THE

PROCEEDINGS

OF THE

LINNEAN SOCIETY

OF

NEW SOUTH WALES

FOR THE YEAR

1936

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and 196 Text-figures.

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CONTENTS OF PROCEEDINGS, 1936.

PARTS I–II (Nos. 263–264).

(Issued 15th May, 1936.)

PARTS III–IV (Nos. 265–266).

(Issued 15th September, 1936.)

PARTS V–VI (Nos. 267–268).

(*Issued 15th December, 1936.*)

49538

ANNUAL GENERAL MEETING.

WEDNESDAY, 25th MARCH, 1936.

The Sixty-first Annual General Meeting was held in the Society's Rooms, Science House, Gloucester Street, Sydney, on Wednesday, 25th March, 1936.

Dr. W. L. Waterhouse, President, in the Chair.

The minutes of the preceding Annual General Meeting (27th March, 1935) were read and confirmed.

PRESIDENTIAL ADDRESS.

Since the Society last met the death of His Majesty King George V has evoked an unprecedented expression of personal loss by his subjects throughout the Empire. We, in common with all other members of this world-wide Empire, join in expressing our sorrow at the loss of one who, during the twenty-five years of his reign—a period which few Royal Houses have survived without ruin and disruption—has, by his personal influence, endeared himself to his subjects throughout the Empire, strengthened their loyalty and devotion to their sovereign, and made more secure the position of the Imperial throne of Britain. Your Council, on your behalf, has despatched, through official channels, a message of sorrow and sympathy to His Majesty King Edward VIII.

The concluding part of Volume lx of the Society's PROCEEDINGS was issued in December. The complete volume (466 plus lxxv pages, nineteen plates and 417 text-figures) contains thirty-two papers from twenty-seven authors, five papers being by Linnean Macleay Fellows and one by the Macleay Bacteriologist.

Exchanges from scientific societies and institutions totalled 1,865 receipts for the session, as compared with 1,866, 1,703 and 1,795 for the three preceding years. During the past year the following institutions have been added to the exchange list: Academie des Sciences d'Ukraine; Department of Geology of Shanghai Science Institute; Entomological Society of Finland; Nederlandsch-Indische Entomologische Vereeniging, Buitenzorg; Transvaal Museum, Pretoria; and Zoological Institute and Museum, University of Athens.

Since the last Annual Meeting the names of seven Ordinary Members have been added to the roll, three have resigned and the names of five have been removed on account of arrears of subscription.

We offer our hearty congratulations to Mr. A. F. Basset Hull on the honour of Membership of the Order of the British Empire conferred on him by His late Majesty, King George V.

On the occasion of the celebration of the Jubilee of the Faculties of Veterinary Science and Agriculture in the University of Sydney, messages of congratulation were sent on behalf of the Society to Professors J. Douglas Stewart and R. D. Watt.

Some time ago, on the death of Mr. J. J. Fletcher, members of the Society subscribed a small sum of money for some personal memorial. The Council recently decided to use this for the installation of clocks in the Society's rooms and for a small inscribed plate to be attached to the Society's portrait of Mr. Fletcher.

During last year your Council was actively interested in several matters concerning the preservation of the native flora and fauna.

Efforts initiated by the Bulli Shire Council, to which this Society lent its aid, resulted in the Government making available the necessary funds for the resumption of an area of land at the foot of Bulli Pass and Sublime Point. Thus there will be preserved one of the few remnants of rain-forest flora within easy reach of Sydney, and also an important part of the beauty of the view from Sublime Point.

Recently Professor Osborn brought under the notice of the Forestry Commission of New South Wales the desirability of declaring an adequate flora reserve in the State Forest south of Barrington Tops, and of adding to it the Williams River section of the Chichester State Forest. This is one of the finest remaining examples of untouched "rain forest", and forms the usual approach to Barrington Tops. This proposal of Professor Osborn was supported strongly by your Council, and word has been received that it is anticipated that an area of about 2,000 acres of the Williams River section of Chichester State Forest No. 292 will shortly be set apart as a Flora Reserve, and that the suggestion that the balance of the Williams River section should be added to the Flora Reserve is being investigated.

The protection of certain species of wild flowers was continued by proclamation by the Government for another year from 1st July, 1935, and, following representations made to the Department of Local Government by your Council, and supported by the Killara Community Service Club, the names of twelve species of orchids were added to the list. There is no doubt that, with this protection, there has been a very marked improvement in the growth of the wild flowers in the areas to which the proclamation applies.

Your Council also addressed a letter of protest to the Minister for Defence against the leasing of the remaining portion of George's Heights, in view of the almost inevitable destruction of native flora and fauna; and also brought under the notice of the responsible authorities the possible danger to the small ground fauna which might result if the Great Mexican Toad were introduced into Queensland and liberated as had been proposed.

Last year representatives of the Society met the Vice-Chancellor of the University and made suggestions for improvement in the conditions under which the Macleay Collections were housed. As a result I am pleased to be able to say that these Collections (and particularly the insect collection) are now housed under much more satisfactory conditions, and I take this opportunity of expressing the thanks of the Society to the University, and particularly to the Vice-Chancellor, for the interest shown in the welfare of the Collections.

The Imperial Forestry Institute submitted a proposal to the Sixth International Botanical Congress at Amsterdam last September for the adoption of the principle of the conservation of specific names (*nomina specifica conservanda*), a proposal which was supported by a number of scientific organizations, including our Society. The Congress rejected the proposal as put forward, but agreed to the appointment of an International Committee to draw up a list of names of economic plants, sanctioned by an International Committee, i.e., drawn up according to the International rules, such list to remain in use for a period of ten years. The Committee was appointed and will proceed with its work, and it is expected that the list will be published, accompanied by lists of *nomina ambigua, nomina confusa* and *nomina rejicienda.*

Charles Darwin's only visit to Australia took place in 1836, from 12th January to 14th March. A special meeting, in which scientific and historical societies joined, was held on 13th March at the University to celebrate the centenary of this visit.

The year's work of the Society's research staff may be summarized thus:

Mr. H. L. Jensen, Macleay Bacteriologist to the Society, concluded his work on the activity of microorganisms in the decomposition of organic matter in soil. His scheme of work comprised series of experiments dealing with (i) decomposition of the organic matter originally present in the soil ("humus"), and (ii) decomposition of organic matter added to the soil. His results indicate that it seems to be a general principle that the metabolism of the soil microflora, as a whole, becomes less economic with increasing temperature, i.e., transformation of a certain quantity of organic material results in the production of less microbial substance and more waste products (water, carbon dioxide, ammonia, nitrate, etc.) at higher than at lower temperatures. These two phenomena, accumulation of protein in microbial bodies and slow or absent decomposition of lignin at low temperature (as shown by other investigators) give a simple explanation for the tendency of plant residues to accumulate as "humus" in soils of cold climates and to be more completely decomposed under warmer conditions. One paper appeared in the PROCEEDINGS for 1935, and a final paper on this work has been completed and will appear in the first part of the PROCEEDINGS for 1936. In January he commenced work on the problem of nitrogen fixation and nitrification in Australian wheat soils. The first experiments have been undertaken in order to ascertain whether such soils are able to enrich themselves in nitrogen when provided with suitable energy materials (sugar or straw) and placed under favourable conditions of moisture and temperature, and what kinds of nitrogen-fixing microorganisms are active, if any. The soils so far examined have not given any clear evidence of biological nitrogen-fixation, but their humus-nitrogen appears readily available for nitrification.

Miss Lilian Fraser, Linnean Macleay Fellow of the Society in Botany, completed three papers in the series of studies on the Sooty Moulds of New South Wales, which were published in the PROCEEDINGS. In pursuing her investigations of the powers of resistance to heat and desiccation of the sooty mould fungi, she has discovered the presence, in air-dry living cells, of a bubble of gas occupying the centre of each cell in the position of the vacuole. This bubble may occupy as much as two-thirds of the cell, and, when water is absorbed by the cell, the gas is taken into solution in the cell sap. The presence of these bubbles has made it possible to determine the osmotic pressure of the cell sap, which could not be done by ordinary plasmolytic methods, and also the absorptive power of cells in atmospheres of controlled vapour pressure, as well as to measure the rate of water loss at different vapour pressures. Experiments have shown that dried mycelium (the cells of which contain gas bubbles) have a greater resistance to heat than mycelium in a moistened condition. Certain sooty mould associations have been found to be characteristic of distinct habitats, e.g., open sunny situations, shaded places, densely shaded and humid places, and these associations fall into definite groups when classified on the basis of their powers of resistance to heat and desiccation. Miss Fraser has also carried out microchemical tests on the walls of cultivated and naturally-occurring sooty moulds. These have shown that a large quantity of mucilage can be extracted; the nature of this mucilage and other substances extracted is being investigated. She has studied the distribution of epiphyllous fungi characteristic of rain forest regions, and has continued her ecological work in the Upper Williams River rain forest area. During the coming year Miss Fraser proposes (i) further experiments on resistance to light and desiccation, leading to a scheme of distribution of sooty mould fungi based on their reactions to heat, light and desiccation, and possibly to the relation of their type of resistance to their physical peculiarities; (ii) additional studies of the gas-bubbles observed during the past year; (iii) completion of work on absorption of water vapour, osmotic pressure, and imbibition already commenced; and (iv) completion, if possible, of the ecological work in the Upper Williams River area.

Dr. I. V. Newman, Linnean Macleay Fellow of the Society in Botany, made a second extensive search in the Cootamundra district for the natural home of *Acacia Baileyana*, the Cootamundra Wattle. As a result he has published a paper, "Studies in the Australian Acacias. v. The Problems of the Status and Distribution of *Acacia Baileyana* F.v.M." This paper gives the first precise records of the natural habitat of the species, with his conclusion that it is a true species. This conclusion is now being examined by germination tests with seeds collected from two of the localities described in the paper. The work on the genetics of *Acacia discolor* has been continued, and seedlings from the 1934 season's crosses have been established. The flower colour was found to be due to the presence of different pigments in different distributions. With improved technique more extensive crossing was done in 1935. No results are yet available. The study of the morphology of the legumes of *Acacia longifolia* and *Acacia suaveolens* has been concluded. It is clearly demonstrated that the legume is a single structure, laterad to the suppressed floral apex. The meristematic activity producing the parts of the flower is described as similar to that producing the leaves of the vegetative shoot, except that the flower is of limited growth. These findings are contrary to the theories of several well-known botanists, and a preliminary note has been published in the Proceedings. A paper giving a full account and discussion of the work has been completed and will appear in this year's Proceedings. During the coming year Dr. Newman proposes to work on polyspermy of the endosperm in *Acacia Baileyana* and *A. discolor*, and on the theoretical and comparative morphology of the legume; he will also continue the work on the genetics of *Acacia discolor*.

Mr. R. N. Robertson, Linnean Macleay Fellow of the Society in Botany, has investigated two distinct botanical problems during the year: the physiology of stomatal movement and the ecology of the Myall Lakes. Both these problems were begun before his appointment to a Fellowship. The problem of stomatal movement was approached from the point of view of the relationship of the movement to the composition of the gas of the intercellular spaces. The gas is analysed after extraction and early in the year the technique of extraction was perfected. Later it was decided to try a different method of analysis and a new apparatus was constructed. The method of investigation has proved very satisfactory. A series of results showing the relationship of several kinds of stomatal movement to changes in the gas composition has been obtained. This method of investigation is quite original and the results indicate that, in addition to clarifying the problems of stomatal movement, they will throw some light on the complex mechanism of photosynthesis in the green leaf. The ecological work (in collaboration with Professor Osborn) is being done on the Myall Lakes area where there is a complex aggregation of plant formations and communities. The area includes dune vegetation, swamp vegetation, eucalypt forest and sub-tropical rain forest. Considerable work has been done on the developments of the dune and swamp formations. The interesting problem of the distribution of the sub-tropical rain forest was also begun this year. During the coming year Mr. Robertson proposes to continue his physiological investigations of stomatal movement, and also the ecological work on the Myall Lakes area.

Five valid applications for Linnean Macleay Fellowships (one of which was ultimately withdrawn) were received in response to the Council's invitation of 25th September, 1935. I have pleasure in reminding you that the Council reappointed Miss Lilian Fraser, Dr. I. V. Newman and Mr. R. N. Robertson to Fellowships in Botany for one year from 1st March, 1936, and in announcing that the Council appointed Miss E. C. Pope, B.Sc., to a Fellowship in Zoology for one year from 1st March, 1936. We may wish all four Fellows a successful year's work.

Miss Elizabeth Carington Pope graduated in Science at the University of Sydney with First-class Honours in Zoology in March, 1935, and was awarded a Science Research Scholarship in Zoology. She has carried out research on the variation of fat and glycogen in oysters, and on the osmotic conditions prevailing in snails when submerged in various aquatic media. During 1935 she worked on the comparative anatomy of the Tiger Flathead. For her year's work as a Fellow she proposes to carry out a study of the morphology and physiology of the Port Jackson Shark and, if suitable live material can be obtained, an investigation of the digestion of Elasmobranchs. She proposes also to take part in a study of the ecology of Long Reef.

SOME OBSERVATIONS ON CEREAL RUST PROBLEMS IN AUSTRALIA.

Introduction.

As is well known, the main objective of our Society is the cultivation and study of the science of Natural History in all its branches. Many of these branches have claimed the attention of the occupants of the Presidential Chair in their addresses given in the years that have gone. Tonight it is intended to deal with certain aspects of what is often regarded as one of the newer branches of science, viz., Plant Pathology.

It is not without interest to recall that on the 25th February, 1880, Rev. J. E. Tenison-Woods, then President of this Society, contributing a joint paper with Mr. F. M. Bailey entitled "On some fungi of N.S.W. and Queensland", made the following statement: "In conclusion, we beg to draw attention to the very great importance which the study of fungi possesses for a young country like ours, which depends so much upon its agriculture. Sad experience has taught us how its prospects may be injured by blight, mildews, smuts, rusts, etc. Little or nothing is known about the origin and spread of these terrible pests, and it is equally certain that if they were known they would in a measure be provided against. Although by many mycologists the polymorphy of these blights has been doubted, yet experience seems to have decided that a blight of one kind affecting one class of plants may be transformed into a mildew or rust amongst cereal crops." Then, after quoting experiments overseas which proved the connection of barberries and wheat rust, the President continued, "In the locality referred to, the destruction of the barberry bushes has been the salvation of the crop."

