the appearance of a cross-vein. A similar condition is to be seen in the forewing of *Merope* (Text-fig. 62); but in this genus the lower branch of the Y is much shorter than the upper. It is a pity that the pupal wing of *Panorpa* has so far not been examined as to the condition of M_5, especially during the first day or two of pupal life.

(c) In the hindwings of the *Meropidae* and *Panorpidae,* and in both fore and hindwings of the *Choristidae, Nannochoristidae* and *Bittacidae,* the upper branch of the Y becomes eliminated, and there is a greater or less degree of fusion between M_{1-4} and Cu_1. It will be seen that this high degree of specialisation is not confined to the Mecoptera, but also characterises the majority of forms in the Trichoptera and Diptera, as well as certain groups in the Megaloptera.

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*Since this was written, Mr. J. Mitchell has forwarded to me from the Upper Permian Beds of Belmont, a new type of Mecopterous wing with the Y-vein present.

[The region of the cubito-median Y-vein not having been preserved in the Triassic Protomecoptera, this Order has to be omitted from the discussion.]

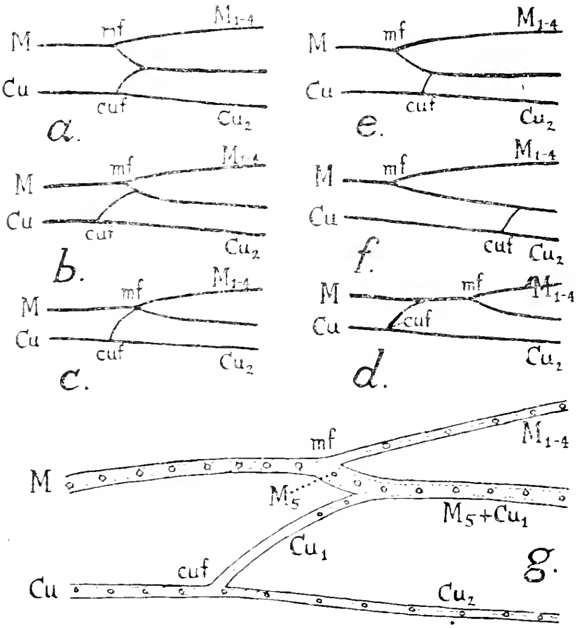
(2) *The Trichoptera.*

In this Order, the three stages indicated above for the evolution of the Y-vein in the Mecoptera are also to be found. The first, or most archaic, stage, is to be seen in a number of genera within the family *Rhyacophilidae*, as, for instance, in *Glossosoma, Mystrophora, Agapetus* and *Catagapetus*, as well as in certain species of *Rhyacophila* itself (Text-fig. 42, *a*). In some species there is actually a tendency for the *lower* arm of the Y-vein, Cu_1, to assume the appearance and direction of a cross-vein, while the upper arm, M_5, remains primitively oblique in position, and is longer than the lower arm. This tendency leads to a new line of specialisation, not represented within the Mecoptera, in which the upper arm of the Y becomes further lengthened, as in the forewing of the undescribed species shown in Text-fig. 42, *f*. The most exaggerated condition of this line of evolution is to be found in certain *Hydropsychidae*, as, for instance, in *Hydromanicus* (15, fig. 322). It is due to a migration of the cubital fork distad, so that the main stem of the Y becomes much shortened, while its upper arm lengthens out.

Further proof that the upper arm of the Y-vein is a true main vein, and not a cross-vein, is to be obtained by a study of the trichiation in the genus *Rhyacophila*. Text-fig. 42, *g*, shows the trichiation of the Y-vein in *Rhyacophila dorsalis* Curtis. The lower arm, Cu_1 is weakened, and has lost all its macrotrichia, except one near the fork. The upper arm, M_5, however, shortened though it be in this species, still carries macrotrichia, and has all the appearance of a part of a true main vein.

The figure of *Rhyacophila dorsalis* (Text-fig. 42, *b*) will serve to illustrate the second stage of evolution of the Y-vein in this Order, in which M_5 becomes definitely shortened. *Rh. fuscula* (Comstock, 15, fig. 320) shows a condition intermediate between the archaic, complete Y-vein, with the two arms approximately equal and symmetrical, and the stage shown in *Rh. dorsalis.* The third stage in the evolution of the Y-vein may also be seen in certain species of *Rhyacophila* (see Comstock, 15, fig. 321), the upper arm of the Y becoming obliterated, and M_{1-4} being fused with Cu_1, either at a point, or for a short distance.

As in the Mecoptera, this last stage has become, for recent Trichoptera, the dominant condition throughout the Order. (Text-fig. 42, *c*, *d*.)



Text-Fig.42.

Evolution of the cubito-median Y-vein in Trichoptera. *a*, *b*, *c*, *d*, successive stages in its reduction, leading to strong fusion of Cu_1 with M_{1-4}, as in *d*; *e*, *f*, stages in its lengthening; *g*, the same stage as in *b*, from *Rhyacophila dorsalis* Curtis, enlarged to show the distribution of the macrotrichial sockets. Lettering as on p.535.

[Not enough is known of the condition of the Y-vein in the Triassic Paratrichoptera to furnish evidence of appreciable value in this discussion. The only genus in which it is partially preserved is *Aristopsyche* (28), in which it would appear that M_{1-4} was already partially fused with Cu_1.]

(3) *The Lepidoptera.*

In this Order, the original condition of the Y-vein may be seen complete in many of the *Micropterygidae*, as already described and figured (26). There is, however, no precedent trachea in M_5 in the pupal wing, and the main stem of the Y is supplied only by the trachea Cu_1.

The same condition is to be found in the pupal wings of *Hepialidae*, of which I have dissected out a large number for the purposes of this paper. Pupæ of the following genera have been dissected: *Leto, Charagia, Porina* and *Oncopera*, the two latter being supplied by Mr. G. Lyell of Gisborne, Vic. In all of these the condition of the Y-vein is the same, viz. M_5 is represented by a pale band without any underlying trachea, while the trachea supplying the main stem of the Y is derived from Cu_1. (Text-figs. 77, 79.)

The only pupal wings in which any sign of trachea M_5 can be detected are those of *Xyleutes* (fam. *Cossidae*). In two of the five pupæ which I dissected, a short but stout branch of M was to be seen arising near the base, and proceeding distad, below the main stem of M, towards the pale band which represents the upper arm of the Y, and which, in this genus, is transversely placed, resembling a cross-vein. It is possible that this trachea may be the lost trachea belonging to M_5.

In advanced pupæ, I have sometimes found a fairly large trachea in M_5; but this is exceptional, as far as my experience goes. In no case have I seen this trachea penetrate far along the main stem of the Y-vein.

The conditions in the freshly emerged imago, of which I have examined a very large number, are very different from those of the pupa. A very strong trachea arises from M, and, passing down M_5, supplies the main stem of the Y-vein right to its distal ends. The original cubital trachea which is found in this vein in the pupa, is often completely ousted, and its truncated remains may frequently be seen near the base of the wing, as in the case of *Wingia* (fam. *Oecophoridae*, Text-figs. 91, 92). It is, therefore, necessary to conclude that the main change takes place at, or very near, metamorphosis, at the same time that M_5 becomes a strongly chitinised vein, and the base of Cu becomes almost completely aborted.

It should also be noted that, in the *Hepialidae*, the condition of the tracheation in the freshly formed imaginal wing is very variable. Comstock (15, p. 328) states that, in all the wings of this family examined by him, M_5 (which he calls the *posterior arculus*) "is traversed by a branch of the median trachea, which extends towards the margin of the wing in the longitudinal part of the cubitus, and parallel with the cubital trachea." In other words, both trachea M_5 and trachea Cu_1 are present in this family,—a condition which may be taken as more primitive than that mentioned above for *Wingia,* and found also in many other Lepidoptera. But an examination which I made of the freshly formed imaginal wings of seven Australian genera of *Hepialidae (Leto, Charagia, Pielus, Porina, Perissectis, Oncopera* and *Fraus),* shows that this condition, though frequently present, is not by any means a constant. Trachea M_5 was found to be frequently of weaker calibre than trachea Cu_1; and there were a few extreme cases in which it had failed to develop much beyond the confines of the upper arm of the Y. In one extreme case (in a specimen of *Charagia splendens* Scott) it was altogether absent, so that the tracheation of this region of the imaginal wing was the same as that of the pupa.

Comstock (15, p. 328) suggests that the trachea which develops along Cu_1 in the imaginal wing, via M_5 (his "posterior arculus"), may be the missing trachea M_4, split back in the same manner that the other tracheæ frequently are in the Lepidoptera. This suggestion cannot be entertained for one moment, for the simple reason that, in many imaginal wings which I have examined, trachea M_4 is present in its natural position, leaving M_{3+4} much further distad along the wing, and descending the upper branch of the distal Y-vein, formed by fusion of M_4 with Cu_{1a}, which is characteristic of the Order Lepidoptera. This formation is fully dealt with in Section vi.

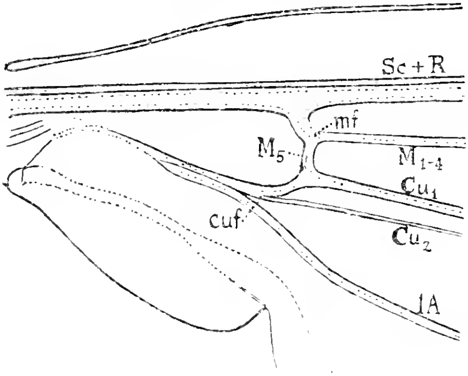
In the great majority of the Lepidoptera, the evolution of the cubito-median Y-vein follows a single definite line, viz. the tendency to strengthen the upper arm, M_5, at the expense of the lower, Cu_1. The result of this is that, in all the higher families, the connection of the main part of vein Cu_1 with the true cubital fork is quite lost, and this vein is continued back more or less directly, via M_5, to the main stem of M. A reference to Text-fig. 91 shows that, in such forms as *Wingia,* M_5 and Cu_1 are not yet completely aligned. In the highest types, the venation at the base of the wing becomes greatly thickened, and the serial vein formed from M_5 and Cu_1 becomes of great strength, and runs perfectly straight from its base to its secondary or distal forking, as in *Euschemon* (Text-fig. 100).

Reviewing the above evidence, we are bound to assume that, at the very beginning of the evolution of the Order Lepidoptera, M_5 had already begun to undergo some amount of degradation from its original condition of a normal main vein preceded by a trachea. That this degradation had not, perhaps, proceeded very far, is indicated by the frequent redevelopment of the trachea M_5 at metamorphosis. The condition seen in many imagines of the *Hepialidae*, in which *two* tracheæ traverse the vein Cu_1, must be held to be more archaic than the commoner condition, in which only a single trachea, viz. that arising from M via M_5, is to be found in this vein. The whole line of evolution seems to me to be exactly paralleled by the similar development in the evolution of the distal Y-vein, which is dealt with in Section vi. In fact, the normal method of reduction of the number of main veins by fusion, in the Panorpoid Complex, is that of *the formation of Y-veins* of the type discussed in this section. Other examples of such formations are, of course, the fusion of M_{3+4} with Cu_1 in forewings of the Myrmeleontoid groups of the Order Planipennia (in which case the upper arm of the Y becomes the *oblique vein*), and the fusion of 1A with Cu_2 in the hindwings of Mecoptera, Trichoptera, Lepidoptera, and some Megaloptera. This latter fusion is dealt with under Section v.

(4) *The Diptera.*

In this Order, as in the Mecoptera and Trichoptera, our study is handicapped by the incompleteness of the pupal tracheation. It is not at all easy to obtain pupæ of archaic Diptera in the right condition for studying the tracheation of the wings. In the few which I have so far examined, there is no sign whatever of the median trachea; though I have found no less than *four* distinct trachea (C, Sc, R and Cu) all well developed in the wing of the Bombyliid *Comptosia* (Text-fig. 50).

In most Diptera, it would appear clear enough that the stage of fusion between M_{1-4} and Cu_1, already described as the third stage in the evolution of the Y-vein in the *Rhyacophilidae*, had already been reached. But some of the more archaic families show definite evidence of an earlier stage of evolution, the upper arm of the Y (M_5) being present in the form of a shortened transverse vein, corresponding fairly closely with the second stage of evolution in *Rhyacophila,* but more transversely placed. This condition is illustrated very well in the Stratiomyiid genus *Sargus* (Text-fig. 43) and others of the same family. I do not know of any Dipteron in which the complete archaic form of the Y-vein can be made out; though I think that it may well be visible in the pupæ of some of the older types, which have not yet been obtained. Thus the evidence in this Order, though containing nothing *against* the supposition that the evolution of the Y-vein has been along the same lines as in the Trichoptera, is still not by any means as complete as we could wish.



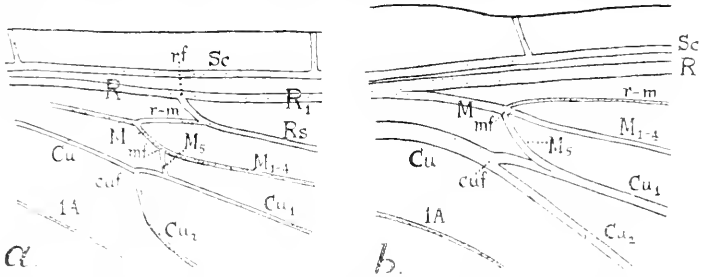
Text-Fig. 43.

Base of wing of *Sargus* sp. (Order Diptera, fam. *Stratiomyiidae*), to show presence of reduced cubito-median Y-vein. Lettering as on p. 535.

(5) *The Megaloptera.*

In this order we meet with a peculiar position. In the more advanced groups, viz. the Raphidioidea and the family *Sialidae* of the Suborder Sialoidea, the forewing shows always a more or less complete fusion of M_{1-4} with Cu_1 basally, as in the third stage of evolution of the arculus in the *Rhyacophilidae* (Text-fig. 42, *d*). In the hindwing, the Y-vein is still evident, though its branches are generally much shortened, and M_5 appears as a very short vein. This condition is shown in Text-fig. 44, *a*, drawn from the archaic Sialid genus *Stenosialis.*

Turning to the family *Corydalidae,* which is generally admitted to be the most archaic family in the Order, and from which, therefore, we might expect some light on the problem, we are surprised to find that there does not appear to be any basal connection at all between M and Cu in the forewing,



Text-Fig. 44.

Cubito-median Y-vein in hindwings of Megaloptera. *a*, from *Stenosialis* sp. (fam. *Sialidae*); *b*, from *Archichauliodes guttiferus* (Walk.), (fam. *Corydalidae*). Lettering as on p.535.

except by means of an apparent cross-vein situated usually just *before* the cubital fork, and therefore not in the position in which one would expect to find M_5, even if it were reduced to a cross-vein in form. In the hindwing, on the other hand, the Y-vein, though small, is quite completely formed in *Archichauliodes* (Text-fig. 44, *b*); and this condition is exactly that from which the somewhat more advanced stage already figured in *Stenosialis* can easily be derived.

We have to ask ourselves, then, whether the stage found in the forewing of the *Corydalidae* is due to the shifting basad of vein M_5, after reduction to a transverse vein, or whether, perhaps, M_5 never existed as a main vein in the forewings of this Order, or whether there may be some further explanation of the case. Remembering how closely allied the Megaloptera are to the Planipennia, we may well turn to these latter for enlightenment, before we make a final judgment.

(6) *The Planipennia.*

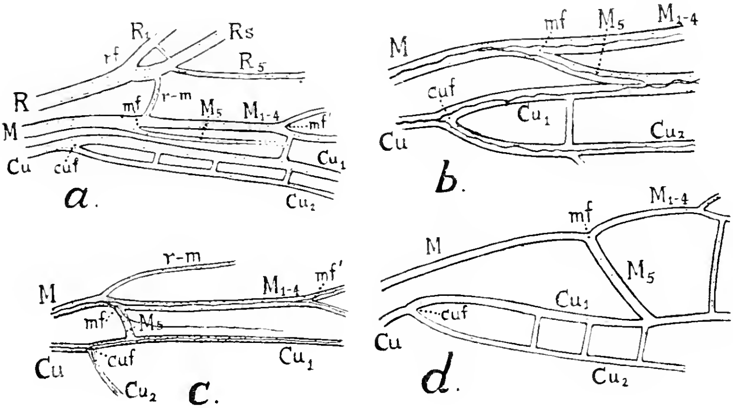
Nearly all of these show no sign of M_5, either in the fore- or in the hindwing. It would be easy to conclude that M_5 had never existed in this Order. However, in the course of my study of a fine Triassic Prohemerobiid (28), I came across what appeared to be a distinct vein in the position of M_5. As this fossil, *Archepsychops*, is clearly allied to the recent

Psychopsidae, I turned to that family for further evidence. The result was the discovery, both in *Megapsychops illidgei* and in *Psychopsis elegans,* of the vein M_5 in its original position, but not strongly connected with Cu_1. This condition is shown in Text-fig. 45*a*. The cubito-median Y-vein is not fully formed, in so far as M_5 weakens distally as it approaches Cu_1. M_5 is also more parallel to Cu_1 than in the normal formation, and is sometimes connected with it by one or more cross-veins.

It is not possible to decide definitely whether the condition found in the Planipennia is a reduction from a more archaic stage than that seen in *Belmontia* (Text-fig. 41*b*), or whether it is due to the effect of a large addition of branches of Rs crowding the older veins together, so that M_5 and Cu_1, though originally forming a Y-vein, have become pressed together in the manner now shown. The evidence from the hindwings would incline us towards the latter supposition, but the point is by no means certain. As the Megaloptera and Planipennia are more archaic than *Belmontia* in certain other venational characters, such as the complete system of costal veinlets, it may well be that the condition of M_5 in the forewing is really due to debasement of this vein from an older stage in which it ran freely between M_{1-4} and Cu_1, without having attained any definite fusion with the latter vein such as we find in *Belmontia.*

An examination of the hindwings of various archaic types in the Order Planipennia shows that M_5 is generally present, and easily recognised owing to its oblique position, and the very evident forking of M which gives rise to it. Thus, we may take as an example *Osmylus* (family *Osmylidae*), in the hindwing of which (Text-fig. 45, *d*) the median fork is particularly well developed, with M_5 as a very strong oblique vein descending on to Cu_1. In the *Psychopsidae,* the trachea supplying M_5 persists in the imago, and passes some distance along Cu_1, thus offering an interesting parallel to the case of the Lepidoptera already discussed. In the American genus *Polystoechotes* (family *Polystoechotidae*) the trachea traverses the base of M_5 only, then leaves it, and runs freely in the membrane between M and Cu for a considerable distance (Text-fig. 45, *c*). This is an interesting survival, in view of the condition found in the forewing of *Psychopsidae,* dealt with above.

In the Planipennia in general, the chitinisation of the base of M is very weak; and this vein is represented at its base, in many forms, by little more than its trachea. In others it is more strongly chitinised; but in no case does the typical main-vein armature of macrotrichia begin on M until well past the position of M_5. Thus we cannot, unfortunately, apply the test of the presence or absence of macrotrichia to M_5 in this Order.



Text-Fig.45.

Cubito-median Y-vein in the Order Planipennia. *a*, from forewing of *Megapsychops illidgei* Frogg. (fam. *Psychopsidae*); *b*, from hindwing of same; *c*, from hindwing of *Polystoechotes punctatus* Say, (fam. *Polystoechotidae*); *d*, from *Osmylus chrysops* (Linn.). (fam. *Osmylidae*). Lettering as on p.535.

The conclusion we are bound to come to is that, in the Planipennia and Megaloptera, M_5 was originally present. The specialisations it has undergone, especially in the forewing, are due to the development of the many-branched Rs in these Orders causing a correlated narrowing of the area supplied by M. The general result has been that M has become squeezed into a narrow space between the two strong convex veins R and Cu, and M_5 has therefore tended to become reduced, and finally obliterated in the forewing, though remaining more normal in the hind.

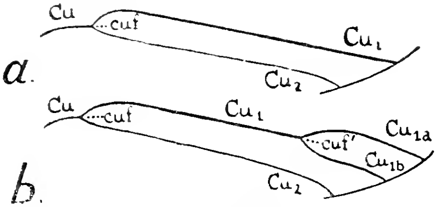
Section iv. THE STRUCTURE OF THE CUBITUS.

(Plate xxxii., fig. 17, Plate xxxiii., figs. 19-20, Plate xxxiv., figs. 21-22, Plate xxxv., fig. 23, and Text-figs. 46-50).

Before we can arrive at a correct conclusion with respect to the archetypic venation of any of the Panorpoid Orders, it is very necessary that we should study the cubital vein with special care, seeing that, on this point more than anywhere else, errors have been allowed to creep in, in the work of the Comstock-Needham school.

Comstock has assumed (15) for the Lepidoptera and Trichoptera, that the cubitus is two-branched, thus making this vein conform, in these two Orders, with his theoretical type. The fact that three branches can be clearly seen in the tracheation of the pupal wing, in all archaic Lepidoptera, is then explained by saying that the first anal trachea has migrated over to the cubitus, and fused with it entirely for its basal portion. The same explanation is given for an exactly similar occurrence in the Homoptera. But it does not seem to have occurred to the author of this extraordinary statement, that a careful comparative study of the veins in question, with the same veins in other Orders closely allied to them, might have offered a much more simple and obvious explanation, viz. that the cubitus is really three-branched, and the first analis remains in its usual position. Yet such is, as a matter of fact, the case, and the proof thereof is a very simple one.

Text-fig. 46*a* shows the form of Cu in the Orders Mecoptera, Paratrichoptera and Diptera. The cubital fork lies close to the



Text-Fig.46.

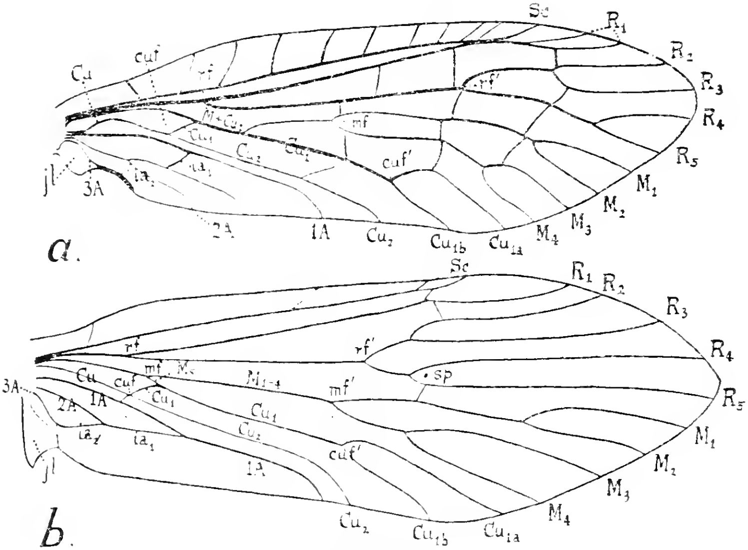
Structure of the cubitus in the Panorpoid Complex. *a*, the two-branched type found in Mecoptera, Paratrichoptera and Diptera; *b*, the original three-branched type found in the other Orders of the Complex. Lettering as on p.535.

base of the wing; and the two branches, Cu_1 and Cu_2, extend nearly parallel to one another, without any further branching. The anterior branch is, as always within the Complex, a strong, convex vein, easily picked out as of almost equal calibre with R, and much more strongly built than any other main vein. The posterior branch, Cu_2, on the other hand, is a very weak, concave vein; in the more specialised types, it tends to sink completely into the anal furrow, and may cease to become chitinised, either altogether or in part, as in many Lepidoptera.

It is necessary to note here that Comstock admits this interpretation of the limits of Cu for the Mecoptera. There is, of course, no doubt about the matter at all in that Order.

Text-fig. 46*b* shows the form of Cu in the Orders Paramecoptera, Protomecoptera, Megaloptera, Trichoptera and Lepidoptera. One of these Orders, viz. the Megaloptera, has holotracheate wings; and hence we are able to examine the structure of the cubital trachea in the pupa. This corresponds exactly with the imaginal venation. Comstock himself figures the tracheation of the pupal wing of *Chauliodes* (15, fig. 170) with the three branches, labelling them Cu_1, Cu_{1a} and Cu_2. But, owing to the fact that he treats the Megaloptera as a portion of the Order Neuroptera, the other part being the Planipennia, he fails to give due prominence to this Order, and has missed the valuable evidence contained in its special type of wing-venation. The form of Cu in the Permian Paramecoptera agrees exactly with that of the Megaloptera, and so does that found in the Triassic Protomecoptera, as far as it is preserved. Thus there can be no doubt as to the antiquity of the extra branch of Cu_1, which dates back to Permian times. As we have already seen in Section iii., the forking of Cu_1 may have been originally due to incomplete fusion of M_5 with Cu_1 distally. But, whether that be so or not, the fact remains that the *true primary cubital fork (cuf)* is not this fork at all, but the point at which Cu originally forked, i.e. much nearer to the base of the wing. All this is admitted by Comstock, as shown by his notation of the wings of Megaloptera (15, figs. 163-169).

Let us now turn to the case of the Trichoptera and Lepidoptera. Text-fig. 47 shows the complete venations of the fore-wings of the Megalopteron *Austrosialis* and the Trichopteron *Rhyacophila*. The former wing is holotracheate, the latter merotracheate; hence we cannot compare their tracheations.



Text-Fig.47.

Comparison of the venation of a Megalopteron (*Austrosialis ignicollis* Till., fig.*a*) with a Trichopteron (*Rhyacophila dorsalis* Curtis, fig.*b*), forewings only, to show the similar structure of the cubitus. Note the strong fusion of M_{1-4} with Cu_1 in *Austrosialis*, and the double fusion of the anal veins in *Rhyacophila*. Lettering as on p.535.

But, *knowing the truth as regards Austrosialis,* we can compare its imaginal venation with that of *Rhyacophila*. We then find that the two venational types agree in practically every detail of the courses and branchings of their main veins, and only differ in the number and arrangement of their cross-veins and veinlets, and in the fact that the Trichopteron shows a high specialisation of the anal area, (viz. the looping-up of the three anal veins), which is absent in the Megalopteron. The correspondence between the venations of the hindwings of the two types is even closer, but need not be figured here. There can, I think, be no doubt whatever that the cubitus in the Trichoptera is three-branched, as in the Megaloptera.

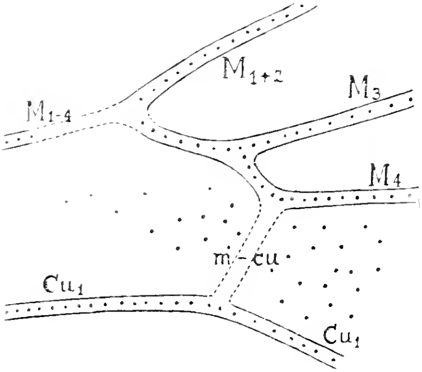
If, finally, we turn to the Lepidoptera, we find that the cubitus in this Order is of the same type as that seen in the

Trichoptera and Megaloptera. Examining the preceding pupal tracheation, we find that this also agrees exactly with the Megalopteran scheme. Where all the evidence from fossils, tracheation and venation alike, agrees exactly, where is the need to invent an explanation such as that given by Comstock, the only merit of which, as far as I can see, is *apparently*, but not actually, to bring the venation into line with Comstock's hypothetical type. For it should be noted that, in making the cubitus two-branched, to conform with this type, Comstock transfers the primary cubital fork to the position of the secondary fork, far distad along the cubital vein; yet he makes no effort to explain how it comes about that such a high specialisation should have taken place, within the limits of a considerable number of Orders.

Further proof of the correctness of the above evidence may be obtained outside the limits of the Panorpoid Complex, by examination of the nymphal wings in the Hemimetabolous Orders Psocoptera and Homoptera, in which the cubitus has been interpreted as being two-branched by Comstock. I have examined the last three consecutive instars in *Psocus*, and the last two in a *Cicada;* and in all these instars the supposed 1A is truly a branch of Cu. If it were really 1A, we can scarcely suppose that so early a stage as the antepenultimate nymphal instar, in an ancient Order like the Psocoptera, would show the specialised fusing already complete. If it did, then our faith in the value of the Comstock-Needham System must be completely shattered, seeing that there would be no telling whether, for instance, Rs might not be really part of M, or M two separate veins fused together. It would only be necessary to explain that a fusion had taken place anywhere, and the venational scheme could be altered *ad infinitum!*

The evidence, then, seems to admit of no doubt whatever. Within the Panorpoid Complex, the cubitus is three-branched in the Orders Paramecoptera, Protomecoptera, Megaloptera, Trichoptera and Lepidoptera; while in the Mecoptera, Paratrichoptera and Diptera it is only two-branched. In all the above Orders, the true primary cubital fork is the more basal forking of that vein. The extra fork, when present, belongs to Cu_1, and may or may not have been caused by incomplete distal fusion between M_5 and Cu_1 when the Y-vein of the arculus was formed. In any case, the two-branched condition must be the more specialised. For, if M_5 had any part in the formation, then the complete fusion, which brought about the two-branched condition, is more specialised than the partial fusion, which left the three-branched condition. But, if M_5 did not extend so far distally, and dthe whole formation belongs to Cu, then the natural explanation would be that the Mecoptera, Paratrichoptera and Diptera had lost the fork, which all the other Orders have retained.

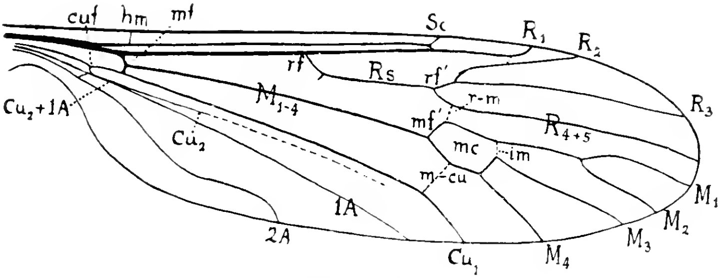
Finally, it is necessary to add a word or two about the limits of Cu in the Diptera. Text-fig. 48 shows the cubitus and portion of the media in the archaic *Rhyphus,* with the trichiation *in situ.* It will be seen that the vein named by Comstock Cu_1 (15, fig. 357) is really M_4, the basal portion connecting it with Cu proper being a true cross-vein, without any macrotrichia, while the short piece connecting it with M, which Comstock names the cross-vein *m-cu,* carries strong macrotrichia, and is therefore the true basal portion of the main vein, M_4.



Text-Fig. 48.

Structure of the media and cubitus in the forewing of a Dipteron, *Rhyphus brevis* Walk. (fam. *Rhyphidae*). The true medio-cubital cross-vein, *m-cu*, carries no macrotrichia. Lettering as on p.535. (x 87.)

Further evidence on the same lines may be obtained by a study of certain archaic Tipulid genera, such as the Australian *Gynoplistia,* in which the original position of the branches of

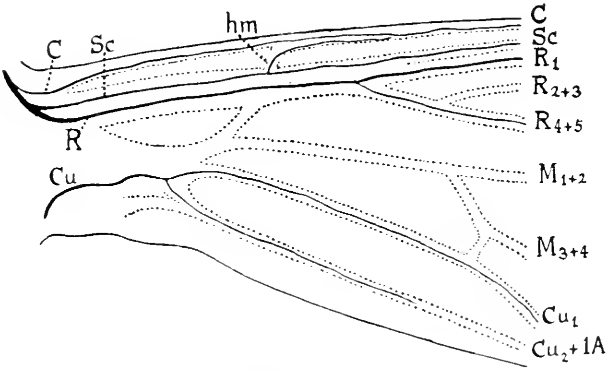


Text.Fig.49.

Gynoplistia bella (Walk.) (Order Diptera, fam. *Tipulidae*) forewing showing the structure of the media and cubitus. Lettering as on p.535.

M are retained. Text-fig. 49 shows very clearly that the interpretation of the veins given above for *Rhyphus* is correct, not only because Cu$_1$ is clearly simple in this ancient type, but also because M^4 comes off directly from the median cell *(mc)*.

In the introductory part of this paper, we remarked that the tracheation of the pupal wing sometimes offered valuable evidence, even in the case of a merotracheate type. Text-fig.



Text-Fig.50.

Base of pupal wing of *Complosia* sp. (Order Diptera, fam. *Bombyliidae*) dissected out from sheath, just before metamorphosis, to show the merotracheate condition, and the complete cubital trachea. (x 36). Lettering as on p.535.

50 shows the base of the pupal wing in a species of the Bombyliid genus *Comptosia.* Only the median and anal tracheæ are missing. The cubital trachea is complete, and shows the cubital fork situated at the extreme base of the wing, with Cu_2 apparently fused with 1A almost for its entire length. Thus not only is the above interpretation of the limits of Cu_1 correct, but we see also that the vein called 2A by Comstock (15, fig. 368) is in reality Cu_2+1A in this genus.

Section v. The Anal Veins.

(Plate xxxiii., figs. 19-20, Plate xxxiv., fig. 22, and Text-figs. 51-54.)

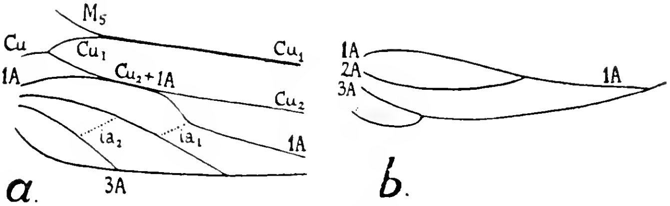
Throughout the Panorpoid Complex, the anal veins are normally three in number, viz. 1A, 2A and 3A. These three veins are all normally convex, the membrane between them being usually more or less concave, and sometimes carrying definite grooves or furrows, which do not, however, carry true veins in them.

The anal tracheæ in the freshly-turned pupa stand in a group by themselves, and are easily recognised by their comparatively small calibre, and by the fact that they usually lie well apart from the cubitus. Corresponding with the sizes of the areas which they serve, the first analis is normally the largest of the three, the second of intermediate size, and the third the smallest. Exceptions to this rule occur when the first or second analis becomes shortened in the formation of a basal Y-vein; or when, owing to expansion of the anal area of the hindwing, both 2A and 3A may become very much lengthened, so as to be of approximately the same length as 1A.

Reductions in the number of anal veins from the normal three are only found in specialised types within the various Orders. In many cases in which an examination of the imaginal venation fails to disclose a definite 3A, the corresponding trachea may still be found in the pupal wing, thus proving that the reduction is a specialisation from a more archaic condition in which 3A occurred. In some of the higher Planipennia, both the anal tracheæ and veins are much reduced; and it is necessary to make a very careful examination of the freshly-turned pupal wings *in situ,* in order to determine the limits of the three anal veins.

The most archaic condition for these three veins is that in which all three run free, and well separated from one another, and 1A is also separated from Cu$_2$ above it. The third anal can always be recognised, in archaic forms, from the fact that, if it is simple, then it bounds the area of the jugal lobe in the forewing externally; but, if it is a forked vein, then its posterior branch occupies the same position.

Specialisations of these veins occur by the approach of one towards another, not far from the base of the wing to form typical Y-veins of the type described in Sections iii., vi., as being formed between M and Cu. Text-fig. 51 shows the formation of *(a)* an incomplete Y-vein, by partial fusion of two veins near their bases, while they again diverge distally, and reach the wing-border far apart, and *(b)* a complete Y-vein, by complete fusion of the two veins from near their bases onwards as far as the wing-border. Of these formations there are two in which the anal veins play a part, viz. the cubito-anal Y-vein, formed by fusion of 1A with Cu$_2$, and the anal Y-vein, formed by fusion of two or more of the anal veins amongst themselves.



Text-Fig.51.

Diagrams to show the formation of *a*, incomplete cubito-anal Y-vein in hindwing, and *b*, complete anal Y-vein, in forewing. Lettering as on p.535.

The Cubito-Anal Y-vein.

If the vein 1A, which is well separated from Cu$_2$ basally, approaches it a little further from the base, and fuses with it for a greater or less distance, then a *cubito-anal Y-vein* is formed, the upper arm being the basal piece of Cu$_2$, the lower arm the basal piece of 1A, and the main stem the fused portions of these two veins (Text-figs. 36, 51*a*, Plate xxxiii., fig. 20), which may be indicated by the notation Cu$_2$+1A.

This formation is an ordinal character for the Mecoptera, Trichoptera and Lepidoptera, *in the hindwing only.* It also occurs in the hindwings of a few Megaloptera, and in both fore and hindwings of some of the higher Planipennia. It also occurs in the forewings of some Diptera (see Text-fig. 50).

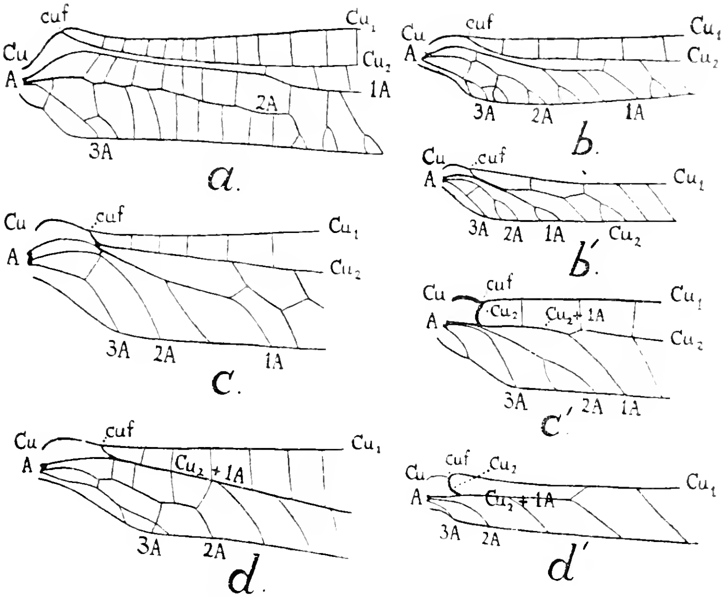
The condition of the cubito-anal Y-vein is generally that of an *incomplete* Y-vein, since the veins Cu_2 and 1A, after fusing for a greater or less distance, diverge again, and run separately to the wing-border. This condition may be studied in Text-figs. 36, 62, 76, 77, 80, 90, and Plate xxxiii., fig. 20. In the Lepidoptera, the formation is as clearly shown in most of the Homoneura as it is in the Trichoptera and Mecoptera. But, in the Heteroneura, it is necessary to study the pupal tracheation, in order to show that a cubito-anal Y-vein does exist. In the pupal hindwing of *Wingia* (Text-fig. 90), I found it absolutely complete; in *Xyleutes* (Text-fig. 87), the fusion was not quite accomplished; and, in many of the higher groups, a secondary specialisation has resulted in the gradual reduction and final extinction of trachea 1A, so that the Y-vein is no longer present. The hindwing of *Carpocapsa* (Text-fig. 89) shows the stage in which the fusion is still present, but 1A is much reduced; while in the Butterflies *Euschemon* and *Euploea* (Text-figs. 99-102) no sign of the Y-vein can be seen.

The best example of this type of specialisation in the Megaloptera is to be seen in *Raphidia* (Text-fig. 107).

In the Planipennia, the approach of 1A towards Cu_2 is first indicated in the *Osmylidae.* In the *Nymphidae* these two veins just touch at a point. In many of the *Myrmeleontidae* the fusion is completed, and the same is true for the *Chrysopidae, Apochrysidae* and *Ascalaphidae.* Text-fig. 52 shows the stages in this line of evolution.

The Anal Y-vein.

An anal Y-vein may be formed in different ways, as follows:—(1). In the forewings of all Trichoptera, and of the most archaic Lepidoptera, 2A loops up with 1A, and 3A with 2A, to form a *double anal Y-vein,* or *double anal loop,* as shown in Text-fig. 53*a*. This formation is confined to these two Orders, for which it is an archetypic character. In the Lepidoptera, the double anal Y-vein may be seen complete in the genera *Sabatinea* and *Mnemonica,* the two most archaic genera of the

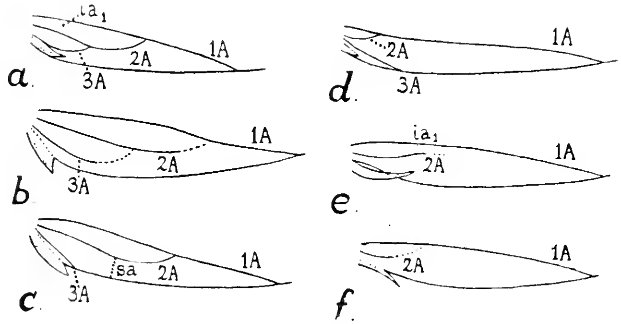


Text-Fig.52.

Evolution of the cubito-anal Y-vein in the order Planipennia. *a*, unfused condition in forewing of *Osmylus chrysops* (Linn.) (fam. *Osmylidae*); *b*, the same condition in forewing of *Osmylops placidus* Gerst. (fam. *Myiodactylidae*); *c*, condition of first contact in forewing of *Nymphes myrmeleonides* Leach (fam. *Nymphidae*); *d*, condition of fusion in forewing of *Glenoleon pulchellus* (Ramb.) (fam. *Myrmeleontidae*); *b'*, *c'*, *d'*, the more advanced conditions of fusion in the hindwings of the same insects as in *b*, *c*, *d*, respectively. Lettering as on p.535.

Jugo-frenata. But, in the other genera of this group, more or less reduction of this formation is generally evident, owing to a progressive weakening of 3A, which results in that vein being unable to maintain its loop intact with 2A. The various stages have been figured already by me in my paper on the *Micropterygidae* (26) and are shown in Text-fig. 53.

It is important to note that, in *Sabatinca* and a number of the Trichoptera, the cross-vein ia_1 persists within the loop

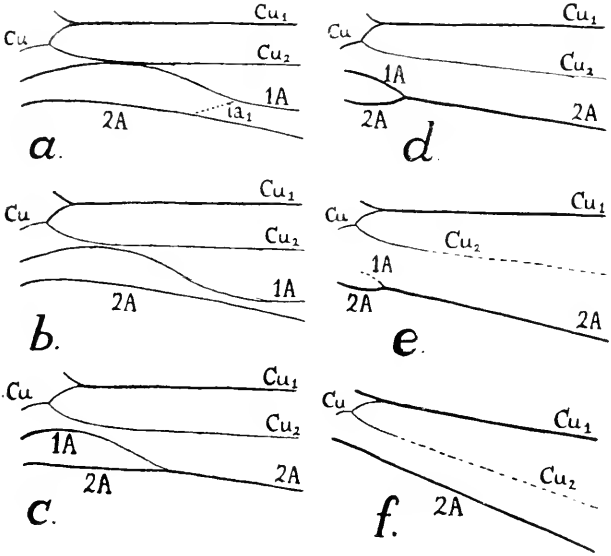


Text-Fig.53.

Evolution of the anal Y-vein in the forewings of Lepidoptera Homoneura, showing progressive stages of reduction. *a*, original complete double Y-vein formation with inter-anal cross-vein (*ia*1) present, in *Sabatinca* (fam. *Micropterygidae*); *b*, loss of ia_1 in *Mnemonica* (fam. *Eriocraniidae*); *c*, loss of lower loop in *Eriocrania* (fam. *Eriocraniidae*), (but note presence of sub-anal cross-vein *sa*); *d*, reduction of upper loop in *Mnesarchaea* (fam. *Mnesarchaeidae*); *e*, partial loss of upper loop, with retention of *ia*1, in *Trictena* (fam. *Hepialidae*); *f*, last stage of reduction in upper loop, in *Leto* (fam. *Hepialidae*). Lettering as on p.535.

formed by 2A and 1A. When we turn to the family *Hepialidae*, we find a further stage in the reduction of the loop indicated in the genus *Trictena* (Text-figs. 53*e*, 79). Vein 3A has ceased to be chitinised, though its trachea still persists. Further, the distal end of vein 2A has become aborted, and a new connection with 1A is being made via the cross-vein ia_1. In other genera of this family, the anal veins become still further reduced (Text-fig. 53, *f*) until, in *Charagia* (Text-fig. 78) there is no sign of the original formation left.

In the Heteroneura, the loop formed between 1A and 2A persists in the great majority of forms, including the Butterflies; but 3A is absent from the forewing. The most archaic condition in this Suborder is probably that in which trachea 2A reaches 1A, and the chitinisation of the loop in the imaginal venation is formed around the two tracheæ *in situ*. But we may note that, in cases in which 2A is reduced, and does not succeed in quite reaching 1A, a recurrent trachea may grow out downwards and backwards from this vein towards the end of 2A, as in *Xyleutes* (Text-fig. 85), and the intervening space will still become chitinised in the imaginal venation, thus completing the formation. I have not succeeded in finding the interanal cross-vein ia_1 in any pupa of this Suborder; unless, indeed, the formation just mentioned in *Xyleutes* indicates that the tracheal outgrowth from 1A proceeds along the channel of that cross-vein. (2) In the hindwings of the older Lepidoptera Heteroneura only, but nowhere else amongst the Orders of the Complex, there is present a remarkable specialisation in the form of an anal Y-vein *secondarily* formed, as the result of the curve given to 1A by the older formation known as the cubito-anal Y-vein,



Text-Fig.54.

Evolution of the secondary anal Y-vein in the hindwings of the Lepidoptera Heteroneura. *a*, original Homoneurous condition; *b*, condition in pupal wing of *Xyleutes* (fam. *Cossidae)*; *c*, condition in pupal wing of *Carpocapsa* (fam. *Tortricidae)*; *d*, condition in imaginal wings of the Tortricina; *e*, stage in which the upper arm of the Y-vein (1A) is degrading; *f*, the final stage, in which 2A is left as a straight, simple vein, as in the Butterflies. Lettering as on p.535.

already dealt with above (p. 577). Text-fig. 54 will explain this formation, which, as far as I am aware, has remained quite unnoticed by all Lepidopterists and students of wing-venation up to the present day. The most archaic stage is to be seen in *Xyleutes* (Text-figs. 54*b*, 87). In this genus, when trachea 1A diverges from Cu_2 after its approach to it more basally, it converges towards trachea 2A, until they come to lie alongside one another for a short distance about the middle of their lengths. It then diverges again from 2A, but fails to reach the wing border. In the imaginal venation (Text-fig. 88), all that part of 1A lying distad from the fusion with 2A fails to become chitinised. Moreover, the basal portions of the two veins are withdrawn towards the base of the wing, so that the final result is a small basal Y-vein, of much the same type as that seen in the highest stages of evolution of the same Y-vein in the forewing (as in the Butterflies).

An examination of the venation of the Superfamily Tortricina shows that this Y-vein formation is almost universally present in the hindwings of this group. The precedent formation in the pupal wing is well shown in *Carpocapsa* (Text-figs. 54*c*, 89). Here we notice a slight advance upon the condition shown in *Xyleutes*, in that trachea 1A is much shortened, and only just succeeds in reaching 2A after diverging from Cu_2. But the resulting formation in the imaginal venation (Text-fig. 54, *d*) is practically the same as in *Xyleutes*.

In the Superfamily Tineina, this basal Y-vein of the hindwing is only to be seen in a few archaic genera. In examining the hindwing of *Wingia* (Text-fig. 93) I was just able to make it out as a weakly chitinised formation in the imago. Turning to the pupal tracheation, I was very surprised to find that trachea 1A was well formed and complete, from base to wing-border, and that it maintained its basal contact with Cu_2 intact. There was no sign whatever of trachea 2A, and the course of that vein in the imaginal wing was indicated only by the usual pale band. If this be the usual condition in the Tineina, it indicates a clear dichotomy between them and the Tortricina; for, in the latter, it is trachea 1A which becomes reduced, whereas in *Wingia* the same fate befalls trachea 2A. While further researches are needed on this point, it should be noted that, whereas the Y-vein is retained almost throughout the whole of the Totricina, it is soon lost in the Tineina, the great majority of the genera of this group showing no trace of it in the imaginal venation.

This same Y-vein formation may be found at the base of the hindwing in the *Castniidae* (Text-fig. 94) and the *Thyrididae* (Text-fig. 98). It is absent, however, from the higher groups, as, for instance, in the Psychina, *Pyralididae* and the Butterflies (Text-figs. 97, 100, 102). An examination of the pupal tracheation in this last group shows that, as in the case of the Tortricina, it must have been the trachea 1A which became aborted. For the only trachea left of the two is placed well apart from Cu_2, and shows no tendency to approach it near the base. Thus we reach the unexpected result that, in the Butterflies, and probably also in the other highly specialised groups, the reduction of the number of anal veins has *not* been by loss of 3A, as hitherto supposed, but by loss of 1A. It should be noted also that, in all these higher groups, although trachea Cu_2 persists in the pupal wing, no chitinisation is formed around it; and so vein Cu_2 is also absent. Thus the only veins lying below the basal cell in the hindwing are 2A and 3A.

We see, then, that the rise and fall of the anal Y-vein of the hindwing is a line of evolution entirely confined to the Heteroneura. Its origin is most certainly to be traced back to a form in which the approach of 1A to 2A took place at the point where these two veins were joined by the cross-vein ia_1, as in the Trichoptera and Jugo-frenata (Text-fig. 54*a*). This cross-vein must have gradually become shortened, and finally aborted, leaving the two veins in contact. The whole series of evolutionary forms is indicated in Text-fig. 54.

In concluding this account of the anal group of veins, I should like to call attention to the fact that it appears to be only an assumption on Comstock's part that the three so-called anal veins are really three separate veins, each of them equivalent to one of the other more anterior main veins. In the Odonata, there is only one anal vein, which gives off a number of branches, *all of which are convex*. In the Orthoptera and Perlaria, 2A and 3A come off from the same stem, though 1A is slightly separated from them. In the Cicada, of which I have examined the tracheation in the wings of several freshly-turned nymphs *in situ*, the anal group of veins comes off from a common stalk in the forewing, as in Odonata, and in the hindwing the condition is that seen in the Orthoptera. I know of no pupal wings in which the three anal veins lie widely separated upon the alar trunk trachea. Even in the Planipennia and Lepidoptera, where they are certainly separate, they lie close together upon this trunk, and are easily distinguished as a separate group. Considering how greatly all the tracheæ are *split back* in the Lepidoptera, even R and M often appearing to arise as two distinct tracheæ from the alar trunk, it would surely seem more logical to take as the more archaic condition that in which the three tracheæ arose from a single base upon the alar trunk, a condition from which all the above described states could easily be derived.

It seems necessary to emphasise this, since otherwise it is hard to understand why the three anal veins should form an exception to the usual rule of alternate convex and concave veins. The fact that they are all three convex certainly points strongly to their being all branches of a single anal vein.

It should be noted that I do not consider Comstock's 1A in Homoptera to be that vein, any more than it is in Lepidoptera. It is certainly Cu_2, and the cubitus is three-branched in both these Orders. The Y-vein on the clavus of the Fulgoroidea is strictly homologous with the anal Y-vein of the Lepidoptera, and is formed by the looping-up of 2A on to 1A.

Section vi. THE DISTAL Y-VEIN, TRIGAMMA, BASAL CELL AND AREOLE IN THE LEPIDOPTERA.

(Plate xxxiv., fig. 21, Plate xxxv., fig. 23, and Text-figs. 55-59.)

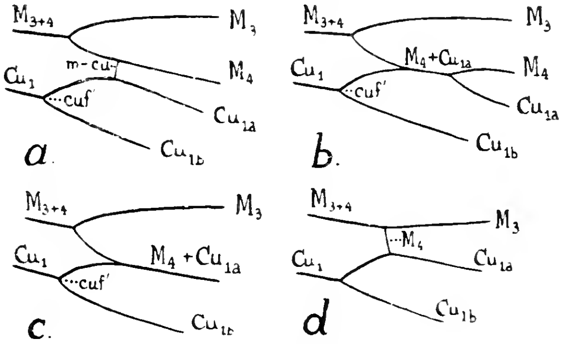
When this research was begun, in 1916, it was recognised that one of the most interesting problems to be studied was the evolution of the Lepidopterous type of wing. At that time, the fossil *Archipanorpa* was known, but *Belmontia* had not been discovered. I saw, then, in the Protomecopterous type of wing-venation, the ancestral form from which the Lepidopterous type could best be derived; and I published a short Preliminary Report (13) in which this idea was followed out. Since then, the discovery of *Belmontia,* and the large amount of time that I have given to researches upon the Lepidoptera, have convinced me that it is the Paramecoptera which are the true ancestral Order from which the Lepidoptera have been derived (29).

The pupal tracheation and imaginal venation of various archaic Lepidoptera have been very fully studied, and the results are given in detail in Section xiv. In this Section, I propose to examine the formation of the distal Y-vein, its evolution into the Trigamma (13), and the stages of the evolution of the basal cell and areole within the Order.

The Distal Y-vein.

I suggest this name for the distal fusion between M_4 and Cu_{1a} which is shown in the *Hepialidae*, and which is a specialisation closely parallel with that called the cubito-median Y-vein between M_5 and Cu_1, nearer to the base of the wing.*

The original condition of M_4 and Cu_{1a} must obviously have been that in which they both ran separately to the wing-border; as they still do, for instance, in the forewings of all archaic Trichoptera (Text-fig. 55*a*). This is followed by an incomplete fusion, in which the two veins are united for a space, and then



Text-Fig.55.

Evolution of the distal Y-vein in Lepidoptera. *a*, the original condition found in the Trichoptera; *b*, the stage of partial fusion, as in hindwing of *Sthenopis* and in the fossil *Archipanorpa* (see Text-fig.57); *c*, formation of the Y-vein completed, as in *Hepialidae* generally; *d*, reduction of M_4 to the transverse position, as in many Lepidoptera. The final stages are shown in Text-fig.59, *b*, *c*, *d*, where M_4 becomes aligned with basal piece of Cu_{1a}. Lettering as on p.535.

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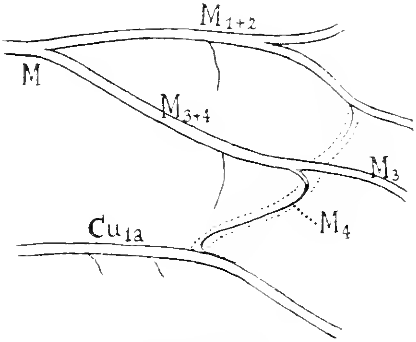
*In this connection, the "Note on the Evidence concerning the Existence of Vein M_4 in the Lepidoptera," on p.651, should be read carefully.

diverge to run separately to the wing-border (Text-fig. 55*b*). This condition is the one found in the hindwing of the well-known atavistic individual of *Sthenopis* figured by Comstock (15, fig. 337), and also seen in the fossil *Archipanorpa* (Text-fig. 57). Further specialisation results in the formation of the complete distal Y-vein, in which the two veins, after fusing, remain in this condition right to the wing-border (Text-fig. 55, *c*). This stage is the one visible throughout the family *Hepialidae*.

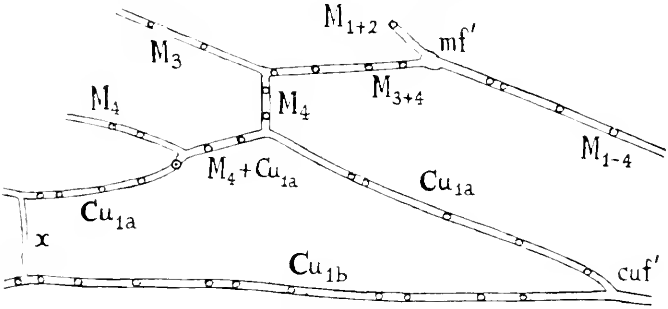
In examining the pupal wing of *Eriocrania*, no trace of a separate trachea M_4 could be found (27). I therefore made very careful examinations of this area of the pupal wing in the *Hepialidae* and *Cossidae*. The result of a large number of dissections proves that trachea M_4 is *never present* in the freshly-turned pupal wing of the *Hepialidae*, though I have succeeded in finding it once (Text-fig. 56) in the freshly-turned pupal wing of the Cossid genus *Xyleutes*. In this case, trachea M_4 was small, but quite distinct, and was bent back in the manner shown in Text-fig. 56, in correlation with the highly specialised direction of vein M_4 in the imaginal wing.



Text-Fig.56.

Detail from the pupal wing of *Xyleutes* (fam. *Cossidae*), to show trachea M_4 *in situ*. (x 8).

In a single pupal wing of *Hepialus* which he examined, MacGillivray (16) also failed to find any trace of trachea M_4. It would be easy to jump to the conclusion that the vein M_4 has been lost altogether in this family, and that the oblique vein forming the upper arm of the distal Y-vein is only a cross-vein*. But a little consideration will show that the case is exactly on a level with that of the cubito-median Y-vein, in which M_5 was originally considered to be only a cross-vein, until the discovery of the fossil *Belmontia* proved it to be a main vein. In the fossil *Archipanorpa* (Text-fig. 57), the vein M_4 descends at right angles from the median cell, and would naturally be taken for a cross-vein, were it not for its very strong formation, and the very evident sockets of the macrotrichia which are still preserved upon it. Thus M_4 in this fossil shows an even more advanced condition than that seen in the *Hepialidae*, as regards its direction; and yet there can be no doubt that it is a main vein.



Text-Fig.57.

Portion of the hindwing of the fossil *Archipanorpa* (Order Protomecoptera) to show the partial fusion of M_4 with Cu_{1a}, and the transverse position of the former vein. The small circles indicate the positions of the macrotrichial sockets. Note their absence from the true cross-vein *x*. Lettering as on p.535. (x 10.)

Having examined the pupal wings of a number of *Hepialidae*, at various stages of development, and still failing to find any signs of trachea M_4, it occurred to me that it might very probably develop at metamorphosis, in the same manner as trachea M_5. For this purpose, I obtained a large number of freshly emerged imagines of *Hepialidae*, from which I prepared cleared mounts of the wings. The result showed that, although, in the majority of cases, trachea M_4 is not present, yet there were a considerable number of specimens in which it was present. In

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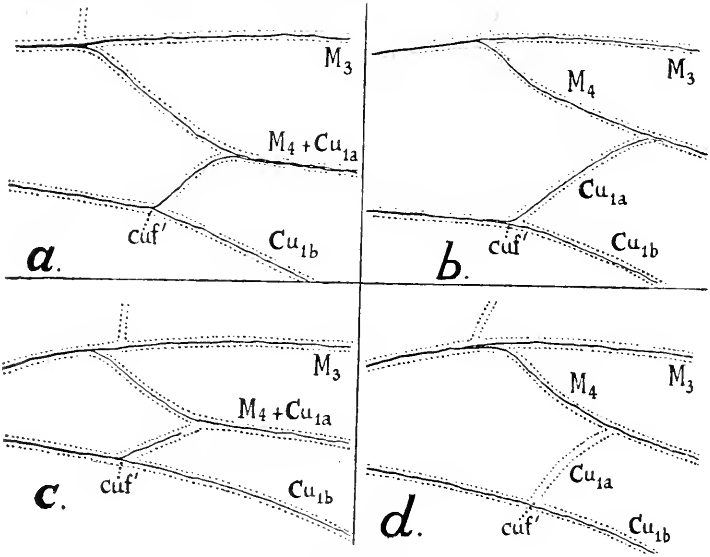
*See the Note on this point on p.652.

one genus, *Perissectis,* of which a large supply was available, it was found that the majority of wings showed M_4 present. Moreover, specimens were found, in all the genera examined, in which all stages of the reduction of this trachea were to be seen. A few specimens were also found in which trachea M_4 persisted at the expense of trachea Cu_{1a}, the latter finally becoming aborted. The condition in which both tracheæ were well developed is shown in Text-fig. 58, *a,* while the stages in the reduction of trachea Cu_{1a} are illustrated in Text-figs. 58, *b-d.*

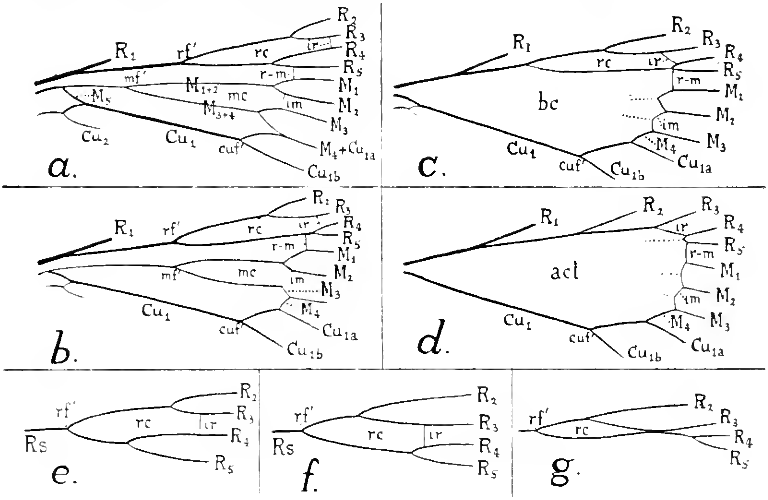


Text-Fig.53.

Condition of the tracheation in the imaginal wings of *Hepialidae*, in the region of the distal Y-vein. *a*, both trachea M_4 and trachea Cu_{1a} complete, in *Perissectis australasiae* Don; *b*, trachea Cu_{1a} becoming reduced, in *Charagia splendens* Scott; *c*, further reduction, in *Pielus* sp.; *d*, complete loss of trachea Cu_{1a}, in *Charagia aslathes* Turn. Lettering as on p.535.

An examination of the imaginal venation shows that, in a number of specimens, the chitinisation of the vein M_4 is stronger than that of Cu_{1a} though the reverse is usually the case. This suggests that in the earliest Lepidoptera, vein M_4 was well developed, but was tending to become weakened by its fusion with Cu_{1a}. The genera in which vein M_4 is most frequently strongly chitinised are also those genera in which trachea M_4 is most frequently present in the imaginal wing, viz. *Perissectis*, *Trictena* and *Pielus*. No pupæ of any of these three genera have yet been obtained; but I shall continue to make every effort to get them, in the hope that trachea M_4 may appear in the pupal wing.

Taking into consideration the above evidence, coupled with the very evident examples of incomplete fusion in *Sthenopis* and the fossil *Archipanorpa*, we are, I think, justified in a belief



Text-Fig.59.

Evolution of the basal cell and areole in Lepidoptera. *a*, original condition, as in Trichoptera (and in *Hepialidae*, except for loss of *ir*); *b*, change to the Heteroneurous condition, as in forewing of some *Cossidae* (note the approach of the forking of R_{2+3} towards rf'); *c*, formation of the open basal cell *(bc)* by abortion of M_{1-4} and its branches, as far as *im*, as in most Heteroneura; *d*, formation of an *areocel (acl)*, by fusion of the areole *(rc)* with the basal cell, through abortion of the chorda (R_{4+5}) as in Tortricina, etc. *e-g*, stages in the evolution of the areole *(rc)*; *e*, the Homoneurous condition *(ir* absent in *Hepialidae)*; *f*, the Heteroneurous condition, with the forking of R_{2+3} approaching closer to rf' than does that of R_{4+5}; *g*, closure of the areole by fusion of R_3 with R_{4+5}, after loss of *ir*. Lettering as on p.535.

that vein M_4 does exist in the Lepidoptera, and forms the upper arm of the distal Y-vein. I think, however, that the notation M_4+Cu_{1a} need only be applied to the fused vein when it is clear that both M_4 and Cu_{1a} have taken part in the fusion, as in the *Hepialidae.* In the Heteroneura, and also in *Eriocrania,* vein M_4 is reduced to the semblance of a cross-vein. While still labelling this vein M_4, it does not appear to me that it takes any part in the fusion; and I should prefer to label the distal part of the Y-vein simply Cu_{1a}.

The Trigamma.

Text-fig. 59, *a-d* shows the stages in the alteration of the direction of M_4 which result in that vein becoming aligned more or less with the basal portion of Cu_{1a}, so that the original form of the distal Y-vein is quite lost. The changes are correlated with the development of the *basal cell,* which requires a strong support below it, as well as above. To the strong three-pronged fork formation found in many higher types of Lepidoptera I have already given the name *trigamma* (13). The forks, named from below upwards, are Cu_{1b}, Cu_{1a} and M_3, the connecting piece between the two last being the highly specialised M_4, as shown in Text-figs. 59, *c, d.*

The Basal Cell and Areole.

Originally, as in the Trichoptera, there were only two closed cells lying away from the base of the wing in the Lepidoptera. These were the *radial cell (rc),* formed between R_{2+3} and R_{4+5}, and closed distally by the cross-vein *ir;* and the *median cell (mc),* formed between M_{1+2} and M_{3+4} and closed distally by the cross-vein *im.* The primitive condition is shown in Text-fig. 59, *a.* The cross-vein *ir* is retained in the Tortricina and Tineina, as well as in a few other genera, e.g. the Cossid *Macrocyttara* (32). But in most cases it has disappeared, and the closure of the radial cell distally is brought about by other means, such as a partial fusion between R_3 and R_{4+5} (Text-fig. 59, *g*). The cross-vein *im*, on the other hand, is present in most Lepidoptera, and may persist long after the main stem of M has become aborted

The radial cell, when it persists as a separate entity in the imaginal venation of the Lepidoptera, is known as the *areole.* The basal part of the stem of R_{4+5}, which separates the areole, when present, from the basal cell below it, has been named by Turner the *chorda* (32).

The *basal cell* of the Lepidoptera is formed normally by the abortion of the main stem of M_{1-4} and its two branches M_{1+2} and M_{3+4}, as far as the limits of the median cell distally, i.e. up to the cross-vein *im*. All stages in this reduction are to be met with in existing types, as can be seen by a study of the wing-venations figured in Section xiv. The basal cell, therefore, includes within itself the original median cell, and is separated from the areole above it by the chorda. The veins bounding the basal cell distally have been called collectively the *disco-cellulars*. But it is better to retain their correct designations, if we wish to preserve in our minds a true picture of what the basal cell really is. The disco-cellulars, from above downwards in order, are the cross-vein *r-m*, the basal piece of M_1, the basal piece of M_2, the cross-vein *im*, and a short basal piece of M_{3+4} Below this, the cell is bounded by the stem of the trigamma.

The basal cell may be enlarged, in the forewing only, by the incorporation within it of the areole or radial cell. This is brought about by the abortion of the chorda, or portion of R_{4+5}, separating them. The complete cell so formed has been named by Turner the *areocel* (32). An areocel is normally formed in those Tortricina in which no separate areole can be seen, and in many Tineina, as, for example, in *Wingia* (Text-figs. 90-93). An areocel of a somewhat specialised type is also formed in the Butterflies, as may be seen from the account given in Section xiv., pp. 679-687. It differs from the areocel of the Tortricina in that, before it was evolved, the radial sector has become split into two parts R_{2+3} and R_{4+5}, arising separarately from R_1, and wide apart. In Text-fig. 59, I have indicated the more important stages in the evolution of the basal cell and areole, culminating in the formation of the highly spesialised areocel.

In the hindwings of Heteroneura, the formation of an areocel is not possible, owing to the reduction of Rs to a simple, unbranched vein. Thus there is never an areole present in this wing, and the most complete formation of the basal cell is that formed by the loss of M_{1-4} and its two main branches, as far as the cross-vein *im*, by the alignment of the discocellulars, and by the strong formation of the trigamma. This type of cell is to be found in all the higher groups, quite independently of whether the forewing possesses an areocel or not.

Section vii. VEINLETS AND CROSS-VEINS.

The distinction between a *veinlet* and a *cross-vein* has already been made in Part 2 of this work (25, p. 628). A *veinlet* is a branchlet of a main vein; it is preceded by a trachea in the pupal wing, and carries macrotrichia in all archaic groups. A *cross-vein*, on the other hand, is a transverse vein which is developed independently of the branching system of any main vein; it is not preceded by a trachea in the pupal wing (except in a few cases of high specialisation), nor does it carry macrotrichia in any archaic group.

Veinlets originally come off obliquely from their main veins. But they frequently tend to assume a transverse position, and so come to take on the characters of cross-veins. In the course of reduction, they may lose their precedent tracheæ, or their macrotrichia, or both. In such cases, their true nature is only to be determined by a study of their homologues in more archaic types.

Cross-veins originally formed transverse struts or supports between main veins or their branches. They may, however, become specialised so as to take up an oblique position, and may even become lengthened, so as to appear like veinlets or even branch-veins. In a few highly specialised cases, they may gain an underlying trachea in the late pupal wing, or at metamorphosis. In two groups, viz. in the higher Planipennia and the Raphidioidea, they gain macrotrichia. In such cases as these, their true nature can only be determined by a study of their homologues in more archaic types.

In certain cases, as, for example, when two main veins fuse together for part of their courses, a small portion of a main vein may become bent at an angle to the rest, and so take on the appearance of a veinlet. Further specialisation may cause the trachea underlying this vein to weaken, so that it becomes a veinlet to all intents and purposes. It may even lose its trachea and macrotrichia, and take on a transverse position, so as to be indistinguishable from a true cross-vein, except by a study of its origin in more archaic forms.

Main veins which have undergone these specialisations are the following:—

The basal pieces of M_5 and Cu_1, during the evolution of the cubito-median Y-vein. (*See* Section iii.).

The basal piece of M_4 in Lepidoptera (Section vi.), or of

M_{3+4} in the higher Planipennia, during the evolution of the distal Y-vein in the former Order, or its homologue, the oblique-vein formation, in the latter.

The only system of true veinlets present in the original Panorpoid wing is the series of small branchlets from the main veins to the costal border. These may be classed as follows:—

(1) *Costal veinlets,* lying between the costal border and the subcostal vein. These extend from near the base to near the distal end of Sc, running obliquely outwards and upwards from Sc, of which they are true branches.

(2) *Pterostigmatic veinlets,* lying between the costal border and R_1, distad from the end of Sc. These are branches of R_1, The evolution of the *pterostigma,* as a hardened patch of membrane covering the area originally supplied by these veinlets, has been already dealt with in Part 2 of this work (25, p. 633).

Besides these original systems of veinlets, there may be developed, as specialisations in the Neuropteroidea only, a series of *terminal veinlets,* formed by the splitting into two of the tips of the veins reaching the wing-border. This splitting may go on almost indefinitely in certain cases, the final result being a long series of veinlets proceeding from quite a considerable portion of the whole length of the vein affected. These extreme cases are only to be found within the Planipennia; and, since they are obvious specialisations, they do not concern us here.

The original system of cross-veins in the Panorpoid wing, to judge by the fossil evidence, was either one in which the cross-veins were only moderately numerous, very irregularly placed, and very weakly formed, or else they were entirely absent. It will be assumed here that the former was the case, for the reason that it is never possible to be quite sure, in examining a fossil, that such weak cross-veins were not present, even if no visible impression of them has been left. The point is not of much importance, because, even if the Panorpoid wing was originally without cross-veins, they certainly soon began to appear. In the Permian fossil *Permochorista,* a few can be definitely made out, while traces of others seem to be indicated. In *Belmontia,* they are weakly formed, but all clearly visible in a good light. The main point to be emphasised is this, that the system of abundant cross-veins found in so many forms, e.g. *Merope,* some of the Megaloptera, and most of the Planipennia, is not the original condition, but is a specialisation of much later date, brought about by the necessity for supporting an abundant main venation by means of numerous transverse struts. A study of the Triassic, Liassic and Jurassic fossil Planipennia proves the truth of this absolutely; while a study of the still existing families of the same Order shows that all the more archaic forms possess only few cross-veins, whereas the higher families show more and more abundant cross-venation, though this is significantly confined only to the *disc*, or middle portion of the wing, and not to the marginal areas. Thus we have the curious result that the Planipennia, which formed a part of the old Order Neuroptera, do not deserve this name at all, as they were originally an open-veined type quite unlike the densely-veined Odonata or Plectoptera, to which the name was much more suitably applied. In other words, Linnæus included, in the one Order, not only those Orders in which the densely-veined condition was the original one, but also those in which it was a high specialisation, only found in the most advanced families. This error has had grave consequences; and, unfortunately, there still remain entomologists who are unable to see the essential differences between the two types, and continue to treat the old Neuroptera as a natural unit.

In determining the Archetypes of the various Orders within the Complex, the conditions of both the system of veinlets and the system of cross-veins must be taken into consideration.

As regards the *veinlets*, the Archetypes may be arranged into four sets showing progressive evolution in this character, as follows:—

(A) Orders in which the more archaic families, and therefore the Archetypes, retain the complete system of veinlets, at any rate as far as the costal series is concerned:— MECOPTERA, PROTOMECOPTERA, PARATRICHOPTERA, MEGALOPTERA and PLANIPENNIA.

(B) Orders in which the costal series is reduced to *three* veinlets only, viz. the humeral *(hm)*, the intermediate *(icv)* and the distal *(dv)*:— PARAMECOPTERA.

(C) Orders in which the more archaic families, and therefore the Archetypes, possess only *two* veinlets in the costal series, viz. the humeral *(hm)* and the distal *(dv)*:— TRICHOPTERA, LEPIDOPTERA.

(D) Orders in which the more archaic families, and therefore the Archetypes, possess only *one* veinlet in the costal series, viz. the humeral *(hm)*:— DIPTERA.

As regards the *cross-veins*, the Archetypes may be arranged into three sets showing progressive evolution, as follows:—

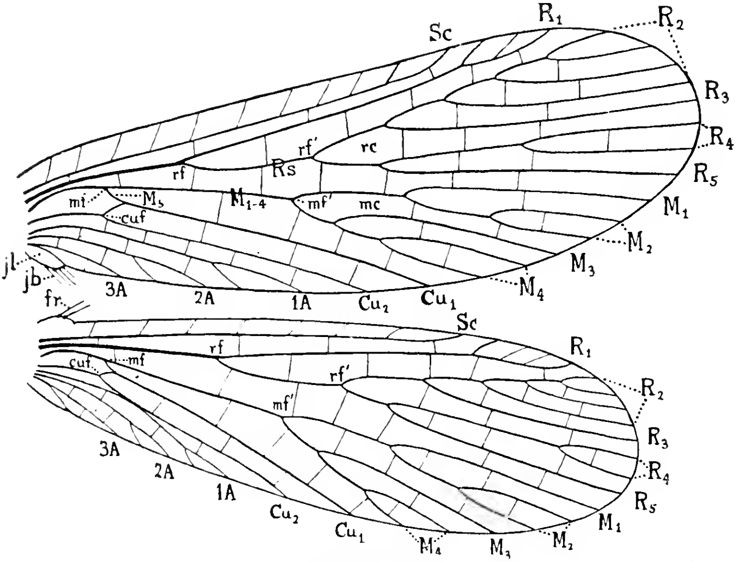
> (A) Orders in which the more archaic families, and therefore the Archetypes, show no definite arrangement of the system of cross-veins, which remain weak and irregularly placed in positions of no special mechanical advantage:—
>
> MECOPTERA, MEGALOPTERA, PLANIPENNIA, PARATRICHOPTERA.
>
> (B) Orders in which the cross-veins are reduced in number, and mostly occupy positions of distinct mechanical advantage, but there may still be more than one cross-vein in a set between two main veins:— PARAMECOPTERA, PROTOMECOPTERA, TRICHOPTERA.
>
> (C) Orders in which the more archaic families, and therefore the Archetypes, have the cross-vein system still further reduced, and confined to a few cross-veins, in positions of distinct mechanical advantage, with not more than one cross-vein between any two main veins:— LEPIDOPTERA, DIPTERA.

As regards the *cross-veins*, the most archaic condition is that in which they were either absent or weakly formed, and show no arrangement in positions of mechanical advantage. The Archetype of the Mecoptera appears to have possessed this condition, which is indicated by A in Table v. on p. 706. In the Megaloptera and Planipennia, a slight degree of specialisation is evident, in so far as there are three cross-veins placed in advantageous positions between R_1 and Rs, two between Sc and R_1, and the rest appear to show some signs of arrangement to mechanical advantage. The Protomecoptera and Paratrichoptera also show slight signs of specialisation in the arrangement of their cross-veins. I have therefore classed these four Orders as slightly specialised under B in the Table mentioned. The Paramecoptera, with an evidently more specialised system of cross-veins (Text-fig. 63) are placed under C. Of the more reduced systems, that of the Archetype of the Trichoptera contains more cross-veins than that of the Lepidoptera, and that of the latter more than that of the Diptera. These may therefore be arranged in ascending order of specialisation, under the letters D, E, F, respectively, in Table v. on p. 706. Complete lists of the cross-veins present in the Archetypes of the Orders Trichoptera, Lepidoptera and Diptera will be found under the Sections dealing with the venations of these three Orders.

Section viii. The Venation of the Mecoptera.

(Text-figs. 60-62.)

Text-fig. 60 shows a diagrammatic representation of the wings of the Archetype of this very ancient Order. In constructing this Archetype, the following points have had to be borne in mind:—



Text-Fig-60.
Wings of the Archetype of the Order Mecoptera. Lettering as on p.535.

(1) In most of the existing genera, the cross-vein system is fairly strongly developed, and usually has the effect of causing a slight zig-zagging of the main veins. In the fossil genera, the cross-vein system is very weakly developed, and, in the oldest genera, there is practically no deviation, due to cross-vein struts, in the courses of the main veins. This is well shown both by the Permian genus *Permochorista* (6) and the Triassic *Mesochorista* (20), as well as by most of the Liassic forms. Consequently the typical zig-zagging of the main veins seen in many recent genera is omitted from the Archetype. The system of dotted cross-veins given in Text-fig. 60 is intended to represent

an entirely irregular and variable system of very weakly chitinised cross-veins, such as can just be made out with difficulty in the oldest fossils, and is not to be taken as indicating that there were any cross-veins fixed in constant positions. Indeed, I would go so far as to express the opinion that Permian forms may yet be discovered in which no cross-veins exist at all, beyond a few in specially suitable positions, e.g. as supports beneath the dichotomous forkings of Rs and M_{1-4}.

(2) Though the cubito-median Y-vein disappeared very early from the wings of this Order, by fusion of Cu_1 with M_{1-4} near its origin, yet this formation is indicated in the pupal wing of *Chorista* (23), and is present, fully formed, in the Triassic fossil *Stereochorista*. It is therefore included in the Archetype. I am also of opinion that Permian forms will be discovered showing this Y-vein as complete as it is in *Stereochorista*, and thus serving to link the Paramecoptera with the true Mecoptera.

(3) The cubitus is two-branched throughout the Order, the fork being close to the base of the wing. Cu_1 is a strong, straight, convex vein without any distal forking. Cu_2 is a weak, concave vein, lying in or near the anal furrow.

(4) A single line of descent is clearly evident, with very little change during many millions of years, from the Permian genus *Permochorista*, through the Triassic *Mesochorista*, to the still existing *Taeniochorista*, with *Chorista* itself as a specialised offshoot. Apart from the changes already indicated in (1) above, the only alteration of importance is the reduction in the number of dichotomic branches of M_{1-4} in the recent genera, which have only five such branches in the forewing, and four in the hind. In the fossil genera, this vein has six branches, all of which are clearly primitive dichotomies. Thus the Archetype of the Order must also have at least six true dichotomic branches of M_{1-4}, as in Text-fig. 60. The manner by which reduction has been brought about is quite evident. The first fork to be eliminated was that of M_4, the result being the condition now extant in the forewings of *Taeniochorista* and *Chorista*. Further reduction, in the hindwings only, led to the loss of the fork of M_2. This condition of a four-branched M_{1-4} persists in all recent winged forms within the Order.

(5) As contrasted with the Australian *Choristidae*, the forms known from the Northern Hemisphere show a progressive reduction not only in the number of dichotomic branches of M_{1-4}

(from six to four), but also in those of Rs, which, in all known *Choristid* forms, from the Permian onwards, only number four. Thus we find in *Merope* either five or six dichotomic branches of M_{1-4}, and always five such branches of Rs. The only specimen of this rare insect which I possess, and from which Text-fig. 61 was drawn, has five branches of M_{1-4} in all four wings; but the specimen figured by Comstock (15, fig. 317) has six on the right side, the extra one being due to a strong dichotomy of M_{4b}. As it seems doubtful whether this extra fork may not be a recent addition due to platygenesis, I have not counted it as an archetypic character.

As regards Rs, the extra fork in *Merope* occurs on R_2, and is so deep that there can be no doubt of its being a primitive dichotomy. The same fork persists throughout the genus *Panorpa*. But, in the archaic genus *Panorpodes* there is to be found a deep forking of R_4 which is also clearly archaic. Thus the northern forms at present existing must have had an ancestor with at least a six-branched Rs, the extra forks being present on R_2 and R_4 respectively.

Further valuable evidence on this point is to be gained by the study of the Liassic genus *Orthophlebia* (2, Pl. xlii.) and allies. Many of these show Rs with no less than *seven* branches, while the rest have six. In this group of fossils, the extra branches all belong to R_2, and tend to be arranged pectinately,—a very striking illustration of how very simple a change might lead to the evolution of the Neuropteroid type of venation, from the older Panorpoid type. Allowing *five* branches as the maximum for R_{2+3}, as in the *Orthophlebiidae*, and *three* for R_{4+5}, as in *Panorpodes*, we see that the Archetype of the Order must have possessed at least *eight* branches to Rs, as shown in Text-fig. 60.

It will by now be clearly evident that the main line of evolution within the Mecoptera has been by *narrowing* of the wings, with suppression of certain of the original archaic branches of Rs and M_{1-4}. With the narrowing there has proceeded also a *lengthening* process, which culminates in such forms as the *Bittacidae*. Thus the name Mecoptera ("long-winged insects") is fully justified for this ancient Order.

(6) In all Mecoptera, and therefore in the Archetype of the Order, Sc is shorter in the hindwing than in the fore, and Cu_2 is fused with 1A for part of its length, not far from the base,

in the hindwing only. These characters are included in Text-fig. 60, and serve to show that Handlirsch's assertion that this Order has retained "archaic homonomous wings" is the result of too cursory a survey of the venational characters.

(7) The apex of the wing is well rounded in all forms throughout the Order.

(8) The pupal wings are merotracheate, as in the archaic *Choristidae* (23).

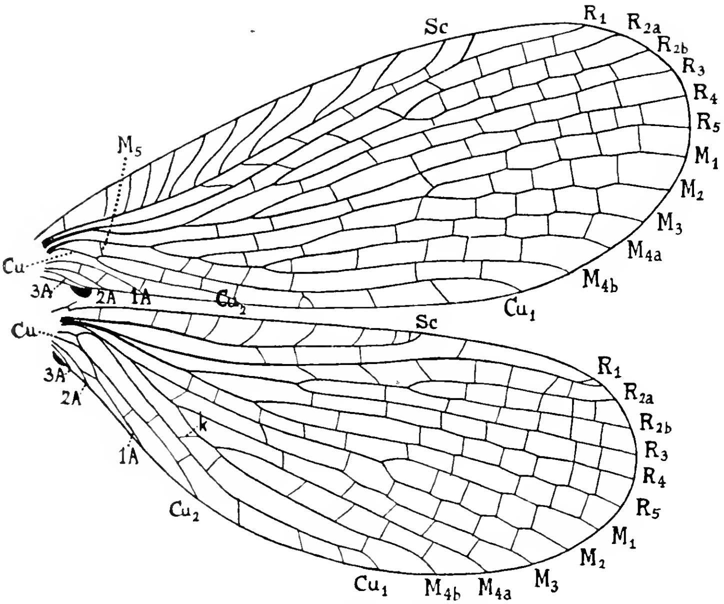
Having now indicated the principal characters of the Archetype of this Order, and the methods by which they have been arrived at, it will only be necessary to give a fuller study of the aberrant but archaic genus *Merope*, the venation of which has been very seriously misinterpreted by Comstock, and to tabulate the principal characters of the known families of the Order.

The Venation of the genus Merope.

In working out the Archetype of the Mecoptera, much weight has to be given to the evidence offered by this genus. Comstock (15, fig. 317) has interpreted its venation along the lines of his hypothetical type, in which the number of branches of Rs and M_{1-4} respectively is limited to four. I have made a careful study of a female specimen of this rare insect, in my own collection, received in exchange from Mr. Nathan Banks, to whom my best thanks are due. As a result, I am quite unable to agree with Comstock.

Text-fig. 61 shows the venation of this insect, and Text-fig. 62 the bases of the two wings, much enlarged. The points in dispute are the limits of M and Cu. The vein which I call M_{4b}, and which, in Comstock's specimen, is strongly forked in both wings, is labelled by him Cu_1; and an ingenious, but quite unsound, argument is used to explain away the obvious fact of its attachment to M. This explanation involves the veins lying below these two, and is best given in Comstock's own words (15, p. 304):—

"In the forewing of the specimen taken at Ithaca, cubitus and the first anal vein coalesce for a short distance. Immediately after vein Cu separates from 1st A, Cu_1 extends transversely to the long axis of the wing and anastomoses with vein M for a considerable distance. . . The anal furrow is along the first anal vein. . . . In the hindwing of this specimen vein Cu_1 anastomoses with vein M_4 for a short distance."



Text-Fig.61.

Wings of *Merope tuber* Newm. (x $6\frac{3}{4}$). Lettering as on p.535. *k*, cross-vein taken by Comstock to be the basal piece of Cu_1.

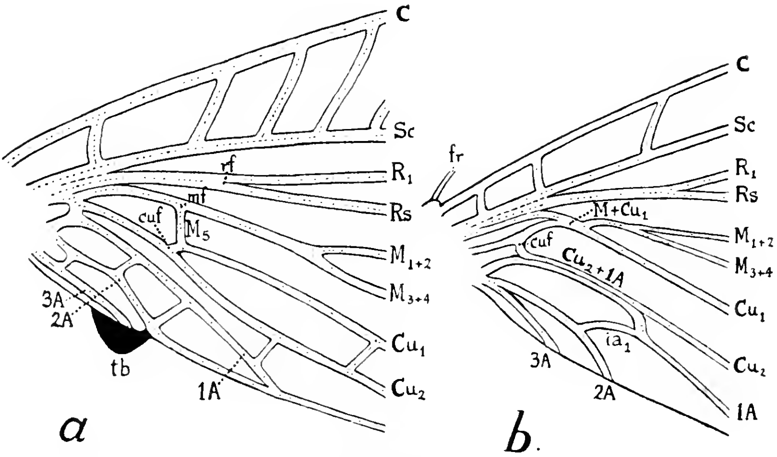
The above explanation is made clear in Comstock's figure by his labelling of the cross-vein which I have marked *k*, in the hindwing, (Text-fig. 61) as Cu_1. The cross-vein in the same position in the forewing is left unlabelled by him; but the wording leaves us without any doubt that this same cross-vein is intended to be taken as Cu_1 in the forewing also, and is the means whereby this vein has become fused with M.

Now, in all Mecoptera, it is the vein Cu_2 (always a very concave vein) which lies along the anal furrow. Also, except in the highly specialised *Bittacidae* and *Nannochoristidae*, the fusion of Cu_1 with M for a short distance is confined to the hindwings. It would be very remarkable if such an admittedly archaic type as *Merope* were to be highly specialised in these two characters. Thus I doubted from the first the correctness of Comstock's diagnosis, and was led to study the genus more carefully myself.

In fixing the homologies of the veins in *Merope*, I had recourse first of all to the trichiation. *Merope*, like all archaic types throughout the Complex (25), has macrotrichia upon the main veins only, and not upon the cross-veins. It was thus a very simple matter to prove that the cross-vein which I have marked *k* (Text-fig. 61), and which Comstock considered to be the basal piece of Cu_1 leading to its fusion with M, was in truth a cross-vein, and not a portion of a main vein. Neither this cross-vein, nor any other cross-vein near it, carries any macrotrichia at all in *Merope*. Having settled this point, I searched for the true cubital fork, and found it easily enough quite close to the base of the wing, as shown in Text-fig. 62. The position of this fork is indicated by Comstock (15, p. 304) by the words "Immediately after Cu separates from 1st A," which imply a basal fusion of Cu with 1A. Such a fusion does not exist. The two veins are, of course, Cu_1 and Cu_2, and their point of separation is the cubital fork *cuf*. Further, in the forewing, a strong bar falling very close up to this fork indicates the position of M_5, which is here present, but in the transverse stage already indicated as present in many Trichoptera (Section iii.). There is no fusion whatever between Cu and 1A in the forewing; and the three anal veins are all present, though 3A is much reduced, and was not noticed by Comstock.

It will be seen that the condition of the venation at the bases of the wings of *Merope* is the normal condition for the Order, except only that the basal part of the wings is much narrowed, and the three anal veins much reduced in consequence. *All the basal or primary dichotomies are present, very close to the base;* and the specialisations found in the hindwing, viz. the fusion of Cu_1 with M_{1-4} for a short distance, and the fusion of Cu_2 with 1A for a longer distance, are exactly paralleled in other genera. In the specimen which I examined, the fusion of Cu_2 with 1A in the hindwing was actually clearly shown by the presence of a line dividing the two fused veins, as shown in Text-fig. 62; so that there could be no doubt whatever as to the correct homologies of these two veins.

Since, then, the boundaries of 1A and Cu are those indicated in Text-figs. 61, 62, it is abundantly clear that M_{1-4} in *Merope*, as in the forewing of *Chorista* and allies, has more than four branches. In my specimen, these branches agree exactly with



Text-Fig.62.

Basal portions of *a*, forewing, and *b*, hindwing of *Merope tuber* Newm., enlarged, to show the true courses of M and Cu. (x 20). Lettering as on p.535. Note the presence of M_5 in forewing, and the fusions of M with Cu_1, and Cu_2 with 1A, in hindwing.

those of *Chorista* forewing. In Comstock's specimen, M_{4b} had an extra fork on the right side only. As this fork is only a small one, and as *Merope* is clearly a type specialised by broadening of the distal portion of the wings (in contrast with the rest of Mecoptera) I have not counted this fork in as an archetypic character, although its presence in Comstock's specimen might easily be claimed as an archaic survival.

In conclusion, it is clear that *Merope* is an archaic type, in so far that it still retains more than four branches of both Rs and M_{1-4}, thus combining the leading characters of the *Panorpidae* and *Choristidae.* But it is specialised along a line of its own, by the intense narrowing of the basal portions of the wings, by the broadening of the distal portions, by the widening of the costal area, and consequent alteration of the form of the costal veinlets, by the increase and density in the cross-venation, and by the formation of the peculiar tubercle at the base of the forewing. It is, in fact, a Scorpion-fly evolving into a cockroach-like type, resting with its wings nearly flat, instead of held in a high roof-like manner, and probably much given to hiding away in crevices or under stones, where this type of specialisation would be of value for concealment. The working out of the life-histories of this remarkable insect, and its ally *Notiothauma* should certainly be undertaken by those living where these insects occur, and may be confidently expected to add much to our knowledge of the Mecoptera.

Table of the Principal Venational Characters for the Families of the Order Mecoptera (Table i.).