Although so generally regarded as a new science, it is seen that the importance of Plant Pathology in Australia was pointed out in this Society more than 50 years ago.

Actually it is a very old subject. As Whetzel (1918) points out, Plant Pathology, like the other natural sciences, had its beginning in the dawn of man's civilization. Wild plants, as well as those which have been brought under cultivation, are subject to disease, and from the earliest times when man set out to utilize plant products, he noticed that diseases robbed him of some or of all his labour. As the art of writing was acquired, he recorded his observations and opinions respecting plant diseases.

Thus we find references in the early Hebraic writings to plants being affected by "blasting and mildew": the latter is believed to be the disease which at the present time we call rust. In those days the cause of the plant maladies was attributed to the Deity.

Of the Greeks, Theophrastus (370–286 B.C.) makes many accurate observations upon plant diseases, including rust. For example, he writes: "Generally speaking, cereals are more liable to rust than pulses, and among these, barley is more liable to it than wheat; while of the barleys, some are more liable than others, and most of all, it may be said, the kind called 'Achillean'. Moreover, the position and character of the land make no small difference in this respect; for lands which are exposed to wind and elevated are not liable to rust, or are less so, whilst those which lie low and are not exposed to wind are more liable. And rust occurs chiefly at full moon."

The Romans also clearly recognized the occurrence of plant diseases. So important was rust in Roman agriculture that a special rust-god pair, Rubigus and Rubigo, were evolved and an annual festival instituted to propitiate them. It fell on the 25th April, now such an important National Day in Australia. Pliny records that wheat was more seriously affected than barley. He recommends early sowing in order that the grain may ripen before the rust comes on, and the sticking of laurel branches in the soil throughout the field so that the rust may go over them.

Following the long lapse of time known as the Dark Era, during which science and learning were slumbering, in the 17th century there came a revival of interest in plant diseases. The philosophy and superstition of the ancients still dominated opinion respecting the causation of disease. One notable event was the enactment of legislation in 1660 in Rouen making it compulsory to destroy barberries because they had some mysterious connection with cereal rusts. During the next 200 years attempts were made to classify diseases and to find out what caused them. The general idea at the time was that the fungi found associated with diseases were plant products and outgrowths, rather than the cause of the troubles.

With the marked mycologic trend of thought about the middle of last century, and with such workers as Kühn, De Bary, Tulasne and Pasteur in the field, the proof that fungi were causal agents of disease was firmly established, and plant pathology as a science was placed on a sound footing. Its growth since those times has been very rapid, and the contributions it has made to the well-being of man have been many and valuable. Nevertheless the successes achieved in this field of endeavour should be neither exaggerated nor underrated, for there remain numerous problems of outstanding importance still awaiting elucidation.

Importance of Plant Diseases.

Plant diseases are of the utmost importance to the welfare of man. Not only do they continuously take a heavy toll of crops, but at times they have actually threatened the food supply of man. They become the limiting factors in crop production in many regions.

The group of diseases known as the cereal rusts well illustrate the above statements. Whilst it is always difficult to obtain exact figures which measure the losses caused by disease, many careful estimates have been made by trained observers, and these are probably not far from the truth in most cases. It is instructive to bring together some of these records of rust damage, and particularly those relating to recent times. The enormous losses occasioned by the cereal rusts are often not realized.

Taking the case of wheat, it is found that wherever this crop is grown, damage is caused by rust. Seasonal variations, of course, vastly affect the incidence of rust and the losses it causes, so that marked fluctuations occur in any given area.

Biffen and Engeldow (1926) suggest that the total annual loss caused by cereal rusts amounts to £100,000,000. This is a stupendous sum, but references to actual losses reported in different countries indicate that it may not be an over-estimate.

Foreign Crop Losses.

There are many records of losses in countries other than Australia. Last year provided a striking example of calamitous rust damage in the North American wheat crops. In U.S.A. it was estimated early in July that the yield would be 731,045,000 bushels. However, seasonal conditions favoured rust development, with the result that the actual quantity harvested was 599,000,000 bushels. If we place a value of 4s. per bushel on these 132,045,000 bushels lost, the damage totalled more than £26,000,000. In Canada it was similarly estimated that the yield would be 365,000,000 bushels. Actually the harvest amounted to 273,971,000 bushels, owing almost entirely to the ravages of rust. Taking the 91,000,000 bushels lost at the same value, the Canadian damage amounted to more than £18,000,000. In addition to this actual crop loss, practically all the grain harvested was of such poor quality that its value was reduced by several pence per bushel. Furthermore, it was estimated that 70,000,000 bushels of the Canadian crop were totally unfit for human consumption. All together these 1935 losses in North America exceed £60,000,000.

Güssow has stated that in Canada the average annual loss over a number of years exceeds £5,000,000. More recently the annual Canadian losses from rust have been put down by Greaney (1933) at 40,000,000 dollars. In India Mehta (1931) states that the annual loss is about £3,000,000. In Kenya Colony wheat rust is reported by Burton (1928) to be "a limiting factor in production". Rust damage in South Africa is well known, although actual figures are not available; Verwoerd (1935) states that several destructive epidemics between 1896 and 1902 nearly terminated wheat growing, and that during the past decade rust epidemics have appeared to become far more prevalent than formerly.

A severe rust epidemic occurred in Europe in 1932. Russian losses were estimated by Grooshevoy (1934) to have amounted to £32,500,000. The damage in Germany was put down by Klemm (1934) at from 30 to 60 per cent. of the normal yield. which that year amounted to 184,000,000 bushels. The Bulgarian damage was estimated by Dodoff (1933) to vary between 30 and 100 per cent. in a crop which yielded 50,000,000 bushels. According to Săvulescu (1933) Rumanian crops suffered to the extent of 50 per cent.; actually they yielded 55,000,000 bushels. It would seem that Biffen and Engeldow's figure was not excessive for 1932.

Losses in France in 1930 owing to stem rust are stated by Crépin (1931) to have amounted to 50 per cent. of the crops in some regions: the harvest in that year amounted to 231,000,000 bushels. In 1929 it was reported from Peru by Abbott (1929), that owing to rust attack the cultivation of wheat has been abandoned in coastal areas. Lindfors (1929) states that ravages of rust ruined the crop in Sweden in that year. Tunis crops in 1928, which yielded 12,000,000 bushels, suffered to the extent of from 40 to 80 per cent., according to Chabrolin (1929). Bailey (1928) records tremendous losses in 1927 when one of the worst rust epidemics occurred in Canada. Great damage was done to crops in Germany in 1926 when the crop harvested amounted to 95,000,000 bushels; these losses were stated (Gunther, 1927) to be the heaviest since 1891, when the loss was estimated to total Mk. 418,000,000. Heavy losses had also been experienced in 1925. Rust caused "a disastrous harvest" in the Argentine in that year, its crop amounting to 191,000,000 bushels. To cite one further case, the terrific rust epidemic in North America in 1916 was responsible for crop losses totalling 300,000,000 bushels, valued at about £75,000,000.

Rust Losses in Australia.

Turning now to Australian losses from rust, and particularly those in New South Wales, it is found that these have been serious. Wheat-growers from the earliest times have had grave difficulties to contend with; rust has not been the least of them.

Reviewing in some detail the first half century in New South Wales, we find that soon after the first settlers came to Australia 150 years ago they encountered the rust problem. Upon their arrival in Port Jackson in 1788, land was cleared and wheat sown in a piece of ground which is now included in the Sydney Botanic Gardens. Darnell Smith (1929) has recently reviewed this situation and confirmed the location. Collins (1798) refers to this work of preparing for the first wheat crop, and Governor Phillip, in a dispatch to Lord Sydney dated 15th May, 1788, and reprinted in the *Historical Records*, says: "The great labour of clearing will not permit more than 8 acres being sown this year with wheat and barley." Collins (ibid.), writing of the condition in September (p. 41), says: "The seed wheat that was sown here did not turn out any better than that at Norfolk Island: in some places the ground was twice cropped and there was reason to apprehend a failure of seed for next year." He had just recorded the return of the supply ship from Norfolk Island with news of crop failure there.

There are several references to the second Australian crop. Thus Collins (p. 88), writing of December, 1789, says: "In the course of this month the harvest was got in; the ground in cultivation at Rose Hill [the present-day Parramatta] produced upward of 200 bushels of wheat, about 35 bushels of barley, and a small quantity of oats and Indian corn, all of which was intended to be reserved for seed. At Sydney, the spot of ground called the Governor's Farm had been sown only with barley, and produced about 25 bushels." Governor Phillip, in a dispatch to Lord Sydney dated 12th February, 1790, gives this same information, and Barrington (1802) also quotes it.

Following upon a gap of six years in the record of crop production, Collins (p. 442), writing of December, 1795, says: "The harvest was begun this month. The Cape wheat (a bearded grain differing much from the English) was found universally to have failed. An officer who had sown 7 acres with this seed at a farm in the district of Petersham Hill [the present site of the University of Sydney], on cutting it down found it was not worth reaping. This was owing to a blight: but everywhere the Cape wheat was pronounced not worth the labour of sowing." The "blight" referred to here may well have been a plant disease, and possibly rust. Governor Hunter, in a dispatch written on 3rd March, 1796, to the Duke of Portland (*Historical Records*, Vol. i, p. 554), also refers to this crop in the following terms: "We have got our harvest in, and it is, upon the whole, in point of quantity as well as quality, very superior to anything which this country has before experienced, although a few blights and other accidents had disappointed the expectations of some very industrious settlers." In a further dispatch dated 28th April, 1796, Governor Hunter says: "At the time of my arrival in Sydney, although our wheat looked well, it was, nevertheless, at that time in that state liable to accident, as appeared afterwards in the destruction of the crop of some of the settlers by blight." The estimated wheat yield in that year was "from 35,000 to 40,000 bushels". The acreage under wheat was stated to be 2,721½ acres, hence the harvest yielded an average of from 12 to 14½ bushels per acre.

After a year's interval in the record, there is the following reference to the succeeding crop contained in a dispatch of Governor Hunter to the Duke of Portland, dated 1st November, 1798 (*Historical Records*, Vol. ii, p. 237): "We have been in an uncommon sultry season attended with a serious drought. . . . Our crops have suffered so much I do not expect we shall reap more than half the quantity we had a right to have expected."

The next year's crop is referred to in the dispatch by Governor Hunter, dated 20th March, 1800. He says (*Historical Records*, Vol. ii, p. 473): "Great part of our last unfortunate harvest, from which I had once the flattering prospect of at least 2 years' wheat in the colony, has been destroyed by an uncommonly wet season."

The first clear and definite reference to rust attack in Australia is interesting. It is made by Mr. Holt, who (Bennett, 1865) was superintending, in 1803, the agricultural operations of Captain Cox, one of the largest cultivators of that period. His holding was known as Brush Farm, in the Dundas district. The present Eastwood railway station is close to its site. It should be borne in mind that Holt's statement is that of an agriculturist; it contrasts rather sharply with statements made by other early historians who were naval officers and what not. In his "Memoirs", Holt writes (Vol. ii, p. 191): "On the 21st October, 1803, a more beautiful appearance of a successful harvest never flattered the expectations of a farmer; it was within 3 weeks of being ripe, the ears were full and plump, the straw clear and well-coloured, and in every respect it was gratifying to look at. . . . In 3 days it was completely destroyed by the rust [this word should be noted], and the produce of 265 acres was not worth £20. This extraordinary blight, which is, I believe, peculiar to this country, is produced by fogs, which come on suddenly and obscure the sky for some days; and if it happens when the wheat is nearly ripe, inevitably destroys it. It covers the whole straw and ear with reddish powder, like the rust of iron, which falls off as you walk through the standing corn and ironmolds cotton or linen articles like iron rust, and so effectually that in a very short time they rot and fall in pieces."

This statement is quoted by Rumsey (1915) and by Potts (1924), who both enlarge upon it.

Official records of the period also refer to this disaster in the young colony. Thus Governor King, in his dispatch of 8th October, 1803 (*Historical Records*, Vol. iv, p. 416), reports: "I have great pleasure in assuring your Lordship that we have the most flattering prospects of a plentiful harvest." Three weeks later, writing on 31st October, he says: "Our crops wear a favourable appearance of yielding such an abundance of wheat that I hope a reduction will be made in the price of that required from individuals next year." Later still, on 14th November, he writes: "Our very promising appearance of abundant crops has considerably suffered by some very unusual blights [this word should be noted] while the wheat was in bloom, which it is estimated have destroyed a fifth of what might have been expected." A last reference to this crop is contained in his dispatch of 1st March, 1804, which reads: "I am very sorry to say that we have experienced the greatest drought, with severe blight, which has much reduced our crop. . . . A change of seed would be a very great acquisition to be sent here from England . . . as there has been no change of seed for some years. As our last year's crop of grain was much injured by rust and smut [these words are noteworthy], about 500 or 1,000 bushels would be sufficient to bring the country into a general change of seed."

The next year's crop in New South Wales is alluded to in Governor King's dispatch of 20th December, 1804 (*Historical Records*, Vol. v, p. 171), as follows: "Our wheat harvest, which is all got in, is esteemed very abundant, although some partial appearances seemed likely to check it." The early expectations of the time that Norfolk Island might become a granary for the young colony were doomed to disappointment, as shown by the dispatch of the same Governor, dated 30th April, 1805 (p. 327): "The crops of wheat belonging to individuals [at Norfolk Island] have generally turned out favourable, but that of the Government's from the circumstance of its having been blighted, is conjectured will not yield more than 9 or 10 bushels to the acre."