In presenting this Table, I have had to divide the Order into a number of distinct families, some of which have not so far been definitely recognised. The *Choristidae* will include the genera *Taeniochorista* and *Chorista,* confined to Australia, and distinguished from the *Panorpidae* (s. str.) by many good characters, one of which is the presence of a five-branched media in the forewing, and the presence of only four branches to Rs in both wings. I have already defined the *Permochoristidae* (6). But I cannot find any good distinctions between the Triassic *Mesochorista* and the Permian *Permochorista,* and am convinced that these two genera must be placed in the same family. Consequently the family name must be changed to *Mesochoristidae,* since that genus was defined first (20). The characters of the *Orthophlebiidae* have already been defined by Handlirsch (2, p. 479), and those of the *Stereochoristidae* (28) and *Nannochoristidae** by myself. The *Meropidae* may be made to include provisionally *Notiothauma* as well as *Merope,* though the venation of the former has not yet been thoroughly worked out on modern lines. The *Bittacidae* are a very distinct group, with very definite wing-characters; while the *Boreidae,* being wingless, are omitted from the Table.

In the Table, the archaic condition of any given character is indicated by the letter A, while more specialised conditions are indicated by B, C, . . . in ascending order. The Archetype of the Order is the type which possesses the condition A for *all* characters. The percentage of archetypic characters possessed by the most archaic representative of each family is shown in the bottom line of the Table, and affords an interesting comparison of the relative archaism of the different families, as far as their wing-venation only is concerned.

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*These Proceedings, xlii., part 2, 1917, pp.284-301.

TABLE I. (MECOPTERA).

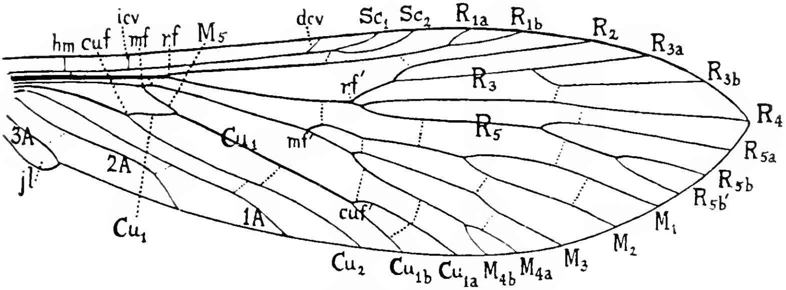
Ref. No.	Character.	*Mesochoristidae* (Permian and Trias)	*Stereochoristidae* (Trias)	*Choristidae* (Recent)	*Nannochoristidae* (Recent)	*Orthophlebiidae* (Lias and Jura)	*Meropidae* (Recent)	*Panorpidae* (s. str.) (Recent)	*Bittacidae* (Recent)
(1)	Number of branches of Rs.—A. More than four. B. Four. C. Only three.	B.	B.	B.	C.	A.	A.	A.	B.
(2)	Number of branches of M_{1-4}. — A. More than four. B. Four.	A.	A.	Fw.A. Hw.B.	B.	A or B.	A.	B.	B.
(3)	Branches of Cu.—A. Two, with Cu_1 complete. B. Two, with Cu_1 cut short.	A.	B.	A.	A.	A.	A.	A.	A.
(4)	Condition of M_5. — A. Complete, as in *Belmontia*. B. Reduced to transverse vein in forewing, absent in hind. C. Lost in both wings.	C.	A.	B or C.	C.	C.	B.	B.	C.
(5)	Fusion of Cu_2 with 1A in hindwing.—A. Present.	A.	[A.]	A.	A.	A.	A.	A.	A.
(6)	Condition of costal veinlets.—A. Full series. B. Greatly reduced.	A or B.	?	A or B.	B.	B.	A.	B.	B.
(7)	Condition of cross-venation.—A. Absent, or very weak and irregular. B. Strongly developed, but irregular. C. Regular, reduced to a few in special positions.	A.	A.	A or B.	C.	A.	B.	A or B.	B.
(8)	Shape of wings.—A. Normal, with well rounded tip; anal veins not reduced B. Narrow base and broad distal portion; anal veins reduced. C. Wing much narrowed and elongated, with petiolate base; anal veins reduced.	A.	A.	A.	A.	A.	B.	A.	C.
	Percentage of archaic characters present in most archaic member of each family:—	75·0	71·4	68·8	37·5	75·0	62·5	62·5	25·0

Section ix. The Venation of the Paramecoptera.

(Plate xxxi., figs. 15, 16, and Text-fig. 63.)

This Order is only represented at present by a single genus, *Belmontia,* from the Upper Permian of Belmont, near Newcastle, N.S.W. Text-fig. 63 shows the restored forewing of this insect. The actual specimen has about 0.5 mm. of the extreme base, including the jugal lobe, missing, and a small piece of the tip of the wing broken off obliquely. There is, therefore, no difficulty in completing the venation with certainty.

As this fossil has already been fully described by me in a former paper (29), it will only be necessary here to refer to that work, and to indicate the principal points in which *Belmontia* differs from the true Mecoptera, as well as those in which it is of importance in indicating the lines of descent of some of the still existing Orders of the Complex.



Text-Fig.63.

Forewing of *Belmontia mitchelli* Till. (Order Paramecoptera, Upper Permian), restored. (x 5) Lettering as on p.535. Note the complete cubito-median Y-vein.

Belmontia differs from all true Mecoptera in the following points:—

(1) Cu_1 is forked distally into Cu_{1a} and Cu_{1b}.

(2) The forking of R_{4+5} takes place exceedingly close to the origin of that vein.

(3) The cross-vein system is reduced to a definite plan, which resembles fairly closely that of the Trichoptera, Lepidoptera and Diptera, though still possessing a number of cross-veins not found in these Orders.

Besides these points, when I founded the Order Paramecoptera, I emphasised the presence of the complete and beautifully formed cubito-median Y-vein, which is unique in its perfection. The only known Mecopteron in which this Y-vein is present is the Upper Triassic *Stereochorista,* which I was, therefore inclined to regard as exceptional for that Order. However, as will now be seen from Section iii., a more complete comparative study of this formation makes it almost certain that this Y-vein was present in all the Orders of the Complex originally. Hence the character may no longer be used for separating the Paramecoptera from the Mecoptera, and one of the principal differences between the two Orders breaks down. I think it can only be a matter of time before other new fossil types, either from the Permian of Newcastle or from the Trias of Ipswich, will be discovered, in which this Y-vein will be found perfectly formed, though perhaps not quite so prominently as in *Belmontia.** Ultimately it will, no doubt, be possible to show a series of forms making a complete connection between *Belmontia* and the true Mecoptera; so that the Paramecoptera may then be merged into the Mecoptera as a separate Suborder. The same will undoubtedly prove to be the case with the Protomecoptera of the Ipswich Trias, dealt with in the next Section, since these are even more like the true Mecoptera than *Belmontia* is.

Another distinction to be noted, of less importance, is that the wing of *Belmontia* was almost certainly more or less pointed, whereas the wings of all true Mecoptera, even those of the very slender-winged *Bittacidae,* are always well rounded at the tips.

The points that are of importance in *Belmontia,* as regards the evolution of the more recent Orders, are as follows:—

(1) *The cubito-median Y-vein.* This is fully dealt with under Section iii.

(2) *The distal forking of* Cu_1. Whether this fork originated from an incomplete fusion of M_5 and Cu_1 distally, or not, it is quite certain that the forked condition is more archaic than the simple straight condition found in the true Mecoptera, the Paratrichoptera, and the Diptera. The forked condition is retained in the Trichoptera, Lepidoptera, Megaloptera and the

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*Since this was written, Mr. Mitchell has forwarded me a new Mecopteron from the Upper Permian of Belmont, N.S.W., in which the cubito-median Y-vein is well formed. R. J. T.

Planipennia. This question will be found discussed under Section iv.

(3) *The peculiar situation of the forking of R_{4+5}.* A little movement of this fork basad would bring it to the main stem of Rs. From this position, R_4 could then become detached from R_5, and begin to migrate along the upper branch of Rs, viz. R_{2+3}. A discussion of the origin of pectinate forking of Rs will be found under Sections ii., xv., and xvi.

(4) *The number of branches of Rs and M_{1-4}.* The branches of these veins in this very archaic type are clearly original dichotomies, not additions to an originally simpler venational scheme. Thus the fact that *Belmontia* possesses *more than four* branches to both is a serious blow to Comstock's original hypothetical type, and prevents us from accepting such a type, with its four-branched Rs and M_{1-4} as in any way representing the ancestral venational type for the Complex. This conclusion is most strongly supported by the condition of Rs and M_{1-4} in the Protomecoptera (Section x.), as well as in the great majority of the known fossil Mecoptera and Planipennia. The question is fully dealt with under Section ii.

The great value of the discovery of the fossil *Belmontia* lies principally in its affording a definite proof of the presence of the extra basal posterior branch of M, viz. M_5, fused with Cu_1 to form the cubito-median Y-vein, and also in disclosing to us a type from which the Trichoptera and Lepidoptera can most certainly be derived, by way of a common stem-form not yet found in the fossil state, but which must have existed somewhere in Triassic times, though not necessarily in Australia. It also tends to show the Mecoptera in their true form, viz. as a somewhat isolated and very early specialisation from the original stem-form of the Complex, and not in any way to be considered as the ancestral Order from which any of the still existing Orders have sprung.

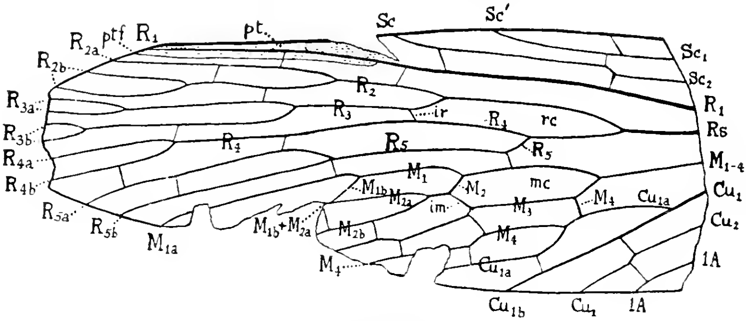
Section x. THE VENATION OF THE PROTOMECOPTERA.

(Text-figs. 57, 64.)

The Order Protomecoptera (5) was founded by me for the reception of the remarkable Upper Triassic fossil *Archipanorpa magnifica* Till., from Ipswich, Q. A large portion of both the fore and the hind wings of this fine insect is preserved. As

I have already described the venation very fully, and figured both wings, together with a restoration, it will only be necessary here to correct an error in my original description, and to emphasise those points which mark this type as distinct from both the true Mecoptera and the Paramecoptera.

Text-fig. 64 shows the preserved portion of the hindwing of this fossil. In my original description (5, p. 188 et seq.) I indicated the presence of a true costal vein, distinct from the anterior margin of the wing, and made this one of the ordinal characters. A further examination of this vein shows me that, like the subcosta below it, it is distinctly a *concave* vein. Now I think that there can be no doubt that a true costal vein, if it were to occur in any insect, would be a *convex* vein; seeing that the main veins are alternately convex and concave, and that Sc, next to C, is well known to be concave. I therefore wish to suggest here that a more correct interpretation of this vein is that it is the anterior branch of the original dichotomy of Sc; and that this dichotomy takes place, in this fossil, near the base of Sc, so that the two branches extend nearly parallel to one another until they reach the anterior border. In Text-fig. 64, this new view is indicated by labelling these two veins Sc′ and Sc respectively.



Text-Fig.64.

Preserved portion of hindwing of *Archipanorpa magnifica* Till. (Order Protomecoptera, Upper Triassic). (x 3¾). Lettering as on p.535.

Not quite so much of the forewing is preserved as of the hind; but what is preserved is much the same area of the wing. The two wings only differ in their shape, in the much longer and narrower pterostigma (*pt*) of the hindwing, in the absence of the distal forking of R_{3a} in the forewing, and in the fact that M_{1b} and M_2 do not fuse to form a Y-vein in the forewing, as they do in the hind. The wonderful preservation of the archedictyon, and of the sockets of the macrotrichia in this fossil has already been emphasised (5, 25); but I think it is necessary here to draw attention again to the fact that the distribution of the macrotrichia upon the veins has been made use of in determining the courses of the main veins. It would not have been possible to determine the correct course of M_4 without these structures, since the basal piece of that vein, though much more strongly formed than any cross-vein present, is bent at right angles to M_3, and would undoubtedly have been considered a cross-vein, if it were not for the presence of large macrotrichia upon it (Text-fig. 57). Also, the inter-median cross-vein (*im*), closing the median cell (*mc*) distally, is bent obliquely, and might easily have been mistaken for a piece of a main vein, were it not for its very weak formation, and the absence of macrotrichia upon it.

It is most unfortunate that we do not know what the basal parts of the wings of this fossil were like. With our present knowledge of *Belmontia* to guide us, it would seem to be extremely probable that the cubito-median Y-vein was present, fully formed. In this respect my original restoration would need to be corrected (5, Pl. ix.).

In a comparison of this fossil with *Belmontia*, it should be noted that, besides being much the larger insect, *Archipanorpa* has the larger number of branches of Rs, viz. ten in the forewing, as against seven in *Belmontia*. Further, it is quite clear that *Archipanorpa* is undergoing stenogenesis, seeing that M_4 and Cu_{1a} are already partially fused in both wings, and M_{1b} with M_{2a} in the hind, not to mention the very obvious crowding of the distal branches together. All the branches of Rs in this fossil are clearly original archaic dichotomies, as they are also in *Belmontia;* there can be no question of the addition of extra branches from the tip backwards, in either form. Thus we have to accept *Archipanorpa* as less reduced and more archaic than *Belmontia*, as regards the condition of its radial sector, in spite of the fact that it is an Upper Triassic form, while *Belmontia* is Upper Permian.

The most crushed together of the branches of Rs in *Archi-*

panorpa are the distal forkings of R_2 and R_3. Elimination of all the branches of R_4, and all but the most basal of R_3, would give us the condition found in *Belmontia*. R_4 only forks once in *Archipanorpa;* the loss of this fork would give the unforked condition of this vein seen in *Belmontia*. The latter genus, however, has the more archaic R_5, with three branches, as against the two present in *Archipanorpa;* and this difference shows that reduction is not proceeding on the same lines in these two forms.

As regards the media, M_1 and M_2 are both forked in *Archipanorpa*, simple in *Belmontia;* while M_4 is simple in the former, but forked in the latter. So that, both as regards Rs and as regards M, *Belmontia* tends to keep the more posteriorly placed forks, *Archipanorpa* the more anteriorly placed ones.

Archipanorpa is more specialised than *Belmontia* in that it already possesses a partial fusion between M_4 and Cu_{1a}, on the same lines as that found in the well-known aberrant hindwing of the genus *Sthenopis* of the family *Hepialidae* (15, fig. 337), and therefore indicating the method by which the present completely fused condition of these two veins has been brought about in the Lepidoptera (Section vi.). Further, M_4 has already attained the transverse position in this fossil,—a fact which makes it much easier to understand the condition of this vein in almost all Lepidoptera to-day. This evolution of M_4 in the Lepidoptera and in the fossil *Archipanorpa* is an excellent example of that *parallel development* which is so frequently noticeable in widely separated types which have sprung from the same stem, and have therefore inherited the same tendencies.

In both *Belmontia* and *Archipanorpa*, it is Cu_{1b} which continues the line of the main stem of Cu_1 distad, while Cu_{1a} arches up away from this line, towards M_4. The condition is of interest, as showing the strong tendency there must have been, from the very first, as soon as stenogenesis set in, for at least a partial fusion of these two veins to take place; or, failing that, for Cu_{1a} to be eliminated entirely, leaving the strong, straight Cu_1 that is so typical of the Mecoptera, Paratrichoptera and Diptera.

It does not seem possible to compare very closely the vein Sc in *Archipanorpa* and *Belmontia*, seeing that we do not know how far back towards the base the dichotomy of this vein took place in the former. All we can say for certain is that *Archipanorpa* exhibits the more archaic condition, and that the subcosta was evidently a strongly forked vein in the Archetype of the Complex.

Section xi. THE VENATION OF THE PARATRICHOPTERA.

(Text-fig. 65.)

In this Order I have recently placed four remarkable genera from the Upper Trias of Ipswich, Q., viz. *Mesopsyche, Triassopsyche, Aristopsyche*, and *Neuropsyche*, described by me in two previous papers (5, 28). At first sight these wings appear to belong to the Trichoptera; but a closer analysis shows that they do not belong to that Order at all, and are much more closely related to the Mecoptera and Diptera.

To these four genera I now wish to add the genus *Mesopanorpodes*, originally described by me under the name *Mesopanorpa*, from the Wianamatta Shale of Glenlee, N.S.W., and probably of very much the same age as the Ipswich fossils (6, pp. 746-7). The name *Mesopanorpa* being preoccupied, I changed it to *Mesopanorpodes*.* Originally, I considered this fossil to be an aberrant member of the Order Mecoptera. But it is now apparent that it will go best into the Paratrichoptera, with which it agrees in every particular, except for the possession of a somewhat larger number of cross-veins than are to be found in the Ipswich genera. We may note especially the presence of two cross-veins in this genus between R_2 and R_3, as in *Neuropsyche*, and between R_4 and R_5, as in *Mesopsyche*. The base of the wing appears to be more narrowed in *Mesopanorpodes* than it is in any of the Ipswich genera. Both in this respect, and in possessing the submedian cross-vein (*sm*) present also in *Protoplasa* (Text-fig. 67), amongst the Diptera, *Mesopanorpodes* is perhaps the nearest Paratrichopterous type yet discovered to the true Diptera.

The archetypic forewing of the Order Paratrichoptera, as shown in Text-fig. 65, has been constructed by selecting all the most archaic characters exhibited by the five genera already named, and incorporating them into one wing-type. The most complete wings are those of *Aristopsyche* (28, p. 202), and *Mesopanorpodes* (6, p. 746); these genera have, therefore, played the greatest part in the formation of the Archetype. *Aristopsyche* is the only genus of the five in which a basal branch of

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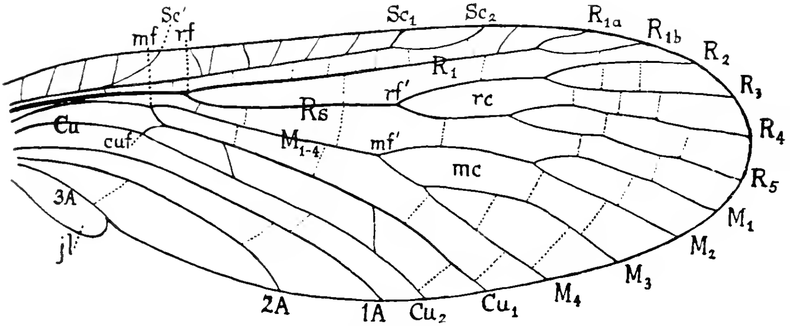
*These Proceedings, xliii., pt. 3, 1918, p.435.

Sc is preserved, as shown in the Archetype. As in the case of the Protomecoptera, I took this branch originally for a true costal vein. Further study of the fossil has, however, convinced me that it is a true branch of Sc, since it is evidently a concave vein, and its attachment to Sc can actually be made out in the fossil itself.



Text-Fig.65.

Forewing of the Archetype of the Order Paratrichoptera. Lettering as on p.535.

The cross-vein system is most abundant in *Mesopanorpodes, Mesopsyche* and *Neuropsyche.* The zig-zagging of the veins R$_4$ and R$_5$ in *Mesopsyche* (5, Pl. vii., fig. 1), caused by the incidence of the two cross-veins already mentioned above, is a specialisation, and is not to be found in *Mesopanorpodes*, which possesses the same two cross-veins. It is, therefore, omitted from the Archetype, which is made to resemble *Mesopanorpodes* in the nearly straight condition of these two veins. But this latter genus is specialised in having the forking of R$_{4+5}$ placed more distally than that of R$_{2+3}$; so that the Archetype must be made to agree with the other four genera in this respect. All the cross-veins shown in Text-fig. 65 are to be found in one or other of the five genera comprising the Order Paratrichoptera.

It is quite impossible, at present, to say what is the significance of the two strong oblique veins descending from Cu$_1$, They are not present in *Mesopanorpodes*, *Mesopsyche* or *Neuropsyche;* but both are preserved intact in *Aristopsyche,* and the more distal one is also clearly to be seen in *Triassopsyche.* As there is no sign of the sockets of the macrotrichia upon these very delicate wings, it is impossible to say definitely whether these veins are specialised oblique cross-veins, or really descending branches of Cu_1 which fuse with Cu_2. Their evident strength would incline one to the latter belief. But the decision must stand over for the present; and I will content myself with calling attention to their existence, without taking them into consideration at all in the construction of the Archetype of the Complex. If further discoveries should prove that they are true branches of Cu_1, then it is clear that that vein must originally have had more branches than we at present suppose; and the Archetype of the Complex must be altered accordingly.

The Archetype of the Paratrichoptera clearly agrees with the usual definition of the venation of the Order Mecoptera in many points. It seems inevitable that, sooner or later, the discovery of intermediate forms, either in the Permian or Trias, must link the two together, and cause us to merge the Order Paratrichoptera into the Mecoptera, with the rank of a Suborder. No Mecopteron is yet known with a basal branch of Sc present, as in *Aristopsyche;* so that, in this character, the Archetype of the Paratrichoptera is more archaic than that of the Mecoptera. The cubito-median Y-vein is not clearly preserved in any of the four known genera, but appears to have been lost by fusion of Cu_1 with M_{1-4} in *Aristopsyche,* as far as this part of the wing can be made out. However, we have already seen how this structure turns up in the more archaic forms of other Orders of the Complex (Section iii.). Hence I have included it in the Archetypic characters, with the firm belief that further fossil finds in this Order will show that it was present.

The Paratrichoptera are specialised from the original Mecopterous type by their distinctly Trichopterous facies, which is most marked in the shortening of the apical forks belonging to Rs and M_{1-4}, and the consequent formation of the radial and median cells (*rc, mc*), and the veins arising from them, on strictly Trichopterous lines. As regards the median cell, it should be borne in mind that the Diptera also share this character with the Trichoptera; and there can be no doubt that this was also the case with the radial cell in the Diptera, before specialisation set in and removed one of the four branches of Rs. As regards the cubitus, the Paratrichoptera differ strongly from the Trichoptera, but agree with the Mecoptera and Diptera, in having Cu^1 running straight to the wing-border, without any distal forking. They also agree with the Mecoptera in the generalised condition of the anal area of the forewing. This character marks them off most strongly from the Trichoptera, in which the three anal veins form a double Y-vein, and from the Diptera, in which the anal area is narrowed, and the anal veins much reduced.

It will be clear from the above evidence that the Paratrichoptera must be regarded as a somewhat specialised side-branch from the old Mecopterous stem, and that they arose at a time when the basal branch of Sc, preserved in *Aristopsyche*, had not been entirely eliminated from the venation. Since this branch of Sc has not yet been noticed in any true fossil Mecoptera, although a much more complete branch is present in the Triassic Protomecoptera (Section x.), we should probably be on very safe grounds in assuming that the Paratrichoptera, like the Protomecoptera, must have already become differentiated in Upper Permian times. Thus, representatives of the Order may confidently be expected to be found, when more complete investigations of the beds of this age, in Australia and elsewhere, can be carried out.

The great importance of the Paratrichoptera as an Order is that they do most certainly indicate the line of descent of the Diptera from ancient Mecopterous-like forms. A comparison of the Archetypes of the two Orders Paratrichoptera and Diptera will be made in the next Section, and will clearly show how simple a derivation of the Diptera from this Triassic Order can be proved, as far as the venation of the forewing is concerned.

Section xii. THE VENATION OF THE DIPTERA.

(Text-figs. 43, 48-50, 66-70.)

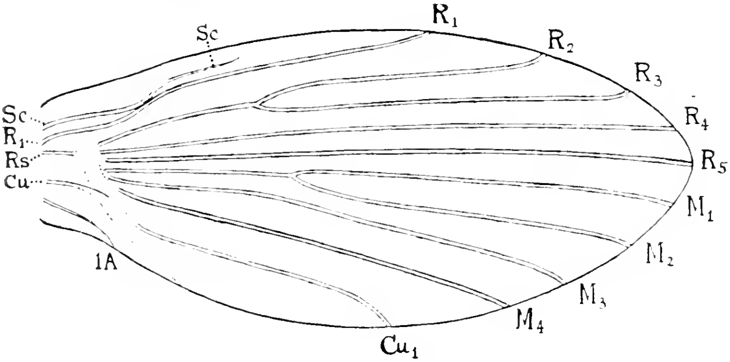
The determination of the venation of the Archetype of this huge Order is a matter of little difficulty, in spite of the immense number and variation of the venational types existing within it at the present day. As the pupal wings are merotracheate,—and, indeed, little is known about them at all in comparison with the pupal wings of the dominant holotracheate Order Lepidoptera,—I have not been able to attempt a complete analysis of the venational types of the various archaic families within the Order, as I have done in Section xiv. for the Lepidoptera. Such an attempt, in the case of the Diptera, would only resolve itself into a study of the comparative morphology of the imaginal venation, and would scarcely be productive of any new evidence concerning the Archetype, or the Phylogeny of the Order as a whole; though it would, no doubt, help considerably in elucidating the phylogeny of the various groups and families within the Order itself.

In constructing the Archetype of this Order, the question of outstanding importance is the determination of the correct limits of veins M and Cu. I have dealt with this under Section iv. The archaic *Rhyphus* (Text-figs. 48, 68*b*) may be taken as the test genus, although the same result will be obtained from any other genus in which the macrotrichia are sufficiently well preserved, as in many of the older *Tipulidae*, *Leptidae*, etc. The result of a study of *Rhyphus*, or any of these latter forms, on the lines indicated in Section iv., is to prove conclusively that Cu$_1$ is a simple, unbranched vein, as in the Mecoptera and Paratrichoptera, and that M$_{1-4}$ is four-branched, the vein M$_4$ being the one which Comstock (15, fig. 357 et seq.) has labelled Cu$_1$, while the true Cu$_1$ is the vein which he has labelled Cu$_2$. The true cross-vein *m-cu* is devoid of macrotrichia, and connects the two veins M$_4$ and Cu$_1$, just distad from the origin of the former in *Rhyphus*. The vein labelled *m-cu* by Comstock is the basal piece of M$_4$ as it arises from the median cell, and carries strong macrotrichia in *Rhyphus* and other archaic genera. The difference between the condition of Cu$_1$ in the Diptera, and the condition of the same vein in archaic Trichoptera and Lepidoptera, where it carries a strong distal fork, has not been sufficiently appreciated hitherto, and is most strongly emphasised here.

In working back to the archetypic venation of this Order, it is at once apparent that we may leave out of account not only all the Cyclorrhapha, which are highly specialised, but also the numerous groups, both in the Nemocera and the Brachycera, in which the venation shows definite reduction, or specialisation by fusion of the distal branches of the main veins. We are thus left with the *Tipulidae* (s. lat.) and *Psychodidae* amongst the Nemocera, the *Rhyphidae*, *Leptidae* (s. lat.), *Stratiomyiidae*, *Thereridae*, *Tabanidae*, *Asilidae* and allies amongst the Brachycera.

The *Psychodidae* are evidently a very archaic group, but specialised by reduction, and by the loss of almost all the original connections between the main veins. At the base of the wings in this family, chitinisation is very weak, so that the connections of the main veins cannot be made out with certainty. It is clear, however, that Rs retains the four-branched condition in *Psychoda* (Text-fig. 66), while, in those genera in which one branch has been lost, the forking of R_{2+3} is still retained, as in other archaic Nemocera. The limits of M and Cu are not determinable with certainty. But the probability is that M_{1-4} has remained four-branched, as in *Rhyphus*, while both Cu and the anal veins have been greatly reduced, by the narrowing of the base of the wing. The labelling of the veins in *Psychoda*, given in Text-fig. 66, assumes this to be the case.

In the *Tipulidae* (s. lat.) there are many archaic types still existing, though all are specialised by the extreme stenogenesis, which has strongly affected the basal parts of the wings. Text-fig. 49 shows the venation of the Australian genus *Gynoplistia*, in which the median cell (*mc*) is very nicely preserved, with M_4 coming off from it in such a manner as to leave not a shadow of a doubt as to the correct interpretation of that vein. In this genus, as in almost all Nemocera, Rs has been reduced by the elimination of the fork of R_{4+5}, while R_2 and R_3 still exist as separate veins. As R_{4+5} usually forks, in all archaic types within the Complex, much closer to the main stem of Rs than does R_{2+3}, it does not seem at all likely that this reduction has been carried out by the removal of this fork distad, until it be-

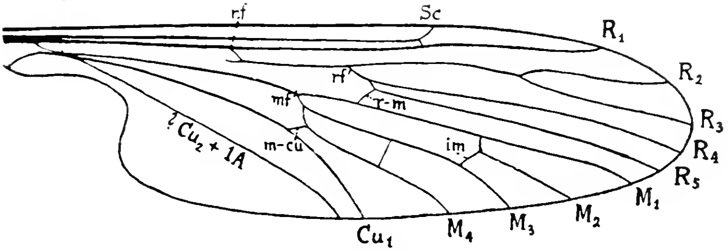


Text-Fig. 66.

Forewing of *Psychoda* sp. (fam. *Psychodidae*, Gosford, N.S.W.). (x 36). Lettering as on p.535.

came lost at the apex. A much stronger probability is that either R_4 or R_5 has been *entirely* suppressed, by lack of chitinisation, as in the case of Cu_2, and occasionally also M_2, in a number of Lepidoptera. Pending a full proof of what has happened, I have labelled the unforked part of Rs, R_{4+5}.

The genus *Protoplasa* (Text-fig. 67) is remarkable in still possessing the four branches of Rs, though R_5 appears somewhat crowded in between R_4 and M_1. The evidence of this genus, then, reinforces that of *Psychoda* as to the original four-branched condition of Rs in the Diptera; and this condition will therefore be adopted for the Archetype. *Protoplasa* also has an extra cross-vein connecting M_3 with M_4, which is strongly suggestive of an original Mecopterous or Paratrichopterous condition, in which the apical forks were supplied with such excess cross-veins.



Text-Fig.67.

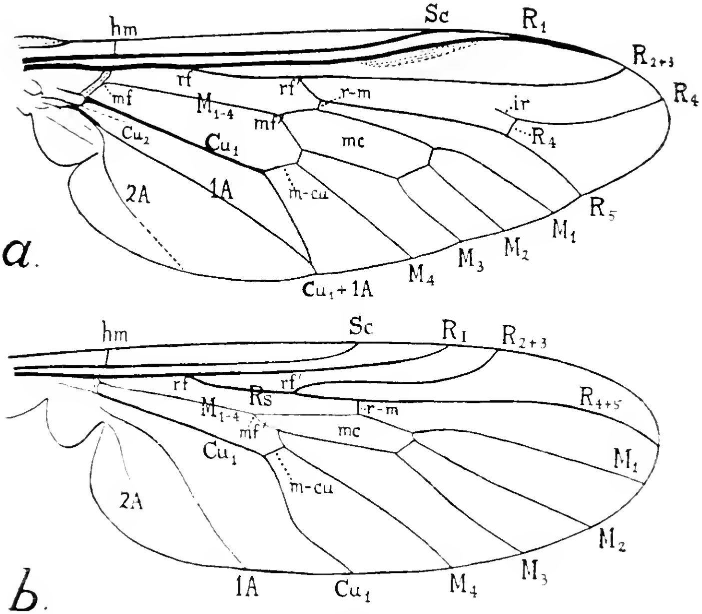
Forewing of *Protoplasa fitchii* (fam. *Tipulidae*) after Comstock, but with lettering altered. Lettering as on p.535.

Some light is thrown upon the condition of the anal part of the wing in Diptera by a study of the *Tipulidae*. In *Gynoplistia* (Text-fig. 49) there is a clearly marked remnant of Cu_2, most strongly chitinised basally, and fused with 1A (a much more strongly marked vein), for some distance beyond the cubital fork (*cuf*). Vein 2A is well developed, and is connected with 1A near its base by the inter-anal cross-vein.

Turning next to the Brachycera, we may select *Tabanus* and *Rhyphus* (Text-fig. 68) as representing two of the most archaic wing-types for this Sub-order, though many other genera of the families mentioned above, on p.615, would do equally well. The points to be noted are:—the reduction of Rs to a three-branched condition, by means of the elimination of the fork of

R_{2+3} (contrast with this the line of evolution in the Nemocera); the archaic condition of the median cell (*mc*) with the four branches of M_{1-4} normally situated with regard to it; and the presence of the cross-veins *r-m*, *im* and *m-cu*, as well as the lower portion of *ir*, in the form of a stump-vein. The humeral veinlet (*hm*) is also present.

The line of evolution within the Brachycera leads to a number of venational types in which a reduction is brought about by the formation of Y-veins of the type already noted in Sections iii., v., vi., but in this Order affecting all the distal branches of the main veins. The Y-vein is formed by fusion of two veins distally, and may be brought about only after much altera-



Text-Fig.68.

Forewings of *a*, *Tabanus circumdatus* Walk. (fam. *Tabanidae*). (x 8). and *b*, *Rhyphus brevis* Walk. (fam. *Rhyphidae*). (x 15) Lettering as on p.535. Note the condition of M_4 and Cu_1. (See also Text-fig.48).

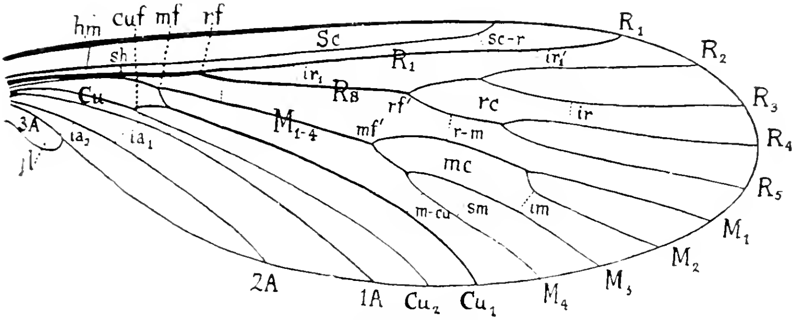
tion in the original courses of the veins involved. All stages of this line of evolution can be followed out within the single family *Bombyliidae;* but its details need not be gone into here.

The probable condition of the cubito-median Y-vein in the oldest Diptera has already been discussed in Section iii. It is only here necessary to refer to Text-fig. 43 for justification of the assumption that this formation did exist in the Archetype of the Diptera, though probably already in a somewhat reduced condition.

The Archetype of the Order, as constructed on the evidence given above, will have the forewing venation as given in Text-fig. 69. The following characters should be noted:—

(1) Both Sc and R_1 are simple, unbranched veins; and the only costal veinlet present is the humeral (*hm*).

(2) Both Rs and M_{1-4} have four branches. The radial cell (*rc*) is present, and is closed distally by *ir*, since this vein is indicated by a short stump-vein arising from R_4 in many *Tabanidae* (Text-fig. 68). The median cell (*mc*) is also present, and closed by *im*.



Text-Fig.69.

Forewing of the Archetype of the Order Diptera. Lettering as on p.535.

(3) The cubito-median Y-vein was present, though probably already in a somewhat reduced form.

(4) Cu_2 was weakly chitinised, and perhaps already obsolescent.

(5) The base of the wing had already become somewhat narrowed; and, as a result, 1A must have been very close up to Cu

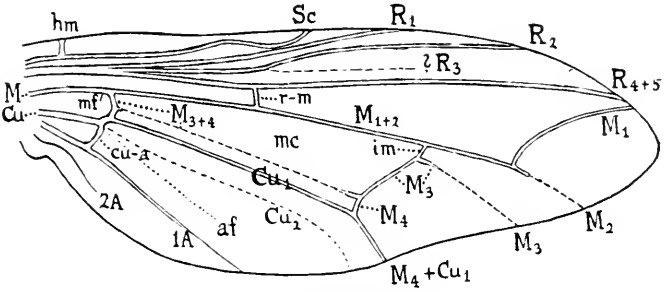
basally. As this vein is fused with Cu_2 in some *Tipulidae*, but with the main stem of Cu in *Stratiomyiidae*, I have left it just free in the Archetype, so as to allow the fusion to take place independently in either position, according to the line of evolution followed.

(6) Vein 3A is, at the most, only present as a very short, weakly chitinised vein bounding the jugal lobe distally.

(7) The cross-vein system is much reduced, and consists of the following only:—the subhumeral (*sh*); the subcosto-radial (*sc-r*); the inter-radial between R_1 and R_2 (*ir'*) present in many *Tipulidae;* the inter-radial (*ir*) closing the radial cell; the radio-median (*r-m*); the intermedian (*im*) closing the median cell; the submedian (*sm*) from M_3 to M_4 (found only in *Protoplasa*); the medio-cubital (*cu-m*); and the first inter-anal (ia_1)

A comparison of this Archetype with that of the Paratrichoptera shows us at once that the Diptera can be directly derived from this fossil Order by reduction. A narrowing of the wing-base, with consequent reduction in the anal veins, and approach of 1A to Cu; reduction of Sc' to the humeral veinlet; loss of all the other costal veinlets and the distal forkings of Sc and R_1; some reduction, probably, in the condition of the cubito-median Y-vein; and, finally, a considerable reduction in the cross-vein system; these changes would produce the archetypic Dipterous forewing from that of the Paratrichoptera. As far as the hindwings are concerned, we have to assume for the Archetype of the Diptera that they were already evolved into well-formed halteres. All the known wings of the Paratrichoptera being almost certainly forewings, we cannot say for certain what the state of the hindwings was in that Order. But it is clear, in any case, that the Diptera are descended from some originally four-winged type, although the intermediate stages of the process are not known to us.

In connection with the Order Diptera, and probably also in the case of the two other Orders, Mecoptera and Trichoptera, in which the pupal wings are merotracheate, I desire here to emphasise the value of a careful study of the imaginal wing, *during and just after expansion*, when the fly emerges from the puparium. My attention was first called to this when I happened to examine the expanding wings of a number of undetermined species of *Tachinidae*, whose puparia I had placed in a



Text-Fig.70.
Forewing of an undetermined Tachinid (x 5) immediately after full expansion. Lettering as on p.535. For full explanation see text.

glass jar. Text-fig. 70 shows the state of the imaginal venation in the freshly expanded wing of this fly. Quite a number of veins were strongly indicated, at this stage, which were seen to disappear again not very long afterwards, when the wing became hardened up. We may mention the following:—

(1) What appeared to be an incipient attempt at redeveloping R^3 was visible as a very slight band arising from R_2 in the position shown, but not reaching the wing border. If this were really R_3, it must indicate an attempt to reproduce a very archaic stage, since the forking of R_{2+3} has been lost in all Brachycera, and therefore, presumably, in the ancestors of the Cyclorrhapha.

(2) M_2 was clearly visible as a distinct band right up to the wing-border. As soon as the wing had hardened up, the only chitinisation left of this vein was the short stump-vein indicated by the continuous black line arising from M_1 in Text-figure 70.

(3) The course of M_{3+4} was clearly marked as a weak band arising from *mf'*, and running parallel to, and a little above, Cu_1. This vein divided distally into M_3, running up obliquely to meet the cross-vein *im*, and then bending again to run longitudinally to the wing-border, and into M_4, which turns at right-angles to M_{3+4} as a short transverse vein and joins Cu_1 immediately below its point of origin. Besides these formations, M_{3-4} was connected, just distad from *mf'*, by the cross-vein *m-cu*, to Cu_1. As the wing hardened up, all the main stem of

M_{3+4} became rapidly obliterated, leaving only the short basal connection from *mf'* to *m-cu*, and a short distal stump-vein projecting inwards from the point of origin of M_3 and M_4. Also, the distal free piece of M_3 became rapidly obliterated, leaving only a short stump attached to *im*, and closely resembling the stump of M_2 above it. Naturally, I expected that these stumps would remain, when the wing had become quite hardened up. But I was surprised to find that both the outwardly projecting stump of M_3, and the inwardly projecting stump of M_{3+4}, became finally eliminated, leaving a single unbroken and only slightly waved vein connecting Cu_1 below with M_{1+2} above. Comstock (15, p. 356) has, naturally enough, taken this vein to be the inter-median cross-vein (*m* of his notation, *im* of mine); whereas it is now seen to be a *composite vein*, made up of a short piece, *im*, above, a long piece of M_3 in the middle, and a short piece of M_4 below. Another change in the hardened wing was the straightening out of the basal stump of M_{3+4}, together with the cross-vein *m-cu*, to form a single strong transverse brace-vein, which might well be named the *secondary arculus*, seeing that it plays the part of bracing the wing in the same region as the original arculus does in older types. Care must be taken to distinguish the two formations, as there is no trace left of the original cubito-median Y-vein in the Myiodaria.

(4) The course of Cu_2, and the line of the anal furrow (*af*) running below it, are visible in the freshly expanded wing, but are obliterated later. 1A, part of 2A, and the cross-vein *cu-a* remain chitinised in the hardened wing.

The above evidence seems to me to be of very great value, as indicating a new method of studying the venation of highly specialised types of Diptera. In particular, I think that every occurrence of *stump-veins* ought to be noted down, and attempts made to find out what their condition is in the freshly expanded imaginal wing. In this connection I will now only refer to the stump-vein arising from R_4 in many *Tabanidae* (Text-fig. 68). I have taken this as the remnant of the inter-radial cross-vein *ir*, which is its most obvious interpretation. But I hope that any entomologist, who may have the opportunity, will examine the freshly formed wing of any suitable species, to see what other formations may be indicated there (as, for instance, the possible presence of a separate R_3).

It should be noted here that there is a very great difference between the most archaic types of the Cyclorrhapha, such as the *Syrphidae*, and the Myiodaria. The former have the original arculus, or cubito-median Y-vein, strongly formed near the base of the wing; while the secondary arculus, formed from the base of M_{3+4} and the cross-vein *m-cu,* is only just beginning to move basad, and is little altered from its normal position as seen in the *Tabanidae.* The line of evolution of the forewings of the Myiodaria, then, parallels that of the forewings of the higher Heteroneurous Lepidoptera, in that it consists chiefly of the movement basad, and finally the suppression, of the cubito-median Y-vein, and a great expansion of the more distal portions of the wing. We may profitably contrast the position of the cross-vein *r-m* in the wings of the *Syrphidae* and the *Tachinidae,* and note also the immense increase in the area occupied by the median cell (*mc*) in the latter.

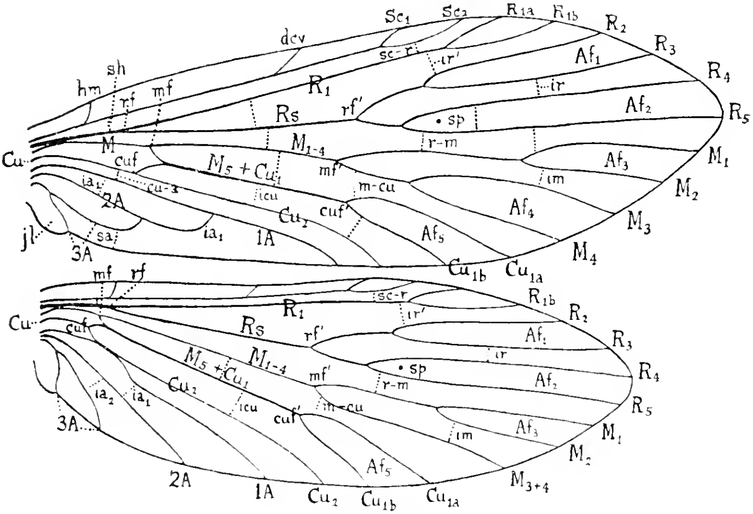
It does not seem necessary here to say much upon the internal Phylogeny of the Diptera. It is quite clear, from the evidence of the wing-venation, that the primary dichotomy must have been into Nemocera and Brachycera, and not into Orthorrhapha and Cyclorrhapha. The Nemocera are properly defined as that line of evolution in which reduction of Rs has been brought about by loss of the fork of R_{4+5}, and in which little or no tendency to a reduction in the distal joints of the antennæ is manifest. The Brachycera, on the other hand, are that line of evolution in which the reduction of Rs has been brought about reduction is evident in the antennal distalia, leading to the three- by the loss of the fork of R_{2+3}, and in which also a progressive jointed type, with arista, as its highest expression. Nature only makes such dichotomies as these *clear-cut,* through the dying-out of intermediate forms. Thus we should neither be surprised nor annoyed, (though it may be very awkward for the framing of good systematic definitions), when we still find, in this Order, a few types which have preserved all four branches of Rs intact (e.g. *Psychoda, Pericoma, Protoplasa*), or a few more which, while obviously Brachycera as regards the condition of Rs, have still fairly numerous distalia in their antennæ (e.g. *Rhyphus, Xylophagus, Arthroceras*). The Phylogenist will welcome the presence of these forms, just as heartily as some Systematists will anathematise them; and it should be remembered that the attitude of mind, that puts systematic convenience before natural fact, is only slightly removed from that of the famous systematist, who is said to have simplified his task by throwing the "varieties" out of the window.

Section xiii. The Venation of the Trichoptera.

(Text-figs. 42, 47b, 71-74.)

Text-fig. 71 shows the venation of the Archetype of this Order. The principal characters to be noted are as follows:—

(1) The pupal wings are merotracheate, the tracheal supply being generally reduced to two tracheæ, which bear no relationship to the imaginal venation. In this character, the Trichoptera stand as the most highly specialised of all the Panorpoid Orders.



Text-Fig. 71.
Wings of the Archetype of the Order Trichoptera. Lettering as on p. 535.

(2) Sc and R_1 are distally forked.

(3) The branches of Rs are reduced to four in number; and the apical forks so formed are destitute of cross-veins, except only that between R_4 and R_5, which possesses a cross-vein in the forewing only, as in the Rhyacophilid genus *Psilochorema.*

(4) The dichotomic manner of branching of these forks is retained, with R_{4+5} forking closer to the base than does R_{2+3}

(5) Between R_4 and R_5, not far distad from their point of origin, there is a conspicuous *wing-spot,* probably indicating the presence of a special gland or sense-organ. This is a unique specialisation, and is to be found in all Trichoptera except only the highly specialised and reduced *Hydroptilidae.*

(6) The cubito-median Y-vein is completely formed, exactly on the same lines as in *Belmontia.* (*See* Section iii.)

(7) Fore and hind wings differ in the manner of branching of M_{1-4}. In the forewing, this vein has four branches, forking dichotomously. In the hind, M_{3+4} is always an unbranched vein; so that the total number of branches is reduced to three. (Contrast this with the condition seen in Lepidoptera, in which M_4 fuses distally with Cu_{1a} *in both wings*).

(8) The cubitus is three-branched, Cu1 forking distally as in the Paramecoptera, Megaloptera, and Lepidoptera.

(9) In the hindwing, 1A fuses with Cu_2 not far from its origin for a short distance, and then diverges from it again.

(10) In the forewing, the three anal veins are looped up to form a double Y-vein. This specialisation is absent from the hindwing.

(11) The costal veinlets are reduced to two, viz. the humeral (*hm*) and the distal (*dcv*). (In the peculiar genus *Perissoneura,* of the family *Odontoceridae,* the costal space of the forewing is widened, and carries a set of from six to eight veinlets. As none of the close allies of this genus show any signs of this peculiarity, I am compelled to regard these veinlets as a special development, like the so-called "false cross-veinlets" or "pseudoneuria" of the *Lasiocampidae* in the Order Lepidoptera. In neither case am I able to accept these structures as being truly archaic, and therefore archetypic, characters.)

(12) The cross-vein system is considerably reduced, the following only being present:—the subhumeral (*sh*); the subcosto-radial (*sc-r*); two inter-radials (*ir*, *ir'*), of which one (*ir*) closes the radial cell (*rc*) distally; the radio-median (*r-m*); the inter-median (*im*), closing the median cell (*mc*) distally; the medio-cubital (*m-cu*); the inter-cubital (*icu*); the first inter-anal (ia_1); in the forewing only, the cubito-anal (*cu-a*) and the subanal (*sa*); and, in the hindwing only, the second inter-anal

(ia_2). Besides these named cross-veins, six extra unnamed ones are shown in the forewing only in Text-fig. 71. These are to be found in the New Zealand genus *Psilochorema* (family *Rhyacophilidae*). The venation of that genus is so peculiar that it may well be that some at least of these cross-veins have been called into being as specialisations to help in adjusting the altered stresses on the main veins; but others may be true ancestral characters, as may readily be gathered by comparing their positions with the cross-veins in *Belmontia* (Text-fig. 63). It has been thought best to include them all in the Archetype, without insisting strongly upon their importance.

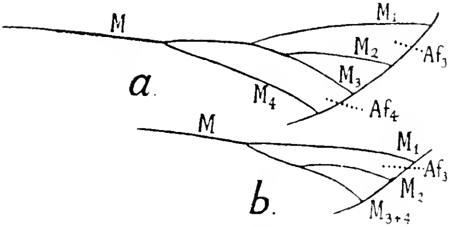
In the construction of the Archetype of this Order, one naturally turns first of all to the Liassic *Necrotauliidae,* and to the closely similar *Rhyacophilidae* (Text-fig. 47, *b*), since this family is regarded by all Trichopterists, without exception, as the oldest existing at the present-day. These latter insects have preserved, more than any other family, the original similarity in shape between fore and hind wings, and this shape can be seen to be easily derivable from the more elongated but otherwise similar shape of the Paramecopterous wing, by a slight reduction in the length compared with the breadth of the wing. As I have already pointed out (29), the reduction of the number of branches of Rs and M_{1-4} to the archetypic condition, and the elimination of any cross-veins originally present in the apical forks, must have been correlated with this shortening.

The genus *Rhyacophila* only differs from the Archetype itself in the loss of the cross-veins *ir* and *im*, and in the specialised position of the cross-veins *m-cu* and *cu-a*. Other genera of the family *Rhyacophilidae*, e.g. *Hydrobiosis,* show *ir* in position, but not *im*. This latter cross-vein is, however, very constant in most families, as well as *ir*, and there can be no doubt that the original condition was that in which both the radial and median cells were closed distally by a cross-vein. The families *Polycentropidae* and *Hydropsychidae* show this condition well; the forewings of these families might well be considered even more archaic than that of the *Rhyacophilidae* in consequence, but the hindwing has become broadened out and of very different shape from the fore, and so must be regarded as more specialised. But of how little real significance such changes are, may be gathered from a reference to the Lepidopterous family *Hepialidae* (Section xiv.), where the similarity in shape of the fore and hind wings is retained in some genera (e.g. *Leto*, Text-fig. 81) and quite lost in others (e.g. *Trictena*, Text-fig. 82).

In constructing the Archetype of this Order, the only difficult points to be decided are (*a*) the archetypic condition of the media in the hindwing, and (*b*) the question of including certain cross-veins.

With respect to the media, we have to show, firstly, that a separate M_4 is never present in this wing, and, secondly, that the cross-vein marked *m-cu* is *really* that cross-vein, and not the reduced basal piece of M_4 after fusion with Cu_{1a} as in the Lepidoptera.

A survey of all the known genera of the Order shows that a separate vein M_4 is absent in the hindwings of all except the two rather highly specialised genera *Helicopsyche* and *Saetotricha* (Text-fig. 72), belonging to the family *Sericostomatidae*. In the hindwings of these two genera, Ulmer (33) has considered the three veins present as M_{1+2}, M_3 and M_4 respectively, on the ground that the apical fork lies between the last two of them;



Text-Fig.72.

Condition of the branches of the media in *a*, forewing and *b*, hindwing of *Saetotricha ptychopteryx* Br. (fam. *Sericostomatidae*), to show transference of M_2 across to M_3. Lettering as on p.535.

whereas, in the hindwings of other Trichoptera, it lies between the first two. The mistake in this is easily seen by comparing the fore and hind wings together, when it will be clear (Text-fig. 72) that, in the forewing, M_2 has migrated across from its original position, as the lower branch of M_{1+2} to M_3, and has thus carried the apical fork along with it. The same specialisation has evidently happened in the case of the hindwing; but, since there is no separate M_4, the true homologies of the three veins became obscured thereby. In Ulmer's notation, the apical fork between M_1 and M_2 is called Af_3, that between M_3 and M_4, Af_2. The correct position of these forks is marked in Text-fig. 72 for the genus *Saetotricha;* the condition in most species of *Helicopsyche* is closely similar. It will be noted that there is no true Af_4 in the hindwing, and the correct naming of the lower branch of M is M_{3+4}. Further evidence in favour of this is afforded by the fact that some species of *Helicopsyche* show M_2 arising almost coincidently with M_1 and M_3 (i.e. the migration across from M_1 to M_3 is only half accomplished), and that the genera of *Sericostomatidae* most closely allied to the two under discussion (e.g. *Thremma*), have the three branches of M in the hindwing normally placed.

As regards the nature of the vein which I have marked *m-cu,* we should note the following points:—

(1) In the genus *Rhyacophila,* it descends from *mf'* obliquely to Cu_1, in the opposite direction to that which it would take if it were portion of a main vein.

(2) In the same genus, an exactly similar vein is present in the forewing also. But, as this wing also has M_4 complete, there can therefore be no doubt whatever that this vein, and its homologue in the hindwing, are both correctly named as the cross-vein *m-cu.*

(3) It is frequently very variable in position, and frequently also quite absent.

(4) It never carries macrotrichia, which it would almost certainly do if it were the basal unfused portion of a main vein.

All the evidence, then, points to this vein being *m-cu,* and hence to there never having been any fusion between M_4 and Cu_{1a} in the Trichoptera comparable with the specialisation seen in both wings of the Lepidoptera. I therefore have no hesitation in naming the lowest branch of M in the hindwings of the Trichoptera M_{3+4}, as shown in the Archetype (Text-fig. 71) and Text-figs. 72, 73.

With respect to the inclusion of certain cross-veins in the Archetype, we may note the following points:—

(1) As the genus *Psilochorema* is exceedingly archaic, I have decided to include the six cross-veins found in the forewing of that genus, over and above the usual ones seen in archaic Trichoptera. One of them, viz. that passing from Rs to M_{1-4}, occurs in almost the same position in *Hydrobiosis,* so that there can be little doubt that it is truly an archetypic character. The

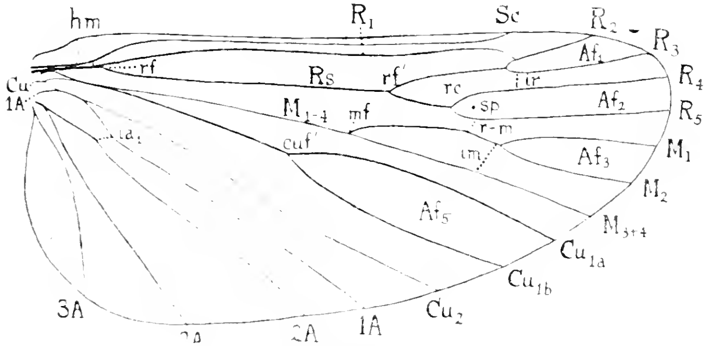
other five are more doubtful, and are only provisionally included until more is known about the venation of these very ancient Rhyacophilids.

(2) The cross-vein *sa* occurs, so far as I am aware, only in the genus *Philopotamus*. But, as a cross-vein occurs in a closely similar position in the archaic Lepidopterous genus *Eriocrania*, I have decided to include it, under the name of *subanal cross-vein*, in the Archetypes of both Orders.

(3) In spite of the formation of the anal Y-vein between 1A and 2A in the forewing, the first inter-anal (ia_1) may still be seen clearly present in a number of genera, as also in *Sabatinca* and *Trictena* amongst the Homoneurous Lepidoptera. There is therefore no doubt that this cross-vein is an archetypic character.

Having, then, determined the Archetype of the Order, we may now briefly indicate the main lines of specialisation in the wing-venation within the Order itself. These may be stated as follows:—

(1) *Broadening of the anal area of the hindwing.* In the most archaic family, the *Rhyacophilidae*, fore and hindwings are closely similar in shape, and the anal area of the hindwing only differs from that of the fore in having 1A fused near its base with Cu_2, and the courses of the three anal veins running separate and free to the wing-border, with the two inter-anal



Text-Fig.73.

Hindwing of an undescribed species belonging to the family *Polycentropidae*, allied to *Stenopsychodes* Ulm., showing the enlarged anal area. Lettering as on p.535. (x 8).

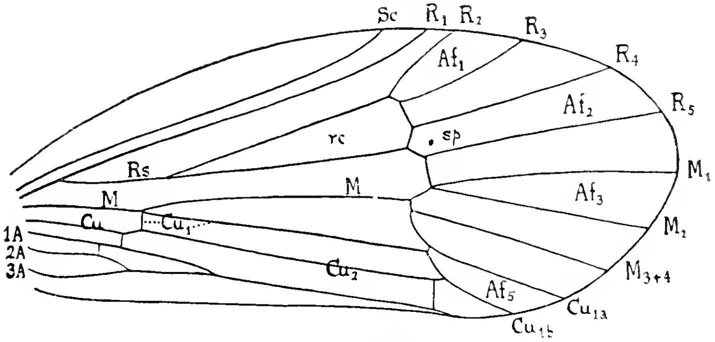
cross-veins (*ia_1*, *ia_2*) placed somewhat longitudinally in position of *ia_2*, may still be found in a very archaic genus of *Polycen-* between them. All these conditions, except only the presence *tropidae* (a family closely allied to the *Rhyacophilidae*), which has not yet been named, but which is closely allied to *Stenopsychodes* Ulmer, as shown in Text-fig. 73. It will be noticed that 2A appears to have forked; and, of course, both 2A and 3A have become greatly lengthened. This hindwing is figured partly for the purpose of drawing attention to the fact that the inception of heteroneurism may be taken as undoubtedly due to the *widening* of the anal area of the hindwing, together with the *narrowing* of its costal and subcostal areas. Both these conditions are well shown in Text-fig 73. If the line of specialisation had been continued, in this case, by further narrowing of the anterior portion of the wing, affecting the radial area, and bringing about (*a*) a fusion of Sc and R_1, as occurs in many Trichoptera, and (*b*) a reduction of Rs to a simple, unbranched vein, there would have resulted a group of heteroneurous Trichoptera exactly parallel with the Suborder Heteroneura within the Lepidoptera.

The amplification of the hindwing may be seen in other families of the Trichoptera, especially in the *Hydropsychidae* and the *Limnephilidae*, and is very greatly accentuated in some genera of these two families.

(2) *Narrowing of both wings, with loss of certain main veins.* This is carried to an extreme in certain *Leptoceridae, Molannidae* and *Hydroptilidae.* All stages of the reduction-process may be studied in the various genera of any one of these families; but there does not seem to be any definite plan by which the main veins are reduced. Moreover, owing to the lack of the precedent tracheation in the pupal wings, it is a very difficult matter to decide, in many cases, what are the correct names of the veins left over.

(3) *Alignment of the distal cross-veins to form a single transverse series.* This line of evolution is followed out in the forewings of the dominant family *Limnephilidae,* which is really the only family of Trichoptera which may be said to have evolved a venational scheme of its own. The first stage in this line of evolution is the formation of the two separate *anastomoses,* viz. the *upper anastomosis,* formed by the alignment of the basal piece of R_3 the cross-vein *ir,* the basal pieces of R_4 and R_5,

and the cross-vein *im*, as an irregular, transverse zig-zag from the base of the second apical fork to the base of M_{1+2}; and the *lower anastomosis*, formed by the basal piece of M_{3+4}, the cross-vein *m-cu*, and a highly specialised arrangement of the ends of the branches of Cu and the cross-vein *icu*, as a second irregular, transverse zig-zag line, taking in the base of the fifth apical fork. The highest stage in this evolution is the alignment of the upper and lower anastomoses to form a single transverse zig-zag line, called simply *the anastomosis*, running from the fork of R_{2+3} right across the wing. This is to be seen in such genera as *Chilostigma* and *Chaetopteryx* (Text-fig. 74).



Text-Fig.74.

Forewing of *Chaetopteryx villosa* (Fabr.), after Ulmer, but with lettering added, to show the formation of the anastomosis. Lettering as on p.535.

The formation of the anastomosis in the family *Limnephilidae* recalls the analogous formation called by the same name in the Order Perlaria.

For a comparison of the Archetypes of the Trichoptera and Lepidoptera, *see* pp. 634-5.

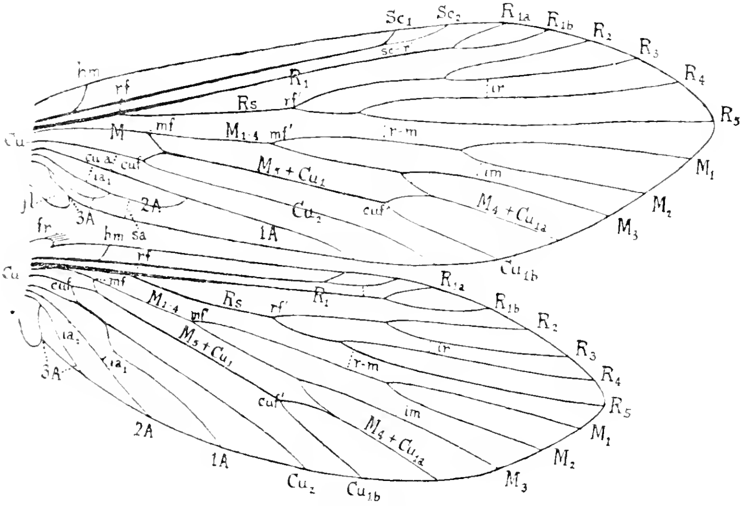
Section xiv. THE VENATION OF THE LEPIDOPTERA.

(Plates xxxii.-xxxv., figs. 17-24 and Text-figs. 36b, 53-56, 58-59, 75-103.)

The venation of the Archetype of this Order is shown in Text-fig. 75, which should be carefully compared with that of the Trichoptera in Text-fig. 71. The following are the chief points to be noted:—

(1) The pupal wings are holotracheate. There is a tendency for the branches of all the principal tracheæ to be split back towards the base of the wing, so that the point of origin of any given branch trachea is nearer to the base than the point of origin of the corresponding vein in the imaginal wing.

(2) Sc and R_1 are distally forked. These archaic characters are preserved more or less fully in various Homoneura.



Text-Fig.75.

Wings of the Archetype of the Order Lepidoptera. Lettering as on p.535.

(3) The branches of Rs are reduced to four in number, and the apical forks so formed are destitute of cross-veins.

(4) The dichotomous manner of branching of these forks is retained, with the fork of R_{4+5} placed nearer to the base of the wing than is that of R_{2+3}.

(5) There is no wing-spot between R_4 and R_5.

(6) The cubito-median Y-vein is completely formed, on the same lines as in *Belmontia*.

(7) Fore and hindwings agree in the manner of branching of M_{1-4}. In both wings, this vein has four branches, arranged dichotomously, but M_4 fuses distally with Cu_{1a}, forming the

distal Y-vein (Section vi.). This character is best shown in the *Hepialidae*.

(8) The cubitus is three-branched. Cu_1 forking distally as in the Parameeoptera, Megaloptera, and Trichoptera.

(9) In the hindwing, 1A fuses with Cu_2 not far from its origin for a short distance, and then diverges from it again. This character is to be seen in the Jugo-frenata, *Hepialidae* and in quite a number of the older Heteroneura. It also occurs in all Mecoptera and Trichoptera, in the Raphidioidea and some Planipennia.

(10) In the forewing, 2A is looped on to 1A, and 3A on to 2A, thus forming a double Y-vein as in Trichoptera. This character is to be found in *Mnemonica* and *Sabatinca*, the two most archaic genera in the Jugo-frenata, but is usually reduced to a single Y-vein, formed by 1A and 2A only, in the other genera of that group. Throughout the Lepidoptera, 3A tends to become obsolete in the forewing, and is absent from most forms, including the *Hepialidae*.

(11) There is only one costal veinlet, viz. the humeral, *hm*. In many pupal wings, this is seen to be supplied by a special trachea running alongside Sc. (Text-figs. 80, 85). This is certainly the homologue of the formation to be seen in the Paratrichoptera (Text-fig. 65).

(12) The cross-vein system is even more reduced than in the Archetype of the Trichoptera, only the following being present:—the subcosto-radial (*sc-r*); the inter-radial (*ir*) closing the radial cell (*rc*) distally; the radio-median (*r-m*); the inter-median (*im*) closing the median cell (*mc*) distally; the cubito-anal (*cu-a*); the first inter-anal (ia_1); the second inter-anal (ia_2) in the hindwing, and the sub-anal (*sa*) in the forewing only. This last is only to be seen in *Eriocrania* (27, and Text-fig. 53, *c*).

Thus, quite apart from the six unnamed cross-veins which, since they are present in the Rhyacophilid genus *Psilochorema* have also been included in the venation of the Archetype of the Trichoptera, the following cross-veins present in that Archetype are absent from the Archetype of the Lepidoptera:—the subhumeral (*sh*); the inter-radial from R_1 to R_2 (ir'); the mediocubital (*m-cu*).—owing, of course, to the fusion of M_4 with Cu_{1a}; and the inter-cubital (*icu*). Thus the cross-vein system of the Lepidoptera is archetypically considerably more reduced than that of the Trichoptera.

The Archetype of the Lepidoptera, as here defined, includes, of course, characters taken from the three archaic Jugo-frenate families of the Homoneura, viz. the *Micropterygidae, Eriocraniidae* and *Mnesarchaeidae.* It was realised from the first that the question of the correct ordinal position of these families was of the greatest importance; and this was one of the reasons that prompted me to devote special attention to them, giving a series of papers on them, to be read concurrently with those of which this paper forms a part. As soon as the study of these three families had progressed sufficiently, I became convinced that they were indeed archaic Lepidoptera, and nothing else; and hence I do not now hesitate to use them in constructing the Archetype of that Order. But, in order that those who may still hold an opposite view may be convinced that it makes no essential difference whether they be included or not, from the point of view of the *archetypic wing-venation,* the alterations which would be caused in the definition of the Archetype are here set down, as follows:—

(A) If the family *Micropterygidae* (s.str.) be excluded, then there will be no difference at all in the Archetypic wing-venation. For Sc is distally forked in *Prototheora* and in *Mnemonica,* R_1 is distally forked in both *Mnemonica* and *Eriocrania, sc-r* is present in *Mnesarchaea,* the other cross-veins in numerous genera, and likewise the fusion of 1A with Cu_2 in the hindwing.

(B) If all the three families of the Jugo-frenata be removed from the Lepidoptera, then the Archetype must be modified, in so far that R_1 will be no longer forked, and the cross-veins *sc-r,* ia_2, *sa,* will be absent; since, as far as I know, these characters do not occur outside the Jugo-frenata. All the other characters are to be found in one or more of the remaining families of the Order. As the differences mentioned are not of very great importance, it will readily be seen that no *essential* alteration will be needed in the venation of the Archetype, even if the whole of the Jugo-frenata were to be removed from the Order.

The relationship between the two Orders Trichoptera and Lepidoptera is a close one, comparable with that between the Megaloptera and Planipennia, but not so close as this latter. In each case, it is the aquatic side-branch (Trichoptera or Megaloptera) which has remained, on the whole, in the more archaic condition, while the main terrestrial stem (Planipennia or Lepidoptera) has advanced, and branched out in many new directions, and has become far more abundant in families, genera and species. But it is essential that we should see clearly that neither the Lepidoptera nor the Planipennia are of aquatic origin, and neither can possibly be derived from its closely related aquatic Order. The close similarity between the archetypic venations of the Trichoptera and Lepidoptera will be sufficiently obvious from a perusal of the characters already set down, and the archetypic diagrams (Text-figs. 71, 75). Their differences are perhaps not so obvious; but they are of very great importance for the right understanding of the phylogenetic problem, and are set down in the accompanying Table (Table ii.)

TABLE II.

TABLE OF DIFFERENCES IN THE WING-CHARACTERS OF THE ARCHETYPES OF THE TRICHOPTERA AND LEPIDOPTERA.

	Character.	TRICHOPTERA	LEPIDOPTERA
(1)	Pupal Wing	Merotracheate	Holotracheate
(2)	Condition of M_4	Present in forewing as a separate vein; absent from hindwing	Present in both wings, but distally fused with Cu_{1a}.
(3)	Wing-spot between R_4 and R_5	Present	Absent
(4)	Cross-veins *sh*, *ir'*, *m-cu*, and *icu*.	Present	Absent
(5)	Functional frenulum	Absent	Present
(6)	Macrotrichia specialised as scales	Absent	Present

With respect to these six differences, the Trichoptera are the more archaic in (4) and (6), and in (2) as regards the forewing only; the Lepidoptera are the more archaic in (1), (3) and (5), and in (2) as regards the hindwing only. Thus the specialisations are fairly equally divided between the two Orders; and it is evident, on more than one count, that neither can be ancestral to the other. They must have arisen as a dichotomy from a common stem, which combined the archaic characters of both Orders.

We must now consider a little more fully the venation of the Lepidoptera, in order to show quite clearly how the archetypic characters have been determined.

It will not be necessary, at this stage, to attempt to prove what is by now universally admitted, viz. that the Suborder Homoneura contains the most archaic existing types of the Order. Also the space at my disposal will not allow of a full review of the characters of the venation, in all families of the huge Suborder Heteroneura. I propose, therefore, to take the families of the Homoneura in order, and study their venation; and then to select only those archaic families of the Heteroneura which will help to elucidate the main problem, together with a few other types which may throw light on important, though subsidiary, problems, such as the origin of the Butterflies. In doing this, it will have to be borne in mind that many of the archetypic characters have already been determined from the evidence in previous Sections, which will be referred to when required.

Suborder **Homoneura**.

Division Jugo-frenata.

This division contains only the three families *Micropterygidae*, *Eriocraniidae*, and *Mnesarchaeidae*.* As a study of their venation, and its relationships with that of the Trichoptera, would have unduly enlarged this Part, the work has already been done separately (26), and the results are taken for use in this paper. In Text-fig. 76, I have given a diagrammatic representation of the Archetypic venation of the Jugo-frenata, by including in the one figure all the archaic characters to be found in the whole of the genera belonging to this division. The distribution of these characters may be gathered both from my previous paper (26) and, as regards the separate families, from the Table given on p. 650. It is only necessary here to call attention to the characters in which the Jugo-frenata themselves are specialised,—in other words, those characters in which the venation given in Text-fig. 76 differs from that of the Archetype of the Order Lepidoptera. These are:—

(1) The far distal position of the forks rf' and mf'. This is an important specialisation, frequently present in *highly reduced forms*, or as the result of stenogenesis. Its presence in the Jugo-frenata is proof that they are of smaller size than the Archetype of the Lepidoptera, which probably came closer to *Belmontia* in size.

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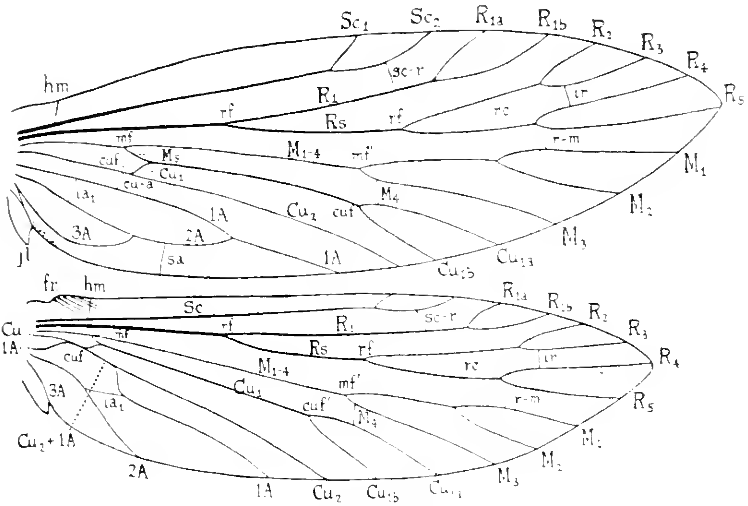
*I propose to treat these as three distinct families from this Part onwards.



Text-Fig.76.

Wings of the Archetype of the Division Jugo-frenata. Lettering as on p.535.

(2) The loss of the original obliquity of M_4 after fusion with Cu_{1a}. This, again, is due to reduction in size. In the larger *Hepialidae*, the obliquity is retained; while, in the *Prototheoridae*, the reduction of M_4 to the appearance of a cross-vein has not proceeded so far as in the Jugo-frenata. (Reference should be made here to the Note on the Evidence concerning the Existence of vein M_4 on p. 651.)

(3) The cross-vein *im* is never present. This is an important specialisation, seeing that this cross-vein closes the median cell (*mc*) not only in the rest of the Homoneura, but also in Heteroneura, and plays its part in the formation of the large basal cell. The loss appears to be due directly to the removal of *mf'* distad, and is therefore to be traced back, like the other specialisations, to reduction in size.

It will be seen from the Table given on p. 650 that the *Micropterygidae* are the most archaic family of Lepidoptera still existing, but that they fall far short of possessing the full number of archaic characters exhibited by the Archetype of the Order, as regards the Wing-venation. The *Eriocraniidae* are somewhat more specialised, being about level with the *Hepialidae* in the percentage of archaic characters which they possess. The *Mnesarchaeidae* are the most highly specialised of all the Homoneura.

The manifest agreements between the venational schemes of the Archetypes of the Jugo-frenata and the Trichoptera are clearly of the utmost importance, since it is on these that Comstock (15) has removed the former to the latter Order. They may be stated as follows:—

(1) Sc and R_1 are distally forked.

(2) The branches of Rs are four in number and dichotomously arranged.

(3) The radial cell is closed distally by *ir*.

(4) The cubito-median Y-vein is completely formed.

(5) The cubitus is three-branched, Cu_1 being forked distally.

(6) The anal veins of the forewing form a double loop or Y-vein.

(7) In the hindwing, 1A fuses with Cu_2 for a short distance not far from the base, and then diverges from it and runs separately to the wing-border.

(8) The cross-vein system in the Jugo-frenata is closely similar to that of most archaic Trichoptera, although *im* is always absent. In particular, ia_1 in the hindwing is longitudinally placed.

With one exception, all the above characters are to be found, not only in Trichoptera and Jugo-frenata, but also in either (*a*) other Panorpoid Orders, or (*b*) other Lepidoptera. The exception is (6). The double Y-vein formed by the looping up of the three anal veins is peculiar to the Trichoptera and to the genera *Mnemonica* and *Sabatinca* amongst the Jugo-frenata. In the other genera, it is either absent (replaced by the single Y-vein usual in Lepidoptera) or occasionally more or less clearly formed. If the complete double-Y formation is the more archaic condition, then it is clear that it must have been inherited from the common ancestor of both Trichoptera and Lepidoptera; but, while the Trichoptera have retained, and, in many cases, elaborated it, the Lepidoptera, on the other hand, almost immediately began to lose it, through degradation of the vein 3A. If, however, the single Y-vein be the older formation, then the already present tendency towards further specialisation must have produced the double-Y formation independently in the Trichoptera and in those Jugo-frenata which possess it, while most of the Lepidoptera failed to reach this stage, through degradation of 3A. In either case, the condition of these veins in the Jugo-frenata is no argument for placing that group in the Trichoptera, as Comstock has done (15); since the group, as a whole, shows the Trichopterous condition in certain genera and the Lepidopterous condition in others (see 27, Text-figs. 1, 6, 9, showing the single loop present in *Eriocrania*, *Micropteryx* and *Mnesarchaea*).

As regards character (8) above, it should be noted that the longitudinal position of the cross-vein ia^1 in the hindwing, which Comstock imagined was peculiar to the Trichoptera and the Jugo-frenata, is also to be found in the Mecoptera and the *Sialidae* (Text-fig. 104). This cross-vein does not occur, so far as I know, in the hindwings of any Lepidoptera outside the Jugo-frenata.*

We may say, then, of the eight characters named above, which are common to the Trichoptera and Jugo-frenata, that they are all of them, except (6), also to be found outside these two groups. Taken together, they form a strong argument for the close relationship of the two Orders Trichoptera and Lepidoptera. But they do not, in any sense whatever, justify the removal of the Jugo-frenata to the Trichoptera.

The complete venational characters of the Jugo-frenata may be gathered from my paper on this group (26). We shall now proceed to discuss the venations of the other two families of the Homoneura, and to note in particular the many points of resemblance between them and the Jugo-frenata.

Division Jugata.

Family HEPIALIDÆ.

This family is of the greatest importance for the correct understanding of the Archetype of the Lepidoptera.

Most of the pupæ studied belonged to species of the genus *Charagia*, the larvæ of which tunnel in the stems of various trees. Text-fig. 77 shows the tracheation of the wings in a freshly-turned pupa of *Ch. splendens* Scott. This pupa was first examined under a lens, while it rested on cotton-wool. The

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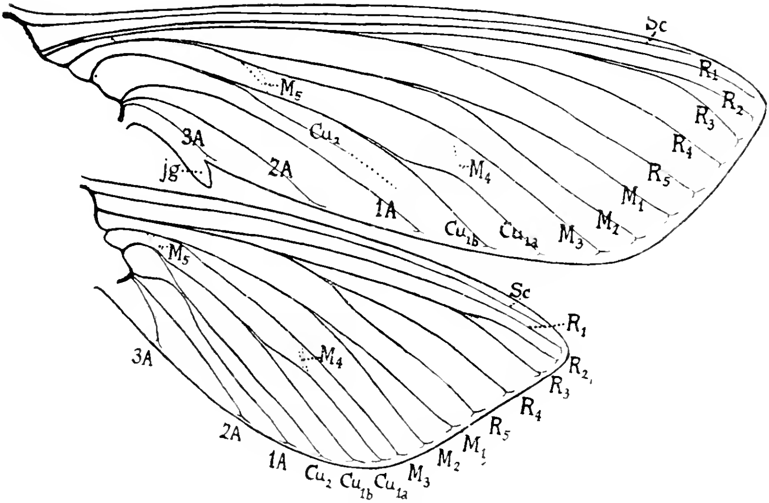
*The complicated condition of the anal venation at the base of the hindwings of certain *Tortricina* suggests that this cross-vein may sometimes be present there. See, for instance, the figure given for *Isotrias* by Meyrick (3, p.542).



Text-Fig.77.
Tracheation of wings of freshly formed pupa of *Charagia splendens* Scott. (x 3·4). Lettering as on p.535.

tracheation of the forewing, and that of the hindwing underlying it obliquely, could be clearly seen; and drawings were made of them. As soon as the pupa had hardened up a little, it was killed with chloroform, and the outer covering of the forewing was dissected off. This exposed the tracheæ of the forewing *in situ*, including their basal connections. A drawing was made of these, under the camera lucida; and then the whole wing was carefully dissected off and floated out on to a slide, where the bases of the tracheæ were photographed (Plate xxxii., fig. 17). Next, a camera-lucida drawing of the hindwing tracheæ was made, the fine membrane separating this wing from the fore having been dissected away. Text-fig. 77 combines the two camera-lucida drawings of the wings *in situ*, and therefore represents the wing-tracheation of a pupa less than twelve hours old.

At this early stage, the courses of the future veins are not clearly indicated; but I have marked the positions of the two exceedingly delicate bands which very soon appear, indicating the positions of M_5 and M_4, forming the upper arms of the cubito-median and distal Y-veins respectively. Neither of these veins is preceded by a trachea in the freshly-turned pupa. Other points to be noted are:—

(1) The composite origin of R, which is particularly noticeable in the forewing.

(2) The composite origin of M (See Plate xxxii., fig. 17).

(3) The fact that Cu^2 is already reduced in the forewing.

(4) The very distinct origin of the anal group of tracheæ, in a single bunch far removed from Cu, with all three anal tracheæ clearly indicated.

(5) The fusion of 1A with Cu^2 in the hindwing, for a short distance near the base. This latter character is claimed by Comstock to be peculiar to the Trichoptera; but, as it also occurs in the Jugo-frenata, it is used as part of the argument for removing those insects to the Trichoptera (15).

(6) The complete separation of the three anal veins in the forewing, except at their bases.

Pupæ dissected at ages from a few days to more than a week old show little difference from the above. The wing becomes generally more opaque, leaving the paler and more transparent bands, along which the imaginal venation is later laid down, clearly visible. No trachea was seen by me along the course of M_5 in any pupa of this age, nor did I ever succeed in finding a trachea along the course of M_4 *in any pupa of any age whatever.*

In the older pupæ, the wing becomes darkened; and, with a little care, it may be removed whole from its sheath, without damage. The base becomes narrowed, so that the condition of the basal tracheation is completely altered. The formation of scales becomes very apparent, and greatly hinders the study of the tracheæ *in situ.* In order to make out the courses of the tracheæ near the base, I cleared some of the wings very rapidly in chloro-phenol*. There is usually only just time to see the condition of the tracheæ plainly, when this strong clearing agent is used; for the tracheæ are no sooner cleared than they begin to shrivel up, so that drawings must be made at once.

In a pupa which was evidently only a few days from metamorphosis, seeing that the colouration of the wings was beginning

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*I have to thank Dr. H. Priestley, Lecturer in Physiology, University of Sydney, for bringing this strong clearing agent to my notice.

to be evident, a fairly strong trachea was seen traversing M_5, in the forewing; but this trachea was not of so large a calibre as the cubital trachea, which still ran strongly in the lower arm of the Y-vein. There is no trachea in M_4. Trachea Cu_2 is still further reduced in the forewing. The anal area has become very much narrowed, and tracheæ 2A and 3A are very much reduced in the forewing. In the hindwing, the fusion of Cu_2 with 1A remains, but has approached nearer to the base of the wing, as has also the position of M_5 in both wings. This points to a great contraction of the base of the wing in the late pupa, and this contraction is very much further emphasised at metamorphosis, when the more distal part of the wing becomes much expanded.

It is necessary here to point out that trachea M_5 does not always appear in the late pupa. In some cases, it may be seen as a very small trachea indeed; while, in one pupa of *Leto*, examined only a few days before metamorphosis, there was still no sign of it.

If a freshly-emerged Hepialid imago be taken and killed, and its wings carefully descaled and cleared, the tracheæ may be found *in situ*, running in the veins, very much as they are to be seen in the late pupa. The principal changes that take place at metamorphosis are as follows:—

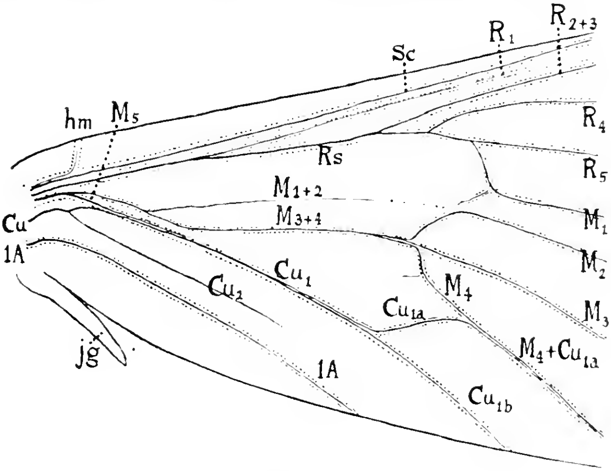
(1) The base of the wing, already reduced in size in late pupal life, undergoes practically no expansion. On the other hand, the more distal portion expands greatly, so that the final result is to bring the primary median and cubital forks very much closer to the base of the wing than they were in the pupa.

(2) Trachea M_5 is frequently of large calibre, and may be considerably larger than trachea Cu_1. There is, however, a great deal of variability in this character, as I have examined a number of imagines in which trachea Cu_1 was considerably the stronger of the two.

(3) Trachea M_4 is usually absent; but it was present in a fair number of wings, and in some cases it was even of larger calibre than trachea Cu_{1a}. In a few specimens, I have seen the latter quite aborted; but in most cases, when present, the two tracheæ run side by side along the stem of the distal Y-vein, M_4+Cu_{1a}. (For details, see Section vi.)

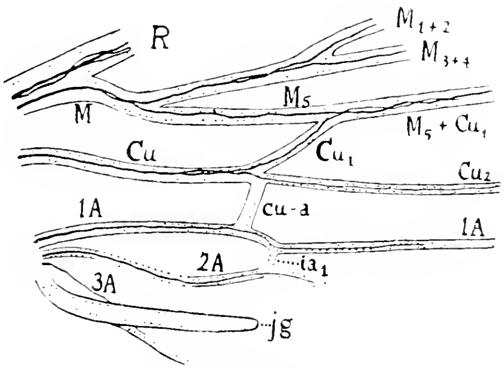
(4) In the case of *Ch. splendens* (Text-fig. 78) scarcely any trace of either 2A or 3A is left in the forewing of the imago,

and there is not at any time any formation of an anal loop or Y-vein between 1A and 2A. The most complete condition of the



Text-Fig.78.

Basal part of forewing of *Charagia splendens* Scott, to show the venation (double dotted lines) and the tracheation. (x 4). Lettering as on p.535.



Text-Fig.79.

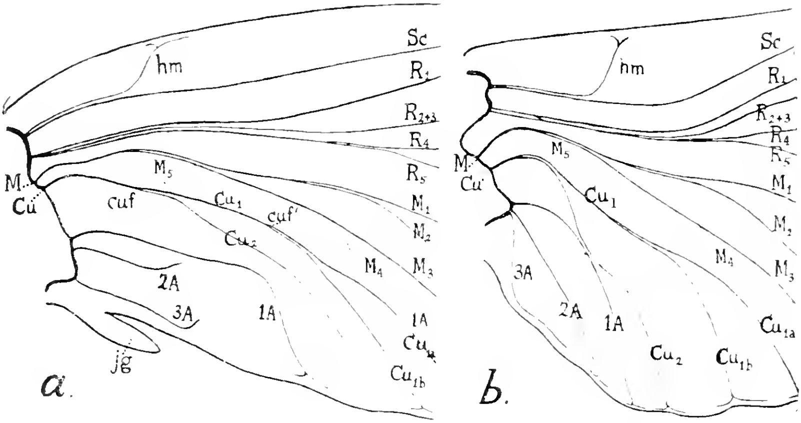
Basal part of forewing of *Trictena labyrinthica* Don., to show the incomplete formation of the anal Y-vein, and the presence of the cross-vein *ia*$_1$. (x 4½). Lettering as on p.535.

anal veins is to be seen in the forewing of *Trictena labyrinthica* (Text-fig. 79), in which this loop is completed by the intervention of the interanal cross-vein ia_1.

The conclusions to be drawn from the above are, I think, that, on the whole, the freshly-turned pupa gives us the most primitive condition of the wing-tracheation; that the tracheation of the imaginal wing shows a considerable amount of specialisation; and that the development of tracheæ M_5 and M_4, the former late in pupal life, the latter occasionally at metamorphosis, may well represent the late appearance of tracheæ which are in process of being lost altogether.

We may now turn our attention to the genus *Leto*, of which I was able to dissect several pupæ obtained for me by Mr. Luke Gallard. These pupæ are of very large size, some being four inches long, so that their dissection is a fairly easy matter, and the tracheation can be studied under a low power.

Text-fig. 80 shows the bases of the wings in an early pupa of *Leto staceyi* Scott, dissected off and floated out upon a glass slide in water. If these be compared with *Charagia* (Text-fig. 77) it will be seen that there are some important differences, as follows:—



Text-Fig.80.

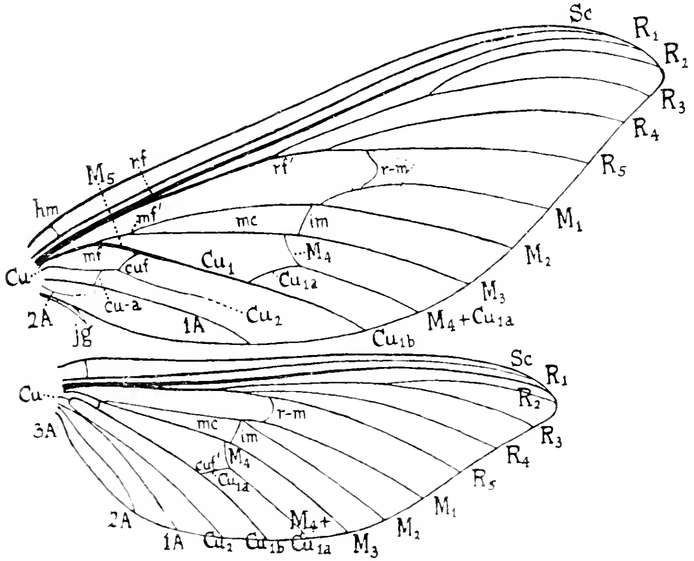
Basal portion of tracheation of *a*, forewing, *b*, hindwing, in the freshly formed pupa of *Leto staceyi* Scott. (x 3). Lettering as on p.535.

(1) The humeral veinlet, *hm*, is supplied by a special trachea which rises with Sc and runs alongside it for some distance. This might be the remnant of the old costal trachea, but is more likely to be a true basal branch of Sc. In any case, it should be noted that the condition seen here in the pupal wing is closely paralleled in the fossil genus *Aristopsyche* of the Order Paratrichoptera (Text-fig. 65). It is also to be found in the pupæ of the *Cossidae* (Text-figs. 85, 86).

(2) In the forewing, trachea 2A is short and tends to bend up towards 1A, thus indicating a tendency towards the formation of the single anal Y-vein found in most Lepidoptera.

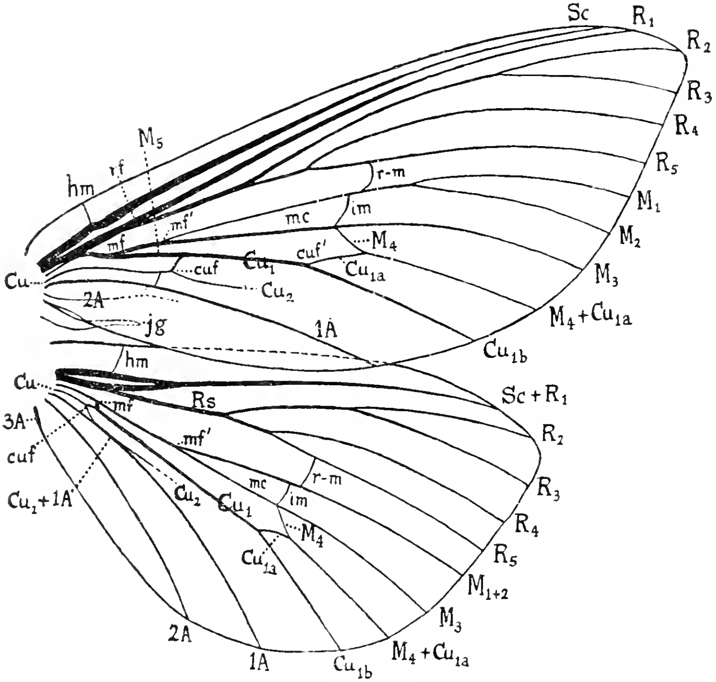
(3) In the forewing the anal group of tracheæ arises differently from that of *Charagia*, the individual members being more widely separated. They are all, however, far removed from Cu, which is close up to M. In the hindwing, the anal group is much the same as in *Charagia*.

As before, I have marked by double dotted lines the positions



Text-Fig.81.

Leto staceyi Scott, imaginal venation (x 0·8). Lettering as on p.535.



Text-Fig.82.