The crop of 1805 is mentioned in King's dispatch of 1st November, 1805 (*Historical Records*, Vol. v, p. 600). He says: "It is a matter of much concern, knowing as we did the blighted state of last year's wheat, that another and more formidable enemy should lessen its quality." It is not within the scope of this address to deal with this additional insect trouble, which was called "fly moth in the grain". A later dispatch, dated 15th March, 1806 (p. 649), goes on: "In October it was found that the wheat when in blossom had in some districts suffered very much by the blights and lightning, and where grain was formed, much smut and rust were found. . . . In this place it is necessary to observe that among other causes of the wheat failure, the want of a change of seed and the careless manner in which many of the settlers prepare and sow their grounds are not the least. . . . And it is to be hoped that the exchange of wheat seed, which may be made with the new settlements under the exertion of 1 or 2 individuals in detaining a change from a small quantity of Red Lammas sent an officer in a letter from England, will in time remedy this want. . . . It is not my intention to discourage the growth of that valuable grain, but I do not think it safe for the settlement to rely wholly on wheat for the general support of every class of the inhabitants. It is soon destroyed in the field by the blight, rust, smut and caterpillar. Also in this climate by fire, both in harvest and in the stack, and by weevils and corn moths when in the granary. . . . I am also of opinion that the period is not far distant when maize must be more generally used than it is at present, because wheat cannot be raised for the general support of the settlement by those at present employed in agriculture."

In 1807, shortly after the arrival of a new governor, we have one further comment worthy of repetition, and then a fairly long gap in the record. Governor Bligh's dispatch of 31st October, 1807 (*Historical Records*, Vol. vi, p. 147), reads: "Indian corn is not so liable to the blight and other casualties as attend English grain. . . . Seasons of drought and south-west winds the country is sometimes injured by, as likewise by lightning, which causes blight, fly-moth and other pernicious insects." It is perhaps appropriate that there should be a gap after such a statement as this!

During this interval colonization of the continent was extended and wheat-growing spread to new areas. A decade later, Montague Smith (1818, p. 9) notes that the plains and the forest lands of the Hunter River district of New South Wales suffered from rust in wheat. He states that the only places which escaped were patches of virgin soil, although the weather conditions were favourable for rust development.

Five years later are found two references of interest. Barron Field (1823) states (p. 5): "The harvest we have just reaped on this side of the mountains, though its quantity is diminished on account of the drought, still proved a saving average crop. The extent of cultivation, compared with that of last year, is increased, the quality of the grain very superior and free from smut and grass seed." In the same year Commissioner Bigge (1823), on p. 19, makes the following comment: "Independent of the effects of an uncertain climate that is not generally favourable to the growth of European grains, and of a degree of heat that either too suddenly or too quickly follows a long series of heavy rains and scorches rather than matures it, the smaller grains of N.S.W., though equal in quality to those of the south of Europe, have to contend with frequent blights at Bathurst, and either from the proper seasons for sowing not having yet been discovered, or from some other cause, the wheat has been always affected with smut."

Atkinson (1826), in his interesting account of early New South Wales, also alludes to crop troubles. He says (p. 43): "Smut is prevalent in wheat. . . . Rust sometimes appears, but is not very common: and wheat is sometimes blighted by the hot winds and other causes in the month of November, more especially upon alluvial lands and other low and confined situations where there is not sufficient circulation of air."

Writers in the *Sydney Gazette* of this period make occasional illuminating references to the crops in the young colony. Thus in the issue of the 7th November, 1829, the Agricultural Report contains this statement: "A dry spell has been followed by September rains. There is much second growth wheat and a danger of smut, rust and blight." The issue of 9th January, 1830, refers to the harvest of this same crop as follows: "The quantity is not up to expectations. 50 sheaves of excellent creeping wheat have been taken to make 2 bushels of grain . . . and when exposed to blight, not less than 160 sheaves were threshed out for 1 bushel." This indicates a severe loss. Writing on the 30th January, 1830, regarding the harvest at Hunter River, the commentator says: "With the exception of a few, all the wheat crops (including Patrick's Plains and upwards) were almost total failures. . . . The late wheat, although to appearance twice the crop of the early wheat, has on an average rather fallen short, than exceeded the latter, on account of the smut and rust which assailed it shortly after the setting in of the rains."

The next season's crop at Hunter River is described in the issue of the *Gazette* of 30th November, 1830, as follows: "Almost all the wheat on the low grounds has been either totally spoiled or materially damaged: but the wheat on the high ground appeared of good quality, neither laid by the rains, nor (except in a few instances) affected either by blight or rust."

Disease was also present in the following season's crop, the reporter in the issue of the *Gazette* dated 3rd December, 1830, writing, in reference to wheat: "In some fields which were sown late, and on land which had been repeatedly cropped, smut and rust have appeared." And, dealing with Bathurst, he says: "The neglect of liming, or some other effective mode, has caused a great deal of smut to appear in the wheat of the present crops, which in all reasonable probability might have been avoided."

Next in chronological order may be mentioned the book of Dawson (1831). Writing of coastal areas (p. 366), he states: "The land is subject to blights in the upper districts. . . . The failure of the last two harvests in succession from droughts and blights, with a similar prospect for the third, is well known." And on page 400: "Mildew is little known in N.S.W.; the plants on the best soils are kept down by the droughts from that degree of plethora which occasions a rupture of the sap vessels in a more humid climate, and which in England I believe to be the cause of what is termed mildew, in contradistinction to blights, which in the higher districts in N.S.W. appear to be caused by the frosts, when the wheat is in bloom. . . . The mischief and distress which have ensued in consequence of the repeated destruction of the wheat crop from the above cause are beyond calculation, and especially during the seasons of 1827, 1828 and 1829. They serve to show, in the strongest manner, how very much the space is limited in which a crop of grain can be calculated upon between the mountains and the sea from the cause of blight alone, independent of the failures which arise from the effect of droughts."

The 1831 crop was again affected. In the *Sydney Gazette* of 12th January, 1832, it is stated, in regard to Bathurst: "In the wheat crops, smut is very prevalent; so much so that parts of some paddocks will not be reaped because the produce would not remunerate for the labour." Again, in the issue of the 2nd February, 1832, referring to Argyle district, the writer says: "The little wheat that has been threshed out yields very badly, being excessive smutty and blighted. Very little will come to Sydney market from hence this year." A few days later, on 7th February, the Bathurst harvest is again referred to as follows: "Most of the farmers complain of the smut, and some have certainly suffered very much from this cause." A more cheering statement occurs in the issue of the 3rd March, 1832, as follows: "A new variety which has been introduced by Mr. Cobb has been found to be peculiarly hardy, and was not affected by smut, although it was grown by the side of Red Lammas, which was much injured by the disease."

Taking finally the crop of 1832, it is described in the *Sydney Gazette* of 4th December, 1832, in these terms in a report dealing with the district of Argyle: "The wheat sown after the middle of April comprises more than three-fourths of the year's crop, is invariably bad, thin upon the ground, and very weak and full of smut." Two days later, the journal states, in regard to Illawarra district: "The wheat is very much affected with smut and rust." The Hunter River crop is described in the issue of 15th December, 1832, in these terms: "The wheat crops ripened quick, and reaping became general early in the month. Smut prevails in every part of the district, and rust partially appears. . . . The wheat from this district will be of inferior quality." Further reference to this same Hunter River crop is contained in the issue of 12th January, 1833, where one reads: "Many persons who had observed smutty ears in the crops in the earlier stages of its growth, have been agreeably disappointed in finding at the time of reaping that they had disappeared, and that their samples of wheat are clean and bright. It is stated that the dry weather has been the cause of this gratifying change, which, if true, is a new fact for consideration of scientific agriculturists."

This melancholy tale of disease damage to the crops goes on during the next hundred years, not only in New South Wales, but in the other wheat-growing States of Australia. It is intended to recount briefly some of the chief references to rust attack during this period. These are somewhat scattered in the earlier part, but show that the trouble persisted and was serious.

In 1860, the wheat crop in New South Wales was a complete failure, according to a report made by McAlpine (1891) to the Second Session of the Rust in Wheat Conference. He says that from 1862 until 1890 the presence of rust was recorded. The years 1863 and 1864 were bad rust years, as were also the years 1878 and 1889.

Holroyd (1864), in the 3rd Annual Report of the Acclimatization Society of N.S.W., records that crops in New South Wales began to show rust as early as October. Rust was an epidemic. He had travelled through many districts and had never seen a field that was not more or less attacked by rust. In the following annual report, Mackellar (1865) states that indigenous grasses are affected by rust. As far as wheats were concerned, "Egyptian Seven-eared" and the Egyptian bearded wheat were not subject to rust.

It was about this time that concerted action in Australia seems first to have been taken to deal with rust. Schomburgk (1873) read a paper in January, 1868, in which he quotes a report to the Board of Agriculture, Melbourne, which in 1865 had appointed a Commission to inquire into the cause of rust in cereals. Baron F. von Mueller's report to the Commission contains many interesting statements, which are quoted by Schomburgk. After urging that the inquiries should be extended over several seasons, he stresses two main considerations. First, he says, the main evidence points to the need for early sowing. "In the sap oliquescent from points of mechanical ruptures, especially if this sap should contain the needful proportion of incombustible elements, the seeds or spores of rust fungus are readily absorbed and brought into germination. . . . The accumulation of these minute vegetating parasites, especially on the stems of the cereal, impedes the free flow of sap, and in consuming and arresting it, prevents the young and weak fruit spikes to asssimilate the needful nutriment during that advanced season of the year when the rust fungus usually commits its ravages.

"Next in importance is the choice of early ripening varieties and those armed with the strongest coating of an epidermal siliceous deposit, and which are otherwise distinguished for their hardihood."

The report goes on to state that the Committee bears out the testimony of Sir Joseph Banks enunciated in an essay as early as 1806, and then republished in Koenig and Sim's Journal, that the seed of diseased wheat, though its aluminous portion might have shrivelled, can be employed for seed grain as long as the embryo is fairly developed. ". . . The seeds of rusted wheat, in most instances, produced a richer yield than crops raised from the best of imported grain—the latter, we need not say, taken from plants free of rust. This apparent anomaly is as yet not satisfactorily explained. . . . It would appear that the plants which succumbed to the fungus were generally of an undue succulence, flaccidity and softness. Tuscan seed wheat imported from Gumeracka, South Australia, turned out very soft and ruined by rust, whilst on the same fields, the English pedigree, Spalding's, red and rough chaff white wheat, remained perfectly free from disease. This singular fact clearly demonstrates that the occurrence of rust is not dependent on climatic conditions alone, but more likely on the effect and reaction of a variety of causes and of circumstances, none of them in themselves, perhaps, sufficient to produce the disaster. It would point also to an innate susceptibility of certain varieties to suffer from the devastation of the fungus. . . . Sowing wheat thickly induces rust. . . . Even if a crop is attacked, dry hot weather may check it. Soaking grain in slaked lime and water, 2 lbs. lime per bushel, and dressing land with common salt have been recommended. For absolutely guarding against successive failures of crops through ravages of parasitic fungi, when their fast spread in a previous season leads us to dread their reappearance, the farmer can only rely on the detection of varieties and kinds of grain which remain free from attacks of the parasite." The report goes on to give detailed observations on the cause of the fearful development and rapid spread of the disease in the season 1867–1868, when there was unusually wet weather in September and October followed by exceptionally early hot winds.

Apart from Victoria, similar action was taken in South Australia. Parliament voted £200 to the Royal Agricultural Society in 1864 to inquire into wheat diseases. McAlpine (1891) states that 1868 was a very bad rust year in South Australia, and in 1869 was published the report of this Commission appointed to inquire into disease in cereals. Further evidence of the confusion which existed between wheat diseases at that time is given by the fact that the first disease dealt with is labelled "Red Rust", and the fourth disease, "Black Rust and Smut"! Tepper (1879), also dealing with South Australia, states that he had first observed rust in 1854–5 near Lyndoch. Since then it had been noticed every year to a greater or less extent. In 1871–2 rust prevailed much in Monarto. At Mount Gambier it was noted in 1862 that "creeping wheat", the latest in ripening, was much less affected, if at all, than any other kind.

Professor Lowrie, reporting to the Second Session of the Rust in Wheat Conference in 1891, stated that rust had been known in South Australia since 1851, and since then had caused more or less loss. In the years 1867, 1889 and 1890 rust was general and resulted in immense loss. The 1889 losses are put down at from 2 to 3 million pounds sterling. These are set out as follows: South Australia, £1,500,000; Victoria, £750,000; New South Wales, £100,000; Queensland, £20,000; Tasmania, £30,000.

Queensland, growing wheat to a much more limited extent, also suffered from rust. Tryon (1889) refers to the rust damage and states that hard wheats enjoy a comparative immunity from the attacks of the fungus. He believed this to be due to the high silica content of these wheats.

With all the Eastern States suffering from rust damage, in 1890 steps were taken to convene conferences of delegates from the different States to consider the rust problem. These "Rust in Wheat Conferences" were held in 1890, 1891, 1892 and 1896, and volumes issued reporting the proceedings. These have been well summarized in early numbers of the *Agricultural Gazette of N.S.W.*, the first issue of which was printed in 1890. This still continues as a monthly publication, and, so far as New South Wales is concerned, is the chief source of information regarding cereal rusts in the crops.

At these conferences various phases of the rust problem were considered. Amongst the delegates who made outstanding contributions to the discussions was William Farrer. He affirmed that he had the greatest faith in the world that the solution to the rust problem could be found. His emphasis was, of course, on the breeding of suitable varieties of wheat.

Turning now to rust losses which have occurred since the "Rust in Wheat Conferences", we find estimates of which many are based upon carefully compiled figures. Guthrie (1914) states that the 1899 loss from rust amounted to £1,500,000. McAlpine (1905) states that 1903 was a bad year; Mr. A. H. E. McDonald, Director of Agriculture in New South Wales, estimated the losses in this State that year to have been three million bushels, worth more than £400,000. The same authority calculated that in the 1916 epidemic in New South Wales, rust losses exceeded £2,000,000.

Referring to the 1917 season, no actual figures are available, but Pridham (1918) writes: "Rust greatly affected the yields, and the best results were obtained from early-maturing varieties." Stening (1918), speaking of the same season, says: "The rains and muggy weather in the spring following upon the abundant winter rainfall supplied very favourable conditions for the development of red rust, which at the time of judging was present on stem and ear." McDiarmid (1918) remarks: "The season (1917) was not so conducive to rust as the previous one, and only occasional areas were affected to any extent."

Three years later further heavy losses occurred. The happenings in 1920, 1925, 1930 and 1934 have recently been critically examined by the Director of Agriculture in New South Wales, and the results kindly communicated to the writer. Mr. McDonald estimates that in 1920 the northern areas of New South Wales, producing 16 million bushels, were affected by rust to the extent of 10%. With wheat valued at 8s. 7d. per bushel, this loss would amount to £686,000. Reynolds (1921), Birks (1921), and Shepherd (1921) all comment upon the incidence of rust in the 1920 crops.

In the following year rust was again recorded in many of the crops, although actual losses were not computed. Birks (1922), dealing with the New South Wales Slopes and Plains says: "So general is the threat of rust, that rust-resistance is one of the main considerations in the selection of varieties for the district." Reynolds (1922) remarks: "It was again noticed that Hard Federation and Federation were both severely affected with rust." Referring to the Corowa district in this same 1921 season, Sparks (1922) reports that "rust was very prevalent, some of the crops being severely attacked".

Following upon a gap of three years in the record, McCauley (1925) writes of the 1924 harvest in the north-western district and refers to "losses of over 50% of the expected yield in some cases". Reynolds (1925) states that in the northern district that year "stem and flag rusts made rapid progress and caused pinched and light grain".

Next year, 1925, Mr. McDonald states that the general loss through rust was 5% of 60 million bushels, valued at 6s. 2d. per bushel, a total loss of £925,000.

Again, after a gap of three years in the record, losses are reported in the 1928 crop. Kerle (1929) estimated losses in the central-western district at 50% of the expected yield. Medley (1929) states that "stem rust alone was responsible for a general reduction in yield by at least 20%, while in varieties showing a heavy infection, the yield was reduced by fully 50%". Bartlett (1929), referring to this same season, says: "Eastern Riverina just escaped a very serious outbreak of rust."

A serious epidemic again occurred in 1930. The losses are estimated by Mr. McDonald to have been 2 million bushels, valued at 3s. 10d. per bushel, totalling £383,000.

Finally, as regards New South Wales, in 1934 heavy losses again occurred. Mr. McDonald states that rust affected an area producing 25 million bushels to the extent of 10%, causing a loss of 2,500,000 bushels valued at 3s. 3d. per bushel, totalling £406,250. There was also damage to quality on 5 million bushels, estimated at 3d. per bushel, or £62,500. Thus the aggregate loss in this year was £468,750.

A brief reference to the rust position in Western Australia, the youngest of the wheat-growing States, will serve to show that rust can be important there. Pittman (1935) states: "Western Australia suffers less from rust than the other Australian States. Serious losses occur only rarely. In fact, during the last 30 years, only on three occasions has the disease assumed serious proportions—in 1915, 1917, and 1934. Black stem rust assumed epidemic proportions in the N.W. parts of the wheat belt in 1934, many farmers suffering losses with some varieties amounting to total failure. It was no uncommon thing for yields to be reduced to the extent of 75 to 80%."

The rust problem is clearly one of considerable magnitude so far as New South Wales is concerned. Taking only the figures set down for the years 1916, 1920, 1925, 1930 and 1934, and omitting altogether the other records of serious damage not here assessed in terms of money (but unquestionably great), during the past 20 years the average annual loss in New South Wales has amounted to a quarter of a million pounds. This figure may seem surprising on account of the apparent insignificance of rust in the crops in some seasons.

It is emphasized again that there is remarkable diversity in the wheat-growing conditions in Australia. This applies also to New South Wales. Taking seasonal conditions, for example, and considering rainfall only, there are striking differences between its incidence in different districts devoted to wheat-growing. Not only does this apply to the averages computed for long periods—marking, for instance, "dry" areas and "good rainfall areas"—but in a particular district marked fluctuations occur. This all has a direct bearing upon rust attack. On an average, the northern and north-western districts, coming as they do within the influence of the monsoonal rains with early summer precipitation, are more liable to rust damage than say the western or south-western districts, in which the Antarctic rainfall system is so important. But departures from the normal rainfalls occur. For example, in a season like 1930, continuous early summer rains and muggy conditions were experienced in the western districts. Inoculum of rust was present in abundance, and the varieties grown susceptible, the whole resulting in heavy rust damage. Whilst on occasion a particular district may sustain a severe rust attack and other districts escape, at other times rust-favouring conditions may be widely experienced and all districts suffer severely from an epidemic.

Having thus reviewed accounts of Australian rust damage in past years, we now turn to present times.

Certain of the cereal rust problems have been receiving attention by the writer during the past 15 years, and it is proposed to summarize and discuss a few of the results that have been obtained. An army of workers is engaged upon rust problems in various parts of the world, and a large library of literature has been built up dealing with the subject. Scant reference only can be made to it in these pages. Excellent bibliographies are given in many of the recent papers that have been published.

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Factors Involved in the Causation of Rust.

In the causation of any plant disease, it is now well established that three factors must be considered, viz., the pathogen, the host and the environment. That is to say, the problem is a three phase one. Not only must the pathogen be present. There must also occur a susceptible host. And thirdly, the environmental conditions must be suitable for the pathogen to attack the host. In the earlier days of disease investigation it was not realized that each of these three factors must be dealt with. At first the pathogen alone was studied. Next the host in its relation to the parasite came up for study. Latterly, the need for studying environment in its bearing upon the other factors has been clearly recognized. Thus for the full development of rust leading to the production of what is called an "epidemic", optimal conditions—or a close approximation to them—relative to all three factors must operate. Absence of the pathogen, although susceptible hosts may be present in a favourable environment, will limit the production of an epidemic. Again, lack of susceptible hosts, even though abundant inoculum may be present in a favourable environment, will militate against the occurrence of an epidemic. Lastly, even though abundant inoculum and susceptible hosts may be present, no epidemic will develop unless the environmental conditions are favourable. The terrific damage is done when all three requirements are met. Then an epidemic occurs.

Each of these factors must therefore receive full consideration. How they act and react upon each other presents a very difficult problem, but one which has to be faced. Within the limitations of this address, it becomes necessary to direct attention only to some aspects of the work dealing with the pathogen, followed by some brief considerations regarding rust control.

The Pathogen.

As already stated, the causal agent of rust is a fungus. Rust fungi are very numerous. Thus McAlpine (1900) records 160 species in Australia, and many more have since been found. They are highly specialized parasites of higher plants. For example, the fungus which attacks wheat cannot attack oats. Certain of the cereal rusts parasitize grasses. On the other hand, many of those which occur on grasses cannot infect any of the cereals. This remarkable specificity in host range is a characteristic of many of these organisms, few groups outside the rusts showing such striking specialization.

In the cereal rusts, there are often two sorts capable of attacking a particular host. Depending upon the plant parts which are parasitized, they are often referred to as "stem rusts" and "leaf rusts". Wheat may be infected by stem rust and leaf rust as well as by a third known as yellow stripe rust. These are three distinct organisms, recognized as separate species. These again are quite different from the rusts which attack oats. Clearly there are numerous rusts of cereals, and each is regarded as a separate entity. What is found to apply to one of them will not necessarily apply to another. Each requires separate treatment.

There are, of course, many features in common to rusts. All are very minute fungi. All are obligate parasites, that is, they cannot at present be grown apart from their normal living host plants. In this regard they are quite different from many other disease-causing organisms which are regularly cultivated *in vitro*. When the appropriate means of thus cultivating rusts are discovered, many of the present obstacles to progress will disappear and a new era in rust investigations will open. All have a complicated life history; many are heteroecious organisms, passing through different stages of their life history on two distinct host plants.

In Australia the cereal rusts that have been identified are six in number. On wheat two occur, viz., stem rust (*Puccinia graminis Tritici* E. & H.) and leaf rust (*P. triticina* Eriks.); the yellow stripe rust (*P. glumarum* (Schm.) E. & H.) has not been recorded, and it seems unlikely that it would become serious in our wheat-growing areas because of the high summer temperatures. Oats are attacked by stem rust (*P. graminis Avenae* E. & H.) and crown or leaf rust (*P. coronata Avenae* (Cda.) E. & H.). Barley is parasitized by stem rust (*P. graminis Tritici* E. & H.) and leaf rust (*P. anomala* Rostr.). Rye harbours two rusts, viz., stem rust (*P. graminis Tritici* E. & H.) and leaf rust (*P. dispersa* E. & H.): the rust known as *P. graminis Secalis* E. & H. has not been recorded.

Of the cereals, wheat is the most important in Australia, and of its rusts, the stem rust does the more damage. Most attention is therefore devoted to this fungus.

Origin of Rust in Australia.

The question is often asked, "How did rust come to Australia?" We know only too well that our list of plant diseases has multiplied alarmingly in recent years, and in some cases we know how these dread pathogens have reached our shores. But in the case of rust, we can only speculate upon the source of the original inoculum.

The cereal rust fungi are not seed-borne. The original "seed" wheat brought to Australia by the early pioneers doubtless introduced smuts, but some other source must be sought for the rusts. As far as stem rust is concerned, barberries are not indigenous and were not brought to Australia until much later in the history of the settlement than the recorded outbreaks of rust. Hooker (1859) refers to *Barbarea vulgaris* being present in that year in Tasmania. In 1864, the Third Annual Report of the Acclimatisation Society of N.S.W. refers to *Berberis* sp. amongst the plants alive in the Botanic Gardens. No close relative of the barberry is a native, and no Australian plant is known to harbour the aecidial stage of the fungus, so that even if teleutospores were brought by the early settlers, they could not have initiated the disease.

Air-borne uredospores from cereal crops in India or elsewhere may have been responsible for the first infections of the early wheat crops. It is known that rust spores have been carried thousands of miles by wind, frequently associated with atmospheric dust. No such determinations have been made in Australia, but many observations are reported by workers in other countries (Stakman et al., 1923; Bailey, 1928; Chabrolin, 1929; Lambert, 1929; Peltier, 1929). These spores were in some cases trapped at very high altitudes. So far satisfactory determinations do not seem to have been made of the distance spores can travel without losing viability. This problem of spore migration is an important one, although difficult to solve. Whereas migration of uredospores across the Mediterranean Sea from Sardinia to Tunis (Chabrolin, 1929) is intelligible, it seems doubtful whether spores would remain viable after the long journey across the Indian Ocean to Australia.

Recently (Waterhouse, 1929) attention has been paid to the occurrence of cereal rusts on grasses in Australia. Certain of the introduced grasses are well known to be attacked by cereal rusts. One of our native perennial grasses, *Agropyron scabrum* Beauv., a near relative of wheat and a widespread plant in the south-eastern portion of the continent, has lately come up for special study as a host of wheat stem rust (Waterhouse, 1934, 1935). In regard to the origin of black stem rust of wheat, the possibility must be borne in mind of the rust having been present on this grass prior to the arrival of the early settlers. If this was so, then when wheat was grown the rust might be expected to spread to it from the grass host. Similarly, in the case of the other cereal rusts, appropriate native grass hosts may have been parasitized before the cereals were brought to Australia, thus providing the inoculum which initiated the cereal attack.

Seasonal Carry-over of Rust.

By whatever means rust originated in Australia, its seasonal carry-over must be considered. The persistence of a pathogen from season to season is a matter of the utmost importance from all points of view. In the case of perennial plants, perennation of mycelium often makes this simple. Some annual plants are known to produce seeds or grains in which the pathogen is directly carried over from generation to generation. But it is different in the case of rusts.

Considering black stem rust (*Puccinia graminis* Pers.), the complicated life history under Northern Hemisphere conditions normally provides for perennation. Teleutospores produced on wheat in the late summer lie dormant throughout the winter. In the spring they germinate and lead to the infection of the young shoots of the barberry. Thence the rust spreads on to young wheat plants, then coming into vigorous growth, and gives rise to the uredospore stage. Later, when the wheat is mature, the teleutospore stage is formed on the straw, completing the life history. Barberries, therefore, are most important in the initiation of the rust attack of the new crop in the spring. In Australia this is not the normal occurrence. Here the problem is not one of over-wintering, but of over-summering.

Different explanations of over-summering in Australia have been suggested, but it is now clear that living rust in the uredospore stage is present on sporadic crop plants or susceptible grasses all the year round. This inoculum is responsible for initiating the rust attacks in the crop. Not long ago it was stated that complete control of wheat stem rust could be had if only agreement could be reached, whereby all growers everywhere in Australia undertook to grow no wheat for one particular season, say from April to December. However, it will be seen from the accumulated evidence that this would not solve the problem.

In Tables 1, 2 and 3 are summarized the results of the examinations that have been made of field collections of three of the rusts, month by month.

TABLE 1.

Summary of the number of isolations of P. graminis Tritici *during each month of the period.*

Month.	Season of collection, ending March of															Totals.
	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936*	
Apr. ..					1		8	3		2			3		1	18
May ..	1	2					4	4	2	4	1	1	2		4	25
June ..		1		1		1		8		2	2		2		4	21
July ..	1						6	9	2	4	4		2	1	4	33
Aug. ..								6	1	13	5	1	4	4	3	37
Sept. ..	1				2	1	3	11		13	10	4	2		4	51
Oct. ..	12	1		20	9	17	10	27	6	30	20	28	13	33	25	251
Nov. ..	8	3	9	30	8	39	91	66	28	50	61	58	27	124	74	676
Dec. ..	7	4	4	35	5	8	43	11	27	40	36	36	29	44	35	364
Jan. ..	5	2	7	13		5	15	8	11	10	7	13	4	5		105
Feb. ..	3	2	3	1	1	4	7	2	5	13	1	2	1	9		54
Mar. ..	3		2		2	14	2	1	8		2	1	4	7		46
Totals ..	41	15	25	100	28	89	189	156	90	181	149	144	93	227	154	1,681

* The record for 1936 extends only to 1st January.

Attention is drawn to the fact that the opportunities for collecting rusted material have been distinctly limited. It is certain that much more rust was available in the field than is indicated by the collections submitted for examination. The figures given are, therefore, the more significant as regards presence of rust at any particular time.

The rusted material obtained during the non-wheat-growing season (late summer and autumn) has consisted mainly of "volunteer" wheat—or oat plants, as the case might be—but some of the specimens were grasses. *Agropyron* *scabrum* was one of the most notable. Some came from the wheat belt. Others were collected in regions of better rainfall, e.g., on the coast. But the latter could easily serve as foci whence infection could spread to the main wheat-growing areas.