Trictena labyrinthica Don., imaginal venation. (x 1½). Note the loss of the fork of M_{1-2} in hindwing. Lettering as on p.535.

of the veins M_5 and M_4, which very soon begin to appear as pale bands with the rest of the imaginal venation. A very important character, viz. the partial fusion of 1A with Cu_2 in the hindwing, is as clearly shown in this genus as in *Charagia.* But, in the first pupa which I dissected, and which I figured in a previous paper (27, Text-fig. 14), this fusion was not present. An examination of the photomicrographs which I took of this pupal wing shows me quite clearly that this was due to displacement while lifting the wing and spreading it out on the slide; for the pale bands which indicate the imaginal venation can be seen fused together between the two tracheæ, which are clearly pulled slightly out of their correct positions. Three other pupæ since dissected all agree in having this fusion clearly marked.

The genus *Leto* differs from all other Australian genera in the possession of a large raised eye-spot on the forewing, covering the cross-vein *r-m*, which forms the top of the ridge, and also in the very close similarity in shape between fore and hindwings, as can be seen from Text-fig. 81.

As a contrast to *Leto*, I show in Text-fig. 82, the venation of the genus *Trictena*, of which, unfortunately, I have not been able to obtain pupæ, but only freshly emerged imagines. Here the difference in shape between fore and hindwing is very great, and is typically that of a Heteroneurous rather than a Homoneurous type. Moreover, the tendency towards heteroneurism is very evident from the fact that there is a vein missing in the hindwing, M_{1+2} being a simple vein, and also because, as in the hindwings of Heteroneura, Sc and R_1 have coalesced near their bases, and run together as a single fused vein to the wing margin. The genus, then, is a living illustration of the manner in which a heteroneurous type can be evolved from a homoneurous type. It does not, however, indicate the actual line of evolution of the Suborder Homoneura; because, in their case, it is not the branches of M which become suppressed in the hindwing, but the branches of Rs. Reduction of the branches of M along the lines indicated in this genus might well have led to the Jurassic fossil family *Palaeontinidae* (p. 654), which, if Handlirsch's restorations be correct, were strongly heteroneurous, but had M reduced to a simple vein in the hindwing.

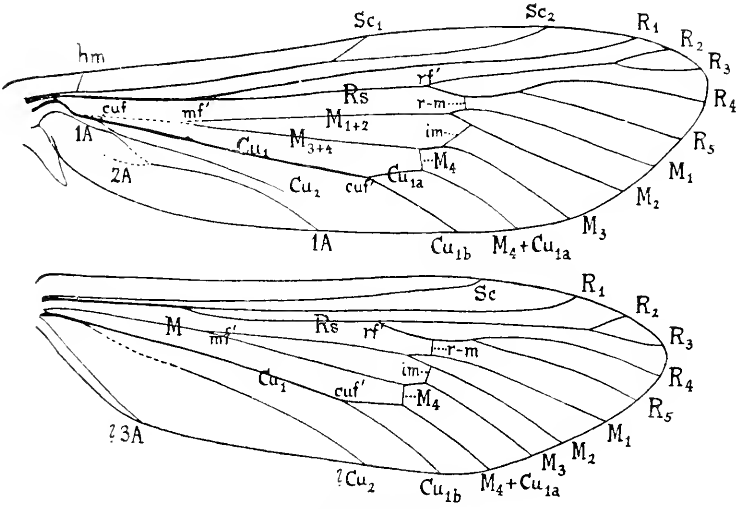
Family PROTOTHEORIDÆ.

This family was founded by Meyrick (9) to contain a remarkable moth from South Africa, *Prototheora petrosema* Meyr., which is in some respects intermediate between the Jugo-frenata and the *Hepialidae*. For material of these rare insects I have to thank Dr. L. Peringuey, Director of the South African Museum, Capetown.

The material sent by Dr. Peringuey, when examined, was found to contain two very distinct species, one of which was probably the same as Meyrick's type, the other very distinct from it. No figures of the venation of these interesting insects have yet been published. Text-fig. 83 shows the venation of the more bluntly winged species (the other has the wings more pointed at apex, with unimportant differences in the venation).

The family agrees with the *Hepialidae* in possessing a true jugum, and in lacking all traces of a frenulum; therefore it is rightly included in the division Jugata. It also agrees with the *Hepialidae* in the basal positions of *rf* and *mf′* (though *rf′* is removed far distad), in the absence of the cross-vein *ir*, in the presence of *r-m* and *im*, and in still showing some indication of the original oblique position of the unfused basal portion of M_4. In having a definite branch of Sc (Sc_1) in the forewing, it is more archaic than most *Hepialidae;* but this condition is closely similar to that seen in *Sthenopis*.

The most remarkable specialisation to be seen in the *Prototheoridae* is the reduction of the venation of the anal area. In the forewing, 1A curves up so as just to touch Cu_2, thus recalling the fusion of these two veins in the hindwings of the *Hepialidae* and Jugo-frenata. 2A is obsolescent, being represented only by its distal end joined on to 1A; this character proves that the anal Y-vein formed from 1A and 2A was complete in this wing, before the obsolescence of 2A began. There is a small, weak 3A bordering the jugum distally, in the usual



Text-Fig.83.

Prototheora sp. (Table Mountain, South Africa). imaginal venation. (x 6). Lettering as on p.535.

position. In the hindwing, the whole anal area is devoid of veins, except for one very close to the wing-border, the homologies of which cannot be determined with certainty, and a vein running below Cu_1, in the usual position of Cu_2, which may be either that vein or 1A.

In the forewing, M is very completely fused basally with Cu, so that all traces of the cubito-median Y-vein are lost. The main stem of M_{1-4} is obsolescent as far as mf'. In the hindwing, this main stem is more clearly shown, and is not fused with Cu; a tiny remnant of the cubito-median Y-vein appears to be visible at the extreme base of the wing.

The discovery of this family is chiefly interesting in that it proves the existence of hitherto unsuspected Homoneurous types. It may reasonably be hoped that further discoveries along similar lines may yet be made. Indeed, the discovery of the remarkable genus *Anomoses* in South Queensland by Dr. A. J. Turner (31) is probably a case in point; for this genus does not appear to be a true Jugo-frenate type, and should probably be placed either in the *Prototheoridae* or in a new family *Anomosetidae*.

In concluding this account of the Suborder Homoneura, it is interesting to compare the wing-venational characters of the five families represented therein, in such a way that the archaic characters in each family may be readily picked out. This is best done by means of a Table (Table iii.), in which the most archaic condition of each separate character is represented under the letter A, while B, C, . . . represent more specialised conditions of the same, in ascending order. The Archetype of the Homoneura will possess all the archaic conditions indicated under A. The "percentage archaism" of that Archetype will therefore be 100. For comparison with this, the "percentage archaism" of each of the five families is worked out in the last column of the Table. When we have studied the Heteroneura, and tabulated their characters in the same manner, it will be seen that that Suborder does not possess a single archaic condition which is not also to be found somewhere within the Suborder Homoneura. In other words, the Archetype of the Homoneura is also the Archetype of the Order Lepidoptera as a whole.

TABLE III.

TABLE OF THE PRINCIPAL VENATIONAL CHARACTERS FOR THE FAMILIES OF THE HOMONEURA.

Ref. No.	Character.	Jugo-frenata			Jugata	
		Micropterygidae.	*Eriocraniinae.*	*Mnesarchaeinae.*	*Hepialidae.*	*Prototheoridae.*
(1)	Forking of Sc.—A. Present in both wings. B. Present in forewing only. C. Absent in both wings.	A or B.	B or C.	C.	B or C.	B.
(2)	Forking of R_1:—A. Present in both wings. B. Present in forewing only. C. Absent in both wings.	B or C.	A or B.	C.	C.	C.
(3)	Number of branches of Rs:—A. Four in both wings. B. Four in forewing, three in hind. C. Three in both wings.	A.	B or C.	C.	A.	A.
(4)	Manner of branching of Rs:—A. Dichotomic. B. Otherwise.	A.	B.	B.	A.	A.
(5)	Closing of radial cell distally by *ir*:—A. Present. B. Absent.	A.	B.	B.	B.	B.
(6)	Positions of *rf'* and *mf'*:—A. Both normal. B. *mf'* normal, *rf'* removed distad. C. Both removed distad.	C.	C.	C.	A.	B.
(7)	Number of branches of M_{1-4}:—A. Four; M_4 oblique and fused distally with Cu_{1a}. B. Apparently only three, M_4 being reduced to a short transverse vein.	B.	B.	B.	A.	B.
(8)	Cubito-median Y-vein:—A. Well developed. B. Reduced or absent.	A.	A.	B.	A.	B.
(9)	Closing of median cell distally by *im*:—A. Present. B. Absent.	B.	B.	B.	A.	A.
(10)	Number of branches of Cu:—A. Three, all complete. B. Three, but Cu_2 reduced in one or both wings.	A.	A.	B.	B.	B.
(11)	Cubito-anal Y-vein in hindwing:—A. Complete. B. Absent.	A.	A.	B.	A.	B.
(12)	Anal veins:—A. All three present. B. 3A absent. C. Only one complete anal present.	A.	A.	A or B.	B.	C.
(13)	Anal Y-vein of forewing:—A. Double Y complete. B. Single Y complete. C. Single Y reduced.	A or B.	A or B.	C.	C.	C.
(14)	Humeral veinlet *hm*:—A. Present in both wings. B. Present in forewing only. C. Absent in both wings.	B or C.	A or B.	C.	A.	B.
(15)	Cross-vein *sc-r*:—A. Present in both wings. B. Present in one wing only. C. Absent.	A or B.	C.	B.	C.	C.
(16)	Cross-vein *r-m*:—A. Present in both wings.	A.	A.	A.	A.	A.
(17)	Cross-vein *cu-a* in forewing:—A. Present. B. Absent.	A or B.	A.	A.	A.	B.
(18)	Cross-vein ia_1:—A. Present in both wings. B. Present in hindwing only. C. Absent from both wings.	A or B.	B.	C.	B or C.	C.
(19)	Cross-veins *sa* in forewing and ia_2 in hindwing:—A. Both present. B. Only ia_2 present. C. Both absent.	B.	A or B.	C.	C.	C.
(20)	Shape of wing:—A. Original elongate form, as in *Belmontia* or *Rhyacophila*. B. Symmetrical, sharply pointed wing. C. With narrow base and broad termen.	B.	A.	B.	C.	A.
	Percentage of archetypic characters present*.	72·5	62·5	17·5	60·0	37·5

*In calculating these percentages, an archaic character present in one wing only, as (2), (3), B, etc., is allowed for as one-half the complete archaic character.

Note on the Evidence concerning the Existence of vein M_4 in the Lepidoptera.

The evidence for the existence of M_4 in the Lepidoptera is not absolutely conclusive, as will be readily gathered from the account of my researches on the *Hepialidae*. The alternative is that the vein here taken to be M_4 is in reality the cross-vein *m-cu*. In the present state of our knowledge, it is impossible to decide finally what is the true state of affairs. My reasons for accepting the presence of M_4, as I have done throughout Sections vi. and xiv., is that the new evidence brought forward in this research seems to me more in favour of that view than the other. The absence of a trachea M_4 in the pupal wing seemed to me for a long time to be almost conclusively against the existence of M_4 in the Lepidoptera. But the small, though very definite, trachea which I found in a pupal wing of *Xyleutes* (Text-fig. 56) tells against this; and it has to be remembered that comparatively *very few* dissections of pupal wings of archaic Lepidoptera have yet been carried out. If the trachea M_4 is present in only 1 per cent. of the wings of *Hepialidae* or *Cossidae*, its existence will nevertheless be a much stronger argument in favour of the presence of vein M_4 than is its absence from the other 99 per cent. for the cross-vein alternative. For it has now to be borne in mind that the existence of vein M_5 could *never* have been proved without the discovery of *Belmontia* or some similar fossil; seeing that, in this case also, trachea M_5 is absent from the early pupal wing, and in most cases, as with M_4, the vein M_5 is reduced to the semblance of a cross-vein.

But there are other strong reasons why the presence of M_4 should be accepted, on the balance of evidence at present. The fossil *Archipanorpa* (Text-fig. 57) shows us a type in which M_4 is reduced to the transverse condition, so that, at first sight, it would appear to be undoubtedly a cross-vein. Yet not only the presence of strong macrotrichia upon it, but also the fact that its fusion with Cu_{1a} is incomplete,—so that it separates from this latter vein further distad, and runs freely to the wing-border,—both prove that it is a main vein in this fossil.

Again, what are we to make of the now famous individual of *Sthenopis*, in which the same state of partial fusion is shown in the hindwing (Text-fig. 55*b*, and Comstock, 15, fig.337) if we will not accept this conclusion? If the upper arm of the Y-vein in this case is the cross-vein *m-cu*, then it must follow that Cu_{1a} is itself a forked vein; for neither of the branches of the terminal fork can belong to M, on this supposition. I do not think that anybody will accept this alternative, and I am unable to suggest any other possible explanation.

The position seems to be this:—that the evidence for the existence of M_4 in the Lepidoptera is not conclusive, but may be accepted provisionally upon the balance of probabilities. The evidence in favour of the cross-vein theory is as complete as it is ever likely to be. But those who support the theory that M_4 is present have all the possibilities of new evidence to count upon, both from further dissections of pupal wings, and from new fossil discoveries which may reinforce the evidence of *Archipanorpa* and *Sthenopis*.

In my researches upon the Jugo-frenata (27), I used the notation *m-cu* for the vein which I here call M_4. The evidence from the pupal wings of *Eriocrania*, on which the notation of that paper is based, is against the presence of M_4, seeing that there is no trachea preceding this vein in the pupal wing. The alteration in the present paper is due to the consideration of much evidence from outside the Jugo-frenata. I should like also to point out that, in both fore and hindwings of the *Micropterygidae* and *Mnesarchaeidae*, and also in the hindwings of the *Eriocraniidae*, the position of this vein is such that it is much more likely to be M_4 than *m-cu*, seeing that the latter, in the Order Trichoptera, is situated either at, or a little basad from, the secondary median fork, *mf'*. Only in the forewings of the *Eriocraniidae* is the position of this vein such that it would naturally be taken for *m-cu*.

A slight correction is necessary in Text-figs. 5 and 6 of the paper here referred to, (27). The dotted line passing transversely from the secondary radial fork *rf'*, to the media below it, should be omitted, since there is no cross-vein in this position.

Throughout Section xiv., the lettering of the Text-figures has been made on the view that M_4 is present, not only in the *Hepialidae*, but also in the rest of the Homoneura, and throughout the Heteroneura. The evidence from the pupal wing of *Xyleutes* (Text-fig. 56) favours this view for the Heteroneura; but, even without that, there can be no doubt that the vein which I have labelled M_4 in the *Prototheoridae* (Text-fig. 83) is the homologue of the vein labelled M_4 in the Heteroneura.

Hence the terminology M_4 must either be accepted throughout the Order, or else it must be altered throughout to *m-cu.*

It is left optional for anybody, who prefers this latter alternative, to reject the account given of the structure and evolution of the Distal Y-vein in Section vi., and to alter the Tables on pp. 650, 706, to suit the new view. The net results of the alteration would be that the *Hepialidae* would have to be regarded as somewhat more highly specialised, the Jugo-frenata slightly more archaic, than the percentages in Table iii. would indicate; and also that the Lepidoptera, as a whole, would be brought slightly nearer to the Trichoptera, seeing that the condition of M *in both wings* of the former will then become the same as that in the *hindwing* of this latter Order.

Suborder **Heteroneura.**

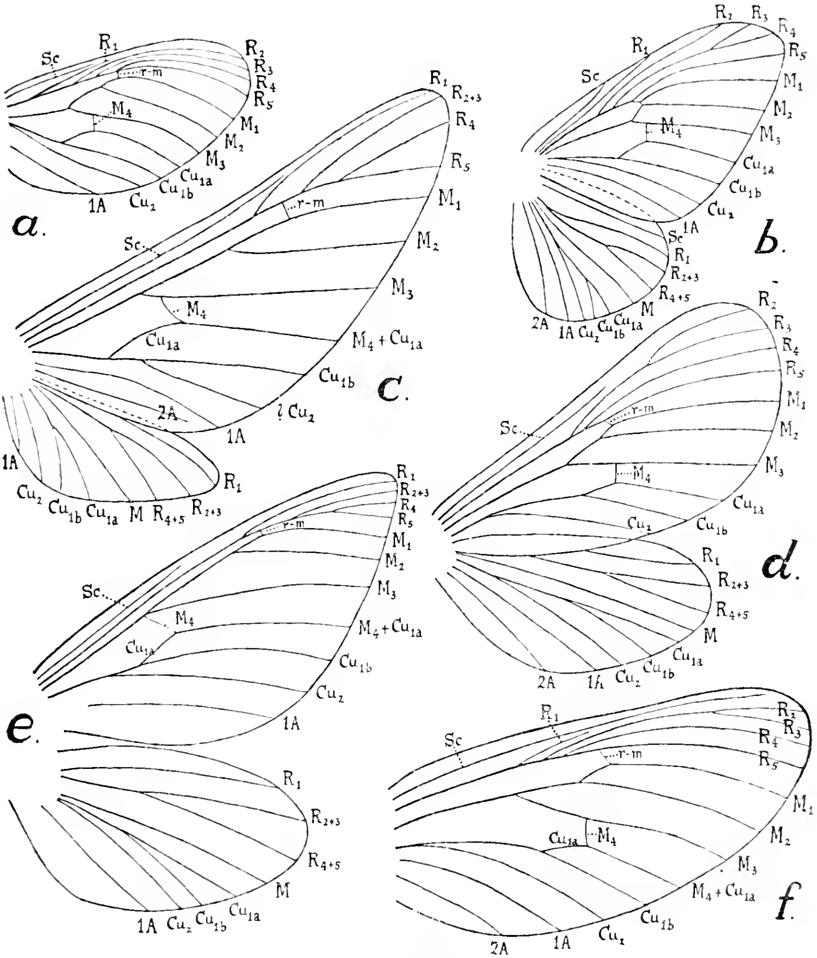
The problem of the evolution of the Heteroneura is a most fascinating one, and vitally concerns us here, in so far as it must be quite evident that no single existing family of the Homoneura at the present day can possibly represent the original stem of the Lepidoptera, from which both Homoneura and Heteroneura, as we know them to-day, arose. All we can be certain of is this:—*that the Heteroneura are derived from a Homoneurous ancestor of which no completely generalised descendant exists to-day.* The task of determining the characters of that ancestor is only to be undertaken by a careful examination of all archaic existing types, together with any fossils known: and the Archetype of the Order must be that type which combines in itself all the archaic features of this ancestor, as well as those of the Homoneura.

That being so, it is necessary here to examine carefully the following groups: (i.) the Jurassic fossil family *Palaeontinidae*, (ii.) the *Cossidae,* (iii.) the superfamily Tortricina, (iv.) the superfamily Tineina, (v.) the *Castniidae,* (vi.) the superfamily Psychina, and (vii.) the superfamily Pyralidina. To these I have added the Butterflies, whose phylogeny is a fascinating problem of its own, as yet unsolved.

The publication of Dr. A. J. Turner's paper on the venation of the *Cossidae* (32) marks a great advance in our knowledge of the phylogeny of the Heteroneura, and I shall not hesitate to refer to it whenever necessary, especially as a previous paper of my own (13) helped to stimulate Dr. Turner in his work, and as this author adopted the main contentions made in it. It will be seen, however, in the course of the present research, that both my previous paper and Dr. Turner's came to certain conclusions which were unwarranted; in my own case, owing to lack of prolonged study of the Order, in Dr. Turner's, inevitably because he confined himself entirely to the imaginal wing-venation, by means of which it is practically impossible to arrive at the truth with regard to certain points. Dr. Turner's paper is of the utmost value, not only because of the detailed comparison of the venations of all the known genera within the *Cossidae*, but also because of the extension of the same method to selected types from all the older families, and because of his definition of the hypothetical ancestors of the Heteroneura, which he calls the family *Protocossidae*,—a name which I shall adopt here. It will therefore not be necessary for me to pass in review a large number of genera, but simply to deal, as far as possible, with those in which I have been able to study the pupal tracheation, and then to compare my results with those obtained by Dr. Turner, by his comparative study of the imaginal venations only.

Family PALÆONTINIDÆ (Fossils only).

In Text-fig. 84, I have reproduced from Handlirsch (2, Atlas, plates xlix., l.) a number of his figures of the best preserved of these fossils. The first of these Jurassic insects to be discovered, and one of the oldest in actual horizon, was *Palaeontina oolitica* Butler (Text-fig. 84, *f*), of which, unfortunately, only the forewing is known. Another interesting type known only from its forewing is *Palaeocossus jurassicus* Opp. (Text-fig. 84, *a*). Besides these, I have figured four genera in which the fore and hindwings are both fairly well preserved. Whether Handlirsch's restorations, which I have reproduced herewith, are correct in every detail, may be a matter of individual opinion. I can only say that, after examining the photographs of the fossils which he also publishes, I cannot see any definite errors in the restorations, though it is perhaps doubtful how far he is justified in restoring the subcosta and radius of the forewings of some of the types on the somewhat abnormal plan that he has sometimes adopted. What is absolutely certain is that those fossils in which the hindwing is preserved were *most certainly not Homoneura*. The hindwings are reduced in size to a level rarely attained, even in highly specialised Hetero-



Text-Fig.84.

Venations of Jurassic *Palaeontinidae*, from Handlirsch, but with lettering added as on p.535. *a*, *Palaeocossus jurassicus* Opp. (x 0·9); *b*, *Limacodites mesozoicus* Handl. (x 0·9); *c*, *Eocicada lameerei* Handl. (x 0.9); *d*, *Prolystra lithographica* Opp. (x 1.2); *e*, *Beloptesis oppenheimi* Handl. (x 1·2); *f*, *Palaeontina oolitica* Butl. (x 0·9) neura of to-day; and the reduction in the number of veins is quite obvious also. It is, therefore, necessary to study, first of all, those types in which the hindwings have been preserved. We shall then be able to compare the *forewings* of those types with the isolated forewings of *Palaeontina* and *Palaeocossus*, in order to determine whether these two latter genera are related to them, or whether, perhaps, they may not be regarded as true Homoneura, not related to the rest.

First of all, then, we must make a comparison of the four hindwings shown, and note the points common to all in Handlirsch's restorations. They all agree in one very remarkable character, viz. that the media is reduced to a single straight vein. As far as I can see, from the photographs given by Handlirsch, there is no doubt on this point. Rs is two-branched in every case; so that it is clear that its two branches may be named R_{2+3} and R_{4+5} respectively. R_1 is present in all; and in at least one case a perfectly separate Sc is also present (*Limacodites*). Cu is three-branched in all cases; and one naturally concludes that these three branches are the homologues of the three branches existing in the Order to-day. (But it may be noted that it would be possible to interpret the vein marked 1A in *Limacodites* as Cu_2 in which case the vein marked Cu_{1a} must be a branch of M captured by Cu^1, as may be seen in many highly specialised forms existing to-day.

The hindwing of the *Palaeontinidae*, then, had the following veins present:—Sc (? sometimes absent), R_1, R_{2+3}, R_{4+5}, M, Cu_{1a}, Cu_{1b}, Cu_2, 1A, 2A (? sometimes absent). This is a possible total of ten veins at the most, out of the thirteen or fourteen that should be present in a truly Homoneurous hindwing. Thus the conclusion is arrived at that the *Palaeontinidae* whose hindwings are preserved are *not Homoneura.*

They must therefore be either (*a*) Heteroneura derived from the same stem as those of the present day, or (*b*) Heteroneurous forms derived from the original Homoneurous stem by an entirely separate line of descent.

Now, as we shall see in our examination of recent Heteroneurous types below, these latter have all been evolved along a single line of descent, from what Turner has called the *Protocossid* ancestral type (32). The method of reduction, in the evolution of that type, has been solely by loss of the branches of Rs, and not by loss of the branches of M. Further, in those highly specialised types in which, after Rs has already become simplified, further reduction leads to loss of branches of M in the hindwing, the main stem of M is always obliterated. Thus there are no known types within the existing Heteroneura which reproduce the condition of the hindwing of the *Palaeontinidae.*

The only conclusion that I can come to is that, although the *Palaeontinidae* in which the hindwings have been preserved are most certainly Heteroneurous, they do not belong to the line of descent from which all our present-day Heteroneura are derived. They must be considered as a separate offshoot from the Homoneura, specialised by reduction of the branches of M in the hindwing, and therefore having left no descendants at the present day, and with no near relatives amongst present-day Heteroneura. Handlirsch, therefore, in arguing in favour of a relationship between these moths and the *Limaeodidae* (2, p. 619), is not on firm ground, and his contention should be abandoned.

We may now return to the study of the family, and consider whether the venation of the *forewings* of those genera in which the hindwings are preserved is sufficiently near to those in which they are not, to justify us in accepting Handlirsch's placing of them all as closely related types.

The answer to this question must undoubtedly be in the affirmative, for the following reasons:—

(1) All the fossil types agree in having the branches of M in the forewing occupying the middle distal portion of the wing, whereas the branches of Rs are crowded up anteriorly, as in the higher Heteroneura of the present day. If we compare this with the condition to be seen in the *Hepialidae* (Text-figs. 81, 82), we see how little justification there is for Meyrick's assertion that "there is little doubt that it (i.e. *Palaeontina oolitica*) belongs to the *Hepialidae*" (17). The forewing of *Palaeontina* is particularly close, in this and most other respects, to that of *Prolystra lithographica* Opp. (Text-fig. 84, *d*), one of the forms in which the hindwing is preserved.

(2) As regards the condition of M_4, there is a gradation from the oblique position, such as is found in the *Hepialidae,* through the intermediate condition seen in *Palaeontina,* to the transverse position seen in *Limacodites* (*b*) and *Prolystra* (*d*). Of all the forms figured, the most archaic condition of M_4 is to be seen in

Eocicada (*c*) which, in the extreme reduction of its hindwing, is the most heteroneurous form of all.

(3) As regards the manner of branching of Rs in the forewing, this comes closest to that of the *Hepialidae* in *Prolystra* and *Palaeontina;* but in the former of these R_1 is missing, and in the latter it is much reduced. Both, then, stand in advance of the *Hepialidae.* In the other genera, the method of branching of Rs, if correctly restored, is highly specialised, and most certainly not of the Hepialid type.

(4) In the forewings of all the genera, Cu_2 is a complete vein, whereas it is reduced in *Hepialidae.* Further, *Eocicada* shows the unique specialisation of having Cu_2, moved distad beyond the secondary cubital fork, an extraordinary character which at once places this genus as far removed from *any* existing type of Lepidoptera.

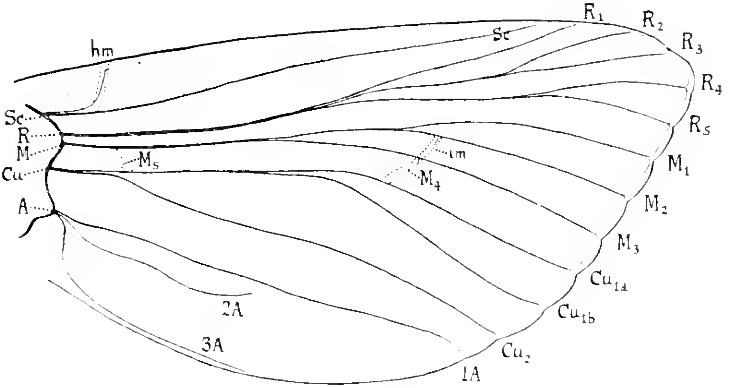
The forewing of *Palaeocossus* (Text-fig. 84, *a*) seems about as closely allied to that of *Prolystra* (*d*) as is that of *Palaeontina;* but it differs from both these latter in having lost the original dichotomic manner of branching of Rs.

To sum up, then, it would appear that the Jurassic *Palaeontinidae* form either a family, or a group of allied families, of distinct heteroneurous venational type, but not related to any existing Heteroneura. They are best regarded as a special line of development from the old Homoneurous stem of the Order, which have died out without leaving any direct descendants at the present day. They should not be included in the Heteroneura as at present defined, but may be regarded as an isolated side-branch, under the name Palæontinoidea.

Family COSSIDÆ.

This family includes both the *Zeuzeridae* and the *Cossidae* (or *Trypanidae*) of some authors. Turner has done a valuable service in establishing the essential unity of these two groups, which Meyrick, for instance (3), placed widely apart on very insufficient grounds. The venational schemes of all the known genera are figured in Turner's fine paper (32).

For the study of this family, I have to thank Mr. Luke Gallard for a large supply of larvæ of the two genera *Xyleutes* and *Culama.* Unfortunately I did not succeed in keeping any of the latter alive until they pupated, although I had them for



Text-Fig.85.

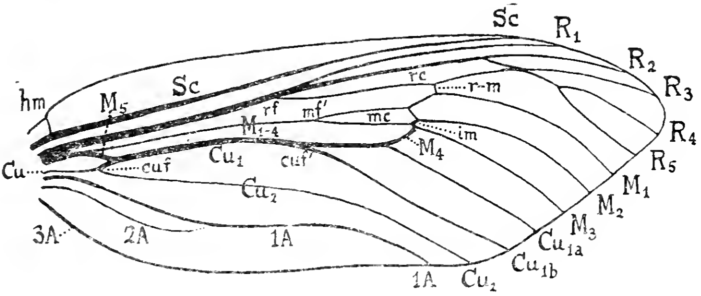
Tracheation of forewing of freshly formed pupa of *Xyleutes eucalypti* (Scott). (x 3·3). Lettering as on p.535.

some months. Of the former I obtained and dissected several pupæ, with very interesting results.

Text-fig. 85 shows the tracheation of the forewing of a pupa only a day or two old. The resemblance of this wing to that of the *Hepialidae* is very striking, and is the more noteworthy when we consider how very different the imaginal forewings of these two families appear. Comparing *Xyleutes* with *Leto* (Text-fig. 80), we note that the tendency towards the splitting-back of the tracheæ is much more marked in the latter (and in all *Hepialidae*), and that the former is the more archaic in having trachea Cu_2 of full length. The subcostal veinlet is supplied, in both forms, by a special trachea arising alongside Sc. In *Xyleutes* there is a well-marked series of branch-tracheæ arising from Sc and proceeding towards the costal border. Similar tracheæ can be seen in the pupæ of many large Lepidoptera, but in none are they so well developed as in this family. I have figured them here in order to call attention to the obvious fact that, if veins were to be formed over the courses of these tracheæ, there would result the original condition of a complete set of costal veinlets, such as has been preserved in the Megaloptera and Planipennia at the present day. As long as these tracheæ still exist in the pupæ of Lepidoptera, can anyone deny the possibility of the evolution of a new line, in which these costal veinlets might be restored in their entirety; supposing that some other change, such as loss of scales in a clear-winged form, might make such a restoration of value to the species?

The forewings of *Xyleutes* and the *Hepialidae* also agree in the absence of the cross-vein *ir* and the presence of *im.* But they differ in the details of the forking of Rs. In *Hepialidae,* the original condition seen in *Belmontia* (Text-fig. 63) and all archaic Trichoptera is retained, viz., that R_{4+5} forks close to *rf'*, R_{2+3} much more distad from it. In *Xyleutes,* the latter trachea forks at a level slightly nearer *rf'* than does the former; and this difference is greatly increased in the imaginal venation (Text-fig. 86). In the pupal wing of *Xyleutes, rf'* lies only just distad from *rf;* but Rs remains separate from R_1, though very close to it. In the imaginal wing, a slight fusion of the basal part of Rs with R_1 takes place, resulting in the appearance of R_{2+3} and R_{4+5} arising as slightly separated from one another upon R_1. This formation is of great interest, since it is a very clear illustration of the manner in which *two apparent radial sectors* can be evolved from the original single one. Similar formations may be seen in many families of Lepidoptera; and, in some cases, notably the Butterflies, the change has extended to the pupal tracheation, and has become a fixed character there. Carried to its fullest extreme, the same character may be seen in the pupal and imaginal wings of the family *Hemerobiidae* (Order Planipennia).

In the pupal forewing of *Xyleutes*, R_{2+3} and R_{4+5} remain



Text-Fig.86.

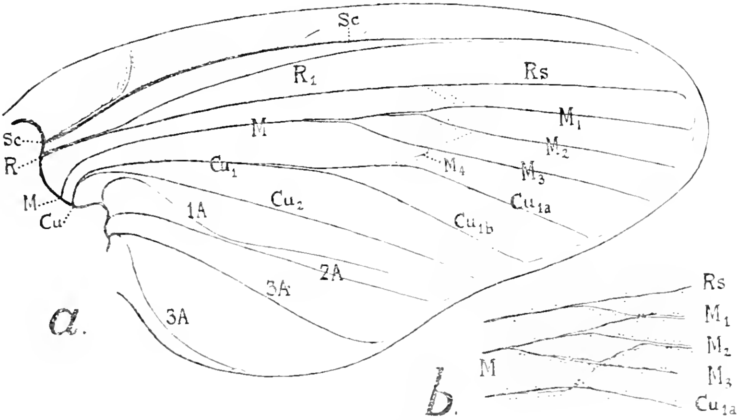
Venation of forewing of *Xyleutes eucalypti* (Scott), imago (x 0·8). Lettering as on p.535.

separate throughout their lengths. In the corresponding imaginal wing, the radial cell or aerole (*rc*) becomes closed distally by a slight fusion of R_{4+5} with R_3 (Text-fig. 86). The original method of fusion of this cell, by means of the cross-vein *ir* (absent in *Xyleutes*) is still to be seen in the more archaic Cossid genus *Macrocyttara* (Turner, 32, p. 169, fig. 22), but this genus has R_{2+3} and R_{4+5} arising more widely apart from R_1 than in *Xyleutes*.

The vein M_5 appears early in the pupal wing of *Xyleutes*, and a trachea of great strength grows out into it either in late pupal life or at metamorphosis. In the imago, this vein remains primitive, in so far as it is not completely aligned with Cu_1; it also becomes of immense size in comparison with the weak main stem of Cu below it (Text-fig. 86). Cu_2 remains a complete vein, though not strongly formed; and the small basal piece of Cu_1 is clearly to be seen as a fairly strong vein.

In one pupa which I dissected, a very definite trachea M_4 was found in both wings. This formation is figured and discussed more fully in Section vi., p. 586. The other changes in the regions of M, Cu and the anal veins can be easily gathered by comparing Text-figs. 85 and 86.

The pupal hindwing of *Xyleutes* (Text-fig. 87) differs, of



Text-Fig.87.

Tracheation of *a*, hindwing of freshly formed pupa of *Xyleutes eucalypti* (Scott). (x 3·3); *b*, tracheation in the region of the discocellulars, in a more advanced pupa. Lettering as on p.535.

course, very materially from that of the *Hepialidae*. The essential points to be noted are the following:—

(1) R_1 gradually approaches the stronger trachea Sc, and fuses with it distally. The result, in the imago, is the formation of a single strong vein $Sc+R_1$ distally, continuing the line of Sc basally; while the basal part of R_1 itself appears as an oblique vein considerably shorter in length than its corresponding trachea in the pupa. Thus "vein 8" of systematic Lepidopterists is proved to be a composite vein, $Sc+R_1$*; and I was in error in my previous paper (13) in calling this R_1. It should be noted that, while this formation is to be found in the hindwings of *all* Heteroneura, nevertheless the share taken in the formation of the vein $Sc+R_1$ by its two components differs very greatly in different families; see, for instance, *Wingia* (Text-fig. 90), in which R_1 is dominant, and *Euschemon* (Text-fig. 99), in which Sc is dominant.

(2) Rs is a single unbranched trachea. This is the condition to be found in the early pupæ of all the older Heteroneurous types. Later on in pupal life, it frequently happens, as in *Xyleutes* itself (Text-fig. 87, *b*), that a trachea of small calibre grows out from Rs towards M_1, traversing the cross-vein *r-m*. This is correlated with the outgrowth of other tracheæ along the cross-vein *im* and the vein M_4, so that the zig-zag veins that are destined to form the distal termination of the basal cell (called collectively the *discocellulars*) become well supplied with tracheæ, by invasion of the region of M both above from Rs and below from Cu_{1a}.

(3) 1A loops up strongly towards Cu_2, but does not quite succeed in fusing with it. The condition is, however, very similar to that seen in the Homoneura, and the failure to complete the fusion may well be due to the very evident increased breadth of the anal area in this wing. In the narrower wing of *Wingia* (Text-fig. 90), the fusion is completed.

(4) After diverging from Cu_2, 1A approaches 2A towards the middle of its length, and fuses with it for a short distance, afterwards becoming of weak calibre, diverging slightly away from 2A, and failing to reach the wing-border. The result of this, in the imaginal venation (Text-fig. 88) is a small basal Y-vein formation, not easy to make out in *Xyleutes*, but evi-

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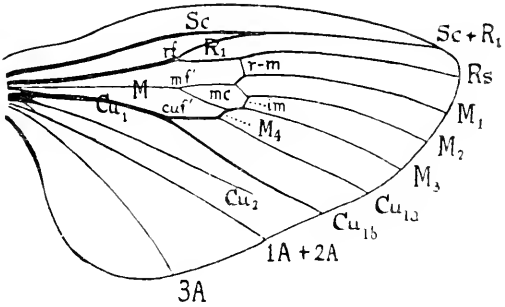
*This specialisation was pointed out by Comstock and Needham as long ago as 1899 (14).

dently closely analogous to the single anal loop or Y-vein of the forewings. It is, however, important to notice that, in the forewing, 1A is the dominant member of the Y-vein, while 2A is reduced. In the hindwing, the reverse is the case. The importance of this formation lies in the fact that it occurs throughout the Superfamily Tortricina, and thus affords a striking proof of the very direct descent of that group from the base of the Cossid stem. This small basal Y-vein is also to be seen in a few Tineina (*Taleporia*, *Adela*, *Wingia*, *Acompsia*), in the *Castniidae* and *Thyrididae*, but is eliminated in the majority of the Tineina and Pyralidina, as well as from all the Psychina and the Butterflies.



Text-Fig.88.

Venation of hindwing of *Xyleutes eucalypti* (Scott). (x 0·8). Lettering as on p.535.

At metamorphosis, there is a great increase in the calibre of the veins at the base of the wing. The basal formations, such as M_5, the approach of 1A to Cu'_2, and the fusion of 1A with 2A, become withdrawn very close to the actual wing-base, and partially lost in the copious deposition of vein-chitin there laid down. An examination of the underside of a carefully descaled wing is necessary to reveal their presence. It will be seen that, in most Heteroneura, the presence of these archaic formations becomes more and more masked as specialisation proceeds, until they become practically obliterated in the higher groups, first in the hindwing, in which they are never so conspicuously developed as in the fore, and then in the latter also.

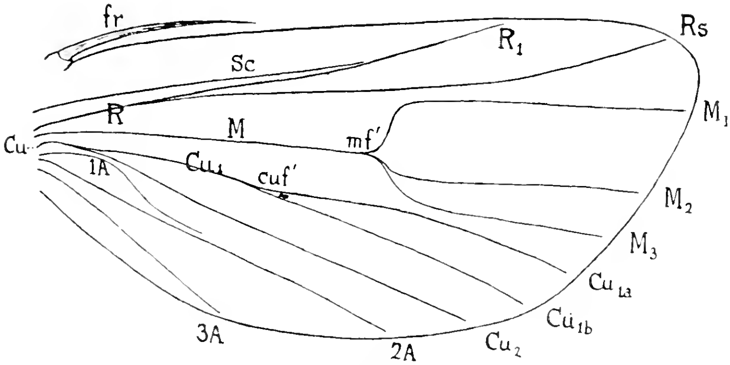
Superfamily TORTRICINA.

The Codlin-moth, *Carpocapsa pomonella* (Linn.) afforded me a plentiful supply of pupæ for this group. The pupa being small, and the wings delicate, the dissections were not at all easy.

The basal tracheation of the pupal forewing is shown in Plate xxxiv., fig. 22. It differs very little from that of *Wingia* (Text-fig. 90), so that there is no need to figure the whole wing separately. The principal differences are that, in the forewing of *Carpocapsa*, the stem of R_{4+5} persists at metamorphosis, so that the basal cell and radial cell or areole remain separate (a more archaic condition than that seen in *Wingia*); that Cu approaches basally so close to M that the formation of the separate vein M_5 is prevented (in *Wingia*, the formation of this vein can just be made out in the early pupa); and that there is no kink in 1A at the point where 2A fuses with it.

In discussing the evolution of the cubito-median Y-vein (Section iii.), it was pointed out how all the successive stages of specialisation, leading to the obliteration of M_5, and finally to a definite fusion between Cu_1 and M_{1-4}, could be seen in a single Order, or even in a single family, such as the *Rhyacophilidae*. The same line of advance is here made evident within the Heteroneura, the stage shown in *Carpocapsa* being closely equivalent to that indicated as the last stage (Text-fig. 42 *d*) in the Order Trichoptera. But there is one important difference, viz. that the fusion in *Carpocapsa* takes place, not between M_{1-4} and Cu1, but between M_{1-4} and the main stem of Cu. This is not due to any movement of the cubital fork distad, for it is quite evident that this fork itself is migrating basad (and, indeed, in many advanced Heteroneura, trachea Cu_2 may be so far split back from Cu_1 as to originate separately from it on the alar trunk); but it is due to the general tendency for the basal formations as a whole to move closer to the base of the wing in this Suborder, and is part of the whole line of evolution by which, in the end, all those basal specialisations which no longer serve any useful purpose become obliterated.

The tracheation of the pupal hindwing of *Carpocapsa* is shown in Text-fig. 89, for the special purpose of illustrating (*a*) the dominance of R_1 over Sc, as in the Tineina, and (*b*) the further weakening of 1A, and the dominance of 2A in the formation of the anal Y-vein. We may note also the close



Text-Fig. 89.

Tracheation of pupal hindwing of *Carpocapsa pomonella* (Linn.), showing weakened condition of 1A. (x 25). Lettering as on p.535.

approximation of trachea M_3 to trachea Cu_{1a}, resulting in the complete obliteration of the remnant of M_4 between them, and the association of the two corresponding veins together, as connate veins arising from the lower angle of the cell in the imaginal hindwing.

As I have made a very complete study of the obliteration of the main stem of M in the case of *Wingia* (see below, p. 669), it is only necessary to say here that *Carpocapsa* agrees with *Wingia* in this and many other respects, which need not be detailed here.

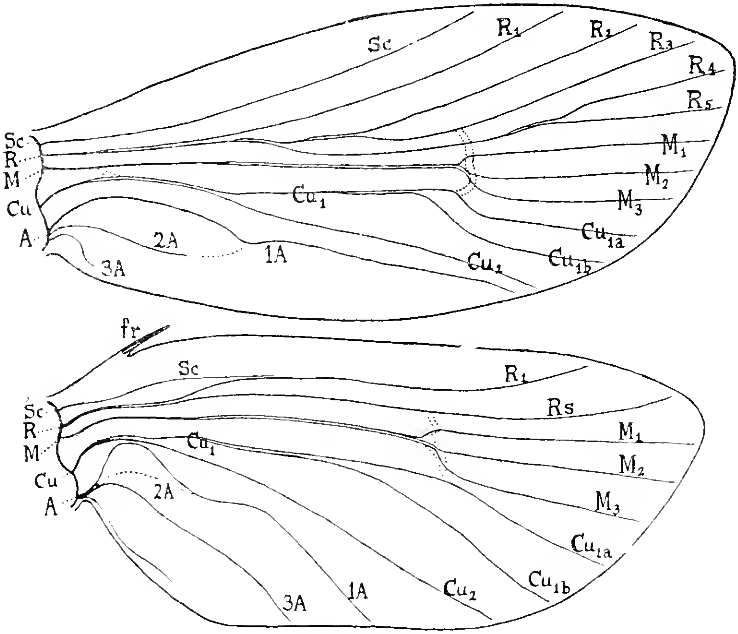
In the imaginal forewing the course of Cu_2 is barely indicated, while in the hindwing it is very weakly chitinised. The tendency throughout the Suborder is for this weak concave vein to become, firstly a mere furrow or groove, without definite chitinisation, and then to be completely eliminated. Contrast *Wingia* (Text-figs. 90, 93), which is more archaic than *Carpocapsa* in this respect, with *Euschemon* (Text-figs. 99, 100), which is more specialised.

The descent of the Tortricina from a Cossid-like ancestor is, I think, very obvious. But, since all those Tortricina, in which the radial cell (areole) is closed, have the closure brought about in the most archaic manner, viz. by the interpolation of the cross-vein *ir*, it is clear that the group is not, as a whole, derivable directly from the *Cossidae*, but rather from Turner's hypothetical ancestral family *Protocossidae*.

Superfamily TINEINA.

In this great group, thanks to the kindness of my friend, Mr. G. Lyell, I was well supplied with pupæ, especially in the cases of the more archaic families *Plutellidae* and *Oecophoridae*. A large number of pupæ belonging to the genera *Wingia, Coesyra, Heliocausta, Cebysa* and *Tinea* were dissected. In the case of *Wingia lambertiella*, Mr. Lyell supplied me with a very long series of well-fed larvæ, and pupæ in all stages; so that I was able to study, in this species, the changes that take place during pupal life, and at metamorphosis, in greater detail than in any other case.

This beautiful moth belongs to the family *Oecophoridae;* its larvæ spin the leaves of Eucalypts together, and pupate inside a thick, white, silken web or tunnel.



Text-Fig. 90.
Tracheation of wings of freshly formed pupa of *Wingia lambertiella* (Wing.), (fam. *Oecophoridae*), (x 8). Lettering as on p. 535.

Text-fig. 90 shows the tracheation in the wings of a freshly turned pupa of *Wingia*. These wings are very delicate, and, being somewhat small, require very careful dissection. Later in pupal life, they become very tough, and can be easily removed from their sheaths without any damage. The late pupal wing can be cleared in chloro-phenol, the tracheæ remaining unshrivelled for some time, even under this strong reagent.

The points to be noted in the early pupal wings are as follows:—

(1) Trachea M is far removed from trachea Cu at its origin, and belongs properly to the costo-radial group.

(2) The three anal tracheæ come off close together in a bunch, far removed from Cu.

(3) All the branch tracheæ are split back very far towards the bases of the main tracheæ to which they belong, so that the actual point of origin of any given branch trachea is situated very much further basad than is the true fork which corresponds to it in the imaginal venation. (This character is to be noted in all Lepidopterous pupæ, to a greater or less extent, but is particularly marked here.)

(4) R_{2+3} divides near the middle of the wing, R_{4+5} much further distad. In the *Hepialidae*, the reverse is the case, as also in the Trichoptera.

(5) M and Cu_2 are complete tracheæ, not reduced in either wing.

(6) In forewing, there is a kink in the course of 1A, indicating the point at which, in the imaginal venation, 2A will loop up with 1A. But trachea 2A does not reach this point, as it stops considerably short of it.

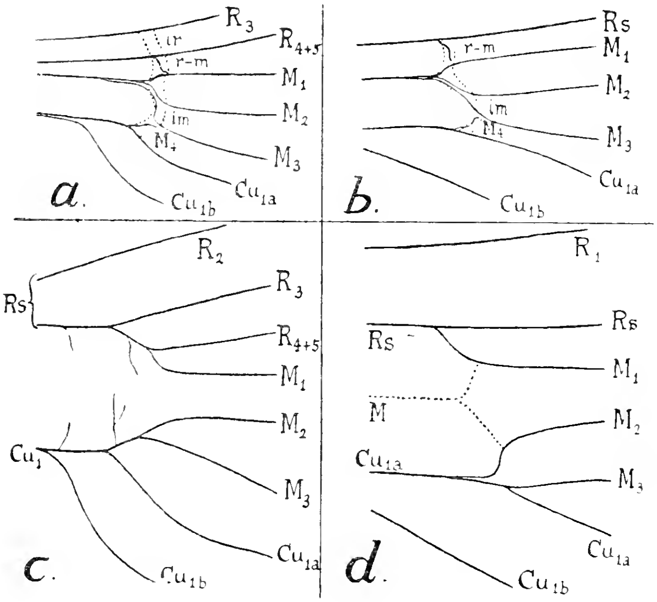
(7) In hindwing, Rs is a simple trachea, and Sc is much reduced, its distal end lying close alongside R_1.

(8) In hindwing, 1A makes a large upward loop, so as to come into contact with Cu_2 not far from its origin. (Compare the condition of these two tracheæ in *Hepialidae*.)

(9) In hindwing, trachea 2A is aborted, the course of the vein in the imaginal wing being indicated only by a pale band, represented by a dotted line in Text-fig. 90.

In Text-fig. 90, I have indicated by dotted lines the positions of M_5, the distal closure of the basal cell, and the completion of the looping-up of 2A on to 1A, although these are not clearly apparent until the pupa is more than a day old. They arise as part of the pale banding which foreshadows the imaginal venation.

The principal changes which take place during pupal life are those which affect the *discocellulars,* at the distal end of the basal cell. Text-fig. 91 shows the condition in a pupa ten days old. A small trachea grows out from R_{4+5} in forewing, or Rs in hindwing, down towards M_1, while another grows out from Cu_{1a} up towards M_3. Just before metamorphosis, these tracheæ are still only quite small. But, during metamorphosis, they capture the respective tracheæ towards which they have been growing; so that, in the freshly-emerged imaginal wing, as soon as it is fully expanded, the condition is that shown in Text-fig. 91, *c, d.* Thus M_1 becomes completely hitched on to



Text-Fig.91.

Details of the changes in the tracheation in the wings of *Wingia lambertiella* (Wing), (fam. *Oecophoridae)* in the region of the discocellulars; *a*, forewing, *b*, hindwing, of late pupal stage; *c*, forewing, *d*, hindwing, of freshly emerged imago. (x 15). Lettering as on p.535.

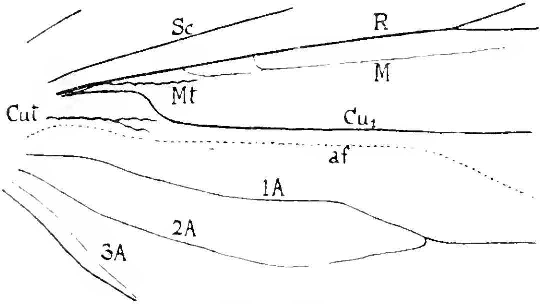
R_{4+5} in forewing, or Rs in hindwing, *at metamorphosis;* while M_3 likewise becomes hitched on to Cu_{1a}.

Moreover, the whole of trachea M becomes aborted at metamorphosis, so that M_2, is cut off from its original source of supply. In the fresh imaginal wing, this trachea is seen to have become hitched on to M_3 in the forewing, but on to Cu_{1a} in hindwing. This must evidently be effected by the outgrowth of a small trachea such as that which captured M_3, though this outgrowth did not begin to appear in the late pupa, and must have developed during metamorphosis.

The final result, in the forewing, is that no part of the true main stem of M, either trachea or vein, is visible at all. In the hindwing, however, a delicate groove indicates the position of M, together with its forking into two distally. This is shown by a dotted line in Text-fig. 91, *d*.

A further remarkable change at metamorphosis is the complete abortion of the stem of R_{4+5}, both trachea and vein, in the forewing, as far as the inter-radial cross-vein *ir*, which is present in *Wingia*, as also in *Carpocapsa* and all archaic Tortricina and Tineina. The manner in which this is brought about can be seen from Text-figs. 91, *a*, *b*. It has already been mentioned that, during pupal life, a small trachea grows out from R_{4+5} in the forewing towards M_1. This small trachea traverses the cross-vein *r-m*, which appears quite early in pupal life, with the rest of the imaginal venation. Above this cross-vein, and in line with it, the cross-vein *ir* is also to be seen in the pupal wing, and it is this cross-vein which furnishes the channel for the greater change at metamorphosis. For, at that time, a further trachea grows out from R_3 along *ir*, and captures both R_{4+5} and its already attached M_1; while, at the same time, the trachea R_{4+5}, basad from *ir*, shrivels up,—the final result being as shown in Text-fig. 91, *c*.

Turner (32, p. 172) has already pointed out, from a study of the imaginal venation only in the Tortricina, that the large basal cell is really a composite structure, formed from both the true basal cell and the areole or radial cell; to this composite cell he has given the name *areocel;* while the basal part of R_{4+5}, which separates the true basal cell from the areole, and by the elimination of which the areocel is formed, is called by him the *chorda*. What he has failed to emphasise is the fact that the cross-vein *ir* is present, and forms the boundary of the areocel between R_3 and R_{4+5} (in *Wingia*), or, in those cases where the latter is not stalked beyond the areocel, between R_3 and R_4 (as in *Carpocapsa*). Unless this cross-vein had been present, to furnish the channel along which the new trachea grew out from R'_3, no areocel could have been formed. Thus we are bound to conclude that the cross-vein *ir* was present in the ancestral forms of the Tortricina and Tineina.*



Text-Fig.92.

Details of tracheation of the imaginal forewing, freshly emerged, of *Wingia lambertiella* (Wing), (fam. *Oecophoridae*). (x 11). Note the shrivelled median trachea *(Mt)* and cubital trachea *(Cut)*. Lettering as on p.535.

Another striking change at metamorphosis in *Wingia* is the complete and quite sudden switching off of the trachea Cu_1 near its point of origin on Cu, across to M, via M_5. In the latest pupal wings which I examined, I could find no trace of a trachea in M_5, though I looked carefully for it. But, in the fresh imaginal wing, a strong trachea proceeds from the base of M, curving down along M_5 (which, in this moth, is not at all well aligned with Cu_1), and supplying Cu_1 right to its ends. Above this trachea could be seen the shrivelled remnant of trachea M_{1-4}, while two much finer tracheæ, proceeding from R, more or less followed the line of M distad from it (Text-fig. 92). Below M_5, the remnant of trachea Cu was plainly visible, with its original dichotomy into Cu_1 and Cu_2, the former still exactly in line with

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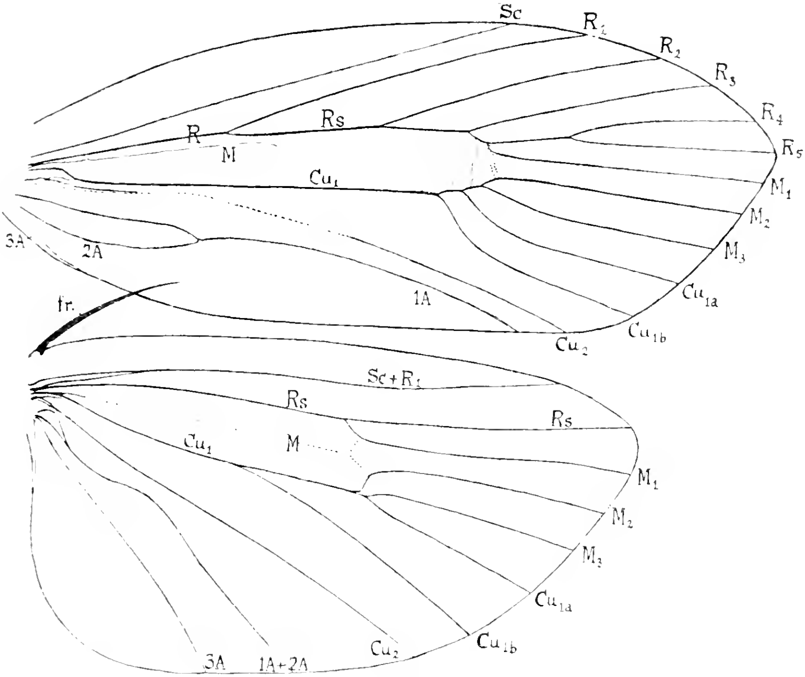
*Further proof of this fact is to be found in the existence of a number of genera, in both these superfamilies, in which the areole or radial cell is retained in its entirety, and in every such case this cell is closed by *ir*. (*See* Turner, 32, figs.24-30).



Text-Fig.93.

Wingia lambertiella (Wing), (fam. *Oecophoridae*). Tracheation of freshly emerged imaginal wings. (x 6). Lettering as on p.535.

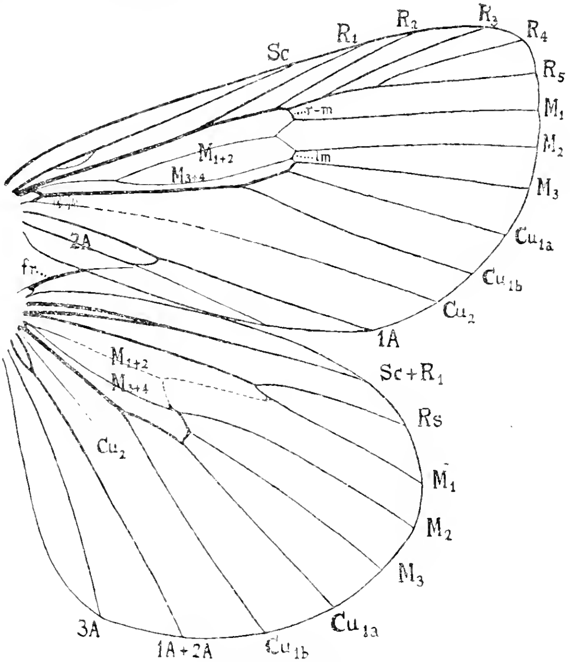
the continuation of Cu$_1$ beyond the bend formed by M$_5$. It should also be noted that, in the forewing, Cu$_2$ becomes aborted through the breaking of its connection with trachea Cu. In the wing from which Text-fig. 92 was drawn, a little piece of this trachea remained near the base, and a longer piece distally. The chitinisation of the vein Cu$_2$ in both wings, and of the anal veins in the hindwing, is very weak.

In Text-fig. 93, the actual venation is omitted, the figure being intended to show the courses of the *tracheae*. The veins themselves are stout, especially Sc in forewing. They enclose all the main tracheæ and their branches, and also complete the basal cell distally, and the anal loop in the forewing.

Family CASTNIIDÆ.

This family is only represented in Australia by the genus *Synemon.* The genus *Euschemon,* originally placed in it, is clearly, both from its venation and its life-history, far removed from the *Castniidae,* and will be dealt with in this Part under the *Hesperiidae,* to which it properly belongs.

Text-fig. 94 gives a diagrammatic representation of the venation of the genus *Synemon,* with all the archaic characters found in the various species included in the one figure. The very large and handsome *S. directa* Walk., from Western Australia, was found to possess the largest number of archaic features; so that its venation approaches very closely to that of the figure. In this species, however, there is no anal Y-vein in the forewing, and 2A runs separately to the wing-border, as shown by a dotted line in the figure.



Text-Fig.94.

Diagram to show venation of the genus *Synemon,* containing the more archaic features selected from several different species. Lettering as on p.535.

Great efforts were made to secure larvæ and pupæ of this genus, but were frustrated by the severe drought of last summer. My thanks are due to Mr. E. J. Dumigan for a large supply of fresh imagines of a small (undetermined) species from South Queensland, and to Mr. G. Lyell for named examples of several species, including Western Australian forms.

The pupal tracheation probably does not differ very much from the venational scheme given in Text-fig. 94. The media is complete in both wings; and, as in the *Hepialidae,* the point *mf'* is placed close to the base of the wing. The stalked arrangement of the branches of Rs in the forewing is a specialisation peculiar to *Synemon;* the genera *Castnia* and *Gazera* have the usual dichotomic arrangement, with the radial cell, or areole, closed by the cross-vein *ir,* as figured by Turner (32, p. 175). Important specialisations are to be noted in the following points:—

(1) M_5 can just be made out as a very short vein at the base of the forewing, but appears to have become completely suppressed in the hind.

(2) In both wings, M_1 has moved a considerable distance away from M_2, and has evidently been captured by Rs, through the outgrowth of a special trachea along *r-m.* (Cf. *Wingia,* p. 669). The importance of this will become more evident when we come to consider the next two groups.

(3) In the hindwing, there is a small basal Y-vein, formed by the fusion of 1A and 2A, as in *Carpocapsa* and other Tor--tricina.

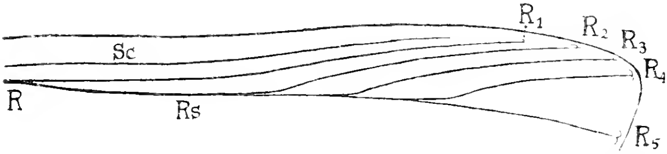
The peculiar form of the basal cell of the hindwing, which remains incomplete and of very irregular shape, is very noteworthy, and shows that this family is far more archaic than the Tortricina and Tineina in this respect.

Taking all these points into consideration, it must be clear that the conclusion of Handlirsch, Turner and others, that this family stands far apart from other Lepidoptera, and is only to be derived as an isolated line of development from the original ancestor of the Heteroneura, is fully justified. The venational scheme shows no possible avenue by which the Butterflies could have evolved from this family; and we can only conclude that the adoption of the day-flying habit, and the correlated development of clubbed antennæ, have been independently gained in the two groups.

Superfamily PSYCHINA.

We come next to a group of rather archaic Heteroneura, in which at least one main branch of M is retained within the basal cell, but the radial cell of the forewing is completely obliterated, and M_1 has become permanently attached to Rs in the hindwing, not only in the imaginal venation, but also in the pupal tracheation.

The families included in this group are the *Limacodidae, Zygaenidae, Megalopygidae* and *Psychidae.* Each family is itself specialised in a very definite direction; but I selected the *Limacodidae* as probably the most archaic, and, at the same time, the easiest (in Australia) in which to obtain plentiful supplies of pupæ. Unfortunately, out of about sixty cocoons of this family collected in 1917-18, not a single larva has so far pupated, although they remain perfectly healthy within them. The reason is probably to be found in the severe drought of last summer. I have, therefore, to be content with dissections of pupæ of the genera *Doratifera* and *Apoda* made in 1917, at a period before I was fully aware of the importance of drawing the basal connections carefully.



Text-Fig.95.

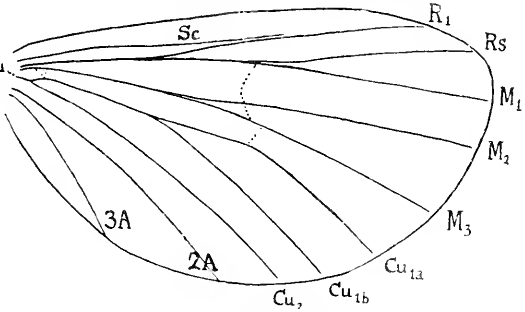
Tracheation of the radial sector in pupal wing of *Doratifera longerans* (Walk.), (fam. *Limacodidae*), to show the transference of R_3 from R_{2+3} across to R_{4+5}. (x 10½). Lettering as on p.535.

The condition of trachea Rs in the forewing of the *Limacodidae* is shown in Text-fig. 95. It will be seen that R_3 has migrated across from R_{2+3} to R_{4+5}, thus automatically preventing the formation of the typical archaic radial cell or areole. In the imaginal venation, this new condition is preserved intact, and the point of origin of R_3 moves even further distad along R_{4+5}. As the condition of Rs in the other families of this group is closely similar to this, it will probably be found to be due to the same cause, when their pupal wings come to be examined.

Text-fig. 96 shows the hindwing of a fairly advanced pupa of

Doratifera longerans. There can be no doubt here that trachea M_1 has become permanently attached to Rs. The dotted lines indicate the position of the veins closing the basal cell in the imago. The only changes at metamorphosis are the much more complete fusion of Sc and R_1,—a fusion which also involves a part of the base of Rs,—and the drawing together of the two main branches of M, so that a single vein M traverses the cell from one end to the other.

The basal Y-vein formed by 1A and 2A in the hindwing is absent in *Doratifera.* A reference to the pupal tracheation shows that this must have been brought about by abortion of trachea and vein 1A, since the only trachea present does not arch upwards towards Cu_2, and must therefore be 2A.



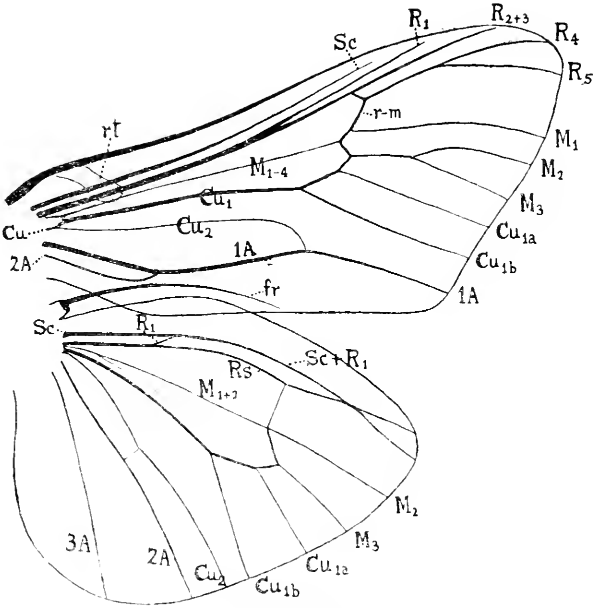
Text-Fig.96.

Tracheation of pupal hindwing of *Doratifera longerans* (Walk.), (fam. *Limacodidae*). (x $9\frac{1}{2}$). Lettering as on p.535.

The tracheation of the pupal wings of *Apoda* agrees closely with the above, but trachea Sc in the hindwing is shorter.

Of the *Zygaenidae* I have, unfortunately, been unable to obtain any pupæ in a suitable state for dissection. The *Megalopygidae* do not occur in Australia. But it has been shown by many authors, without any doubt, that both these families are closely related to the *Limacodidae;* so that we may reasonably assume that the pupal tracheation will not differ very greatly from that of this latter family.

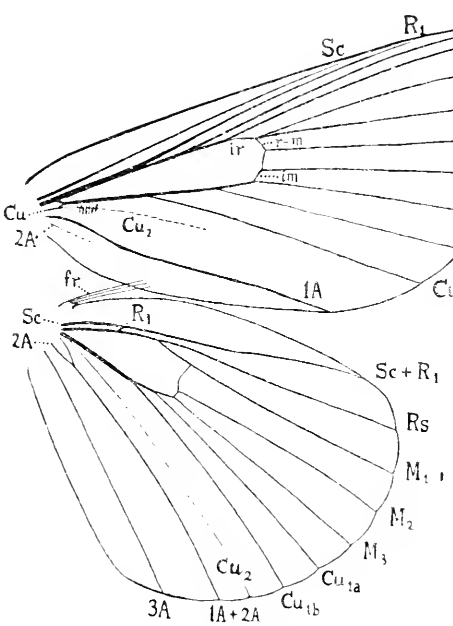
The *Psychidae* appear to be the most highly specialised family, because of their lack of scales, their extraordinary life-history, and the great differentiation between the small, swift-flying males and the huge, larviform, wingless females. The venation is correspondingly specialised, M_1 having apparently been com-



Text-Fig.97.

Clania tenuis Rosen. (fam. *Psychidae*), imaginal venation, (x 7). Lettering as on p.535. Note the cross-vein joining Cu_2 with 2A in hindwing, and the fusion of Cu_2 with 1A in forewing.

pletely eliminated from the hindwing; while, in the forewing, there is a unique specialisation in the form of a union of Cu^2 with 1A, well beyond the anal Y-vein. The frenulum in this family is enormous, and the retinaculum is developed from just below the thickened costa of the forewing, as shown in Text-fig. 97. In this same figure it will be seen that there is a cross-vein joining Cu_2 with 1A. If this be really the archaic *cu-a*, it is an extraordinary thing that it does not occur anywhere else in the Lepidoptera, and not even in other genera of the *Psychidae*, as far as I know. I have, therefore, decided to treat this formation as a unique specialisation, which will not affect the archetypic characters of the Order. It looks as if the hindwing had undergone extreme alteration of shape; and that, during the widening of the anal area, Cu_2 and 1A, probably originally more or less approximated in part, had been drawn away from one another,



Text-Fig.98.

Rhodoneura scitaria (Walk.), (fam. *Thyrididae*), imaginal venation (x 4½). Lettering as on p.535. Note the small basal Y-vein formed by 1A and 2A in hindwing.

with the formation of a cross-vein between them at the point of original greatest approximation.

Superfamily PYRALIDINA.

This group contains the *Thyrididae*, *Pyralididae* (s. lat.) and the highly specialised offshoots of the latter. Undoubtedly the most archaic family is the first-named. An attempt to obtain pupæ of the genus *Rhodoneura* from North Queensland met with no success, very little being known about the life-history of these moths. I have to thank Mr. G. Lyell for a small supply of imagines of this genus and the allied *Addaea*.

The advance made by this group over the last is very evident, in that the basal cell is now for the first time cleared of all traces of M in both wings,* and a definite form of wing, with regularly radiating veins from the cell as a common basis of origin, is firmly established. There is a peculiarity of the *Thyrididae* which is worthy of note, viz., that the splitting back of the branch tracheæ, originally only a specialisation of the *pupal* wing, has reacted on the imaginal venation also, thus throwing back the origins of most of the branch veins to points nearer the base than they were in the ancestral condition. This is well seen in Text-fig. 98, and is the principal cause of the comparative shortness of the basal cell in this family and its relatives, as compared with other groups. Compare, for instance, the type of cell found in the Butterflies (Text-figs. 99-102) with that of the *Thyrididae,* and there can be no doubt which of the two comes closest to the original condition, as regards size.

In the hindwing of *Rhodoneura,* 1A and 2A are fused together very close to the base to form a small Y-vein. The vein below this is the true 3A, homologous with that of the *Cossidae* and the Tortricina.

Unfortunately I have not dissected any pupæ of *Pyralididae,* though the family is abundant enough in Australia. In attempting to keep this research down to a reasonable level, I had to confine myself to studying only the more archaic families. Having failed to obtain pupæ of the *Thyrididae,* it will now be necessary to turn to those of the *Pyralididae* for the elucidation of a very important point, viz. the manner in which the arrangement of the branches of Rs in the imaginal forewing has been brought about. This piece of research must be left for a future occasion; for, as far as I know, no descriptions of the pupal tracheation of the *Pyralididae* have yet been published.

The importance of this question is due to the fact that the relationships of the Pyralidina to the Psychina, on the one hand, and to the Butterflies on the other, depend very greatly upon the answer. For, as we have already shown on p. 674, the condition of Rs in the *Psychina* is one in which R_3 has migrated over to R_{4+5} in the pupal tracheation; and this specialisation has become even more emphasised in the imaginal venation. But, in the Butterflies, the condition of Rs in the pupal tracheation is quite different from this. As we shall show on p. 684, through-

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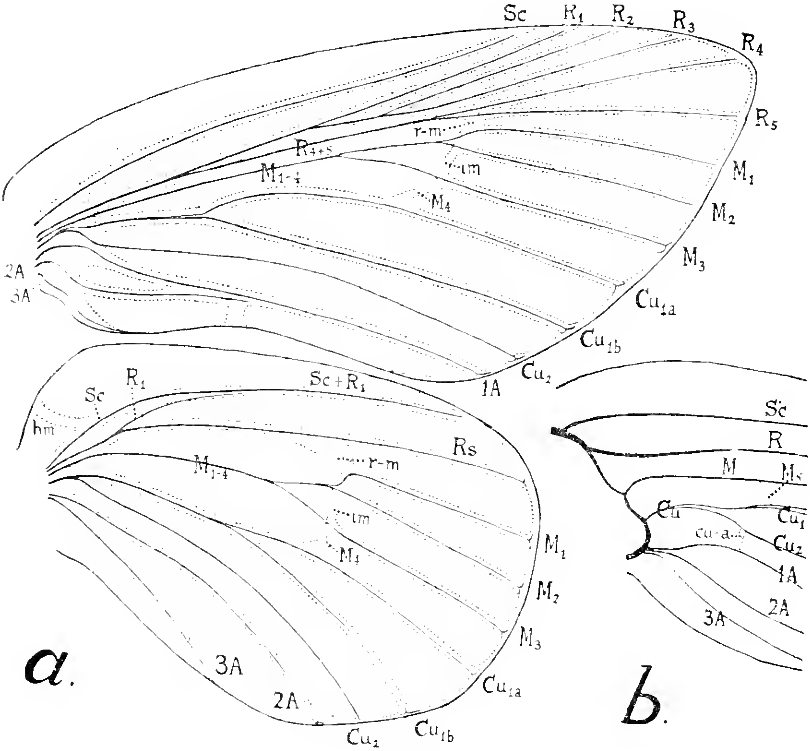
*The course of M is sometimes indicated by a faint line or groove, but is never chitinised as a true vein.

out this great group tracheæ R_{2+3} and R_{4+5} arise from the main stem of R as *two separate tracheae*, whose points of origin on R are widely distant. This is a high specialisation, in quite a different direction from that shown in the *Psychina*. But, owing to the obliteration of the chorda or main stem of R_{4+5} in the imaginal venation, the result attained in the imago is *not unlike* that to be seen in the *Psychina*, in that both groups show no *apparent* radial cell. The basal cell of the *Psychina* is merely that cell, without any additions; but the basal cell of the Rhopalocera is an *areocel*, formed by fusion of the radial cell or areole with the true basal cell. It will be seen from Text-fig. 98 that it is impossible to determine which of these conditions is truly present in *Rhodoneura*, and the same may be said for *Pyralididae*.

The solution of many interesting questions rests principally on the type of Rs present in the pupal tracheation of the fore-wing of the *Thyrididae* and *Pyralididae*. For there are many authors who unite the latter family (together with its highly specialised offshoots), into a single series with the Psychina, under the name "Pyrali-Zygænoid Series"; though, it should be noted, they do not always include the *Thyrididae* in this same series. This latter family is placed by some in close relationship with the *Pyralididae*, but by others it is removed far away from them, and placed close to the Tortricina. Most interesting of all is the claim made by Meyrick and Hampson that the *Thyrididae* are the ancestral group from which the Butterflies have been derived (3, p. 326). It is quite evident that the claims of the *Thyrididae* to being the ancestors of the Butterflies, and to being the close relatives of the Tortricina, on the one hand, and to the Pyrali-Zygænoid group on the other, are in some measure conflicting. There will be no difficulty in deciding the case for the *Pyralididae*, since pupæ of this family should easily be obtainable; but for the *Thyrididae* it is quite another matter, the family being confined to the Tropics, and very little being known about the habits of the larvæ.

The BUTTERFLIES, or Superfamily RHOPALOCERA (PAPILIONINA).

The most archaic genus in this group is certainly *Euschemon*, which stands at the very base of the family *Hesperiidae*, and is the only Butterfly in which a frenulum is present in the male. A visit was made to Port Macquarie in January of this year,



Text-Fig.99.

Euschemon rafflesia Macleay, (fam. *Hesperiidae*), *a*, tracheation of wings of a ten-days-old pupa (x 6·7); *b*, tracheation of basal portion of forewing of a freshly formed pupa (x 10) for comparison with *a*. Lettering as on p.535. In *a*, the pale bands foreshadowing the imaginal venation are shown as double dotted lines.

and a number of larvæ and pupæ of this rather rare insect were secured, thanks to careful directions given me by Mr. G. A. Waterhouse, who had discovered it there the previous year. The larva and pupa show definite Hesperiid characters. We shall now be able to study fully the pupal tracheation and the changes that take place at metamorphosis. The material at my disposal was only excelled by that of *Wingia*, and I was able to study the wings at all stages of pupal life.

In order to save space in the figures, and also to show a stage different from any of those exhibited in the case of *Wingia*, I have drawn, in Text-fig. 99, *a*, *both the tracheation and renation* of the wings of a ten-days-old pupa. The pale bands, which foreshadow the imaginal venation proper, are indicated by the double dotted lines, each pair of which encloses a trachea, represented by a continuous black line. Alongside this figure, in Text-fig. 99, *b*, is shown the basal portion of the forewing in the freshly-turned pupa, somewhat more enlarged. From this we can see how well separated the bases of the main tracheæ are at first, and how closely they tend to approximate as pupal life progresses. An exception is the group of three anal tracheæ, which arise, as usual, very close together in a single bunch.

The following important points should be noted:—

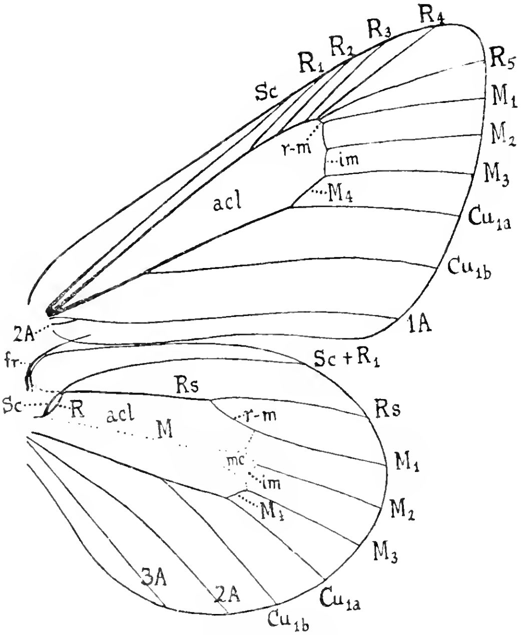
(1) In the forewing, R_{2+3} and R_{4+5} come off widely separated from the main stem of R. This is a characteristic of the pupal forewing of all true Butterflies (with a few exceptions in very highly specialised cases), and marks *Euschemon* definitely as belonging to the Rhopalocera.

(2) Although R_{2+3} is much shorter than R_{4+5}, it forks nearer to the base than does the latter. This agrees with *Xyleutes*, *Wingia*, etc., but differs from the more archaic condition seen in the *Hepialidae*.

(3) In the hindwing, Sc and R_1 fuse to form a single vein; but trachea Sc is dominant, as in *Xyleutes*; whereas, in *Carpocapsa*, *Wingia*, and *Doratifera*, R_1 is dominant.

(4) The development of a very broad humeral area in the hindwing has thrown the frenulum back right to the extreme base of the wing (Text-fig. 100), carrying with it the remnant of the humeral veinlet, which appears as a pale band in the early pupa, but does not become fully chitinised in the imago. Probably correlated with this is the shortening of the separate basal portions of Sc and R_1 in the imago to form a small loop. This loop is characteristic of the *Hesperiidae*; and, in many genera, the veinlet *hm* is to be seen projecting from it basad, much more strongly than in *Euschemon*. In other Butterflies, this loop is reduced to a minute vestige, or completely closed up.

(5) In the early pupa, M_5 forms as a very distinct pale band



Text-Fig.100.

Euschemon rafflesia Macleay, (fam. *Hesperiidae*), imaginal venation (x 2¼). Lettering as on p.535.

in the usual position, as shown in Text-fig. 99, *b*. Later on, a huge mass of vein-chitin is laid down over the bases of the main veins, and M_5 becomes completely enclosed within it. Trachea M_5 does not appear until near metamorphosis.

(6) The cross-vein *cu-a* is laid down as a pale band in the forewing only, in the early pupa, as shown in Text-fig. 99, *b*. It suffers the same fate as M_5, being swallowed up in the mass of vein-chitin which forms around it later on.

(7) Tracheæ M and Cu_2 remain complete throughout pupal life. But no chitinisation takes place either along Cu_2 or along any part of M lying within the basal cell.

(8) In the forewing, no chitinisation takes place along R_{4+5}, from its origin on R to the point where it forks. This is an important point to bear in mind when studying the method of formation of the basal cell at metamorphosis.

(9) In the forewing, the distal end of 2A lies alongside 1A; the anal Y-vein formed around them is very prominent in the pupal wing, but is reduced to a very small size in the imago.

(10) In the hindwing, trachea 1A appears to have been completely eliminated, as in *Doratifera*. Thus there is no basal Y-vein, and the two anal veins present in the imaginal wing are 2A and 3A, not 1A and 2A as has hitherto been believed. (See Section v.)

At metamorphosis, the changes that take place are much the same as those already described for *Wingia*, except that there is a much greater comparative increase in the size of the wings. The basal part does not increase at all in size; and, consequently, the bases of the tracheæ together with the vein M_5 and the anal loop, become crowded together close to the base, and are hard to make out in the imago. The shape of the forewing alters greatly, the base becoming very narrow, by reduction of the anal area, while the distal margin expands, giving the whole wing a triangular shape. In the imago, only the barest remnant of the anal loop can be seen, while 3A is entirely lost in the forewing. The hindwing broadens out on the whole, but its anal area becomes narrowed, instead of widened as in *Wingia;* 3A is only weakly chitinised.

Tracheæ M and Cu are so close in the wings of this insect at metamorphosis, that the transfer of Cu_1 to M, via M_5, takes place without any appreciable change in direction; and the serial vein which has M_5 for its basal piece, and Cu_1 as its distal continuation, is practically a straight line. Moreover, although trachea Cu partly shrivels up, as in *Wingia*, it appears to become actually enclosed within the thick chitinisation that forms the base of this serial vein. For, in a carefully prepared cleared forewing of *Euschemon*, taken from a specimen that had emerged only four hours previously, I could plainly see the remains of Cu, with its forking into Cu_1 and Cu_2, lying just below M_5 within this vein. On the other hand, Cu_2 loses its trachea entirely, and is not chitinised in either fore or hind wing.

The completion of the basal cell at metamorphosis is a process of great interest in this insect. If we look at Text-fig. 99, *a*, we shall see that the narrow cell bounded posteriorly by R_{4+5}, anteriorly partly by the main stem of R. and partly by R_{2+3}, and closed distally by the short cross-vein *ir* between R_3 and

R_4, is really the radial cell or areole, which has become sessile upon R, owing to the separation of R_{2+3} and R_{4+5} basally. At metamorphosis, not only all that part of trachea M, lying within the basal cell, becomes aborted, but also the stem of R_{4+5}, which properly separates the areole from the basal cell. Thus, in the imaginal forewing, the basal cell becomes an *areocel*, and is the homologue of the basal cell of the Tortricina and Tineina. The actual method by which this change is brought about is the same as that already seen in *Wingia*, viz., a trachea from R_5 captures M_1, and another trachea from R_3 captures R_4 and R_5. Hence all the tracheæ from R_4 to M_1 become hitched on to R_3, so that trachea R appears, at metamorphosis, as a trachea having *six* branches all given off anteriorly in order. M_3 is captured by Cu_{1a}, as in *Wingia*. But M_2 loses its tracheal supply, and fails to become annexed by either the radial or cubital group of tracheæ.

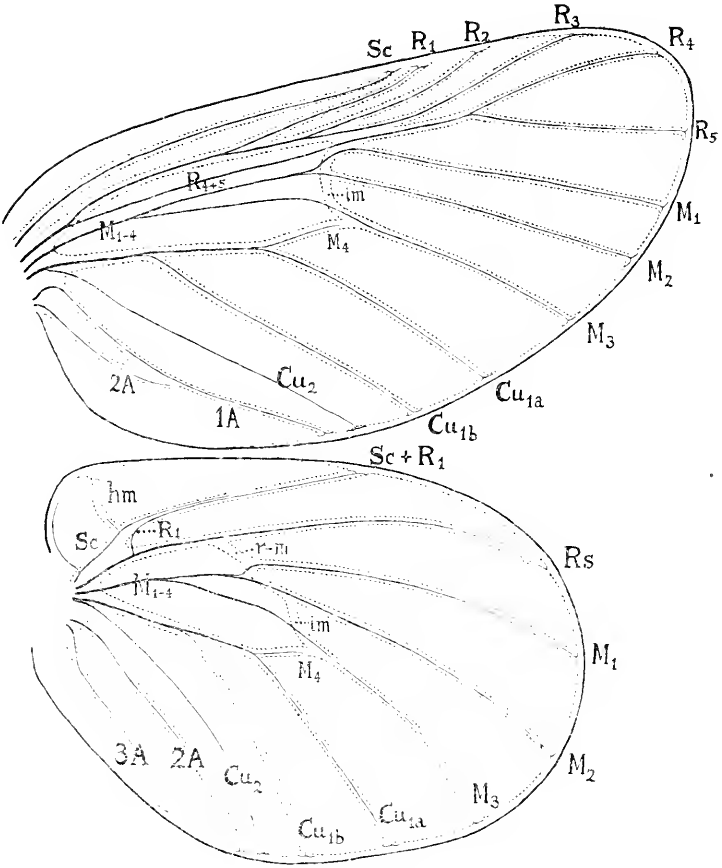
In the hindwing, M_1 is captured by Rs at metamorphosis, and M_3 by Cu_{1a}. But, as in the forewing, M_2 loses its tracheal supply, and fails to become annexed to either group. Though the vein M_2 is chitinised in *Euschemon*, it tends to become aborted in many *Hesperiidae*, and its loss is primarily due to the failure to secure a tracheal supply.

Text-fig. 100 shows the imaginal venation of *Euschemon*, for comparison with Text-fig. 99.

As a contrast to *Euschemon* I studied the pupal tracheation of one of the highly specialised *Nymphalidae*, *Euploea corinna*. Text-fig. 101 shows the condition of the wings in a pupa of this species about three days old, the veins and tracheæ being indicated in the same manner as in Text-fig. 99. The only important differences are as follows:—

(1) In the forewing, I could find no sign of M_5; and M_{1-4} forks much closer to the base of the wing than in *Euschemon*. Also 2A is greatly reduced, and 3A completely absent. Besides these differences, there is a fairly strong tracheal outgrowth from Cu_{1a} along the vein M_4 towards M_3. This is the same outgrowth which appears in *Euschemon at metamorphosis*. The condition in *Euploea* is, then, an advance upon that seen in *Euschemon*.

(2) In the hindwing, the condition of M is as in the forewing. R_1 comes off from the main stem of R in a highly specialised manner, but is dominant over Sc. The latter trachea gives off a

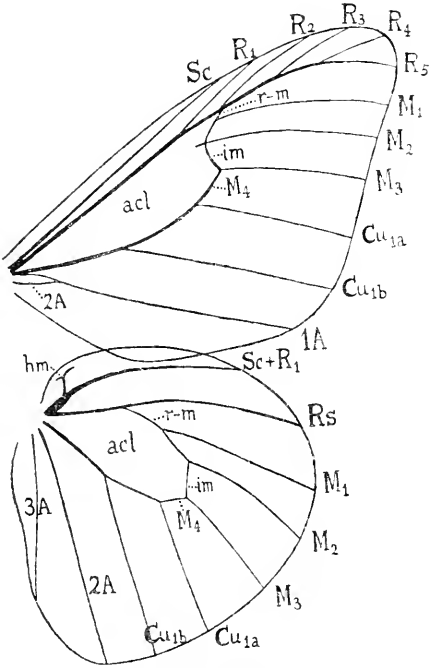


Text-Fig.101.

Euploea corinna Macleay, (fam. *Nymphalidae*), tracheation of wings of three-days-old pupa, (x 4). The pale bands foreshadowing the imaginal venation are shown by the double dotted lines. Lettering as on p.535.

definite branch to *hm* (this does not occur in *Euschemon*, and there is also a second branch arising from the extreme base of Sc, and running to where the frenulum would be situated if it were present. The trachea outgrowing from Cu_{1a} along M_4 is smaller than in the forewing. 2A and 3A are present, but 1A and the basal Y are absent, as in *Euschemon*.

The changes at metamorphosis are the same as in *Euschemon*, resulting in the formation of an areocel in the forewing, and a generally similar type of venation. The chief differences lie in the retention of a short spur of M_{1+2} within the basal cell of the forewing, and in the anal Y-vein remaining quite as large as it was in the pupal wing (Text-fig. 102), and hence somewhat more conspicuous than in the imago of *Euschemon*. In some *Nymphalidae*, not only a short spur of M_{1+2}, but also corresponding spurs of R_{4+5} and M_{3+4}, may be seen projecting into the cell of the forewing; while, in the hind, the positions of the same structures may be indicated by knobs or swellings. These are easily to be seen in the large *Danainae*, e.g. *Danaida archippus* Fabr. In the hindwing, the small closed space between Sc

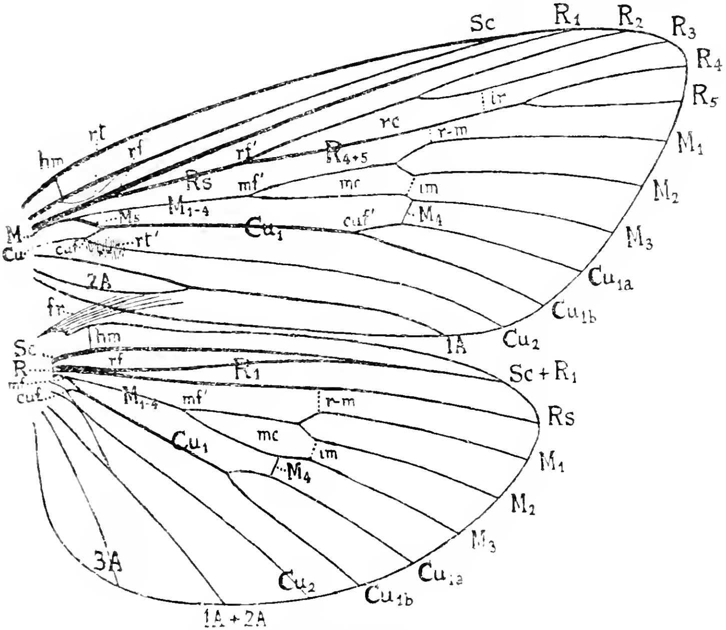


Text-Fig.102.

Euploea corinna Macleay, (fam. *Nymphalidae*), imaginal venation, (x 1½). Lettering as on p.535.

and R_1 basally is obliterated in *Euploea*, though a remnant of it may still be seen in *Danaida*. The veinlet *hm* develops into a strong costal spur, which helps to strengthen the enlarged amplexiform humeral area. Text-fig. 102 shows the imaginal venation of *Euploea corinna*, for comparison with that of *Euschemon rafflesia*.

The Archetype of the Suborder Heteroneura may now be determined, by summing up the characters of the various groups studied, and selecting the most archaic condition of each. This is most conveniently done by means of a Table (Table iv.) similar to that already given for the Homoneura, in which the letter A indicates the most archaic condition for each character, while B, C, . . . indicate more specialised conditions in ascending order. The Rhopalocera are included in this Table, though not strictly one of the more archaic groups of this Sub-



Text-Fig.103.

Wings of the Archetype of the Suborder Heteroneura. Lettering as on p.535.

order, because they have been studied in this Section, and a tabulation of their characters for comparison with the older groups may prove of great value later on in helping to solve the problem of their origin. On the other hand, the fossil *Palaeontinidae* have been omitted; for, as already indicated, there is no proof that they have been derived from the old Homoneurous stem of the Order along the same line of descent as our present-day Heteroneura. They are best treated as an entirely separate group, until, perhaps, further discoveries, or more detailed study of the existing fossil types, may have demonstrated conclusively where they properly belong.

Text-fig. 103 gives a diagrammatic representation of the wing-venation of the Archetype of the Heteroneura. The Table shows conclusively that, of all existing Heteroneura, the *Cossidae* stand far nearer to this Archetype than do any other group. Thus Dr. Turner's name of *Protocossidae* for the archetypic family of the Suborder is fully justified. Next to the *Cossidae* would come the most archaic Tineina, such as *Titanomis*, and then the *Castniidae* and the bulk of the Tortricina and Tineina. The groups above these are more highly specialised.

It is interesting to compare the Archetype of the Heteroneura with that of the Homoneura, i.e. of the whole Order Lepidoptera. The characters in which it is specialised may be briefly stated as follows:—

(1) Absence of the distal forking of Sc.

(2) Absence of the distal forking of R_1.

(3) In forewing, R_{2+3} forks nearer to base than does R_{4+5}.

(4) In hindwing, Sc and R_1 are fused distally.

(5) In hindwing, Rs is a simple, unbranched vein.

(6) M_4 is already placed in a transverse position, resembling a cross-vein, and its trachea is, at the most, only feebly developed.

(7) The cubito-median Y-vein, though present, is never so typically developed as in the Jugo-frenata.

(8) 3A is absent from the forewing, though present in the hind.

(9) Only a single Y-vein is present in the anal area of the forewing.

(10) 1A and 2A are fused near the base in the hindwing, to form an anal Y-vein.

(11) The following cross-veins are absent:—*sc-r*, *cu-a*, ia_1, ia_2, and *sa*.

(12) The shape of the wings is much altered from the ori-

ginal, the forewing already having the apex well forward and a distinct termen, while the hindwing has its costal, subcostal and radial areas much narrowed (and consequently their venation much reduced), but its anal area widened.

In connection with characters (1), (2), (7), (8) and (12), together with the retention of the cross-veins *ir*, *r-m* and *im*, and the increase in size of the anal area and its veins, note the close parallelism between *Stenopsychodes* and its allies in the Trichoptera (p. 629), and that of the Archetype of the Heteroneura in the Lepidoptera. If the family *Polycentropidae* had continued this line of evolution, by reducing the subcosta and radius of the hindwing, there would have resulted a group of Caddis-flies closely comparable with the Heteroneura amongst the Lepidoptera.

The "percentage archaism" of the Archetype of the Heteroneura, as compared with that of the Order, if worked out on the twenty characters given in Table iii. on p. 650, will be found to be 52.5, i.e. less than that of the *Micropterygidae, Eriocraniidae* and *Hepialidae*, as might have been expected. But a fairer comparison would be obtained by adding to this Table also those characters given in Table iv. on p. 690 in which the Heteroneura are specialised, but which are not included in Table iii., since they do not come into question in the case of the Homoneura. By this method, a percentage archaism of 44.4, out of a total of twenty-seven characters, will be obtained; and this percentage, I think, very fairly represents the correct position of the Archetype of the Heteroneura in the evolution of the Order.

By multiplying the percentages obtained in Table iv. by the factor 0.444, we can obtain a comparison of the "percentage archaisms" of the various groups of Heteroneura, when the percentage for the Archetype of the Order, and hence of the Homoneura also, is given as 100. To make this comparison fair for the Homoneura also, we must add to the twenty characters given in Table iii. the seven characters in which the Archetype of the Heteroneura is specialised, and in which, therefore, *all* the Homoneura must be credited with an extra seven "A's." The combined results will then be as follows:—

Micropterygidae 79.5, *Eriocraniidae* 72.2, *Hepialidae* 79.3, *Prototheoridae* 53.7, *Cossidae* 41.7, *Mnesarchaeidae* 38.9, Tineina 33.3, *Castniidae* 30.7, Tortricina 27.8, Psychina 22.2, Pyralidina 18.2 and Rhopalocera 15.3.

TABLE IV.

PRINCIPAL VENATIONAL CHARACTERS FOR THE MORE ARCHAIC GROUPS OF THE HETERONEURA, AND FOR THE BUTTERFLIES, BUT EXCLUDING THE FOSSIL PALÆONTINOIDEA.

Ref. No.	Character.	*Cossidae.*	Tortricina.	Tineina.	*Castniidae*	Psychina.	Pyralidina	Rhopalocera.
(1)	Sc and R_1 in pupal hindwing:—A. Fused for distal half only. B. Fused more than half their length.	A.	A.	A or B.	?	A.	? B.	B.
(2)	Condition of Rs in pupal forewing:—A. A single sector, branching dichotomously, with fork of R_{2+3} nearer to base than that of R_{4+5}. B. Single sector, with R_3 transferred to R_{4+5}. C. R_{2+3} and R_{4+5} arising separately from R.	A.	A.	A.	A.	B.	? B or C.	C.
(3)	Rs in pupal hind wing:—A. Reduced to a simple, unbranched vein. B. Ditto, with capture of trachea M_1.	A.	A.	A.	?	B.	? B.	A.
(4)	Condition of radial cell or areole in pupal forewing:—A. Present, closed by cross-vein *ir*. B. Present, closed by fusion of R_3 with R_{4+5} (*ir* absent). C. Absent. (*areole sessile on main stem of R).	A or B.	A.	A.	A or C.	C.	?	A.*
(5)	Basal cell and areole in imaginal forewing: A. Separate. B. Forming a single areocel.	A.	A or B.	A or B.	A.	A.	?	B.
(6)	Condition of M_{1-4} within basal cell of forewing:—A. Fully present. B. Incomplete. C. Absent.	A.	B or C.	A, B or C	A or B.	A or B.	C.	C.
(7)	Condition of M_5 in imaginal forewing:—A. Distinct. B. Reduced or aligned with Cu_{1a}.	A.	B.	B.	B.	B.	B.	B.
(8)	Trachea M_4 in pupal wings:—A. Small, present. B. Absent.	A or B.	B.	B.	B.	B.	B.	B.
(9)	Condition of vein Cu_2 in imaginal wing:—A. Present in both wings. B. Present in hind, but reduced, weak or absent in fore. C. Absent, or nearly, in hind, weakened in fore. D. Absent in both.	A.	B.	B.	C.	A.	B.	D.
(10)	Basal fusion of tracheæ Cu_2 and 1A in pupal hindwing:—A. Completed. B. Nearly complete. C. Absent.	B.	B.	A.	?	C.	C.	C.
(11)	Anal Y-vein of forewing:—A. Present. B. Very small. C. Incomplete. D. Absent.	A.	A.	A-D	A or D.	A.	C or D.	B or D.
(12)	Condition of 1A and 2A in hindwing:—A. Fused to form a small basal Y-vein. B. Reduced to a single vein.	A.	A.	A or B.	A.	B.	A or B.	B.
(13)	3A in hindwing:—A. Present.	A.	A.	A.	A.	A.	A.	A.
(14)	Humeral veinlet:—A. Present in both wings. B. Present in one wing only. C. Absent from both wings.	A or B.	C.	C.	C.	C.	C.	B.
(15)	Cross-vein *im*:—A. Present.	A.	A.	A.	A.	A.	A.	A.
(16)	Cross-vein *r-m*:—A. Present.	A.	A.	A.	A.	A.	A.	A.
	Percentage of archetypic characters present in most archaic representatives of each group (excluding undetermined characters):—	93·8	62·5	75·0	69·2	50·0	40.9	34·4

Note:—The percentages given for the *Castniidae* and Pyralidina in the above Table cannot be accurately determined until the tracheation of the pupal wing can be examined. If all the doubtful characters in the case of the Pyralidina were thus to be proved to be archaic (a very unlikely happening), the percentage for this group would be raised to 59·4; whereas, if they were all to be proved to be specialised, the percentage would be lowered to 28·1.

Section xv. The Venation of the Megaloptera.

(Text-figs. 36*a*, 39-40, 44, 47*a*, 104-108.)

This Order, as at present constituted, consists of a small number of archaic types not very closely related amongst themselves. Probably none of their ancestors has ever been dominant at any time, and this may well be the reason why, though the Order contains chiefly forms with aquatic larvæ and inhabiting the banks of streams, the fossil record is exceedingly poor.

Some authors, including Handlirsch (2), consider the terrestrial Raphidioidea to belong to a separate Order, distinct from the Sialoidea. Others again merge the Megaloptera with the Planipennia into a single Order Neuroptera. I have, for the present, taken the intermediate course of uniting the two groups Raphidioidea and Sialoidea into a single Order Megaloptera, while keeping the Planipennia distinct. The important point is not whether there are one, two or three Orders represented, but rather that we should keep clearly in mind the different lines of evolution indicated, whether we choose to class them as belonging to one, two or three Orders. It will be seen in the sequel that differences of opinion on this latter point will not appreciably affect the definitions of the Archetypes involved; and, as far as the venational scheme is concerned, at any rate, the evidence will be found to favour only one conclusion.

The problem of determining the Archetype of the Megaloptera is not an easy one. In order to grasp the problem fully, it will be necessary to figure examples of all the different types known in the Order. This I have done in Text-figs. 104-107.

There are two Sub-orders, viz. the Sialoidea, consisting of forms whose larvæ are aquatic or semi-aquatic, and the Raphidioidea, whose larvæ are terrestrial. The latter are, in most respects, rather highly specialised insects. But they cannot be descended directly from the Sialoidea, because they all possess the original condition of having Sc and R_1 quite separate in both wings; whereas all the known Sialoidea have these veins fused distally, as in the higher Planipennia. We may, for the present, dismiss the specialisations shown by the Raphidioidea from our minds, and only remember that this condition of a separate Sc and R_1 has to be present in any Archetype from which they can possibly have been derived.

The Sialoidea are universally admitted to be more archaic than the Raphidioidea. It is also generally agreed that the family *Corydalidae* (Text-figs. 105, 106) is more archaic than the family *Sialidae* (Text-fig. 104), these being the only two families represented within the Suborder. It is in the comparison of the venational types found in these two families that we meet with our principal difficulties in the construction of the Archetype of the Order.

The outstanding feature of the venation of the two Neuropteroid Orders, Megaloptera and Planipennia, as contrasted with that of the Panorpoidea, is the generally strongly developed tendency towards the pectination of Rs. This character is beautifully illustrated in almost all Planipennia, but is by no means so evident in the older Megaloptera. We have here to study this peculiarity, and to decide what the archetypic condition was, from which the pectinate type of Rs was originally evolved.

A little consideration will show us that the tendency towards pectination in Rs probably did not, at first, affect R_{4+5},* but only R_{2+3}. For, in all the *Sialidae*, R_{4+5} remains still dichotomously branched, as shown in Text-figs. 47a, 104; while, in the *Corydalidae,* where the pectinate form of branching of Rs is generally much more in evidence, there are many examples of the retention of the original dichotomic forking of R_{4+5}, as, for instance, in *Protohermes* (Text-fig. 106). Further, in those genera in which pectination has become more complete, through the loss of the original fork of R_{4+5} (as in *Archichauliodes,* Text-fig. 105, *Chauliodes, Corydalus* and allies), specimens are not infrequently found with this fork retained in one or more wings. Thus we must conclude that, in the Archetype of this Order, pectination of Rs, if present, had only affected R_{2+3}.

Our next difficulty lies in the presence of some forms in which no pectination of Rs is visible at all, and from which we might be led to the conclusion that the Archetype of the Order had a dichotomic Rs. I refer in particular to the Australian genera *Austrosialis* and *Stenosialis*, which are reduced archaic offshoots from the family *Sialidae.* In Text-fig. 47, I compared the venation of *Austrosialis* with that of the Trichopteron *Rhyacophila*,

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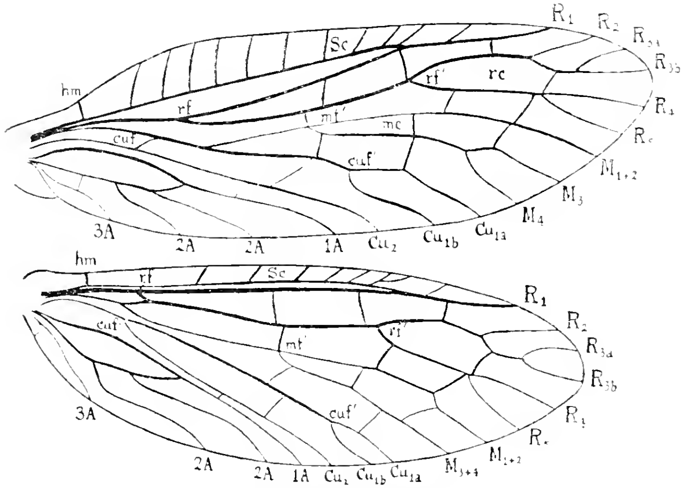
*See, however, footnote on p.552, and Text-fig.39. The vein taken to be R_{4+5} may possibly have been an originally branched R_5.

and showed how remarkable it was that these two genera should possess exactly the same type of branching of all the veins, in both fore and hind wings. At first sight, one is tempted to postulate a Megalopterous origin for the Trichoptera, and to say that *Rhyacophila,* and therefore the Order Trichoptera, must have originated from a type very close to *Austrosialis.* But a little consideration will show us that this would be a very serious misinterpretation of the actual facts of the case. The *Sialidae* are the most highly specialised of the aquatic Megaloptera, and are undoubtedly derived from ancestors that were more like the *Corydalidae. Austrosialis* is much more highly specialised than *Rhyacophila* in the very long and complete fusion between Cu1 and M_{1-4}; the consequent loss of all traces of the cubito-median Y-vein; the removal distad of the secondary radial fork, and consequent reduction in the length of the branches of Rs; and the distal fusion of Sc with R_1. *Rhyacophila,* on the other hand, is specialised in quite a different direction, in having the anal veins of the forewing completely looped up into a double Y-vein. There are, of course, many other differences, but those mentioned will suffice for our purposes. Complete proof or disproof of any suggested origin of the Trichoptera from the *Sialidae* could only be supplied by a study of many other characters besides the venation; and the possibility of such a descent will again be discussed in the part of this research which has to deal with larval characters. For the present, we must put it aside, and see only in the resemblances between *Austrosialis* and *Rhyacophila* a very striking instance of parallel development. between two widely separated types which, as we shall see later on, have nevertheless had a common origin in a more remote period.

If we compare *Austrosialis* (Text-fig. 47*a*) with *Sialis* (Text-fig. 104), we can see in the latter the preservation of the old Corydalid tendency to pectination of R_{2+3}. For, by comparing the radial sector of this latter genus with that of *Archichauliodes,* we see at once that suppression of the original terminal forking of R_2, with a shifting of the tips of R_{2+3} somewhat costalwards along the wing-margin, would result at once in the form found in *Sialis.* Moreover, the extra branch of R_2 is also frequently present in specimens of the genus *Sialis* (though not in the example figured), but is usually found to have migrated across to the base of R_3; so that the type of pectination found in this



Text-Fig.104.

Wings of *Sialis lutaria* Linn., (fam. *Sialidae*), (x 6). Lettering as on p.535.

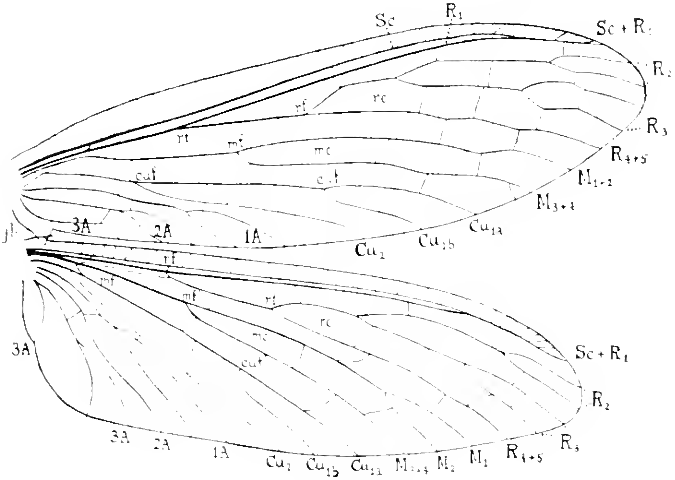
genus tends to become unique in having the terminal branches of R_{2+3} arranged anteriorly, instead of posteriorly.

It should be noted here that there is really no justification for the assumption that there has been any constant addition to the branches of the main veins in the *Sialidae*, by terminal twigging or splitting, such as is found in the Planipennia. No such additions are to be found either upon M or Cu; and it is purely a gratuitous assumption to say that they are present on Rs, when the condition of that vein is much more reasonably derived directly from the older Corydalid type.

We may, then, fairly assume that the *Sialidae* are a reduced offshoot from the older *Corydalidae*. Such a conclusion is supported by the whole weight of the evidence from other characters, the *Corydalidae* being, both in their morphology and life-histories, by far the more archaic of the two families.

A typical archaic Corydalid genus is the Australian *Archichauliodes* (Text-fig. 105). In this genus, Cu retains the original three-branched condition, without any alteration in the position of its forkings; M is generally reduced either to three or two branches; and Rs retains the terminal dichotomic forkings of R_2 and R_3, though generally (but not always) the original dichotomy of R_{4+5} is suppressed.

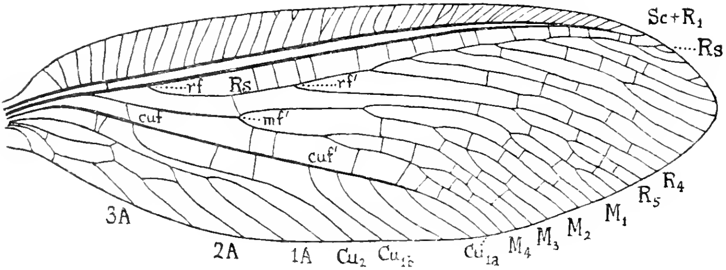
We must now contrast this with the somewhat different type shown in *Protohermes* (Text-fig. 106), claimed by van der Weele to be the most archaic type within the Order.



Text-Fig.105.

Wings of *Archichauliodes guttiferus* (Walk.), (fam. *Corydalidae*), (x 2·7). Lettering as on p.535.

The first thing to be noted in *Protohermes* is the clear evidence of *addition* of extra branches to the main veins, on the Plannipennian plan, from the tip inwards. This is best seen in the case of Cu_1, which has become transformed from its original dichotomic condition into a pectinate vein, on the lines indicated in Text-fig. 40. The same thing has happened with M, although it seems also quite clear that this vein possessed at least four branches when the additions began, seeing that both M_{1+2} and M_{3+4} fork dichotomically at about the same level as the original forking of Cu_1. Some of the branches of Rs have evidently been added from the tip backwards also; but there is certainly no evidence to restrict the original number of branches of this vein to four.



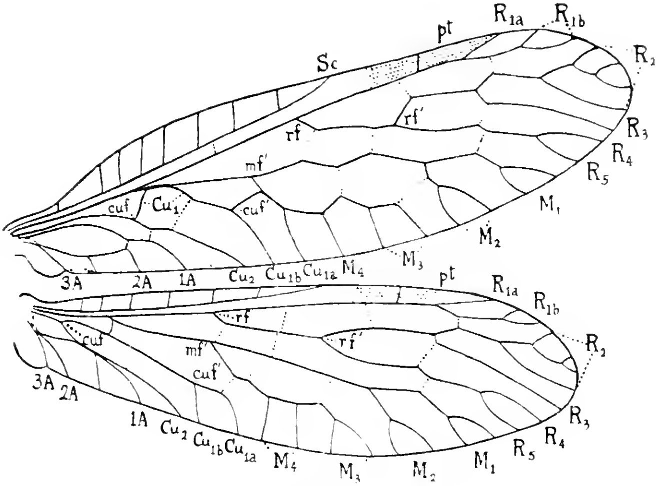
Text-Fig.106.

Forewing of *Protohermes davidi* Weele, (fam. *Corydalidae*), (from van de Weele, but with lettering added, as on p.535).

A fair judgment between the two types shown in *Archichauliodes* and *Protohermes* would, I think, refuse to recognise that one type was at all more predominantly archaic than the other. Both are derivable from a very close common ancestor, in which, on the one hand, no reduction had occurred in the number of branches of M, and, on the other, no additions had been made to the venation from the tips of the veins inwards. Such a type would have to possess the following venational characters:—At least six branches of Rs, viz. a dichotomic fork of R_2, a similar one belonging to R_3, and the original fork of R_{4+5} still preserved; four branches of M_{1-4}, arranged in the original dichotomic manner; and a normal, archaic, three-branched Cu.

This common type will be seen at once to be the Archetype, not only of the family *Corydalidae*, but also of the family *Sialidae*, and hence of the whole Suborder Sialoidea. We have now to consider what modifications are required in it, in order that it may also be the Archetype of the Raphidioidea, and therefore of the whole Order.

Text-fig. 107 shows the venation of *Raphidia maculicollis* Steph. The specialisations to be seen in this type are chiefly those by which the original courses of the main veins and their branches have been greatly altered from the normal condition. M has become strongly fused basally with R; and, in the forewing, Cu_1 has become very strongly fused with M. The terminal twigging of R_{1b} and the upper branch of R_2 are clearly



Text-Fig.107.

Wings of *Raphidia maculicollis* Steph., (fam. *Raphidiidae*). (x 7½). Lettering as on p.535. The cross-veins are indicated by dotted lines.

additions to the original venational scheme; and it is probable that the same cause has operated to produce the extra forks of M. As against these specialisations, we find Sc and R_1 remaining unfused distally, and no sign of any tendency towards expansion of the anal area of the hindwing, such as is very obvious in all the Sialoidea.

We should also note that, in the Sialoidea, there is no fusion of 1A with Cu_2 in the hindwing, though the two veins approach very close to one another. This fusion is completed in the Raphidioidea, as already mentioned in Section v.

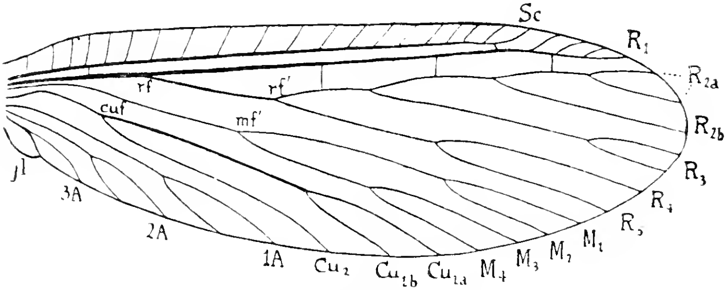
As regards the costal veinlets, there is a complete system present in all Megaloptera, and hence also in the Archetype.

The cross-vein system can be seen to be closely similar in *Raphidia*, the *Sialidae* and *Archichauliodes*, but is most primitive in the last-named, where there is little tendency to any definite arrangement. A constant character is the presence of only *three* cross-veins between R_1 and Rs. The addition of numerous cross-veins between these two main veins in *Protohermes* (Text-fig. 106) is clearly not an archaic character, as van der Weele imagined, but is correlated with the increase in the number of pectinate branches of Rs.

We are now able to construct our Archetype, of which we have figured the forewing only, in Text-fig. 108. The characters which mark this type may be briefly stated as follows:—

(1) Sc and R_1 distinct, not fused distally, and a complete series of costal veinlets present.

(2) Rs with more than four original branches, and with a tendency towards a pectinate arrangement of these branches in R_{2+3} only.



Text-Fig.108.

Forewing of the Archetype of the Order Megaloptera. Cross-veins omitted, except only those between Sc and R_1 and between R_1 and Rs, which are constant. Lettering as on p.535.

(3) Cubito-median Y-vein reduced, with M_5 weakly formed and failing to make a strong union with Cu_1 in forewing; in hindwing, this Y-vein is fairly normal.

(4) M_{1-4} with only four branches, dichotomically arranged.

(5) Cu three-branched, Cu_1 being distally forked, as in Paramecoptera, Trichoptera and Lepidoptera.

(6) No fusion of 1A with Cu_2 in hindwing, but these two veins approach close to one another in both wings.

(7) Cross-vein system rather irregular, widely spaced, not very numerous; only three cross-veins between R_1 and Rs.

In constructing the above Archetype, I have not brought into consideration the two known Lower Triassic fossil genera which are supposed to belong to this Order. These are *Chauliodites* Heer and *Triadosialis* Heer. The former does not seem to me to be definitely Megalopterous; the latter is very probably a somewhat reduced Corydalid type, and falls well within the archetypic definition. It has a pectinate Rs, and both M and Cu are three-branched.

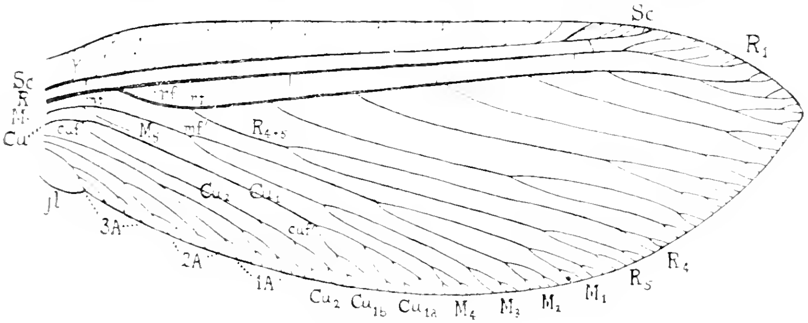
It will be realised, from Text-fig. 108, that the Archetype of the Megaloptera possesses a very primitive type of venation; and that it is older, in some respects, than the Permian *Belmontia*. This speaks for a very ancient origin for the Order. The question is more fully discussed in Section xvii.

Section xvi. THE VENATION OF THE PLANIPENNIA.

(Text-figs. 36*a*, 39-40, 45, 52, 109-110.)

This Order is the dominant one amongst the Neuropteroidea, and exhibits a wealth of venational specialisations not equalled in any other known Order, except perhaps in the Odonata. To deal with all these would take us far beyond the limits set down in this Part. I shall confine myself here strictly to the construction of the Archetype of the Order, while leaving a fuller discussion of the internal phylogeny of the different families for a later paper. In this connection, it is only necessary to refer the reader to the excellent figures and descriptions given by Comstock (15, chap. ix.), which will be mentioned also when certain types are being discussed.

The fossil record of the Planipennia, unlike that of the Mega-



Text-Fig.109.

Forewing of an archaic representative of the family *Prohemerobiidae*, with R_{4+5} still dichotomously branched. The same type will stand for the Archetype of the Order Planipennia. Cross-veins omitted, except only those between Sc and R_1, and between R_1 and Rs, which are constant. Lettering as on p.535.

loptera, is a rich one. It begins in the Upper Triassic of Ipswich, Queensland, and continues through the Lias and Upper Jurassic of Europe. The dominant type of Planipennian wing present in all these strata is that belonging to the family *Prohemerobiidae* (Text-fig. 109). This may be defined as a very primitive type, having no distal fusion of Sc with R_1, no specialisation of the main stems of Sc, R_1 and Rs to form a *vena triplica* like that of the *Psychopsidae,* and no definitely arranged system of cross-veins. Superimposed upon this very archaic foundation is a highly specialised condition of the radial sector, in which the pectinate condition of the branches is very clearly marked.

The oldest known fossil Planipennia, viz. *Archepsychops* (28) and *Protopsychopsis* (5) of the Ipswich Trias, are definitely Prohemerobiid types, as I have already proved. The former, moreover, shows such close affinity with the still existing *Megapsychops* of the family *Psychopsidae*, that there can be no doubt of the origin of this latter family as a direct offshoot of the ancient Prohemerobiid stem (28).

We have now to consider whether there may not still exist some archaic type, which may be considered to be either truly Prohemerobiid in itself, or even, perhaps, older than the fossil types so far discovered. Such a type is surely to be found in the *Ithonidae* (12, 30), an archaic side-branch of the Order, confined to Australia, and differing from all the other Planipennia in the possession of a melolonthoid larval type, in which the paired sucking jaws are of a very primitive form.

The type of venation in this family is definitely Prohemerobiid, but even more archaic than are many of the fossils of that family, in that the dichotomic forking of R_{4+5}* is still preserved in the majority of specimens; and the resemblance to the Megalopterous type of venation is even closer than is the case with the fossils.

The specialisations to be seen in the venation of *Ithone*, apart from the pectination of Rs already mentioned, are the abundant additions to the branches of the main veins, in the form of terminal twigs or branchlets, and the apparent complete loss of M_5. The former is an ordinal character for the Planipennia, being clearly shown in all types except the excessively reduced

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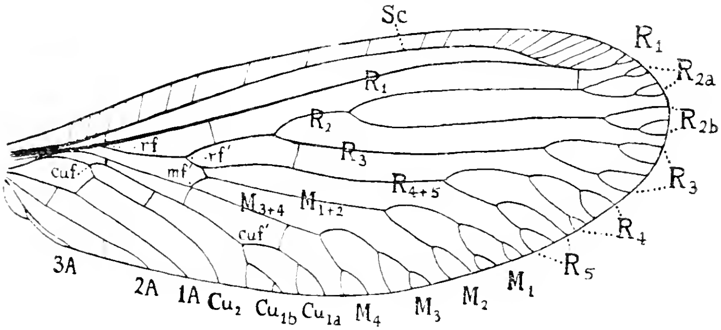
*See foot-notes on pp.552, 692.

Coniopterygidae, which may well have been descended from forms which originally possessed it. The loss of M is also to be noted in most families of the Order; but this vein has been found by me in the fossil *Archepsychops*, as well as in recent *Psychopsidae* (Section iii.).

Another archaic existing family is the *Sisyridae* (Text-fig. 110), in which clear evidences of reduction from the Prohemerobiid type may still be found; though the specialisation of the larva for feeding upon fresh-water sponge, and the heavy reduction in size, and consequently in density of venation, undergone by the imago, have considerably simplified the general scheme. The pectination of R_{2+3} is as clearly evident as is the retention of the original dichotomy of R_{4+5}. Further, the condition of M, when compared with that of Cu, shows the strong probability of the former having been originally four-branched, though most families of the Planipennia have this vein only two-branched. It will be clear that, quite apart from the smaller terminal twigs of normal Planipennian type, the series of forks marked *x*, *y*, *z*, and *cuf'* are certainly homotypic, and must therefore either all represent additions, or all be part of the original archaic venational scheme. Now the condition of Cu, apart from the terminal twigs, is quite primitive, and shows the three-branched condition quite clearly, as in the Megaloptera, Trichoptera and Lepidoptera. The point marked *cuf'* is clearly the secondary cubital fork, at which Cu_1 divides into



Text-Fig.110.

Forewing of *Sisyra brunnea* Banks, (fam. *Sisyridae*), (x 17). Lettering as on p.535.

Cu_{1a} and Cu_{1b}. Likewise also the fork marked x clearly represents the archaic position of the fork of R_{4+5}; while it is even possible that the vein above it, R_3, may also have preserved a somewhat smaller fork. Thus we can only conclude also that the forks y and z, belonging to M_{1+2} and M_{3+4} respectively, are the original forkings of those veins, and not additions like the smaller terminal twigs.

Closely allied to the *Sisyridae*, but less reduced, are the terrestrial *Berothidae* (in which the *Trichomatidae* may be also included as, at most, a distinct subfamily). They are, however, specialised by the long series of pectinate descending branches of Cu_1 in the hindwing. The affinity of this family with the *Prohemerobiidae* is quite obvious.

The *Hemerobiidae* are also a direct offshoot of the *Prohemerobiidae*, specialised by partial fusion of the main stem of Rs with R_1 in the forewing; the result being that some of the pectinate branches of this vein appear to come off from R as separate sectors. *Drepanepteryx* and allies are the most archaic types of this family (12). From these, all stages of reduction to very small, highly specialised forms with reduced venation can be easily followed out.

All the other families of the Planipennia are specialised in one or more directions, and need not be considered here in the construction of the Archetype.

It is an interesting fact that, in the families *Sisyridae*, *Berothidae* and *Hemerobiidae*, in which the cross-vein system is not greatly developed, the same three cross-veins can generally be seen between R_1 and Rs as in the majority of the Megaloptera. Sometimes they are reduced to two in number, as in Text-fig. 110. If, now, we turn to the *Polystoechotidae* (15, fig. 181) we find that, though the number of branches of Rs has greatly increased, the number of cross-veins is still only three or four in this position. It seems fair to conclude from this that the number of cross-veins between these two veins was *originally three* in both Orders, and that the increase seen in *Protohermes* and allied genera (Text-fig. 106) in the Megaloptera, and in the great majority of families of the Planipennia, is correlated with the increase in cross-veins in other parts of the wing.

As all the other families of this Order are specialised in one or more directions, I have omitted them from consideration in the construction of the Archetype. The conclusion we are bound to come to is that this Archetype was essentially of a Prohemerobiid type, but with R_{4+5} still dichotomically branched, as in Text-fig. 109, which may be taken as the forewing of the Archetype as well as that of a typical Prohemerobiid wing. M_{1-4} was four-branched, and Cu three-branched. Terminal splitting or twigging of the veins is typical of the Order; and this character is therefore included in the Archetype. The system of costal veinlets also tended to split at the tips. The cross-vein system was probably very primitive, but showed a slight specialisation, as in the Megaloptera, in having only three cross-veins between R_1 and Rs, and probably also only two (*sh* and *sc-r*) between Sc and R_1.

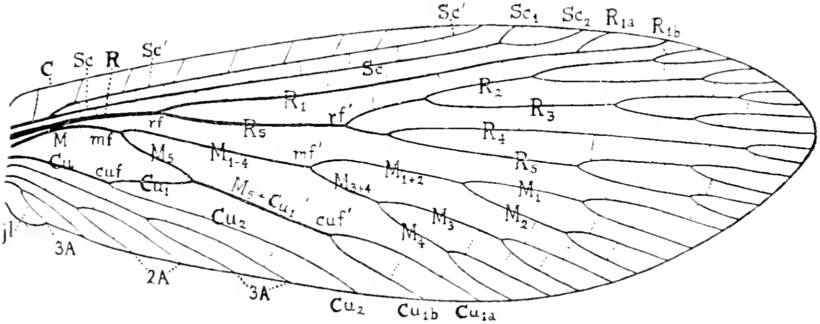
It will now be clear that there is only a single character in the wing-venation of the Megaloptera which is more highly specialised than the corresponding one in the Archetype of the Planipennia, viz., the absence of any remnant of M_5 in the forewings of the former. Apart from this, the Planipennia can be directly derived from the Archetype of the Megaloptera by further increase in the tendency to pectination and addition of branches to Rs, and by the beginnings of the terminal splittings of the veins. Thus the two Orders, in respect of their wing-venation, are barely distinct, and may be shown as a dichotomy from a common stem, which must itself have been derived from somewhere along the original main stem of the Complex, probably somewhat before the point indicated by *Belmontia* in Text-fig. 112. The two Orders are more closely related than are the Trichoptera and Lepidoptera; and those who prefer to merge them into a single whole, as two Suborders of a single Order Neuroptera, are quite logical in doing so. We shall continue to keep them distinct, for purposes of discussion, throughout this research, and shall only make a final decision on the question, when the whole of the evidence bearing upon it has been dealt with.

Section xvii. PHYLOGENETIC RESULTS.

(Text-figs. 38, 111, 112.)

We may now summarise the results of the preceding Sections as briefly as possible, with a view to deducing some phylogenetic conclusions therefrom. We shall arrange these as follows:—

(1) Construction of the Venation of the Archetype of the Complex.



Text-Fig.111.

Forewing of the Archetype of the Panorpoid Complex. (See also Text-fig. 38). Lettering as on p.535.

(2) Table of the Characters of the Wings for the Archetypes of the Complex and its Orders.

(3) The Phylogeny of the Orders of the Complex.

The Venation of the Archetype of the Panorpoid Complex.

Text-fig. 111 shows the forewing obtained by selecting the most archaic condition of every venational character to be found within the Complex. The following definition of this Archetype will be found to cover all the important characters:—

Wings shaped much as in *Belmontia* or *Rhyacophila*, but somewhat wider in comparison with their length. No true *costal vein* present, distinct from the anterior border of the wing. *Subcosta* forking close to base, into Sc′ above and Sc below; the latter again forked near tip, into Sc_1 and Sc_2. A complete series of costal veinlets present. *Radius* forking near base into R_1 and Rs, at *rf;* R_1 a fairly straight vein, forking near tip into R_{1a} and R_{1b}; Rs dichotomically forked, the number of branches greater than four, but essentially variable; the forking of R_{2+3} into R_2 and R_3 placed further from *rf′* than is the forking of R_{4+5} into R_4 and R_5. *Media* running very close to R basally, then diverging at the arculus, and dividing at *mf* into M_{1-4} above and M5 below. M_{1-4} dichotomically branched, the number of branches greater than four, but essentially variable; the forking of M_{1+2} into M_1 and M_2 placed further from *mf′* than is the forking of M_{3+4} into M_3 and M_4, M_5 fused with Cu_1 to form a well-marked *cubito-median Y-vein,*

M_5 forming the upper arm, Cu_1 the lower, and the stem of the Y being the fused vein M_5+Cu_1, which forks again distally. *Cubitus* three-branched, Cu_1 forking distally after fusion with M_5, Cu_2 remaining weakly formed and simple. *Anal veins* three in number, all separate, either forked or simple. *Convex veins* R, M_5+Cu_1 and the three anals. *Concave veins* Sc, M_{1-4} and Cu_2. *Cross-vein system* consisting of very weakly formed cross-veins, more or less irregularly placed, and not in any special positions of mechanical advantage.

Wing-coupling apparatus (24) complete, the forewing with jugal lobe and bristles, the hind with humeral lobe and frenulum.

Wing-trichiation (25) showing both microtrichia and macrotrichia, the former all over the membrane on both sides, the latter confined to the main veins and their branches, including the costal veinlets, and to the archedictyon, which is more or less aphantoneuric.

Fore and hind wings closely similar in shape and venation, but the latter somewhat shorter than the former, more weakly chitinised, and with somewhat shorter Sc.

In repose, the wings are held roof-wise over the back of the insect (*stegopterous* position).

Table of the Characters of the Wings for the Archetypes of the Complex and its Orders. (Table v.)

In the Table here given, the characters of the wings for the various Archetypes constructed in Sections viii.-xvi., and for the Archetype of the whole Complex, are arranged together for comparison. For each character selected, the most archaic condition is indicated by the letter A. This is usually only contrasted with a single specialised condition, represented by the letter B. In the case of characters in which a series of evolutionary stages can be recognised, these are represented by the letters A, B, C. . . .. in ascending order of specialisation.

For the purpose of comparing the venations of the various Archetypes, their respective *Comparative Archaisms* may be calculated. These are defined as "*the percentage of archaic characters retained by the given Archetype.*" The Comparative Archaism for the Archetype of the Complex is, of course, 100, since this type contains all the known archaic features. In calculating the percentages for the other Archetypes, the following method has been adopted:—In case of characters represented by A or B only, A scores 1, B nil; for those represented by A, B, C, A scores 1, B $\frac{1}{2}$, C nil; for those represented by A, B, C, D, A scores 1, B $\frac{2}{3}$, C $\frac{1}{3}$, and D nil; and so on. Thus due allowance is made for the possession of any degree of archaism; and the only condition that scores nothing at all is the most highly specialised condition in each case. In the case of the cross-vein system, there are no less than six evolutionary stages recognisable, which have been arranged in ascending order as A, B, C, D. E and F, with scores 1, $\frac{4}{5}$, $\frac{3}{5}$, $\frac{2}{5}$, $\frac{1}{5}$, and nil respectively (Section vii.).

In the case of fossil Orders, when the part of the wing showing a particular character has not been preserved, that character is shown in brackets in the condition in which it most probably existed in the fossil. It stands to reason that the missing characters, in the Permian and Triassic fossils, will almost certainly, when discovered, prove to have been present in the most archaic condition, A. The only exception made has been in the condition of the wing-coupling apparatus, which cannot be judged, and has therefore been entirely omitted.

The results obtained from the Table show that the two fossil Orders Paramecoptera and Protomecoptera are the most archaic, the Archetype of the latter scoring 90.0 per cent., and that of the former 86.1 per cent. Next to these comes the Archetype of the Mecoptera, with 77.8 per cent. The two Neuropteroid Orders, Megaloptera and Planipennia, have also very archaic Archetypes, with 73.9 and 65.6 per cent. respectively. The Paratrichoptera are the most specialised of the purely fossil Orders, with 66.5 per cent. The two Orders Trichoptera and Lepidoptera, as might be expected, come very close together, with 48.5 and 44.6 per cent. respectively. Finally, as was also very evident from the beginning, the most highly specialised Archetype is that of the Diptera, which possesses only 35.3 per cent of the total possible archaic characters.

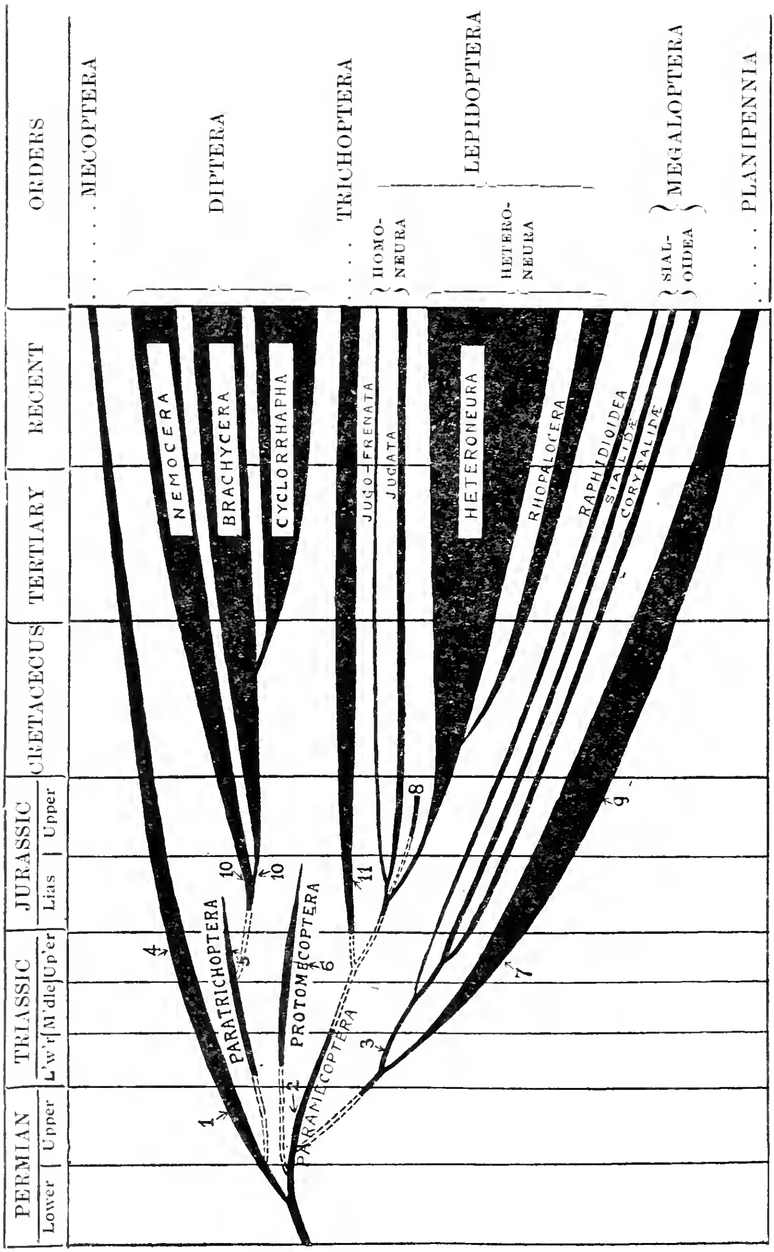
The Phylogeny of the Orders of the Complex.

In Text-fig. 112, I have attempted to represent, by means of a Phylogenetic Diagram, the true relationships of the Orders comprised in the Complex, and their most probable lines of descent. All the known fossils have been made use of; and a series of small numerals are used as indicators for the positions

TABLE V.

TABLE OF THE CHARACTERS OF THE WINGS FOR THE ARCHETYPES OF THE COMPLEX AND ITS ORDERS.

Ref. No.	Character	Complex	Mecoptera	Paramecoptera	Protomecoptera	Paratrichoptera	Diptera	Trichoptera	Lepidoptera	Megaloptera	Planipennia
(1)	Tracheation of pupal wings:—A, Holotracheate. B, Merotracheate.	A	B	[A]	[A]	[B]	B	B	A	A	A
(2)	Costal Veinlets:—A, complete series. B, reduced to three. C, reduced to two. D, reduced to one only *(hm)*.	A	A	B	A	A	D	C	C	A	A
(3)	Basal forking of Sc:—A, Sc′ complete. B, Sc′ reduced to a short vein. C, Sc reduced to veinlet *hm*.	A	C	C	A	B	C	C	C	C	C
(4)	Distal forkings of Sc and R1:—A, present. B. Absent.	A	A	A	B	A	B	A	A	A	A
(5)	Manner of branching of Rs:—A, dichotomic. B, R_{2+3} pectinate.	A	A	A	A	A	A	A	A	B	B
(6)	Number of branches of Rs:—A, more than four. B, four only.	A	A	A	A	B	B	B	B	A	A
(7)	Number of branches of M_{1-4}:—A, more than four. B, four only.	A	A	A	A	B	B	B	B	B	B
(8)	Cubito-median Y-vein:—A, complete. B, reduced.	A	A	A	[A]	[A]	B	A	A	B	B
(9)	Distal fusion of M_4 with Cu_{1a}:—A, absent. B, partial. C, complete.	A	A	A	B	A	A	A	C	A	A
(10)	Number of branches of Cu:—A, three. B. two.	A	B	A	A	B	B	A	A	A	A
(11)	Anal Y-vein in forewing:—A, absent. B, present.	A	A	A	A	A	A	B	B	A	A
(12)	Hindwing:—A, present. B, reduced to a halter.	A	A	A	A	A	B	A	A	A	A
(13)	Fusion of Cu_2 with 1A near base in hindwing:—A, absent. B, present.	A	B	[A]	A	[A]	—	B	B	A	A
(14)	Marginal splitting or twigging of veins:—A, absent. B, present.	A	A	A	A	A	A	A	A	A	B
(15)	Cross-vein System:—A, quite unspecialised. B, C, D, E, F, consecutive steps in arrangement and reduction, ending with the most highly specialised (Dipterous) system.	A	A	C	B	B	F	D	E	B	B
(16)	Wing-trichiation; macrotrichia:—A, unspecialised, on main veins and archedictyon only. B, unspecialised, but absent from membrane. C, mostly specialised as scales.	A	A	A	A	A	A	A	C	A	B
(17)	Wing-trichiation; microtrichia:—A, normal. B, reduced.	A	A	[A]	A	[A]	A	B	B	A	A
(18)	Wing-coupling apparatus:—A, complete. B, jugal bristles lost. C, jugal bristles and frenulum both lost.	A	A	—	—	—	C	C	B	B	B
	Comparative Archaism (percentage of archaic characters);—	100·	77·8	86·1	90·0	66·5	35·3	48·5	44·6	73·9	65·6


ORDERS
MECOPTERA
DIPTERA
TRICHOPTERA
LEPIDOPTERA
HOMO-NEURA
HETERO-NEURA
SIAL-OIDEA
MEGALOPTERA
PLANIPENNIA
RECENT
TERTIARY
CRETACECUS
JURASSIC
Lias
Upper
TRIASSIC
L'w'r
M'd'le
Up'er
PERMIAN
Lower
Upper
NEMOCERA
BRACHYCERA
CYCLORRHAPHA
JUGO-FRENATA
JUGATA
HETERONEURA
RHOPALOCERA
RAPHIDIOIDEA
SIALIDÆ
CORYDALIDÆ
PARATRICHOPTERA
PROTOMECOPTERA
PARAMECOPTERA
1
2
3
4
5
6
7
8
9
10
10
11

Text-Fig.112.

Phylogenetic Diagram for the Orders of the Panorpoid Complex, as worked out on the characters of the wings only. The small numerals represent the geological and phylogenetic positions of the following important fossil types:—*1*, *Permochorista* (Upper Permian of Belmont, N.S.W.); *2*, *Belmontia* (Upper Permian of Belmont, N.S.W.): *3*, *Triadosialis* (Lower Trias of Germany); *4*, *Mesochorista* (Upper Trias of Ipswich, Q.); *5*, *Aristopsyche* and allied genera (Upper Trias of Ipswich, Q.); *6*, *Archipanorpa* (Upper Trias of Ipswich, Q.); *7*, *Archepsychops* and *Protopsychopsis* (Upper Trias of Ipswich, Q.); *8*, the *Palaeontinidae* (Jurassic of England and Bavaria); *9*, the *Kalligrammatidae* (Jurassic of Bavaria); *10*, the Liassic Diptera; and *11*, the *Necrotauliidae* (Lias of England and Germany). The vertical columns represent the consecutive geological ages, from Lower Permian up to Recent. The black lines showing the descent of the various Orders are made to vary somewhat according to the abundance of species in each Order at different geological horizons, and are shown as broken lines where the evidence is not sufficient to allow of a definite decision.

of the more important of these, in fixing the phylogenies of the various Orders. Where the line of descent of any given Order is shown as a continuous black line, this indicates that there is a reasonable amount of certainty that this line is correct. Where the line of descent is shown broken, then there is no reasonable certainty, either as regards the *character* of the ancestry, or as regards the *geological time* at which the Order began to evolve. The widths of the black lines, indicating the various lines of descent, are made to vary somewhat in proportion to the relative abundance in species of the Orders which they represent, at each geological period.

The following conclusions appear to be justified:—

The Archetype of the Complex, which may be defined as *that group of closely related forms from which all the Orders of the Complex arose,* must have existed in the Lower Permian, and possibly even in the Upper Carboniferous. As far as its wing-venation is concerned, it may have been a specialised offshoot from either the Palæodictyoptera or the Protorthoptera, both of which show closely similar types of wing-venation. It seems fairly certain that this Archetype is not represented by any known fossil, and it is probable that it arose in some part of the world far removed from any of the known insect-bearing beds of the Carboniferous.

The four Orders Mecoptera, Paramecoptera, Protomecoptera and Paratrichoptera represent a group of closely related forms, which will probably be included in a single enlarged Order Mecoptera when further discoveries in the Permian and Triassic Beds have been made. Every new type discovered from now on, belonging to this group of Orders, will manifestly tend to help to close up the gaps that at present exist between them. Consequently I have no hesitation in stating that *Mecopteroid forms* were the first Holometabolous Insects to appear, and that they were well represented, probably by all these four Orders, both in the Upper Permian and the Trias.

From the Table, it would appear that the Protomecoptera are, on the whole, the nearest to the Archetype of the Complex. This Order must clearly have existed alongside the Mecoptera and Paramecoptera in the Upper Permian, and serves in some measure to connect the two. Neither the Protomecoptera nor the Paramecoptera can be derived from the other; and we are compelled to assume that both arose from a common ancestral stem in the Permian. This common stem was evidently also the original main stem of the Panorpoid Complex. From this main stem, apparently as a separate line of specialisation, in which Cu_I became an unbranched vein, there arose the common stem of the true Mecoptera and the Paratrichoptera,—two very closely allied Orders, neither of which is derivable from the other, seeing that the Paratrichoptera possessed originally the basal branch of Sc, which the otherwise more archaic Mecoptera lacked. These relationships between the four Mecopteroid Orders are indicated by broken lines in the Phylogenetic Diagram (Text-fig. 112).

In the Upper Trias of Ipswich, the Paratrichoptera were well represented by some fine forms. These serve to connect the Mecoptera with the Diptera, and indicate very clearly the line of descent of this latter Order. While it is not claimed that any of the known types of Paratrichoptera from the Ipswich Beds are in themselves the *actual ancestors* of the Diptera, I think that there can be no doubt that some types within this fossil Order, by reduction of their hindwings and narrowing of the bases of their forewings, gave rise to the dominant Order Diptera of to-day. True Diptera first appear in the Lias; and these are, as might be expected, chiefly Nemocerous types, though a few show the condition of Rs typical of the Brachycera. The Cyclorrhapha probably arose in the Cretaceous, as a side-branch from the older Brachycerous stem; their only known fossil representatives are of Tertiary age.

The line of ascent of the Parameeoptera leads directly to the common stem of the Trichoptera and Lepidoptera, as has been already shown in a previous paper (29). This common stem probably divided, somewhere in the Trias, into true Trichoptera, on the one hand, and Homoneurous Lepidoptera, of a Jugo-frenata type, on the other. From this latter stem, the present Homoneurous Lepidoptera are directly derived. The *Micropterygidae*, *Eriocraniidae* and *Mnesarchaeidae* are three very reduced and isolated remnants of the original stem, the true Jugata a somewhat more successful side-branch, reaching a comparatively high stage of evolutions in the *Hepialidae*. The Jurassic *Palaeontinidae* may well have been a specialised offshoot from the old Homoneurous stem, unconnected in any way with present-day Heteroneurous types, seeing that the method of reduction of the veins of the hindwing is not the same in these fossils as it is in recent Heteroneura. The Heteroneura, representing, at the present day, the great bulk of the Order Lepidoptera, arose from the Homoneura as their archetypic family, the *Protoeossidae*, probably either in the Upper Jurassic or in the Cretaceous; but the only known fossils definitely referable to this Suborder are of Tertiary age.

The two Neuropteroid Orders, Megaloptera and Planipennia, are venationally scarcely distinct enough to be retained separately, and are best regarded morphologically as two Suborders of a single Order Neuroptera. The Table shows that the common stem of these two Orders must have possessed a high percentage of archaic characters, and must have branched off from the original stem of the Complex very early. The recognition marks for fossil wings of these two Orders are the complete series of costal veinlets, and the pectinate form of Rs. The earliest known Megaloptera are found in the Lower Trias, the earliest Planipennia in the Upper Trias. But it is clear that the Archetype of the Megaloptera, at any rate, is more archaic than the Permian *Belmontia* in possessing a complete series of costal veinlets, and also in its type of cross-vein system. The possession of a distally forked Cu_1 marks the Megaloptera and Planipennia as an offshoot from the main stem of the Complex, rather than from the line of the true Mecoptera and the Paratrichoptera, which had this vein unbranched. Thus we are led to indicate, by a broken line, a probable origin for these two Orders from the main stem of the Complex a little before the point represented by *Belmontia.* The earliest forms must obviously have been of Megalopterous appearance, the Planipennia being a specialisation from the very base of the old Corydalid stem.

The construction of a Phylogenetic Diagram has been undertaken in this Part, because the only available evidence, in the case of the Fossil Orders, is that of the venation. The lines of descent of the other Orders may have to be modified, when we have considered the evidence which a study of other parts may bring forward. But, on the other hand, that study will gain much in interest, now that we have the results founded upon the wing-venation set out clearly before us.

APPENDIX A.

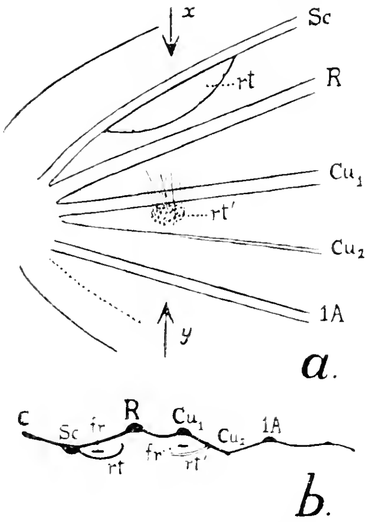
Note on the Wing-Coupling Apparatus of the Micropterygidae (sens. lat.).

In a short paper in the Entomological News, (26), and also in Part i. of this work (24), I described the wing-coupling apparatus of this group of insects. I now call attention to a correction which I have made in this description, in my paper on these insects recently published (27). The original description of the jugal lobe is true for the *Micropterygidae* (sens. str.) and for the *Mnesarchaeidae,* but not for the *Eriocraniidae,* in which the jugal lobe is of the same type as in the Trichopterous *Rhyacophila.*

APPENDIX B. (Text-fig. 16, corrected).

Note on the occurrence of the retinacula in the Lepidoptera Heteroneura.

I am indebted to Dr. A. J. Turner, F.E.S., of Brisbane, for some valuable criticisms of the results contained in Part i. of this research, so far as they concern the structure of the retinacula in the Heteroneurous Lepidoptera. Dr. Turner points out that the male retinaculum, which I termed *radial,* is in reality *subcostal.* The error is mine, and I gladly accept the correction. He also points out that the female retinaculum does not actually spring from the cubitus, but from a position below it, and suggests that it be termed the *subdorsal* retinaculum. This is also correct, and the terminology which he suggests for the two retinacula, *subcostal* and *subdorsal*, is an excellent one, which I gladly adopt. Consequently it will be necessary to alter the headings in the Table on p. 311 of Part i. (24), and to correct the lettering of Text-figs. 15-16 in that paper.



Text-Fig.16. (corrected).

a, Base of forewing of *Synemon* sp., male, from Killarney, Q., viewed from below, to show the correct positions of the two retinacula; *rt*, subcostal retinaculum; *rt′*, subdorsal retinaculum. (x 12). *b*, Section through same, taken along the line *xy* in fig. *a*, to show the positions of mechanical advantage of the two retinacula; *fr*, frenulum *in situ*. Other lettering as on p.535.

At the time Part i. was written, I had no fresh material of *Synemon*. Last summer Mr. E. J. Dumigan, of Clermont, Queensland, very kindly secured for me a number of fresh specimens of an undetermined species. I have descaled and cleared the wings of some of these, and give herewith a figure showing the exact positions of the two retinacula in the male (Text-fig. 16, *a*). It will be seen that the subdorsal retinaculum is a bunch of stiff hairs arising on the underside of the membrane, in the space between the strong convex vein Cu_1 and the weak concave vein Cu_2, which is obsolescent in this genus.

It is evident that the retinacula, being developed upon the *underside* of the wing, will attain the most advantageous position if they are developed either on or near those veins which project most below the general level or plane of the wing-surface. The concave veins are Sc, M and Cu_2; of these, M has been eliminated during the formation of the basal cell. Text-fig. 16 *b*, shows diagrammatically the mechanical advantage of the positions in which the two retinacula actually occur.

Dr. Turner also points out that both subcostal and subdorsal retinacula occur commonly in the males of *Noctuidae, Arctiidae, Liparidae* and *Pyralidae*, and can sometimes be detected in the *Geometridae*. He infers that "this double arrangement is the rule in the Heteroneura." Also, "in at least some female Noctuids there is an attempt at a subcostal retinaculum, though I cannot say that it is functional." He also draws my attention to the following interesting point:—"If you consult Sir G. Hampson's Catalogue of the Lepidoptera Phalænæ, vol. XI., you will find that the subfamily *Acontiinae* have normally a bar-shaped subcostal retinaculum in the male, but that, in some or all species of some genera, e.g. in *Earias*, this has been lost, and the frenulum articulates with the subdorsal retinaculum, as in the female. It is remarkable that, in two closely allied species, the male in one may have a well-developed subcostal bar-shaped retinaculum, in the other not."

There is, evidently, still a wide field of research open in the study of the evolution of the frenulum and its retinacula within the Lepidoptera Heteroneura.

APPENDIX C.

Note on the Resting-Position of the Wings in the Panorpoid Complex.

During my research upon the Panorpoid Complex, the Resting-Position of the Wings was carefully studied, with a view to giving a separate Part on this subject. The conclusions arrived at, however, show that no phylogenetic results of value can be attained, as regards the separate Orders. *All* the Orders of the Complex exhibit archaic types in which the resting-position is *stegopterous*, i.e. the wings are held, when at rest, in a slanting roof-like manner over the body. The angle of inclination of the wings depends, not only on their width, and the stoutness of the build of the insect, but also upon the form of the resting-surface; as, for instance, in the case of the *Psychopsidae,* in which that angle is very acute when the insect rests upon a twig, and very obtuse when it rests upon a flat surface. In the more archaic Orders Mecoptera, Megaloptera and Planipennia, the stegopterous position of rest is practically universal. In the Trichoptera, it is the usual condition in all but the specialised *Hydroptilidae.* In the Lepidoptera, the stegopterous position is that adopted by all the Homoneura, and by many of the older forms within the Heteroneura. In the Diptera, the same position of rest is seen in the case of the *Psychodidae*, while the position of rest in the *Tabanidae* and many of the Cyclorrhapha (as in the Blowfly) shows little alteration from it.

The conclusion to be drawn from this is that, as regards the resting-position of the wings, the whole of the Complex was originally the same. The evidence, then, is in favour of a monophyletic origin for the Orders of the Complex, and helps to strengthen the conclusions already arrived at, from a study of the wing-coupling apparatus, the trichiation and the venation.

The stegopterous position of rest is found also in certain Orthoptera, and in the Psocoptera and the Homoptera. It is a more specialised position than the position with wings outspread (as in Anisopterous Odonata), or lifted vertically up over the body (as in Plectoptera), but more archaic than the flatteneddown condition found in the Blattoidea, Perlaria (in which, also, the wings are more or less curved round the body), Heteroptera, Hymenoptera, etc.

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EXPLANATION OF PLATES.

Plate xxxi.

(Order PARAMECOPTERA).

Fig. 15. *Belmontia mitchelli* forewing (x 19); basal portion to show the cubito-median Y-vein.

Fig. 16. Portion of same wing, further enlarged (x $42\frac{1}{2}$), to show the trichiation of M_5 and Cu_1. (The arrows point to the bases of two macrotrichia, one on M_5, and the other on Cu_1.

(This Plate is the same as Plate xiii. in the paper numbered (29) in the Bibliography).

Plate xxxii.

(Order LEPIDOPTERA).

Fig 17. *Charagia splendens* Scott (fam. *Hepialidae*). Base of pupal forewing (x 18). To show the formation of M from two separate tracheæ, one from the costo-radial and the other from the cubito-anal group. (The edge of a cover-slip is visible crossing the tracheæ near their bases).

Fig 18. *Charagia eximia* Scott (fam. *Hepialidae*). Base of pupal forewing (x 56), from a specimen in which M and Cu arise close together from the cubito-anal group. Base of wing to the right; above, a portion of R, showing multiple origin.

Plate xxxiii.

(Order LEPIDOPTERA).

Fig. 19. *Xyleutes eucalypti* Scott (fam. *Cossidae*). Base of pupal forewing (x 10), to show the formation of the anal Y-vein by shortening of 2A. 3A is marginal.

Fig. 20. *Charagia eximia* Scott (fam. *Hepialidae*). Base of pupal hindwing (x 19), to show the union of Cu_2 with 1A near the base, and their separation further distad.

Plate xxxiv.

(Order LEPIDOPTERA).

Fig. 21. *Wingia lambertiella* Wing. (fam. *Oecophoridae*). Middle portion of pupal forewing (x 20), to show the five-branched R, the three-branched M and Cu, and portion of 1A. (The origin of Cu_2 lies to the right, just outside the photograph).

Fig. 22. *Carpocapsa pomonella* (Linn.) (Superfam. Tortricina). Basal portion of pupal forewing (x 57), to show cubital fork and formation of anal Y-vein.

Plate xxxv.

(Order LEPIDOPTERA).

Fig. 23. *Xyleutes eucalypti* (Scott) (fam. *Cossidae*). Lower distal portion of pupal forewing, to show the branches of M (in middle) and Cu_1 (x 6). A small part of Cu_2 is see in the lower right-hand corner.

Fig. 24. Small part of hindwing of same pupa, much enlarged (x 10), to show the fusion of Sc (the large upper trachea) with R_1. Note also the simple Rs. Base of wing lies to the right, and a part of M is visible in the lower portion of the photograph.

Postscript, added 30th September, 1919:—During a recent visit to Jervis Bay, I carried out some researches which have strengthened certain conclusions come to in this paper. These may be briefly summarised as follows:—

(1) A native Cockroach of the genus *Escala* was found very commonly under bark, and a number of specimens were taken which were still white and soft after undergoing an ecdysis. The wing-sheaths of these were dissected off, and the tracheation carefully studied. The result is that there can be no doubt whatever that the *vena dividens*, determined by Comstock as vein 1A fused with Cu, is in reality vein Cu_2. Thus the Cockroaches fall into line with the insects of the Panorpoid Complex, as well as with the Cicada and the Psocids, already mentioned in Section iv. of this paper.

(2) Further research upon the wing-tracheation of the *Hesperiidae* was carried out by obtaining pupæ of the well-known Skipper, *Hesperilla picta* Leach, in fine condition, and dissecting out their wings. This insect belongs to the Subfamily *Trapezitinae*. The results show that its pupal tracheation agrees in every important particular with that of *Euschemon rafflesia* already dealt with fully in this paper (Section xiv.). The only important difference is to be found in the imaginal venation, the vein M_2 failing to chitinise in the hindwing of *H. picta*, whereas it does so in the hindwing of *E. rafflesia*. We may therefore conclude from this, (*a*) that *Euschemon* is a true Hesperiid, and (*b*) that the Butterflies as a whole are a monophyletic group, the first dichotomy of which resulted in two lines of evolution, one leading to the *Hesperiidae*, with *Euschemon* as an archaic offshoot from near its base, and the other leading to all the rest of the Butterflies. It is clear that no existing type of Hesperiid represents the ancestral type of the Butterflies; but, on the other hand, *Euschemon* itself has not departed far from that lost ancestral type. R. J. T.

Fig. 1. Saltmarsh fringed by band of reeds (*Cladium junceum* and *Juncus maritimus* var.); Salicornia meadow in middle distance. Buffalo Creek.

Fig. 2. Parallel bands of *Juncus* and *Cladium*; *Juncus* in the tidal zone. Buffalo Creek.

F. W. Carpenter, photo.

Fig. 3. *Juncus* (drooping tufts) in tidal zone; *Cladium* (erect) on bank. Buffalo Creek.

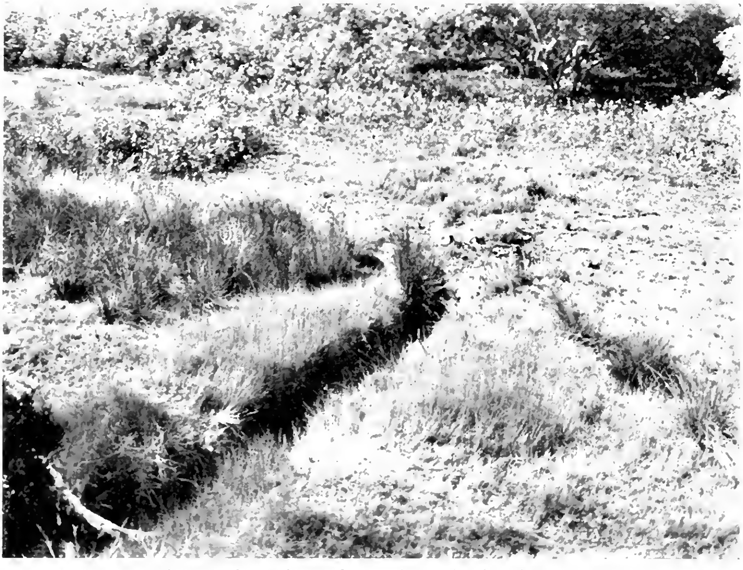


Fig. 4. Intrusion of *Juncus* formation by *Cladium*. Buffalo Creek.

F. W. Carpenter, photo.

Fig. 5. Luxuriant growth of Salt-grass (*Sporobolus virginicus*), Buffalo Creek.

Fig. 6. Debilitated culms of the Salt-grass, Cook's River.

F. W. Carpenter, photo.

Fig. 7. *Salicornia australis* encircling a *Ruppia* pool.
Homebush Bay.

Fig. 8. Tufts of *Salicornia* bordering a detritus mound crowned with Salt-grass.
Cook's River.

F. W. Carpenter, photo.

Fig. 9. *Ruppia maritima* L. (lying on mud) and *Triglochin striata* (lining the bank). Cook's River

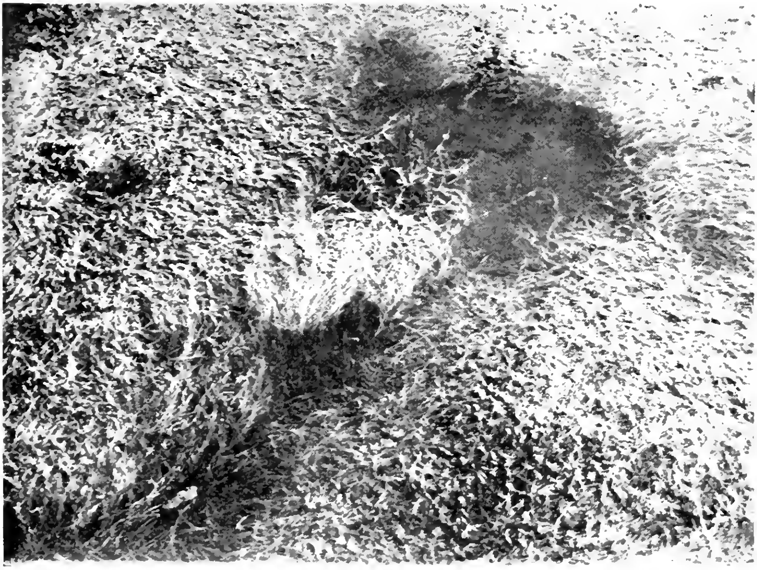


Fig. 10. Dense growth of *Ruppia maritima*. Cook's River.

F. W. Carpenter, photo.

Fig. 11. Encroachment by Seablite (*Suaeda maritima*). Homebush Bay.

Fig. 12. Pure culture of Seablite at Homebush Bay. Debilitated mangroves in foreground

F. W. Carpenter, photo.

Fig. 13. Intermingled patches of *Salicornia* and Seablite. Homebush Bay.

Fig. 14. *Juncus maritimus* on margin of salt-encrusted plain. Cook's River.

F. W. Carpenter, photo.

Fig. 15. Meadow of *Cotula coronopifolia* bordering Thatch-reed formation; *Juncus maritimus* in foreground. Undercliffe.

Fig. 16. Dense sward of *Salicornia* breaking up into mats. Cook's River.

F. W. Carpenter, photo.

Fig. 17. Thatch-reed (*Phragmites communis*) bisected by band of *Scirpus littoralis*. Undercliffe.

Fig. 18. Weak growth of Thatch-reed invaded by *Triglochin striata*. Undercliffe.

F. W. Carpenter, photo.

Fig. 19. Forest of Swamp Oak (*Casuarina glauca*) with undergrowth of Tea-trees (*Melaleuca* spp.) Bray's Bay.

Fig. 20. Stranded mangroves (*Avicennia officinalis*) invaded by grass and ruderal pasture. Cook's River.

F. W. Carpenter, photo.

Fig. 21. *Wilsonia Backhousii* Hook. f.

Fig. 22. Seablite (*Suaeda maritima*, Dumort)

F. W. Carpenter, photo.

Fig. 23. *Triglochin striata* Ruiz. et Pav.

Fig. 24. *Melilotus parviflora* Desf.

F. W. Carpenter, photo.

Fig. 25. *Selliera radicans* Cav.

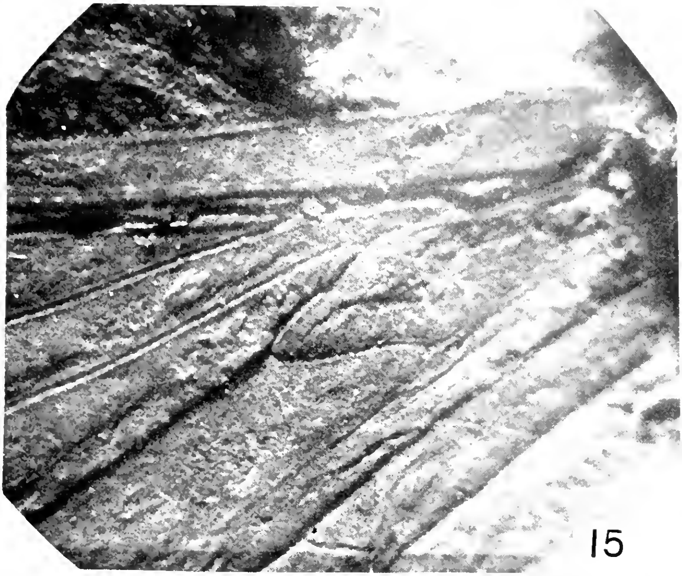
F. W. Carpenter, photo.

Fig. 26. Swamp Oak (*Casuarina glauca* Sieb.)

Fig. 27. *Juncus maritimus* var *australiensis*.

Fig 28. *Cladium junceum* R. Br

F. W. Carpenter, photo.



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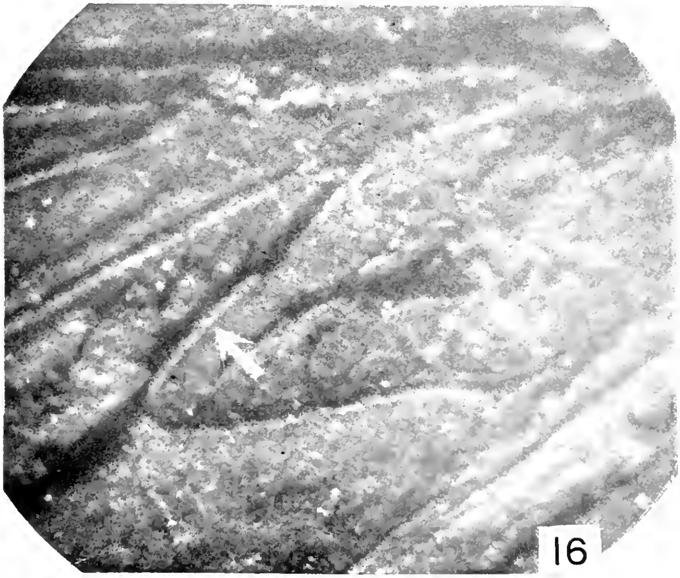

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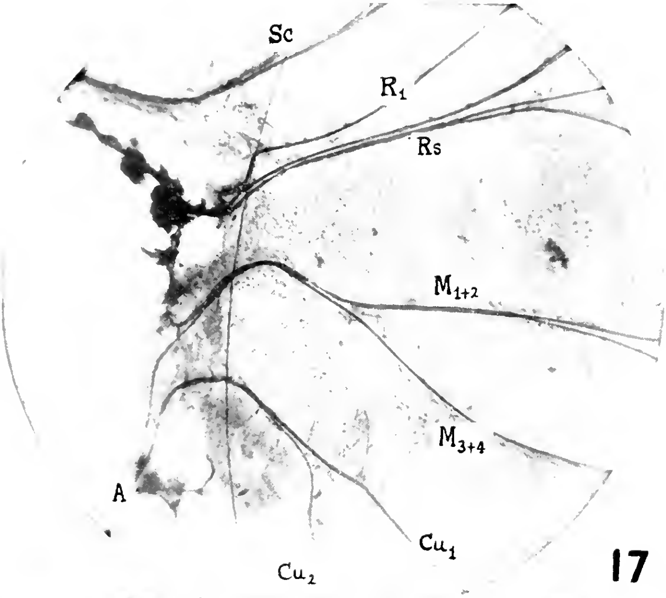
Belmontia mitchelli Tillyard.



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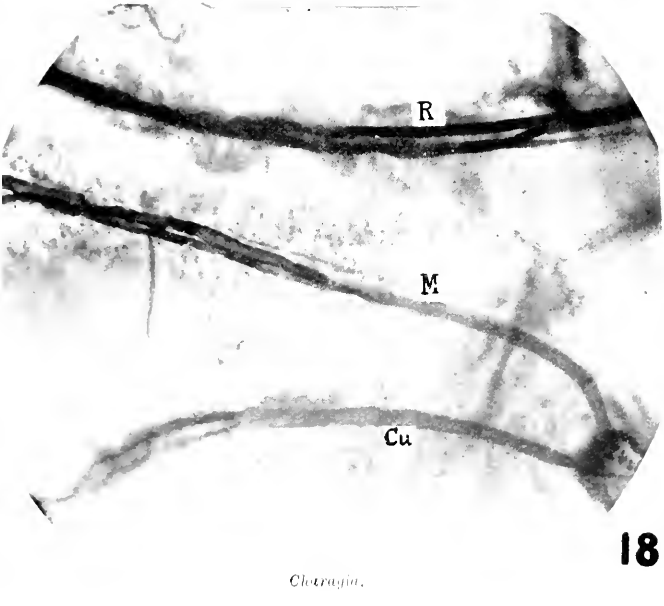

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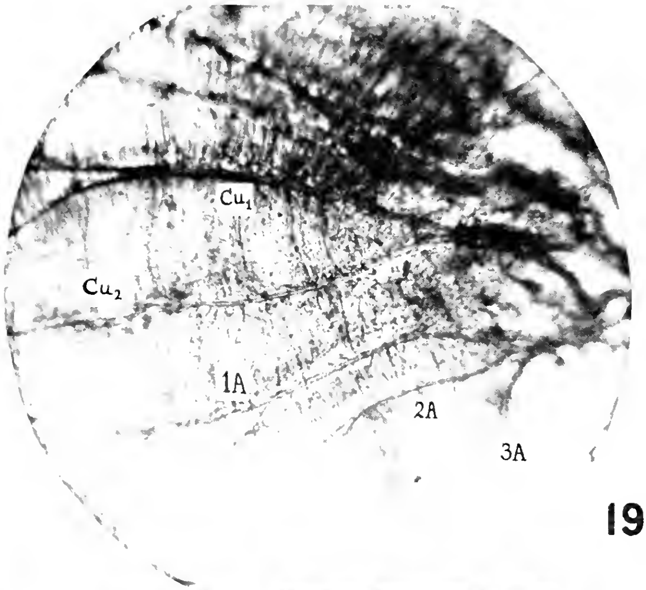
Charagia.



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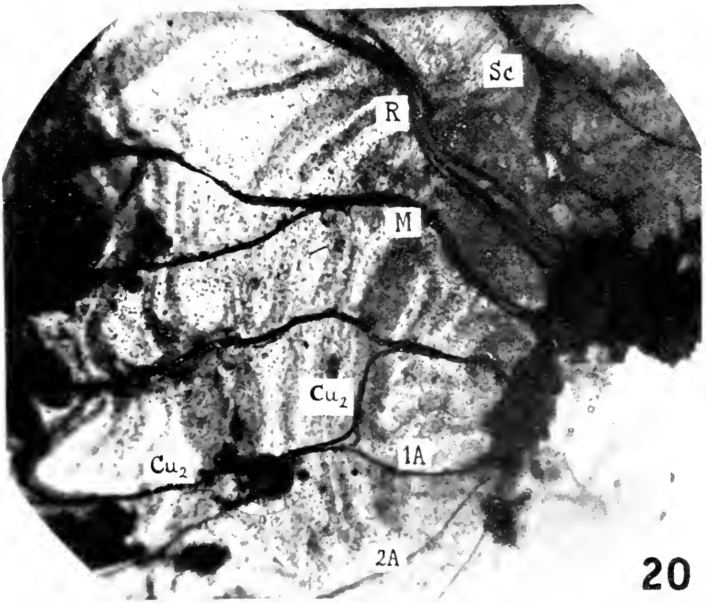

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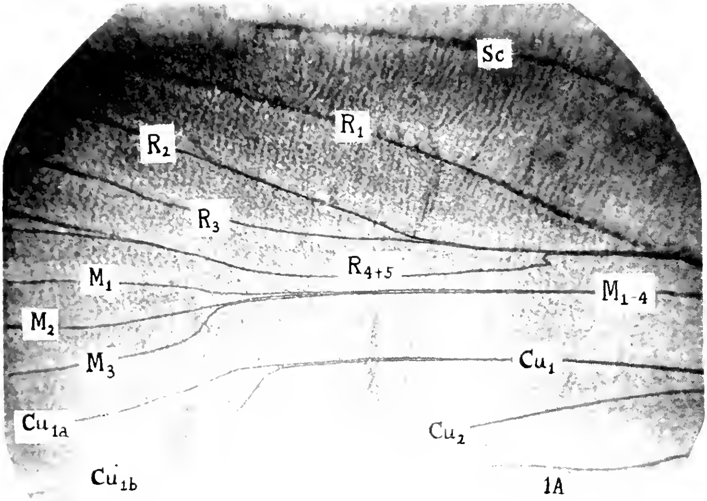
19. *Xylentes*. 20. *Charagia*.



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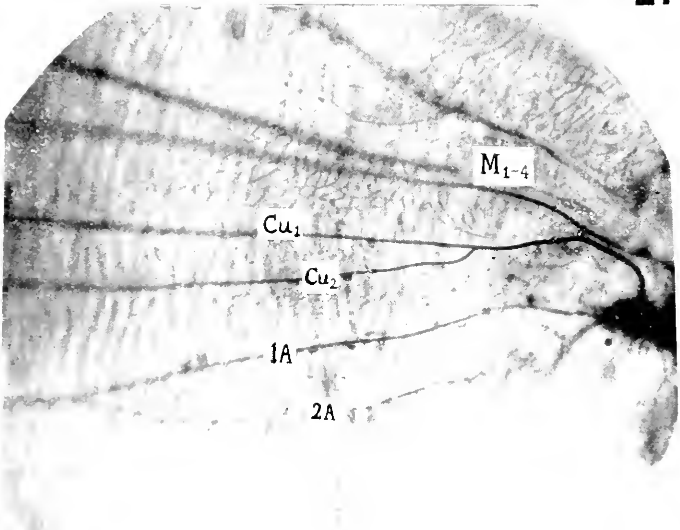

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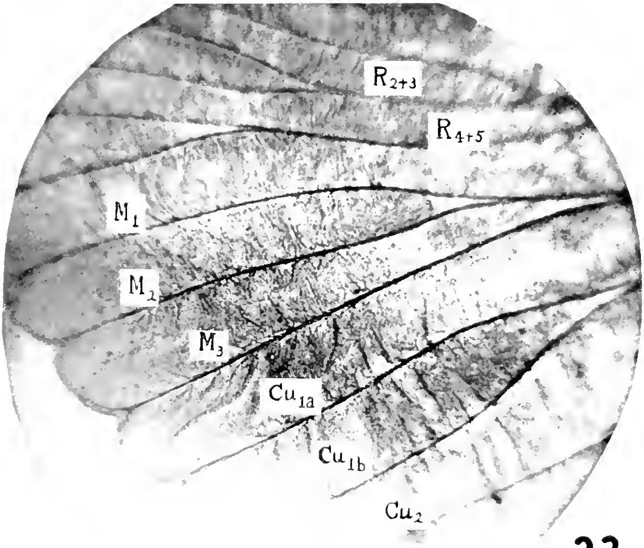
21. *Wingia.* 22. *Carpocapsa.*



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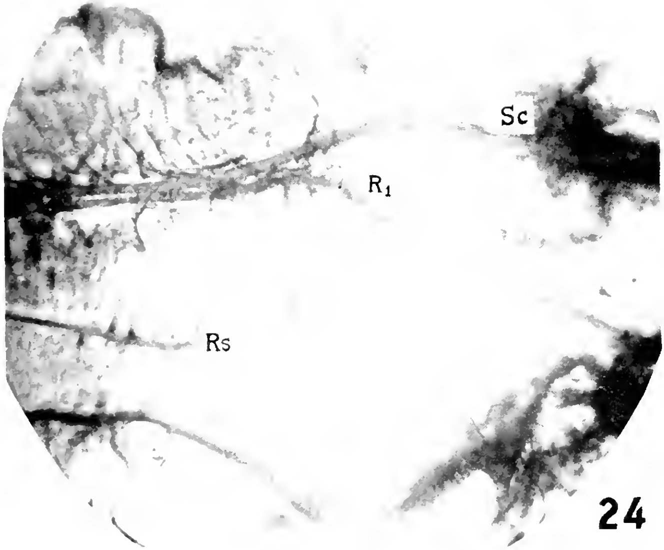


24

Xyleutes.

ORDINARY MONTHLY MEETING.

29th October, 1919.

Mr. J. J. Fletcher, M.A., B.Sc., President, in the Chair.

The President made the following announcements:—

(1) That the Council is prepared to receive applications for four Linnean Macleay Fellowships, tenable for one year from 1st April, 1920, from qualified Candidates. Applications should be lodged with the Secretary, who will afford all necessary information to intending candidates, not later than 30th November, 1919.

(2) That the Council had decided to resume publication of the Abstract which had been suspended since July, 1916.

(3) That the Council had decided to allow authors of papers fifty reprints instead of thirty as formerly.

(4) That the Council had decided on an alteration of the size of the volume to crown quarto, to commence with Part 1 of the Proceedings for 1920.

Letters were read from Messrs. W. M. Carne and W. R. B. Oliver returning thanks for congratulations and welcome on their return from active service.

An invitation having been received by the President to be present at the fiftieth anniversary of the foundation of the Otago Institute, it was resolved that a friendly message of greeting and congratulation be conveyed to the Institute.

A letter was read calling the attention of members to the proposed memorial to mark the retirement of Professor Sir Baldwin Spencer from the Chair of Biology in the University of Melbourne.

An invitation was received for members to attend a meeting of the Wild Life Preservation Society of Australia on 5th November, when lectures will be delivered on Antarctic Fauna and Australian Birds.

The Donations and Exchanges received since the previous Monthly Meeting (24th September, 1919) amounting to 5 Vols., 58 Parts or Nos., 2 Bulletins, 2 Reports and 1 Pamphlet, received from 36 Societies and Institutions and one private doner, were laid upon the table.

NOTES AND EXHIBITS.

Dr. R. J. Tillyard exhibited the larva, subpupa and pupa of the Great Cicada-hunting Wasp, *Exeirus lateritius* Shuck., figured in Mr. Froggatt's "Australian Insects" as *Salius bicolor.* These huge wasps were very busy making their large sand-mounds around Hornsby during the summer of 1917-8, and a number were watched dragging their prey to a large burrow with about twenty separate entrances. One wasp took a Cicada in a straight line for 95 yards, crossing a ditch and a fallen tree-trunk *en route.* In August, 1918, the burrow was dug up, and about thirty large cocoons, each placed beside the skeletal remains of a Cicada, and containing a full-fed larva inside, were secured. There were no connections between the separate tunnels. The cocoons were kept through the very dry spring and summer of 1918-19, but no wasps emerged. After the rains of the present Spring, the cocoons were damped considerably, and a fortnight later they were opened up, with the result that several of the larvæ were found to have changed to the subpupal and pupal stages. This points to the necessity of spring rainfall for the emergence of these wasps, and the same condition holds for the Cicada. Both these insects should, therefore, be fairly abundant during the coming summer.

Mr. A. A. Hamilton exhibited a series of specimens from the National Herbarium, Sydney, showing irregular phyllotaxy, petaloid heterotaxy, and frondescent prolification. (*a*) *Rosa* Hort. var. (F. Hallmann, 3, 1917), (*b*) *Rosa* "Maman Cochet" (J. L. Boorman, 4, 1919), (*c*) *Rosa* "Devoniensis" (W. Napier, 4, 1916). In example (*a*) four leaves have been produced in juxtaposition in the metamorphic region, forming an irregular whorl (the normal phyllotaxy of the genus is alternate). The whorl of leaves is intruded by a petal, and two opposing adventitious petals have replaced the foliage leaves at the nodes immediately above. Worsdell (Principles of Plant Teratology, p. 227) regards the spiral leaf arrangement as the primitive type of phyllotaxis. He refers to the phyton theory of Gaudichaud and other authors who maintain that the stem is built up of a succession of segments each composed of a leaf blade and a leaf base, and presents the monocotyledonous seedling as an example. In a reference to *Umbelliferae,* Worsdell (p. 228) notes that Domin, who has described a typical genus (*Didiscus*) of this family with unsegmented stem structure, observed an interesting reversion to the original segmented condition in an individual plant of *D. cyanopetala* Benth.— an endemic Australian species—which had throughout, leaves with sheathing bases enclosing the stem. In example (*b*) the shoot has been prolonged through the flower, and in example (*c*) the branch is fasciated and contorted in the region of flower formation, and two shoots have sprung from the contorted apex.

Dr. J. B. Cleland exhibited ovo-testes from mullet (*Mugil grandis*) and a testis and an ovary from normal fish for comparison. The anterior poles on both sides, more so in one than the other, are composed of testicular tissue, the rest of the organs being ovarian. Microscopically there was no difference between the testis and the ovary of the double organs and those of normal fish.—He also detailed the occurrence of auricular beats several hours after death in a Capuchin monkey, *Cebus fatuellus,* received for post-mortem examination from the Zoological Gardens.

Mr. E. Cheel exhibited flowering specimens of "Giant Bamboo" (*Bambusa arundinacea*) taken from lateral growths of plants which had been cut down in Mr. Hugh Dixson's shrubberies at "Abergeldie," Summer Hill.

It is interesting to note that flowering specimens are very rarely seen on the upper parts of the giant canes, but when cut down flowering spikelets are produced fairly freely on the lateral growths. In the National Herbarium, there are flowering specimens taken from plants formerly cultivated in the Government House grounds opposite the Health Office by Mr. W. F. Blakely, who stated that they were taken from lateral growths produced after the canes had been cut down.

Mr. A. F. Basset Hull contributed the following note on mortality amongst *Puffinus tenuirostris*:—On the 19th instant, numbers of Short-tailed Petrels (Mutton Birds) *Puffinus tenuirostris,* were observed off Sydney Heads, and during the following days very large numbers of dead birds were cast up on the beaches north and south of the Heads, from Deewhy to Bondi. On the 24th instant, Dr. Cleland collected twelve specimens, which were, with two exceptions, in an advanced stage of decomposition. They were all of the one species which breeds on the Islands in Bass Strait, and on the Victorian coast; they were extremely emaciated, and three examples sexed were females. Numerous instances of mortality amongst these birds are on record, and various theories have been advanced as to the cause—storm, waterspout, epidemic disease, and conflict with the species breeding along the coast of N.S.W., but I suggest that there is little doubt that the cause is starvation. The birds having followed a food supply northwards, and the failure of this supply, has resulted in the death of the birds. In 1911 I noted and examined numerous dead and dying specimens of this species at Ulladulla, N.S.W.

Mr. J. J. Fletcher showed examples of leafy galls on *Cassinia* sp., caused by a fly (*Trypeta* sp.), and some teratological developments, not understood, on *Aster ramulosa* and *Kennedya monophylla*.

ON A NEW ISOPODAN GENUS (FAMILY *ONISCIDAE*) FROM LAKE CORANGAMITE, VICTORIA.

By Chas. Chilton, M.A., D.Sc., LL.D., F.L.S., C.M.Z.S.,
Professor of Biology, Canterbury College, New Zealand.

(With twenty Text-figures.)