TABLE 2.

Summary of the number of isolations of P. triticina *examined during each month of the period.*

Month.	Season of collection, ending 31st March of															Totals.
	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936*	
Apr.								4					5	4	4	17
May	2						1	5	2		1	4	3		2	20
June							2	9	6			4	2	1	1	25
July							1	11	4	10	7	2	4	3	5	47
Aug.								17	2	8	7	3	3	8	5	53
Sept.	1		1				2	41	2	18	9	7	4	8	3	96
Oct.	6					1	16	23	11	17	16	17	11	27	31	176
Nov.	3					2	75	16	6	12	31	31	29	90	64	359
Dec.	1						25	4	2		38	25	32	33	15	175
Jan.	1							1	4		2	16	4	2		30
Feb.						1				4	2	1		6		14
Mar.	1					2			1			4	2	5		15
Totals ..	15		1			6	122	131	40	69	113	114	99	187	130	1,027

* The record for 1936 extends only to 1st January.

TABLE 3.

Summary of the number of isolations of P. graminis Avenae *examined during each month of the period.*

Month.	Season of collection, ending March of															Totals.
	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936*	
Apr.							3	1	3	2	1	1	2		2	15
May							2	2	2	4			1		1	12
June						1			2				1	1	4	9
July	1			2				3		2					2	10
Aug.								2	1		2		1	1	1	8
Sept.	1							3	1	5	3	1	2		5	21
Oct.	5		1	5			1	5	2	5	14	3	6	4	9	60
Nov.	1		1	11	1	14	17	28	13	17	25	23	10	42	19	222
Dec.	2			11		3	11	3	2	26	10	19	10	15	12	124
Jan.	1		2			1	7	2	9	5	2	4	2	3		38
Feb.			1	1	1	1	2		1	9	1	2	3	5		27
Mar.					1	1	4		4		1	1	1	6		19
Totals	11		5	30	3	21	47	49	40	75	59	54	39	77	55	565

* The record for 1936 extends only to 1st January.

There has been evidence of rust development taking place first in the warmer—and earlier—districts. Thus crops in Queensland commonly show a marked rust development as early as August, and migrations from these to the areas in the north-west of New South Wales and thence to the southern areas have been demonstrated. On the other hand, heavily rusted wheat plants have frequently been submitted from the cold districts in the tablelands during February and March.

It is clear from the tables that rust in the uredospore stage is, like the poor, always with us. In considerations of rust control, there can be no possibility of eradication by simply not growing a crop for a season. Other means must be sought.

In concluding this section on the persistence of rust, it is pointed out that the recent discovery of natural infection of barberries in New South Wales (Waterhouse, 1934) does not affect the position. The production of the aecidial stage in September and October—vastly important as it can be in the production of new physiologic forms—can hardly have any appreciable effect upon the abundance of inoculum, already plentiful in the crops in the uredospore stage.

Physiologic Specialization.

The phenomenon of physiologic specialization is a matter of the greatest importance. It has received considerable attention in recent years. Many otherwise inexplicable happenings become quite intelligible in the light of our present knowledge of specialization, and future prospects of success in disease control are enhanced thereby.

In a general way, it may be stated that physiologic forms are groups of an organism, stable in their characteristics, which cannot be differentiated by morphological criteria, but only by their host relationships. Perhaps in the rusts and the powdery mildews are to be found the best examples of this phenomenon. For example, if uredospores of stem rust from wheat are placed on both wheat and oat plants under suitable conditions, the wheat is infected, but not the oats. If spores from oats are sown on the two cereals, only oats are infected. Thus the rusts—apparently identical morphologically—on wheat and oats are clearly differentiated from each other by their ability to establish themselves on definite hosts. This means that the former conception of similarity of the members within a species of such a fungus has to be altered. One now has to visualize the occurrence within the species of many groups of forms which differ in their parasitic capabilities. They are distinct entities. Thus the fungus named *Puccinia graminis* Pers. is now known to consist of a group of forms (about 150 in number) which attack wheat; another group of forms (about 10) which infect oats but not wheat; yet another group of about 14 forms infecting rye; and others again which infect certain of the grasses. The complexity of the problem of breeding for rust resistance is increased as a result of this advance in knowledge, and yet to ignore it is but to court failure in the endeavour. As Aamodt (1934) has recently stated, "Knowledge concerning the number, prevalence and distribution of physiologic forms of any pathogenic organism is of vital importance to the plant breeder. . . . To produce new varieties that are not resistant to all the forms of the pathogen that are present in the region in which the variety is to be grown is to acquiesce, at least, to only temporary or partial success."

To Eriksson (1894) belongs the honour of discovering the existence of specialized races of rusts. Stakman perhaps more than any other worker has contributed to our knowledge of the subject, both by his own brilliant and untiring researches and by the wonderful stimulus he has given to a large band of investigators, now scattered over the face of the earth. The technique developed by Stakman and Levine (1922) has come into general use.

The determination of physiologic forms is based upon their reactions as shown on a range of selected differential host varieties. In this work it is essential that the host varieties should be genetically pure. The inoculation experiments must be carried out on plants at the same stage of development, and within definite limits of temperature, light, humidity and nutrition. Variations in these environmental conditions may cause profound disturbances in the results. Thus it has been found (Waterhouse, 1929) that a rust giving a particular series of reactions defining it as a particular form under one set of environmental conditions, will have to be designated as something quite different on the basis of the reactions it gives under altered environmental conditions. Unless there is standardization of procedure, the gravest confusion is likely (Waterhouse, 1933). Difficulties of this nature would disappear if it were possible for one central institution to undertake all the work, but this does not appear to be practicable at the present time.

Turning now to the results that have been obtained in Australia, grateful acknowledgement is first made of the generous help always given by Drs. E. C. Stakman and M. N. Levine, as well as other North American workers, without whose assistance the work could not have been carried out. Many other workers have made invaluable contributions to this work.

Specialization in Puccinia graminis Tritici.

The 12 standard varieties so carefully selected by Stakman and Levine are used in this determination. Seedlings to the number of about 15 are grown in each pot. The first seedling leaf is moistened with sterile water, and by means of a flat sterile needle, the uredospores of the rust under examination are placed in this water which adheres to the leaf. The pots are then incubated in a saturated atmosphere for 48 hours. They are afterwards placed on well-lighted benches in the plant house at a temperature of 70–75° F., to allow the rust to develop. Notes are later taken of the infection that occurs.

The types of infection shown by each host are recorded by a simple notation. Six types of infection are recognized: 0 = immune; 1 = very resistant; 2 = moderately resistant; 3 = moderately susceptible; 4 = very susceptible; x = heterogeneous. Different degrees of infection of these types are indicated by symbols plus and minus.

Since the commencement of the studies in 1921, and carrying the work up to 1st January, 1936, eight naturally occurring forms of *P. graminis Tritici* have been determined in Australia. Their characteristics are set out in Table 4.

These forms have in the great majority of cases been isolated from wheat. Some have come from barley, some from rye, and yet others from grasses like *Hordeum murinum*, *H. maritimum* and *Agropyron scabrum*.

The forms 43, 44 and 54 show close similarities, and on the other hand, forms 45, 46 and 55 resemble each other. That is to say, these six forms, the only ones determined up to 1926, fall into two different groups. Tests covering several hundred varieties of wheat showed that there were many which showed either resistance or susceptibility to all three members of a group. This gave

TABLE 4.
Typical reactions of the naturally-occurring physiologic forms of Puccinia graminis Tritici *in Australia.*

Physiologic Form.	Type of reaction on differential wheat variety.											
	Little Club C.I. 4066.	Marquis C.I. 3641.	Kanred C.I. 5146	Kota C.I. 5878.	Arnautka C.I. 4072.	Mindum C.I. 5296.	Spelmars C.I. 6236.	Kubanka C.I. 2094.	Acme C.I. 5284.	Einkorn C.I. 2433.	Vernal Emmer C.I. 3686.	Khapli C.I. 4013.
11	4	4	3++	3++	4	4	4	3++	3++	3	0;	1=
34	4	4	3++	3++	4	4	4	3++	3++	1=	0;	1=
43	4	3++	0	0;	0;	0;	0;	x	1	3	1	0;
44	4	3++	0	0;	0;	0;	0;	3+	3+	3	1	0;
45	4	2	0	2−	4	4	4	x	x	3	3	1
46	4	3++	0	2−	4	4	4	1	1	3	3	1
54	4	3++	0	0;	0;	0;	0;	1	3	3	1	0;
55	4	4	0	2−	4	4	4	x	x	3	3	1

a clear basis for the selection of varieties worth using as parents in the crosses designed to give complete resistance to all six forms in the progeny.

Forms 34 and 11 are quite distinct from the other six. They are both well-known forms in many of the other wheat-growing countries where determinations have been made. Thus Dr. E. C. Stakman states that form 34 was the prevalent form in the United States of America in 1934.

The distribution of these forms in Australia and New Zealand is set out in Table 5. There have been excluded from these considerations the determinations made from an extensive batch of specimens submitted from New Zealand in 1935; these results are to be recorded separately. They show the presence mainly of form 34, with a few isolations of form 45 and form 11.

TABLE 5.
Summary of the number of isolations of physiologic forms of P. graminis Tritici *grouped according to their origin.*

Physiologic Form.	Origin of material.								Totals.
	F.C.T.	N.S.W.	Vict.	Qland.	S.Aust.	W.Aust.	Tas.	N.Z.	
11	1	6							7
34	36	1,000	54	73	98	49	14	20	1,344
43		130	7	17	3	2	1		160
44		39		4	2		1		46
45	1	33	3		7		2	1	47
46		43	4	3	1		9	2	62
54		4			1				5
55		9		1					10
Totals ..	38	1,264	68	98	112	51	27	23	1,681

It is seen that most of the identifications (nearly 80%) deal with New South Wales material. The facilities, thanks largely to the officers of the N.S.W. Department of Agriculture, are greater in this State than elsewhere. Nevertheless, many of the collections submitted from other States were random samples representative of extensive areas.

Taking next the time distribution of these eight forms during the period of the rust survey, the results are summarized in Table 6. Quite empirically the years are taken as beginning on 1st April of the year previous to 31st March of the year named.

TABLE 6.

Summary of the number of isolations of the naturally occurring physiologic forms of P. graminis Tritici *in Australia and New Zealand in the various years.*

Physiologic Form.	Season of isolation ending 31st March of the year stated.															Totals.
	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936*	
11														3	4	7
34					4	18	152	156	90	181	139	143	93	220	148	1,344
43	20	10	10	55	15	14	21				10	1		4		160
44	2	4		1	3	30	6									46
45	3			15	5	17	5								2	47
46	14		15	24	1	6	2									62
54		1				3	1									5
55	2			5		1	2									10
Totals ..	41	15	25	100	28	89	189	156	90	181	149	144	93	227	154	1,681

* The record for 1936 extends only to 1st January.

In the aggregate, form 34 has been present in 80% of the cases examined. It was unknown prior to November, 1925, only the two groups comprising the six forms having been found. On that occasion only form 34 was present in wheat received from Western Australia, where previously form 43 had occurred. Although many determinations were made from material collected in the south-eastern areas of Australia in that same season, form 34 was not found again until October, 1926. Then wheat from Curlewis in the north-western district of New South Wales yielded a mixture of forms 34, 43, 44 and 45. Additional samples from Western Australia received soon afterwards revealed the presence of only form 34. It also began to appear in various parts of the New South Wales wheat belt, associated with certain of the other six forms. Material (the first for that season) received a month later from South Australia, Victoria and Queensland gave the same result. Next year—in November, 1927—form 34 dominated the situation to the almost entire exclusion of the other six forms. Certain of these, and notably form 43, were found very infrequently in New South Wales as late as December, 1927: the last identification was made from Tasmanian material received in January, 1928. During the following seasons, when, it will be noticed, quite large numbers of samples were examined, only form 34 was found. Later, wheat from Queensland, followed soon afterwards by wheat from Grafton, in the far north-eastern corner of New South Wales, revealed the presence of form

43 mixed with form 34. Since then there has been one isolation of form 43, intermixed with 34, in samples sent in October, 1932, from the same Queensland locality where it formerly occurred, followed by a year in which it did not show up at all. The only other occurrences were in October and November of 1934, when samples from the same far north-eastern corner of New South Wales and the same Queensland locality yielded form 43 mixed with form 34. The season just ended failed to reveal its presence.

It is of interest to note that the results of the small series of tests made with material from New Zealand show general agreement with the Australian happenings. Prior to 1927 the three collections examined revealed the presence of members of the two groups of six forms. Since then, 20 collections (omitting the 1935 batch) spread over the period, have yielded only form 34.

To account satisfactorily for the change in the rust flora, leading to the dominance of form 34, is difficult. It is improbable that it arose from an aecidial infection of the barberry. It may have originated as a mutation, but one would scarcely have expected it to supersede the other forms so widely and so rapidly. If viable uredospores can be carried across the Indian Ocean in air currents, it may have come from India. Actually, Indian teleutospore material obtained in 1927 was found to yield form 16 from barberry infections produced in the plant house. In the present state of our knowledge, one can only speculate upon the origin of form 34 in Australia.

Independent evidence supports this finding of a change in the rust flora at about this time. Inquiries from several prominent wheat-growers in New South Wales have elicited the information that they have noticed that "since about 1927" varieties which formerly showed a degree of rust resistance have become completely susceptible to attack. As already pointed out, certain commercial varieties are resistant to one or other of the two groups of the six forms. For example, the variety "Canberra" is resistant to the first of the groups, and in localities where only these forms were present, it was not attacked. Similarly, a wheat like "Yandilla King", exhibiting resistance to a different group of forms, was not attacked in areas where only these rusts occurred. Now, practically all the commercial varieties of Australian wheats are susceptible to form 34. With its advent, "Canberra", "Yandilla King", and other sorts were attacked. Furthermore, it is noticeable in controlled plant-house work that this form produces uredo pustules on susceptible wheats in a much shorter time than any of the other forms that have been studied. This of course means increased virulence. One's own observations confirm the reports that crops in the field have been more heavily attacked during the past decade than formerly.