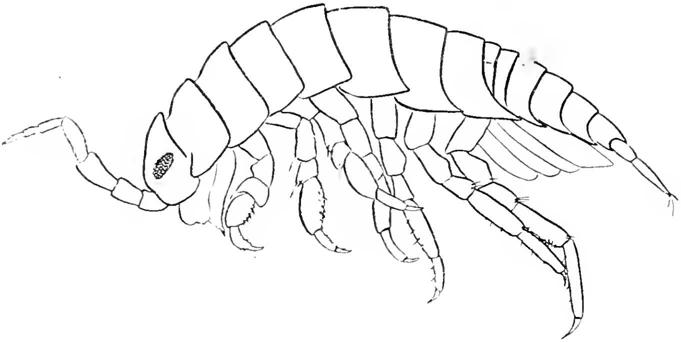
In 1918 I received from Professor W. A. Haswell, of Sydney, a single specimen of an Isopod that had been collected in Lake Corangamite, Victoria, by Mr. J. Searle, of Melbourne. Examination showed that the Isopod could not be placed under any of the genera known to me and that a full examination of the species was desirable. On my inquiring for further specimens, Mr. Searle very kindly sent on the whole of the remaining animals, eight in number, which he had collected. They had been gathered during an excursion to Lake Corangamite and district in March and April, 1918, and the circumstances under which they were found are described by Mr. Searle as follows:—

"Another interesting 'find' in this lake was an Isopod, certainly undescribed for Victoria, and probably new to science. Its capture was the result of inductive reasoning. Along the lake shore and in the shallow water Dottrel were observed. As the netting operations captured nothing larger than Copepoda, and the algae on the rocks sheltered Ostracoda and the little univalve mollusc *Cociella striatula*, curiosity was aroused as to what the Dottrell found to eat. Selecting a rock on the shore where one could kneel without getting unduly wet, the muddy bottom of the lake was scrutinised for any appearance of living creatures. Finally our patience was rewarded by observing a movement just under the surface of the fine silt, and the quick insertion of the fingers resulted in the capture of an Isopod. Twenty minutes' close search was rewarded by the capture of eight or ten specimens. When next there is an opportunity of visiting this lake, apparatus will be taken for the special investigation of this class of animal life, and perhaps further new species may be secured."*

I suggest the following name and diagnosis for this interesting Isopod, the specific name being chosen in honour of Mr. J. Searle, its discoverer.

HALONISCUS SEARLEI, nov. gen. et sp. (Text-figs 1 to 20.)

Diagnosis.—Body narrow oval, moderately convex, with lateral portions not greatly expanded. Dorsal surface smooth, and, like the appendages, covered with very minute short hairs. Cephalon slightly rounded in front and without lateral lobes. Pleon not greatly narrowed, first and second segments without epimera, third, fourth and fifth with epimera well developed, last segment large and with well developed lateral portions in addition to the triangular extremity. Eyes well developed, lateral. First antenna very minute. Second antenna well developed, flagellum with 3 joints. Mandibles with not more than 2 penicils behind the cutting part. Second maxilla with outer edge not angularly produced near the base. Legs consisting of two series, the anterior four more or less subchelate and of approximately the same size and shape; the fifth, sixth, and seventh simple, longer than the anterior pairs, and increasing in length posteriorly, dactyls bi-unguiculate, without special dactylar seta. Pleopoda with opercular plates greatly de-



Text-fig. 1. *Haloniscus searlei*, male, side view.

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*Victorian Naturalist, xxxv., p.27. (June, 1918.)

veloped, delicate and without air cavities; the endopods small. Uropods well produced and exposed, inner ramus attached only slightly in front of the outer which it resembles in structure.

Colour.—Slaty grey, whole surface thickly covered with irregular pigment spots, appendages lighter.

Length of largest specimen, 8 mm. *Breadth* about 3.5 mm.

Locality.—Lake Corangamite, Victoria (in salt water).

I have considerable difficulty in assigning this species to its proper place in the Oniscoidea. In the second antenna and the mouth parts, and in the absence of a special dactylar seta,* it agrees well with the characters laid down by Sars† for the *Oniscidae*, and must certainly be placed in that family. It differs, however, in having the second maxilla not angularly produced near the base and the outer branch of the uropod is not flattened; moreover, the terminal segment of the body is much better developed than in other members of this family, and has the lateral portions distinct as well as the terminal triangular part. In the last character the animal is more like *Ligia,* a genus which it also resembles in the general appearance of the body and of the legs; these characters, however, being perhaps purely adaptive. Of the genera usually assigned to *Oniscidae* it seems to come perhaps nearest to *Philoscia,* though it differs very markedly from this genus in the points mentioned above and in its aquatic mode of life.

I give below a more detailed account of the animal and of its appendages.

Antenna 1 (fig. 2) minute, of 3 joints, the 1st longer and broader than the 2nd, 3rd tapering, with one or two simple setæ at the apex and near the apex.

Antenna 2 (fig. 3) with first 3 joints subequal, 4th longer, and 5th considerably longer than the 4th; flagellum slightly longer than the last joint of peduncle, of 3 joints, 1st and 3rd subequal and longer than the 2nd, 3rd tipped with tuft of setæ; all the joints covered with minute setæ, a few stouter ones at the extremities of the joints of the peduncle as shown in the figure.

Upper lip (fig. 4) much broader than long, central part fringed with fine setæ.

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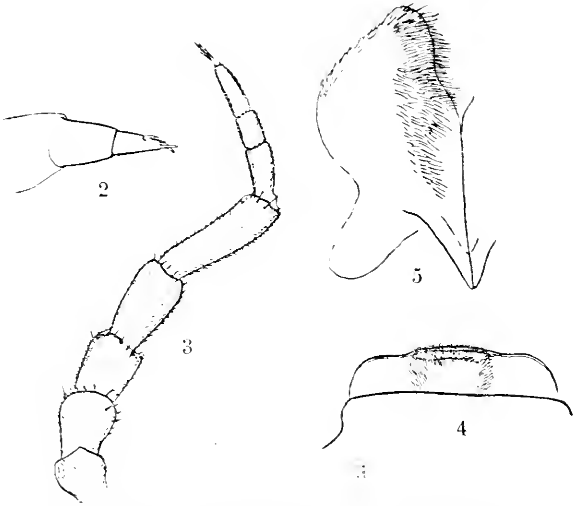
*Chilton. Trans. Linn. Soc. London, Zool., Vol. viii., 1901, p.102.

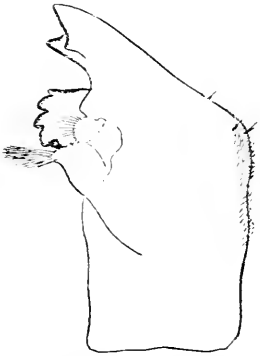
†Crustacea of Norway, Vol. ii., Isopoda, 1899, p.169.



Text-fig. 2. First antenna (highly magnified).
Text-fig. 3. Second antenna. Text-fig. 4. Upper lip.
Text-fig. 5. Lower lip.

Right mandible (fig. 6) of the usual form, outer cutting edge strong, composed of 3 teeth, dark brown in colour, inner cutting edge small, ending in 2 teeth, two penicils between the inner cutting edge and the usual tuft of long plumose setæ; ciliated lappet small.

Text-fig. 6. Right mandible.



Text-fig. 7. Left mandible.

Left mandible (fig. 7) with the inner cutting edge large, formed of 4 teeth, dark brown in colour, only one penicil visible; ciliated lappet delicate, fringed with many fine setæ.

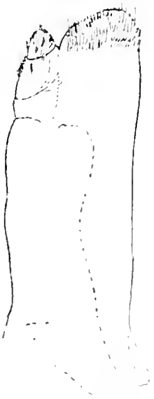
Both mandibles with numerous fine setæ near the bend in the outer margin.

Lower lip (fig. 5) small, narrow, outer and inner margins and surface near the inner margin thickly covered with fine setæ.

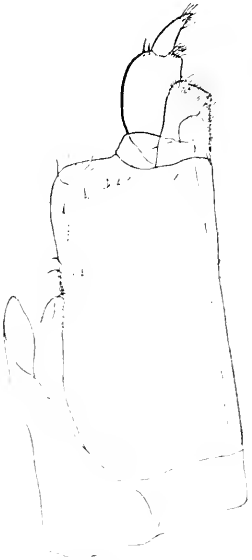
Maxilla 1 (fig. 8) with the outer margin of outer lobe somewhat sinuous; a tuft of fine setæ towards distal end; apex bearing 6 or 7 strong teeth, the outer stronger than the inner and brown in colour. Inner lobe delicate, rather broad, a small tuft of fine setæ at distal end of outer border, apex with the usual two plumose setæ.

Maxilla 2 (fig. 9) very delicate, inner lobe broad, covered at the apex with fine setæ, outer lobe narrower, more strongly chitinous, apparently marked off from the inner by a suture and indistinctly divided into two joints, both thickly supplied with short setæ.

Text-fig. 8.
First maxilla.



Text-fig. 9.
Second maxilla.

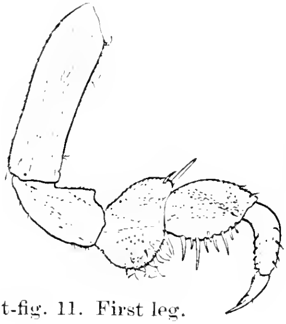


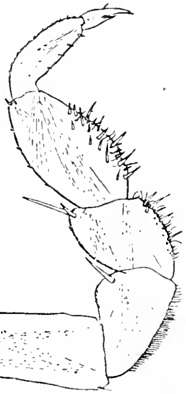
Text-fig. 10. Maxilliped.

Maxilliped (fig. 10) with basal joints broad, rectangular, terminal portion short with two joints, last one narrow and tipped with setæ. Masticatory lobe truncate, covered with short setæ. Epipod rather more than half as long as the basal joint, narrowing distally, delicate.

First pair of legs (in the male) (fig. 11) short, the merus expanded, much broader than long, produced on inner side into a rounded, scabrous lobe bearing a few fine setæ in addition to the short setæ forming the scabrous surface, carpus oval, longer than merus, much narrower, its inner surface bearing a number of stout setæ of different lengths; propod narrow, curved, and together with the dactyl bent back upon the carpus forming a subchelate limb; dactyl slender, bi-unguiculate, its inner margin minutely roughened, no special dactylar seta to be seen.

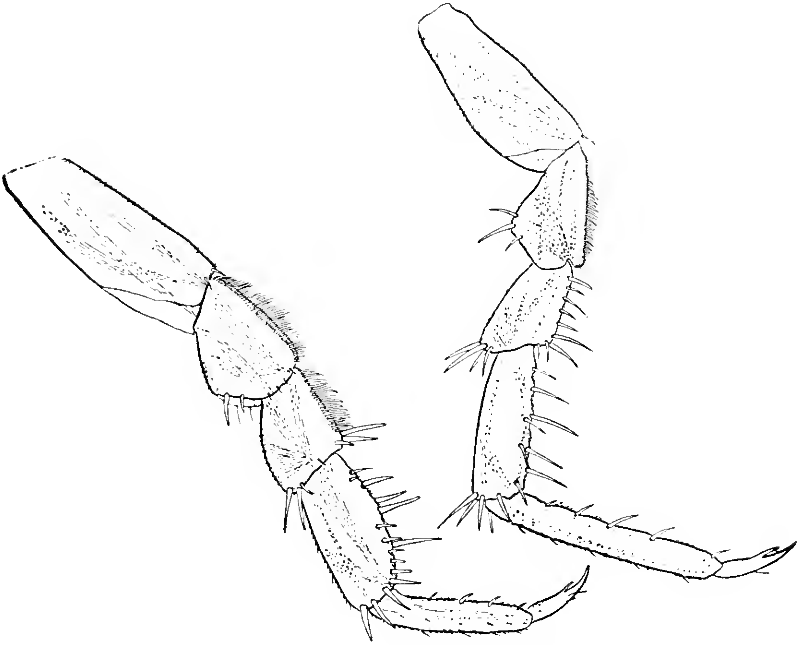
Second pair of legs (fig. 12) similar to the first but slightly longer, whole inner margin of ischium regularly fringed with fine setæ; merus narrower than in the first leg, inner margin not produced into a lobe but bearing numerous stout setæ and fine hairs; carpus, propod and dactyl similar to those of the first pair of legs except that the carpus is longer.


Text-fig. 11. First leg.


Text-fig. 12. Second leg.

Third and fourth pairs of legs similar to the second, each slightly longer than the preceding.

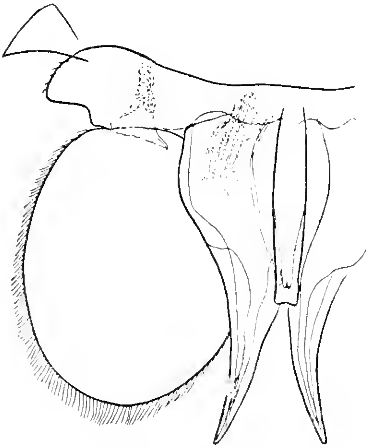
Fifth, sixth and seventh pairs of legs similar and longer than any of the anterior four pairs. In the fifth (fig. 13) both ischium and merus have the inner margin regularly fringed with fine setæ; in the sixth and seventh (fig. 14) the ischium is thus fringed but the fine setæ are almost absent from the merus. Stout setæ or spines on all the joints as shown in the figures. Sixth leg longer than fifth and seventh longer than the sixth.



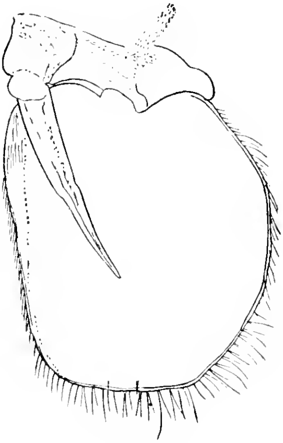
Text-fig. 13. Fifth leg. Text-fig. 14. Seventh leg.

First pair of pleopods (in the male) (fig. 15) of the usual structure, exopod forming a very delicate rounded plate with the margin regularly fringed with setæ; endopod modified, broad at the base, tapering to the apex and bearing a groove fringed distally with short setules; male organ single, narrow, slightly emarginate at the end.

Second pair of pleopods (fig. 16) with the exopod or outer plate similar to that of the first, the modified endopod reaching



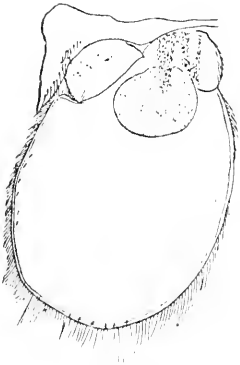
Text-fig. 15.
First pleopod of male.



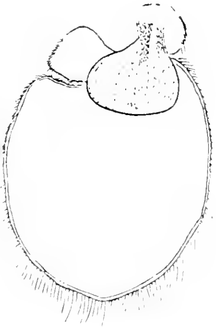
Text-fig. 16.
Second pleopod of male.

two-thirds towards the end of the outer plate, apparently formed of 2 joints, the terminal one tapering to the acute apex, with groove corresponding to that in first pleopod.

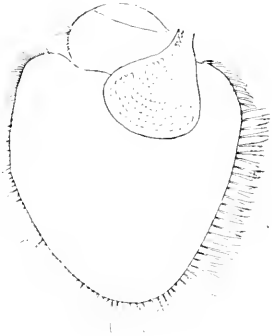
Third (fig. 17), *fourth* (fig. 18), *and fifth* (fig. 19) *pair of pleopods* are similar, the third being the largest, the fourth and



Text-fig. 17.
Third pleopod.



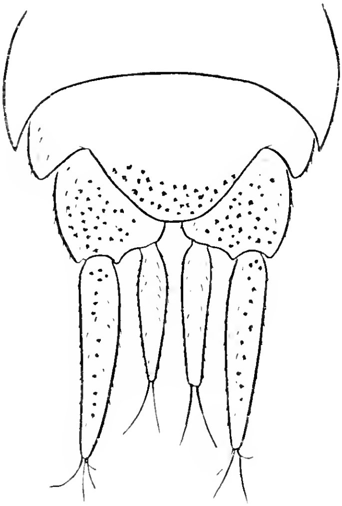
Text-fig. 18.
Fourth pleopod.



Text-fig. 19.
Fifth pleopod.

fifth subequal, in each the outer or opercular plate is large, rounded, very delicate in structure and regularly fringed with fine setæ, the endopod is small and rounded.

The *uropods* (fig. 20) have the basal joint about as broad as long, inner ramus attached only slightly anteriorly to the outer, both rami slender, cylindrical, tapering slightly and ending in a small tuft of long setæ.



Text-fig. 20. Uropoda and terminal segment.

The terminal segment (fig. 20) is only slightly narrower than the preceding segment, and has the lateral portions better developed than in other *Oniscidae* in which the terminal segment is usually reduced to a small triangular plate.

The above description has been taken mainly from the large male specimen first received and dissected. None of the other specimens bear eggs or can for other reasons be definitely recognised as female, and in all of them the legs have the same general character as those already described, though in the smaller specimens the special characters of the first and second pairs of legs are not so well marked. Two or three of the eight specimens are certainly males, as can be seen without dissection from their first and second pleopods, the others may also be males, but I cannot feel certain without dissecting the pleopods, and as they appear quite similar in all other characters, it seemed hardly necessary to do this.

Remarks.—The occurrence of this Oniscid living in the waters of Lake Corangamite raises an interesting question to which it is not easy to give a decisive answer. All the other members of the *Oniscidae* known to me are more or less strictly terrestrial. Some of them may be found near the seashore, but they do not live actually in the water, but in places under stones, leaves, etc., where the air is moist. Most of them it is true are still branchial breathers, but the outer branches of their pleopods form opercula and are pressed close to the body enclosing the branchiae in spaces where the air can be kept moist for long periods of time;* in other cases the branchiæ themselves are specially modified to allow of their breathing air or they even contain air passages and cavities that act as tracheae†. In *Haloniscus searlei* on the contrary the outer branches of the pleopoda are particularly large and delicate and hang loosely below the body and they perhaps act as branchiæ supplementing the branchiæ proper formed by the inner branches which are smaller in comparison than is usual in the family.

There is however no doubt that the *Oniscidae* and the other terrestrial Isopoda are originally descended from marine ancestors. Some such as *Scyphax*, *Scyphoniscus* and *Deto*,‡ belonging to the family *Scyphacidae* closely allied to the *Oniscidae*, still live on the seashore between tide marks and are consequently periodically submerged. Their mouth parts, pleopoda, etc., are on the whole of a slightly more primitive character and not so specialised as in the more strictly terrestrial *Oniscidae* under which *Haloniscus searlei* must be placed. The

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*Dorothy A. Stewart has shown (Mem. and Proc. Manchester Lit. and Phil. Soc., lviii., Session 1913-1914, No. 1) that in *Ligia oceanica* the respiratory functions of the exopod, "if they exist, are very slight," and that though the animals eventually die if constantly submerged in water, either fresh or salt, they possess "a considerable adaptability in regard to immersion in sea-water."

†J. H. Stoller. "On the organs of Respiration of the *Oniscidae*," Zoologica, Heft 25, 1899.

‡Chilton. Jour. Linn. Soc. London, Vol. 32, 1915, p.435.

question therefore arises—is *Haloniscus* a form that has always lived in salt water or is it a terrestrial form that has become re-adapted to aquatic life? To decide this question we naturally examine its characters to see if any of them show the primitive structure we would expect if it has always lived in the water. But none of them give decisive evidence of this. The terminal segment of the body is more fully developed than in other *Oniscidae* and the uropods are more exserted but not more so than in *Ligia*, *Trichoniscus* and other genera which live almost or quite wholly on land. The pleopoda, as already mentioned, do differ somewhat from those of other *Oniscidae* but this may be due to secondary adaptation. The mouth parts, antennæ, etc., agree so closely with those of the *Oniscidae*, one of the most strictly terrestrial families, that it seems improbable that *Haloniscus* should differ from the other members in never having taken to a life on land.

This tentative conclusion may be confirmed or disproved by a consideration of the origin of Lake Corangamite—is it a portion of the ocean that has become separated from the rest or is it of separate origin and its saltness due to other causes? For information on these points I applied to Professor W. N. Benson of the University of Otago who replied that in the article on Lakes of the Commonwealth in the Commonwealth Yearbook, No. 4, 1911, p. 73, Lake Corangamite is classed as one of the "Lakes filling subsided areas which have resulted from the adjustment of the surface to the new conditions following the transference of large quantities of rock from underground to the surface in the form of lava flow (basalt)." It is one of the "lakes in basalt plains." "Most of these have no streams entering them." Professor Benson adds that the maximum depth of the lake is 10 ft., its height above sea-level 380 ft., and that the basalt in which the lake lies is of late Tertiary age.

It seems evident from the information thus kindly supplied by Professor Benson that the Lake is not of marine origin and this appears to be confirmed by the brief account of the plants of Lake Corangamite given by Mr. A. D. Hardy,* for though on its shores there occur *Salicornia*, *Enteromorpha* and other halophytic plants there does not seem to be anything distinctly

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*Victorian Naturalist, Vol. xxxv., p.28.

marine in its flora. Moreover Lake Colac, which is situated only a few miles away, is fresh and in its waters lives the little freshwater crab *Hymenosoma lacustris* found in fresh water streams and lakes in Australia, Tasmania, New Zealand, Norfolk Island and Lord Howe Island,* thus apparently showing that the places where it is found cannot have been submerged below the sea for a period extending sufficiently far back in the past to account for its present wide distribution.

On the whole therefore I incline to the opinion that *Haloniscus* is the descendant of a form that was terrestrial in habits and that, owing to the special circumstances arising from its habitat, it has become re-adapted to aquatic life.

I wish to record my thanks to Professor W. A. Haswell and Mr. J. Searle for the opportunity of examining and describing this Isopod, and to Miss E. M. Herriott, M.A., Assistant at the Canterbury College Biological Laboratory, for the care and accuracy with which she has prepared the figures illustrating the paper.

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*Chilton. Trans. N.Z. Inst., Vol. 47, p.316, and Proc. Roy. Soc. Tasmania, 1919, p.93.

DESCRIPTIONS OF NEW SPECIES OF AUSTRALIAN COLEOPTERA. Part xv.

By Arthur M. Lea, F.E.S.

SCARABAEIDAE.

Rhopaea polita, n.sp.

♂ Of a bright pale castaneous and highly polished, elytra and antennal flabellum somewhat pale. Upper surface almost glabrous, sterna densely pilose.

Head moderately convex, and with moderately large, sharply defined punctures, becoming crowded at sides. Clypeus scarcely bilobed in front; punctures much as on rest of head, but sparse along middle. Antennae ten-, flabellum five-jointed; third joint cylindrical and fully twice as wide as long, fifth acute inwardly. Apical joint of maxillary palpi with a shallow, longitudinal depression. *Prothorax* apparently about twice as wide as long, sides strongly rounded and obtusely serrated; hind angles almost rectangular; median line short and vaguely impressed; punctures moderately large, but nowhere dense. *Scutellum* with rather numerous punctures. *Elytra* with vague geminate striae, enclosing four obtuse discal costae on each elytron; the interspaces with numerous fairly large punctures. *Pygidium* with dense, shallow, and mostly longitudinal punctures; its tip obtusely bilobed. Front *tibiae* strongly tridentate. Length, 19 mm.

Hab.—Queensland: Banana (E. Barnard), unique.

The upper surface is glabrous except for a few hairs between the eyes, and a dense fringe overlapping the base of the scutellum; the elytra have marginal fringes, the pygidium has very sparse and short pubescence. The middle of the base of the head is impunctate; the whole of the upper-surface and the pygidium are very finely shagreened; the elytral punctures are of one kind only, instead of two, as in most species of the genus. If the character AAAA of Blackburn's table of the genus was without the expression "(only apical 3 of them full length)" this species could be referred to that group, but as it stands it cannot be so referred, as the five joints are of even length; of the species referred to that group, the sixth joint (first of the flabellum) in *R. morbillosa* and *R. planiceps* has an acutely pointed ramus, about half the length of that of the following joint; in *R. incognita* the first and second joints of the flabellum are both described as shorter than the third, and the clypeus was described as "alte reflexo," in the present species the upturn of the clypeus is much as in *R. planiceps.* At first glance it is much like *Pararhopaea callabonnensis,* but the labrum, antennae, etc., are very different.

MICRORHOPAEA, n.g.

Head short; clypeus short, bilobed in front. Eyes large and very finely faceted. Labrum on the same plane as front face of clypeus, and considerably longer than it. Labial palpi short; maxillary palpi moderately long, apical joint as long as the two preceding ones combined. Antennae ten-jointed, the flabellum consisting of seven long rami. *Prothorax* short. *Scutellum* large. *Elytra* without regular striae; covering most of the pygidium. *Metasternum* elongate. *Legs* moderately long; front coxae widely transverse; femora moderately wide; front tibiae tridentate; tarsi long and thin, claws long, thin, and each with a small but acute basal appendix.

By Blackburn's table of the subtribes of Melolonthides* this genus must be referred to the true Melolonthides, and by his table of that subtribe† it would be associated with *Rhopaea,* several of whose species have the flabellum seven-jointed. The much smaller size and different appearance (although the head is short and bilobed as in *Pararhopaea* and *Lepidiota*) of the only known species, indicate that the genus is distinct from *Rhopaea,* but almost the only apparently valid distinction is in

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*Trans. Roy. Soc. S. Aust., 1905, p.276.

†*L. c.*, 1911, p.187.

the claws; each of these has a very small and acute tooth near the base and at the extreme base a gentle swelling; in *Rhopaea* the tooth is considerably larger and more distant from the base. At first glance it has the appearance as of being allied to *Liparetrus* and *Comophorus*. The spurs to the hind tibiae are acute and almost evenly decrease in width from the base to the apex.

MICRORHOPAEA FLAVIPENNIS, n.sp.

♂ Black; elytra and antennae flavous, basal joint of the latter darker, palpi and tarsi of a more or less dingy red. Elytra with sparse, short, depressed, white setae; rest of upper surface, under surface and legs with rather dense, long, white hair.

Head (including clypeus) with coarse, crowded punctures. Antennae with basal joint slightly longer than two following combined, second narrow at base and suddenly dilated at apex; rami of the flabellum of equal length and slightly longer than clypeus is wide. *Prothorax* about twice as wide as long, front angles almost completely rounded off, hind ones obtuse; with large and coarse punctures, but leaving an impunctate median line on basal half. *Scutellum* with coarse punctures at base, apex shining and impunctate. *Elytra* with sides gently rounded, each obliquely truncated at apex; without striae except one with coarse punctures on each side of suture; punctures rather large, but not so crowded (although in places confluent) as on prothorax. *Pygidium* with dense, more or less concealed punctures. Apical tooth of front *tibiae* long and acute, second acutely triangular, third small. Length, 9.5 mm.

Hab.—Northern Territory: Darwin (N. Davies).

The colour, clothing, and beautiful fan-like antennae render this species an extremely distinct one; it is the smallest Australian member of its subtribe.

ENGYOPS CASTANEUS, n.sp.

Bright reddish-castaneous. A fringe of long hairs on each side of prothorax and elytra, rest of upper surface glabrous; pygidium with a conspicuous fringe; under surface and legs sparsely and irregularly clothed.

Head with sparse and rather small punctures between eyes. Clypeus semicircular, margins moderately upturned, and near base suddenly deflected outwards, hind suture curved to middle;

punctures denser and coarser than between eyes. Antennae nine-, club three-jointed, rami almost the length of front tibiae. *Prothorax* about twice as wide as long, sides evenly rounded, apex and base gently bisinuate; front angles gently rounded off, hind ones more strongly; with rather sparse punctures, much as on head between eyes. *Elytra* feebly dilated to beyond the middle, with rows of fairly large punctures in feeble striae, or the striae deep and their punctures small, even interstices wider than the others, and with fairly numerous punctures, the odd interstices with smaller and sparser punctures. *Pygidium* with rather sparse punctures, but denser in angles. Front *tibiae* tridentate, the two first teeth large and fairly close together, the third small, but acute, and slightly nearer the base than the second; basal joint of hind tarsi slightly longer than the second. Length, 12.5—13 mm.

Hab.—Queensland: Coen River (H. Hacker).

Much larger and wider than *E. spectans,* and with the third tooth of the front tibiae more distant from the second than in that species; from *E. flavus* it also differs in being considerably larger and darker, clypeus longer, etc.; the mentum more nearly approaches that of *spectans* than that of *flavus.*

TELURA SUTURALIS, n.sp.

Flavous, suture infuscated almost to apex. Upper surface glabrous except for two hairs on each side of clypeal suture and a few at sides of prothorax and of elytra; three segments of abdomen each with a transverse row of long stiff hairs, a few similar hairs on metasternum and legs.

Head rather convex and with sparse and minute punctures, becoming larger and denser at sides and in front. Clypeus more than thrice as wide as long, margins moderately upturned, front very gently incurved to middle (almost straight); punctures larger and denser than elsewhere on head. Antennae nine-, club three-jointed, rami slightly longer than inner apical spur of front tibiae. *Prothorax* not twice as wide as long, sides evenly rounded, front angles produced and acute, hind ones rounded off but almost rectangular; punctures sparser and slightly smaller than on clypeus. Apex of *scutellum* impunctate. *Elytra* long, thin and almost parallel-sided; striae well-defined, but becoming faint posteriorly, punctures irregularly placed in them, and often partly on interstices, the latter with rather sparse punctures. *Pygidium* with minute punctures. *Legs* long and thin; front tibiae tridentate, apical tooth long and acute, second acute but much smaller, third very small and ill-defined. Length, 9-10 mm.

Hab.—Western Australia: Mullewa (Miss J. F. May).

A long narrow species, nearer to *T. clypealis* than to *T. vitticollis*, but front tibiae with the third tooth very feeble, and clypeus gently incurved to middle (in shape it is intermediate between that of the two other species). The club is three-jointed on the two specimens before me, possibly indicating that they are females.

PHYLLOTOCUS FUGITIVUS, n.sp.

♂ Black, front legs and claws more or less reddish. Prothorax and elytra fringed with thin setae, similar, but more numerous setae on under-surface and legs.

Head with dense and comparatively coarse, crowded punctures. Clypeus distinctly shorter than an eye, its sides lightly upturned; labrum about half the length of clypeus, its front edge gently upcurved, truncated in middle, the angles widely rounded off. Antennae eight-, club three-jointed, lamellae each as long as the five basal joints combined. *Prothorax* about once and two-thirds as wide as long, sides moderately rounded, apex evenly incurved, with the front angles acute but not separately produced, hind ones rounded off; punctures sparser, especially in middle, and smaller than on head. *Elytra* punctate-striate, the sutural stria on each suddenly deflected so as almost to touch the suture at the summit of the apical slope. Sides of hind *coxae* scarcely longer than metasternum, and each with rather crowded punctures; hind femora stout; front tibiae tridentate; front claws unequal, the larger one more strongly curved than the other, and with a large basal appendix. Length, 5.5-6 mm.

Hab.—New South Wales: Richmond River (W. W. Froggatt).

Structurally close to the following species, but with the hind femora edentate; it is also allied to *P. cribriceps*, but is larger and the prothorax appears to be opaque from most directions, although slightly iridescent from others; the elytra also are conspicuously iridescent from some directions, and opaque from others; but on *P. cribriceps* the upper surface from all points of view appears polished and iridescent; the fifth joint of the antennae is larger, although small, and the fourth is shorter than on that species. From directions in which the prothorax appears opaque its punctures have a dust-like appearance, but from other directions they are distinct; the apparent depths of the elytral striae also vary with the point of view, and their contained punctures to an even more noticeable extent. The punctures on the labrum are almost as large as the inter-ocular ones.

Var. A. Another specimen from the Richmond River differs in being smaller (5.25 mm.), and with the elytra reddish-flavous, except that the suture is infuscated, and that the sides are black, narrowly at the base, and becoming wider posteriorly, so that the whole apex is black.

PHYLLOTOCUS TRUNCATIDENS, n.sp.

♂ Black; elytra flavous, the suture and sides infuscated or black, front legs mostly flavous. Prothorax and elytra fringed with whitish hairs, similar hairs on head and fairly numerous on under surface and legs.

Head with dense and well-defined punctures, becoming crowded and larger towards clypeus. Clypeus about one-fourth as long as its basal width, sides gently upturned, its hind suture somewhat uneven but fairly distinct; the front one well-defined; labrum in middle not much shorter than clypeus, its apex slightly and evenly curved, and moderately uplifted. Antennae eight-, club three-jointed, each lamella almost as long as the five basal joints combined. *Prothorax* about once and two-thirds as wide as long, sides moderately rounded, front angles produced and acute, hind ones widely rounded off; punctures smaller and much sparser than on head. *Elytra* with distinct striae containing fairly large punctures; interstices gently convex, somewhat wider near suture than elsewhere. *Metasternum* with a small conical tubercle at the middle of its extreme apex. Sides of hind *coxae* not as long as metasternum; hind femora stout and with a large truncated tooth; front tibiae and claws as described in preceding species. Length, 6 mm.

Hab.—New South Wales: Comboyne (W. H. Muldoon), unique.

A comparatively compact species, like a robust *P. luridus*, but the prothorax is somewhat shorter and opaque (from some directions, however, parts of it appear to be slightly iridescent), and the tooth or flange on each hind femur is larger and truncated; there is also a curious little tubercle on the metasternum that does not occur on *luridus*. From behind the elytra appear opaque, with the striae and their contained punctures much smaller than they really are.

PHYLLOTOCUS OBSCURUS, n.sp.

♂ Dark brown, two obscurely defined elytral vittae and parts of under surface and of legs paler. Prothorax and elytra fringed with whitish hairs, similar ones on under surface and legs.

Head flattened in front and with small, sharply defined punctures, becoming crowded on clypeus. Clypeus more than five times as wide as long, hind suture somewhat irregular, front and side margins gently upturned; apex of labrum slightly more upturned than apex of clypeus. Antennae eight-, club three-jointed, lamellae almost as long as the five basal joints combined. *Prothorax* about one-fourth wider than long, basal half parallel-sided, front angles produced and acute, the hind ones rounded off; punctures distinct but sparser and smaller than on head between eyes. *Elytra* comparatively short, with fairly deep striae containing large punctures; interstices gently convex, those near the suture wider than the others, all with small punctures. Sides of hind *coxae* slightly shorter than metasternum; hind femora stout and unarmed; front tibiae with two strong teeth, and a third vaguely indicated; front claws unequal. Length, 6 mm.

♀ Differs in being slightly smaller, prothorax more transverse, abdomen larger, lamellae of antennae slightly shorter, front tibiae with the third tooth small but distinct, and front claws simple.

Hab.—New South Wales: Galston (A. M. Lea).

The types, one of each sex, in general appearance are like dark specimens of *P. antennalis*, but the antennae have one less joint, the third and fourth joints are very differently proportioned, and the club is composed of but three lamellae. The larger front claw of the male has a large sharply triangular appendix, so placed that from certain directions the claw appears strongly bifid; the middle tarsi are missing from the type male, but as the front ones are without long quill-like appendages the species evidently does not belong to *Phyllotocidium*. Viewed at right angles the labrum is seen to be of exactly the same length as the clypeus, although not so wide, but from behind it appears to be much shorter. The elytral vittae of the male are of a rather dingy flavous and distinct to the naked eye, but are not sharply limited; they extend from the base to near the apex in slightly oblique directions, covering from three to five interstices; on the female they are scarcely indicated; on both, the middle of the metasternum (narrowly in front, widely behind) is somewhat flavous, but the paler parts of the legs are very obscure.

PHYLLOTOCUS BILOBUS, n.sp.

Dark brown; head and prothorax almost black, elytra obscure reddish-brown, the suture and sides slightly darker. Prothorax and elytra fringed with whitish setae, similar setae on under-surface and legs.

Head flat, and with small, dense, asperate punctures. Clypeus at base more than four times as wide as the median length, base bisinuate, apex very feebly incurved and slightly upturned, sides somewhat sinuous; punctures slightly coarser than between eyes; labrum moderately upturned in front, and slightly but distinctly bilobed. Antennae eight-, club three-jointed *Prothorax* about once and one half as wide as long, basal two-thirds parallel-sided, base gently and widely rounded in middle, front angles produced and acute, the hind ones rectangular; punctures not very dense and small but sharply defined, a few larger ones margining apex and a few on disc. *Elytra* parallel-sided to beyond the middle; striae well-defined but irregular and not very deep, their contained punctures mostly ill-defined. *Abdomen* small and curved to tip. Sides of hind *coxae* at least one-fourth longer than metasternum; front tibiae with two strong teeth and a small obtuse one; all claws simple, the front ones shorter than the others. Length, 4.5 mm.

Hab.—New South Wales: Sydney.

The type is structurally very close to *P. antennalis* and *P. obscurus;* at first glance it looks like a small specimen of one of the dingy forms of *P. moestus*, but the clypeus and labrum are very different to these parts in that species, and there are many other differences of the body and appendages. From the side each hind angle of the prothorax is seen to be a right angle, not at all rounded off, but from above it appears to be somewhat acute, and to feebly embrace the shoulder; the punctures on the head (including the clypeus) are small, and so crowded together that the surface might fairly be regarded as shagreened. From some directions parts of the upper surface appear to be vaguely iridescent. There are long hairs set in the large discal punctures of the pronotum, and a few on the elytra. The front claws are equal, and this is usually a feminine character in the genus; but the abdomen is small and slightly curved to the tip, and this, in conjunction with the second specimen, now to be noted, convinces me that it is a male.

A specimen which is probably a female of the species differs from the type in being larger, entirely pale (except for the club) and with the abdomen much larger and convex in the middle; the structure of its head (including some unusual features of the clypeus and labrum), and the base of its prothorax are exactly the same, it has also a few hairs on the prothorax and elytra.

SAULOSTOMUS BRUNNEOVIRIDIS, n.sp.

Dark brown with a conspicuous metallic-green gloss. Clothed with long, white hairs, front femora with a row of reddish bristles in front, and similar bristles at base of under surface of head.

Head with dense, asperate punctures, becoming well-defined about base. Clypeus thrice as wide as long, front angles rounded off, front margin rather strongly upturned and straight, sides feebly upturned and almost parallel; punctures similar to those on rest of head. Antennae ten-, club three-jointed; club about as long as width of head at base, one side straight, the other gently curved. *Prothorax* about once and one-half as wide as long, front angles produced and subacute, hind ones obtuse, sides rather strongly and evenly rounded, base lightly bisinuate; with rather large but shallow, unevenly distributed punctures, and with numerous minute ones. *Scutellum* with apical half impunctate. *Elytra* not much wider than prothorax, not much longer than wide, apex conjointly rounded (almost truncate), each with two obtuse discal elevations; with rather large punctures, dense in places, and frequently transversely confluent. *Pygidium* with rather dense, but small and shallow, partially concealed punctures. Front *tibiae* rather strongly tridentate; basal joint of front tarsi (as seen from below) distinctly longer than second. Length, 14 mm.

Hab.—New South Wales: Hunter River (Macleay Museum).

Structurally close to *S. villosus*, but very differently coloured, and the clypeus and antennae different. The head and middle of prothorax are of a darker green than elsewhere, the antennae and palpi are dark-brown and glossy, but not metallic, parts of the under surface and of the legs are of a rather bright castaneous, with the greenish gloss less conspicuous than on their darker parts. The long hairs on the elytra are numerous and evenly distributed but not dense; on the scutellum they are dense about the base, but absent from the apex; on the sides of the prothorax they are as on the elytra, but the middle (possibly from abrasion) is glabrous; on the head they are sparse; the pygidium is more densely clothed than the elytra, and in addition has a fringe of longer hairs; on the under surface and parts of the legs the clothing is longer and sparser than on the upper surface. The second tooth of the front tibiae is much nearer the first than the third. The sex of the type is doubtful; on the right front tarsus the larger claw is cleft at the apex (a feminine character), but on the left tarsus both claws are simple; the club of the antennae is large, but it is large on the females of other species, although smaller than on their males; the punctures on the head are more crowded than is usual on males of the genus.

AMBLYTERUS TARSALIS, n.sp.

Dark castaneous-brown; head (except clypeus) and prothorax with a metallic bluish or coppery-green gloss, some marginal parts and the tibial teeth black. Abdomen (including pygidium) with rather dense, depressed, silvery hairs, mixed with longer ones, mesosternum densely clothed with long white hairs.

Head with rather large and crowded, but sharply defined punctures. Clypeus about thrice as wide as its median length, sides strongly narrowed from near base, apex strongly upturned, with its outer angles widely rounded off; punctures even more crowded and less defined than on rest of head. Antennae ten-, club three-jointed; club slightly longer than distance between eyes. *Prothorax* about once and one-fourth as wide as long, sides almost parallel from base to apical two-fifths, and then strongly narrowed to apex, front angles lightly produced and rather widely rounded off, a narrow impressed line close to each margin: punctures moderately dense, and sharply defined but not very large. *Scutellum* with fairly dense punctures on each side of base. *Elytra* slightly wider than prothorax; with irregular punctures and striae. *Pygidium* with very dense, but more or less concealed, punctures. Front *tibiae* strongly tridentate; front tarsi with three basal joints densely padded on under surface, first joint distinctly longer than second, larger claw cleft on all tarsi. Length, 18-19 mm.

Hab.—Queensland: Dalby (Mrs. F. H. Hobler).

As the labrum is not as in *Anoplognathus*, and its immediate allies, and the larger claw on each tarsus is cleft, this species by the table given by Ohaus* could only be referred to *Amblyterus*, or to a new genus; the lower lip is somewhat pointed, in this respect differing from *A. cicatricosus* and *A. clypealis*, and this, with the distinctive pads on the front tarsi may eventually be considered as of generic importance. The general appearance of the species is strikingly like that of larger specimens of *cicatricosus*, and the size is well within its range, but the clypeus is very different from that of each sex of that species, the hind claw-joint is very different, having a projection near the base that causes the tarsi to appear as if six-jointed; on the middle claw-joint there is a remnant of the projection, but not on the front one. There is not a trace of the projection on *cicatricosus* or *clypealis*, but there is on the species of *Schizognathus* and *Paraschizognathus*. On the type the metallic gloss of the upper surface is but slight, and is distinctly purplish-blue; on a second specimen it is of a bright coppery-green, and is vaguely extended on to the sutural portion of the elytra. The upper surface is glabrous, except for a marginal fringe on each elytron, and for a few white hairs on the ocular canthi. The prothorax has but vague remnants of a median line. Some of the elytral striae are deep and well defined, with small punctures, and with a subgeminate arrangement, but others are irregular and with larger ring punctures, so that they appear as little more than irregular rows of punctures; near the scutellum the punctures are larger than elsewhere, and the sur-

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*Stett. Ent. Zeit., 1904, p.66

face is more or less wrinkled, the sides near the shoulders are also wrinkled, some of the interstices have a few large punctures. The clypeus seems to indicate that the specimens described are females, but the clothing of the front tarsi can scarcely be other than a masculine feature.

CRYPTODUS ATER, n.sp

Black, highly polished; parts of antennae and of palpi obscurely reddish.

Head with crowded, reticulate punctures, becoming isolated, but still dense. in middle of base; with a shallow median depression, on each side of which is a feeble elevation. Clypeus gently rounded, outer margins upturned throughout, but less on sides than in front. Mentum gently incurved at base; with dense, reticulate punctures there, becoming smaller and sparser in front. Antennae ten-jointed, first joint strongly and evenly dilated at apex. *Prothorax* with sharply defined but not very large or dense punctures, becoming smaller, crowded, and transverse on frontal, and latero-frontal margins; median line lightly impressed. *Elytra* with numerous series of elliptic punctures, each separated from the adjacent surface by a fine ring, punctures on the interspaces few and small. *Pygidium* with reticulate sculpture; at apex with fairly dense but isolated punctúres. Front *tibiae* rather strongly tridentate. Length, 22-24 mm.

Hab.—New South Wales: Jenolan (J. C. Wiburd), Sydney (A. M. Lea).

In general appearance close to *C. tasmannianus*, and with similar reticulation of the pygidium, but the base of the mentum is distinctly notched, although much less deeply than on most species of the genus. From the description and figure of *C. politus* it differs in being smaller, head with crowded punctures, punctures of under surface not "tenuissime" and elytral costae much less conspicuous (even less so than *tasmannianus*), the shape, but not the punctures, of the mentum is much as that of Westwood's figure (4 *b*); *C. debilis* is described as having the base of the mentum truncate, the antennae nine-jointed and the size much less. The elevations on the head are so feeble that they could scarcely be regarded as tubercles. The punctures on the under-surface vary considerably, in places being rather small and isolated, elsewhere small and each in the centre of a circle, these having a reticulate appearance, whilst elsewhere the circles are reduced to segments and isolated, but each with a small puncture; on one specimen the punctures in the median line of the pronotum are larger and more transverse than the adjacent ones, but on the other specimen they are no different. As the front tarsi are simple they are probably both females; but this is not necessarily the case as the males of *C. paradoxus* and of at least two other species, the sex of which I have proved by dissection, have simple front tarsi.

CRYPTODUS CONCENTRICUS, n.sp.

♂ Black, highly polished, parts of antennae obscurely diluted with red.

Head with crowded, reticulate punctures; a wide depression in middle. Clypeus with margin strongly upturned in front, less so on sides. Mentum with base deeply notched or bidentate, with crowded reticulate punctures, becoming smaller and more isolated in front. Antennae ten-jointed, first joint strongly dilated at apex. *Prothorax* with sharply defined but rather small and not very dense punctures, becoming crowded and transverse on frontal and latero-frontal margins; median line distinct, becoming rather deep and wide in front. *Elytra* with series of fairly large, elliptic, or round, ringed punctures, the interspaces with small and sparse punctures. *Pygidium* with dense, concentric scratches, and numerous small punctures. Intercoxal process of *prosternum* with a transverse carina, its ends nodose. Front *tibiae* strongly tridentate; front claws uneven. Length, 21-22 mm.

Hab.—New South Wales: Albury (W. Dumbrell and A. M. Lea).

A highly polished species, but smaller and differing in many other respects from the description of *C. politus;* the conspicuously foveate head, and concentric sculpture of the pygidium (as on many Cetonides) readily distinguishes it from all other species known to me. The excavation on the head occupies the median third in width, and about three-fourths the length; on each side of it there is an obtuse swelling that could hardly be called a tubercle; the scratches on the pygidium are not parts of a system of circles, each with a central pit (as on many species of the genus) but are more or less concentric, wavy lines, isolating numerous thin elevations, each of which on an average has from three to five punctures; on the under surface, especially on the sides of the sterna, the scratches are deeper, on the abdomen they are mostly transverse; the elytral costae are fairly distinct, but not sharply defined. One of the front claws is much the same as those of the other legs, but the larger one is thicker, more strongly curved, and with a wide basal appendix, from some directions it appears to have a basal tooth (as in the figure of *politus*), but it really has a wide flange-like appendix there, which, viewed from the sides, gives the appearance as of a tooth.

CRYPTODUS QUADRIDENTATUS, n.sp.

Black, highly polished; parts of antennae obscurely diluted with red.

Head with crowded, coarse, reticulate sculpture; with a shallow median depression, on each side of which is a feeble elevation. Clypeus with margins rather lightly upturned, the front feebly or not at all incurved to middle. Mentum deeply notched and tridentate at base; with crowded, reticulate sculpture, becoming less confused in front. Antennae ten-jointed, basal joint dilated at apex, more conspicuously on one side than another. *Prothorax* with fairly large, and moderately dense, shallow punctures, each with a central pit, becoming more crowded on the sides in front; median line lightly impressed. *Elytra* with rows of rather large, elliptic, ringed punctures, becoming small and more rounded towards sides, interstices with fairly numerous and rather small but sharply defined punctures; costae well defined. *Pygidium* obliquely flattened, with dense, reticulate sculpture, but at apex with simple punctures. Front *tibiae* with four teeth, the sub-basal one small, the others large. Length, 22-23 mm.

Hab.—Queensland: Dalby (Mrs. F. H. Hobler), Cunnamulla (H. Hardcastle).

With the quadridentate front tibiae of *C. foveatus*, and with very similar elytral sculpture, but the pygidium nonfoveate. The reticulation of the head is continued even on to the clypeal margins. The front tarsi of both specimens are simple.

MELANDRYIDAE.

SCRAPTIA POROSA, n.sp.

Of a rather dingy flavo-testaceous. Rather densely clothed with short, pale pubescence.

Head with crowded subasperate punctures of moderate size. Eyes moderately separated in male, more widely in female, deeply notched. Antennae thin, second and third joints very small, third slightly the smaller. *Prothorax* at base about thrice as wide as the median length, sides feebly decreasing in width from base to middle and then strongly to apex; with crowded and well-defined punctures of moderate size. *Elytra* parallel-sided to beyond the middle; with dense and fairly large punctures, in places subconfluent, becoming somewhat smaller and less crowded posteriorly. Spurs to hind *tibiae* rather short and unequal. Length, 3-3¾ mm.

Hab.—New South Wales: Wollongong, National Park (A. M. Lea).

Structurally closer to *S. lunulata* than to any other described species, but elytra immaculate, etc. In the male the antennae are longer and stouter than in the female, and the eyes are but little more than half the distance apart. There are no distinct markings on the elytra, but on one of the two females before me there are some very feeble infuscations; on the only male most of the abdomen is dark; the legs are paler than the other parts. The punctures on the head are somewhat transversely arranged towards the base.

SCRAPTIA OCULARIS, n.sp.

Of a rather dingy flavous. With very short and moderately dense whitish pubescence.

Head with crowded but rather small punctures, and with a feeble median line. Eyes rather widely separated, deeply notched. Antennae thin, second joint slightly larger than third, both very small, their combined length about equal to that of fourth. *Prothorax* about twice as wide as the median length, sides almost parallel on basal half, and then strongly narrowed to apex, with a rather conspicuous median channel and a distinct depression on each side; with crowded and rather small subasperate punctures. *Elytra* parallel-sided almost throughout; with crowded and rather coarse punctures, becoming smaller posteriorly. *Legs* moderately long, spurs to hind tibiae short and subequal, about the length of the second tarsal joint. Length, 3½-4 mm.

Hab.—Tasmania: Mount Wellington, Waratah (A. M. Lea).

Readily distinguished from the other Tasmanian species by its much coarser elytral punctures, the derm also appears to be of harder texture than usual. Of the three specimens under examination two are uniformly flavous, except that the appendages are slightly paler than the body parts; but the third is slightly darker, and vaguely infuscated along the suture. They are apparently all of one sex, probably female as the eyes are separated more than the length of the first joint of antennae; the notch in each eye is rather wider than deep; the outer portion of each is subtriangular in shape, and considerably larger than the inner portion.

SCRAPTIA FUMATA, n.sp.

♂ Of a dingy testaceous brown. Densely clothed with extremely short, pale pubescence.

Head with crowded and small indistinct punctures. Eyes large, almost touching in front, with a deep almost U-shaped notch. Antennae long and moderately thin, passing elytra for a short distance, second joint slightly smaller than third, their combined length distinctly less than that of fourth, fourth and fifth subequal. *Prothorax* not twice as wide as the median length, sides parallel on basal half, then obliquely strongly narrowed to apex; with very dense and minute punctures. *Elytra* at base slightly wider than prothorax, and with slightly smaller punctures. *Legs* long and thin; spurs to hind tibiae very unequal, the longer slightly shorter than the claw joint, the shorter traceable with difficulty. Length (♂, ♀) 4¼-5¾ mm.

♀ Differs from the male in being somewhat wider, eyes smaller and more widely separated (at their nearest point they are distant about the length of the first joint of antennae), antennae decidedly thinner and shorter, and front tarsi less dilated.

Hab.—Western Australia: Mullewa, Lennonville (Miss J. F. May).

The under surface is usually darker than the upper, the two females before me are paler than the six males, but even they have a dingy, smoky appearance. There are three depressions on the pronotum of all the specimens, but they are usually very vague, and appear to be due to slight contractions; the elytra and abdomen are rather badly shrivelled on most of them, and even the legs are sometimes shrivelled.

SCRAPTIA MICROSCOPICA, n.sp.

Blackish, appendages not much paler. Rather densely clothed with short, dingy pubescence.

Head with crowded and rather small punctures. Eyes widely separated, rather deeply notched. Antennae moderately long and thin, second joint small, slightly larger than third, the latter indistinctly separated from fourth. *Prothorax* about thrice as wide as the median length, sides feebly rounded towards base, but strongly towards apex; punctures much as on head. *Elytra* at base the width of prothorax, sides feebly dilated to beyond the middle, and then feebly narrowed to apex; punctures slightly sparser and better defined than on pronotum, but of similar size. Spurs to hind *tibiae* very unequal, the longer about the length of second tarsal joint. Length, $1\frac{3}{4}$-2 mm.

Hab.—Western Australia: Geraldton.—Tasmania: Huon River (A. M. Lea).

A very small dark species, at first glance suggestive of some of the small species of *Dasytes* of the *Malacodermidae.* The notches in the eyes are rather deep, but owing to the black colour of the head they are distinct only on close examination. A specimen from New South Wales (National Park) appears to belong to the species, but is not in condition for confident identification.

TEMNOPALPUS TRICOLOR, n.sp.

Black, elytra deep purplish-blue, prothorax reddish flavous, tarsi somewhat paler. Sparsely clothed with rather short blackish hairs, becoming shorter and somewhat denser on undersurface.

Head with fairly dense and rather coarse punctures. Eyes very prominent. Antennae passing scutellum, first joint moderately stout, almost as long as second and third combined, third slightly shorter than second or fourth, first to sixth shining, the others subopaque and slightly wider. *Prothorax* transverse, sides strongly rounded, base narrower than apex, with a shallow depression towards each side of base; punctures the size of those on head, but much sparser. *Elytra* distinctly wider than prothorax, almost parallel-sided throughout; punctures slightly larger than on prothorax, and midway in density between those on prothorax and on head, but becoming much smaller posteriorly. Length, 4¾ mm.

Hab.—Tasmania: Waratah, unique (A. M. Lea).

Structurally close to *T. bicolor*, but elytra of a deep purplish-blue, and legs with only the tarsi conspicuously pale.

TEMNOPALPUS NIGER, n.sp.

Black, tarsi flavous, knees obscurely diluted with red. Rather sparsely clothed with straggling blackish pubescence, or short hairs. Length, 5 mm.

Hab.—King Island, unique (A. M. Lea).

Structurally close to the preceding species, but very differently coloured, elytral clothing somewhat denser, punctures denser (more noticeably so on the prothorax than elsewhere), head rather more convex, antennae slightly longer, with the seven basal joints shining and only the three apical joints slightly wider than the preceding ones, and pronotum with the depressions more distant from the base. On the types of both species the elytra do not quite cover the abdomen.

TRICHOSALPINGUS LONGICOLLIS, n.sp.

Of a dingy reddish-brown, some parts paler. Closely covered with short ashen pubescence.

Head lightly convex, with a vague longitudinal depression near each eye, clypeal suture semicircular and well-defined; eyes fairly large, lateral and prominent. Antennae scarcely passing scutellum, second joint shorter than third but somewhat stouter. *Prothorax* slightly longer than wide, sides almost parallel, base and apex truncate, with an oblique impression on each side of base opening out into a very shallow submedian impression. *Elytra* much wider than prothorax, parallel-sided for a short distance, and then dilated to near apex. Length, 4¼-4½ mm.

Hab.—New South Wales: Mount Kosciusko, 5700-6000 feet (R. Helms).

The prothorax is longer in proportion than that of any other described species, and in actual size the species is only exceeded by *T. lateralis*. On the type, the suture and two large suboval spots on each elytron (the first at the basal third, the second at the apical third) the tarsi and knees are obscurely flavous or testaceous; on a second specimen the elytral spots are very vaguely indicated, and the tarsi are no paler than the tibiae. The punctures on the upper surface are very dense and small, but well-defined; they are slightly denser in the pronotal depressions and somewhat smaller towards apex than elsewhere. In some lights there appear to be vague remnants of elytral striation.

TRICHOSALPINGUS LATICOLLIS, n.sp.

Of a dingy piceous-brown, legs paler, tarsi almost flavous. Clothed with very short, ashen pubescence.

Head wide and rather flat, without distinct longitudinal impressions. Eyes large and lateral. Antennae scarcely passing scutellum, second joint stouter than third and very little shorter. *Prothorax* distinctly wider than long, sides gently rounded and increasing in width from base to near apex, with a shallow oblique depression on each side of base. *Elytra* much wider than prothorax, sides distinctly dilated from base to beyond the middle, and then widely rounded. Length, 3½-3¾ mm.

Hab.—New South Wales: National Park (A. M. Lea).

Wider than *T. brunneus*, prothorax notably more transverse, and with impressions much reduced in size and depth. On the type, in addition to the basal depressions, there is a feeble depression on each side; on a second specimen there are no traces of these, but there is a vague sublatero-apical depression on each side of the disc. The punctures on the upper surface are dense, fine and rather sharply defined, but they become shallower and smaller towards apex of elytra.

TRICHOSALPINGUS NIGER, n.sp.

Black, parts of legs and of palpi obscurely paler. Closely covered with very short whitish pubescence.

Head lightly convex, clypeal suture semicircular. Eyes large, lateral and prominent. Antennae slightly passing base of prothorax, second joint stouter and slightly shorter than third, eleventh almost as long as first. *Prothorax* slightly longer than wide, sides feebly increasing in width from base to near apex, and then decreasing to apex, which is a trifle wider than base; each side with a conspicuous, semicircular impression. *Elytra* much wider than prothorax at base, sides gently increasing from shoulders to about the basal third, and then more noticeably dilated. Length, 4 mm.

Hab.—Tasmania: Mole Creek, Mount Wellington (A. M. Lea).

The black colour, together with the conspicuous latero-basal impressions of the prothorax, render this species very distinct. The greatest width of the elytra is at the apical fourth, where the width is about thrice that of the prothorax; the punctures on the head and elytra are dense and small, but sharply defined, on the prothorax they are denser and subgranulate in appearance.

ORCHESIA EUCALYPTI, n.sp.

Black or blackish brown, elytra with flavous zigzag markings, antennae and legs, and usually most of the under surface, of a dingy castaneous. Clothed with extremely short pubescence.

Head almost concealed from above, with small, dense punctures. Antennae thin, four apical joints slightly thickened. *Prothorax* about once and one-half as wide as the median length, sides strongly rounded and much wider at base than at apex, with a shallow depression towards each side near base; with small dense punctures; marginal carina on each side short and basal. *Elytra* at base the width of prothorax, sides feebly dilated to near the middle, and then rather more strongly diminishing in width to apex; punctures much as on pronotum. *Under surface* strongly ridged along middle. Hind spurs slightly longer than their supporting *tibiae*, and almost as long as the following joint. Length, $2\frac{1}{2}$-$3\frac{3}{4}$ mm.

Hab.—Tasmania: Summit of Mount Wellington, numerous specimens beaten from *Eucalyptus cocciferus* trees (A. M. Lea).

Structurally fairly close to *O. austrina*, but narrower at both ends, and elytra with conspicuous markings. The under surface is sometimes entirely blackish, and on such specimens parts of the legs are usually deeply infuscated. The elytral markings vary somewhat in extent and completeness, but not in disposition, and consist of an antemedian zigzag fascia and a postmedian one; the first (when complete) commences on each side at the basal third, and crosses the suture also at the basal third; the second (on many specimens appearing as three disconnected spots obliquely placed on each elytron) commences on each side at about the apical fourth, and crosses the suture just beyond the middle. One small specimen (possibly immature) is of a rather dull red, with the part between the zigzag fasciae (these unusually pale) almost black, so that the elytra are tricolourous.

ORCHESIA BRYOPHILA, n.sp.

Flavous or fusco-flavous, under surface more or less infuscated, pronotum with an infuscate (usually semi-double) discal blotch; elytra with three infuscate zigzag fasciae. Clothed with extremely short pubescence. Length, 3-4 mm.

Hab.—Tasmania: Mount Wellington, Hobart, in moss (A. M. Lea).

Structurally very close to the preceding species, but elytra with dark markings on a pale background, instead of *vice versa*. Four specimens were obtained from moss on three occasions. The head is more or less deeply infuscated, on one specimen being almost black. Of the elytral fasciae the first is sub-basal and touches the sides at the apical fourth, it has several dark extensions towards the base, so that it appears to mark off from six to ten longitudinal flavous spots; the second is submedian and, commencing from the suture, extends obliquely forwards, then backwards, and from about the middle of the backward part there is a short spur connected with a suddenly and widely dilated lateral portion; the third fascia is at about the apical fourth, is less sharply defined than the others, and from the suture has a backward trend; between it and the median fascia, on some specimens, the flavous portion appears as six elongate, partially disconnected spots; the suture is pale, except close to the base. From some directions the elytra appear to be rather conspicuously striated, but there are no true striae, although there is a shallow longitudinal depression on each side of the suture.

ORCHESIA MEDIOFLAVA, n.sp.

Dark piceous-brown, tip of prothorax, muzzle, antennae (base paler), legs and parts of under surface of a rather dingy castaneous, palpi and median portion of elytra flavous. Clothed with extremely short pubescence. Length, 4¼ mm.

Hab.—Tasmania: Mount Wellington, unique (A. M. Lea).

Structurally very close to the two preceding species, but somewhat thinner, antennae thinner and depressions on pronotum slightly larger and with a third one in middle. The elytral markings are also very different; their flavous portion (which is not of an uniform shade throughout, but in places has slight infuscate stains) occupies about one-half of the surface; towards the base on each elytron it is encroached upon by three extensions of the dark portion, two of which are acutely triangular; towards the apex it is also encroached upon by two acutely triangular dark extensions; the suture is obscurely pale almost to the base.

ORCHESIA PICTIPENNIS, n.sp.

Castaneous; pronotum black, parts of under surface infuscated, elytra with flavous and infuscate markings. Densely clothed with short pubescence.

Head with rather small but clearly defined punctures. Antennae rather short, apical joints clavate. *Prothorax* about once and one half as wide as long, sides strongly rounded, base truncate and much wider than apex; punctures as on head, marginal carina on each side curved and continuous throughout. *Elytra* at base the width of prothorax, sides feebly dilated to basal fourth, and then narrowed to apex, punctures as on prothorax. *Under-surface* strongly ridged along middle. Hind spurs distinctly longer than their supporting *tibiae*, and as long as the following joint. Length, 3½-3¾ mm.

Hab.—Tasmania: Mount Wellington, two specimens from moss, Latrobe, one from flood debris (A. M. Lea).

The pale elytral markings may be regarded as two zigzag fasciae; of these the first is partly before and partly on the middle, and consists of six irregular spots irregularly conjoined; the second is at about the apical third on the suture, and on the apical fourth at the sides; they are rendered very conspicuous by the derm adjacent to them being deeply infuscated (almost black). The specimen from Latrobe has much less conspicuous markings than the others; on it the elytra slightly beyond the middle have an infuscate fascia, with the derm before and after it considerably paler, but not flavous, although the flavous markings of the type may be made out in a blurred fashion. The elytra from some directions appear to be distinctly striated, but true striae (except for a vague subsutural one on each elytron) are really absent.

ORCHESIA CALOTRICHA, n.sp.

Bright castaneous. Densely clothed with somewhat golden pubescence, conspicuously waved on elytra, and less conspicuously so on pronotum.

Antennae short, five apical joints forming a loosely compacted club. *Prothorax* about thrice as wide as the median length, sides strongly and evenly rounded, base much wider than apex, with a fairly deep impression on base towards each side; marginal carina on each side distinct throughout. *Elytra* dilated for a short distance from base, and then narrowed to apex, each with a feeble longitudinal elevation on basal third at one third from suture. *Under-surface* strongly ridged along middle. Hind spurs about as long as their supporting *tibiae*, and slightly shorter than the following joint. Length, 3¼ mm.

Hab.—Queensland: Mount Tambourine, unique (H. Hacker).

Structurally close to *O. austrina*, but with beautifully waved elytral clothing; this causes the elytra (when viewed from behind) to appear transversely multi-fasciate. The punctures are dense and fine throughout, but are slightly more conspicuous on the front of the head than elsewhere.

ORCHESIA WELLINGTONIANA, n.sp.

Black; parts of appendages obscurely diluted with red, spurs to hind tibiae somewhat paler. Densely clothed with short, dingy pubescence.

Head almost concealed from above. Apical joints of antennae forming a loose club. *Prothorax* about once and one fourth as wide as the median length, sides feebly rounded from base to middle and then strongly to apex, with a vague depression on each side of base; marginal carina on each side subbasal. *Elytra* the width of prothorax at base, sides feebly dilated to beyond the middle, and then narrowed to apex. *Under surface* rather strongly ridged along middle. Hind spurs subequal, slightly shorter than their supporting *tibiae*, and distinctly shorter than the following joint. Length, 1⅞-2 mm.

Hab.—Tasmania: Summit of Mount Wellington (A. M. Lea).

Allied to *O. minuta*, but without metallic gloss, pubescence distinctly shorter, spurs to hind tibiae shorter (although decidedly long), and elytra rather more dilated about the middle. One of the four specimens before me has the pronotum and apical portion of elytra very obscurely diluted with red. The punctures are dense and rather fine throughout.

ORCHESIA MINIMA, n.sp.

Black with a distinct metallic gloss, parts of appendages obscurely diluted with red. Clothed with very short pubescence. Length, $1\frac{1}{3}$ mm.

Hab.—Tasmania: Mount Wellington; a single specimen from moss (A. M. Lea).

The smallest species of the family known to occur in Australia: in general appearance it is like a very small specimen of *O. minuta*, but with shorter pubescence, and proportions of the elytra and hind tibiae as in *O. wellingtoniana;* from the latter it differs in its smaller size, somewhat metallic lustre, punctures more distinct, and prothorax without subbasal depressions.

TABLE OF SPECIES OF *Orchesia*.

A. Derm of elytra uniformly coloured or almost so.
  a. Derm more or less blackish.
    b. Without metallic gloss ... ... *wellingtoniana.*
    bb. With metallic gloss.
      c. Elytral clothing excessively short (scarcely visible under a Coddington lens) ... ... *minima.*
      cc. Elytral clothing longer than in *c* ... ... *minuta.*
  aa. Derm more or less castaneous[*]
    d. Elytral pubescence waved ... ... *calotricha.*
    dd. Elytral pubescence uniformly disposed.
      e. Length $5\frac{1}{2}$ mm. or more ... ... *macleayi.*
      ee. Length 4 mm. or less ... ... *austrina*
AA. Derm of elytra with conspicuous markings.
  B. Markings rendered very conspicuous by clothing *multinotata.*
  BB. Markings distinct in themselves.
    C. Elytra with a wide median flavous patch ... *medioflava.*
    CC. Elytra with two zig-zag pale fasciae.[†]
      f. Pronotum with a depression towards each side *eucalypti.*
      ff. Pronotum without such depressions ... ... *pictipennis.*
    CCC. Elytra with three zig-zag dark fasciae.
      D. Pronotum with a large semidouble infuscate blotch ... ... *bryophila.*
      DD. Pronotum immaculate ... ... *macilenta.*

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[*] On some specimens of *O. austrina* the derm is somewhat blackish, but such specimens are always larger than those of *a*.

[†] Some specimens of *O. pictipennis* have the markings less conspicuous than on the typical form.

CTENOPLECTRON SERICEUM, n.sp.

Blackish; under surface and appendages of a dingy reddish-castaneous. Densely clothed with extremely short, silken pubescence.

Head rather convex. Eyes large, subreniform. Antennae moderately long and thin, second joint about half the length of third, the latter slightly shorter than first. *Prothorax* about as long as wide, base lightly bisinuate and near base with three shallow round depressions, hind angles obtuse, front ones strongly rounded off; marginal carina on each side acute from base to slightly beyond the middle, but vanishing before the apical third. *Elytra* long, thin, and parallel-sided to beyond the middle, striation fairly well-defined. Four hind *tibiae* strongly serrated on the upper surface, spurs to hind pair very unequal, the longer about twice the length of the other, and about half the length of the following joint. Length, 8 mm.

Hab.—Tasmania: Ulverstone, unique (A. M. Lea).

With the general appearance of *C. agile,* but elytra more strongly striated, the suture not serrated posteriorly, and the pronotum with the median line absent except for a vague basal depression. The punctures are dense and everywhere very minute, so that they are scarcely to be seen under a Coddington lens.

CERAMBYCIDAE.

CREMYS DIOPHTHALMUS, Pasc.

A specimen from New South Wales possibly represents a variety of this species; it differs from the description in having the derm of the prothorax entirely black, and the elytra black except for a narrow line on each elytron; this line commences near the side about the middle, is directed obliquely towards the suture, and is then deflected upwards parallel with the suture half-way to the base; the femora and tibiae are dark. In the original description the elytra are noted as having only the apical half black, and with a pale line apparently as on my specimen; the prothorax was also noted as having two black spots. Later, in diagnosing the genus, Pascoe again commented upon two black prothoracic spots. Lacordaire, however, shows* the elytra as having a postmedian fascia and the suture pale

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*Atlas, Pl. 93, fig.3.

almost throughout; on my specimen no part of the suture is pale, but on holding it up in certain lights the silken pubescence appears to become fasciate at the summit of the apical slope. Lacordaire's figure also shows that the black prothoracic spots are really two small fascicles of upright setae, as on the specimen before me.

ZOEDIA GRACILIPES v. d. Poll.

Two specimens from Waterfall Gully (near Sydney) appear to belong to this species, but differ from the description and figure in having the legs and prothorax of the same shade of red as the base of the elytra, and the head but little darker.

NOTES ON THE COLOURATION OF THE YOUNG FOLIAGE OF EUCALYPTUS.

By J. H. Maiden, I.S.O., F.R.S., F.L.S.

Most people have noticed, particularly during the winter and early spring, that on the young branchlets, the foliage of Eucalypts is, in some species, of a brilliant colour, shades of crimson and purple being the commonest.

There are few allusions to the character in botanical literature, one of the few being the following:—

> "Then again, the red color of new foliage, so commonly seen here, is an outward sign of adaptation, in that the color apparently acts as a screen to prevent the chemical rays of light (blue end of the spectrum) from penetrating the living workshops; their admission to the young leaf cells would be detrimental; whilst the heat rays (red end) are collected and thus secured as likely to help along the life processes more rapidly to remove the new growth from babyhood to maturity."*

Some years ago it entered into my mind to collect data as to the colours in question, but I found practical difficulties arising from the fact that the colours that we see on the living plant alter in tint within a few hours after removal. I then tried taking the register of colours to the trees themselves, but found the standard work I have adopted (Dauthenay's "Repertoire de Couleurs") so heavy that it was out of the question to carry it far in the bush. Accordingly I submit some notes only on plants growing wild or cultivated in the Sydney district, but I feel that observers who desire to continue the work may get over the difficulty in many cases by packing the leaves in closely shut tins, and posting them, provided that they are not longer than a day or two in the receptacle.

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*C. T. Musson in "The Hawkesbury Agricultural College Journal," March 25, 1905, p.68.

I tried, while in the bush, imitating the records by blotches of water colour, but failed; oil colours would be better, but I had neither the ability nor the time to adopt this method.

It is understood, of course, that my observations are so few, that there is but little opportunity for generalization. Without going so far as to say that in all cases the botanist of the future will be able to determine every species by the colour of its flush, I believe that my observations in regard to the matter (most of them not standardised) justify the belief that a number of species, and some groups, can be diagnosed by this means.

I quote the dates and localities, because we have yet to learn whether the colour varies to any extent with these variables.

Each species (or rather each plant, for each plant varies somewhat within the species) has an *optimum* for colour, which requires to be ascertained. It will therefore be necessary to make a number of observations (as many as possible should be made on the same tree) before we ascertain the colour which we record as most characteristic of the species.

In some cases (not reproduced) I have marked the colours "secondary," as I am of opinion that they are not characteristic of the species, but represent one or more outside colours. In a few I have noted the colours of the young twigs, for whatever they may be worth. In most cases the colour-references have been made by Miss Margaret Flockton or Mr. W. F. Blakely. Most of the leaves have been collected by Mr. Blakely and Mr. J. L. Boorman.

A. The *Renantherae* preponderatingly cluster around vinous purple (Plate 171).

E. microcorys, placed by Bentham and Mueller in this Section, has dull carmine lake (plate 106), and in this respect and in a number of other characters (e.g., kino, anthers and seedlings), as I shall show in my "Critical Revision of the Genus Eucalyptus," it is so aberrant, that it should be removed from the *Renantherae*.

E. capitellata Sm.
Port Jackson.
Young foliage—"vinous purple," see Plate 171.
Very young foliage—"garnet dull," Plate 163, shades 1-3.

E. eugenioides Sieb.

1. Cabramatta, 10.7.17.
   Young foliage—"vinous purple," Plate 171, shade 4.
2. Bankstown, 23.7.19, Plate 171, shades 1-3.
3. Glenfield, 9.10.18.
   "Slate violet," Plate 173, shades 1-4.

E. pilularis Sm.

Como, George's River 9.9.16.
Young foliage—"vinous purple," Plate 171, shades 1-4.
Young twigs angular and red.

E. piperita Sm.

1. Corso, Manly, 14.9.16.
   "Vinous purple," Plate 171, shade 3.
   (Young twigs pale yellow-green, tinted with red).
2. Sutherland, Como, 16.10.16.
   "Slate violet," Plate 173, shades 1-4.
3. Blackheath, 12.17.
   Young foliage—"dark violet," Plate 193, shades 1-4. (These were two days old).
4. Emu Plains to Blaxland, 17.4.19.
   "Garnet brown," Plate 164, shades 1-4.

E. radiata Sieb.

Blackheath, 12.17.
Young foliage—"plum violet," Plate 172, shades 3-4. (These were two days old when registered.)

E. Sieberiana F. v. M.

1. Spit Road, Manly, 14.9.16.
   Young foliage—"plum violet," Plate 172, shades 3-4.
   Young twigs—a rich deep red.
2. Same locality, 28.7.17.
   Young foliage—"plum violet," Plate 172.
   Young twigs scarlet to purple brown.
3. Near Mt. Colah Station, near Hornsby, 7.17.
   Young twigs—"dull purple lake," Plate 170, shades 3-4.
   Very young leaves—"deep carmine violet," Plate 174, shades 3-4; the older leaves shading to violet-lilac, Plate 175, shades 2-4.
4. Blackheath, 12.17.
   Young foliage—"plum violet," Plate 172, shades 1-4. (Two days old when registered.)

E. umbra R. T. Baker.
Hawkesbury to Cowan by the old road. 26.1.18.
Young foliage—"dull purple lake," Plate 170, shades 1-4.
E. microcorys F. v. M.
Cultivated, Botanic Gardens, Sydney, 8.17.
Juvenile foliage—"dull carmine lake," Plate 106, shades 1-4.

B. The *Corymbosae* have mostly shades of purple. All belong to the same general group, the garnet-brown of *E. haematoxylon* being most aberrant, but we must learn more of this species.

E. corymbosa Sm.
1. Como, George's River, 9.16.
Young foliage—"purple brown," Plate 166, shade 2.
2. Old Berowra Road, Hornsby, 17.6.17.
"Purple brown," Plate 166, shades 3-4.
3. Sutherland, Como. 16.10.18.
"Vinous purple," Plate 171, shades 1-4.
E. eximia Schauer.
Emu Plains to Blaxland, 17.4.19.
"Plum violet," Plate 172, shades 1-4.
E. haematoxylon Maiden.
(A W.A. species cultivated Botanic Gardens, Sydney). 7.1.18.
Young foliage—"garnet brown," Plate 164, shades 1-4.
E. maculata Hook.
Mt. Misery, Liverpool. 17.7.17.
Young twigs—"purple brown," Plate 166, shades 2-3. Highly glazed.
Young twigs—"purple brown," Plate 166, shades 2-3.

C. *E. amplifolia*, *E. botryoides*, *E. hemiphloia*, *E. siderophloia*.

These are four miscellaneous species. The slender evidence shows an affinity between the first, third, and fourth species that will be kept in mind, and between the second and the fourth.
E. amplifolia Naudin.
Liverpool, 17.7.17.
Young foliage—"plum violet," Plate 172, shades 1-3.
Young twigs—"plum violet," Plate 172, shades 3-4.

E. botryoides Sm.

1. Corso, Manly, 14.9.16.
   Young foliage—"garnet," Plate 162. (This is a difficult plate to use, because of its lustre, its appearance becoming nearer to or more removed from Plate 193 according to the incidence of the light.)
2. Glenfield, George's River, 9.10.18.
   "Dark violet," Plate 193, shades 1-4.

E. hemiphloia F. v. M.

1. Cabramatta, 10.7.17.
   Young foliage—"vinous purple," Plate 171, shades 2-3.
   Young twigs—Plate 171.
2. Bankstown, 22.7.19.
   Young foliage—Plate 171, shades 1-4.

E. siderophloia Benth.

Cabramatta, 10.7.17.

Young foliage—"garnet brown," Plate 164, shade 3; also "vinous purple," Plate 171, shade 3.

Young twigs—"garnet brown" (Plate 164), 'purple brown" (Plate 166).

D. *E. haemastoma, E. punctata, E. squamosa, E. virgata.*

In these species I have only noted greens in the young foliage so far, but we have only touched the fringe of the subject.

E. haemastoma Sm. var. *micrantha.*

Como, George's River, 9.16.

"Dark drab green," Plate 237, shade 2. Midrib yellow or reddish. Stems angular, red or yellow.

E. punctata DC.

Como, George's River, 9.16.

Young foliage—"laurel green," Plate 269, shade 2. Back of leaves a pale glaucous green, shiny on the upper side, midrib yellow or red.

Young twigs red and yellow, angular.

E. squamosa Deane and Maiden.

Como, George's River, 9.16.

Young foliage—"dull sage green," Plate 278, shade 2. Leaves the same colour on both sides. Red midribs and edges. Surface dull.

Young twigs bright red, terete or slightly angled.

E. virgata Sieb. (*Luehmanniana* F. v. M.)

1. National Park, 4.7.17.
   Young foliage—"quaker green," Plate 271, shade 1; also "pale green oxide of chromium," Plate 243, shades 1-4; "old moss green," Plate 290, shade 1.
   Young twigs and petioles—"yellow green" or "primrose yellow," Plate 16.
2. Same place and date.
   Young foliage—Plates 271 and 245.
   Petioles—"lemon yellow," Plate 20, shade 4.
   Young stems—"ox's blood red," Plate 94, shade 2.
3. Spit Road, Manly, 14.9.16.
   Young foliage—"spinach green," Plate 270, shade 2. Leaves the same on both sides, surface dull, bright yellow midrib and edges.
   Branchlets coarse, angular, flattened, lemon-yellow.

The following notes on colours have not been standardised by reference to Dauthenay, or any similar work.

a. E. affinis. Stuart Town (J.L.B.) "Leaves atropurpureus."

b. Red (bleeding heart) leaves in *E. obliqua* (Tas.).

c. "As a young tree, the marked purplish cast of its foliage gives it an ornamental appearance." *E. Planchoniana* in Part IX., p. 291, C.R.

d. "A specimen of *E. purpurascens* Link, in Herb. Vindob., is in the opposite-leaved stage, and is probably *E. amygdalina* Labill. The underside of the young foliage of this species is often purple. *E. amygdalina*, C.R., Part VI., p. 153.

NEW GENERA OF MONAXONID SPONGES RELATED TO THE GENUS *CLATHRIA*.

By E. F. Hallmann, B.Sc., Formerly Linnean Macleay Fellow of the Society in Zoology.

(Plates xxxvi.—xl., and three Text-figures.)

The new genera proposed in this paper are *Dendrocia, Allocia, Isociona, Paracornulum, Megaciella, Tenaciella, Axociella, Isociella, Isopenectya,* and *Paradoryx.* Reference to the last-mentioned, which is for the reception of certain species formerly incorrectly assigned to *Clathria,* will be found below in my remarks on the genus *Dendrocia;* the others are dealt with, each under its own heading, in the order in which they have been enumerated.

Genus Dendrocia, gen. nov.

Definition.—Desmacidonidae in which the microscleres are isochelae palmatae (perhaps sometimes accompanied by toxa), the main skeleton is formed of dendritically ramifying spiculo-spongin fibres cored with smooth slender styli (tornostyli) and echinated by small acanthostyli, and the dermal megascleres also are tornostyli, identical in kind with those coring the fibres.

Type, *D. pyramida* Lendenfeld (13).

In addition to the type-species, originally described as *Clathria pyramida,* this genus will include also *Clathria alata* Dendy. The former is from the coast of New South Wales, the latter from Port Phillip (4) and Western Australia (9).

The reason for the exclusion of these two species from the genus *Clathria* I have already indicated in a previous paper (6). In all indubitable species of *Clathria* the styli coring the skeletal fibres,—the *principal* styli,—are different in kind from those occurring dermally and interstitially,—the dermal or *auxiliary* styli. The former spicules are almost invariably more or less curved and gradually tapering (i.e. somewhat conical in shape), whilst the latter, with rare exception, are straight and throughout almost their entire length approximately cylindrical. In *Dendrocia,* apparently, it is the auxiliary styli which both core the fibres and occur dermally and interstitially,—the spicules corresponding to the principal styli of *Clathria* being altogether absent.

In the paper above referred to (6),—in which also a corrected description of *D. pyramida* is furnished,— I suggested that certain species previously admitted in the genus *Clathria,* but distinguished by their non-possession of principal megascleres, might provisionally be referred to the genus *Wilsonella* Carter. I would now, however, restrict the latter genus to comprise only its type-species, *W. australiensis.* For the species which I designated *W. curvichela, W. dura* and *W. oxyphila,*—the microscleres (isochelæ) of which are not of the palmate type,—a new genus is required for which I propose the name *Paradoryx.* In this genus also,—of which *P. dura* may be considered the type,—almost certainly should be included *Clathria piniformis* Carter (2) and *Clathria elegantula* Ridley and Dendy.

The species which I described under the name *Wilsonella conectens* may be assigned provisionally to the genus *Clathria.*

Genus Allocia, gen. nov.

Definition.—Desmacidonidae in which the microscleres are isochelae palmatae (perhaps sometimes accompanied by toxa), the skeleton is a regular reticulation of spiculo-spongin fibre cored by smooth slender styli and echinated by small acanthostyli, and the dermal spicules are smooth amphistrongyla.

Type, *A. chelifera* Hentschel; the only species.

The single species for which this genus is established has been recorded by Hentschel from Western Australia (9) and the Arafura Sea (10) under the generic name *Spanioplon.* Its retention in that genus, however, is surely inadmissible, inasmuch as in *Spanioplon fertile,* the species for whose reception Topsent (21) established the genus, the smooth megascleres of the main skeleton are oxea, the extra-fibral smooth megascleres are tylostyli occurring only interstitially, and microscleres are wanting.

Genus Isociona, gen. nov.

Definition.—Desmacidonidae in which the microscleres are isochelae palmatae (perhaps sometimes accompanied by toxa), the main skeleton is a renieroid or sub-renieroid reticulation of small acanthostyli, and the only additional megascleres present are smooth dermal styli or tylostyli belonging to the category of *auxiliary* megascleres.

Type, *I. tuberosa* Hentschel (9); the only species.

The species for which this genus is proposed was referred by its author to *Lissodendoryx*. Its exclusion from the latter genus, however, is necessitated by the fact that its isochelæ are of the palmate type. In some other respects also it departs from typical species of *Lissodendoryx* considerably. The species is from Western Australia.

Genus Tenacia O. Schmidt.

Definition.—Desmacidonidae in which the microscleres are isochelae palmatae and toxa (the latter sometimes occurring in dragmata), the main skeleton is a reticulation of well-developed spiculo-spongin fibres echinated by acanthostyli, and the additional megascleres are smooth styli incompletely differentiated, chiefly as regards size and situation, into three sorts occurring respectively (i.) within the skeletal fibres, (ii.) interstitially and subdermally, and (iii.) at the surface, directed perpendicularly thereto, forming a dense dermal skeleton.

Type, *T. clathrata* O. Schmidt (18).

The genus which in a former paper (6) I defined under the name *Rhaphidophlus* Ehlers, I now consider to be more correctly designated *Tenacia* O. Schmidt. This is chiefly in view of the fact that, whereas the identity of the latter has been definitely established by the re-description of *Tenacia clathrata* furnished by Wilson (25), the identity of the latter,—concerning which we have no other information than is contained in Ehler's imperfect description of *Rhaphidophlus cratitius* (5),—is open to question. The original publication of both generic names was in the same year, 1870; and it is now difficult to ascertain which has the absolute priority. The evidence, however, is in favour of *Tenacia*, for, whilst Schmidt's paper was listed in the Zoological Record for 1870, that of Ehlers received first mention only in the Record for 1872.

In spite of the rejection of the genus *Rhaphidophlus* by certain authors, the right to recognition of *Tenacia*, as distinct from *Clathria*, seems to me beyond dispute. In *Clathria* the styli coring the skeletal fibres—the *principal* styli as they are commonly termed—are phylogenetically widely distinct from the dermal styli,—the former undoubtedly having been derived from acanthostyli* cognate with those echinating the fibres, while the latter are just as certainly homologous with the megascleres which function as dermal spicules throughout the majority of Desmacidonid genera, and which I (6, p. 137) have termed auxiliary megascleres. In *Tenacia*, on the other hand, and in the closely related genus *Tenaciella* described below, the three sorts of smooth styli which are present are not perfectly distinct in kind, but are connected by an uninterrupted series of spicules of intermediate size and form, thus clearly revealing their common derivation from an originally single type of styli. Whether it is from principal styli they are derived, however, or whether from auxiliary, is not clear. Their curved and slightly tapering form inclines rather to that which is characteristic, in general, of principal megascleres; but also they are provided basally with a cap of spinules, and in this respect they display a feature which, in every other instance of its occurrence, appears to be exclusively a peculiarity of auxiliary megascleres. In the case of *Tenacia*, the analogy in spiculation which it bears to various other related genera, as provided by the fact that the styli occurring within the skeletal fibres are destitute of basal spinules,** led me originally to consider these intrafibral styli as homologous with the similarly situated principal styli of *Clathria*. The evidence afforded by *Tenaciella canaliculata*, however,—in which species the transition of the several forms of smooth styli one into the other is gradual and

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* I have elsewhere already suggested (7, p.454) that evidence is not lacking which points to the possibility that the acanthostyli of the Desmacidonidæ originated from spirasters or forms related thereto. The opinion to which I am inclined to subscribe is that the Desmacidonidæ have evolved from ancestors not remotely related to certain genera at present included in the family Spirastrellidæ; and that the classificatory distinction between Tetraxonida and Monaxonida, as originally proposed by Sollas (20) is fundamentally correct. From this point of view the principal and the echinating megascleres of the Desmacidonidæ are primitively derived from spicules homologous with the microscleres of the Spirastrellidæ, while in all probability their dermal megascleres are derived from spicules homologous with the tylostyli of the same family.

** I have, however, recorded the occasional occurrence of basal spinules in the case of some of the intrafibral spicules of *Tenacia paucispina* var. *multipora* (6, p.185).

unmistakable—proves conclusively that this view is erroneous. Thus my suggestion that *Clathriopsamma reticulata* Lendenfeld might be included in the genus *Rhaphidophlus* (now *Tenacia*) becomes untenable, and I now propose to recognise the genus *Clathriopsamma* as distinct.

The species known to me which I consider to belong to *Tenacia* are those (excepting *Clathriopsamma reticulata* and very probably also *Clathria spiculosa* Dendy) of which I have already furnished a list (6, p. 227) in connection with my previous remarks on *Rhaphidophlus;* and, in addition, *Rhaphidophlus filifer* var. *cantabrica* Orueta (15), and *Clathria typica* var. *porrecta* Hentschel (10), of whose existence I had not, at that time, information. Since then, also, have been described by Hentschel (10) *Clathria nuda* and *Clathria frondifera* var. *dichela;* and so far as can be judged from their descriptions and figures, it seems to me very probable that they too belong to *Tenacia*. Whether *Tenacia arcifera* O. Schmidt is another species properly to be included in the genus, I am unable to say, not having seen its description.

Genus CLATHRIOPSAMMA Lendenfeld.

Definition.—Desmacidonidae in which the microscleres are isochelae palmatae and rhaphidiform toxa (the latter typically indistinguishable from long slender oxea, and in part occurring in dragmata); in which the main skeleton is an irregular reticulation of spiculo-spongin fibres, of which the main (if not also the connecting) fibres are cored by foreign bodies and by smooth (principal) styli, and are echinated by small acanthostyli; and in which the auxiliary megascleres, occurring both dermally and scattered interstitially, are smooth slender styli or tylostyli, typically provided on the basal extremity with a cap of minute spinules.

Type, *C. reticulata* Lendenfeld; the only species.

Of the two species which Lendenfeld (6, p. 227) referred to his genus *Clathriopsamma*, the first-described, *C. lobosa*, is now known to be identical with *Wilsonella australiensis*. The other, *C. reticulata*,—of which I have already furnished a brief redescription in a former paper (6, p. 177),—possesses characters which appear to me sufficiently distinctive to warrant our retention of the genus *Clathriopsamma* for its reception.

Genus PARACORNULUM, gen. nov.

Definition.—Desmacidonidae typically of massive or encrusting habit, in which the microscleres, when present, are isochelae palmatae and (or) toxa, and the megascleres are of two kinds, viz., smooth amphistrongyla or amphitornota (perhaps always with spinulous extremities) forming the main skeleton, and small acanthostyli, acanthoxea, or acanthostrongyla occurring scattered.

Type, *P. dubium* Hentschel (10).

I define this genus to comprise, in addition to Hentschel's *Cornulum dubium* (which is from the Arafura Sea), two other species, both imperfectly known, viz., *Cliona purpurea* Hancock,—lately referred by Kirkpatrick (11) to his genus *Dyscliona,* but subsequently found by Topsent (22) to possess isochelae palmatae and toxa,—and *Suberites fuliginosus* Carter. The last-named (the locality of which is doubtfully given as Torres Strait) is possibly without microscleres, inasmuch as Carter makes no mention of their presence; nevertheless its considerable resemblance to the other two species—and more especially to *P. purpurea*—in the matter of megascleric spiculation, points to the probability of its close relationship thereto.

Paracornulum appears to stand in the same relation to *Cornulum* as *Histodermella* Lundbeck (14) to *Histoderma.*

Genus MEGACIELLA, gen. nov.

Definition.—Desmacidonidae in which the microscleres are isochelae palmatae and non-spinulous toxa (the latter in part attaining to extreme length), the main skeleton is an irregular and confused arrangement of very long smooth styli united by a minimal amount of spongin, and the only additional megascleres are dermal amphitylota, typically with spinulous extremities.

Type, *M. pilosa* Ridley and Dendy; the only species.

Amphilectus pilosus Ridley and Dendy (17) bears in many respects considerable resemblance to two species at present included in the genus *Artemisina,* viz., *A. annectens* Ridley and Dendy and *A. strongyla* Hentschel (11),—and, indeed, is especially distinguished from them only in the fact that its toxa are without spinulous extremities and are in part transformed into oxea-like spicules of extraordinary length. In view, however of the constancy of form maintained by the toxa throughout the several species of *Artemisina*, it seems advisable to continue to regard them as an essential characteristic of that genus. Consequently, as there is no other established genus to which *Amphilectus pilosus* might be referred, a new one for its reception is required.

Genus TENACIELLA, gen. nov.

Definition.—Desmacidonidae in which the microscleres are isochelae palmatae and toxa, the main skeleton is a reticulation of strongly developed spiculo-spongin fibre, and the megascleres are smooth styli incompletely differentiated into three kinds occurring respectively (i.) within the fibres, (ii.) interstitially and subdermally, and (iii.) at the surface, directed perpendicularly thereto, forming a dense dermal skeleton.

Type, *T. canaliculata* Whitelegge (23); the only species.

This genus differs in no essential respect, save in the absence of acanthostyli, from *Tenacia* O. Schmidt as defined above.

TENACIELLA CANALICULATA Whitelegge.

(Pl. xxxvi., figs. 1, 2; Pl. xxxvii., fig. 1; Text-fig. 1.)

1906. *Esperiopsis canaliculata*, Whitelegge, Austr. Mus. Mem., iv., Part 9, p. 471, Pl. xliii., fig. 7.

External characters.—The sponge is erect, stipitate, ramose, with from few to numerous, cylindrical to irregularly subcylindrical, occasionally anastomosing branches, varying from 6 to 11mm. (but usually about 8 or 9mm.) in diameter (Pl. xxxvii., fig. 1). Of fifteen specimens available, the largest measures 195mm. in total height. The length of the branches seldom exceeds 100mm., and is usually less than 65mm.; and the stalk, which is no stouter or only slightly stouter than the branches, may reach a length of 60mm. The mode of branching is such that successive branches tend to be given off in the same plane, with the consequence that sparsely branched specimens are often somewhat flabellate. The consistency of the sponge in alcohol is tough, compressible and resilient, and the colour brownish grey; dry specimens are slightly brittle, and their colour on the surface is pale brownish or yellowish grey.

The dermal membrane is exceptionally well-developed, forming a firmly and closely adherent, not very tough skin, about $\frac{1}{5}$mm. in thickness. In dry specimens undamaged by maceration it persists intact, with smooth, unwrinkled surface, and is of somewhat corky (rather than leathery) consistency. In spirit-specimens the membrane is rather fleshy in appearance, and the surface of the sponge is smooth, almost glabrous. The dermal pores cannot be discerned.

An especially distinctive external feature of the species is the presence, on each branch, of a more or less well-marked longitudinal groove, extending along the whole or greater part of its length. This groove marks the course of a main excurrent canal, which runs subjacent to it immediately beneath the dermal membrane. The groove, in all probability, is not a feature of the living sponge, but is due to collapse of the dermal membrane in consequence of contraction.

Maceration of the sponge by means of caustic potash removes not only the dermal membrane, but also an additional layer of the sponge to a depth of about 1mm. from the surface. This is owing to the almost complete absence of spongin in the outer portion of the main skeleton. The skeleton which remains is a rather coarse-textured reticulation of yellowish-grey fibres, harsh to the touch; it shows no trace of the longitudinal groove which is so conspicuous a feature of the intact sponge.

Skeleton.—Examined microscopically in longitudinal median section (of an unmacerated branch of the sponge) the main skeleton presents three usually fairly well-marked regions, viz., a central, an intermediate, and a subdermal. The central region (Pl. xxxvi., fig. 2), occupying the whole interior to within from 1 to 1.5mm. of the surface, consists of an irregular, rather wide-meshed reticulation of brownish yellow, multispicular spongin-fibres,—with the main fibres running more or less nearly longitudinally (the more peripherally situated ones, however, gradually trending surfacewards), and connected together, in irregular fashion, both by transverse fibres and by inosculation among themselves. From the outermost fibres of this region, short fibres branch off, which run directly outwards to the surface in a direction usually not far from perpendicular thereto; these, which may be termed the radial fibres, are (excepting for an extremely short distance beyond their origin) apparently entirely devoid of spongin; are unconnected by transverse fibres; and, after a short course (throughout which their spicules are arranged compactly side by side), subdivide to form each a widely-outspread, usually rather dishevelled brush of spicules, the outer extremities of which impinge upon and sometimes slightly project beyond the dermal membrane (Pl. xxxvi., fig. 1). The brushes occur so closely situated that their spicules intercross with one another, and the latter are so numerous that collectively they produce an appearance as of a continuous, somewhat halichondroid layer of spicules underlying and supporting the dermal skeleton. The intervening zone between this subdermal layer and the central skeleton, traversed by the radial fibres, constitutes the second or intermediate region of the skeleton above referred to; and the subdermal layer itself, the third. It is these two regions of the main skeleton which, together with the dermal layer, are removed by the action of caustic potash.

The main longitudinal fibres of the skeleton range in stoutness from about 140 to 260μ, the connecting fibres between them from about 45 to 180μ. Their constituent spicules, as a rule, are not so aggregated as to form a compact axial core surrounded by a zone or sheath of spongin free from spicules, but tend to be dispersed more or less completely throughout the entire spongin substance. The radial fibres (which, as already stated, are composed solely of spicules) are scarcely less in stoutness than the main fibres. The connecting fibres, when shortest, are of a single spicule's length, and contain sometimes only three or four spicules; but more frequently they are longer, and occasionally the number of their contained spicules is such that they approximate in appearance to the main fibres. The irregular pattern of the skeleton-reticulation is due partly to the fact that the main fibres run rather crookedly (and, hence, at varying distances apart), and partly to the fact that the direction of the longer connecting fibres between them is usually more or less oblique. Between the fibres very numerous loose megascleres are scattered, the great majority of which are similar or nearly similar in kind to those composing the subdermal brushes; but amongst them there are also very many which are identical in shape and size with the dermal spicules, and also a moderate number similar in every respect to those of the fibres. The microscleres, both toxa and chelae, occur scattered everywhere in moderate abundance, except in the dermal layer. The chelae are of two kinds, but the smaller are very difficult to perceive, in ordinary sections, owing to their minute size.

Megascleres.—(i) The styli of the fibres (Text-fig. 1, *a*) are, almost without exception, more or less curved, and of nearly uniform diameter throughout the greater part (not less than two-thirds) of their length, tapering thence gradually to a sharp point; as a rule they are slightly stouter in the middle than at their base. Their curvature is generally greatest in the case of the shorter spicules, and is such that the summit of curvature is usually not very far distant from the mid-point of the spicule. They vary rather considerably in size in the same specimen, but not much as regards their maximum size in different specimens. In the particular specimen in which, of all those examined, the megascleres were of smallest dimensions, the range in size of the fibral spicules was from 130 × 6μ to 410 × 22μ while in the specimen with the largest spicules it was from 160 × 10μ to 465 × 26μ. The smallest of them, up to an observed size of 230 by 13μ, occasionally exhibit a faint spinulation on the summit of their basal extremity, similar to (but much less distinct than) that which is characteristic of the dermal spicules. Proceeding towards the outer extremities of the radial fibres, the fibral megascleres become gradually more uniform in size and of greater average length than in the more interiorly situated fibres of the skeleton, and finally, in the subdermal brushes, become indistinguishable from the next-described or interstitial styli.

(ii.) The styli composing the subdermal brushes and occurring also in great numbers scattered interstitially (Text-fig. 1, *b*), are invariably straight or nearly so; are usually considerably stouter near the middle than at the base; and taper (throughout more than one-third, at least, of their length) gradually to a sharp point. Amongst those occurring interstitially, however, there is comprised a complete series of forms, of progressively diminishing size, the smallest of which are identically similar in every respect to the dermal styli. Their maximum size varies in different specimens from about 520 × 13.5μ to 590 × 16μ. The smallest spicules of which the form approximates more closely to that characteristic of the largest interstitial spicules than to that characteristic of the dermal spicules are usually not much less than about 240 × 10μ in size. Up to this size, almost without exception, the interstitial spicules are provided basally with a small cap of spinules; and even spicules of considerably greater length are often similarly pro-

Text-fig.1.

Tenaciella canaliculata. *a*, styli of the fibres; *b*, interstitial and subdermal styli; *c*, dermal styli; *c'*, basal extremities of dermal styli, more highly magnified; *d*, larger isochelæ; *d'*, early developmental stage of a larger isochela; *e*, smaller isochelæ (some of which are contort); *f*, toxa; *f'*, smallest toxa, more highly magnified; *g*, megascleres of an embryo.

vided: the largest observed spicule with spinules measured 475 × 12μ.

(iii.) The dermal spicules (Text fig. 1, *c*) are slightly to moderately curved subtylostyli, with somewhat fusiform shaft, and invariably provided with a cap of spinules on the basal extremity. Those located actually in the dermal skeleton range from about 100 up to 165μ in length and up to 7.5μ in stoutness; but spicules of similar form, occurring scattered between the skeletal fibres, range in size up to occasionally as much as 240 × 10μ. In their earliest developmental stages the dermal spicules are extremely slender tylostyli, the smallest of which are only about 80μ in length.

Microscleres.—(i.) The larger isochelae palmatae (Text-fig 1 *d*,) are of the ordinary type occurring in *Clathria* and related genera, and measure from 14 to 22μ in length.

(ii.) The smaller isochelae palmatae (Text-fig 1, *e*), like those of *Rhaphidophlus typicus* Carter, are peculiar in being frequently asymmetrical with respect to their opposite extremities, —the asymmetry being such as would result through torsional rotation of one end of the shaft through an angle of 90°. They appear often to be somewhat abnormal in other respects also, but the details of their form are difficult to make out owing to their very minute size. They measure only from 4 to 8μ in length.

(iii.) The toxa (Text-fig. 1, *f*, f_1) comprise an apparently complete series of forms, of gradually varying shape, ranging in length from less than 10μ up to occasionally as much as 800 μ The shortest and by far the most numerous,—seldom much exceeding 80 or 90μ in maximum length,—are more or less distinctly tricurvate; those of intermediate length have the arms straight or nearly so, and are bent in the centre somewhat angulately; and the longest are mostly quite straight, resembling extremely long and slender, rhaphidiform oxea. The last-mentioned,—although usually difficult to discover in sections of the sponge owing to the multitude of other spicules,—are in some specimens by no means rare; but in others they appear to be almost entirely absent. In one of the latter specimens, the longest rhaphidiform toxa that could be found measured only 360 × 2μ; whereas in the specimen in which they were most numerous, the longest one observed measured 810 × 4.5μ.

Embryos.—Most of the specimens contain not very numerous, scattered embryos, the largest of which are more than 1mm. in diameter and are provided with irregularly scattered megascleres in the form of excessively slender, straight to flexuous styli (Text-fig. 1 *g*), mostly with a bead-like dilatation just above the basal extremity, and ranging in length from less than 80 up to about 200 μ. (The specimens were collected about the middle of the month of March.)

Loc.—Coast of New South Wales, off Wata Mooli (52-71 fms.), off Bulgo (57-63 fms.), and off Wollongong (55-56 fms.). "Thetis" Expedition.

Genus AXOCIELLA, gen nov.

Definition.—Desmacidonidae with isochelae palmatae and (or?) toxa as microscleres, and of erect lamellar or ramose habit: in which the main skeleton consists axially of a condensed reticulation of strongly-developed spiculo-spongin fibres, and extra-axially of strands or bundles of spicules (perhaps sometimes reduced to single spicules) directed radially; and in which the megascleres are smooth styli of three kinds, occurring respectively (i.) in the fibres of the axial reticulation, (ii.) in the radial strands, and (iii.) interstitially and dermally. Typically the fibral megascleres are scarcely different from those of the extra-axial strands except in being of smaller size, and are connected with them by intermediate forms; but the dermal megascleres are quite distinct, and belong to the category of auxiliary megascleres.

Type, *A. cylindrica* Ridley and Dendy; the only species.

I identify the type-species of this genus with Ridley and Dendy's *Esperiopsis cylindrica.* The sponge recorded by Whitelegge (23) under the same name is a quite distinct species, which it will be convenient to include provisionally in the genus *Ophlitaspongia;* and as the species is a new one I propose for it the name *O. thetidis.**

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* In this species,—of which a figure illustrating the external form has been provided by Whitelegge (23, Pl. xliii., fig.6) and another (showing a much more profusely branched specimen) is given here (Pl. xxxviii.),—the skeleton is reticulate throughout, fairly regular in pattern, and scarcely or not at all condensed axially (Pl. xxxix., fig.2). The main fibres, which vary in stoutness from about 50 to 150μ, are only very sparsely cored with smooth stylote megascleres (ranging in size from less than 200 × 10μ to rarely upwards of 600 × 20μ) in the more interior

AXOCIELLA CYLINDRICA Ridley and Dendy.

(Pl. xxxvii., figs. 1, 2, 3; Text-fig. 2.)

1886. *Esperiopsis cylindrica,* Ridley and Dendy (16), p. 340.
1887. *Esperiopsis cylindrica,* Ridley and Dendy (17), xx., p. 79, Pl. xix., figs. 2, 2*a*, 2*b*.

External features.—The single specimen (Pl. xxxvii., fig. 4) upon which the following description is based closely agrees in outward habit with the original specimen. It is a sparsely and dichotomously ramose sponge, with relatively long and slender, distally tapered, cylindrical branches, measuring up to-4.5μ in stoutness and up to 128mm. in uninterrupted length. In the present specimen the stalk is missing: that of the original example measured 187mm. in length, and had a flattened, branching base, 19mm. in diameter. The surface of the sponge is

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region of the skeleton; but on nearing the surface their spicules increase greatly in number and also rather considerably in average dimensions (attaining in some specimens to upwards of 800 × 30μ in maximum size) and assume a more and more plumose disposition, finally forming at the extremity of the fibre a scopiform tuft,—while at the same time the spongin-substance gradually diminishes in quantity to the verge of disappearance. The connecting fibres are of a single spicule's length, and contain only one or two spicules. The dermal megascleres proper are, apparently, relatively very few, but their true number and manner of arrangement cannot be ascertained, since, unfortunately all the specimens are in a dried and washed-out condition and entirely destitute of dermal membrane; they are straight to flexuous styli or subtylostyli, usually with a slightly truncated basal extremity capped with a few indistinct spinules, and ranging from 165 to 350μ in length and up to 5μ in diameter. In the peripheral region of the skeleton, lying between the main fibres, and directed parallelly thereto, there occur,—sometimes singly, sometimes several together in a parallel bundle (dragma),—long and relatively slender, usually symmetrically or flexuously curved, rhaphidiform oxea: these,—which presumably are derivatives of toxa,—appear to vary, both in number and in size, very considerably in different specimens, and are possibly sometimes very rare; in one of the specimens examined they ranged only from about 300 to (very rarely) slightly above 700μ in length and up to 5μ in diameter, whereas in another they were seldom less than 850μ long and attained a maximum size of 1280 × 9μ. Isochelae palmatae, 12 to 16μ long, and tricurvate toxa, ranging from 25 to rarely upwards of 130μ in length, and up to 4μ in stoutness, are scattered fairly abundantly through all parts of the interior.

finely hispid with the points of projecting spicules. The dermal membrane is thin and closely adherent; the dermal pores could not be discerned. Oscula are apparently absent. In alcohol the colour is yellowish-grey, the texture dense, the consistency fairly firm and tough; the branches, however, are lax, not stiff. The original specimen apparently was more rigid, since its consistency has been described as hard and tough. As a result of maceration (by means of caustic potash) a thin superficial layer of the sponge, of softer consistence, disappears, and there is left a dense, solid-looking core, the surface of which presents a somewhat bristly appearance due to the stubs of radially-directed, detruncated spicule-strands.

Skeleton.—The skeleton (Pl. xxxvii., fig. 3) presents, in each branch of the sponge, a very dense axial region, or core, occupying from about one-third to somewhat above one-half the diameter of the branch, and composed chiefly of longitudinally-running, closely apposed, sponginous fibres containing each a fairly compact core of moderately short and slender, slightly curved styli. These main fibres are connected, partly by very short and inconspicuous, aspicular to paucispicular, transverse fibres, and partly also by occasional inosculation with one another, to form an indistinct reticulation with elongated, very narrow meshes. Also participating in the formation of the axial skeleton are rather numerous slender straight styli, similar in every way to those composing the dermal spicule-bundles. These auxiliary, extra-fibral styli are directed parallelly to the main fibres, and are aggregated for the most part into bundles and strands. In the youngest portions of the sponge, towards the extremities of the branches, spongin is developed only to an extremely slight extent (Pl. xxxvii., fig. 2); but in the older portions it increases in quantity till finally the interstices of the axial skeleton are entirely obliterated. The outermost fibres of the axial skeleton, however, remain always comparatively scantily provided with ensheathing spongin; and the pattern of the peripheral zone of the axial skeleton is generally somewhat irregular and confused.

From the outermost fibres of the axial skeleton there proceed outwards to the surface, perpendicularly or nearly so thereto, numerous short, non-plumose paucispicular columns of comparatively long and stout styli—the points of the (slightly divergent) terminal ones of which impinge upon, or project slightly beyond, the dermal membrane. These radial columns are usually not much longer than the largest spicules composing them,—thus approximating in character rather to bundles or tufts; are unconnected by transverse fibres or spicules; and are entirely unprovided with spongin except proximally for a short distance beyond their origin from the longitudinal fibres. Outside the axial skeleton, in a narrow zone immediately surrounding it, there also occur numerous long slender auxiliary styli directed longitudinally. The dermal skeleton is composed of numerous parallel or slightly penicillate tufts of the same spicules, the extremities of which usually project somewhat beyond the surface.

The microscleres are numerous isochelae palmatae and scarce toxa, the former occurring most abundantly in the superficial layers of the sponge and only very sparsely within the interstices of the axial skeleton, whilst the toxa are almost entirely confined to the latter region of the skeleton.

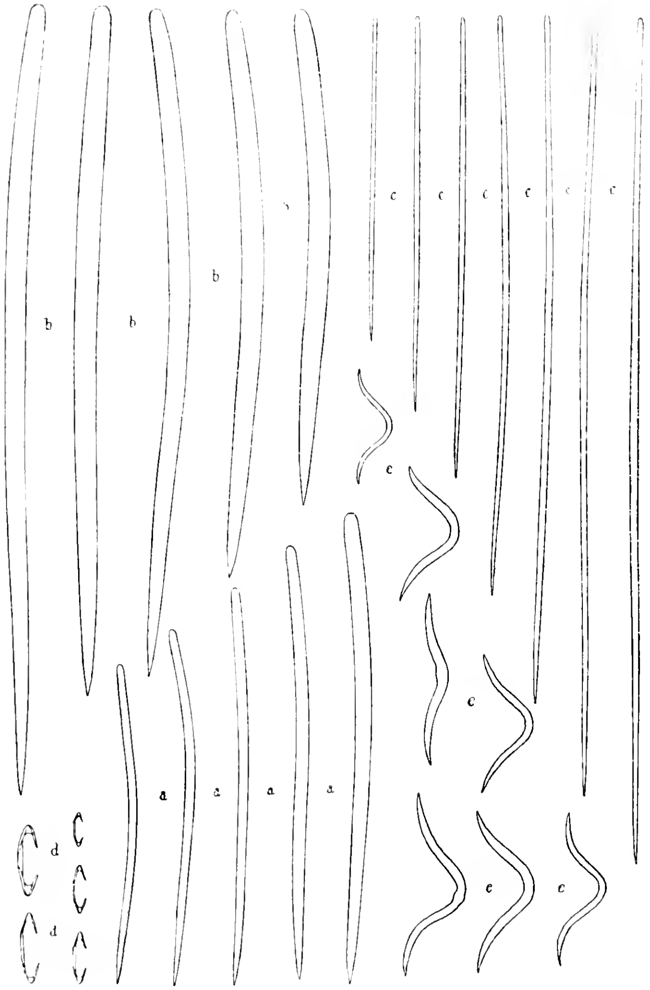
Megascleres.—(i.) The styli (Text-fig. 2, *a*) which core the fibres of the axial skeleton are slightly curved, and of nearly uniform diameter throughout the greater part of their length, tapering thence gradually to a sharp point. They range in size from about 260 by 7μ or less to occasionally slightly upwards of 375 by 15μ. The largest of them approximate closely both in form and size to the smallest of the "radial" styli.

(ii.) The styli (Text-fig. 2, *b*) composing the radial columns range in size from rarely less than 400 by 16μ up to 690 by 24μ. They also are slightly curved and gradually sharp-pointed, but they differ from the preceding styli in being usually more or less narrowed towards the base.

(iii.) The auxiliary or dermal styli (Text-fig. 2, *c*) are mostly straight or nearly so, somewhat gradually sharp-pointed, and also slightly attenuated towards the base. They range in length from about 250 to 710μ, and in diameter up to 9.5μ.

Microscleres.—(i.) The isochelae palmatae (Text-fig. 2, *d*) are of the usual *Clathria* type, and measure from 9 to 24μ in length. They are very nearly divisible into two groups with respect to size—individuals between 15 and 18μ in length being extremely rare.

(ii.) The toxa, which are rather scarce, are of the form shown in the figure (Text-fig. 2, *e*). They are characterised by the great degree of their bending, and by the not uncommon occur-



Text-fig.2.

Axociella cylindrica. *a*, styli of the fibres; *b*, styli of the "radial columns"; *c*, dermal styli; *d*, isochelæ; *e*, toxa.

rence of a slight dilatation at or near their centre. They range from very rarely less than 60 up to about 110μ in length and from 2 to 6μ in diameter. The occurrence of toxa in this species was not definitely recorded by Ridley and Dendy, by whom they probably were overlooked owing to their scarcity.

Loc.—Port Jackson.

Genus Isociella, gen. nov.

Definition.—Desmacidonidae in which the microscleres are isochelae palmatae (perhaps sometimes accompanied by toxa), the skeleton is a sub-renieroid reticulation of smooth, typically curved styli mostly free or nearly free from spongin except about their extremities, and the only additional megascleres are smooth slender styli (tornostyli), belonging to the category of auxiliary megascleres, and occurring chiefly dermally.

Type, *I. flabellata* Ridley and Dendy; the only species.

The name originally bestowed on the species for which I establish this genus was *Phakellia flabellata;* but subsequently Dendy (4), finding that the same name had previously been given by Carter (2) to a Port Phillip sponge, proposed that the specific name be changed to *jacksoniana.* In view of the fact, however, that Ridley and Dendy's species should never have been assigned to *Phakellia* (and, indeed, would not have been, had not its microscleres been overlooked), and the fact that Carter's species also is not now considered to belong to *Phakellia,* it seems to me better that the original name be adhered to.

Isociella flabellata differs only in one important respect from certain species at present included in the genus *Ophlitaspongia,* namely, in its non-possession of well-developed reticulating spongin fibres. From the majority of the species of the latter genus it further departs in the fact that its fibres are not echinated; but this latter point of difference is probably one of only minor importance. Whether, when the very needful revision of the genus *Ophlitaspongia* is made, certain of its species will not require to be associated with *I. flabellata* in one and the same genus is perhaps open to question. It is beyond doubt, however, that *I. flabellata* and the typical species of *Ophlitaspongia* can never be so associated.

ISOCIELLA FLABELLATA Ridley and Dendy.

(Pl. xl., figs. 1, 2; and Text-fig. 3.)

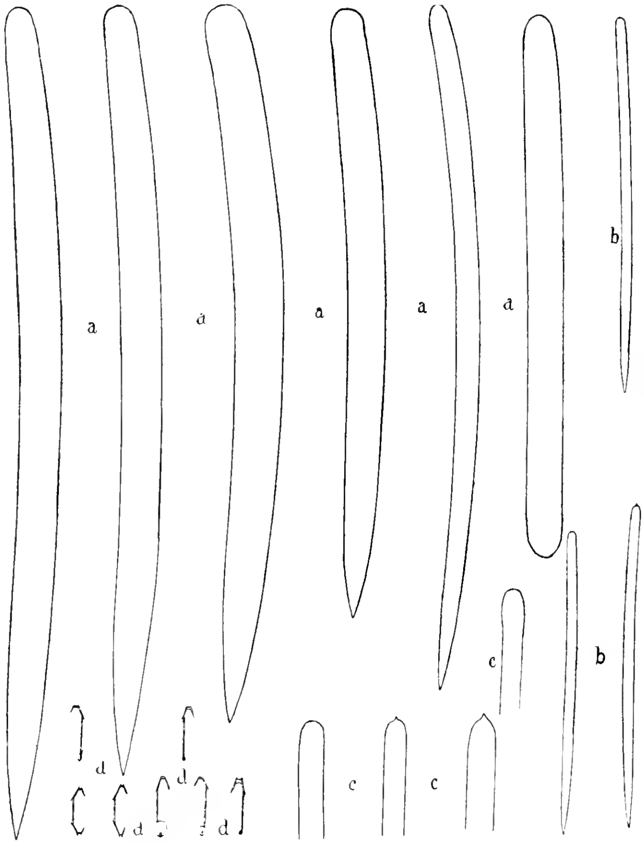
1886. *Phakellia flabellata,* Ridley and Dendy (16), p. 478.
1887. *Phakellia flabellata,* Ridley and Dendy (17), p. 171, Pl. xxxiv., figs. 2, 3, 3a; Pl. xl., figs. 6, 6a.
1897. *Phakellia jacksoniana,* Dendy (4), p. 236.
1907. *Phakellia jacksoniana,* Whitelegge (24), p. 507.

External characters.—With respect to external features, the previous description (17) of the species, based upon eleven specimens, requires but little to be added to it. The sponge (17, Pl. xxxiv., figs. 2, 3) is erect, flabelliform, with a rather short, cylindrical stalk terminating below in a flattened base of attachment, and above expanding, usually more or less suddenly, into a single, entire or lobately subdivided, vertical frond varying from 2 to 3 mm. in thickness. Not infrequently the frond presents one or a few, usually more or less elongated, open spaces or fenestrae, mostly of inconsiderable size, which are evidently due to an incomplete concrescence of originally separate lobes; and sometimes (though very exceptionally) the lamella remains subdivided into separate lobes almost to the apex of the stalk. Of the specimens so far obtained the largest measures 180mm. in total height; the greatest breadth which the frond attains in any specimen is 125mm.; and the stalk varies in different specimens from 4 to 8.5mm. in greatest diameter and up to 40mm. in length. Invariably the surface, on one side of the frond is thrown into more or less prominent, rather irregular, longitudinal furrows and ridges (the latter, in part, sometimes discontinuous, and replaced by a succession of low hummocks), while on the other it is comparatively smooth and bears numerous minute oscula (rarely exceeding 0.5mm. each in diameter) disposed in subcircular groups, with about from 8 to 12 oscula in each group. The subcircular areas occupied each by a group of oscula vary from 4 to 6 mm. in diameter and from 6 to 10mm. in distance apart measured from centre to centre; are usually slightly depressed below the general level of the surface; and are fringed each by a series of more or less distinct, radiating, short, shallow grooves, which give to them a stellate aspect (17, Pl. xxxiv., fig. 3a). The dermal membrane—according to the previous description of the species—is thin and transparent; and the dermal pores (described as round or oval openings about 70 to 100 μ in diameter) are very abundant on the surface which bears the oscula ("occurring in small groups over the ends of the inhalant canals, where they reduce the dermal membrane to a mere network"), but are extremely scarce or absent on the opposite side of the sponge. In the specimens upon which the present description is based,—four in number and, with one exception, in a dried state of preservation,—the dermal membrane is wanting, and the surface opposite to that on which the oscula occur is closely dotted with numerous pin-hole-like perforations,—only slightly smaller in diameter than the oscula themselves,—which are the openings of the inhalant canals: as a consequence the dry specimens, when held between the eye and the light, present a minutely perforate appearance. Also clearly visible, when the sponge is thus examined, are stout, branching veins radiating upwards through the frond, from stalk to margin, at a distance apart varying from about 5 to 10mm. On careful desarcodisation of the sponge by means of caustic potash the skeleton is obtainable intact, and the "veins" are then very conspicuous—appearing as stout, sponginous, dark yellowish or brownish-coloured fibres (Pl. xl., fig. 1); whereas the rest of the skeleton, owing to its extreme deficiency in spongin-cement, appears almost pure white. The colour of the sponge in alcohol is greyish yellow, and the consistency rather soft and brittle; dry specimens are crisp to the touch, inelastic, and very easily crushed.

Skeleton.—Exclusive of the very few stout spiculo-spongin fibres forming the "veins" above referred to, the skeleton (Pl. xxxix., figs. 1, 2) consists of pauciserial lines of (smooth stylote) spicules—or, strictly speaking, spicule-fibres extremely scantily provided with spongin,—united together, for the most part, by single transverse spicules entirely free from spongin except at their extremities. Not infrequently, however, the distance between adjoining spicule-fibres is greater than (sometimes nearly as much as twice) a spicule's length and the interconnecting spicules then form between them an irregular unispicular meshwork. In either case the connecting spicules are very numerous, and are inclined to the direction of the fibres at very varying angles; and always a small proportion of them—through failure to effect connection apically—appear simply to project from the fibres in the manner of echinating spicules. The spicules forming the fibres are disposed parallelly to the direction of the fibres, and their number in a cross-section of a fibre at any point is usually about 4 or 5—though varying from 2 to (very rarely) upwards of 8 or 9. Immediately beneath the dermal membrane,—occurring about the extremities of the fibres, and also scattered in between,—are bundles of short and slender auxiliary (or dermal) styli. Auxiliary styli, in small number, also occur scattered singly in the interstices of the main skeletal reticulation.

As seen in thin, or moderately thin, longitudinal sections perpendicular to the plane of the sponge-frond,—owing to the fact that in such sections, as a rule, many or most of the fibres are intersected by the plane of section,—the skeleton often appears as if irregularly isodictyal in pattern, with triangular and quadrangular meshes the sides of which are of a single spicule's length; and sometimes, in its denser and more irregular portions, it appears somewhat halichondroid. The true conformation of the skeleton is generally more plainly and immediately apparent in sections parallel to, and in, the mid-plane of the sponge-frond (Pl. xl., fig. 2); and such sections, also, display best the structure of the "veins." The pauciserial spicule-fibres originate as branches from the stout fibres forming the "veins," and, proceeding therefrom in a more or less obliquely ascending direction, pass upwards in the mid-plane of the sponge and outwards to the surface, continually multiplying by dichotomy as they proceed. The veins would thus appear to constitute the primary axes of the growth of the sponge. Each vein is composed of several fibres united both by occasional anastomosis and by (numerous) connecting spicules. These fibres,—which attain a diameter of over 400μ in the oldest portions of the skeleton, gradually diminishing to less than 150μ at the margin of the sponge,—are densely sponginous, and are filled with closely packed styli (similar to those occurring elsewhere in the main skeleton) the apices of which, almost as frequently as not, are directed towards the base of the sponge.

Megascleres.—(i) The principal or skeletal styli (Text-fig. 3, *a*) are smooth, slightly curved, and of nearly uniform diameter usually throughout about four-fifths of their length, tapering thence to a sharp point. As a rule they are very slightly stouter in the middle than at the base. They range from 350 to 530μ in length and up to 31.5μ in diameter; indi-



Text-fig. 3.

Isocielta flabellata. *a*, skeletal styli; *b*, dermal styli; *c*, basal extremities of dermal styli, more highly magnified; *d*, isochelæ, often more or less contort, and frequently passing into anisochelæ.

viduals less than 400 μ in length or less than about 15 μ in stoutness are scarce. Among the styli, occasional modifications thereof in the form of strongyla occur; these are of lesser average length than the styli—the shortest one observed measuring only 290 μ long.

(ii.) The auxiliary or dermal styli (Text-fig. 3, *b*) are smooth, almost invariably quite straight, and (like the principal styli) somewhat abruptly sharp-pointed; and are frequently provided with a minute mucro on the basal extremity (Text-fig. 3, *c*). They range from 155 to 250μ in length and from 3.5 to 7μ in diameter.

Microscleres.—The only microscleres (Text-fig. 3, *d*) are moderately scarce, extremely slender chelae of the palmate type, measuring from 11 to 15.5μ in length, and peculiar in the fact that the flukes at one extremity (more especially the median fluke) usually exhibit some degree of atrophy—occasionally being reduced almost to the verge of disappearance—and frequently are disposed asymmetrically relatively to those at the opposite extremity, by rotation about the shaft amounting sometimes to as much as 90°. The flukes are relatively small—even the median one seldom exceeding 4μ in length.

Loc.—Coast of New South Wales, in and near Port Jackson.

Genus ISOPENECTYA, gen. nov.

Definition.—Desmacidonidae without microscleres, in which the skeleton is a renieroid reticulation either regularly isodictyal throughout and composed entirely of spongin-ensheathed acanthostyli of a single kind, or also sparsely traversed by pauciserial spiculo-spongin fibres containing, in addition, smooth styli of a form that suggests their original derivation from the acanthostyli; in either case the acanthostyli are replaced in the outermost region of the skeleton by the smooth styli, which project from the surface of the sponge. Also present are megascleres of a third kind, in the form of smooth slender styli, occurring dermally and interstitially. Typically the amount of spongin in the skeleton is comparatively small.

Type, *I. chartacea* Whitelegge (24); the only species.

In the absence of microscleres the affinities of this genus are somewhat uncertain. In certain respects, including the pattern of the skeleton, it shows some degree of resemblance to *Suberotelites demonstrans* Topsent (21), but in the latter species the acanthosceleres are tylostrongyla, and auxiliary megascleres are wanting. The existence of species like those of *Suberotelites* suggests that the correct position of the genus *Metschnikowia* Grimm,—placed by Lundbeck in proximity to *Reniera*,—is likewise in the family Desmacidonidae.

In conveying the impression that the acanthostyli of *I. chartacea* occur as echinating spicules, and that spongin is developed in connection with the skeleton-reticulation in considerable amount the original description of the species,—as I have already indicated (6, p. 208),—is in error.

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DESCRIPTION OF PLATES XXXVI.—XL.

Plate xxxvi.

Fig. 1.—Moderately thin transverse section of a branch of *Tenaciella canaliculata* Whitelegge. The very dense peripheral layer is formed by the dermal skeleton and the subdermal brushes. The central region of the skeleton is relatively sparse and not displayed to advantage; but the intermediate zone between it and the peripheral layer, consisting of the radial fibres, is well shown. (x 12½).

Fig. 2.—Longitudinal section of the main skeleton of a branch of *Tenaciella canaliculata* Whitelegge. (x 15).

Plate xxxvii.

Fig. 1.—Entire specimen of *Tenaciella canaliculata* Whitelegge.

Fig. 2.—Longitudinal section of the skeleton, in proximity to the tip of a branch, of *Axociella cylindrica* Ridley and Dendy. (x 12½).

Fig. 3.—Longitudinal section of the skeleton of an older portion of a branch of *Axociella cylindrica* Ridley and Dendy. (x 12½).

Fig. 4.—Portion of a specimen of *Axociella cylindrica* Ridley and Dendy.

Plate xxxviii.

Entire specimen of *Ophlitaspongia thetidis* sp. nov.

Plate xxxix.

Fig. 1.—Portion of a section of the skeleton of *Isociella flabellata* Ridley and Dendy, taken from near the outer margin of the sponge—the plane of section being approximately parallel to the mid-plane of the sponge-lamina. (x 12½).

Fig. 2.—Portion of a longitudinal section of the skeleton of *Isociella flabellata* Ridley and Dendy, taken at some distance from the margin of the sponge—the plane of section being perpendicular to the mid-plane of the sponge. The stouter fibres appearing in this section are exceptional; they are "veinlets" which here and there proceed off from the stout "veins" shown in Pl. xl., fig. 1. (x 12½).

Plate xl.

Fig. 1.—Portion of a longitudinal mid-plane section of the skeleton of *Isociella flabellata* Ridley and Dendy, taken from an older portion of the sponge at some short distance above the stem; showing the stout ramifying "veins" or "funes." (Owing to the extreme fragility of the skeleton the section is not intact). (x 5).

Fig. 2.—Longitudinal section of the skeleton of a branch of *Ophlitaspongia thetidis* sp. nov. (x 12½).

PERIDINEAE OF NEW SOUTH WALES.

By G. I. Playfair.

(With Plates xli.-xliii. and 19 Text-figures.)

No definite effort was made to collect the species of *Peridineae* which form the subject of this paper; they are merely such as happened to be occluded in various gatherings made principally for freshwater algæ. Nevertheless a very fair representation has been obtained and most of the forms noted have been confirmed from several localities. Only two districts have been worked, viz. Sydney and Lismore in New South Wales, but with regard to these minute organisms, forms observed in one district are certain to occur under similar conditions wide-spread throughout the State. Corroborative evidence has been admitted in some cases from Brisbane, Queensland, but only one variety not yet found here has been mentioned viz. *Peridinium umbonatum* var. *inaequale* Lemm., a single cell of which was found in a Brisbane sample.

Altogether 39 varieties have been listed, distributed thus:—*Hemidinium* 1, *Gymnodinium* 4, *Glenodinium* 3, *Peridinium* 27, *Ceratium* 1, *Exuriella* 3. Figures of all forms are given (from Australian specimens) except in the case of *Ceratium hirundinella* and *Gym. aeruginosum*.

Types.—Owing partly to inexperience, partly to unsuitable lenses and lack of a good guide to the Order,* the notes on *Peri-*

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*The present paper was only made possible through my coming into possession of a copy of Dr. A. J. Schilling's "Dinoflagellatæ" 1913 (in Dr. A. Pascher's "Die Süsswasser-flora Deutschlands, Osterreichs und der Schweiz") a most useful little brochure with excellent illustrations of all the freshwater forms known from Central Europe, in most cases after the original types. I have not yet succeeded in obtaining Dr. Schutt's "Gymnodiniaceae" (Engler and Prantl-Die naturlichen pflanzenfamilien).

dineae in my former paper "Plankton of the Sydney Water-Supply" left much to be desired. They have now been carefully revised, the nomenclature corrected, the types checked from the original samples and better figures supplied. A source of considerable error at that time was the expectation of finding here a considerable number of European types. On the contrary, up to date only two such have been recognised viz. *P. Willei* Huitfeld-Kaas, and *P. umbonatum* var. *inaequale* Lemm. and even these were not quite the same as the published types. Also, the larger European forms all have areolate membranes with the exception of *P. Westii* Lemm. in which the membrane seems to be of the same character as in *P. hieroglyphicum* mihi. But in our waters are found no less than five distinct types of membrane besides, viz. granular, striolate, scalariform, ridged, and banded. These give the cell such a distinct appearance that in spite of some similarity in the epivalve I have not considered it reasonable to arrange them under the nearest European type. There are also, in almost all cases, other differences, slight perhaps but well-marked and characteristic, and it seems to me unwise to complicate a distinct type by the inclusion within it of another type. Their connection can be much better recognised by forming them into groups such, for instance, as (1) the *P. tabulatum* group to which *P. bipes* Stein and *P. striolatum* mihi belong; (2) the *P. cinctum* group under which fall *P. Westii* Lemm., *P. granulosum* mihi and *P. zonatum* mihi; (3) the *P. Willei* group including *P. australe* mihi and *P. hieroglyphicum* mihi. There will be found also, connected with each of these types, quite a number of distinct variations, partly caused by differences in dimensions and partly the result of various modes of growth. For example, whether the cell is angular (faceted) or rounded, that is, whether the plates are concave or convex, makes a vast difference to the appearance of a specimen, while at the same time the arrangement of the plates may be identical. I found it difficult to persuade myself to place var. *guildfordense* under *P. caudatum*.

Polymorphism.—Wider experience of the *Peridineae* and closer study of the various forms has convinced me that the lumping together of the various types is inexpedient even if it can be maintained from a biological point of view. Nevertheless this closer study has itself brought to light a phenomenon which seems to point to polymorphism through diverging lines of development for its solution. In the following notes, if the figures (dorsal view) of *P. caudatum* var. *guildfordense* (Text-fig. 5, *a*) *P. geminum* type (Text-fig. 9, *a*) and *P. umbonatum* var. *centenniale* (Text-fig. 14, *a*) be compared, it will at once be seen that not only are they all of a size and of quite remarkable similarity in characteristics, but that *P. geminum* holds the central position between the other two. In that species four plates meet at a point a little below the apex. Let this point become either a vertical line by longitudinal development, or a horizontal line by transverse growth and either *P. caudatum* var. *guildfordense* or *P. umbonatum* var. *centenniale* is the result. From their minute size it is certain that all three are the outgrowth of resting-cells such as I have already figured (*op. cit.*, Pl. lvii., f. 4). Is it not possible, though they are representatives of distinct types (types which are still more distinct in their larger and more mature forms) that they are the results of three diverging lines of growth from the same resting-cell?

General remarks.—There is another point that calls for remark. Such a large proportion of the cells have the antapical plates set obliquely; very often also the apex of the epivalve is eccentric. This is neither a specific nor varietal characteristic, but is common to almost all cells in which the hypovalve is not regularly domed over and the terminus of the longitudinal furrow definitely fixed. Along with this peculiarity goes another viz. that the transverse furrow is more or less spiral, being dragged downwards *always on the left side* in ventral view. In such cells, the fact is, there are two longitudinal axes, a dorsal which is straight and vertical, and a ventral which is curved (*cf.* Text-figs. 14, 15; Pl. xli., fig. 3 *b, b'*).

The convex side of the curve is *always on the left* in ventral view, and the plane of the antapical plates is at right angles to the curved axis, hence its obliquity with respect to the other. The apical pit in the epivalve, which always tends to be ventral rather than dorsal, is very often drawn aside (but to a less extent) conformably to the same influence. As I consider the shape and relative proportions of the antapical plates to be of more importance than their position on the cell I have always drawn the diagram of the hypovalves on the oblique plane. The cause of this asymmetry seems to be a longer period of growth (or a stronger growth) on one side, this perhaps being due to the greater action there of the tip of the transverse flagellum.

DINOFLAGELLATAE or PERIDINEAE.

Genus HEMIDINIUM Stein.

HEMIDINIUM NASUTUM Stein. (Text-fig. 1, *c*).

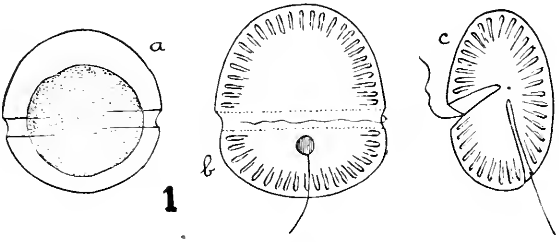
Long. 24-28, lat. 14-17 μ. Lismore (302, 332, 345, 347); Byron Bay.

Doubtless widespread in swamps and pools, but only noted from the localities named. Exactly the size given by Schilling.

Genus GYMNODINIUM.

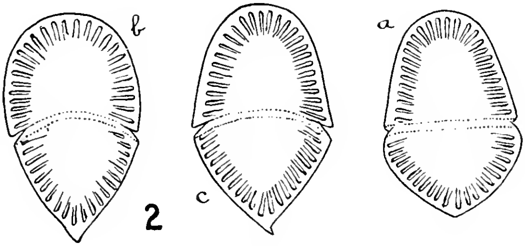
GYMNODINIUM AERUGINOSUM Stein.

Specimens noted in March, 1909, from the Gardener's Road swamp, Botany, are supposed to represent this species. In size and appearance they tallied fairly well with the figures given by Schilling (Dinoflagellatae, p. 19, f. 18) but the contents were a



Text-fig.1.

(a) Glenodinium oculatum var. *circulatum*, n. var. (x 660); *(b) Gymnodinium paradoxum* Schilling, forma (x 660); *(c) Hemidinium nasutum* Stein (x 1000).



Text-fig.2.

(a) Gymnodinium australe mihi; *(b, c)* var. *acutum*, n. var. (x 500).

dull violet blue, not blue-green. Accompanying them were others of similar size and shape but with the usual yellow-brown chromatophores. The movements of the two were widely different however, the blue form darting rapidly here and there in a very lively manner indeed.

Long. 30, lat. 25 μ. Botany (108).

GYMNODINIUM PARADOXUM Schilling. (Text-fig. 1 *b*).

Forma parte anteriore latissime rotundata, altius crateriformi, parte posteriore magis depressa, fossa transversa magis distincta.

Long. 38, lat. 34 μ. Lismore (347).

Exactly the size recorded by Schilling, *l.c.*, p. 18, f. 15, who gives long. 39.7, lat. 34.5 μ. Our form however has the anterior part more broadly rounded, deeply bowl-shaped and the hinder part depressed, transverse groove a little more pronounced. Chromatophores yellow-green. Noted in some quantity from a swampy pool.

GYMNODINIUM AUSTRALE mihi. (Text-fig. 2 *a*).

Gymnodinium magnum, parte anteriore alte campanulata, sursum late rotundata; lateribus fere rectis; parte posteriore triangulari pone acuminata interdum apiculata. Chromatophoris luteo-fuscis vel luteo-viridibus, stigmate nullo.

Long. 53-56, lat. 36-38 μ.

Sydney Water Supply; Botany (92); Lismore (316).

Syn. *G. fuscum* var. *cornifax* (Schilling) Playf. in Plankt. Sydney Water, these Proceedings 1912, p. 545, Pl. lvii., f. 18, 19. A fine large species generally distributed here and apparently more common than any other. It has points of resemblance both with *G. fuscum* (Ehr) Stein, and with *Gym.* (*Cystodinium*) *cornifax* Schilling, but as it everywhere retains its own characteristics I have decided to give it a name. The anterior portion is deeply bell-shaped, broadly rounded above, with nearly straight sides somewhat everted at the transverse groove; hinder part triangular with slightly arched sides, the end acuminate or apiculate, the apiculus nearly always turned to one side, suggesting a connection with the peak of a cyst. Contents yellow-brown or yellow-green; no stigma, the spot indicated, *l.c.*, f. 18, must have been a red oil-drop. It was this species I found in company with cysts (containing the living creature) markedly agreeing with those of *Cystodinium cornifax* (Schilling) Klebs, but the shape of the encysted organism was not distinct and I have never felt quite certain of a connection between the two. Moreover it seems to me not at all unlikely that all species of *Gymnodinium* form these cysts; for these reasons I have not placed it under *Cystodinium*.

Var ACUTUM, n. var. (Text-fig. 2 *b, c.*)

Forma major, magis ovata, præ latitudinem longior, angulis acutioribus, parte anteriore interdum rotunda nec campanulata, fossa transversa, arcuata.

Long. 58-70, lat. 36-42 μ. Lismore (241, 327, 332, 347).

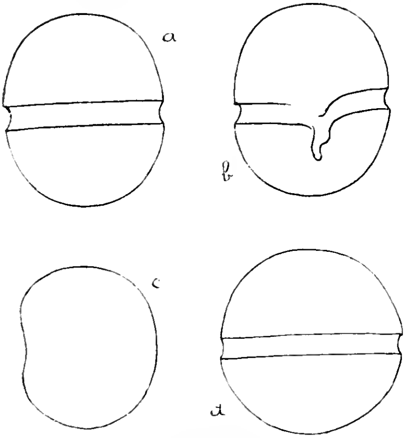
A larger form, longer in proportion to the breadth and with more pointed angles, the transverse furrow arched upwards, not straight across, the anterior part of the cell sometimes rounded and not bell-shaped.

Genus GLENODINIUM Ehr.

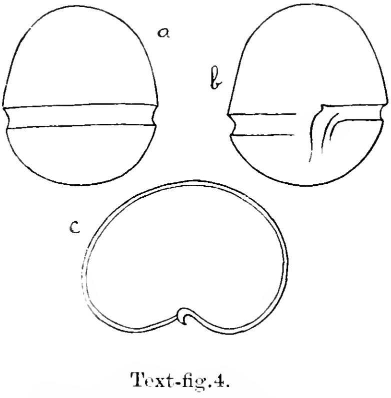
GLENODINIUM OCULATUM Stein. (Text-fig. 3 *a, b, c.*)

Long. 31-34½, lat. 26-31½, crass. 23 μ.

Botanic Gardens, Sydney (3); Lismore (312).



Text-fig.3.
Glenodinium oculatum Stein. (*a*) dorsal view, (*b*) ventral view, (*c*) end view, *(d)* var. *circulatum*, n. var. (x 800).



Text-fig.4.
Glenodinium australicum, n.sp. (*a*) dorsal view, (*b*) ventral view, (x 500), (*c*) end view (x 660).

An oblong or broadly oval form with hemispherical ends and almost central transverse groove, the latter somewhat spirally disposed. Our form agrees very well with Stein's figures (Naturg. d. Flagell. i.) but is half as large again according to the dimensions (long. 20-23μ) given by Schilling, *l.c.*

Var. CIRCULATUM, n.var. (Text-figs. 1 *a*, 3 *d*.)

Forma pæne exacte circulata, fossa transversa mediana, chromatophoris luteo-fuscis.

Long.=lat.=31-35 μ. Auburn (140); Canley Vale (94); Lismore.

In dorsal view almost exactly circular, the length equal to the breadth; transverse groove central, on the ventral side very slightly spiral. Chromatophores yellow-brown; in the type they are given as yellow-green, but these two are entirely interchangeable not only in the *Peridineae* but in other flagellates also.

GLENODINIUM AUSTRALICUM, n.sp. (Text-fig. 4).

Glenodinium magnum, latissime ovale pæne globosum, fossa transversa distincta minime spirali in partes duas maxime inæquales divisum; parte superiore alte-crateriformi, late-rotundata; parte posteriore arcuata, scutelliformi, parte superiore paullo angustiore; fossa longitudinali distincta. A vertice visum modo compressum, subreniforme. Membrana glabra.

Long. 40-45, lat. 36-40, crass. 28 μ. Botany (152).

A very broadly oval almost globose form, divided into two very unequal parts by a distinct though shallow transverse furrow which is very slightly, if at all, spiral. The upper and larger part is deeply bowl-shaped with broadly rounded end; the hinder portion arched and saucer-shaped. The longitudinal furrow is quite distinct. In end view the cell is slightly compressed, subreniform. Membrane smooth. This species reminds one of *Gl. neglectum* Schilling, and still more of *Gl. uliginosum* Schilling, *op. cit.*, pp. 24, 25, figs. 25, 28. *Gl. australicum* however is broader and more globose than either, more rounded than the former, and with the upper part less deeply bowl-shaped than in the latter. The transverse furrow also is much more shallow than in either of Schilling's species.

Genus PERIDINIUM Ehr.

PERIDINIUM CAUDATUM mihi. (Text-fig. 5 *g*).

Peridinium minutum, ovatum, angulatum, fossa transversa fere circulata divisum; membrana glabra. Epivalva subtriangulariconica, angulata, tabulis concavis, ad apicem fovea instructa apice interdum producto; tabulis æquatoriis 7, apicalibus dorsalibus 3, ventralibus 2. Hypovalva valde angulata, tabulis concavis; pone in spinas 2-3 protracta.

Long. 30, lat. 21-25, epiv. alt. 15-17 μ. Sydney Water Supply (64, 66).

Syn. *P. tabulatum* v. *caudatum* Playf., *l.c.*, p. 544, Pl. lv., f. 18. A small form and rather rare even in the slimes from the Sydney Water filters. The cell is ovate, strongly faceted, with concave plates. The epivalve almost triangularly conical with an apical pit. The apex is sometimes produced. Hypovalve depressed, very angular, with angles produced backwards into 2 or 3 short spines, plates concave. Membrane smooth.

PERIDINIUM CAUDATUM var. GUILDFORDENSE, n. var. (Text-fig. 5).*

Peridinium minutum, subglobosum (vel ovale), glabrum, ubique rotundatum; fossa transversa tenui, modo spirali fere circulata. Epivalva conico-rotundata, lateribus, asymmetrice arcuatis, fovea subapicali instructa; tabulis æquatoriis pentagonis 7; apicalibus 4 magnis hexagonis, ventralibus 2, dorsalibus 2; tabula singula dorsali pentagona (fere quadrata) pro tabulis ventralibus disposita. Hypovalva tenuis, pæne scutelliformis, quam epivalva angustior; tabulis æquatoriis 5, antapicalibus 2, non omnius æqualibus, modo oblique dispositis; fossa longitudinali brevi.

Long. 19-31½, lat. max. 17-28½ μ.

Guildford (70); Auburn (148); Fairfield (83); Botany (17); Rookwood; Centennial Park (133); Lismore (308, 316, 327, 337, 347).

A minute form first obtained in considerable quantity from a pool at Guildford. The general shape is so very broadly ovate as to be almost globose, and smoothly rounded everywhere but slightly faceted in the hypovalve. More oval specimens are also met with however. Transverse furrow very shallow, the longitudinal furrow short and distinctly defined. Hypovalve very much smaller and decidedly narrower than the epivalve, convex behind. The sides of the epivalve are unequally arched, the left side (in dorsal view) being flatter than the other, and on this side is found a slight pit which is therefore subapical. The outlines of the plates are often very delicate and with diffi-

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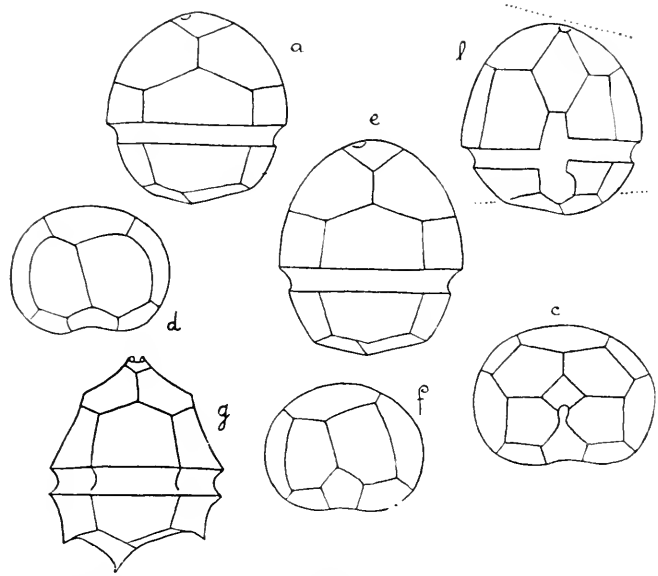
*In all the text-figures read thus: (*a*) dorsal view, (*b*) ventral view, *c*) epivalve, *(d)* hypovalve, unless specified otherwise.



Text.fig.5.

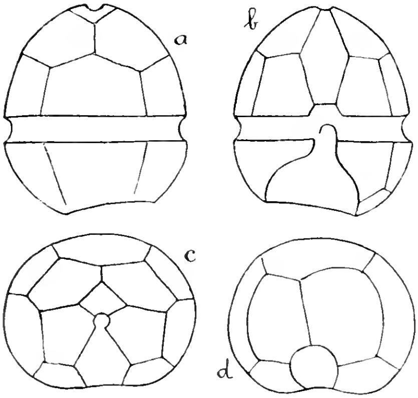
a-f, *Peridinium caudatum* var. *guildfordense*, n. var. (x 1000).
(a) dorsal view, *(b)* ventral view, *(c)* epivalve, *(d)* hypovalve, *(e)* more oval form, *(f)* hypovalve of same.
g, *Peridinium caudatum* mihi, forma (x 1000).

culty discernible; intercalated plates, as is usually the case here even in the largest species, being generally absent. The two antapical plates of the hypovalve are not quite equal, and are arranged obliquely. In the epivalve the rhomboidal plate is continued right into the subapical pit.

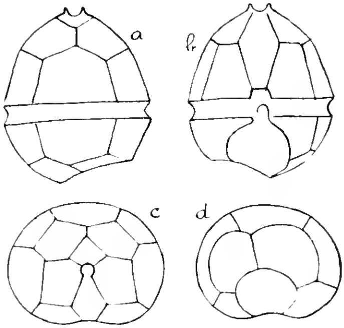
Var. PLANKTONICUM mihi. (Text-figs. 6, 7).

Forma late ovata, modo angulata; fossa transversa circulata. Epivalva conica, lateribus symmetricis, fovea apicali instructa. Hypovalva tam lata quam epivalva, a tergo modo excavata; fossa longitudinali valde dilatata usque ad marginem posteriorem extensa; tabulis antapicalibus modo inæqualibus, paullo oblique dispositis.

Long. 23-32, lat. 20-28 μ. Sydney Water Supply (66, 115); Brisbane.



Text-fig.6.



Text.fig.7.

Peridinium caudatum var. *planktonicum*, n. var. from Sydney (text-fig.6) and Brisbane (text.fig.7). (x 1000).

Syn. *P. tabulatum* var. *africanum* (Lemm.) mihi, (*P. africanum* Lemm.) *op. cit.*, p. 544, Pl. lv., f. 17. This form is not identical with *P. africanum* Lemm. (Cf. G. S. West. Frw. Algae 3rd Tanganyika Exp., p. 188, Pl. 9, f. 1) though it bears considerable resemblance to it especially when found with intercalated plates. It is a distinctly ovate form, slightly faceted, with conical epivalve the sides of which, unlike those of the preceding variation, are symmetrical, and the pit apical. The latter is sometimes quite plain, sometimes with a thickened rim and occasionally its edges appear in dorsal and ventral view as minute spines. The hypovalve is as broad as the epivalve, with a slight excavation behind, which indicates the posterior margin of the greatly dilated longitudinal furrow. The antapical plates are large, not quite equal and set somewhat obliquely—quite different from those of *P. africanum*.

Var. MORSUM mihi. (Text-fig. 8).

Epivalva apice in rostrum brevem truncatum producta. Hypovalva depresso pone latissime excavata.

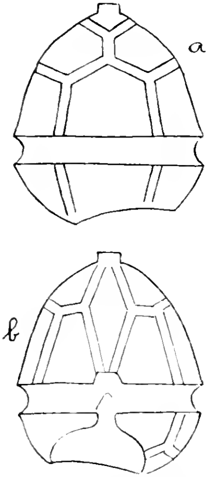
Long. 23-28½, lat. 20-26 μ. Sydney Water Supply (66); Brisbane.

Syn. *P. tabulatum* var. *pusillum* f. *morsa* Playf., *l.c.*, p. 544, Pl. lv., f. 19-21. *P. pusillum* Penard, Perid. du Leman, Pl. iv.,

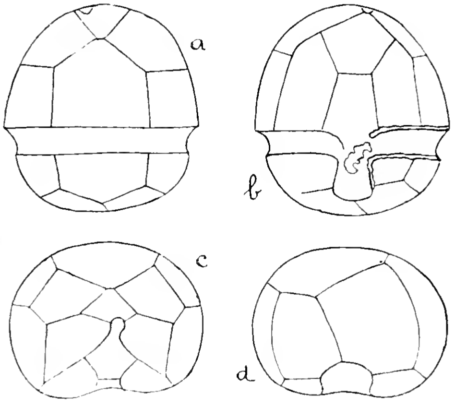
f. 1-3, has indeed the same apical prolongatum of the apex, but this form is ruled off from any connection with it on account of the different arrangement of the plates. *Cf.* Schilling, *l.c.,* p. 41. fig. 45.

PERIDINIUM GEMINUM, n.sp. (Text-fig. 9).

Peridinium minutum ad *P. caudatum* var. *guildfordensem* valde accedens, glabrum, subglobosum; fossa transversa tenuis. Epivalva crateriformis, fovea subapicali instructa; lateribus asymmetricis, arcuatis; tabulis æquatoriis pentagonis 7; apicalibus 5 (dorsalibus 3, ventralibus 2). Hypovalva tenuis, depressa, scutelliformis quam epivalva angustior; tabulis antapicalibus magnis 2, inæqualibus, oblique dispositis; fossa longitudinali brevi.



Text-fig.8.
Peridinium caudatum var. *morsum.* n. var. (x 1000).



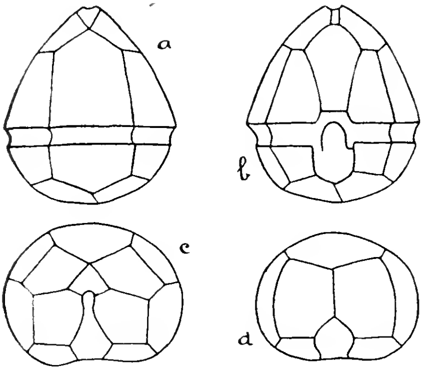
Text-fig.9.
Peridinium geminum, n. sp. (x 1000).

Long. 20-31, lat. epiv. 18-26, lat. hypov. 16-23, crass. 20-23μ.
Guildford (70); Botany (17).

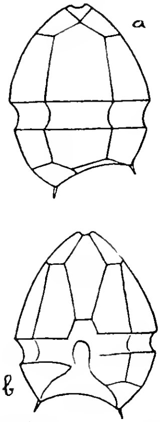
Found originally in company with *P. caudatum* var. *guildfordense,* and so named from its marked similarity to that type in dimensions and general characteristics. The arrangement of the plates in the epivalve also is on much the same lines in both, and there is a similarity in their disposition in the hypovalve. Yet on the other hand there are distinct differences which are constant, no intermediate forms have been noted, and there is a series of well-marked varieties connected with each species. The fundamental character of the species is (in dorsal view) the 4th equatorial and two dorsal apical plates meeting at a point (or nearly so) below the apex. This point in the type is about two-fifths of the altitude of the epivalve from the tip.

Var. ELEGANS, n.var. (Text-fig. 10).

Forma valde ovata, modo angulata. Epivalva conica, fere triangularis, sursum acuminata; fovea apicali instructa; lateribus symmetricis quam levissime arcuatis, fere rectis, paullulo angulatis; tabulis æquatoriis præ epivalvæ altitudinem altissimis; tabula rhomboidea sursum plus minus arcuata. Hypovalva tabulis antapicalibus æqualibus. Cetera ut in forma typica.



Text-fig.10.
Peridinium geminum
var. *elegans*, n. var.
(x 1000).



Text.fig.11.
Peridinium geminum
var. *excavatum*, n. var.
(x 1200).

Long. 25-26, lat. 21-23, epiv. alt. 14½-16 μ.

Guildford (70); Sydney Water Supply (100).

A very elegant form, quite symmetrical and markedly ovate, slightly faceted. The transverse furrow, as in the type, very shallow, the longitudinal furrow short, and distinctly outlined. Apart from the pointed conical almost triangular epivalve, the chief characteristics are the depth of the equatorial plates in proportion to the height of the epivalve, and the rhomboidal plate, which is arched above, its outline often resembling a loop. The antapical plates are quite regular.

Var. EXCAVATUM, n.var. (Text-fig. 11).

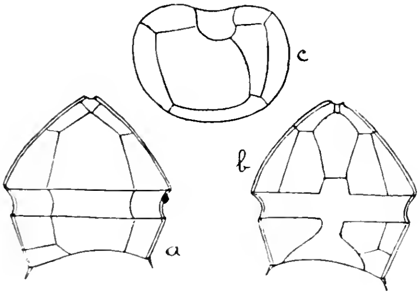
Forma ovata vix angulata. Epivalva conica, fovea apicali, lateribus symmetricis quam levissime arcuatis; tabulis æquatoriis altissimis, tabula rhomboidea longissima. Hypovalva pone oblique excavata, interdum spinis minutis binis armata; fossa longitudinali valde dilatata usque ad marginem posteriorem extensa.

Long. 16-21, lat. 14-15½ μ. Sydney Water Supply (64, 66).

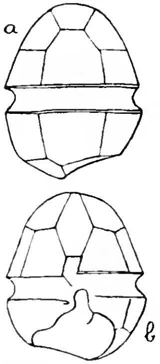
A minute form, in shape like var. *elegans,* but with the hypovalve considerably excavated behind, where it is sometimes armed with a couple of minute spines. The longitudinal furrow is greatly dilated and extends right back to the hinder margin of the hypovalve. This form also has very deep equatorial plates in the epivalve. The markings were extremely faint, and I was not able to make out the end view at all.

Var. ANGULOSUM, n.var. (Text-fig. 12).

Forma angulosa, præ longitudinem latissima, fossa transversa



Text-fig.12.
Peridinium geminum
var. *angulosum*, n. var.
(a) dorsal view, *(b)* ventral view, *(c)* hypovalve (x 1000).



Text-fig.13.
Peridinium umbonatum
var. *inaequale,* Lemm., forma. (x 1000)

tenui. Epivalva latissime conica, subtriangularis; fovea apicali; lateribus symmetricis fere rectis; tabulis æquatoriis altissimis. Hypovalva valde excavata pæne truncata, interdum spinis minutissimis binis armata, lateribus rectis, fossa longitudinali latissime dilatata; tabulis antapicalibus maxime inæqualibus.

Long. 19-25, lat. 19-22 μ. Botanic Gardens, Sydney (3).

A very distinct form, but the plates in dorsal and ventral view are as in the type. The cell is very angular, the length and breadth nearly equal. The epivalve is very broadly conical and so flat in the sides as to be almost exactly triangular in optical section. The equatorial plates again very deep. The hypovalve is so deeply excavated as to be almost truncated and the widely dilated longitudinal furrow is merged in this excavation. The sides of the hypovalve are flat and the posterior angles often tipped with a minute spine. The antapical plates are very unequal, one large and almost square, the other very narrow, differing in this both from the type and from var. *elegans*. I have this form only from a tank in the Botanic Gardens, Sydney, fed by the city water.

PERIDINIUM UMBONATUM var. INAEQUALE Lemm. (Text-fig. 13).

Forma fossa transversa fere mediana, hypovalva major, vix angulata, tam lata quam epivalva; in epivalva fovea apicali nulla.

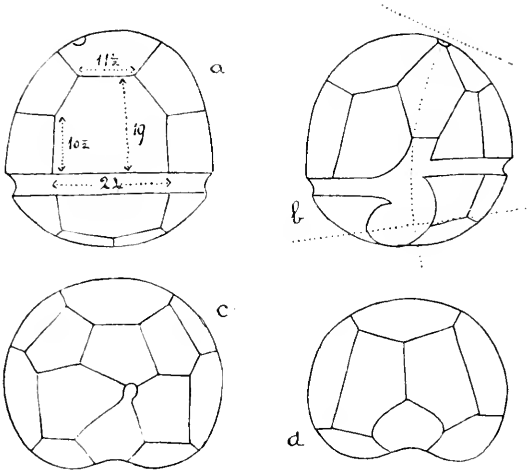
Long. 22½, lat. 19, epiv. alt. 10½, lat. foss. trans. 3 μ. Brisbane.

A single cell noted in a plankton sample from Brisbane. It does not quite agree with Lemmermann's figure given by Schilling, *l.c.*, p. 40, f. 44. The transverse furrow is nearly median, the hypovalve therefore deeper. The latter is as broad as the epivalve and hardly faceted at all. There is no apical pit, a very unusual thing in all forms of small species in our waters. I did not manage to secure end views.

Var. CENTENNIALE, n.var. (Text-fig. 14).

Peridinium parvum, subglobosum, ubique, rotundatum, haud angulatum, fossa transversa in partes duas maxime inæquales divisum; fossa transversa tenui, in spira disposita. Epivalva rotundata, crateriformis, fovea subapicali instructa, lateribus asymmetricis. Hypovalva tenuissima, scutelliformis, pone convexa, multo quam epivalva minor et paullulo angustior; fossa longitudinali modo dilatata usque ad marginem posteriorem extensa; tabulis antapicalibus æqualibus, modo oblique dispositis.

Long.=lat.=30-44, crass. c. 32 μ.



Text-fig.14.

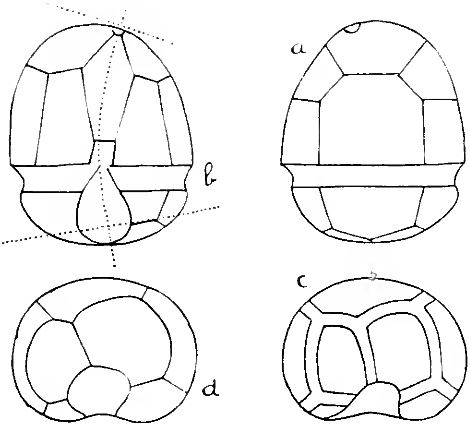
Peridinium umbonatum var. *centenniale*, n. var. (x 800).

Centennial Park, Sydney (133); Lismore (327).

A small form, rounded and very nearly globose, the length and breadth almost always equal. A shallow groove divides the cell into two very unequal valves, the epivalve being quite two-thirds of the total length. The latter is rounded and bowl-shaped, with unequally arched sides and subapical eccentric pit as in *P. caudatum* v. *guildfordense* and *P. geminum*. Hypovalve very shallow, saucer-shaped, a mere lid gently arched behind, a little narrower than the epivalve. Antapical plates equal (probably not always however), obliquely disposed. In these rounded forms there seem to be three kinds of antapical plates (1) angular with straight sides, (2) angular with arched sides, (3) rounded; and these appear to be interchangeable in the same form.

Var. OVALE, n.var. (Text-fig. 15).

Peridinium parvum, ovale, ubique rotundatum, per fossam transversam tenuem in partes duas maxime inæquales divisum. Epivalva altissima, rotundata, alte crateriformis; lateribus asymmetrice arcuatis; fovea excentrica, subapicali. Hypovalva multo quam epivalva minor paulluloque angustior, scutelliformis, pone arcuatis; fossa longitudinali modo dilatata, usque ad marginem



Text-fig. 15.

Peridinium umbonatum var. *ovale*, n. var. *(a)* dorsal view, *(b)* ventral view. *(c, d)* two hypovalves. (x 1000).

posteriorem extensa; tabulis antapicalibus inæqualibus, oblique dispositis.

Long. 28½-32, lat. 21-28, epiv. alt. 18-22 μ. Guildford (70); Lismore (337).

Practically an oval form of var. *centenniale,* though not found with it.

PERIDINIUM INTERMEDIUM mihi. (Text-fig. 16 *a-e*).

Peridinium medium, maxime angulata; fossa transversa fere circulata; membrana glabra. Epivalva quam hypovalva paullo major, angulata, ad apicem fovea distincta instructa; foveæ marginibus quasi spinis minutis protractis; tabulis concavis, æquatoriis 7; apicalibus pentagonis, dorsalibus 3 minoribus, ventralibus 2 majoribus. Hypovalva rotundata; fossa longitudinali valde dilatata, usque ad marginem posteriorem extensa; tabulis concavis, antapicalibus maxime plerumque (?) inæqualibus, angustis, excavatis.

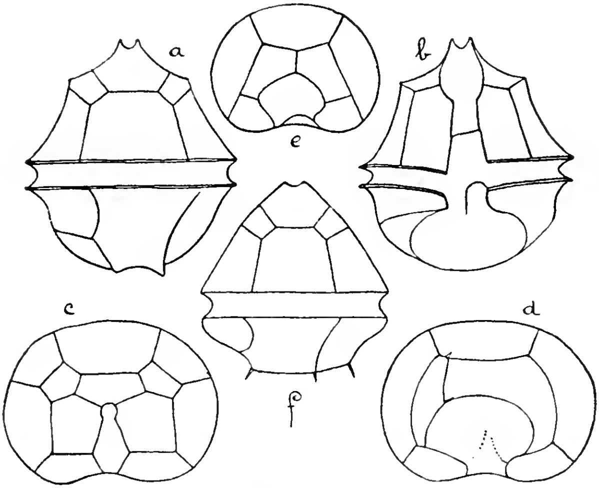
Long. 44-46½, lat. 40-42, crass 25 μ.

Sydney Water Supply (100); Lismore (332).

Syn. *P. tabulatum* var. *intermedium* Playf., *op. cit.*, p. 544, Pl. lv., f. 15, 16. A very distinct species this, principally characterised by the two apical dorsal plates in the epivalve being very small. These show up very clearly in the dorsal view of the cell, forming the upper corners of the 4th equatorial plate. The type is very angular, being strongly faceted with concave plates. Epivalva with a strongly accentuated apical pit, the rim drawn out and appearing as a pair of minute spines. Hypovalve with longitudinal furrow greatly dilated and carried right back to the hinder edge. The antapical plates are very unequal in size and of very peculiar shape, being greatly hollowed out on the ventral side by the dilated longitudinal furrow. Specimens are occasionally found with the plates equal however.

Var. CONICUM, n. var. (Text-fig. 16 *f*).

Forma minus angulata; tabulis minime concavis. Epivalva late-conica, subtriangularis; lateribus fere rectis; fovea apicali sine spinis. Hypovalva depressa, subtruncata, spinis ternis armata.



Text-fig.16.

Peridinium intermedium mihi. *(a)* dorsal view, *(b)* ventral view, *(c)* epivalve, *(d)* hypovalve, *(e)* rarer form of hypovalve, *(f)* var. *conicum*, n. var. (x 660).

Long. 38, lat. 38, epiv. alt. 23 μ. Sydney Water Supply (100).

A neater, less strongly faceted, more regular form, with the plates only slightly concave. The epivalve is broadly conical, in optical section triangular; sides almost flat; apical pit present but less pronounced, rim not produced. Hypovalve somewhat depressed, subtruncate furnished with three small spines behind.

PERIDINIUM STRIOLATUM, n.sp. (Pl. xli., f. 1).

Peridinium magnum, ovale vel ovatum, fossa transversa circulata (vel minime spirali) in partes duas inæquales divisum; a vertice visum multo compressum; membrana per longitudinem crasse striata. Epivalva rotundato-conica, haud angulata, ad apicem late-rotundata; tabulis æquatoriis 7; apicalibus dorsalibus 4 (medianis hexagonis 2, lateralibus pentagonis 2); tabulis apicalibus ventralibus pentagonis 2; tabula rhomboidea plerumque rotundata, circulata vel ovali; fossa longitudinali (parte superiore in epivalva) plerumque longissima et cum tabula rhomboidea plus minus coalita. Hypovalva crateriformis, interdum plus minus angulata; fossa longitudinali pone dilatata usque ad marginem posteriorem extensa; tabulis antapicalibus æqualibus, depressis, ad latera protractis, sæpe oblique dispositis.

Long. 44-48, lat. 34-38, epiv. alt. 23-25, crass. 23 μ.

Centennial Park, Sydney (133); Botany (17).

This large handsome species is characterised by its membrane regularly longitudinally coarsely striate. In general shape it is oval, in end view compressed. The epivalve which measures nearly half the length of the cell, is bell-shaped or conical, broadly rounded above, not faceted. The hypovalve is bowl-shaped, generally faceted, equal in breadth to the epivalve. The longitudinal furrow is dilated behind and extends right back to the posterior margin of the cell. There is a tendency for this dilated portion to be shut off from the rest, the furrow being constricted and an imperfect ridge often formed. The length of the longitudinal furrow within the epivalve is remarkable and characteristic of the species in all its forms as is also the shape of the rhomboidal plate. The latter is almost always rounded, circular, ovate or oval, extending nearly to the apical margin of the valve, and seems in many cases to be merely a dilatation of the furrow. The antapical plates also have well-marked characters, being depressed and spread out laterally.

Var. RUGOSUM, n. var. (Pl. xli., f. 2).

Forma hypovalva magis angulata, tabulis concavis; tabulis antapicalibus interdum inæqualibus et contortis; nonnunquam granulis vel costis brevibus in serie unica paullo infra fossam transversam ornata. Cetera ut in forma typica.

Long. 44-51, lat. 34-46, epiv. alt. 23-27, crass. 23-27 μ.

Centennial Park (133); Botany (17).

The hypovalve in this form is very irregular behind, more faceted and with plates concave; the antapical plates are sometimes (but not always) unequal and contorted. There is occasionally a single row of granules or of short costae below the margin of the transverse groove. (Pl. xlii., f. 3).

Var. TRUNCATUM, n. var. (Pl. xlii., f. 1, 2).

Forma hypovalva pone truncata, lateribus arcuatis. Cetera ut in f. typica.

Long. 51-52, lat. 42-49 μ. Botany (17); Lismore (327).

Another common form; it is more or less truncate behind, with rounded sides to the hypovalve. The larger specimens in all these forms seem to be proportionately broader and less oval than the type. The striae are generally faint, but occasionally quite distinct, when they appear as rows of partly coalesced granules or scrobiculae, probably the latter.

Var. ACUMINATUM, n. var. (Pl. xlii., f. 4).

Forma modo irregularis; epivalva magis acuminata.

Long. 52, lat. 46 μ. Centennial Park, Sydney (133).

A rather irregular form with epivalve more pointed above. The transverse furrow is generally slightly spiral in all the forms, its breadth in the specimen measured was 5-6 μ, of the longitudinal furrow 6-10 μ, the rhomboidal plate seems to be entirely coalesced with the latter.

Var. AUBURNENSE, n. var. (Pl. xlii., f. 5-7).

A forma typica differt solum in membrana per longitudinem levissime costata, inter costas late reticulata.

Long. 45-57, lat. 40-53, epiv. alt. 24-30 μ.

Auburn (148); Centennial Pk. (133); Lismore (297, 302, 308).

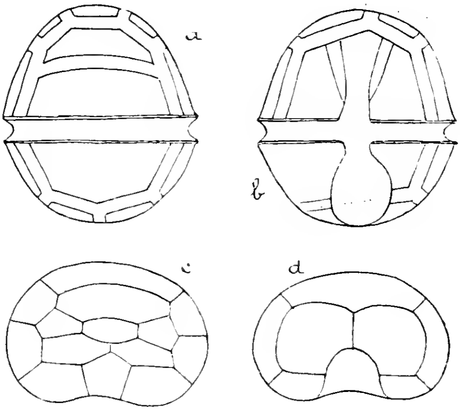
A very curiously marked form, first noted at Auburn (Sydney). The membrane is lightly costate longitudinally, the spaces between the costae being filled in with an irregular lattice work of reticulations. The same series of forms may be noted with this membrane as with the striate. Var. *auburnense* is abundant round Lismore and numerous specimens were measured, so that the range of dimensions for this form may reasonably be taken to represent those of the whole species. Transverse furrow diam. 4-5 μ ; rhomboidal loop lat. max. 12½ μ and perhaps more. The ratio of "total length" to "altitude of epivalve" in eight specimens taken haphazard was 1.7, 1.7, 1.8, 1.8, 1.8, 1.8, 1.9, 2.0 to unity. Specimens were observed partly striate and partly latticed.

PERIDINIUM WILLEI var. AUSTRALE G. S. West. (Text-fig. 17).

Long. 37-57, lat. 40-55, crass. 32-43 μ

Botany (17) ; Sydney Water Supply (66) ; Lismore (308).

Syn. *Peridinium Volzii* var. *australe* G. S. West, Algae of the Yan Yean Res., p. 80, f. 10 A-G. *P. Volzii* Lemmermann (Dr. Volz gesammelten Süsswasseralgen, 1904, p. 166, T. xi., f. 15-18) is practically *P. Willei* Huitfeld-Kaas wrongly drawn, and curiously enough the same error is present in the figure of the Victorian specimens. The band separating the 4th equatorial plate in the epivalve from the large dorsal apical plate has been omitted, as a comparison of the dorsal view of the cell (*l.c.*, fig. 10 B) with the diagram of the epivalve (fig. 10 C) will show. There is a slight error also in Huitfeld-Kaas' type figure, the antapical plates are reversed from right to left, the hypovalve having probably been viewed from the inside. The



Text-fig.17.
Peridinium willei var. *australe* G. S. West. (x 500).

smaller plate is always on the left in end view from the ventral side. This is the only European type I have so far noted here.

Var. BOTANICUM, n. var. (Pl. xli., f. 3).

Forma in conspectu dorsali fere circulata nec ad latera protracta; hypovalva a tergo spinis minutis binis armata; fossa longitudinali magis distincte definita.

Long. 42-60, lat. 40-60, epiv. alt. 21-30, crass. 30-37 μ.

Botanic Gardens (3); Botany (17); Canley Vale (94); Guildford (70, 77); Fairfield (83); Sydney Water Supply (100, 115); Lismore (332, 333).

Syn. *Peridinium tabulatum* in Plankt. Sydney Water Supply, p. 452, Pl. lvii., f. 1-3. In this form the cell in dorsal view is almost circular, the margins of the transverse furrow projecting very distinctly; the cell is not produced laterally in the manner which has caused the synonym *P. alatum* to be given to the type. In the hypovalve there are two minute spines on the posterior edge, and the longitudinal furrow is strictly defined. In the epivalve the plates are somewhat different in dorsal view and in end view. The three plates in a series resembling a Christmas cracker are really exactly apical and neither dorsal nor ventral. In a cell of lat. 52 μ the three together measured 40 μ long (12 + 16 + 12), lat. max. 8 μ.

PERIDINIUM GRANULOSUM mihi. (Pl. xliii., f. 1, 2).

Long. 49-76, lat. 53-76, crass. 63 μ.

Sydney Water Supply (66, 100); Botanic Gardens (22); Botany (109); Auburn (140); Fairfield (143); Brisbane.

Syn. *Peridinium tabulatum* var. *granulosum* Playf., *op. cit.*, p. 542, Pl. lv., f. 1-4. First found in the Sydney City water and since noted from several other localities. The arrangement of plates in the end view of the epivalve shows that it belongs to the *P. cinctum* group, but it has quite a number of distinct characteristics of its own. In size it is only equalled by *P. tabulatum* v. *meandricum* Lauterborn; the membrane is not areolate but granulate, sometimes finely and faintly, sometimes coarsely and distinctly, either in lines or scattered irregularly. There is an apical pit in the epivalve connected by a groove with the rhomboidal plate and generally bordered by two minute spines, two are present also at the back of the hypovalve. In this it resembles *P. bipes* Stein. There is a curious twisted appearance in the hypovalve, the intercalated grooves between the equatorial plates in dorsal view do not coincide in position with those of the epivalve and also run back obliquely. The antapical plates also are uneven in size and obliquely disposed, the central suture running slantwise across from the centre of the longitudinal furrow to a point near the edge of the third equatorial plate. The longitudinal furrow is greatly dilated behind and carried right back to the margin of the hypovalve.

These peculiarities are just as distinct in specimens from Brisbane, though the latter were considerably smaller. The "crass. 63 μ" noted above was from a Sydney specimen 74 × 70 μ; those from Brisbane measured 49 × 46-53, crass. 42 μ.

(P. TABULATUM) var. OVATUM Playf.

Loc. cit., p. 544, Pl. lv., f. 14. This is a very rare form and I have not been able to secure further specimens. It is very transparent and I think the central line at the apex of the epivalve belongs to the ventral side. With long. 50, lat. 44 μ it probably falls under *P. granulosum.* It has of course nothing to do with *P. tabulatum* but might conceivably be connected with *P. caudatum* mihi.

PERIDINIUM AUSTRALE mihi.

Peridinium magnum, globosum vel subglobosum, plerumque rotundatum sed interdum angulatum; fossa transversa submediana paullo spirali divisum. Membrana rugulosa, rugis per longitudinem dispositis. Epivalva hemisphærica interdum fovea apicali atque spinis minutis binis instructa, præcipue ad apicem versus compressa; tabulis æquatoriis 7; subapicalibus 3 (dorsali una latissima, ventralibus 2) et inter eas, pæne exacte apicalibus, tabulis 3 angustis (mediana minima, rectangulari) in serie transversa dispositis; tabula rhomboidea ad apicem extensa. Hypovalva hemisphærica; fossa longitudinali usque ad marginem posteriorem extensa, pone modo dilatata; tabulis antapicalibus 2, inæqualibus, coalitis; margine rotundata; sutura obscura.

Long. 44-54, lat. 42-59, crass. 31-40 μ. Sydney (Pl. xlii., × f. 8).

Long. 47-53, lat. 38-48 μ. Brisbane (Pl. xli., f. 4).

Sydney Water Supply (66, 100); Centennial Park (133); Botany (145); Guildford (146); Brisbane.

Syn. *Peridinium tabulatum* var. *Westii* f. *australis* Playf., *l.c.*, p. 542, Pl. lv., f. 5-9. Formerly I considered that on account of its ridged membrane this form should be placed under *P. Westii* Lemm. The latter, however, belongs to the *P. cinctum* group, while the diagram of the epivalve shows that *P. australe* must be grouped with *P. Willei* Huitfeld-Kaas.

The membrane is covered all over with coarse irregular disjointed ridges running longitudinally. All the plates in dorsal view are very broad. The epivalve is greatly compressd towards the apex so as to form there a transverse apical ridge composed of 3 very narrow plates which cannot be said to be either dorsal or ventral. The central one of these is small and exactly rectangular, sometimes so indistinctly delimited that all three appear to form a single plate. In the hypovalve the two antapical plates have coalesced to form a single plate with rounded outline, a slight notch on the dorsal side and an indistinct suture alone showing that the two are of unequal size.

PERIDINIUM ZONATUM mihi. (Pl. xliii., f. 3).

Peridinium magnum, globosum; fossa transversa, spirali, submediana, divisum; membrana glabra; tabulis omnibus (antapicalibus exceptis) rugis incrassatis, rectis, parallelis, binis, transverse dispositis ornatis; tabulis antapicalibus ut in *P. australi* rugulosis. Epivalva hemisphærica rotundata haud angulata; tabulis æquatoriis 7; tabulis subapicalibus dorsalibus 2, ventralibus 2; tabula apicali una, laterali una. Hypovalva hemisphærica, rotundata, haud angulata; tabulis æquatoriis 5, apicalibus 2 in tabulam unam subcirculatam coalitis.

Long. = lat. = 50-54 μ. Sydney Water Supply (100, 102, 115).

Syn. *Peridinium tabulatum* var. *zonatum* Playf., *l.c.*, p. 543, Pl. lv., f. 10-12. This species seems to belong to the *P. cinctum* group along with *P. granulosum* and *P. Westii*. In dorsal view the markings are those of *P. caudatum* var. *guildfordense* when the cell is in a certain position, but on turning the cell a little, the edge of another (the lateral) plate comes immediately into view. The arrangement of plates in end view of the epivalve is difficult to make out exactly but seems to be on the lines of *P. cinctum*. There are 2 subapical ventral plates, 2 distinctly dorsal, one almost exactly apical and one lateral. In the hypovalve there are two antapical plates usually coalesced into one with a subcircular outline. Rarely two regular distinct antapical plates are formed (Pl. xlii., f. 9). The ridging here is that of

P. australe. On all the other plates of the cell there are 2 rough incrassate parallel ridges transversely disposed.

PERIDINIUM HIEROGLYPHICUM mihi.

Syn. *Peridinium tabulatum* var. *hieroglyphicum* Playf., *l.c.*, p. 543, Pl. lv., f. 13. Long. = lat. = 54 μ.

Var. OVATUM, n. var. (Pl. xliii., f. 4, 5).

Forma ovata, plus minusve angulata; fossa transversa spirali in partes duas inæquales divisa; superne et a tergo spinis minutis binis sæpe ornata; zonis intercalaribus nullis. Membrana notis hieroglyphicis disjunctis ornata.

Long. 44-46½, lat. 40-42, epiv. alt. 27½ μ. Sydney Water Supply (100).

Var. ROTUNDUM, n. var. (Pl. xliii., f. 6).

Forma late-ovalis, ubique rotundata; fossa transversa spirali in partes duas inæquales vel æquales divisa; interdum sine spinis.

Long. 46½-48½, lat. 42-44½ μ.

Sydney Water Supply (100).

This is a very rare species, and I have not been successful in obtaining end views of the hypovalve and epivalve in any of its forms. In dorsal view all that can be seen are four plates in each half, a large central almost rectangular plate with part of one on each side, above and below. In ventral view the markings are normal, with a well-defined longitudinal furrow hardly dilated behind but running right back to the posterior margin; in the epivalve the rhomboidal plate extends quite up to the apex. In all forms the membrane is covered with irregular incrassate markings.

Genus CERATIUM Schrank.

CERATIUM HIRUNDINELLA O. F. Muller.

Long. 244-324, lat. 50-63, corn. apic. 113-144 μ.

Sydney Water Supply; Auburn.

Our specimens agree very well with the excellent figure given by Schilling, *op. cit.*, fig. 62, but the apical horn is perfectly straight and the antapical horns not quite so sharp-pointed. I have not yet observed any of the depressed forms commonly noted in European waters.

Mihi incertae sedis.

Genus EXUVIELLA Ehr.

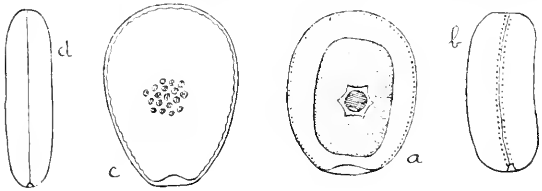
EXUVIELLA LIMA (Ehr.) Schutt. (Text-fig. 18 *a, b*).

Membrana levis vel punctata.

Long. 30-33, lat. 21-26, crass. 10½-15 μ.

Canley Vale (94); Fairfield (112); Botanic Gardens (125); Centennial Park (133).

Syn. *Dinopyxis laevis* Stein; *Xanthodiscus Lauterbachi* Schewiakowski. Found in freshwater only in Australia; a marine organism, apparently, elsewhere. *Cf.* Stein, Naturg. d. Flagell., ii., T. 1, f. 27-33; Schutt, *Gymnodiniaceae*, p. 8, fig. 9.



Text-fig. 18.

(*a*) *Exuviella Lima* (Ehr.) Schutt, (*b*) side view (x 660); (*c*) var. *major*, n. var., (*d*) side view. (x 500).

Var. SCROBICULATA, n. var.

Membrana crasse scrobiculata; areolata etiam. Dimensiones ut in forma typica. Cum priori.

The type, as Stein's synonym shows, has a clear membrane, but specimens may be found finely punctate. With them however are often found others with every degree of scrobiculation, even to being areolate. These scrobiculae are on the inner side of the membrane. The test consists of dorsal and ventral valves merely adhering to one another longitudinally by the rims, not overlapping as in the *Diatomaceae*. The dorsal valve is simply slightly flattened at the end while the ventral one is deeply notched at the same place. Along the suture in each valve is a series of markings resembling the carinal dots in the diatomaceous genus *Nitzschia*, but these are not always present. The valves in side view almost always appear somewhat curved. I have noted a smaller size than those given above—long. 25, lat. ?, crass. 8 μ.

Var. MAJOR, n. var. (Text- fig. 18 *c, d*).

Forma duplo major, ovalis vel ovata; membrana crasse scrobiculata. A latere visa lineari-elliptica, haud curvata, apicibus rotundatis.

Long. 48-52, lat. 36-38 μ. Botany (109).

A much rarer form almost double in length to the usual specimens commonly found here. Such as I noted were linear-elliptic in side view, not curved, with rounded ends. Membrane coarsely scrobiculate on the inside.

EXPLANATION OF PLATES XLI.-XLIII.

All figures x 660, unless otherwise specified; (*a*) dorsal view, (*b*) ventral view, (*c*) epivalve, (*d*) hypovalve.

Plate xli.

Fig. 1.—*Peridinium striolatum*, n. sp.

Fig. 2.— ,, ,, var. *rugosum*, n. var., (*c*) hypovalve.

Fig. 3.— ,, *Willei* var. *botanicum*, n. var., (*d*, *e*) two types of hypovalve.

Fig. 4.—*Peridinium australe* mihi, from Brisbane.

Plate xlii.

Fig. 1.—*Peridinium striolatum* var. *truncatum*, n. var., dorsal view.

Fig. 2.— ,, ,, ,, another specimen, ventral view.

Fig. 3.—*Peridinium* ,, var. *rugosum*, n. var., (*b*) hypovalve.

Fig. 4.— ,, ,, var. *acuminatum*, n. var.

Fig. 5.— ,, ,, var. *auburnense*, n. var.

Fig. 6.— ,, ,, ,, another specimen, ventral view.

Fig. 7.— ,, ,, ,, scalariform markings, greatly enlarged.

Fig. 8.—*Peridinium australe* mihi, from Sydney; (*b*) epivalve, (*c*) usual hypovalve, (*d*) unusual hypovalve with intercalated plates.

Fig. 9.—*Peridinium zonatum* mihi, rare form of hypovalve with intercalated plates.

Plate xliii.

Fig. 1.—*Peridinium granulosum* mihi, from Sydney, (*c*) hypovalve (x 500).