This change in the physiologic forms has profoundly affected the breeding problem, and further emphasizes the vital need for studying the physiologic specialization exhibited by a pathogen if varieties resistant to it are to be produced. The very great effect it had upon the breeding work for rust resistance has already been recorded (Waterhouse, 1930). By controlled work in the plant house and the field, agronomic types resistant to all the six forms were synthesized from crosses between two wheats, one carrying resistance to the first group of forms, the other having resistance to the second group. In 1927 their resistance "broke down". This was simply a manifestation of the newly arrived form 34, to which each of the parents used in the cross was completely susceptible.

Following upon the advent of form 34, it will be seen from Table 6 that there have been two further changes in the rust flora. In one case the origin of the form concerned can probably be indicated.

As recently recorded (Waterhouse, 1935), in rusted wheat collected in November, 1934, by Mr. J. G. Churchward at Bectric, N.S.W., and by Mr. R. N. Medley at Leeton, N.S.W., the hitherto unrecorded form 11 was found, mixed with form 34. In March, 1935, the same two forms occurred on rusted *Agropyron scabrum* growing near Yetholme. Still more recently (November-December, 1935) the same two forms have been identified from rusted wheat collected at Goolagong, Sebastopol, Bathurst, N.S.W., and Canberra, F.C.T. Form 11 has become more widespread in the year.

Now form 11 has been found (unpublished data) to arise from barberries which have been inoculated under controlled conditions with form 34. This means that the latter is heterozygous. So far several forms, including form 11, have been identified as barberry derivatives of form 34. It is significant that in November, 1933, the first occurrence was recorded of natural infection of barberries in Australia (Waterhouse, 1934). This took place on the Central Tablelands at Yetholme, N.S.W. The evidence pointed clearly to *Agropyron scabrum* being the source of the inoculum which infected the barberries. Only a little of the uredo stage was available for examination in that year and yielded only form 34. In 1935, when a search was made for rust on this grass in the same area, form 11 was found as well as form 34. Doubtless it had spread to wheat also in the meantime.

There is a clear case for eradication of barberries throughout Australia, following upon the good example set by so many other countries. It is probable that natural infection is uncommon, but there is proof that, at least occasionally, Australian conditions make it possible for infection to take place. From only one such infection there is always the possibility of new forms arising. These may completely upset the work of breeding for rust resistance. The legislative action recently taken which makes barberry destruction compulsory is to be highly commended, and should be loyally carried out. The only regret is that eradication was not commenced earlier, following upon the evidence presented 15 years ago (Waterhouse, 1921), that stem rust in Australia had not lost its ability to infect the barberry.

As further showing the extreme importance of the barberry in relation to the derivation of physiologic forms, the following facts recently communicated by Dr. E. C. Stakman are illuminating. In last season's rust survey in U.S.A., a total of 1,375 identifications of forms was made. Of them, 1,209 were uredial identifications and comprised 22 forms. The remaining 166 were aecidial (barberry) identifications and were found to comprise 25 forms. That is to say, the ratio of number of forms to number of identifications is: uredial, 1 : 55; aecidial, 1 : 7.

Striking as this difference is, it should probably be even wider. Dr. Stakman states that a number of forms have been listed as "Uredial" identifications, which might have been placed in the heading of "Aecidial identifications", because they were obtained from uredial material in the immediate vicinity of barberry bushes under circumstances which make it certain that the rust came directly from the barberries.

Not only did the barberry multiply forms in this way, but the aecidial forms thus produced were found in many cases to be forms which attack "Vernal Emmer" and "Yaroslav". This is the wheat which has been used with such marked success in crosses with vulgare wheats to give resistant varieties like "Hope". These wheats in turn are largely used as resistant parents in crosses. A multiplication of forms capable of attacking these wheats simply vitiates the plant breeders' work.

The second change in the flora is the recent recurrence of form 45. After an absence extending back to 1927, this form was found, mixed with forms 11 and 34, in rusted wheat submitted from Bathurst, N.S.W., and Canberra, F.C.T., in December, 1935. In passing, it should be mentioned that it has also been found in material sent from New Zealand. The rusted wheat forwarded by Mr. F. W. Hely from Canberra was the variety "Ford", which, he reported, was more heavily attacked than "Dundee". This is important, since wide experience has shown that "Ford" is much more resistant to form 34 than is "Dundee".

No clear explanation of the recurrence of this form can be given at present. It may be significant that at Bathurst and Canberra, as well as in New Zealand, barberries are known to occur, and in the former area are known to have been recently infected. In experiments with the heterozygous form 34 alone, form 45 has not been recovered as a segregate from barberries, although form 11 has. Work is in progress to determine whether a cross between form 11 and form 34 gives rise to form 45.

Specialization in Puccinia graminis Avenae.

Oats are sometimes severely attacked by stem rust. This rust does not attack wheat. Nevertheless it infects the barberry and is closely related to the wheat stem rust. Johnson and Newton (1933) have recently been able to hybridize form 9 of *P. graminis Tritici* with form 6 of *P. graminis Avenae*, leading to the production of an entirely new form of rust. Specialization studies of oat stem rust which have been in progress for some time here are briefly summarized.

The same general methods are used in the determination of the physiologic forms of this rust, utilizing, of course, a group of oat varieties instead of wheats, to effect the differentiation. The same precautions regarding purity and the same control of environmental conditions are essential if trustworthy results are to be obtained. One of the differential varieties named "Joanette" shows marked differences in its reactions under different temperature conditions. Thus a rust determined as, say, form 1, under winter temperature conditions becomes form 2 under summer temperatures. The reaction on "Joanette" changes from resistance to susceptibility. It is for this reason that, in the absence of facilities for doing all the cultural work under conditions of controlled temperature, forms 1 and 2 are here grouped, and in the same way and for the same reason, forms 3 and 7 are linked. Low temperatures for determinative work are clearly indicated as essential.

To date, five naturally occurring physiologic forms of *P. graminis Avenae* have been found. The typical reactions of these forms are shown in Table 7.

These identifications have been made mainly from cultivated oats. Wild oats and certain other grasses also have been found to be important hosts of this pathogen, notably *Vulpia bromoides*, *Hordeum murinum*, *Dactylis glomerata*, *Phalaris minor*, *Calamagrostis aemula*, and *Koehleria cristata*.

These five forms fall into three groups. Form 6 stands alone. Forms 1 and 2 definitely occur, but are only separable under conditions of low temperatures. Forms 3 and 7 behave similarly.

The distribution of these forms is set out in Table 8.

TABLE 7.

Typical reactions of the naturally occurring physiologic forms of P. graminis Avenae *in Australia.*

Physiologic Form.	Type of reaction on oat variety.		
	White Tartar.	Joanette.	Richland.
1	2	1	2−
2	2	3+	2−
3	4	1	2
6	4	3+	4
7	4	3+	2−

TABLE 8.

Summary of the number of isolations of physiologic forms of P. graminis Avenae *grouped according to their origin.*

Physiologic Form.	Origin of material.								Totals.
	F.C.T.	N.S.W.	Vict.	Qland.	S.Aust.	W.Aust.	Tas.	N.Z.	
1 and/or 2	7	386	17	32	28	8	7	5	490
6		6	2						8
3 and/or 7	1	40	2	2			6		51
Totals ..	8	432	21	34	28	8	13	5	549

Here again the great majority of identifications were made from material collected in New South Wales owing to the better facilities for its submission. It is seen that nearly 90% of the identifications proved to be forms 1 and/or 2. The "forms 3 and/or 7" have in the main been form 7: in a few cases it was not possible to make certain of this separation, and for this reason they are grouped. Together they comprise about 10% of the determinations. Form 6—the most virulent of all five forms—fortunately has been found only rarely, and not at all in recent years.

The distribution in time of these identifications is summarized in Table 9.

It is seen that no change like that recorded for the wheat stem rust is shown here. Forms 3 and 7 are characterized by their capacity to attack "White Tartar" as well as other "side" or "banner" oats which are resistant to forms 1 and 2. These oats, with a few exceptions, are late-maturing sorts, and so it is usual to find forms 3 and 7 only late in the season. It has not yet been possible to make experimental tests dealing with the carry-over of these forms from season to season.

Specialization in Puccinia triticina.

There is often a tendency to under-estimate the importance of leaf-rust of wheat. Observation convinces one that it does more damage than many people think. It is more insidious in its damage than stem rust. It seldom wipes out

TABLE 9.

Summary of the number of isolations of the physiologic forms of P. graminis Avenae *from Australia and New Zealand in the various years.*

Physiologic Form.	Season of isolation, ending 31st March of the year stated.												Totals.
	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936*	
1 and/or 2	30	3	21	38	39	38	62	54	48	34	72	51	490
6				2	6								8
3 and/or 7				7	4	2	13	5	6	5	5	4	51
Totals	30	3	21	47	49	40	75	59	54	39	77	55	549

* The record for 1936 extends only to 1st January.

a crop as does stem rust under epidemic conditions. A season favourable for the development of a stem rust epidemic also leads to abundant development of leaf rust. But its onset is overshadowed by the stem rust, which causes severe shrivelling of the grain as one of its usual effects. Leaf rust usually appears earlier in the season, sometimes being known as "spring rust" in contrast with the name "summer rust", given to stem rust because of its later attack. However, in the absence of severe stem rust development the leaf rust alone can do much damage. Humphrey (1934) has summarized investigations on this rust which show that it causes a definite diminution in the yield, expressed firstly in the production of fewer heads per plant and fewer grains per head, and secondly in reduced grain size.

In the past there has been a good deal of confusion regarding the determination of physiologic forms of this rust. There has not been the same unanimity regarding the appropriate differential varieties as in the case of the stem rusts. Numerous physiologic forms certainly occur. Mains (1933) lists 53 forms, but it is probable that some of those determined by other workers are different from any of those recorded by Mains.

Numerous determinations of *P. triticina* have been made in Australia, with the result that the reactions characteristic of the form recorded by Johnston and Mains (1932) and Mains (1933) as form 26 were shown. But the chance discovery was made in 1926 that in some cases this rust gave a strongly resistant reaction on "Thew", one of Farrer's varieties of wheat, whilst in others the reaction showed full susceptibility. That is to say, "Thew" served to differentiate in the clearest way between two entities which are each *P. triticina* form 26. For the present these are designated "*Aust. 1*" when Thew is resistant, and "*Aust. 2*" when it is susceptible. These two forms show significant differences in their uredospore measurements (Waterhouse, 1930), and are now known to be readily separable on numerous varieties in addition to "Thew". When crossed, they give rise to new forms (Waterhouse, 1932).

In the specialization studies that have been in progress since 1926, the separations have been made on the above basis. The distribution of these two forms in space and in time is summarized in Tables 10 and 11. In all cases the isolations came from wheat, with the exception of one from *Agropyron scabrum*.

TABLE 10.

Summary of the number of isolations of the two Australian physiologic forms of P. triticina *grouped according to their origin.*

Physiologic Form.	Origin of material.								Totals.
	F.C.T.	N.S.W.	Vict.	Qland.	S.Aust.	W.Aust.	Tas.	N.Z.	
Aust. 1	11	423	21	20	33	9	1	8	526
Aust. 2	9	393	19	14	36	5	1	8	485
Totals ..	20	816	40	34	69	14	2	16	1,011

TABLE 11.

Summary of the number of isolations of the physiologic forms of P. triticina *from Australia and New Zealand in the various years.*

Physiologic Form.	Season of isolation ending 31st March of the year stated.										Totals.
	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936*	
1	3	52	60	20	35	63	58	54	107	74	526
2	3	70	71	20	34	50	56	45	80	56	485
Totals	6	122	131	40	69	113	114	99	187	130	1,011

* The record for 1936 extends only up to 1st January.

It will be seen that the two forms have occurred with approximately equal frequency. In the great majority of cases, both forms have been present in the one collection examined. It has been interesting to find repeatedly that differential varieties like "Thew", growing in the field where both forms occur, show on their mature leaves both susceptible and resistant reactions. Whilst many varieties are known with resistance to "Aust. 1", few have been found which are resistant to "Aust. 2".

It will be noticed that both these forms have been found in samples from New Zealand. Several other forms have lately been determined on wheat from the Dominion. The records of these, as well as of the stem rust identifications, are to be made available later.

Specialization in Puccinia coronata Avenae.

This "crown rust" or "leaf rust" of oats is most frequently found in the better rainfall regions, e.g., in our coastal areas where oats are mainly grown for green feed. Serious attacks sometimes occur and lead to considerable loss. The effects of this rust on oats have recently been studied by Murphy (1935).

Specialization studies here have only recently been commenced, thanks to the receipt from Dr. H. B. Humphrey of the set of differential varieties of oats used by U.S.A. workers (Murphy, 1935). Previously it was possible only to test collections on two or three varieties which had been found to give resistant reactions. No differences were discernible in the isolations, although they came from divergent sources.

Now that the accepted differentials are available, the studies are placed upon a proper footing. To date three physiologic forms have been determined in New South Wales, viz., form 6 (Murphy, 1935) and two others not recorded and not yet assigned their appropriate numbers by Dr. H. B. Humphrey, to whom they have been submitted for this purpose. It is not yet possible to express an opinion on the relative abundance or the distribution of these forms. No species of *Rhamnus*, the aecidial host, are indigenous to Australia, and there is no record of any infections of such plants as have been planted in shrubberies. Infections in the plant house under controlled conditions have been obtained.

Specialization in Puccinia anomala.

Leaf rust of barley is known at times to cause considerable damage to barley grown for green feed in coastal areas. Identifications have been made from a number of collections obtained from widely divergent localities. Only one physiologic form has been found. It closely resembles the form 1 recorded by Mains (1930). It has been found, however, that the reactions of this Australian rust on certain varieties which were not included by Mains in his set of differentials are different from those shown by his form 1. Thus, by making use of some of these varieties, it can be shown that the Australian rust must be considered as different from the American, therefore constituting a third known form. *Ornithogalum umbellatum*, the aecidial host, is not indigenous.

Specialization in Puccinia dispersa.