Fig. 2.—*Peridinium* ,, from Brisbane, (*c*) hypovalve.

Fig. 3.— ,, *zonatum* mihi, (*d*) hypovalve (x 500).

Fig. 4.— ,, *hieroglyphicum* var. *ovatum*, n. var., dorsal view.

Fig. 5.— ,, ,, ,, another form, ventral view.

Fig. 6.— ,, ,, var. *rotundum*, n. var.

ORDINARY MONTHLY MEETING.

26th NOVEMBER, 1919.

Mr. J. J. Fletcher, M.A., B.Sc., President, in the Chair.

Mr. LESLIE LIONEL HALL, Kareela Road, Cremorne, was elected an Ordinary Member of the Society.

Candidates for Fellowships 1920-21 were reminded that applications must be lodged not later than the 30th instant.

The President made regretful reference to the decease of Mr. W. J. Rainbow, F.E.S., who had been a Member of the Society since 1892.

The Donations and Exchanges received since the previous Monthly Meeting (29th October, 1919), amounting to 9 Vols., 54 Parts or Nos., 1 Bulletin, 3 Reports and 1 Pamphlet, received from 36 Societies and Institutions and one private donor, were laid upon the table.

NOTES AND EXHIBITS.

Mr. W. W. Froggatt exhibited—(i.) a series of mounted specimens of the Bugong Moth, *Agrotis infusa,* taken at the Government Sheep Fly Experiment Station, Warrah, on 7th November, and read a note on their habits.—(ii.) a living specimen of the Ironbark Beetle, *Zosperosis georgei,* from a banana plantation, Murwillumbah, where it is reported to be common.—(iii.) five forms of *Apiomorpha pileata* Sch., a Brachyscelid Coccid gall, (*a*) slender capped female galls on *Eucalyptus Sieberiana* from Cordeaux Dam, (*b*) young female galls without caps or just shedding them, (*c*) massed female galls on branchlet, in which the bulk of the female coccids and tails have become aborted; some male galls among them, on *Eucalyptus* sp. from Wyong, (*d*) normal lipped adult female galls, with typical male gall on leaf, and (*e*) thick-set form of *Apiomorpha pileata,* in which the lips round the apical orifice do not extend across the whole of the apex.

Mr. F. H. Taylor exhibited two photographs depicting a Brazilian disease called "Rabbit Myxoma" or Blepharo-conjunctivitis. It is said that the domestic animals—horses, cattle, goats, cats and dogs—are immune; nothing has so far been proved concerning the pig.

Mr. W. M. Carne exhibited from the National Herbarium. a specimen of *Bupleurum protractum* Link. and Hoffm. from Beecroft, N.S.W.—an introduced plant not previously recorded from Australia. Other records in the National Herbarium are from Lismore, Orange, and the Murrumbidgee District.

This species has long been confused with *B. rotundifolium* L. of which there are no Australian specimens in the Nat. Herb. Bailey records *B. rotundifolium* (Weeds and Suspected Poisonous Plants of Queensland, 1906) but the accompanying illustration is of *B. protractum*. Ewart, Rees and Wood (Proc. Roy. Soc. Victoria, vol. 23, f. 54) in recording *B. rotundifolium* recognise the confusion but doubt the validity of *B. protractum*. It would appear that their remarks are based upon incomplete descriptions of the two plants.

Specific Differences.

(De Candolle, Prodromus, vol. 4, f. 129.)

B. protractum Link and Hoffm.—Stem foliage ovate oblong; umbels 3-rayed; fruits echinate granular in the intervals.

B. rotundifolium L.—Stem foliage ovate nearly round; umbels 5-rayed; fruit smooth in the intervals.

Mr. A. A. Hamilton exhibited a series of specimens from the National Herbarium, Sydney, showing various stages of synanthy and syncarpy. (*a*) *Cosmos bipinnatus* (1. J. H. Camfield, Bot. Gar., Sydney; 2. Thos. Steel, Pennant Hills). In both examples the united peduncles are fasciated at the apex and slightly contorted bringing the flower-heads together laterally; (*b*) *Helianthus* Hort. var. (W. F. Blakely, Hornsby). Four capitulas are coherent in two pairs. The fusion of the lower pair is almost complete, forming a flower head whose phyllotaxy—as shown by the position of the ray florets—is only broken by their limited suppression in the region of intrusion by the upper pair. (*c*) *Chrysanthemum frutescens* (A. A. Hamilton, Ashfield). In this series the fusion originated with banded stem fasciation which was gradually reduced until two stems only remained united. At a later stage the degeneration of the flowers was accelerated and the development of the colouring matter in the petals arrested (virescence). Further examples of synanthy exhibited were *Coreopsis lanceolata* (J. W. Sawtell, Vaucluse); *Helianthus cucumerifolius* (J. H. Camfield); *Chrysanthemum leucanthemum* (Miss Dorothy Wright, Lawson); *Rosa* Hort. var. "Grace Molyneux" (Dr. T. Guthrie, Burwood); *Rosa* Hort. var. (Thos. Steel, Strathfield); *Cypripedium sedani* (E. Cheel, Bot. Gar., Sydney). Examples of syncarpy were shown in *Eucalyptus caesia* (W. Catton Graspy, Fauntleroy. W.A.); *Eucalyptus Bancroftii* (J. L. Boorman, Guyra); *Angophora cordifolia* (A. A. Hamilton, Killara). Specimens of flowers and fruits in which this condition is normal were also exhibited.

A REVISED ACCOUNT OF THE QUEENSLAND *LECYTHIDACEAE.*

By C. T. White, F.L.S., Government Botanist of Queensland.

(With Plate xliv.)

In going through the *Barringtonia* and *Careya* material in the Queensland Herbarium, it was found that previous accounts of the species found in Queensland of the former genus were considerably in need of revision, and the following account of the Queensland plants of both genera is offered in the hope that it may prove acceptable to Australian botanists. The advisability of keeping these plants and their allies as a distinct family from the *Myrtaceae* is now generally recognised.

Barringtonia Forst.

Barringtonia speciosa Forst.

B. speciosa, J. R. & G. Forst., Char. Gen., 76, t. 38, figs. A. B. & C.; Benth., Fl. Austr., iii., 248; Bail., Queens. Flora. ii., 666; F. v. Muell., Fragm., ix., 118; Miers, Trans. Linn. Soc., Bot., i., 56, t. 10; *Agasta asiatica,* Miers, Trans. Linn. Soc., Bot., i., 61, t. 12, figs. 10 to 16.

Habitat.—Cape York, Dayman's Island, and Endeavour Straits (W. Hill); Rockingham Bay (Dallachy); Dunk Island (E. J. Banfield).

The fruits are commonly picked up on the ocean beach both in northern and southern localities.

Distribution.—India, Ceylon, Malaya, and Polynesia.

BARRINGTONIA CALYPTRATA R.Br.

B. calyptrata, R.Br. ex Benth., Fl., Austr., iii., 288; Bail., Queens. Agric. Journ., xviii., 125; *B. racemosa,* F. v. Muell., Fragm., ix., 118; Bail., Queens., Fl., ii., 666; Rept. Aus. Assoc. Adv. Science, vii., 435; Rept. Bellenden Ker Exped., 42 (*non* Gaud.); *B. edulis,* Bail., Qland. Agric. Journ., xviii., 125, Pl. xi.; *Butonica calyptrata,* R.Br., *ex* Miers, Trans. Linn. Soc., Bot., i., 76; *Huttum calyptratum,* Britten, Journ. Bot., xxxix., 67 and Illustr. Bot. Cook's Voy., ii., 40, Pl. 123 (with synonyms).

Habitat.—Lizard Island (Banks and Solander), Rockingham Bay (Dallachy), Mulgrave River and Hammond Island (F. M. Bailey), Cairns (Dr. F. H. Kenny), Kamerunga (H. Newport), Johnstone River (H. J. Ladbrook), Bloomfield River (Rev. W. Poland), Port Douglas (J. P. Reynolds).

Distribution.—Papua: Yule Island (C. T. White).

Note.—The following is a note received from Mr. J. P. Reynolds, Port Douglas on this plant—"It is known locally as Corn-beef Wood as when it is first cut it has a smell like corned beef, it has been cut up for fruit cases, but is considered too heavy for that purpose."

BARRINGTONIA LONGIRACEMOSA, sp. nov. (Plate *xliv.*)

Arbor, ramulis subvalidis; foliis breviter petiolatis elliptico-lanceolatis breviter et obtuse acuminatis infra medium sensim cuneatis utrinque glabris et reticulatis, marginibus minute denticulatis; racemis terminalibus elongatis multifloris; floribus modice remotis, pedicellis tenuibus (ca. 1.3 cm. longis), calyce quadrilobo, petalis oblongis, ovario 4-loculari.

A tree, branchlets rather stout. Leaves lanceolate or elliptic-lanceolate, bluntly acuminate, gradually narrowed at the base into a short petiole, prominently reticulate on both the upper and lower surfaces, margins minutely denticulate, 6-10 in. (15-25.5 cm.) long. $1\frac{3}{4}$-$2\frac{3}{4}$ in (4.5-7 cm.) broad, petiole 2-4 lines (5-9 mm.). Racemes terminal, slender, elongate [all broken in our specimens, the longest part measuring about 14 in. (35.5 cm.)], rhachis puberulous. Flowers not crowded; pedicels about 6 lines (1.3 cm.) long; calyx about 6 lines (1.3 cm.) long, breaking into 4 rounded segments or lobes; petals oblong, 7 lines (1.5 cm.) long, 4 lines (9 cm.) broad (in the dried specimens light-brown streaked with white); stamens numerous, the longest about 1 in. (2.5 cm.) long; ovary 4-celled.

Habitat.—Johnstone River (Dr. T. L. Bancroft).

Distribution.—Endemic in Queensland.

These specimens had previously been placed in the Queensland Herbarium with some doubt under *B. acutangula* from which however they differ in possessing larger leaves, very much larger flowers and 4-celled ovaries.

I am much indebted to Prof. Ewart for the loan of a series of specimens of *B. acutangula* from the Northern Territory for purposes of comparison. The Australian plant has been separated by Miers (Trans. Linn. Soc., Bot., i., 87) as a distinct species under the name of *Stravadium gracile*, and he himself suggests that two species may be represented under this name; they are both however very distinct from the Queensland plant. Whether Miers name shall stand or whether there are more than one species in the Northern Territory only a larger series of specimens than at present exists in any collection will show.

BARRINGTONIA SP.

Habitat.—Johnstone River (Rev. N. Michael).

Mr. Michael's specimens are in fruit and may quite likely be identical with *B. longiracemosa* but the leaves are much larger, in the specimens to hand attaining 17 in. (43.5 cm.) in length and 6¼ in. (16 cm.) in breadth; the fruits (immature) are 1½ in. (4 cm.) long and acutely angled.

CAREYA Roxb.

CAREYA AUSTRALIS F. v. M.

Careya australis, F. v. M., Fragm., v., 183; Bail., Queens. Flora., ii., 667; Comprehns. Cat. Queens. Plants, 209, fig. 184; Ewart & Davies, Fl. North. Terr., 198 (also p. 199 under *Barringtonia* by a misplacement of text); Lauterb. in Lorentz Nova Guinea, viii., 313; *C. arborea*, Ten. Woods., Proc. Linn. Soc. N.S.W., vii., 81 (*non* Roxb.); *C. arborea* var. *australis*, Benth., Fl. Austr., iii., 289; *Barringtonia Careya*, F. v. Muell., Fragm. Phytog., v., 183; *Planchonia crenata* Miers, Trans. Linn. Soc. (Bot.), i., 91, Pl. viii., figs. 1-15.

Habitat.—Very common in Queensland and generally known colloquially as "Cockatoo Apple." It is represented in the Queensland Herbarium from as far south as Fraser Island (Coll. W. R. Petrie, who states he has also seen it growing on the mainland opposite at Torquay); from thence it extends practically all round the Queensland Coast to the Gulf of Carpentaria.

Distribution.—New Guinea.

EXCLUDED SPECIES.

Barringtonia racemosa Gaud. The Australian plant is *B. calyptrata* R. Br.

Barringtonia acutangula Gaertn. This species was recorded by Mueller (second Census Aus. Pl., 102) from Queensland; it is recorded by Bailey (Queens. Fl., ii., 667) from "Around the Gulf of Carpentaria." There are, however, no specimens of the plant from any Queensland locality in the Queensland Herbarium, and Prof. Ewart informs me that neither are there any from a Queensland locality in the National Herbarium, Melbourne; therefore, though it is very likely this species does occur in the north-west of the State, I think it better that it should be removed from the list of Queensland species until authentic specimens have been collected.

AN INTERESTING FORM OF SUB-SURFACE DRAINAGE.

By M. Aurousseau, B.Sc.

(With Plate xlv.)

During the autumn and winter of 1915 my attention was attracted by certain features of minor drainage, at two widely separated points on the Darling Range, W.A., namely, in the Greenmount District, east of Perth, and at Roelands, 102 miles further south. There has been no opportunity of examining other parts of the range at the same time of the year, but it is highly probable that the type of drainage to be described is of wide occurrence. I have been informed that it is familiar to residents of the Donnybrook District.

In the regions examined, the soil covered slopes of the range, and the piedmont deposits, exhibited, in places, a dangerous series of small holes, of varying sizes, up to one foot in diameter and three feet in depth. They were frequently spaced irregularly along definite lines, which suggested a certain connection between holes on the same line. Their true relation to one another was shown on the steeper soil-clad slopes. Here the lines consisted partly of a series of holes, and partly of varying lengths of trench-like depressions which terminated in a tunnel at either end. The walls of the depressions were generally steep, even at the ends. They had obviously been formed by the breaking away of the surface soil, which was extremely liable to collapse if trodden on between the holes.

It was evident that the holes and trenches indicated lines of sub-surface drainage, which were found in all stages of development, from strings of widely separated holes, to long, deep rifts, separated by narrow bridges of soil, through or under which the water would run, as under a culvert. All were dry when examined (Pl. xlv., Fig. 2). At Roelands, a small gully with steep sides and a cirque-like termination appeared to represent an extreme stage of development.

The sub-surface channels had no rational relation to contour such as that of ordinary surface drainage. The collapsed roof soil had in many cases been completely removed from the channel along great lengths of the course, though no trace of outwash material at lower levels could be found at any point. At Greenmount, in one instance, a small tree on the course had been completely undermined and uprooted (Pl. xlv., Fig 1). This would indicate a considerable strength of flow.

The formation of lines of sub-surface drainage in the Darling Range is to be attributed not to any peculiarity of the soil, which is derived from granites and laterite (1), but to the climate of the region (2), which is characterised by marked seasonal rainfall (3). During the hot, dry summer, fissures form in the sub-soil, but do not extend to the soil, owing to its binding of vegetation. During the heavy, winter rains, much of the water sinks straight into the dry ground, which soon becomes saturated. Relief is afforded by flow along the sub-soil fissures, which soon become widened into definite underground channels. Pressure causes the surface soil to burst at the weakest spots, with the formation of pot-holes. As the channel is deepened and widened, the roof tends to collapse more or less along the whole length of the original fissure.

This form of sub-surface drainage (distinct from underground drainage in general) has a certain minor physiographic importance. By ignoring the steepest natural slopes it initiates erosion in unlikely places, thereby hastening the process of denudation. It is probably a factor in the artesian intake of the coastal basin of Western Australia, as by its means, a large volume of rainfall is taken at once into the deeper layers of the piedmont apron of the range during the winter rains.

REFERENCES.

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2. Taylor, T. Griffith—The Australian Environment. Advisory Council Sci. and Ind., Commonwealth of Aust., Mem. No. 1, 1918, pp.59-66.
3. Official Yearbook, Commonwealth of Austr., No. 11, 1918, p.67.

EXPLANATION OF PLATE XLV.

Fig. 1. Trench formed by sub-surface drainage, Greenmount, W.A. Looking downhill. Shows sapling undermined.

Fig. 2. The same, looking uphill. Shows collapsed roof in foreground, earth bridge (remnant of roof) in centre, and continuation of trench in background.

TABANIDAE FROM CAMDEN HAVEN DISTRICT, NEW SOUTH WALES, WITH DESCRIPTIONS OF NEW SPECIES.

By Eustace W. Ferguson, M.B., Ch.M. and Marguerite Henry, B.Sc.

(Plate xlvi.

In January, 1917, an experimental station was established at Kendall in the Camden Haven district for the study of the means of transmission of *Onchocerca gibsoni* in cattle. During the course of the last three years, while these investigations were being carried on, special attention was paid to the Tabanidae as possible vectors of the larvae whether as mechanical transmitters or as intermediate hosts. Collections of these flies were made for identification and reference, and examination of the material at our disposal shows that many of the species collected are apparently undescribed. Descriptions of the new species will be found in the following paper together with a record of all the species obtained with such notes on the times of occurrence, place of capture, etc., as are available.

Kendall lies on the Camden Haven River, which runs to the north of the West Brother; the valley of the river is practically surrounded by high hills; along the river are rich flats devoted to dairying, with stretches of uncleared bush and patches of jungle in the gullies; near Kendall there is also a good deal of marshy ground, while lower down, the river flows through Watson Taylor's lake before entering the sea. The locality is pre-eminently suitable for the study of Tabanidae as is evidenced by the number of species (41) obtained. Many of the species were taken around the cows in the dairy yards, but others were only obtained in the bush and were rarely or never found in the yards.

SEASONAL DISTRIBUTION.

A table has been constructed to show the weekly records of capture of all the various species found in the locality. Of necessity it is restricted to the months when work was being carried on at Kendall; these however, comprised the summer practically from the end of November to the end of March. Records for the end of 1917 are very meagre, 2 specimens of *Erephopsis gibbula* on 30th October and one each of *T. sanguinarius* and *T. kendallensis* on 4th November. Records for 1918 show that November and December are favourable months for the appearance of many species; in 1917, however, these months were very wet and no flies were about, though they were searched for. In January, 1919, no collecting was done, and as in 1917 work was only commenced during this month, and the records for January are practically confined to 1918.

Study of these records shows that while certain species were equally common during the November-December and January-March periods, as, for instance, *E. guttata, E. concolor, T. parvicallosus* and *T. circumdatus*, in other cases the seasonal incidence is much more marked. Thus the following species were almost restricted to the November-December period—*E. quadrimacula* and *E. contigua, D. auriflua, D. abdominalis* and *Silvius luridus*. In still further cases the numbers taken during January to March greatly predominate, such are—*D. inflata, T. macquarti* and *T. innotatus*. In many species the number of specimens obtained was so small as to make any deductions impossible. It seems possible that in these instances we were dealing with flies which had their headquarters elsewhere and were only of exceptional occurrence in the Kendall District—*D. brevirostris* is a good instance, as we know it to be common in certain areas—the Blue Mountains, New England and the Clarence River—while only 13 specimens have been taken at Kendall; it is probably a mountain species wandering occasionally down to the coast. The Camden Haven district seems near the meeting point of the northern and southern forms of Tabanidae, both being almost equally represented. As Southern forms may be cited all the *Pangoninae* represented, excepting *Silvius*, and possibly *Caenoprosopon* and the hairy-eyed group (*Therioplectes*) of the genus *Tabanus*. As Northern forms, all the species of *Tabanus* not belonging to the section *Therioplectes* and the genus *Silvius*. *D. testacea* is a northern species in that

TABLE SHOWING SEASONAL DISTRIBUTION OF

		1917										1918				
			February				*March*					*January*				
SPECIES.	Ref. No.	Jan.	1-7	8-14	15-21	22-28	1-7	8-14	15-21	22-28	29-4 Apl.	1-7	8-14	15-21	22-28	29-4 Feb.
Erephopsis guttata	2	14	23	65	54							2	5	1	4	13
media	50															
niveovittata	39															
aureovestita	46															
quadrimacula	43	These two species were not separated in the field														
contigua	47															
concolor	14	25	2		17	5				3		15	27	31	4	6
gibbula	30	2 specimens only, taken on Oct. 2nd, 1917														
Diatomineura auriflua	12 45	2														
abdominalis	13 31	1			3										1	1
testacea	49	One specimen only														
fulgida	44															
montana	34															
inflata	24	4	6	13	24	15				21	2					5
brevirostris	41 42															
clavata	29									3	1					
crassa	48	Not separated from *D. auriflua* in the field														
Caenoprosopon wainwrighti	40	One specimen only, no date														
Silvius luridus	8	261	11	11		7							5	7		2
paraluridus	17 18	357	5	4	4							97	150	147		25
fergusoni	4	9										14	16	5		1
Tabanus vespiformis	36															
parvicallosus	1	148	12	28	17	5				3	1	23	114	129	3	44
trilinealis	37															
victoriensis	33															
macquarti	19	9		4	5								3	25	2	24
pygmaeus	15	9														

ABANIDAE IN CAMDEN HAVEN DISTRICT.

1918 *February*				*March*						*December*			1919 *February*					*March*		
5-11	12-19	20-26	27-5 Mar.	6-12	13-19	20-26	27-2 Apl.	19 Nov-25	26 Nov-2 Dec.	3-9	10-16	17-23	1-6	7-13	14-20	21-27	28-6 Mar.	7-13	14-20	21-28
37	32	2	4	5	2	5		2	3	42	57	25		13	11	17	15	16	2	
									1											
					1														1	3
										2	1									
								48	21	278	237	150								
57	29	14	8	2					3	28	66	50	1	13		36	22	24		1
	1		2					78	16	68	18	15			5	2	3			
2								131	35	99	21	78								
								37		3	7						1			
	1							1												
23	17	21	35	90	29	4									151	353	327	192	8	
								10		3										
		1	3		3					1					4	1	1	1		
5	2	1		2				17	20	298	171	125			4					
30	36	27	16	12	5			12	6	162	122	54	7	6	7	3	3			
2		5	4					3	14	43	28			1		1	2	1		
	1																			
66	93	131	29	31	4	1		30	26	95	61	50	15	32	35	12	27	19	4	1
1	1	1						2		2	4									
3	4	1		1	2			1	2	3	8		1	4	5	3	7	1		
48	25	37	7	16	8	1			1	4	4		7	28	81	38	20	18	11	2
		1												31						

TABLE SHOWING SEASONAL DISTRIBUTION OF

		1917										1918				
			February				*March*					*January*				
SPECIES.	Ref. No.	Jan.	1-7	8-14	15-21	22-28	1-7	8-14	15-21	22-28	29-4 Apl.	1-7	8-14	15-21	22-28	29-4 Feb.
Tabanus kewensis	38	Not always distinguished from *T. circumdatus*														
cyaneus	27 28				1		1						1			
sanguinarius	10	57		7	4	2	(Nov. 4, 1917 1 spec.)					35	38	53	2	9
davidsoni	32															
ochreoflavus	5	7	1	1		6						8	19	8		7
circumdatus	22 23	10	21	63	86	69	6			40	9	1	21	43	1	40
edentulus ?	35	*T. edentulus* not distinguished from *T. circumdatus* in the field;														
sp. ?	11	10														
innotatus.	21	4	1		1					2	1	1	2	9		10
regis-georgii.	7	118	2	1						2	1	27	30	21	1	
postponens	6	3														
kendallensis.	3	5	19	23	68	4	(Nov. 4, 1917 1 spec.)			17	4	5	15	4	36	55
neobasalis ?	25	1	1	1							1		1			
sp. ?	26		1							3	1					1

it is found commonest in Northern Queensland, but it belongs to the typically Southern group of *Diatomineura*. The numbers of these groups represented are therefore: Southern 26, Northern 15.

Sub-family PANGONINAE.

EREPHOPSIS GUTTATA Donovan.

Illust. Ent. I. Hym. et Dipt., 1806; Ric., Ann. Mag. Nat. Hist., (7), v., p. 144 (1900).

This fine species was fairly abundant from November 20th to March 20th. It attacks animals fiercely in the bush, especially horses; it is not often seen in the dairies or in the open. In all the 4th posterior cell is narrowed at the margin and in some specimens this cell is actually closed.

TABANIDAE IN CAMDEN HAVEN DISTRICT.

1918													1919							
February				*March*						*December*			*February*					*March*		
5-11	12-19	20-26	27-5 Mar.	6-12	13-19	20-26	27-2 Apl.	19 Nov-25	26 Nov 2 Dec.	3-9	10-16	17-23	1-6	7-13	14-20	21-27	28-6 Mar.	7-13	14-20	21-28
		4	2	5																
1		2									1									
16	34	53	35	41	10	2		101	179	1159	381	279	19	36	49	77	31	13	11	
1	2	2	1	3	1			11	2	12	2			3			3			
14	15	8	4	5	3	2		54	68	251	92		15	38	35	16	24	7		2
212	275	159	108	88	39	14	2	339	82	321	186	173	9	46	237	344	678	461	33	4
most of the specimens labelled No. 23 were probably *T. edentulus*																				
4								4	5	34	5									
15	12	27	19	19	2			3	1	3			1	9	2	4		4		
39	38	14	7	3	2	1		149	40	116	53	85		27	28	32	14	2		
1	1							1												
136	78	20	47	24	13	5		203	22	48	33		3	16	79	118	45	57	137	5
			1					5		4	1									
2	3	7	2	4	3	2														

EREPHOPSIS MEDIA Walker.

List. Dipt., Part 1, p. 142 (1848); Ric., *l.c.*, p. 114.

A single specimen agreeing with the description of this fine species was found among the specimens of *E. guttata* in the collection. It was collected on November 20th, 1918.

EREPHOPSIS NIVEOVITTATA, sp.n.

A moderately large, oblong, black species with a vitta of white hair on each side of the thorax. Not closely allied to any other described species in Australia.

Female. Length, 15 mm; width across eyes, 5 mm; wing, 13 mm.

Head. Black, face with greyish tomentum and fairly numerous black hairs; cheeks clothed with rather long black hair. Beard black. Proboscis hardly longer than the head, black. Palpi black, 2nd joint long and thin, tapering to a point, club-shaped, feebly concave at base; twice as long as 1st joint. Antennae black, the first two joints moderately densely clothed with black hair. Forehead parallel, black, clothed with black hair and two tufts of dense pilose hair, one above the antennae, one a little in front of the middle. Eyes hairy. Thorax black with a faint greyish stripe on each side of the middle, and one at each side, sides with long dense white hair extending from the anterior border to scutellum. The pleurae black with long dense black hair. *Abdomen* oblongate, black, subnitid, moderately densely clothed in parts with short depressed black hairs; sides with a fringe composed of tufts of long black hair extending from the third segment to the apex.

Wings greyish, hyaline, veins black, stigma faint, yellowish, first posterior cell open, almost closed at the apex; in one specimen the cell was closed; no appendix present.

Legs black, pubescence black.

This species has been placed in *Erephopsis* instead of *Diatomineura,* as the first posterior cell is narrowed towards the margin and actually closed in one specimen. In appearance it is not unlike a small specimen of *E. guttata* but may be readily distinguished by its more oblongate form, without spots on the abdomen and by the clear wings. This was a rare fly at Kendall. Dates of capture were from March 13th to March 29th, and all the specimens were taken in thick bush. A single specimen was also taken at Milson Island on the 21st January, 1918.

EREPHOPSIS AUREOVESTITA, sp.n.

A moderate sized golden-coloured species.

Female. Length, 13 mm.; width across eyes, 5 mm.; wings, 12 mm.

Head. Mars yellow; face clothed with golden tomentum; cheeks with rather fine golden hairs, beard golden. Proboscis short, about the length of the head. Palpi Mars yellow, second joint long and moderately stout at base tapering to a fine point, about three times the length of the first joint. Antennae Mars yellow, the first two segments clothed with similarly coloured hairs. Forehead sub-parallel, moderately broad, clothed with golden tomentum, and with brownish hairs. Eyes clothed with golden hair.

Thorax. Brownish black where denuded in centre, elsewhere covered with golden tomentum, and with scattered depressed golden pubescence and long semi-erect brownish hairs, fringed posteriorly at sides with long, somewhat scanty, golden hairs. Pleurae with tufts of long golden hair. Scutellum Mars yellow with golden tomentum.

Abdomen. Mars yellow more or less densely clothed except where abraded with fine, depressed, golden pubescence, under surface Mars yellow.

Legs. Similar in colour; femora rather lighter.

Wings clear, slightly tinged yellowish along the fore border and at base, stigma yellowish, first posterior cell closed; no appendix present.

A brilliantly coloured golden species not resembling any other Australian form. Three specimens only were taken, two at Kendall in the bush on December 3rd, and one at Lorne about two miles distant on December 17th. Eyes a bright metallic green when alive.

EREPHOPSIS QUADRIMACULA Walker.

List. Dipt., Part 1. p. 138 (1848); Ric., *l.c.,* p. 117.

Specimens of a large maculate winged species agree with the description of *E. quadrimacula,* and pending confirmation from the British Museum have been labelled as such. Specimens were plentiful from November 19th to December 23rd. It was found in the bush and the dairies, and was easy to feed on experimental calves.

EREPHOPSIS CONTIGUA Walker.

List. Dipt., Part 1, p. 138 (1848); Ric., *l.c.,* p. 116.

This species has also been provisionally identified, our specimens agreeing with Walker's description. No field notes are available of this species as in the field they were confused with *E. quadrimacula,* and the notes given above should apply to both species.

EREPHOPSIS CONCOLOR Walker.

Dipt., Saunders, Part 1, p. 14 (1850); Ric., *l.c.,* p. 118.

This species, which has been identified on comparison with Walker's type, has been placed in *Erephopsis* as in our series the first posterior cell is more frequently closed than open, and as in general appearance it is closely allied to the last two species. It occurred from November 26th to March 26th, and was fairly abundant, especially in February and the beginning of March. Specimens were collected in the bush and dairies.

EREPHOPSIS GIBBULA Walker.

List. Dipt., Pt. 1, p. 140 (1848); Ric., Ann. Mag. Nat. Hist. (7), v., p. 117 (1900). *E. vertebrata,* Bigot, Mem. Soc. Zool. Fr., v., p. 618 (1892). *D. carnea,* Bigot, *l.c.,* p. 618 (1892); Ric., *op. cit.,* (8), xvi. (1915).

Two specimens in the collection are somewhat doubtfully assigned to this species as they differ from Western Australian specimens in having the forehead distinctly narrower. This form occurs not uncommonly in the north of New South Wales and South Queensland, and may require to be separated from the Western species. Both our specimens were taken early in October.

DIATOMINEURA AURIFLUA Donovan.

Gen. Illust. Ent., Pt. 1; Ric., *l.c.,* p. 119.

This well known species was fairly abundant from November 20th till March 6th; specimens were mostly taken in the bush, and it was not often seen in the dairies. Our series shews a good deal of variation in size, and to some extent in the amount of abdominal clothing present. The eyes are metallic coloured green and purple banded, iridescent when alive.

DIATOMINEURA ABDOMINALIS Ricardo.

Ann. Mag. Nat. Hist., (8), xix., p. 209 (1917).

Specimens of this species identified by comparison with a paratype occurred fairly abundantly in November and December, the range of occurrence being November 19th to February 7th. The specimens were mostly collected in the bush.

DIATOMINEURA TESTACEA Macquart.

Dipt. Exot., i., p. 103 (1838); Ric., Ann. & Mag. Nat. Hist., (8), xvi., p. 31 (1915).

One specimen of this Northern species, identified by comparison with specimens from Kuranda occurs in the collection. There is also a series of abraded females which closely approach to *D. testacea,* but which are probably abraded specimens of *D. abdominalis* as traces of the whitish tufts are present at the sides of the thorax.

DIATOMINEURA FULGIDA sp.n.

A dark reddish brown species allied to *D. testacea.*

Female. Length, 12 mm.; width across eyes, 4 mm.; wing, 11 mm.

Head. Reddish brown, face clothed with greyish tomentum. Beard white. Proboscis short, scarcely longer than head. Palpi with second joint elongate, slender, somewhat club-shaped at the base, twice as long as the first. Antennae testaceous, the first two segments reddish brown with black hairs at apices. Front dark reddish brown, slightly wider at vertex than anteriorly, clothed with greyish tomentum and with moderately dense brownish hair; callus elongate, narrow. Eyes clothed with whitish hairs.

Thorax. Dark reddish brown, shiny, shoulders slightly darker, clothed towards side and posteriorly with greyish tomentum; tufts of long whitish hairs present posteriorly on each side above wing roots, scanty in type but forming a distinct fringe on each side in another specimen; pleurae reddish, clothed with greyish tomentum, and long white hairs. Scutellum similar to thorax.

Abdomen dark reddish brown, moderately densely clothed with fine depressed reddish pubescence. Under surface ferruginous with fine depressed pubescence of similar colour and whitish hairs at the side of each segment.

Legs testaceous.

Wings clear, faintly clouded brownish yellow along the fore border, stigma yellowish brown, veins brownish, first posterior cell open; no appendix present.

This species is allied to *D. testacea* and *D. abdominalis* but readily distinguished from both by its darker colour and shiny appearance. Specimens occurred from November 19th to March 3rd, never very numerous; most specimens were obtained in November; all specimens were taken in the bush.

DIATOMINEURA MONTANA Ricardo.

Ann. Mag. Nat. Hist., (8), xvi., p. 34 (1915).

Only two specimens were received, one November 25th and the other February 12th. They are identical with a specimen from Victoria compared with the type in the British Museum.

DIATOMINEURA INFLATA Ricardo.

Ann. Mag. Nat. Hist., (8), xvi. (1915).

Abundant in February and the beginning of March, this fly never occurred early in the season, the first date being January 28th, and the latest March 29th. Specimens were caught both in the bush and on the cows in the yards, and proved to be a good species for experimental work. The eyes are a brilliant green when alive.

DIATOMINEURA BREVIROSTRIS Macquart.

Dipt. Exot., Supp. 4, p. 326 (1842); Ric., Ann. Mag. Nat. Hist., (7), v., p. 113 (1900); *id.* (8), xvi., p. 29 (1915).

Common on the Blue Mountains and Clarence River, this species was never abundant in the Kendall district, only about a dozen specimens being obtained. Dates range from November 19th to December 8th.

DIATOMINEURA CLAVATA Macquart.

Dipt. Exot., 1, p. 101 (1838); Ric., *op. cit.*, (8), xvi. (1915).

About 20 specimens of this fly were collected, between December 5th and March 28th. They are identical with Victorian specimens compared with the specimens identified in the British Museum.

DIATOMINEURA ? CRASSA Walker.

List. Dipt., Part 1, p. 144 (1848). *Pangonia aurata* Macquart, Dipt. Exot., 1, p. 100 (1838); Ric., Ann. Mag. Nat. Hist., (7), v., p. 120 (1900); *id.*, *op. cit.*, (8), xvi. (1915).

Specimens agreeing fairly closely with Walker's description have been provisionally identified as this species. No field notes are available as the species was confused with *D. auriflua*, but two of the specimens bear dates in November and December.

CAENOPROSOPON WAINWRIGHTI Ricardo.

Ann. Mag. Nat. Hist., (8), xvi., p. 268 (1915).

A single specimen of this species was found; it agrees with a specimen from the Hawkesbury River identified by comparison with Miss Ricardo's type.

SILVIUS LURIDUS Walker.

List. Dipt., 1, p. 140 (1848); Ric., Ann. Mag. Nat. Hist., (7), v., p. 121 (1900); *id.*, *op. cit.*, (8), xvi., p. 260 (1915).

A very abundant species occurring from November 20th to March 6th. It occurs commonly on cattle and horses and especially round about the hoofs. Specimens were also taken in the bush. This species has been identified by comparison with Walker's type.

SILVIUS PARALURIDUS, sp.n.

(Plate xlvi., fig. 7.)

A large, reddish brown species very similar in appearance to *S. luridus.*

Female. Length, 15.5 mm.; width across eyes, 5.25 mm.; wings, 13 mm.

Head. Black; face covered with grey tomentum. Beard white. Palpi long and slender slightly dilatate and concave at base, brownish in colour. Antennae similar to *S. luridus,* third joint slightly less dilatate at the base. Subcallus black, protuberant not shiny as in *S. luridus.* Forehead slightly wider at vertex than anteriorly; clothed with brownish tomentum; frontal callus similar to *S. luridus,* darker in colour and extending farther posteriorly. Eyes bare, ocelli distinct.

Thorax blackish in colour covered with dark brown tomentum with two stripes of grey pubescence on each side; the median pair wider and more brownish in colour posteriorly, shoulders reddish. Scutellum dark reddish brown, covered with dark greyish pubescence.

Abdomen reddish yellow with lighter segmentations, last three segments blackish except at the sides, traces of white median spots on second to fifth segments and with a fringe of whitish hairs at sides, elsewhere clothed with short dark appressed hairs; under surface reddish yellow, dark at apex, segmentations with fringes of short hairs.

Legs reddish yellow, tarsi darker; femora clothed with white hairs; elsewhere black. Spurs present on hind tibia, small.

Wings hyaline, no appendix present, stigma yellowish, inconspicuous.

Very close to *S. luridus* Walker, but a more reddish yellow coloured species. Long series of both species are before us and the differences though slight appear to be constant, and the species are readily separable by their appearance. In its general facies this species presents a strong resemblance to *Tabanus circumdatus.*

This species was very abundant from November 19th to March 4th. Frequently found in the cattle yards; bites the fetlocks of cows and horses almost exclusively.

SILVIUS FERGUSONI Ricardo.

Ann. Mag. Nat. Hist., (8), xix., p. 214 (1917).

Though never very plentiful compared with some of the other species, a fairly large number of specimens were taken on dates ranging from November 4th—March 7th. Specimens have been compared with the type in the British Museum.

Sub-family TABANINAE.

Group iv.

Tabanus vespiformis, sp.n.

A large brownish species with yellowish segmentations and bright yellow legs.

Female. Length, 16 mm.; width across head, 6 mm.; wing, 14 mm.

Face reddish yellow with a large brown median spot, cheeks brown in middle, yellowish at sides, clothed with yellowish pubescence, a few straggling creamy hairs; beard creamy. Palpi bright yellowish, 2nd joint moderately stout at base, with rather sparse mingled black and creamy hairs and with long creamy hairs on under surface at base. Proboscis short. Antennae bright reddish yellow, basal joint more yellowish, 1st joint small, subcylindrical, 2nd joint shorter and wider than 1st, a few black hairs at apex, 3rd joint widened and strongly angulate at base, basal portion about equal in length to annuli. Sub-callus yellow clothed with yellow tomentum. Forehead slightly wider at vertex than anteriorly, clothed with brownish somewhat variegated pubescence and with a few golden hairs; callus absent.

Thorax dull black, brownish at sides above wing roots, shoulders yellowish covered with greyish yellow tomentum, with a few straggling cream coloured hairs at sides; pleurae reddish brown with creamy hairs. Scutellum black. *Abdomen* elongate, black with rather narrow, yellowish brown segmentations clothed with yellowish tomentum. Venter black, segmentations yellowish brown.

Legs bright reddish yellow, femora with yellowish hairs, elsewhere blackish.

Wings long, tinged yellow on the costal cell and at base; veins yellow at base, brown towards apex, stigma inconspicuous, long appendix present.

This species which presents quite a wasp-like appearance from its elongated abdomen is not close to any other Australian species with which we are acquainted. The type which is unique is unfortunately in rather poor condition but we have described it, as it is such a distinct species. The single specimen was brought in by a schoolboy on February 19th.

Group vii.

TABANUS PARVICALLOSUS Ricardo.

Ann. Mag. Nat. Hist., (8), xiv., p. 394 (1914).

Specimens of this species were compared with Miss Ricardo's type in London, and found to be identical. This was one of the commonest species in the district, specimens being taken from November 19th to March 29th; most plentiful in January and February. These flies were very abundant round the dairies feeding on the cows and were also taken in the bush.

TABANUS TRILINEALIS, sp.n. (Plate xlvi., fig. 3.)

A dark brownish species, thorax with three conspicuous black stripes, and with a median abdominal stripe composed of elongated creamy spots.

Female. Length, 11 mm.; width across head, 4.5 mm.; wing, 10 mm.

Head densely clothed with creamy yellow pubescence and with a beard of the same colour. Proboscis very short and thick. Palpi moderately stout, rather strongly curved, yellowish, clothed with greyish tomentum and short black hairs. Antennae light yellowish brown, 1st and 2nd joints with scattered short black hairs, 3rd joint with basal portion rather long, moderately expanded, obtusely angulate at base and above, but without definite tooth, annuli darker. Forehead parallel, moderately wide, densely clothed with creamy yellow tomentum, and with somewhat scattered brown hairs; callus rather large sub-quadrate, not quite reaching eyes and with a lineal extension somewhat longer than the callus.

Thorax with three, prominent, broad, dark stripes of a dark reddish brown colour approximating to blackish, separated by equally broad, creamy-coloured stripes. Pleurae light brownish rather scantily clothed with hairs. Scutellum light reddish brown, clothed at sides with creamy pubescence, traces of dark brown pubescence in centre continuing the median vitta of thorax.

Abdomen dark brown approximating to warm sepia, with a median row of elongate triangular shaped creamy spots on the segments, becoming shorter posteriorly and forming an almost continuous vitta, traces of creamy hairs on the spots, elsewhere with brownish hairs. Segmentations narrowly edged with cream, scanty creamy hairs present at the sides of segments. Venter light reddish brown, segmentations creamy, expanding at each side, scantily clothed with brownish hairs.

Legs light reddish yellow, anterior femora darker, anterior tibiae dark at apex, tarsi dark.

Wings hyaline brownish, stigma elongate light brown. Moderately long appendix present.

This species does not appear to be close to any of the described members of group vii., it may be readily distinguished by the very dark stripes on the thorax together with the single line of elongated triangular spots on the abdomen. This is a rare species at Kendall, only a few specimens having been obtained, all in the bush. It occurred from November 24th till February 28th.

Group viii.

TABANUS VICTORIENSIS Ricardo.

Ann. Mag. Nat. Hist., (8), xv., p. 275 (1915).

This was never a very common species, occurring from November 25th to March 15th. The wings in these specimens are more lightly marked than in specimens received from Victoria, but Miss Ricardo informs us she does not consider it specifically distinct.

Group ix.

TABANUS MACQUARTI Ricardo.

L.c., p. 277.

Fairly numerous from November 29th to March 25th. Specimens were collected in the bush and occasionally in the cattle yards.

TABANUS PYGMAEUS, sp.n. Plate xlvi., fig. 2.

A small black fly with pale, narrow, abdominal segmentations.

Female. Length, 8.5 mm.; width across eyes, 4 mm.; wing, 7.5 mm.

Face dark grey, clothed with greyish tomentum; a few sparse whitish hairs, beard scanty whitish; palpi light yellowish brown, rather stout at base, clothed with scattered pale and dark hairs, proboscis very short, hardly longer than palpi. Antennae reddish-yellow, first two joints small with a few black hairs, 3rd joint with basal portion longer than the annuli, expanded at the base, obtusely angalate without distinct tooth. Front parallel, black, clothed with yellowish brown tomentum; callus subquadrate, large, protuberant, resting on subcallus, reaching eyes on each side with hardly any linear extension. Eyes bare.

Thorax black, clothed with dark brownish tomentum, grey on sides, scutellum similar; pleurae clothed with grey tomentum, and rather scanty whitish hairs below wing roots.

Abdomen black, with very narrow, pale whitish segmentations, clothed with brownish tomentum with scattered depressed brownish hairs and a few white straggly hairs on segmentations. Venter blackish, segmentations narrow, pale, dark brown tomentum in the middle, paler at the sides.

Legs reddish yellow, fore legs darker, tarsi somewhat infuscate.

Wings clear; veins brownish; stigma light brown, inconspicuous. No appendix present.

Only a few specimens were obtained. Dates of occurrence January 16th till February 20th.

A small species closely allied to *T. brevior* and *T. parvus*, but with a differently shaped frontal callus reaching the eyes on each side. In general appearance it is very suggestive of *Silvius australis* Ricardo.

TABANUS KEWENSIS, sp.n. (Plate xlvi., fig. 5.)

A medium sized brownish species resembling a light coloured species of *T. circumdatus* in appearance.

Female. Length, 11.5 mm.; width across eyes, 5 mm.; wing, 10 mm.

Face densely clothed with white tomentum, with scattered whitish pubescence. Beard white. Palpi light yellowish brown, slightly thickened at the base, with rather dense, silky white pubescence, thickest at base, intermingled with darker hairs. Antennae yellowish brown, annuli darker, 1st and 2nd joints densely clothed with thick hairs, 3rd joint strongly expanded and angulate at base, basal portion about as long as annuli. Subcallus light brown densely clothed with grey tomentum. Forehead moderately wide, slightly narrowed at vertex, clothed with dense grey tomentum and with scanty brownish hairs, thicker at vertex. Callus light brown, shining, almost square, reaching the eyes on each side, resting on subcallus, with a moderately long lineal extension to beyond middle. Eyes bare.

Thorax light brown with three darker stripes, darker portions clothed with brownish, the lighter with grey tomentum, with moderately thick dark semierect hairs anteriorly and posteriorly, and with fine scattered white silky hairs; pleurae grey with long pubescence, brown above, white below and posteriorly. Scutellum light brown.

Abdomen light brown (Mars brown) becoming darker to apex, with greyish segmentations, moderately densely clothed with black depressed pubescence, pale creamy hairs on segmentations, thickest at sides and in centre where it forms a series of more or less distinct spots from 2nd to 6th segments. Venter yellowish brown with lighter segmentations, clothed with whitish pubescence, thickest on segmentations.

Legs yellowish, anterior femora with light hairs below, dark above; other femora mainly whitish hairs, tibiae with black hairs.

Wings clear, veins brown, stigma conspicuous, short appendix present.

In appearance this species strongly resembles *T. circumdatus* but will be readily distinguished by the bare eyes. It is perhaps closest to *T. eidvoldensis*, but may be readily distinguished by the more reddish thorax and the light coloured forelegs. Taylor has placed *T. eidvoldensis* in Group vii., but it seems to me that its natural position is with *T. kewensis* in Group ix. The whole question, however, of the grouping of our Australian species of *Tabanus* requires revision. Specimens were taken from February 20th to March 6th, but it was always a rare species.

Group x.

TABANUS CYANEUS Wied.

Ausszwerfl. Ins., 1, p. 152 (1828); Ric., *l.c.*, p. 284.

This fine metallic blue species was never very common. Specimens were obtained between December 10th and March 7th. The eyes are distinctly red when alive. Two of the specimens are decidedly larger than the others, but in other respects identical.

TABANUS SANGUINARIUS Bigot.

Mem. Soc. Zool. de Fr., v., p. 675 (1892); Ric., *l.c.*, p. 287.

An exceedingly abundant species, dates of occurrence ranging from November 4th to March 26th; most numerous in November and December; more than a thousand were found in one week. It occurred everywhere, in the bush, in the cattle yards, and by the sea at Laurieton. This species died quickly in captivity.

TABANUS DAVIDSONI Taylor. (Plate xlvi., fig. 4.)

Proc. Linn. Soc. N.S. Wales, xliv., p. 65 (1919).

Only a few specimens of this species were collected, some on cows, others resting on a fence; they were not seen outside the Kendall dairies. Dates of occurrence from November 21st to March 15th. A specimen has been kindly identified by Mr. Hill by comparison with Taylor's type.

TABANUS OCHREOFLAVUS, sp.n. (Plate xlvi., fig. 1.)

A medium sized, yellowish brown species, with golden pubescence.

Female. Length, 12.5 mm.; width across head, 5 mm.; wing, 11 mm.

Face densely clothed with yellowish grey tomentum, sides beneath the eyes golden, hairs scanty, greyish; beard white. Palpi moderately long, slightly thickened at base, ochraceous tawny, pale golden hairs at the base. Proboscis short. Antennae,—1st two joints similarly coloured to palpi, apically fringed with black hair, 3rd joint reddish yellow with basal portion longer than the annuli, moderately broad at base, obtusely angulate, with a very small tooth. Forehead narrow, parallel, densely clothed with golden tomentum and with blackish hairs; callus narrow, elongate, reaching not quite to middle.

Thorax black, densely covered with tomentum of an old gold colour, with erect brownish hairs and a scanty depressed golden pubescence, shoulders with old gold tomentum and long dark brown hairs. Pleurae clothed with grey tomentum and with long creamy hairs, scutellum similar to thorax.

Abdomen ochraceous tawny, darker at the bases of segments 3—7, but whole abdomen uniformly clothed with ochraceous tawny tomentum, and dark blackish brown decumbent pubescence, golden along posterior margins, venter light cream, darker at bases of apical segments, thickly clothed with depressed creamy pubescence.

Legs similarly coloured to abdomen, tarsi slightly infuscate, posterior tibiae with a fringe of rather dense black hairs.

Wings clear, brownish yellow along the anterior margin, stigma same colour, veins brownish, appendix present.

Judging from the descriptions this species should be distinct from all those previously described belonging to this group. Eyes bright green when alive. Specimens were most plentiful in December and occurred from November 19th till March 29th. Specimens were collected in the bush at Kendall and Lorne and in the cattle yards, generally biting the cow's legs.

Group xi. Therioplectes.

TABANUS CIRCUMDATUS Walker.

List. Dipt., i., p. 185 (1848); Ric., Ann. Mag. Nat. Hist., (8), xvi., p. 280 (1915).

This was the most abundant species at Kendall, dates of capture ranging from November 19th to April 4th. It occurred in the dairy yards and in the bush and, indeed, could be found anywhere, even on the windows of houses. Sometimes they were seen to settle on sheep and apparently bite them. This species lives well in captivity. Specimens agree well with a specimen identified as *T. circumdatus* by Miss Ricardo.

TABANUS EDENTULUS ? Macquart.

Dipt. Exot., Supp. 34, 68., Tab. iii., fig. 13 (1845).

Specimens of a species of *Therioplectes* appear to correspond fairly closely to the Tasmanian species identified by White as *T. edentulus* Macquart. These were not separated in the field from *T. circumdatus,* and the field notes of that species may be taken as applying also to this.

TABANUS SP. ? (Reference No. 11).

A single specimen of a small dark species close to *T. imperfectus* Walker is in the collection. Others, possibly the same, were used in the experiments in the fly cages. The field notes referring to these state that specimens were never plentiful, the dates of collection ranging from November 23rd to February 5th; most specimens were taken in December. It occurred in the bush between Kendall and Laurieton. Pending the acquisition of more material it has been thought advisable not to attach a name to the single specimen. Other specimens (Ref. No. 26) probably represent a distinct species, the only specimens available (3) are too damaged for description.

TABANUS (THERIOPLECTES) INNOTATUS, sp.n. (Plate xlvi., fig. 6.)

Large dusky species allied to *T. circumdatus*, black.

Female. Length, 15.5 mm.; width across head, 5.5 mm.; wing, 13 mm.

Face clothed with greyish tomentum and long silvery grey pubescence, beard silvery, subcallus black clothed with grey tomentum, palpi with 2nd joint long, moderately stout at base, dusky yellow, clothed with grey tomentum and whitish hairs. Antennae black, 1st two joints clothed with black hairs, 3rd joint broad at base with prominent angle. Eyes finely covered with scanty hair. Front parallel, moderately broad, clothed with grey tomentum becoming black at vertex; callus subquadrate reaching eyes, with a stout extension reaching a little beyond the middle.

Thorax black, dark reddish brown at sides above wing roots, clothed with dark greyish tomentum and with three indistinct black stripes, hairs blackish; shoulders black, slightly tinged reddish posteriorly, clothed with grey tomentum and long black hairs; pleurae black with grey tomentum and long black and white hairs; scutellum similar to dorsum.

Abdomen black, segmentations very narrowly margined with reddish brown, this colour extending on to the lateral margin; pubescence black. Venter dark reddish brown becoming black at apex, segments lighter reddish brown with whitish hairs at sides.

Legs black, tibiae reddish brown, tarsi dusky, femora with long whitish hairs.

Wings hyaline black, veins black, stigma brownish, long appendix present.

A uniformly dark species of the *circumdatus* group, readily distinguished by its colouration and dark wings. *T. dubiosus* is a smaller species with well defined white segmentations and colourless wings. Specimens were taken from November 31st till March 31st; it was more plentiful in February and March than earlier in the season. Specimens were mostly taken in partially cleared country.

TABANUS REGIS-GEORGII Macquart.

Dipt. Exot., i., p. 132 (1838); Ric., *l.c.*, p. 276 (1915).

Specimens of this species were compared with the British Museum specimens and identified by Miss Ricardo.

This small species was very abundant; specimens were caught mainly in the bush. On Milson Island, however, this species occurs commonly around the feet of the cattle. Dates of occurrence were from November 19th to March 29th.

TABANUS POSTPONENS Walker.

List. Dipt., i., p. 179 (1848); Ric., *l.c.*, p. 282 (1915).

Only a few specimens of this species were collected, dates ranging from November 25th to February 12th. Only one specimen occurs in the collection, the others having been used in the experiments. This has been compared with specimens from Milson Island, which were identified by comparison with the type in the British Museum. The eyes are bright metallic green with reddish brown reflections when alive.

TABANUS KENDALLENSIS Taylor.

Proc. Linn. Soc. N.S. Wales, 1919, xliv., p. 68.

This small species was very plentiful right throughout the season from November 4th to March 30th. It occurred both in the bush and on the cows at milking time. Specimens have been identified by comparison with a paratype received from Mr. Taylor. The species is extremely variable in the colouration of the abdomen and specimens in our series approach very closely to specimens of *T. oculatus,* named from comparison with the type, but appear to differ in the absence of the golden hairs on the thorax, as a rule also the forehead of *T. oculatus* is wider. In both species the eyes are bright green when alive.

TABANUS NEOBASALIS ? Taylor.

Records Australian Museum, xii., 5, p. 67 (1918). *T. basalis* Walker, List Dipt., i. (1848), p. 182; Ricardo, *op. cit.,* (8), xvi. (1915), p. 282.

Specimens of a species that occurred rarely at Kendall have been provisionally referred to this species. The size is, however, larger (13 mm.) and the third antennal joint has the base very broad though hardly angulate above. The type of *T. basalis* Walker was seen in London, and the impression remains that it was not the species we have from Kendall, but a smaller one only separated from *T. kendallensis* by the wholly yellow legs. While any uncertainty exists it seems better to refer the present species to *T. neobasalis,* as it agrees in all except size with Miss

Ricardo's description, until a specimen can be compared with the type.

Specimens were taken at Kendall from November 25th to April 4th, but the species was rare and not always distinguished in the field from *T. circumdatus*.

Specimens are in the collection of the Department of Public Health from Wolseley Park and Wee Jasper.

EXPLANATION OF PLATE XLVI.

Fig. 1.—	*Tabanus ochreoflavus*, n. sp.	Head and antenna.
Fig. 2.—	,, *pygmaeus*, n. sp.	,, ,, ,,
Fig. 3.—	,, *trilinealis*, n. sp.	Head.
Fig. 4.—	,, *davidsoni*, Taylor.	Head and antenna.
Fig. 5.—	,, *kewensis*, n. sp.	,, ,, ,,
Fig. 6.—	,, *innotatus*, n. sp.	,, ,, ,,
Fig. 7.—	*Silvius paraluridus*, n. sp.	,, ,, ,,

Postscript, added 10th February, 1920.—The species somewhat doubtfully identified as *E. contigua* Walker, *E. quadrimacula* Walk., and *D. crassa* Walk. have proved, by comparison of specimens with the types, to be correctly named. We are indebted to Dr. Guy Marshall, of the Imperial Bureau of Entomology, for these and other determinations.

SOME ADDITIONAL TRILOBITES FROM NEW SOUTH WALES.

By John Mitchell, late Principal of the Newcastle Technical College and School of Mines, N.S.W.

(With Plate xlvii.)

Order **OPISTHOPARIA.**

Family ACIDASPIDAE.

Genus Ceratocephala.

CERATOCEPHALA PHALAENOCEPHALA,[*] n.sp.

(Plate xlvii., figs. 1-3.)

Only the headshield known. This is very mildly convex, sub-oblong, much wider anteriorly than posteriorly, much expanded at the anterior angles, thence contracting towards the genal angles rather strongly; tuberculation sparse consisting of small even-sized tubercles arranged in rows on its different parts; anterior and posterior borders parallel; greatest width, 14 mm., length, 6 mm. *Glabella*—medial lobe very mildly convex and oblong, two pairs of glabellar furrows and lobes present—the second and basal pairs—each pair of the furrows appearing to be continuous and forming an open shallow U-like sulcus; both pairs of lobes are indistinct. The neck furrow is relatively deep

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[*] With a head like a moth.

and wide, and its lateral extension distinct. Neck ring and its lateral extensions narrow, front border or limb reduced to a sharp edge. Axial furrows relatively wide and shallow. Fixed cheeks sub-reniform, very mildly convex; each bears a row of about six tubercles longitudinally; anterior eye-lines well defined, narrow, and surmounted with about five tubercles, of which the anterior and posterior are most distinct. Free cheeks large, depressed, subtriangular; their front borders, mildly thickened, bear about eighteen tubercles, some of them near the antero-lateral angles being subulate but not spinate; furrows are faint, neither borders nor furrows are present laterally; eyes small, circular or conoid, fairly prominent, situated about midway between the anterior and posterior margins. Genal spines of moderate length and nearly straight, directed horizontally outward at an angle of about sixty degrees. Occipital spines appear to be equal in length to those of the genal angles, straight, horizontally directed backward, and only mildly divergent.

Obs.—The line of greatest width of this headshield lies just behind the front border, and thence to the bases of the genal spines its width diminishes. The posterior to anterior width is 12 : 17, and the transverse distance between the eyes from outer edge to outer edge of each equals the posterior width across the genal angles or spines. In outline this shield bears some resemblance to *C. vogdesi* E. and M. but in other respects, however, it differs from that species materially. For instance, in *C. vogdesi* the cephalic spines are sub-erect for some distance from their points of origin and then strongly arched and falcate. Those of the present form are directed horizontally backward and are nearly straight. In the former the neck spines, as a very recently acquired and perfect cephalon of that species shows, arise from the front of the occipital ring, but in the case of the latter they arise from the posterior of this ring. The occipital ring in the former is very wide, in the latter just the opposite. The eyes in the former are near the anterior border and directed outward at an angle of about 45°, depressed and overhang the free cheeks; in the latter the eyes are situated about midway between the anterior and posterior borders and are erect. The greatest width of the cephalon of *C. vogdesi* is across the medial line and behind the eyes; in the present form it is anterior and in front of the eyes. This new cephalon also resembles that of *C. jacki* E. and M., but the strongly spined border of the free cheeks of the latter clearly separates the one from the other.

From *Acidaspis vesiculosa* Barr. the present species differs in having the front margin of the cephalon almost smooth and the anterior-lateral angles more acute.

Loc. and horizon.—Minahan's Selection, Bowning Creek, Parish of Bowning, County Harden, N.S.W. Lower Trilobite Beds of Bowning-Yass Series. Upper Silurian, probably the equivalent of Barrande's étage E.

ODONTOPLEURA HARTLEII, n.sp.

(Plate xlvii., figs. 4-8.)

Whole form unknown.

Cephalon.—Subsemicircular, only very moderately convex and appears to have been finely granulated. Greatest length and width 6.25 and 15.6 mm. respectively, or approximately two and a half times as broad as long. Glabella—medial portion moderately convex, finely granulate, antero-lateral angles expanded and prominent; two pairs of lateral glabellar furrows present; they are deep and circumscribe the glabellar lobes, the first pair of which is subquadrate, and the second or basal pair is much the larger. Neck furrow medially exceedingly faint, but narrow and deep behind the basal lobes. Neck ring wide, gently arched; bases tuberculate, and join directly with the genal lobes thus interrupting the axial furrows, and the lateral extensions of the neck furrow. Fixed cheeks small, the lobes only moderately tumid and small; eye lines or ridges mildly developed and surmounted by a row of small tubercles. Triangular areas of moderate size, slightly concave. Wings long and very narrow, traversed by very narrow and almost invisible furrows; along the anterior and posterior margins are rows of very fine granules. Front border linear and very finely dentate. Free cheeks large, fairly tumid, spaces between the eyes and lateral furrows bear five or six irregular rows of tubercles of varying sizes; lateral furrows shallow, borders strongly thickened and bear fourteen or more spines. Genal spines strong, long and slightly falcate. Eyes small, situated opposite the neck furrows.

Thorax not known.

Pygidium.—Greatest length to width approximately 2 : 5. surface finely granulated, articulating face straight to near the extremities, whence it turns rather abruptly backwards. Axis moderately convex, consisting of two wide rings, indefinitely separated. Axial grooves shallow. Side lobes depressed, pleural divisions indistinct, but they are each divided into two lobes by faint ridges. Border strong, thickened, carries eight or doubtfully ten spines, two being intermediate to the strong pair.

Obs.—This trilobite in some particulars resembles both *O. rattei* E. and M. and *O. jenkinsi* E. and M., but is more nearly related to the former than the latter, and this relationship is very noticeable in comparing their pygidia; but even in these parts material differences are readily observable. For instance, the tail spines in the present are eight and doubtfully ten at most; in *O. rattei* they number twelve. The two strong spines in the latter species, subtend from strong pleural ridges, but in the former weak ones. The wings of the fixed cheeks in *O. hartleii* too are relatively longer and slenderer than in *O. rattei* or in *O. jenkinsi.* The central part of the glabella in *O. rattei* is relatively longer and more convex than in the present species. The limb is much more distinctly dentate in the former than in the latter; in the latter, also, the antero-lateral angles of the glabella are much more expanded than in the other. The neck furrow and rings in *O. rattei* are well developed; the opposite is the case in the present form.

Dedicated to Mr. Charles Hartley of Balheary, Chatsbury, a member of one of the pioneering families of the Goulburn district and who collected the specimens above described.

Loc. and horizon.—Back Creek. Tarlo River, Parish of Turrallo, County Argyle, one mile N.W. of the slate quarry, associated with undetermined *Encrinurus.* Probably Upper Silurian.

Order **HYPOPARIA.**

Family TRINUCLEIDAE.

TRINUCLEUS CLARKEI, n. sp.

(Plate xlvii., figs. 12-14.)

A pygidium obtained from Duntroon associated with *Encrinurus duntroonensis,* I have determined to belong to the above genus. The following are its chief features:—Widely triangular, mildly convex and apparently had been granulated;

widest across the articulating face. Greatest width 15 mm., length 6 mm. approximately. Axis prominent, steep sided, dorsally depressed, made up of ten rings which bore transverse rows of granules, ridges narrow, prominent and traversed by fine sutures, sulci deep and relatively wide; its anterior width is much less than that of one side lobe, and ends abruptly at the inner edge of the border with a width approximately two thirds of the anterior width. Axial grooves wide and shallow. Pleura mildly convex between the axial grooves and border, divided into five segments, of which the fifth is faint; the first two anterior pairs are at right angles with the axial line the others only gently directed backwards. Border relatively wide, faintly separated from the pleural segments, of which only the anterior pair crosses it to the outer margin; under surface striated, the striae being concentric and apparently seven in number.

Obs.—I have very little doubt that in determining this pygidium to belong to a species of the genus *Trinucleus,* the determination is correct, and if so it is the first and only part of a trilobite of that genus described and figured from this State.

The late Rev. W. B. Clarke recorded the occurrence of specimens of this genus at Yarralumla and that one species had been dedicated to him by Sir W. Macleay, but of those specimens no further record was ever made, and what became of them is unknown. The discovery of the pygidium above described will tend to confirm Clarke's announcement with reference to the presence of *Trinucleus* in the rocks of this State. (Clarke, Quart. Journ. Geol. Soc., iv., 1848, pp. 64, 66.) Yarralumla, where Clarke said he found a *Trinucleus* which he could not separate from *T. caractici,* is only two miles from where the present pygidium was found.

The Duntroon specimen resembles the pygidium of *T. albidus* Reed (Reed, Pal. Tril. Girvan, supp. Pal. Soc., 1913, pp. 3, 4, Pl. 1, fig. 2) in outline, in number of axial rings in the axis and in its border, but possesses fewer pleural segments, and is more than double the size of *T. albidus.*

No *Trinucleus* pygidium known to me closely agrees with the one described above. In selecting a specific name I have chosen to confirm the dedication of the late Sir W. Macleay.

Loc. and horizon.—Near Duntroon homestead, Parish of Canberra, County Murray, associated with *Encrinurus duntroonensis* E. and M. Evidently Ordovician.

Family PROETIDAE.

Genus CYPHASPIS.

CYPHASPIS FILMERI, n.sp.

(Plate xlvii., figs. 9-11.)

Only the medial portion of a head shield of this trilobite is at present known, and, although its singular features led me many years since to conclude that it represented a new species for Australia, in the expectation of acquiring additional and better specimens, the description of it was deferred till now.

Sp. Chars.—Cephalic shield probably subsemicircular and depressed. Glabella subquadrate or suboval, moderately elevated and dorsally depressed, sides steep, as are also both front and back, granulated with six to seven longitudinal rows of even-sized granules. Glabellar basal lobes not sufficiently well preserved to determine their characters. Neck furrow relatively wide and deep. Neck ring narrow, strap-like, surmounted by one very distinct medial tubercle and a less distinct one on each side of it near the axial grooves. Limb relatively wide, finely granulated, strongly upturned, deeply furrowed or convex in front. Axial furrows defined. Fixed cheeks small, wings short. Free cheeks and eyes unknown. Facial sutures anteriorly between eyes and inner boundary of limbs straight, thence diverge at an angle of about 30°. Margin not thickened. Length of head, 4.7 mm.

Obs.—The only Australian *Cyphaspis* that has come under notice that bears any resemblance to the present type is *C. horani*, and to that species the resemblance is confined to the character of the granulation on the glabellae. To no head shield of any foreign *Cyphaspis* which has come under my notice does the present species bear close resemblance or at least to the portion of it available for the above description.

Dedicated to Mr. W. D. Filmer, of Toronto, N.S.W., an enthusiastic collector of natural history specimens.

Loc. and horizon.—Great Southern Road, Belle Vale estate, Parish of Yass, County King. Lower Trilobite Beds of Bowning and Yass series; associated with *Cyphaspis yassensis* and *Calymene australis*, Upper Silurian.—etage E. of Bohemia.

EXPLANATION OF PLATE XLVII.

Ceratocephala phalaenocephala Mitchell.

Fig. 1. —Photo of a perfect headsfield. Coll. Mitchell.

Figs. 2 & 3. —The same more or less restored.

Odontopleura (Acidaspis) hartleii Mitchell.

Fig. 4. —Photo of a headshield from a badly preserved specimen. Coll. Mitchell.

Fig. 5. —The same with the features restored.

Figs. 6 & 7. —Photos of a pygidial fragment; 7 being restored in part. Coll. Mitchell.

Fig. 8. —Photo of a free cheek partially restored.

Cyphaspis filmeri Mitchell.

Figs. 9 & 10. —Photo of a fragmentary headshield in which the medial portion is preserved.

Fig. 11. —The same with the features restored.

These figures show how closely the glabella and its limbs resemble a cheese cutter peaked cap.

Trinucleus clarkei Mitchell.

Figs. 12 & 13. —Photos of a nearly complete pygidium. Coll. Mitchell.

Fig. 14. —The same more or less restored.

MESOZOIC INSECTS OF QUEENSLAND.

No. 7. Hemiptera Homoptera; with a Note on the Phylogeny of the Suborder.

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

(With Twenty-four Text-figures.)

The first collection of fossil insects made by Mr. Dunstan at Ipswich contained only a single Hemipteron belonging to the Suborder Homoptera. This specimen I named *Mesojassus ipsviciensis* (8, p. 35, Pl. 2, fig. 7), placing it in the family *Jassidae.* In the two consignments following, no less than twenty-two specimens of Homoptera are represented, some of them in a very perfect state of preservation. Thus this group now becomes next in importance to the Coleoptera, as regards its numerical preponderance in the Ipswich Insect Fauna; and the working out of the material has been a matter of considerable interest on this account, as well as on account of the beauty and remarkable preservation of some of the forms.

In writing this paper, I have been fortunate in having had the advice and criticism of Mr. F. Muir, F.E.S., of Honolulu. Mr. Muir is a recognised authority upon the Homoptera, and I desire to thank him for reading the MS. and offering some valuable criticisms.

All the material consists of tegmina, either whole or in fragments. The toughness of the Homopterous tegmen renders it, like the elytron of the Coleoptera, particularly suitable for preservation in the fossil state; whereas the hindwing is, in most families, so delicate that it is not surprising that it is seldom found. Further, owing to the fact that the tegmen is divided obliquely by a deeply impressed furrow along the vein Cu_2, it is particularly liable to split along this vein; so that many of the fossils consist either of the main portion of the wing lying anterior to this furrow, or only of the *clavus*, or anal area, lying posterior to it. This clavus is only a small part of the wing, with nothing but the anal veins preserved upon it; and yet, as we shall see in the course of this paper, every clavus discovered by itself should be preserved and described, because there is on the clavus, at least one character of great importance for the correct classification of the fossil forms.

The oldest known Homoptera are three forms from the Upper Permian, viz. *Scytinoptera kokeni* Handl. (3, p. 392) from the Kama River, Russia, *Permoscarta mitchelli* Till. (9, p. 728) from Newcastle, N.S.W., and *Permofulgor belmontensis* Till. (9, p. 731) from Belmont, near Newcastle, N.S.W. Handlirsch places *Scytinoptera* in a distinct Order Palæohemiptera; but I have already expressed my opinion that this is nothing more nor less than a true Homopteron (10, p. 587). *Permofulgor,* as a very distinct type unlike anything existing to-day, was put into a new family *Permofulgoridae.* *Permoscarta* I placed in the *Cercopidae;* but, on maturer consideration, I think it should be removed to the *Scytinopteridae.*

From the Upper Trias only two Homoptera are so far known. One of these is *Mesojassus ipsviciensis* Till., already mentioned; the other *Triassopsylla plecioides* Till. (9, p. 754) from the Wianamatta Shale of Glenlee, N.S.W.

Handlirsch lists no less than twenty-two species of Homoptera from the Lias, and there are undoubtedly others from various localities in England, which have not been properly described as yet. The named species come from England, Switzerland and Germany, the most prolific locality being Dobbertin in Mecklenburg, with seventeen species. They are placed as follows:—*Fulgoridae*, 4 genera, 13 species; *Procercopidae,* 1 genus, 3 species; *Jassidae,* 1 genus, 5 species; *Archipsyllidae,* 1 genus, 1 species.

Thus it will be seen that the Ipswich beds have already yielded an Homopterous fauna as rich as any yet found in the Palaeozoic or Mesozoic epochs; and it may reasonably be hoped that many more may be discovered later on. That being so, it is of especial importance that these fossils should be most carefully studied, in the hopes that they may throw some light upon the Phylogeny of the Homoptera.

Here we meet with the initial difficulty that the classification of the Homoptera is based for the most part upon characters other than the wing-venation; such as, for instance, the number and position of the ocelli, the form of the legs and prothorax, and the shape of the head. Recent studies of the nymphal tracheation in the various families have much improved our knowledge of the venation, but they have not yielded a really satisfactory basis of classification on venational characters only.

In this connection, I should like to point out that the vein which has been interpreted by Comstock and his school (1, 2, 4, 5, 6) as 1A in the Homoptera is certainly not that vein, but Cu_2. Its precedent trachea comes off from Cu, not far from its origin, in all families of the Homoptera, and in all instars in which the wing-sheaths are developed far enough for examination. This condition is exactly parallel with that to be found in all instars of the Cockroaches, in which I have recently satisfied myself that the *vena dividens*, or concave vein separating the anal area from the rest of the wing, is undoubtedly Cu_2; and, as this vein also borders the clavus or anal area in the Homoptera, there is no longer any need for a far-fetched attempt to name it 1A, by trying to explain that its trachea has become fused with Cu. The condition shown in the Homoptera and the Cockroaches is also exactly the same as that seen in the Panorpoid Orders, in which I have already shown (11) that Comstock makes the same mistake in working out the venation of the Trichoptera and Lepidoptera, though he has got the names of the veins right in the Megaloptera, and thereby himself admitted his error in the other Orders. I have also, finally, studied the venation in all examinable stages of the Psocoptera, in which this same condition is also to be found. The only conclusion to be come to is that the cubitus in all these groups is normally three-branched, Cu_1 forking distally into Cu_{1a} and Cu_{1b}, while Cu_2 is a straight, concave vein, which, in those Orders which have a separate clavus, borders that area anteriorly. I have therefore marked the *vena dividens*, in all my figures, as Cu_2; in this respect, my nomenclature for the Homoptera differs from all the figures of the venation of this Order so far published except Muir's (7).

It follows from this that the veins on the clavus itself are 1A and 2A. Vein 3A is absent in all recent forms, but is clearly to be seen in the Permian genus *Permofulgor* (9), and in the Liassic genus *Archijassus* (3).

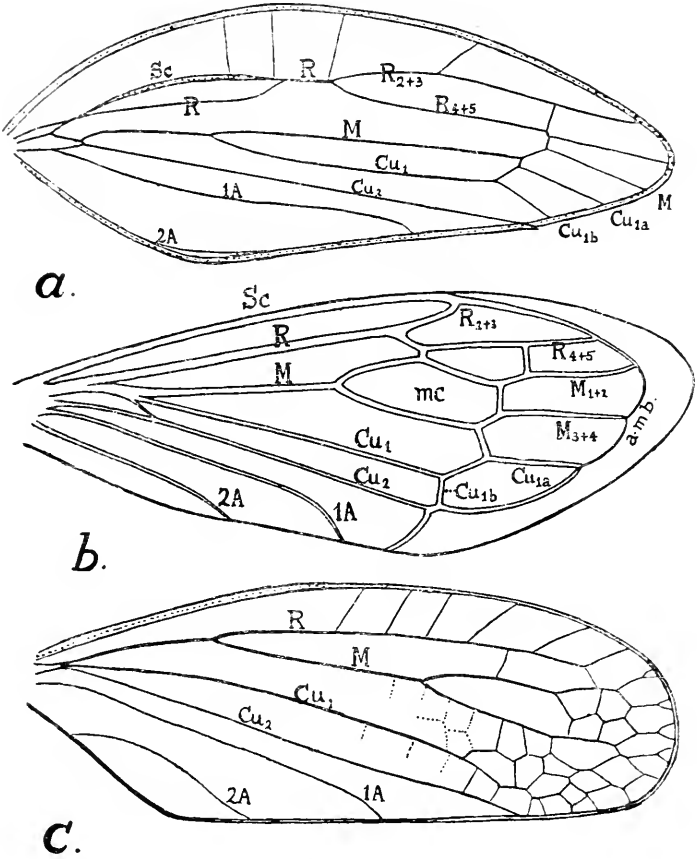
In working out the Ipswich fossil Homoptera, it is at once evident that they all belong to the division Auchenorrhyncha, comprising, at the present time, only the families *Cicadidae, Cercopidae, Jassidae, Membracidae* and the old family *Fulgoridae,* this last being now usually split up into seven or more families (Fulgoroidea). Further than this we may also say that the *Cicadidae* are not represented in the collection under review. Their type of venation is very distinct; and nothing approaching it has been found at Ipswich, with the single exception of the puzzling genus *Mesogereon,* which has been allotted a special part of this work to itself, seeing that it constitutes a very special problem involving the discussion of other Orders as well. There remain, then, only the other families of the Auchenorrhyncha in question; and hence we have to determine, as far as possible, what are the venational differences to be considered in separating one family from another, and thus in placing our fossils in their correct families.

First of all, the old family *Fulgoridae* contained, with very few exceptions, insects in which the clavus of the tegmen had the two veins 1A and 2A united together for a greater or less distance distally, to form a true Y-vein, of the same type that I have already discussed in the Lepidoptera (11). We may, then, take it that any Fulgoroid fossils would have this character. It is only present in a single genus of the fossils, viz. *Ipsvicia.* As these tegmina are very distinct from anything known at the present day, I have placed them together in a new family *Ipsviciidae,* belonging to the superfamily Fulgoroidea.

The *Cercopidae, Jassidae* and *Membracidae* all agree in having tegmina in which 1A and 2A remain apart from one another. This character is clearly shown in all the remaining tegmina in which the clavus is preserved. In separating the remaining fossils, therefore, we have to consider the venation of the rest of the tegmen more carefully.

In Text-fig. 1, I have shown the venation of an Australian genus *Cercopidae, Philagra* (*a*), of an Australian Membracid genus *Sertorius* (*b*), and an archaic Australian Jassid genus, *Eurymela* (*c*).

In all *Cercopidae* which I have seen, as in *Philagra* here figured, veins Sc and R are distinct and separate for a considerable distance basally, and then become united. We may take it, therefore, that this character should appear in any fossil tegmina that are to be considered true *Cercopidae.* As it is not present in



Text-fig.1.

Venations of tegmina of recent *Cercopidae*, *Membracidae* and *Jassidae*. *a*, *Philagra* sp. *(Cercopidae)* from Mount Tambourine, Q. *b*, *Sertorius* sp. *(Membracidae)* from Jervis Bay, N.S.W. *c*, *Eurymela* sp. *(Jassidae)* from Gosford, N.S.W. For lettering see p.895.

any of our fossils, we may decide that they are not members of this family.

The *Jassidae* and *Membracidae* are very closely allied. The two families probably arose from a common stem, the *Mem-*

bracidae becoming specialised in the sculpture of the prothorax. The *Membracidae* are also specialised in certain aspects of their wing-venation, notably in the very distinct narrowing of the clavus, and in the development of a complete distal *ambient vein* (Text-fig 1 *b, amb.*), uniting the tips of R, M and Cu; with a definite clear wing-area, uncrossed by any veins, between it and the wing-margin. Neither of these characters, again, is to be found in any of our fossils; and therefore they are not to be considered as *Membracidae.*

Apart from the *Ipsviciidae,* already mentioned, all the fossil tegmina from Ipswich belong either to the *Jassidae,* or to some archaic family of Auchenorrhyncha not existing at the present day. The characters of the Jassid tegmen are sufficiently well shown by the genus *Eurymela* (Text-fig. 1 *c*). The clavus is, typically, fairly broad, in the form of an obtuse-angled triangle, separated from the rest of the wing by a very straight, and usually deeply impressed, vena dividens (Cu_2), and having the veins 1A and 2A lying upon it far apart, vein 2A being frequently waved. Sc is absent, or completely fused with R. R and M are fused together basally for some distance. The branchings of these two veins vary considerably, as may be seen by studying a number of different species of the genus *Eurymela.* Cu_1 is a straight, or nearly straight, vein running above and about parallel to Cu_2, and remaining unbranched until near its distal end.

Three of the Ipswich fossil tegmina agree with the *Jassidae* in all these points, and may therefore be placed definitely within that family. These are *Mesojassus* Till. (8), *Triassojassus* n.g., and *Eurymelidium* n.g.

There still remain over a number of tegmina which cannot be satisfactorily placed in any existing family. We have, therefore, to consider whether there are any known fossil forms with which they show affinity. The fossil forms already known in the Homoptera, which do not belong to existing families, are the Liassic family *Procercopidae* of Handlirsch, and the Permian genus *Scytinoptera* Handlirsch. The venation of the former is that of the true *Cercopidae.* Handlirsch only placed them in a separate family because he was of opinion that true *Cercopidae* could not have existed in the Lias. They may, therefore, be dismissed from the question. With respect to *Scytinoptera,* which comes from the Upper Permian of the Kama River, Russia. Handlirsch placed this fossil, together with the genus *Prosbole*, in a new Order Palaeohemiptera, and formed, for the reception of this single fossil, the new family *Scytinopteridae*. I have already discussed the genus *Prosbole* in connection with the Triassic *Dunstaniidae* from the Ipswich Beds, and have, in the same place, given it as my opinion that *Scytinoptera* is a true Homopteron (10). A survey of the new Ipswich Homoptera now shows that this opinion is correct. For there can be no doubt that the forms included in this part are true Homoptera, all of them having the tough, leathery consistency of the tegmen so frequently found in the Suborder, with distinct separation of a claval area along a straight vena dividens, and also definitely Homopteroid venations. And when we come to compare the venation of *Scytinoptera* with that of those Ipswich fossils which we have not so far been able to place, we are struck at once with the close similarity between this Permian genus and two of the Ipswich forms, which I have placed in a new genus *Mesoscytina*. These forms are undoubtedly closely related to *Scytinoptera*, and should go into the same family. I have, therefore, no hesitation in removing *Scytinoptera* from the Palaeohemiptera to the true Homoptera, and in constituting the family *Scytinopteridae* to contain the most archaic venational types of Homoptera yet discovered.

The *Scytinopteridae* are distinguished at once by the lack of fusion between R, M and Cu basally, there being instead, generally, a very peculiar formation at the base of these three veins, which is well shown in the genus *Scytinoptera* itself (Text-fig. 4). It would appear that three veins start out separately from the extreme base, and then come together again at a point a little further on. This same formation is to be seen in the *Ipsviciidae*.

Apart from this, the *Scytinopteridae* have the veins R, M and Cu separate, and diverging from one another from near the base outwards. In the original genus *Scytinoptera*, the clavus was not preserved. In one of the two species of *Mesoscytina*, n.g., described in this paper, a considerable portion of the claval area is preserved. From this we can see that the anal angle was somewhat rounded, not obtuse-angled as in the *Jassidae*, and that 1A and 2A are of very primitive form, and lie far apart from one another. In another new genus from Ipswich, *Mesodiphthera*, in which only the basal half of the tegmen is preserved, the whole of the clavus is present, showing complete agreement with that of *Mesoscytina,* as far as the latter is preserved. We may therefore place *Mesodiphthera* also in the *Scytinopteridae.*

Mesodiphthera n.g. differs from the rest of the *Scytinopteridae* so far mentioned, in that R branches into two at about the same level as the fork of M; whereas, in the other genera, R remains unbranched until near the apex of the wing. This gives us at once a connection with the Permian genus *Permoscarta* Till., (9, p. 727) from the Newcastle Beds. Originally, I placed this genus in the *Cercopidae;* but more mature study has convinced me that this type is far too generalised to go definitely into any existing family; and I now take the opportunity of removing it to the *Scytinopteridae,* as constituted in this paper. At the same time, we may reconsider the position of the genus *Permofulgor* (9, p. 730) from the Belmont Beds. For this genus, I made a new family *Permofulgoridae.* With the widening of the definition of the family *Scytinopteridae,* it is now evident that the *Permofulgoridae* are only a subfamily within that family; and, as Handlirsch's generic name *Scytinoptera* is older than my *Permofulgor* I now propose to sink the *Permofulgoridae* definitely to the status of a subfamily *Permofulgorinae,* within the *Scytinopteridae.*

It will thus be seen that all the known Permian Homoptera now go into the one family *Scytinopteridae;* and this affords additional proof, if such were now needed, of the Upper Permian age of the Upper Coal Measures of the Newcastle district.

Four more genera still remain to be placed, amongst the Ipswich fossils dealt with in this paper. Of these, *Chiliocycla* is a well defined genus, remarkable for the exceptionally strong and specialised tuberculation of the basal two-thirds of the wing. Its venation, so far as preserved, is closely allied to that of both *Scytinoptera* and *Mesoscytina,* and thus it may most certainly be placed within the *Scytinopteridae.* Another genus, *Triassoscarta,* n.g. shows distinct affinity with *Permoscarta* Till. from the Newcastle Beds, and, through this genus, with *Mesodiphthera;* this also can therefore be placed in the same family. The remaining two genera differ from all the rest in having three branches to R, and thus have a venation which, though definitely Scytinopterous in other respects, also resembles that of the *Cixiidae* amongst the Fulgoroidea. As, however, amongst the many claval areas preserved at Ipswich, none but those of the highly specialised *Willcoxiidae* are of the Fulgoroid type, it would seem fairly certain that these two fossils may not be classed with the Fulgoroidea. They are better regarded as belonging to a separate subfamily of the *Scytinopteridae*, from which, perhaps, the *Cixiidae* arose later on, by specialisation of the veins of the clavus. I propose to name this subfamily the *Mesocixiinae*, from the name of the best preserved of the two genera, *Mesocixius*, n.g.; the other genus is *Triassocixius*, n.g.

We may now sum up the above results as follows:—

(1) In the Upper Permian, both in Russia and Australia, the first true Homoptera were present in the form of a single family having very primitive venational characters, viz. the *Scytinopteridae*, represented by the three genera *Scytinoptera* Handl. (Kama River, Russia), *Permoscarta* Till. (Newcastle, N.S.W.) and *Permofulgor* (Belmont, N.S.W.).

(2) In the Upper Trias of Ipswich, the *Scytinopteridae* were still the dominant family of Homoptera, being represented by no less than six genera. The *Ipsviciidae* were a highly specialised offshoot from this ancient family. Nothing like them is known elsewhere, either fossil or recent. Amongst recent families, the *Jassidae* were present at Ipswich, and represented by three genera. Other existing families were not represented at Ipswich, so far as known.

(3) In the Lias of the Northern Hemisphere, true *Scytinopteridae* appear to have become extinct. True Fulgoroids, Jassids and also Cercopids (Handlirsch's *Procercopidae*) were present.

It is interesting to note that, at Ipswich in the Upper Trias, the Homoptera formed nearly 20 per cent. of the total insect fauna, as preserved in the fossils, while at Belmont and Newcastle (calculated on a much smaller number of preserved forms) they formed 50 per cent. In the Lias, the Homoptera were only 6.6 per cent. of the total insect fauna. This percentage decreased to 4.5 in the Tertiary, and to 3.6 at the present day. The drop in the percentage from the Ipswich Trias to the Lias is due in part to the dying out of the *Scytinopteridae*, but more to the great rise in the representation of other Orders. If further evidence were needed of the approximate age of the Ipswich Beds, the percentage of Homoptera would place them definitely between the Upper Permian of Newcastle and the Lias of the Northern Hemisphere, but somewhat closer to the latter than to the former.

We may now proceed to the classification and description of the Ipswich fossil Homoptera. For this purpose, I offer first of all a list of the fossils, arranged in their families, and will then take each family in turn, and give keys to the subfamilies and genera included in it.

LIST OF THE FOSSIL HOMOPTERA FOUND AT IPSWICH.

Family SCYTINOPTERIDAE Handl.

Genus CHILIOCYCLA, n.g. (Genotype, *Ch. scolopoides*, n. sp.)
1. *Chiliocycla scolopoides*, n. sp. (p. 869).

Genus MESOSCYTINA, n.g. (Genotype, *M. australis*, n. sp.)
2. *Mesoscytina australis*, n. sp. (p. 871).
3. *Mesoscytina affinis*, n. sp. (p. 872).

Genus MESODIPHTHERA, n.g. (Genotype, *M. grandis*, n. sp.)
4. *Mesodiphthera grandis*, n. sp. (p. 873).

Genus TRIASSOSCARTA, n.g. (Genotype, *T. subcostalis*, n. sp.)
5. *Triassoscarta subcostalis*, n. sp. (p. 874).

Genus MESOCIXIUS, n.g. (Genotype, *M. triassicus*, n. sp.)
6. *Mesocixius triassicus*, n. sp. (p. 877).

Genus TRIASSOCIXIUS, n.g. (Genotype, *Tr. australicus*, n. sp.)
7. *Triassocixius australicus*, n. sp. (p. 878).

Family IPSVICIIDAE, fam. nov.

Genus IPSVICIA, n.g. (Genotype, *I. jonesi*, n. sp.)
8. *Ipsvicia jonesi*, n. sp. (p. 879).
9. *Ipsvicia maculata*, n. sp. (p. 881).
10. *Ipsvicia acutipennis*, n. sp. (p. 883).

Family JASSIDAE.

Genus EURYMELIDIUM, n.g. (Genotype, *E. australe*, n. sp.
11. *Eurymelidium australe*, n. sp. (p. 885).

Genus MESOJASSUS, Till. (Genotype, *M. ipsviciensis* Till.)
12. *Mesojassus ipsviciensis* Till. (p. 886).

Genus TRIASSOJASSUS, n.g. (Genotype, *Tr. proavitus*, n. sp.)
13. *Triassojassus proavitus*, n. sp. (p. 888).

Besides the above, there are five good impressions of Homopterous clavi, which I have decided to figure and describe, though they cannot be named.

There are also five other impressions of Homopterous tegmina which are too fragmentary or indistinct to be either described or figured. The total number of Homoptera so far found at Ipswich is therefore twenty-two specimens.

Family SCYTINOPTERIDAE Handl., a me emendata.

Primitive Homoptera belonging to the Upper Permian and Trias, in which the veins R, M and Cu come off separately from a point close to the base, and diverge from one another distad. Sc may or may not be present as a separate vein. M and Cu_1 are always forked, the former usually, the latter always towards the distal part of the wing. Condition of R very variable.

Clavus separated from rest of wing by a straight, deeply impressed vena dividens (Cu_2). Veins of the clavus (1A, 2A), standing far apart, 1A being waved, 2A very short, 3A usually absent. Anal angle rounded.

Tegmina of a tough, leathery consistency, finely tuberculated or pitted all over in most genera, but sometimes (*Chiliocycla*) armoured with large, closely-set, circular, flat tubercles, or quite smooth (*Permofulgor*).

Key to the Subfamilies and Genera of the family SCYTINOPTERIDAE.

(1) Tegmen very narrow and elongated, smooth; clavus with three separate veins upon it. ——Subfam. PERMOFULGORINAE.
(Only one genus, Permofulgor Till. from the Upper Permian of Belmont, N.S.W.)
Tegmen much broader in proportion, more or less tuberculated or pitted; clavus with only two separate anal veins, placed wide apart. ——2.

(2) R with only two main branches, or not branched at all until near distal end. ——Subfam. SCYTINOPTERINAE. 3.
(Upper Permian and Upper Triassic).
R dividing into at least three main branches (venation of distinct Cixiid type). ——Subfam. MESOCIXIINAE. 8.
(Upper Trias of Ipswich, Q.)

(3) Basal two-thirds or more of tegmen covered with large, flat, circular tubercles, closely set together. ——Chiliocycla, n.g.
No such tubercles present on tegmen. ——4.

(4) Area of tegmen between costa and R free of transverse veinlets from base to beyond half-way along the wing. ——5.
Area of tegmen between costa and R with a series of transverse veinlets beginning before half-way. ——7.

(5) M remains unbranched except at its distal end. ——Scytinoptera Handl.
(Upper Permian of Kama River, Russia).
M branching into two at or before middle of wing. ——6.

(6) R remains unbranched until well beyond half-way along the wing. ——————MESOSCYTINA, n.g.
R branches into two slightly before the level of the branching of M. ——————MESODIPHTHERA, n.g.