Rye grown on the coast for green feed is also sometimes very heavily attacked by leaf rust. Little indeed seems to be known concerning its specialization. No differential set of varieties has been selected for the determination work. Indeed, until December, 1935, no rye was available here which showed any resistance to this rust. Then a plant was noted growing in an open-pollinated row of "Star" rye at Hawkesbury Agricultural College, which showed the distinct hypersensitive flecks characteristic of strong resistance in that plant. Adjacent plants were heavily attacked. Grain of this resistant plant has been saved, and it is hoped that it may give a starting point for specialization studies of this rust. No indigenous species of *Anchusa*, its alternate host, are known to occur in Australia.

Conclusion of Specialization Studies.

The investigations have established the fact of specialization in the Australian cereal rusts, and revealed the identity of the forms present. This gives a basis for breeding for rust resistance. It is clearly essential that the work be continued, not only to assist the breeder for resistance, but also to gain information leading to a fuller understanding of the phenomenon of specialization.

Rust Control.

So far no method of entirely eliminating cereal rusts has been developed. Various practices can be depended upon to reduce crop losses very markedly. That complete control will eventually be gained now seems certain.

Cultural practices have been improved greatly during this century. The aim, of course, has been to increase yields, and this has been largely attained. In part this has been effected by reducing the incidence of disease.

Careful selection of the land is the first consideration. Plants in hollows and low-lying land remain wet with dew and rain and tend to produce rank growth, thus providing better conditions for rust infection than plants on higher ground with its better air and soil drainage. In a paddock with an uneven surface it is usual to find the heaviest rust development in the low-lying portions.

Proper preparation of the soil so that a suitable seed bed is available should not be neglected. Weed growth, if not prevented, may assist rust development. Weeds may include rust-susceptible hold-over plants infected by rust. These would pass the inoculum on to the crop. Again, by overshadowing the crop plants, strongly-growing weeds may make the conditions in their vicinity more conducive to rust development.

Early sowing may be of the utmost importance. Some wheats for their proper development demand a long growing season. Varieties of this nature were in common use before William Farrer commenced his monumental work. Varieties which do not mature until late in the season are more likely to meet with conditions favourable to the spread of rust. There is a race between the wheat plant and the rust parasite. If the wheat can ripen before much rust is present, it may escape damage. Hence, apart from the use of early-maturing sorts, early seeding on well-prepared land is important.

The application of the proper fertilizers may assist in reducing damage. The real test of the value of fertilizers lies, of course, in their effect upon yield and quality of the product. But it should be borne in mind that excessive use of nitrogenous fertilizers may lead to severe rust damage. Too much nitrogen may cause heavy flag growth and delay the ripening, thus giving rust both a better and a longer opportunity of developing. On the other hand, phosphatic and potassic fertilizers applied to soils which respond to them promote the development of a good root system (Watt, 1914), stiff straw, and early ripening. These features reduce damage from rust.

The use of early-maturing varieties may be of the utmost value in minimizing losses from rust. William Farrer, by developing varieties which were suited to Australian conditions and were early-maturing, effected a wonderful improvement in our wheats, apart from any of the other contributions he made. Even in recent seasons when *P. graminis Tritici* form 34 has severely damaged crops, an early-maturing variety like "Florence" has matured plump, well-filled grain owing to its capacity to ripen early and thus escape rust damage. In passing, it is pointed out that "rust escape" may be regarded as being different from rust resistance. It is obvious that varieties must have other desirable qualities in addition to earliness if they are to be worth growing. Apart from its serious defect of being so very susceptible to disease, Farrer's "Federation" marked a striking improvement in our wheats and, in the breeding work in progress, it is being largely taken as the type to aim at, plus resistance to disease.

It has been remarked by writers that Farrer was responsible for changing the colour of our wheat fields. Varieties grown before his day were mainly golden-chaffed. Farrer wheats like "Federation", "Florence", "Canberra", and others have bronze chaff. When these came into cultivation the colour of the wheat fields was changed from gold to brown. Recently an observation in the field indicates one advantage which the dark-chaffed wheats have over the light-chaffed. It is well known that during harvesting operations work cannot be commenced in the morning if the heads are still wet with dew. It was remarked that heads of a bronze-chaffed variety were dry and ready for harvesting earlier than those of a golden-chaffed variety in the same paddock. Absorption of heat apparently made the difference. Because time is so often an important consideration in harvesting operations, a difference of this nature may significantly favour the dark-chaffed variety.

Eradication of alternate hosts should always be aimed at. This may not be effective in Australia in preventing infection of the crop early in the spring—a very important consideration in the Northern Hemisphere. But it has been shown in the case of stem rust of wheat (Waterhouse, 1929), as well as that of leaf rust (Waterhouse, 1932), that new physiologic forms arise by hybridization on the alternate host. Clearly, then, the presence of an alternate host constitutes a grave danger of increasing the forms of rust, with consequent increased difficulty in breeding resistant varieties.

The introduction of infected straw from overseas should be prevented. In the past, straw has been imported for the use of stock during periods of drought. It also arrives as packing round articles of commerce. Teleutospores on such material may lead to barberry infections, with the consequent production of physiologic forms at present unknown in Australia.

Dusting crops with fungicidal powders in North America has recently been shown to give a remarkable control of rust, as well as other diseases. Work in this sphere has lately been reviewed (Greaney, 1933). Sulphur dust in a very finely divided condition is mainly used. The powder is distributed over the crops from special power dusters or aeroplanes. A first application is made at about heading time, and subsequent dustings at intervals of about a week until just before harvest. Experiments have proved the efficacy and the practicability of this method of controlling rust. It remains to be seen whether the practice is economically sound on a large scale, that is to say, whether, over a period of years, farmers would find that it pays to dust their crops with sulphur. It is simply a question of cost.

Breeding for resistance offers the only satisfactory method of combating plant diseases. This raises problems of great complexity which have long been the subject of study and experiment in many countries. Upon their solution depends the ultimate control of rust and other diseases.

It is impossible to deal adequately with this all-important subject in the short time that remains. A vast literature has grown up dealing with its many phases, and wonderful progress has been made during recent years in developing varieties of crop plants which are resistant to various diseases. Indeed, it is sometimes asserted that one of the causes of over-production is the development of high-yielding types of plants by plant breeders. Actually the use of efficient varieties is essential as a means of lowering the cost of production.

Time permits of brief mention only of one outstanding Australian wheat breeder. The work of William James Farrer has probably never received the full recognition that it deserves. His have been remarkable contributions to Australia's wealth. Apart from other improvements, he achieved great success in breeding varieties resistant to bunt. His work in breeding for resistance to rust is sometimes stated to have failed. Certainly it was not successful if it is judged in the light of present-day rust resistance. This, however, is not a fair test to make. Facts relating to physiologic specialization were, of course, unknown in Farrer's day. In the absence of controlled investigations, there is no way of determining now what forms of rust were present then. We know that he definitely aimed at the production of rust resistant varieties. It is not without interest, therefore, to find that of the 19 varieties listed by Guthrie (1922) as productions of Farrer, 14 show resistance to one or more of the six physiologic forms present up till 1926. No one of these varieties is resistant to the now ubiquitous form 34. It seems improbable that this virulent form was present when Farrer did his work, otherwise there would scarcely have been claims (Guthrie, 1922) that some of his varieties were resistant. That they were definitely resistant to certain forms has already been demonstrated (Waterhouse, 1930). Farrer, then, was successful in breeding for rust resistance as it relates to certain Australian forms of rust.

Since Farrer's time great advances have been made in science. Rapid developments, particularly in genetics, plant breeding, plant pathology and cytology, have placed tools of enormous value in the hands of breeders, and with a realization of the importance of breeding resistant varieties, and with adequate support and the provision of proper facilities, the prospects for ultimate success seem to be very bright. There is still a vast amount of information required in regard to many fundamental happenings. For example, despite all the progress that has been made, it must be admitted that we really know very little about such a basic requirement as what actually constitutes resistance. The great need is for intensive work on such fundamental problems. With this knowledge it can scarcely be doubted that many present-day obstacles will disappear, and the way be paved for certain success in the future.

Conclusion.

Finally, grateful reference must be made to the cordial assistance rendered by members of your Council at all times throughout the year. The duties of a President are greatly lightened by such happy cooperation. In the Secretary you have a man who with unflagging zeal and outstanding ability attends to the affairs of the Society, and this opportunity is taken of again recording appreciation of his fine services and of thanking him for his work on our behalf.

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The Secretary (for Dr. G. A. Waterhouse, Honorary Treasurer) presented the balance-sheets for the year ended 29th February, 1936, duly signed by the Auditor, Mr. F. H. Rayment, F.C.A. (Aust.); and he moved that they be received and adopted, which was carried unanimously.

No nominations of other candidates having been received, the Chairman declared the following elections for the ensuing session to be duly made:

President: C. A. Sussmilch, F.G.S.

Members of Council: C. Anderson, M.A., D.Sc., Professor A. N. St. G. H. Burkitt, M.B., B.Sc., H. J. Carter, B.A., F.R.E.S., Professor J. Macdonald Holmes, B.Sc., F.R.G.S., A. F. Basset Hull, M.B.E., and C. A. Sussmilch, F.G.S.

Auditor: F. H. Rayment, F.C.A. (Aust.).

A cordial vote of thanks to the retiring President was carried by acclamation.

Linnean Society of New South Wales.

GENERAL ACCOUNT. Balance Sheet at 29th February, 1936.

LIABILITIES.

	£	s.	d.	£	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				9,227	7	7
Fletcher Memorial Fund at 29th February, 1936				23	17	0
Commercial Banking Co. of Sydney Ltd.				499	7	0
				£29,750	11	7

ASSETS.

	£	s.	d.
Society's Freehold	11,000	0	0
Consols	500	0	0
Loans on Mortgage	3,600	0	0
Science House (one-third share)	14,540	0	0
Cash in hand	10	0	0
Income Account at 29th February, 1936	100	11	7
	£29,750	11	7

INCOME ACCOUNT. Year Ended 29th February, 1936.

	£	s.	d.	£	s.	d.
To Balance from 1934–35				98	17	10
,, Salaries				1,010	0	0
,, Printing Publications	485	9	10			
,, Illustrations	91	10	10			
				577	0	8
,, Rates and Insurance				192	10	11
,, Library				27	16	8
,, Postage	45	5	1			
,, Petty Cash	11	12	10			
				56	17	11
,, Audit	7	7	0			
,, Printing	27	19	9			
,, Attendance and Cleaning	36	11	0			
,, Expenses	28	11	1			
,, Legal Expenses	2	2	0			
				102	10	10
,, Interest on Overdraft, etc.				8	4	6
,, Bank Expenses				0	3	3
,, Rent—Science House				140	13	8
,, Appropriation: Contingencies Reserve				7	7	0
				£2,222	3	3

	£	s.	d.	£	s.	d.
By Subscriptions: 1935–36	131	5	0			
Arrears	21	17	3			
In Advance	15	4	4			
Associates	2	0	0			
				170	6	7
,, Entrance Fees				7	7	0
,, Interest				173	19	0
,, Sales (including 60 copies of PROCEEDINGS purchased by Government of New South Wales)				144	14	5
,, Fellowships Account (surplus income at 29th February, 1936, transferred)				651	3	0
,, Rent—16 College Street				274	1	8
,, Science House Returns				200	0	0
,, Appropriation: Contingencies Reserve				500	0	0
,, Balance to 1936–37				100	11	7
				£2,222	3	3

Examined and found correct. Securities produced.
F. H. RAYMENT, F.C.A. (Aust.),
Auditor.
9th March, 1936.

G. A. WATERHOUSE,
Hon. Treasurer.
3rd March, 1936.

LINNEAN MACLEAY FELLOWSHIPS ACCOUNT.

BALANCE SHEET at 29th February, 1936.

LIABILITIES.	£	s.	d.	ASSETS.	£	s.	d.
Amount bequeathed by Sir William Macleay ..	35,000	0	0	Consols	11,400	0	0
Surplus Income Capitalized	14,849	8	0	Loans on Mortgage	37,700	0	0
				Rural Loan	477	10	0
				Commercial Banking Company of Sydney, Ltd. ..	170	8	0
				Commonwealth Savings Bank	101	10	0
	£49,849	8	0		£49,849	8	0

INCOME ACCOUNT. Year Ended 29th February, 1936.

	£	s.	d.		£	s.	d.
To Salaries of Linnean Macleay Fellows	1,200	0	0	By Interest	2,253	5	0
,, Expenses	2	2	0				
,, Capital Account	400	0	0				
,, General Account	651	3	0				
	£2,253	5	0		£2,253	5	0

Examined and found correct. Securities produced.
F. H. Rayment, F.C.A. (Aust.),
Auditor.

9th March, 1936.

G. A. Waterhouse,
Hon. Treasurer.

3rd March, 1936.

BACTERIOLOGY ACCOUNT.

BALANCE SHEET at 29th February, 1936.

LIABILITIES.	£	s.	d.
Amount bequeathed by Sir William Macleay	12,000	0	0
Accumulated Income Capitalized	3,820	0	0
Income Account at 29th February, 1936	529	17	6
	£16,349	17	6

ASSETS.	£	s.	d.	£	s.	d.
Consols				15,820	0	0
Cash—						
Commercial Banking Company of Sydney Ltd.	303	0	7			
Commonwealth Savings Bank	220	16	11			
In hand	6	0	0			
				529	17	6
				£16,349	17	6

INCOME ACCOUNT. Year Ended 29th February, 1936.

	£	s.	d.
To Salary	600	0	0
„ Expenses	10	5	9
„ Petty Cash	1	11	6
„ Balance to 1936–37	529	17	6
	£1,141	14	9

	£	s.	d.
By Balance from 1934–1935	516	15	8
„ Interest	624	19	1
	£1,141	14	9

Examined and found correct. Securities produced.
F. H. Rayment, F.C.A. (Aust.),
Auditor.
9th March, 1936.

3rd March, 1936.

G. A. Waterhouse,
Hon. Treasurer.

ABSTRACT OF PROCEEDINGS.

ORDINARY MONTHLY MEETING.

25th March, 1936.

Mr. C. A. Sussmilch, F.G.S., President, in the Chair.

The Donations and Exchanges received since the previous Monthly Meeting (27th November, 1935) amounting to 46 Volumes, 373 Parts or Numbers, 19 Bulletins, 14 Reports and 31 Pamphlets, received from 147 Societies and Institutions and 5 private donors, were laid upon the table.