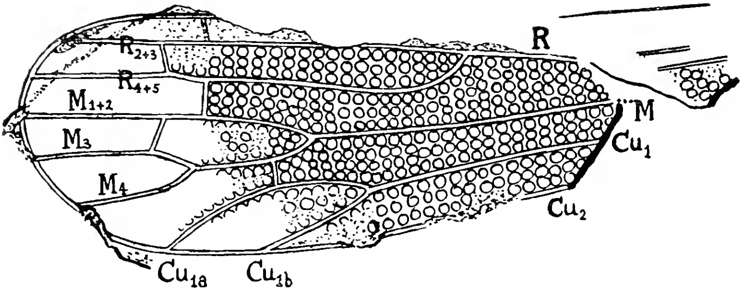
(7) R unbranched; the series of veinlets between it and the costa extending from base to apex. ——————TRIASSOSCARTA, n.g.
R branched just before half-way; the veinlets between it and the costa beginning just beyond the dichotomy of R, and continuing to the apex, with a series of cross-veins beneath them, between the two branches of R. ——————PERMOSCARTA Till.
(Upper Permian of Newcastle, N.S.W.)

(8) First dichotomy of R placed closer to the origin of R from M than to the second dichotomy of R; only two veinlets from the most anterior branch of R to the costa. ——————MESOCIXIUS, n.g.
First dichotomy of R much closer to second dichotomy than to the origin of R; a series of parallel veinlets from the most anterior branch of R to the costa. ——————TRIASSOCIXIUS, n.g.

Subfamily SCYTINOPTERINAE.

Genus CHILIOCYCLA, n.g. (Text-fig. 2).

Basal two-thirds or more of the tegmen covered with a remarkably strong sculpture of small, flat, circular tubercles set closely together. R with a single posterior branch arising a little before half-way; this branch connected to M_{1+2} by a single cross-vein above the median cell. M branches dichotomously at a level only slightly nearer to the base than the apical end of the clavus; the lower branch of M again divides, and the median cell is closed by a cross-vein from M_{1+2} to M_3. Cu_1



Text-fig.2.
Chiliocycla scolopoides, n.g. et sp. (x 15). For lettering see p.895.

a straight vein with a strong distal fork; a cross-vein connects Cu_{1a} with the median cell above it. (Clavus not preserved).

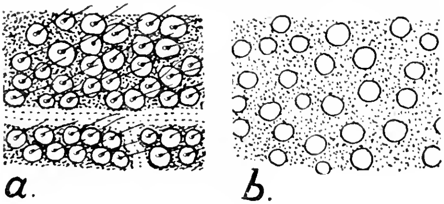
Genotype, *Chiliocycla scolopoides*, n.sp. (Upper Triassic, Ipswich, Q.)

This genus is evidently allied to *Scytinoptera* Handl., but differs from it not only in the remarkable sculpture of the tegmen, but also in the form of the posterior branch of R, which is longer and straighter, the very definite branching of M, with the formation of a definite median cell, and the stronger forking of Cu.

CHILIOCYCLA SCOLOPOIDES, n.sp. (Text-fig. 2).

Total length of preserved portion of tegmen, 6.4 mm., representing a tegmen of about 8 mm. *Greatest breadth*, 2 mm.

The area of strong tuberculation extends from the base outwards to about the level of the apical end of the clavus, with indications of some tubercles along the veins slightly distad from that level. Examined under a fairly high power, the tubercles are seen to be flat and circular, very closely and regularly arranged, there being three rows of them between the two branches of R, three rows between the posterior branch of R and M, three or four rows between M and Cu_1, and three rows between Cu_1 and the vena dividens (Cu_2) which is mostly obliterated in the fossil. Each tubercle is distinctly raised up above the level of the membrane surrounding it. On most of the tubercles there can be made out, situated at or near the centre of the circle, the impression of a socket of a hair or macrotrichia. Tubercles of this kind are not uncommon on the tegmina of existing Homoptera, as, for example, on many *Membracidae*, and in the Cercopid genus *Philagra*, but they are seldom developed over so large an



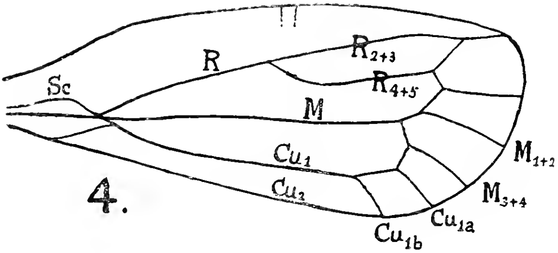
Text-fig.3.

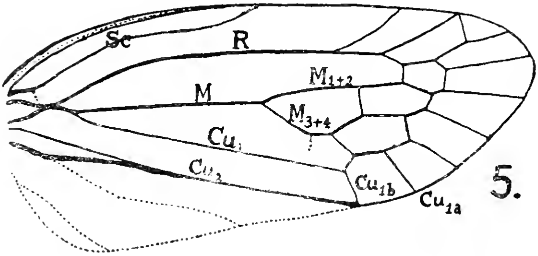
Two small areas from the tegmen of *Philagra* sp. (*Cercopidae*) from Mount Tambourine, Q. *a*, tuberculate area. *b*, normally pitted area. (x 100).

area of the tegmen as in *Chiliocycla.* In Text-fig. 3, I have shown portions of the tegmen of *Philagra* sp., contrasting a tuberculate area (*a*) with a normally pitted area (*b*). In *a,* each tubercle carries a short hair set in a definite socket, alongside of which there is a minute circular area devoid of pigment, probably representing a small gland containing fluid and opening at the base of the hair. I would suggest that the tubercles of *Chiliocycla* only differ from those of *Philagra* in their greater abundance and regularity of arrangement, and in being all of about the same size, those of *Philagra* being unevenly distributed and varying considerably in diameter. No systematic value can be placed upon the presence of these tubercles as regards the family relationships of *Chiliocycla,* as they appear to crop up almost anywhere within the Hemiptera.

Type, Specimen No. 158*a*. (Coll. Queensland Geol. Survey).

Horizon: Upper Triassic, Ipswich, Q.





Text-fig.4. *Scytinoptera kokeni* Handl. From Handlirsch. (x 8). For lettering see p.895.

Text-fig.5. *Mesoscytina australis,* n.g. et sp. (x 7·5). For lettering see p.895. The missing clavus is shown dotted in.

Genus SCYTINOPTERA Handl. (Text-fig. 4).

In Text-fig. 4, I have shown the venation of *Scytinoptera kokeni* Handl., from the Upper Permian of the Kama River, Russia, for comparison with *Chilioecycla*, *Mesoscytina* and other Ipswich genera defined in this paper. Points to be noted are the peculiar shape of the costal margin, the manner of branching of R, the absence of any definite branch of M, and the very regular arrangement of the veins ending on the distal border of the tegmen. The tegmen is tough and leathery in appearance, and is finely pitted all over.

The genus is monotypic, the genotype having been originally described by Handlirsch in 1904 (Mem. Acad. Petersburg, xvi., (5), 3. 1904. Pl., figs. 3, 4.). See also Handlirsch (3, p. 392).

Genus MESOSCYTINA, n.g. (Text-figs. 5-6).

Closely related to *Scytinoptera* Handl., from which it differs in the following points:—M branches into two at about the middle of the wing; M_{3+4} again divides into M_3 and M_4 distally; the branches of M are connected by cross-veins, so that two closed cells are formed between them. R remains unbranched until well beyond half-way along the wing, when it gives off an ascending branchlet (R_1), and soon after divides into R_{2+3} and R_{4+5} the latter again dividing into R_4 and R_5. Two cross-veins between R_{4+5} and M_{1+2} and two between M_{3+4} and Cu_{1a}; the latter diverging strongly from Cu_2 at its origin. The basal portion of the costal margin is convex, instead of being slightly concave as in *Scytinoptera*, and there is a short vein close below it, which is probably Sc.

Genotype, *Mesoscytina australis*, n.sp. (Upper Triassic, Ipswich, Q.).

Two species are represented in the collection: they may be distinguished as follows:—

Sc faintly indicated, curved, reaching well beyond the curved basal portion of R. ——————*M. australis*, n. sp.

Sc strongly marked, straight, only reaching about as far as the curved portion of R. ————————*M. affinis*, n. sp.

MESOSCYTINA AUSTRALIS, n.sp. (Text-fig. 5).

Total length, 9.4 mm.; *breadth* at apical end of clavus, 3.5 mm. Tegmen complete, except for the absence of the clavus, which has been restored on typical Scytinopterid lines in Text-fig. 5.

Peculiarities in the venation which are probably only of specific value are the following:—the slight double-curving of Sc; the presence of a cross-vein connecting R_4 with the extreme tip of R_{2+3} above it; and the irregular course of M_{3+4} from its origin to the point at which it forks, with the consequent obliquity of the cross-veins connecting both it and M_4 with Cu_{Ia}.

Tegmen evidently of a tough, leathery nature, finely pitted all over; the costal margin strongly formed basally.

Type, Specimen No. 112*a*. (Coll. Queensland Geol. Survey).

Horizon: Upper Triassic, Ipswich, Q.

A comparison of this fossil with *Scytinoptera kokeni* Handl. reveals a close similarity in the apical portions; but the four closed cells present in *M. australis*, n.sp. are only represented by a single closed cell, between M and Cu, in *S. kokeni.*

MESOSCYTINA AFFINIS, n.sp. (Text-fig. 6).

Total length of fragment, 6 mm., representing a tegmen of total length about 9 mm. *Greatest breadth*, 3.3 mm.

Tegmen evidently of a tough, leathery nature, strongly pitted all over; all the veins very strongly marked.

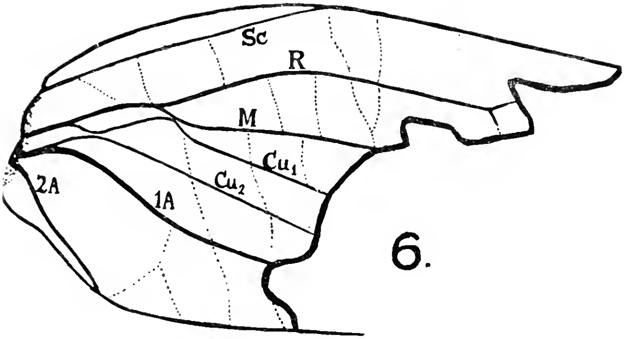
Peculiarities in the venation which are probably only of specific value are the following:—the straight, short course of Sc, and its strongly marked nature; the peculiar curvature of the vein Cu near the base; and the excessive shortness of 2A on the clavus. The dotted lines in Text-fig. 6 indicate definite creases which are probably cracks due to pressure on this tough tegmen during fossilisation.

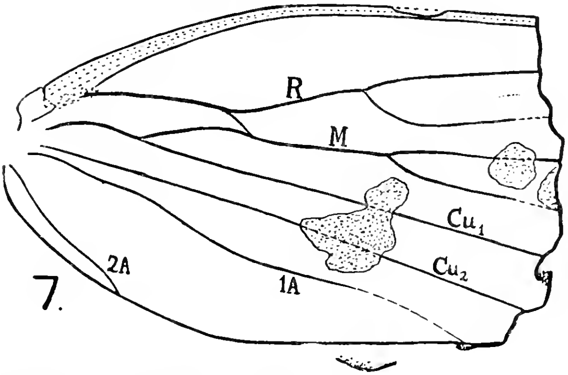
The specimen is very incomplete, being broken off along a very irregular line, as shown in Text-fig. 6. Most of the clavus is preserved, and the vein 1A shows a very definite waviness, 2A being almost straight. The vena dividens, Cu_2, is not very strongly impressed, and there is no difference between the form and size of the pits upon the clavus and the rest of the tegmen.

Type, Specimen No. 235. (Coll. Queensland Geol. Survey)

Horizon: Upper Triassic, Ipswich, Q.

The preservation of the clavus in this fossil is of great value, since it enables us to determine at once what was the form and venation of this area in the more typical *Scytinopteridae.*





Text-fig.6. *Mesoscytina affinis*, n.g. et sp. (x 13·5). For lettering see p.895.

Text-fig.7. *Mesodiphthera grandis*, n.g. et sp. (x 6·3). For lettering see p.895.

Genus MESODIPHTHERA, n.g. (Text-fig. 7).

Differs from *Mesoscytina*, n.g. in having R branching dichotomously at a level just before the branching of M. (Basal half of tegmen only preserved).

Genotype, *Mesodiphthera grandis*, n.sp. (Upper Triassic, Ipswich, Q.).

MESODIPHTHERA GRANDIS, n.sp. (Text-fig. 7).

Total length of fragment, 12 mm., representing a tegmen of total length over 20 mm. *Greatest breadth*, 7.5 mm.

The whole of the basal half or more of the tegmen is excellently preserved, including the whole of the clavus except the extreme apex. The peculiarities of the branchings of R and M are well shown in Text-fig. 7. As far as preserved, Cu_1 is a very straight vein, diverging slightly from Cu_2. The peculiar waviness of 1A is very evident; and this vein, as in *Mesoscytina*, stands very far apart from 2A, which is a short vein, very slightly waved. The anal angle of the clavus is broadly rounded, much as in *Mesoscytina.*

The tegmen appears to be of a leathery nature, but not so tough as those of the genus *Mesoscytina;* the indications of pitting are also fainter.

Type, Specimen No. 213 *a-b.* (Coll. Queensland Geol. Survey).

Horizon: Upper Triassic, Ipswich, Q.

Text-fig. 7 represents the larger piece of the preserved fossil, which is the *mould,* since the vena dividens stands on a high ridge. Alongside it, in the same box, there is a broken piece of the cast, not so perfect; a study of this does not yield any additional information about the venation of this fossil.

Genus TRIASSOSCARTA, n.g. (Text-fig. 8).

R unbranched, but connected with the costal margin by a long series of transverse veinlets, extending from near base to near apex. M and Cu arising together by a very short stalk. On the clavus, vein 2A ends up about as far from the end of 1A as the latter is from the apex of the clavus. (Course of M, beyond half-way, obliterated).

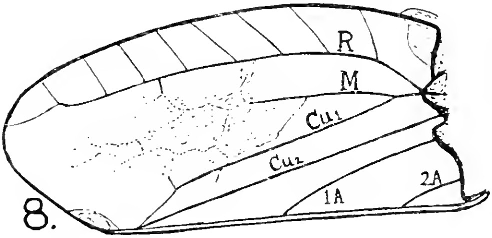
Genotype, *Triassoscarta subcostalis,* n.sp. (Upper Triassic, Ipswich, Q.)

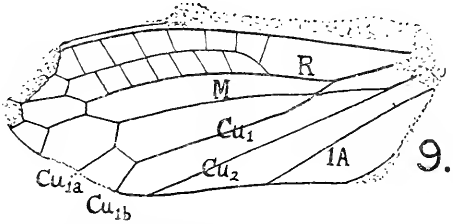
Clearly allied to *Permoscarta,* from the Upper Permian of Newcastle, N.S.W., but differing from it in the simpler structure of R, as explained in the key to the genera.

TRIASSOSCARTA SUBCOSTALIS, n.sp. (Text-fig. 8).

Total length, 8 mm. *Greatest breadth,* 3.8 mm.

The number of veinlets connecting R with the costal margin is eight, arranged at approximately equal intervals; the second, third and fourth of these are more obliquely placed than the others. The middle distal portion of the tegmen has the venation obliterated; but there are slight indications that M was forked near half-way, and the short basal piece of Cu_{1a} visible above the secondary cubital fork suggests that the venation of this part of the tegmen may have resembled somewhat that of *Mesoscytina*. Cu_{1b} is a short, straight vein which descends to meet the vena dividens at the apex of the clavus. 1A and 2A are both well marked, curved veins. The anal angle is well rounded.





Text-fig.8. *Triassoscarta subcostalis*, n.g et sp. (x 7·5). For lettering see p.895.

Text-fig.9. *Permoscarta mitchelli* Till. (x 8·3). For lettering see p.895.

The tegmen appears to be of a leathery nature, finely and closely pitted all over.

Type, Specimen No. 116*a*. (Coll. Queensland Geol. Survey).
Horizon: Upper Triassic, Ipswich, Q.

Genus PERMOSCARTA Till.

We figure the tegmen of *Permoscarta mitchelli* Till. in Text-fig. 9, for comparison with that of *Triassoscarta subcostalis*, n.sp. The genus comes from the Upper Permian of Newcastle, N.S.W. (9, p. 726). The chief differences between the two types are given in the generic key above. We may note, in addition, that the radius of *Triassoscarta* arches strongly upwards near the base, much as the upper branch of R does, further on, in *Permoscarta;* that, in this latter genus, Cu_{1a} does not end at the apical angle of the clavus; and that vein 2A seems to be absent.

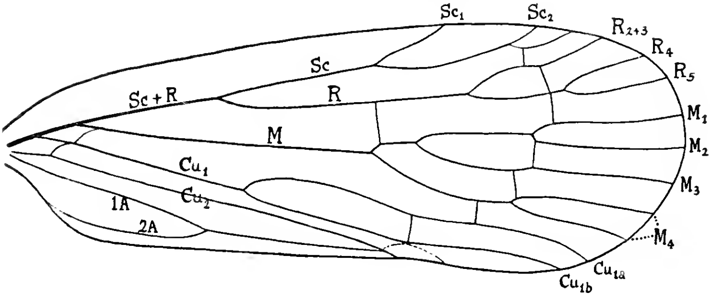
Subfamily MESOCIXIINAE.

Genus Mesocixius, n.g. (Text-fig. 11).

Tegmen considerably broader near base than towards apex. Costal area fairly wide. R branches dichotomously at about one-third of the wing length from the base. The upper branch of R branches again at a point further from the original forking than the latter is from the origin of R; the upper branch so formed sends only two veinlets to the costal border, while the lower divides into two simple branches, R_2 and R_3. M forks dichotomously at about two thirds of the wing length from the base; the upper branch, M_{1+2} divides into two near the border; the lower, M_{3+4}, has four short, subparallel, descending branches. A closed median cell is present, by a strong cross-vein. Cu_1 has a strong distal fork. Cu_{1b} ends up a little beyond the apical angle of the clavus, while Cu_{1a} is itself forked near the wing border. Cross-veins connect R_1 with R_2, R_{4+5} with M_{1+2} and M with Cu_{1a}. (Clavus not preserved).

Genotype, *Mesocixius triassicus,* n.sp. (Upper Triassic, Ipswich, Q.).

It is, of course, impossible to decide whether Sc is really present in this fossil or not. The naming of the branches of R is given only provisionally, to facilitate comparison with other genera of the family. If this genus and the succeeding one



Text-fig. 10.

Nesocharis sp., tegmen (*Cixiidae*). (x 12). For lettering see p.895.

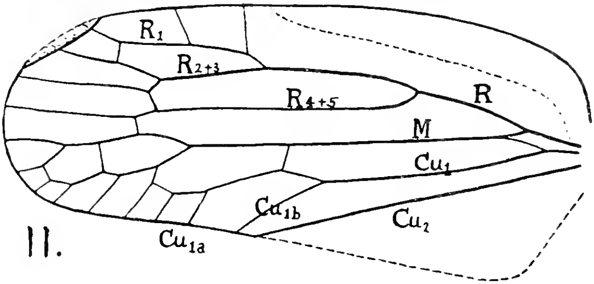
really belong to a group ancestral to the true *Cixiidae,* then it should be noted that the first dichotomy of the vein here called R is really a dichotomy of a fused stem R-Sc into Sc above and R below, and that Sc branches again, while R remains unbranched. For comparison of the venations of the fossil with the true *Cixiidae,* I give, in Text-fig. 10 the venation of the tegmen of *Nesocharis* sp.

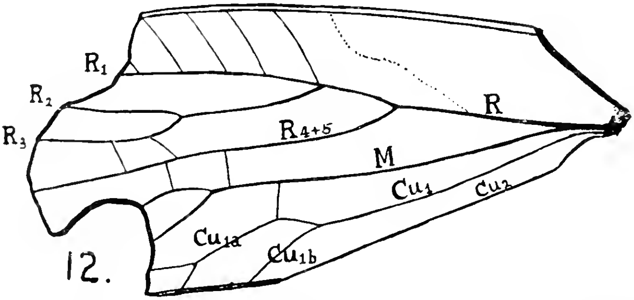
MESOCIXIUS TRIASSICUS, n.sp. (Text-fig. 11).

Total length of tegmen, 10 mm. *Greatest breadth,* 4 mm.

The venational characters have been included in the generic definition. The tegmen appears to have been moderately tough and leathery, and is finely and closely pitted all over. The specimen is complete, except only for a tiny piece missing above the apex, and the loss of the clavus, which, as usual, has become detached along the groove of the vena dividens.

Type, Specimen No. 215 (Coll. Queensland Geol. Survey).





Text-fig. 11. *Mesocixius triassicus,* n.g. et sp. (x 7·5). For lettering see p.895.

Text-fig. 12. *Triassocixius australicus,* n.g. et sp. (x 7·5). For lettering see p.895.

Genus TRIASSOCIXIUS, n.g. (Text-fig. 12).

Allied to *Mesocixius*, from which it differs by the closer approximation of the first and second dichotomies of R, and by the presence of a series of oblique veinlets running from the most anterior branch of R to the costal border. The condition of the media and cubitus is much the same as in *Mesocixius*, but there are two cross-veins between R_{4+5} and M, and also between R_3 and R_{4+5}. (Clavus not preserved.)

Genotype, *Triassocixius australicus*, n.sp. (Upper Triassic, Ipswich, Q.).

With regard to the naming of the branches of R, the same remarks apply to this genus as to the previous one.

TRIASSOCIXIUS AUSTRALICUS, n.sp. (Text-fig. 12).

Greatest length of fragment, 10.5 mm., representing a tegmen of total length about 12.5 mm. *Greatest breadth*, 5 mm.

The venational characters are included in the generic definition. The specimen is incomplete, not only in the loss of the clavus, but also in having a considerable part of the apical area of the tegmen broken off along a very irregular line, together with a small portion of the base. It is very finely and closely pitted all over, closely resembling *Protocixius* in this respect.

Type, Specimen 267*a*. (Coll. Queensland Geol. Survey).

Family IPSVICIIDAE.

On the clavus, veins 1A and 2A form a definite Y-vein, but 2A lies very close to the margin for portion of its length. Tegmina of moderate size and of a peculiar cultriform shape, the apex more or less pointed, the anal angle strongly marked, and the posterior border from this angle to near the apex quite straight. Main veins separate at their bases, but Sc, R, M and Cu all meet at a point not far from the base, much as in the more typical *Scytinopteridae*. From this point only two veins proceed distad, the anterior one being R, the posterior one M + Cu, which divides further distad into M and Cu. The distal portions of these veins very indistinctly marked. Border of tegmen thickened, especially anteriorly, into a coriaceous margin.

Genus IPSVICIA, n.g. (Text-figs. 13-15).

R gives off a series of transverse branches to the anterior border. Cu diverges from M at about one-third of the wing-length from the base, or less. The whole tegmen is covered with irregularly placed patches of small tubercles, very definitely preserved in the fossils, and apparently originally pigmented; these give a very definite pattern to the tegmen, and are of quite a unique appearance. Between these patches, the tegmen is finely pitted all over, the pits being shallow and placed farther apart than are the tubercles in the patches, and evenly aligned along the courses of the main veins.

Genotype, *Ipsvicia jonesi*, n.sp. (Upper Triassic, Ipswich, Q.).

Three species of *Ipsvicia* are represented in the Ipswich Beds. They may be separated by the following key:—

(1) Apex of tegmen sharply pointed. ———*I. acutipennis*, n. sp.
Apex of tegmen broader and more rounded. ———2.

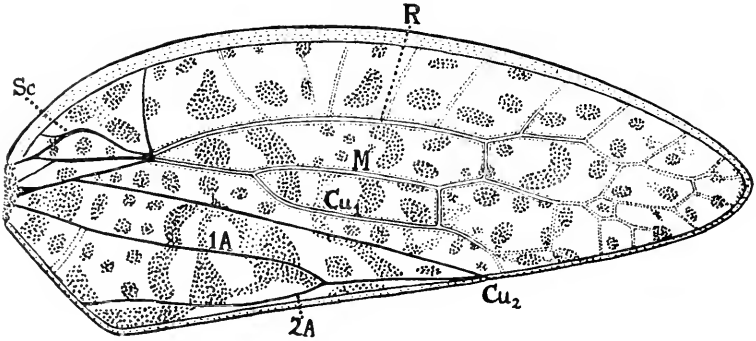
(2) M and Cu united for a distance distinctly less than the width of the space between R and the costal border above it. Tubercular patches distinct and well separated. ———*I. maculata*, n. sp.
M and Cu united for a distance slightly greater than the width of the space between R and the costal border above it. Tubercular patches larger, some of them more or less confluent. ———*I. jonesi*, n. sp.

IPSVICIA JONESI, n.sp. (Text-fig. 13).

A complete and beautifully preserved tegmen, representing the *mould* of a left tegmen, and therefore having its apex to the right (1A stands on a high ridge in the fossil, whereas in the actual wing it lies in a deep furrow).

Total length, 14.2 mm. *Greatest breadth*, 5.6 mm.

Veins of the clavus distinct, those of the rest of the tegmen faint, becoming very indistinct distally, so that their terminal branchlets cannot be made out with certainty. (This is not due to faulty preservation, but is the actual condition of the venation in the insect, as in the case of *Philagra* and other Fulgoroids, in which the membrane of the tegmen has become much thickened). Sc, R, M and Cu are well-marked from the base to their point of union, from which a transverse vein runs upwards, very distinctly, to the costal border. Costal border coriaceous, wide and strongly built. Between it and R there are altogether nine weakly-indicated cross-branches, besides the one already



Text-fig.13.
Ipsvicia jonesi, n.g. et sp. (x 6·7). For lettering see p.895.

mentioned. Of these, the first is inclined upwards and inwards obliquely, the second is very faint and also slightly inclined upwards and inwards, the third arises on R very close to the second, but inclines upwards and outwards, the rest are placed at fairly equal intervals, inclined upwards and outwards, the ninth being a small twig near the end of R. R is united with M, at about one-third of the wing-length from the base, by a strong cross-vein, and, beyond this, by two more very indistinct and somewhat oblique cross-veins, which thus separate out, between R and M, two distinct, irregular polygonal areas. Below these, M branches into weak and irregular twigs, very difficult to follow. M is connected with Cu by a well-marked cross-vein at a level somewhat basad from the strong cross-vein connecting R with M. Beyond this, Cu becomes very faint, but appears to arch downwards so as to end up close to the apex of the clavus, and gives off also a faint distal branch, which is connected again with M by a faint cross-vein. In the clavus, the Y-vein is very distinct, but 3A must be followed out with care, as it runs very close to the border, and might be mistaken for it under a cursory survey.

The pattern of the tubercular patches is well shown in Text-fig. 13. The smaller patches are round or oval, the larger ones often reniform, and some of them are connected by areas in which tuberculation is evident, but not so strongly developed. The preservation of the separate, minute, flattened tubercles forming these patches is perfect.

This tegmen appears almost unicolorous in the fossil; but it is probable that the tubercular areas would have appeared pigmented in the cast, if that had been preserved, seeing that, in the other two species, in which portions of both cast and mould are preserved, the former shows the patches strongly darkened.

Type, Specimen No. 122*a*. (Coll. Queensland Geological Survey).

Horizon: Upper Triassic, Ipswich, Q.

This tegmen is certainly the most perfect of all the Ipswich fossils, and it would be hard to imagine that any wing could be preserved in better condition.

It gives me much pleasure to dedicate this species to Mr. A. J. Jones, the present Minister for Mines in Queensland.

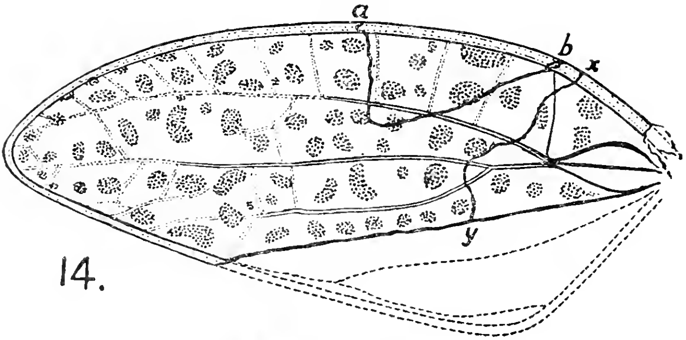
IPSVICIA MACULATA, n.sp. (Text-fig. 14).

This species is represented by portions of both cast and mould of a right tegmen. Of these, the cast shows the whole tegmen, except only the clavus, which is broken off irregularly along 1A, and the base of the tegmen above it, which is missing as far as the line *xy* in Text-fig. 14. The mould also has the clavus missing, but the base of the wing is preserved; there is, however, a piece missing from the costal border, out of which a triangular piece has been torn, as represented by the line *ab* in the same figure. Making separate drawings of both cast and mould, reversing one and placing it on top of the other, we get the composite figure shown in Text-fig. 14, which has been drawn with apex to the left, for convenience of arrangement with the figures of the other two species.

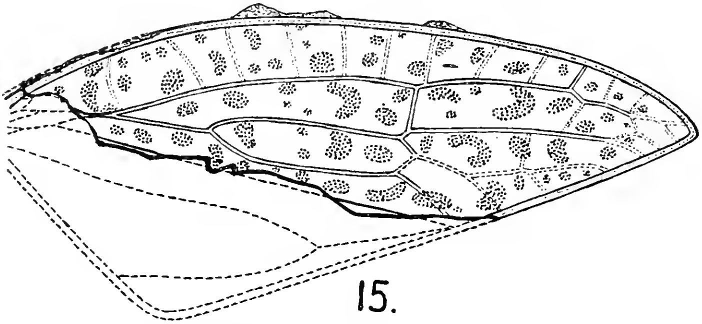
Total length, 13.5 mm. *Greatest breadth*, 4.6 mm. at apex of clavus, representing a probable maximum breadth at the claval angle of about 5.8 mm.

This species comes close to *I. jonesi*, n.sp., from which it may be distinguished as follows:—

The coriaceous costal border is not so strongly built. The width across the tegmen at the apex of the clavus is greater, though the total length of the tegmen is slightly less; this indicates a somewhat different shape, as shown in the restored tegmen in Text-fig. 14. Veins very faintly indicated. R tends to converge towards the costal border distally, so that the space between them narrows gradually, instead of remaining nearly the same length throughout, as in *I. jonesi*. There are ten cross-



14.



15.

Text-fig.14. *Ipsvicia maculata*, n.g. et sp. (x 6·7). The missing clavus is shown dotted in, restored on the plan of *I. jonesi*. For lettering see p.895.

Text-fig.15. *Ipsvicia acutipennis*, n.g. et sp. (x 6·7). The missing clavus is shown dotted in, restored on the plan of *I. jonesi*. For lettering see p.895.

veins in this space, including the one from the point of union of the main veins; these are more regularly spaced than in *I. jonesi*, the second and third being at a normal distance apart. Instead of R and M being united by a straight cross-vein, at a distance of one-third the wing-length from the apex, as in *I. jonesi*, R appears to give off a weak posterior branch somewhat beyond half-way along the wing, and the cross-vein to M descends from this branch, whose further course is obliterated.

M and Cu are united for a much shorter length than in *I. jonesi;* their distal courses are too faint to be made out with certainty. The tubercular patches are smaller, more distinct and more separated than in *I. jonesi,* and appear of a dark brown colour on a pale ground. Between these patches, the tegmen is strongly pitted all over, the pits being fairly large and shallow, and placed considerably further apart than are the tubercles of the patches. The courses of the veins are marked by the regular arrangement of these pits along either side of them.

Type, Specimens 208*a* (cast) and 208*b* (mould), in separate boxes. (Coll. Queensland Geological Survey).

Horizon: Upper Triassic, Ipswich, Q.

The specific name indicates the very strongly spotted appearance of the tegmen, especially in the cast, when viewed with the naked eye.

IPSVICIA ACUTIPENNIS, n.sp. (Text-fig. 15).

This species is represented by a well preserved cast, broken off irregularly along the vein 1A, so that the whole of the clavus and a small portion of the base are missing; also by a small portion of the mould, showing only the middle parts of the veins R, M and Cu.

Total length, 13.5 mm. *Greatest breadth,* 4 mm., just beyond apex of clavus.

Apex much more acute than in the two preceding species, the costal coriaceous border less strongly marked, the space between costal margin and R distinctly narrower, and crossed by twelve regularly arranged cross-veins. R is united with M by a strong cross-vein as in *I. jonesi,* but the course of M beyond this point is much straighter than in that species. M united with Cu for about the same distance as in *I. jonesi;* just before the level of the cross-vein connecting it with R, M gives off a descending branch, which meets the upper branch of Cu, thus forming an elongate closed area between them. Distal courses of Cu and lower branch of M indistinct, but rest of venation more clearly marked than in the other two species.

Tubercular patches small, distinct and separate, much as in *I. maculata,* the previous species, and appearing strongly pigmented in dark brown, on a pale ground-colour, especially in the cast.

Type, Specimens 204*a* (cast) and 204*b* (mould), glued side by side in a single box. (Coll. Queensland Geological Survey).
Horizon: Upper Triassic, Ipswich, Q.

Family JASSIDAE.

Sc usually absent; if present, weakly formed, and not looped up with R as in *Cercopidae*. R, M and usually Cu_1 fused together into a single stalk basally for an appreciable distance. Clavus triangular, the anal angle obtuse; separated from the rest of the tegmen by a straight vena dividens (Cu_2'). No claval Y-vein; the claval veins 1A and 2A both usually present, placed far apart. 1A usually waved, 2A enclosing the anal angle.

Key to the Upper Triassic Genera.

(1) Cu_{1b} ending up exactly at apex of clavus; apical third of tegmen with many closed cells. ——— *Eurymelidium*, n.g.
Cu_{1b} ending up somewhat beyond apex of clavus; apical third of tegmen with few closed cells. ——— 2.

(2) R without apparent longitudinal branches; the median cell *(mc)* normal, without any supporting cells beneath it. ——— *Mesojassus* Till.
R with definite longitudinal branches; the median cell *(mc)* abnormal, divided by a cross-vein, and with small supporting cells between it and the cubitus. ——— *Triassojassus*, n.g.

Genus EURYMELIDIUM, n.g. (Text-fig. 16).

Sc absent. R, M and Cu_1 fused together for a considerable distance from base. Distance between origin of Cu_1 from common stem and point of separation of R from M less than length of common stem of all three veins. After leaving M, R arches up considerably towards costa, then bends away again, dividing into R_{2+3} and R_{4+5}, the latter fusing almost at once with M_{1+2}. Between R_{2+3} and costal margin is a series of transverse veinlets, of which the first may represent the shortened R_1. Courses of R_{2+3} and R_{4+5} somewhat irregular, the space between them divided by three cross-veins into cells. After leaving R, M bends downwards; about the middle of the wing, it divides into M_{1+2} and M_{3+4}, the former arching up to unite with R_{4+5}, the latter continuing straight on; the space between the two branches of M is divided up by four cross-veins into cells. Two cross-veins connect M with Cu, one being not far from the origin of M from the common stalk, the other much further distad. Cu_{1a} fused with M_{3+4} for a short distance, so that its basal portion resembles a cross-vein. Cu_{1b} ending up exactly upon the apical angle of the clavus. On the clavus, 1A is waved and diverging strongly from the vena dividens.

Genotype, *Eurymelidium australe*, n.sp. (Upper Triassic, Ipswich, Q.)

EURYMELIDIUM AUSTRALE, n.sp. (Text-fig. 16).

Total length of preserved portion of tegmen, 5 mm., representing a complete tegmen of about 5.5 mm. long. *Greatest breadth*, 2 mm.

The tegmen is closely pitted all over, the venation being fairly strongly marked. There is a slight piece out of the costal margin near the middle, and a small part of the base is missing; otherwise, the preservation is complete. The venational characters have been included in the generic definition.

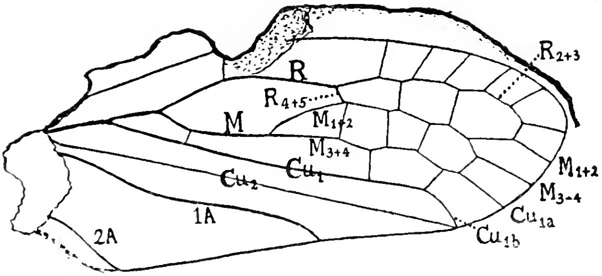
Type, Specimen No. 248*a*. (Coll. Queensland Geol. Survey).

A comparison with Text-fig. 1*c* will show the resemblance of this fossil to the existing Australian genus *Eurymela*.

Genus MESOJASSUS Till. (Text-fig. 17).

Mesojassus Tillyard, 1916 (8, p. 34).

Sc slightly indicated as a separate vein running a little below the costal margin. R, M and Cu_1 united in a common stalk for a considerable distance from base, Cu_1 coming off from it very strongly, M as a weakly indicated vein at a considerably further distance along it. R with no longitudinal branchings, but giving



Text-fig. 16.

Eurymelidium australe, n.g. et sp. (x 13·3). For lettering see p.895

off a strong transverse veinlet (probably R_1) before half-way, then running straight and without any branches for some distance, and finally becoming slightly zig-zagged distally, giving off two more veinlets to the costal margin, and connected with M_{1+2} by two cross-veins. Main stem of M very weakly chitinised; it divides into two about the middle of the wing, and remains weak for the basal half of the length of the median cell (*mc*) after which it becomes more strongly marked. Median cell (*mc*) of normal form, closed distally by a cross-vein, and connected below by another cross-vein with Cu_{1a}. Distal fork of Cu_1 very small; Cu_{1b} ending up at an appreciable distance from the end of the vena dividens. On the clavus, 1A is waved, but diverges very little from Cu_2; 2A encloses the anal angle.

Genotype, *Mesojassus ipsviciensis* Till. (Upper Triassic of Ipswich, Q.)

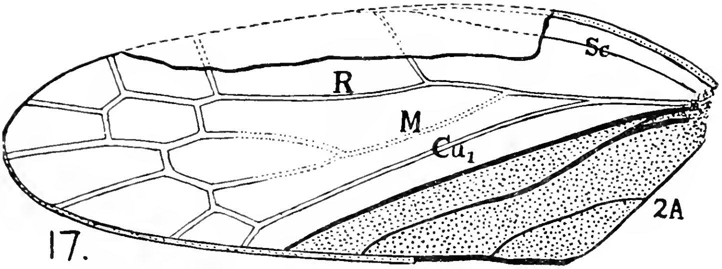
My original definition of this genus (8, p. 34) was very incomplete, as I had not then succeeded in obtaining a really good drawing of the fossil, in which the impression of the venation is weak, especially in the region of M. The drawing given in Text-fig. 17 was made under exceptionally good conditions in very strong, oblique, evening sunlight, and adds much to our knowledge of this interesting fossil form. In the original generic definition, the condition of the pitting of the wing was included. I do not now regard this as of more than specific value. The genus itself is not far removed from the recent genus *Jassus*.

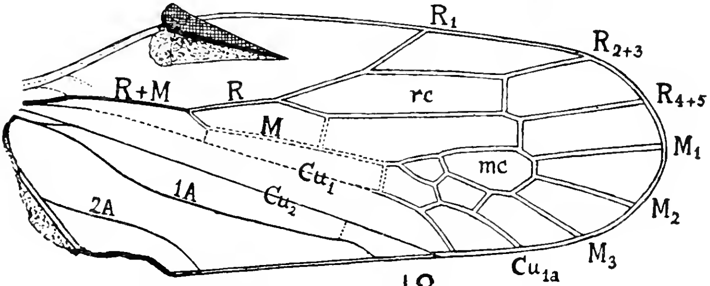
MESOJASSUS IPSVICIENSIS Till. (Text-fig. 17).

Mesojassus ipsviciensis Till., 1916, (8, p. 35, Plate 2, fig. 7).

Total length, 6.2 mm.; *greatest breadth*, 2.2 mm. (The measurements given in my original description were somewhat smaller, owing to the limits of the tegmen not being clearly made out).

The pitting of the tegmen is not quite as described by me originally. The basal portion of the tegmen is fairly strongly pitted, but the pits become more and more indistinct towards the distal end. Transversely across the middle of the wing there is an indication of a change in the amount of pigmentation, the basal half being somewhat darker than the distal; but I do not think that this line indicates the limit of any special development of the pitting.





Text.fig.17. *Mesojassus ipsviciensis*, Till. (x 15). For lettering see p.895.

Text-fig.18. *Triassojassus proavitus*, n.g. et sp. (x 15). For lettering see p.895.

Apart from the fact that there is a considerable portion of the costal area missing, this tegmen is perfect.

Type, Specimen No. 33. (Coll. Queensland Geol. Survey).

Genus TRIASSOJASSUS, n.g. (Text-fig. 18).

Costal margin strongly arched from near the base outwards in the basal third of the tegmen. Sc absent. Cu_1 departing from R + M very close to the base. R and M fused together for more than one-fourth of the wing-length. R divides, a little before half-way along the wing, into R_{1-3} and R_{4+5}. The former gives off R_1 as a very distinct oblique veinlet to the costal margin, a little beyond half-way along the wing. R_{2+3} and R_{4+5} run subparallel to one another and unbranched to the apical margin, and are connected by a single cross-vein, which closes the radial cell (*rc*) distally. Basal portion of M weakly chitinised, and connected with R_{4+5}, not far from its origin, by a weak cross-vein. M forks well beyond half-way along the wing, sending finally three distinct branches to the distal margin of the wing. Cross-veins between these and connecting them with Cu_1 are so arranged that a set of four irregular cells are formed, two between the branches of M, and therefore representing the true median cell (*mc*), and two below these, between M and Cu_1. Cu_1 weakly chitinised, its fork normal; a short, weak cross-vein connected Cu_1 with M just distad from the origin of the latter; Cu_{1b} ends up slightly distad from the apex of the clavus. On the clavus, 1A is waved, but approaches the vena dividens distally, and ends up not far from it; 2A encloses the anal angle.

Genotype, *Triassojassus proavitus*, n.sp (Upper Triassic, Ipswich, Q.).

A comparison between this genus and *Eurymela* (Text-fig. 1*c*) shows the very primitive condition of the radius in the fossil type, R_1 being distinct, and R_{4+5} remaining a complete longitudinal vein, without any fusion with M. This condition is also to be found in the Liassic genus *Archijassus* Handl. (3, p. 501), which also agrees with *Triassojassus* in having the median cell divided by a cross-vein. *Archijassus*, however, has two cross-veins connecting R_{2+3} with R_{4+5}, and three connecting the latter with M_{1+2}; also, it has four distinct distal branches to M, and, apparently, from Handlirsch's figure (3, Atlas, Plate xliii., fig. 41, copied from Geinitz) it had not less than three distinct anal veins upon the clavus, like the Permian genus *Permofulgor*. Handlirsch figures three other species placed provisionally in *Archijassus*, but they are not well preserved, and need not be discussed here.

TRIASSOJASSUS PROAVITUS, n.sp. (Text-fig. 18).

Total length, 5.8 mm. *Greatest breadth*, 2.2 mm.

The tegmen is beautifully preserved, and complete except for a small piece missing at the anal angle of the clavus, and the mark of the knife or chisel used in delamination of the rock, which has cut into the costal area as shown in Text-fig. 18. The impression is of a dark colour, finely pitted on the clavus, but elsewhere almost smooth. As the vena dividens stands upon a high ridge, the impression is actually a *mould* of a left tegmen, and the pits of the clavus appear as slightly raised tubercles.

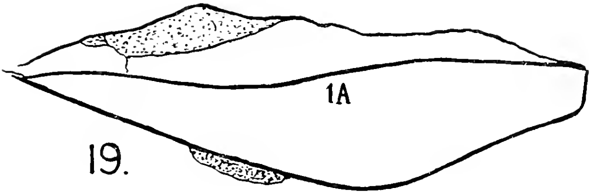
Type, Specimen 191*a*. (Coll. Queensland Geol. Survey).

UNNAMED CLAVAL AREAS.

Amongst the fossil Homoptera dealt with in this paper, there are five portions of tegmina consisting chiefly or entirely of the claval area, which are worth figuring, though they cannot be named. These are Specimens No. 109*a*, 163, 172*a*, 247*a-b* and 257*b*.

Specimen No. 109a is shown in Text-fig. 19. It is portion of the clavus of a very large tegmen, the fragment measuring 10.5 mm. in length, so that the complete clavus must have been at least 12 mm., and the tegmen probably 15 mm. or more in length. The specimen is a mould, showing only the vein 1A strongly impressed upon a tough, leathery clavus with shallow, irregular pitting and considerable pigmentation in the form of large, dark patches of irregular shape. 2A is absent; hence it is possible that it belonged to a large Cercopid.

19.



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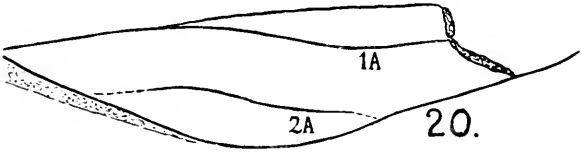
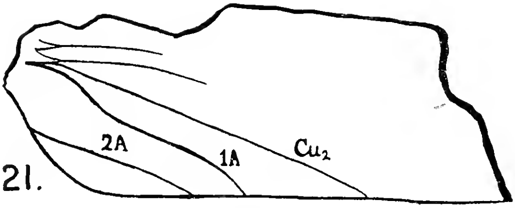
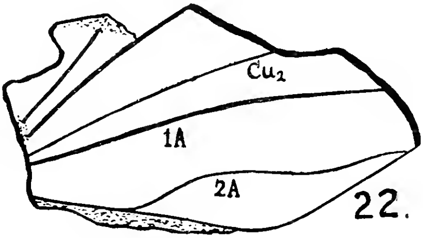


Text-fig. 19. Specimen No. 109*a*. (x 6·7).

Text-fig. 20. Specimen No. 163. (x 6.7).

Specimen No. 163 is shown in Text-fig. 20. This is somewhat more complete than the last specimen, and shows most of 1A, together with all of 2A, on a clavus which is unicolorous and finely pitted all over. The specimen is a *cast.* Total length, 10 mm. It probably belongs to a large Scytinopterid.


21.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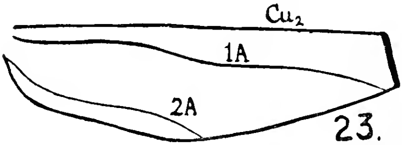

23.

Text-fig.21. Specimen No. 172*a*. (x 7·5).
Text-fig.22. Specimen No. 247*a*-*b*. (x 7·5).
Text-fig.23. Specimen No. 257. (x 7·5).

Specimen No. 172a is shown in Text-fig. 21. A considerable portion of the tegmen is preserved, but there is no definite venation except upon the clavus. Cu$_2$, 1A and 2A are all clearly marked, together with the extreme basal portions of the veins

Cu_1 and M. The tegmen is roughly granulate. Total length of fragment, 5 mm., of clavus, 3.6 mm. In this specimen, vein 1A is waved, and diverges from Cu_2 much as it does in the genus *Eurymelidium.* But 2A is nearly straight, and ends up rather close to 1A. The specimen may possibly belong to the *Jassidae.*

Specimen No. 247a-b shows, in the same box, side by side, portions of the cast and mould of the base of a fairly large tegmen, of a dark colour and tough, leathery appearance, and lightly granulate all over. Total length of fragment, nearly 7 mm. About half of the vena dividens (Cu_2) is preserved, with most of 1A and the whole of 2A and the anal angle; there are also short pieces of Cu_1 and M shown above these. 1A is fairly straight, 2A very waved, a condition which suggests some resemblance to Scytinopterid genus *Triassoscarta.* (Text-fig. 22).

Specimen No. 257b is a nearly complete clavus, finely pitted, and about 7 mm. long. 1A is waved, and diverges considerably from Cu_2. 2A is waved, and runs very close alongside the somewhat flattened-in anal border. This clavus should belong to some Scytinopterid genus. (Text-fig. 23).

It is worthy of note that none of the claval areas preserved in the Ipswich Homoptera, with the single exception of the genus *Ipsvicia,* shows any formation of a Y-vein. In the *Ipsviciidae,* the Y-vein is only just formed, 2A being, for part of its length, very close indeed to the border of the clavus. But for this character, the venation of the rest of the tegmen in this family would suggest that they belonged to the *Cercopidae,* though the condition of Sc is probably more specialised than it is in this latter family.

OTHER UNNAMED SPECIMENS.

Besides the above, there are no less than five specimens which I have considered too fragmentary or too poorly preserved to merit either naming or figuring. These are Specimens No. 164*a*, 164*b*, (mould and cast, respectively, of the same tegmen), 176*a*, 184*a*, 192*a-b* and 234. Of these, No. 184*a* appears to be a tegmen of the genus *Triassoscarta,* the basal part of the series of costal veinlets being clearly visible. No. 192*a-b* shows two main veins branching much like R and M in *Mesodiphthera,* and is evidently a small part of a large tegmen. The rest are too poorly preserved to invite comment.

NOTE ON THE PHYLOGENY OF THE HOMOPTERA.

A study of the known Homoptera from Permian and Triassic strata should now convince us that the forms which I have included under the family *Scytinopteridae* represent very closely the original type of tegmen for this Suborder. There was little or no fusion of the veins at the base of the wing, and great diversity of the manner of branching of R, M and Cu. The clavus was marked off from the rest of the wing along a fairly straight *vena dividens* (Cu_2), and its anal angle was more or less rounded, not angulated. Either three, or only two, anal (or claval) veins were present, without any approach to union of 1A with 2A to form a Y-vein. This type, as represented by *Scytinoptera* in the Upper Permian, or by the allied *Mesoscytina* or *Chiliocycla* of the Upper Trias of Ipswich, is not very far removed from the Palæohemipterous genus *Prosbole,* from the Upper Permian, from which I have already pointed out that the Triassic *Dunstaniidae,* and therefore the whole of the Heteroptera, may be derived.

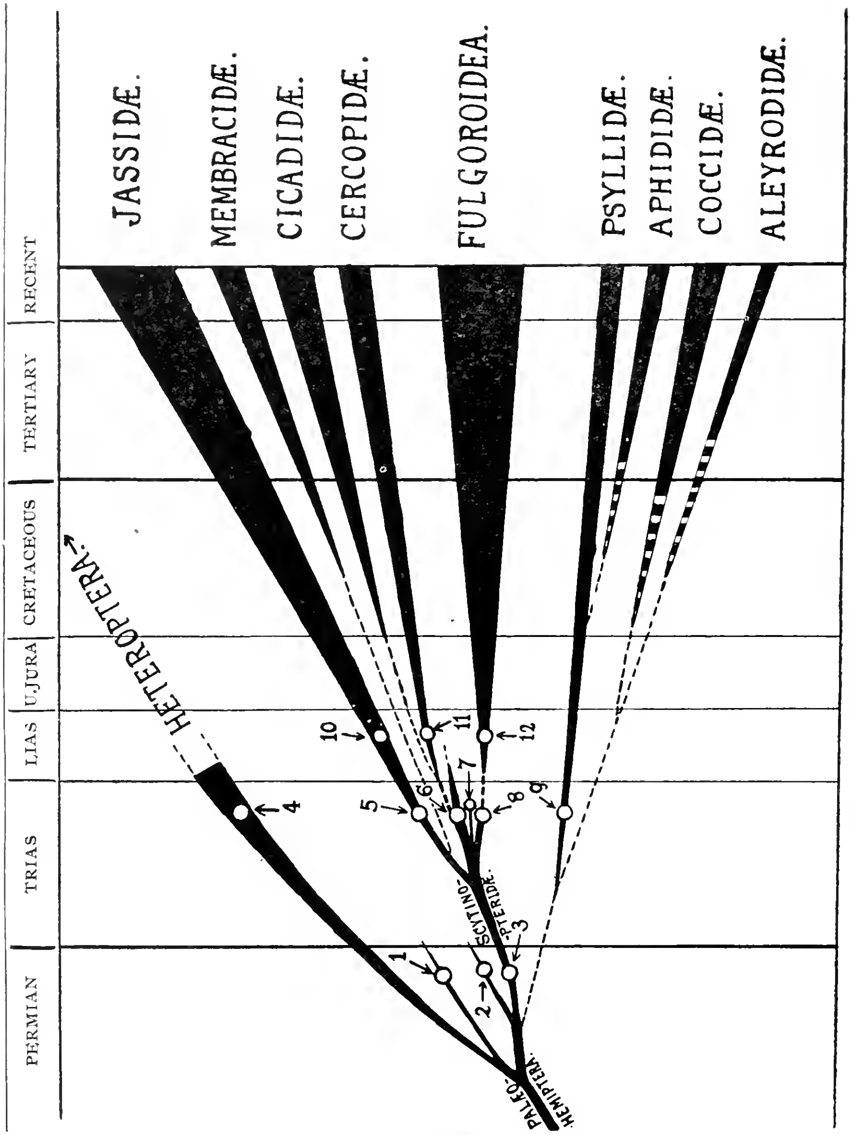
As far as we know at present, the only recent family that appears in the Trias is the *Jassidae.* The *Ipsviciidae* are to be regarded as an early specialisation of a remarkable kind, possibly foreshadowing the later *Cercopidae,* but almost certainly not ancestral to these latter. They may be considered as having died out, leaving no recent representatives. True *Cercopidae* appear first in the Lias, there being no reason, so far as I can see, to doubt that Handlirsch's *Procercopis* belonged to this family. True Fulgoroids also appear for the first time in the Lias (genus *Fulgoridium* Handl.). But this great group, which in many respects represents the highest development of the old Auchenorrhynchous stem, may well have originated amongst the Cixiid-like forms of the subfamily *Mesocixiinae* within the family *Scytinopteridae,* by development of the claval Y-vein from the more primitive Scytinopterid condition.

The oldest known Psyllid is *Triassopsylla* from the Upper Trias. This family is also known from the Lias. The *Aphididae, Coccidae* and *Aleyrodidae* are later and more specialised developments from the same stem as the *Psyllidae.*

Structurally the *Cicadidae* are undoubtedly archaic in many of their characters. But they are not found fossil before the Cretaceous, and the origin of the family is at present a mystery. They are undoubtedly closely allied to the *Cercopidae.* Ancestors with distinct Cicadid characters in their venation might be expected to have existed somewhere in the Trias, but apparently neither in Australia nor in the Northern Hemisphere.

It would appear proved that the Homoptera became differentiated from a single Palæohemipterous stock, of which *Prosbole* is a representative, in the Middle or Upper Permian. From the same stock the Heteroptera became separated off at a somewhat later period, the oldest true Heteroptera known being the *Dunstaniidae* from the Upper Trias of Ipswich. Thus the Homoptera are older than the Heteroptera, as is evident on morphological as well as palæontological grounds. The separation of the Sternorrhyncha from the Auchenorrhyncha must have taken place before the Upper Trias. The oldest existing family of the Auchenorrhyncha appears to be the *Jassidae;* the oldest of the Sternorrhyncha are the *Psyllidae.* Venationally, but not in all other characters, the *Jassidae* are the older of these two. It may also be pointed out that, after the Jassids became differentiated out, the old main stem of the Auchenorrhyncha went on, and continued to be represented by many forms which, *in certain directions,* still preserved archaic characters which the Jassids had lost (e.g., the existence of a well developed subcostal vein). Thus there is no difficulty in understanding how the Fulgoroidea and the *Cercopidae* could have arisen *later in point of time* than the *Jassidae,* though preserving certain archaic features which the Jassids had lost. This is the same problem as that which confronts us in studying the Panorpoid Orders, in which it is clear, palæontologically, that the Mecoptera were the first recent Order to be differentiated out, though they are, in some respects, more highly specialised than other Orders, which arose from the main Panorpoid stem *at later dates,* such as the Megaloptera.

The above ideas may be expressed in the Phylogenetic Diagram given herewith in Text-fig. 24. There can be no doubt that further exploration of the Ipswich Beds would yield us more valuable material in the Homoptera, and help to fill in the gaps that are only too evident in the present state of our knowledge.


RECENT
TERTIARY
CRETACEOUS
U.JURA
LIAS
TRIAS
PERMIAN
JASSIDÆ.
MEMBRACIDÆ.
CICADIDÆ.
CERCOPIDÆ.
FULGOROIDEA.
PSYLLIDÆ.
APHIDIDÆ.
COCCIDÆ.
ALEYRODIDÆ.
HETEROPTERA
SCYTINO-PTERIDÆ.
PALÆO-HEMIPTERA.
1
2
3
4
5
6
7
8
9
10
11
12

Text-fig.24.

Text-fig.24.

Diagram showing the phylogeny of the Homoptera. There is no palaeontological evidence for the portion of the phylogenetic scheme shown by means of broken lines. The positions of important fossil types are indicated by circles, to which numbers are attached by means of arrows, as follows:—*1*, *Prosbole*; *2*, *Permofulgor*; *3*, *Scytinoptera* and *Permoscarta*; *4*, *Dunstaniidae*; *5*, *Eurymelidium*, *Mesojassus* and *Triassojassus*; *6*, *Mesoscytina*, *Mesodiphthera* and *Triassoscarta*; *7*, *Ipsvicia*; *8*, *Mesocixiinae*; *9*, *Triassopsylla*; *10*, *Archijassus*; *11*, *Procercopis*; and *12*, *Fulgoridium*.

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LETTERING OF TEXT-FIGURES.

amb, ambient vein; 1A, first anal vein; 2A, second anal vein; Cu, cubitus; Cu_1, first cubitus; Cu_{1a}, its upper, and Cu_{1b}, its lower branch; Cu_2, second cubitus or vena dividens; M, media; M_1, M_2, M_3, M_4, its branches; *mc*, median cell; R, radius; R_1 R_2, R_3, R_4, R_5, its branches; *rc*, radial cell; Sc, subcosta; Sc_1, Sc_2, its branches.

CORRIGENDA:—The following alterations need to be made in No. 6 of this series of papers (These Proceedings, xliv., 1919 Part 2, pp. 358-382, Text-figs. 29-40):—

p. 373, last line but one—*for* "*S. blabelloides,* n.sp." *read* "*S. blattelloides,* n.sp."

p. 377, line 11—*for* "SAMAROBLATTA BLABELLOIDES, n.sp." *read* "SAMAROBLATTA BLATTELLOIDES, n.sp."

p. 378, Text-fig. 37—*for* "*Samaroblatta blabelloides,* n.sp." *read* "*Samaroblatta blattelloides,* n.sp"

p. 378, last line—*for* "*Blabella* Caudell" *read* "*Blattella* Caudell."

All the above being typographical errors, Article 19 of the International Rules may be applied in the first three cases. The author therefore takes this, the first opportunity, of altering the specific name *blabelloides* to its correct form *blattelloides.*

R. J. T.

SPECIAL GENERAL MEETING.*

18TH DECEMBER, 1918

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

Business—To consider the following proposed alteration in Rules xi., and xii., recommended by the Council, namely—

> In Rule xi., line 3—omit the words *"other than the Secretary."*
>
> In Rule xii., line 2—omit the words *"a Secretary"*—and transpose the word *"and,"* so as to come after *"Vice-Presidents."*
>
> In Rule xii., line 3—omit the words *"with the exception of the Secretary."*

So that Rules xi., and xii., will then read:—

> xi.—The affairs of the Society shall be managed by a Council of nineteen Members including Office-bearers, and the Members of such Council shall be elected from amongst the Ordinary Members of the Society as hereinafter provided.
>
> xii.—The Office-bearers of the Society shall consist of a President, four Vice-Presidents, and a Treasurer, all of whom shall be elected as hereinafter provided and shall hold office until the next Annual General Meeting.

Mr. Campbell moved, pro forma, and Dr. Priestley seconded, that the alterations proposed be adopted. On being put to the Meeting the motion was lost.

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* The report of this Meeting was inadvertently omitted from the Proceedings for 1918.

DONATIONS AND EXCHANGES.

Received during the period 25th November, 1918, to 26th November, 1919.

(From the respective Societies, etc., unless otherwise mentioned.)

Accra.

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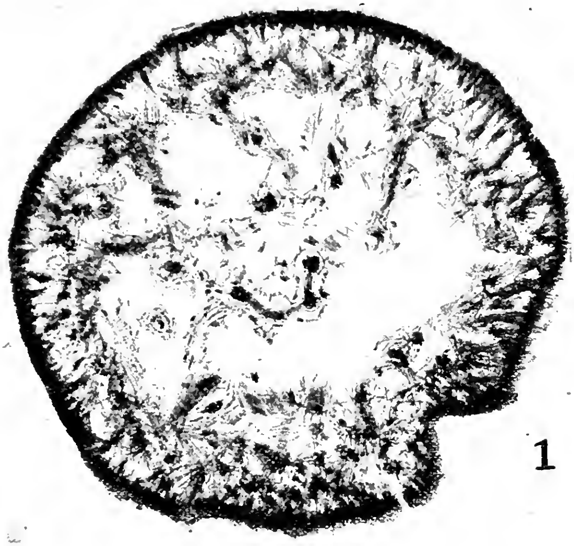

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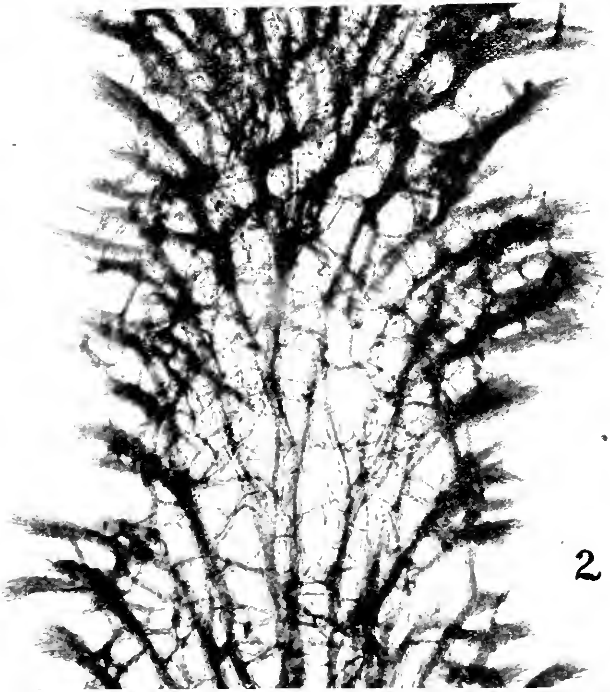
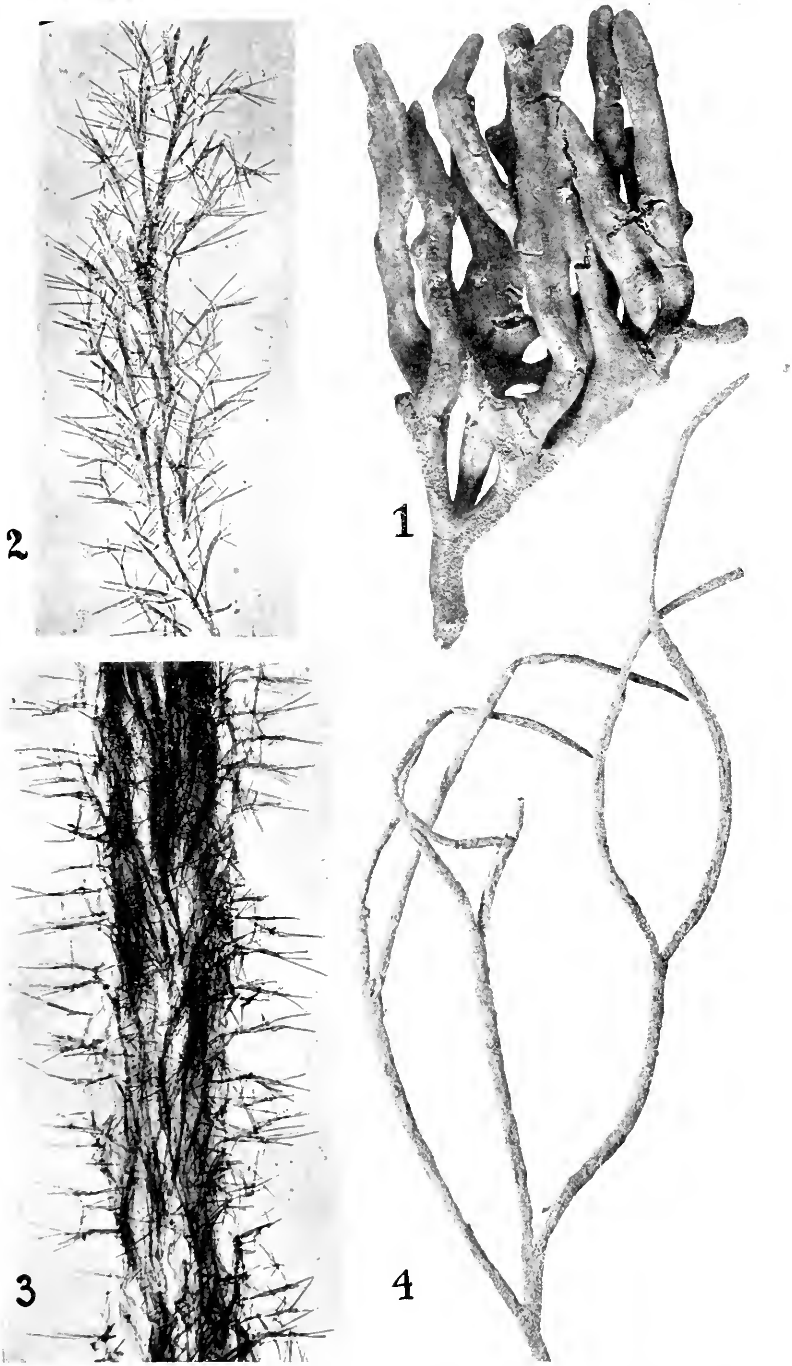
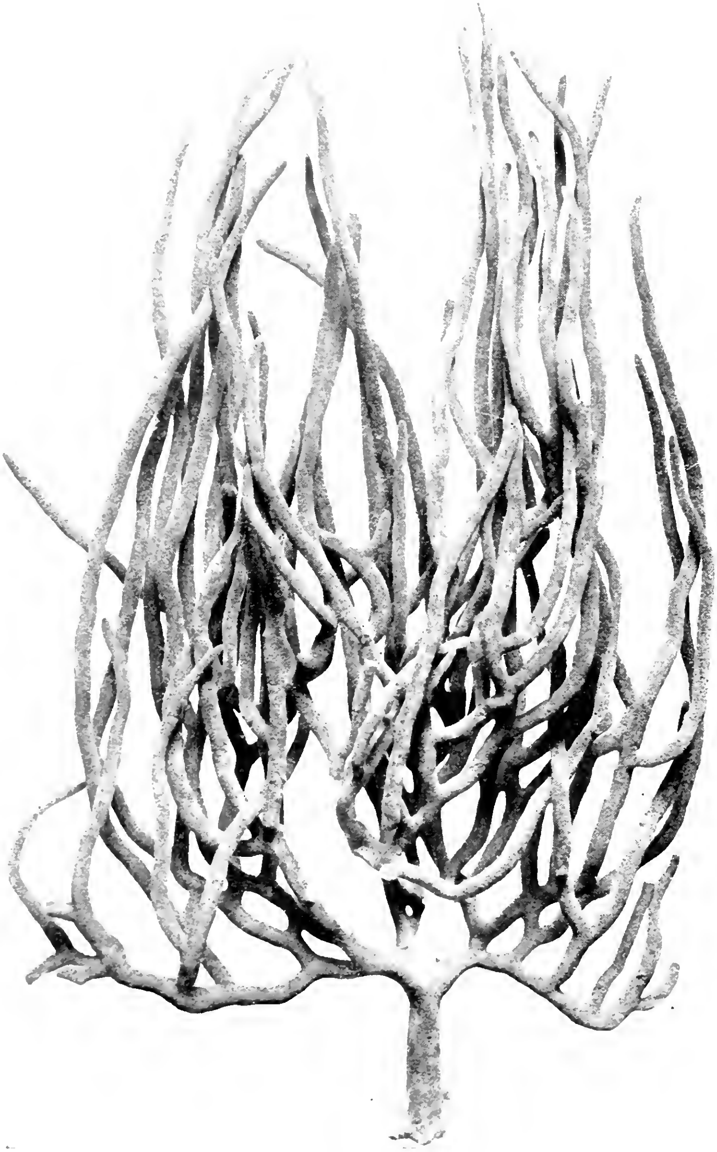


2

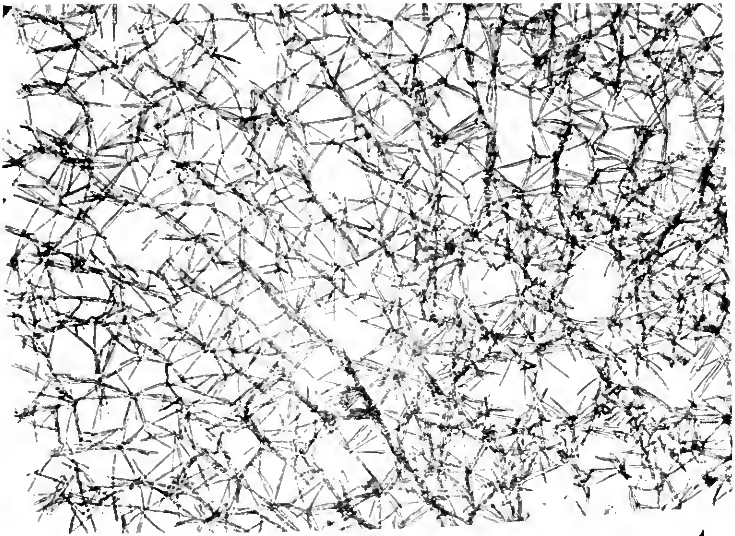
Tenaciella canaliculata Whitelegge



1. *Tenaciella canaliculata* Whitelegge; 2-4. *Axociella cylindrica* Ridley and Dendy.



Ophlitaspongia thetidis, n.sp.



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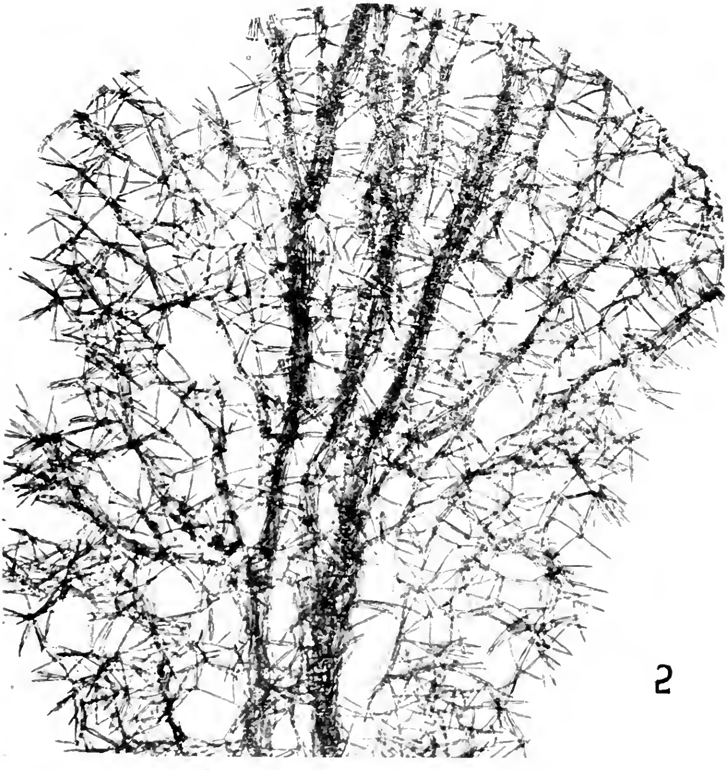

2

Isociella flabellata Ridley and Dendy.

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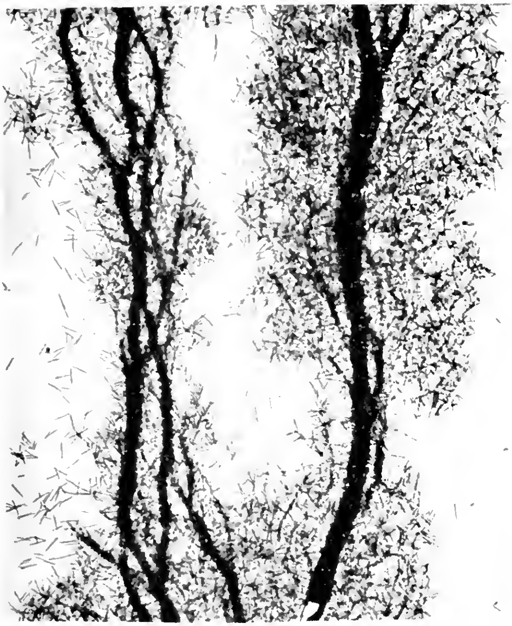

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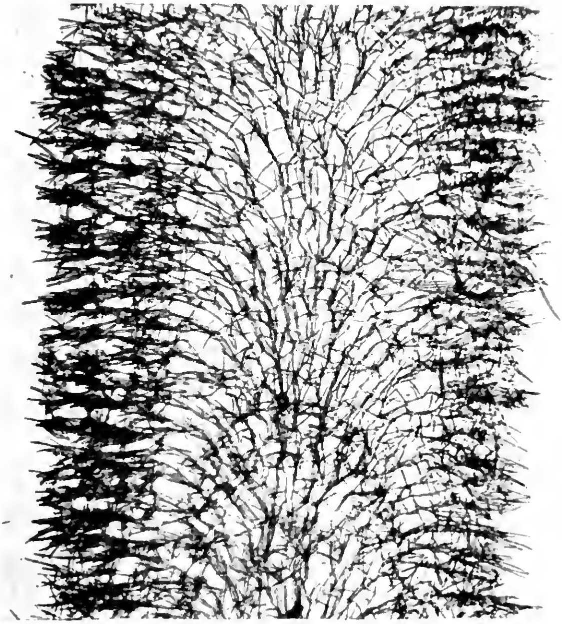

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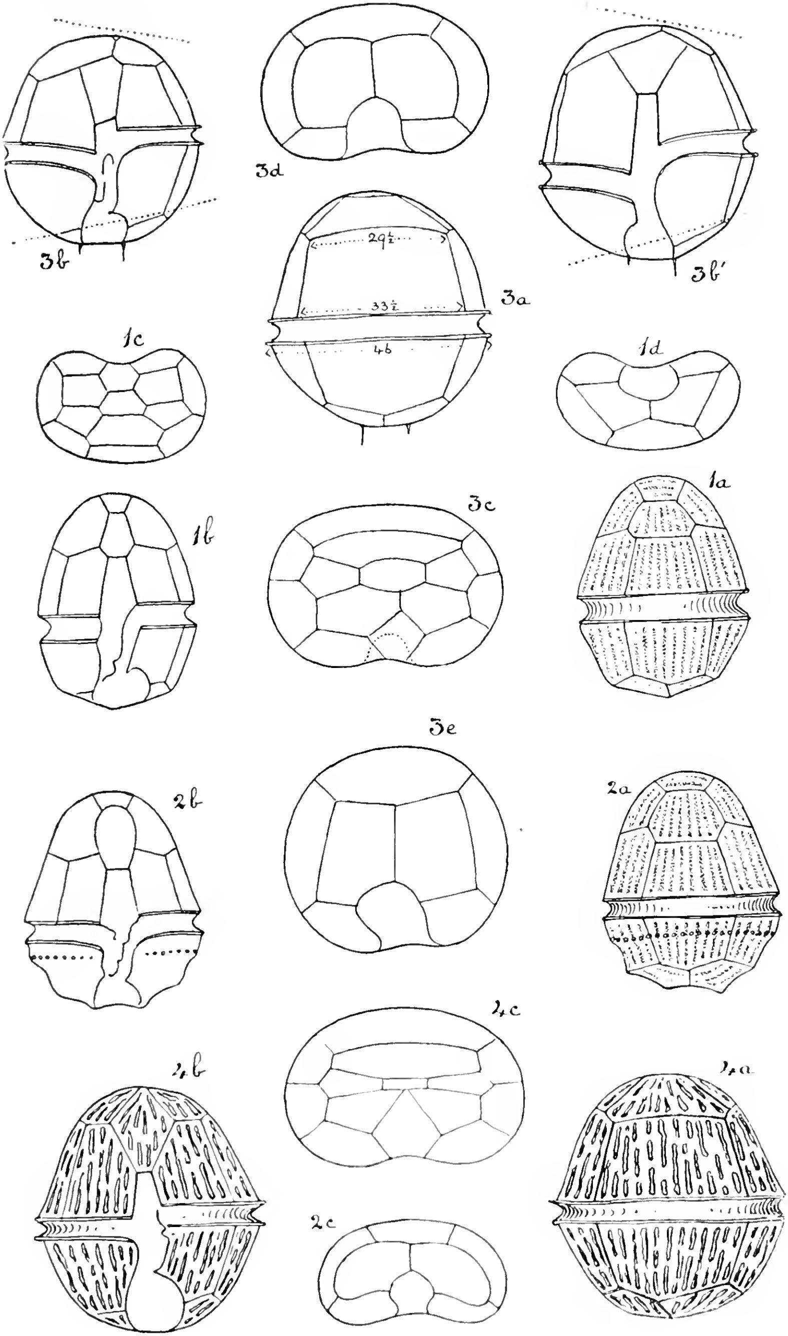
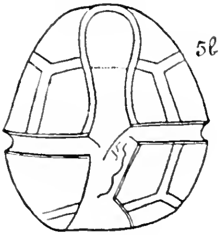
2. *Ophlitaspongia thetidis*, n.sp.



Peridineae of New South Wales.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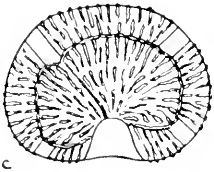
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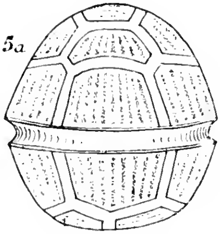
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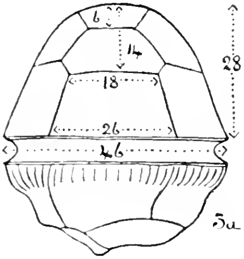
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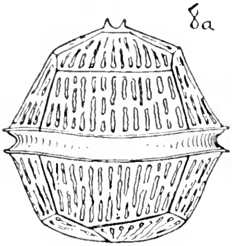
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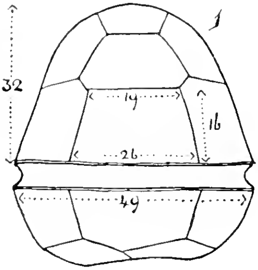
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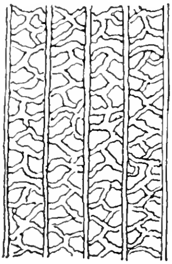
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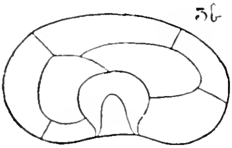
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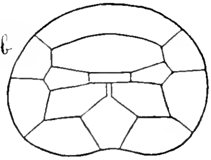
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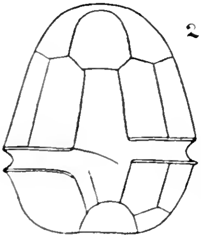
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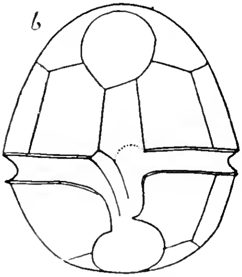
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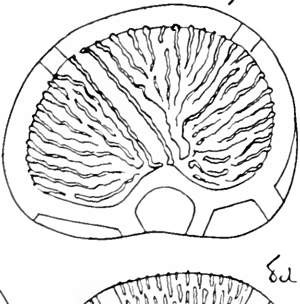
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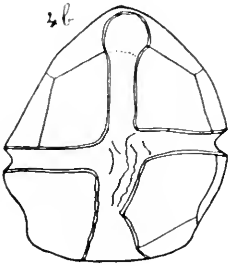
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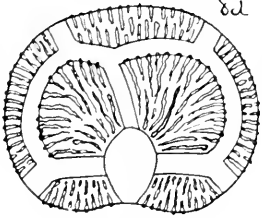
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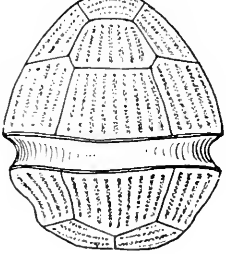
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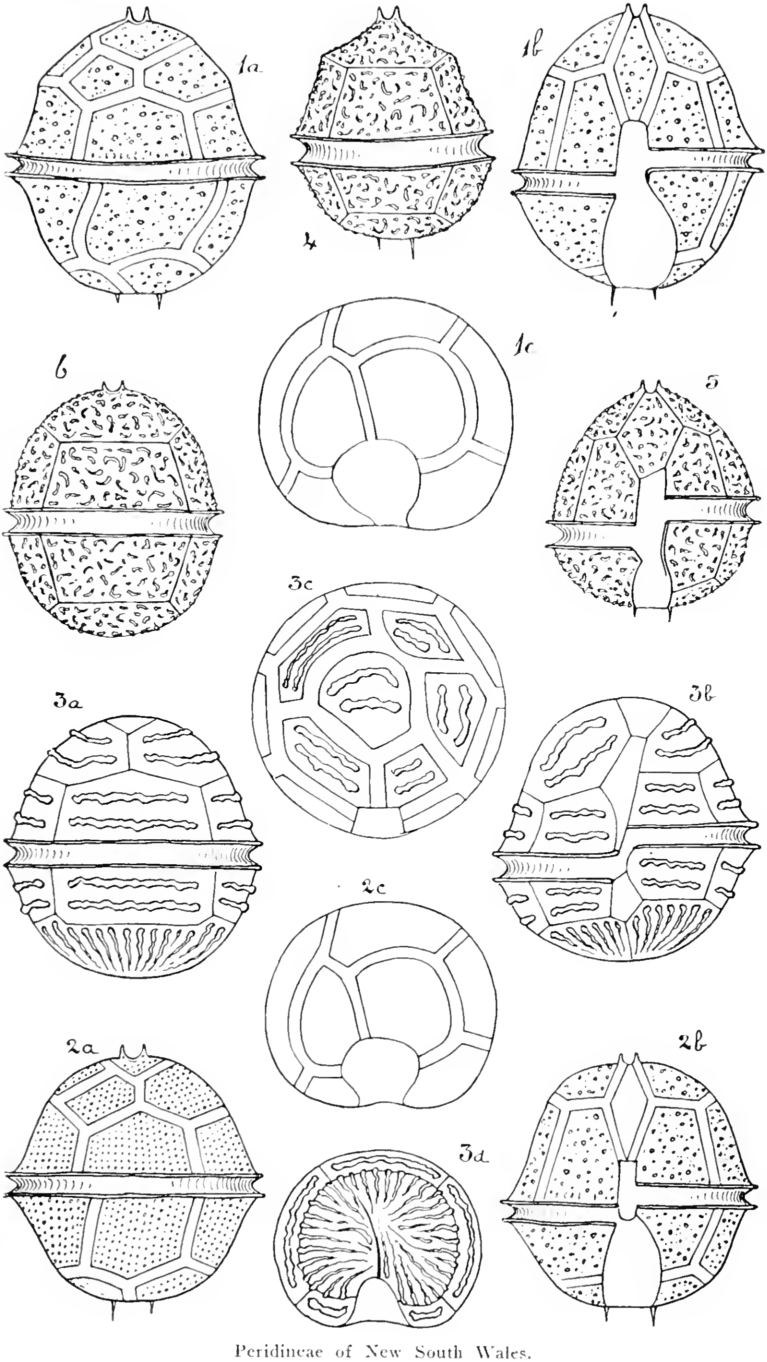
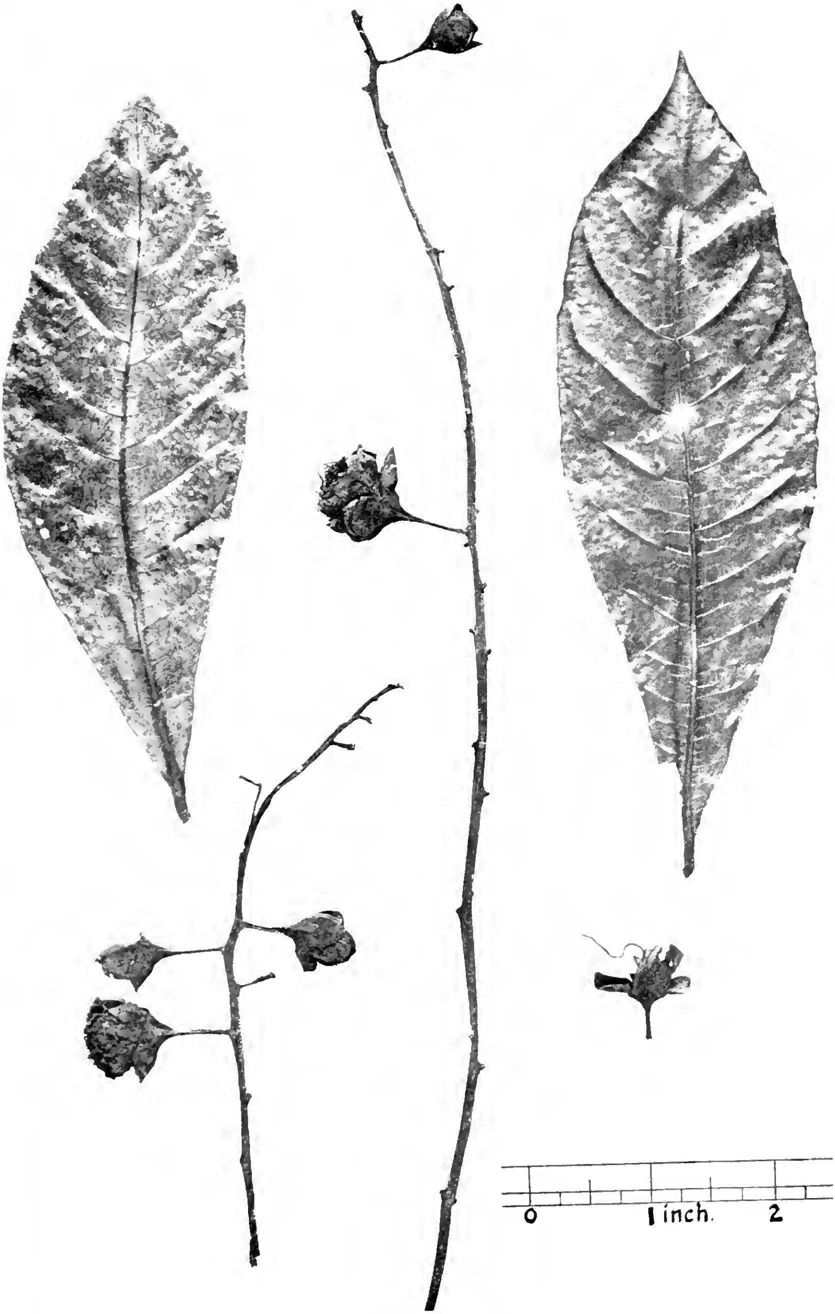
Peridineae of New South Wales.



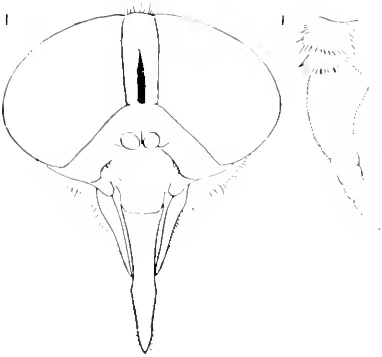
Peridineae of New South Wales.



Barringtonia longiracemosa n.sp.

Trench formed by subsurface drainage, Greenmount, W.A.
1. Looking downhill; 2. Looking uphill.

1



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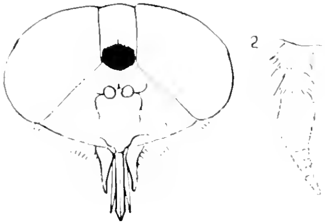

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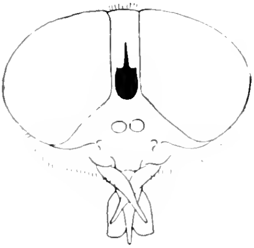

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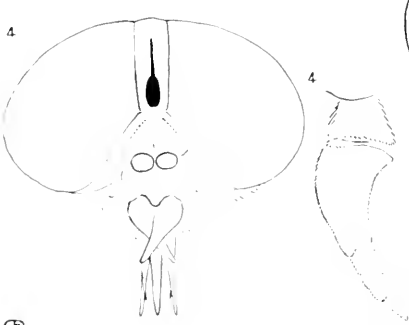

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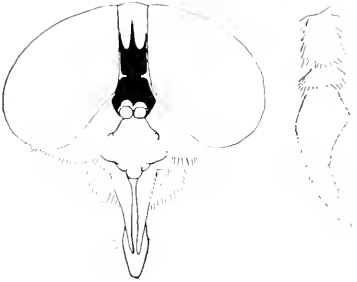

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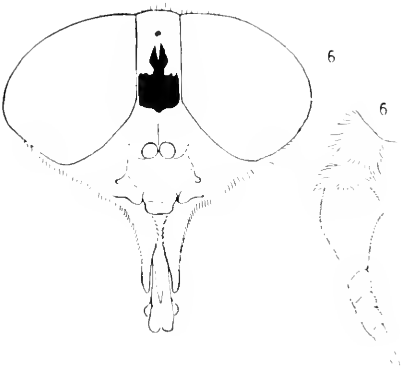

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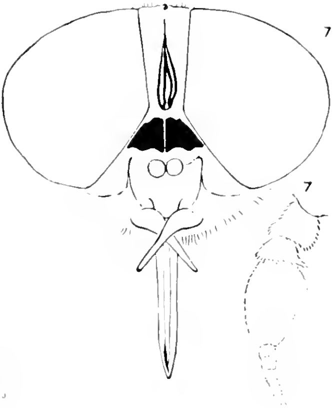
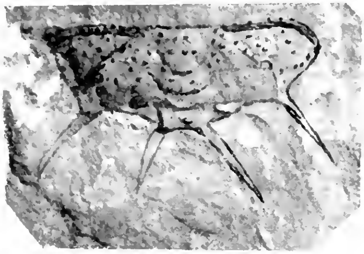


1-6. *Tabanus*; 7. *Silvius.*



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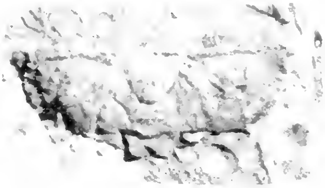

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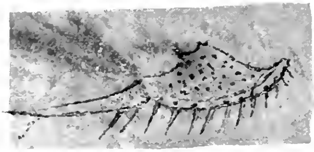

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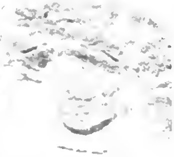

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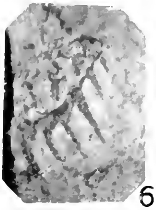

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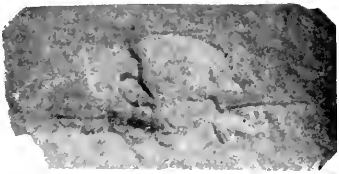

4

Trilobites from N.S.W.

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No. 173

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FOR THE YEAR

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WITH EIGHT PLATES

[Plates i.-viii.]

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