PAPERS READ.

1. Notes on Australian Diptera. xxxv. By J. R. Malloch. (*Communicated by F. H. Taylor.*)

2. Notes on the Biology of *Scaptia auriflua* Don. (Diptera, Tabanidae). By Mary E. Fuller, B.Sc.

ORDINARY MONTHLY MEETING.

29th April, 1936.

Mr. C. A. Sussmilch, F.G.S., President, in the Chair.

Messrs. M. F. Day and D. F. Waterhouse were elected Ordinary Members of the Society.

The President announced that the Council had elected Dr. C. Anderson, Professor A. N. Burkitt, Professor W. J. Dakin and Dr. W. L. Waterhouse to be Vice-Presidents for the Session 1936–37.

The President also announced that the Council had elected Dr. G. A. Waterhouse to be Honorary Treasurer for the Session 1936–37.

The Donations and Exchanges received since the previous Monthly Meeting (25th March, 1936), amounting to 19 Volumes, 144 Parts or Numbers, 10 Bulletins and 5 Reports, received from 76 Societies and Institutions, were laid upon the table.

PAPERS READ.

1. Contributions to the Microbiology of Australian Soils. iv. The Activity of Microorganisms in the Decomposition of Organic Matter. By H. L. Jensen, Macleay Bacteriologist to the Society.

2. Studies in the Australian Acacias. vi. The Meristematic Activity of the Floral Apex of *Acacia longifolia* and *A. suaveolens* as a Histogenetic Study of the Ontogeny of the Carpel. By I. V. Newman, M.Sc., Ph.D., F.L.S., Linnean Macleay Fellow of the Society in Botany.

NOTES AND EXHIBITS.

Professor F. E. Lloyd exhibited specimens showing the behaviour of the living trap of *Utricularia lateriflora.* In view of the anatomy of the trap of *Utricularia lateriflora*, as already described by him from preserved material, it was expected that the living trap would display the kind of behaviour common to others (e.g., *U. capensis*, *U. Welwitschii*, etc.) in which the plane embracing the axis of the door or valve lies obliquely to the plane of the threshold. Satisfactory living material having been obtained in the vicinity of Sydney, through the thoughtful co-operation of the Department of Botany of the University of Sydney, he was able to determine the accuracy of the above expectation. The critical points to be observed are the postures of the door in the set and relaxed condition of the trap. In the set posture the upper region of the door is concave (as seen from the outside of the trap). The trap is actuated by touching the upper region of the door. As to the precise point of maximum mechanical sensitivity, it is difficult to decide. By analogy, one would say that part nearest to the lower region of the door. When actuated, the vigour of implosion (insuction of water through the entrance) is sufficient to suck in a needle point and thus plug the opening. In the relaxed posture the upper region of the door is strongly convex (in the above sense) and the lower region of the door stands at a smaller angle of contact with the pavement epithelium of the threshold. The door in this species seems to be devoid of trigger mechanism—as compared with *U. capensis.* It probably is represented by low trichomes with their cylindrical heads transverse to the door axis. The excessively small size (0·6 mm.) of the trap makes it difficult to decide experimentally. An attempt will, however, be made. Its form is unique, only two other species approximating it.

Mr. E. Cheel exhibited specimens, coloured drawings, and photographic illustrations of 15 species of *Nicotiana*, including 6 new species recently described by Dr. Helen-Mar Wheeler in "Studies in Nicotiana. ii. A Taxonomic Survey of the Australasian Species" (University of California Publications in Botany, Vol. 18, No. 4, pp. 45–68, 1935):

Nicotiana Benthamiana Domin. See *Biblioth. Bot.*, 22, 1929, 591, Pl. 37, fig. 1. (*N. suaveolens* var. *cordifolia* Benth.) North-west coast of W.A. (Bynoe), Ashburton and Yule Rivers, and Central Australia.

Nicotiana excelsior Black. (*N. suaveolens* var. *excelsior* Black, *N. macrocalyx* Domin.) Birksgate Range and Everard Range, S.A.

Nicotiana Debneyi Domin. (*N. suaveolens* var. *parviflora* Benth., as often interpreted. Not *N. suaveolens* var. *Debneyi* of Bailey.) Lord Howe Island and numerous localities in New South Wales.

Nicotiana fragrans Hooker. *Bot. Mag.*, t. 4865. (*N. Macgillivrayi* Seeman.)

Nicotiana occidentalis Wheeler. Port Headland (Mjoberg). Type.

Nicotiana Gossei Domin. See in *Biblioth. Bot.*, 22, 592, Pl. 36, figs. 2–5. Type. From centre of South Australia.

Nicotiana megalosiphon Heurck and Muell. Arg. (*N. suaveolens* var. *longiflora* Benth.) Bellata and Narrabri, N.S.W.

Nicotiana velutina Wheeler. Tibooburra, Toorale-Goonery. Type from Broken Hill (Morris).

Nicotiana maritima Wheeler. Near Adelaide (Cleland).

Nicotiana suaveolens Lehmann. (*N. undulata* Veut.) *Bot. Mag.*, t. 673. Bulby Island, Lake Macquarie (Cheel). Recorded from several other localities from the coast to Snowy River.

Nicotiana stenocarpa Wheeler. Laverton, W.A. (Maiden). Type.

Nicotiana ingulba Black. Central Australia to W.A.

Nicotiana rotundifolia Lindley. (*N. fastigiata* Nees; *N. suaveolens* var. *rosulata* Moore; *N. rosulata* Domin, Pl. 36, fig. 11).

Nicotiana Goodspeedii Wheeler. Ivanhoe district (Reuss).

Nicotiana exigua Wheeler. Dalby, Queensland (McCarthy). Type. Specimen not represented in Herbarium of N.S.W.

Dr. W. L. Waterhouse, on behalf of Mr. F. W. Hely, B.Sc.Agr., of the C.S.I.R., Canberra, exhibited a hitherto undescribed rust attacking Kangaroo Grass, *Themeda Forskalii*. In the course of a plant disease survey which Mr. Hely is making of the Federal Capital Territory, this rust was found severely attacking leaves and stems of the grass. To date only the uredospore stage has been discovered, but work is in progress to complete the determination of the rust and its host range.

Mr. F. H. Taylor exhibited photographs of (1) a new subspecies of flea, belonging to the genus *Xenopsylla*, which is intermediate between a species from South Australia and another from Hawaii; and (2) a new species belonging to the genus *Stivalius*. The host of both fleas is *Rattus culmorum* from North Queensland.

Dr. I. V. Newman read extracts from letters he had received from Miss E. R. Saunders of Cambridge and Professor J. McLean Thompson of Liverpool asking him to correct a statement he had made concerning their views on carpel morphology. The statement, made at the meeting on 30th October, 1935, was that their interpretations of the legume were based on the assumption that the legume is terminal. Miss Saunders wished it to be stated that there is no assumption; but that her interpretation is based on the "demonstrable fact" that the whole of the residual vascular cylinder remaining after the exsertion of the androecium passes into the legume. Dr. Newman's reply was that in saying "assumption" he did not mean to imply any lack in amount of observation and illustration. But he regards the evidence produced and illustrated by Miss Saunders as not proving her contention; and he considers that if at the stages illustrated by her the whole vascular cylinder that appeared to be residual after the exsertion of the androecium does pass into the gynoecium, even then the terminality of the origin of the legume is not a necessary conclusion. The question is discussed in the paper read at this meeting by Dr. Newman. Professor Thompson asked it to be stated that he has "made it abundantly clear that the legume is not a terminal structure". In reply Dr. Newman quoted from the conclusion of Professor Thompson's paper (of which he could find no refutation) on the Leguminous strobilus (*Publn. Hartley Bot. Lab. Liverpool*, No. 7, 1931), where it is stated that: "Throughout the long series of species examined with single legume, the latter has been found to be of terminal origin. . . ." This matter is now a subject of correspondence in the columns of *Nature*.

ORDINARY MONTHLY MEETING.

27th May, 1936.

Dr. W. L. Waterhouse, Vice-President, in the Chair.

Messrs. C. E. Chadwick, B.Sc., C. V. Morisset, N. L. Roberts, E. H. Zeck, and Miss Ilma M. Pidgeon, B.Sc., were elected Ordinary Members of the Society.

The Donations and Exchanges received since the previous Monthly Meeting (29th April, 1936), amounting to 19 Volumes, 173 Parts or Numbers, 4 Bulletins, 3 Reports and 16 Pamphlets, received from 82 Societies and Institutions and 1 private donor, were laid upon the table.

PAPERS READ.

1. A Redescription of *Solomys* (*"Mus"*) *salamonis* Ramsay. By E. Le G. Troughton, C.M.Z.S.

2. Check-list of the New South Wales Pteridophytes. By Alma T. Melvaine.

3. Australian Coleoptera. Notes and New Species. No. 10. By H. J. Carter, B.A., F.R.E.S.

4. Notes on Sarcophaginae in India and Australia. By G. H. Hardy.

NOTES AND EXHIBITS.

Mr. E. Cheel exhibited specimens of a weed commonly known as "Paraguay Burr" (*Acanthospermum brasilum* Schrank; syn. *A. xanthoides* DC.), recently received from the Manager of the Experiment Farm at Glen Innes, New England district. The species has not previously been recorded for Australia and, although the burr-like fruits are not quite so large as those of *Acanthospermum hispidum*, which is recorded as a naturalized weed in Queensland, or those of "Bathurst Burr" (*Xanthium spinosum*), and "Noogoora Burr" (*Xanthium chinense*; syn. *X. occidentale*), the burrs are sufficiently large and produced in such large numbers for it to be regarded as a serious menace to those engaged in sheep farming.

Mr. Cheel also exhibited fruiting specimens of *Crataegus pubescens* forma *stipulacea* Stapf (*Botanical Magazine*, t. 8589) received from Mr. C. L. Mackenzie, Guyra. The plant is commonly known as "Texocotl" or "Rock Apple", spelt "Tejocote" in Mexico, also "Mauzana" or "Manzanilla" in Spanish. Specimens of a weed very common on lawns in Hyde Park and other localities in the metropolitan area of Sydney and Newcastle and listed under the name "Chilian Witlow" were recently submitted to the Royal Herbarium, Kew (England), for correct classification and have been determined as *Paronychia brasiliana* DC., and not *P. chilensis* as recorded in These PROCEEDINGS, 1913, p. 110. Specimens of *Protium australasicum* Sprague (syn. *Bursera australasica* Bailey) were exhibited from Palm Dale, Cudgera Creek, Moobal, N.S.W., collected by Mr. W. A. W. de Beuzeville. This species has previously been recorded from Eumundi, Queensland.

Mr. N. L. Roberts exhibited the foliage of *Casuarina suberosa*, Castlereagh district, infested with *Loranthus linifolius* in which the foliage of the parasite has taken on the form of the host plant.

Mr. R. N. Robertson, Linnean Macleay Fellow in Botany, exhibited some specimens of *Utricularia dichotoma* var. *uniflora* which he had collected near the Sydney University Biological Society's Research Station. These specimens had been given to Professor F. E. Lloyd, but were exhibited with his permission. The bladders which trap the small animals appear to be all on the surface of the soil, and, it would seem, trap animals which are washed over them by the surface waters. In these specimens no subterranean bladders have been found, though they may occur in the species. The only other species which has bladders on the surface of the soil is *U. monanthos* from Western Australia.

Mr. Robertson made reference, as a matter of interest, to the fact that he spent his annual vacation at Wallerawang House, as the guest of Mr. J. W.

Barton. Wallerawang House was one of the places which Darwin visited on his way to Bathurst, 100 years ago last January. He records in the "Voyage of the Beagle" how he was taken on a kangaroo hunt and how he first saw *Ornithorhynchus paradoxus*, which is still common in the river. The original homestead of Wallerawang Station—built in early colonial style—is still standing, though it is now unoccupied.

Mr. G. P. Whitley exhibited a larval eel which was regarded as the *Leptocephalus* stage of the Little Conger, *Congromuraena longicauda* Ramsay & Ogilby. The specimen was washed ashore at Maroubra on May 24, 1936, and measured 70 mm. in length. There were 127 myomeres along the body and pectoral fins were undeveloped.

Mr. Whitley also exhibited specimens of flies which were commonly found running over sand-dunes behind Maroubra Beach, jerking their wings as they proceeded. These had been identified by Mr. Anthony Musgrave as *Ephydroscinis* (*Neoborborus*) *raymenti* Curran, a species hitherto known only from Port Phillip, Victoria.

Mr. H. J. Carter drew attention to a copy of a rare pamphlet on Buprestidae by F. W. Hope; this was published privately in 1836 and was the subject of discussion in 1867 as regards the validity of the names published in it (see *Proc. Ent. Soc. London*, 1867, p. cix, and *Trans. Ent. Soc. London*, 1868, p. 1).

ORDINARY MONTHLY MEETING.

24th June, 1936.

Mr. C. A. Sussmilch, F.G.S., President, in the Chair.

Messrs. A. Goerling and D. J. Lee, B.Sc., were elected Ordinary Members of the Society.

A letter was read from the Acting Official Secretary, Government House, Sydney, conveying the appreciation of His Majesty the King, Queen Mary and other members of the Royal Family for the message of sympathy in the death of His late Majesty King George V.

The President referred to the death of Mr. A. H. S. Lucas, who had been a member of the Society since 1893, President 1907–1909, and a member of Council since 1895 with the exception of the years 1924–1926.

The Chairman offered the congratulations of members to Dr. J. G. Churchward, who had recently received the degree of Ph.D., of the University of Minnesota.

The Donations and Exchanges received since the previous Monthly Meeting (27th May, 1936), amounting to 21 Volumes, 131 Parts or Numbers, 4 Reports and 3 Pamphlets, received from 78 Societies and Institutions and 2 private donors, were laid upon the table.

PAPERS READ.

1. A Comparison of the Rydal and Hartley Exogenous Contact-zones. By Germaine A. Joplin, B.Sc., Ph.D.

2. The Structural Geology and Petrology of an Area near Yass, N.S.W. By Kathleen Sherrard, M.Sc.

3. Contribution to a Knowledge of Papuan Tipulidae (Diptera). By C. P. Alexander. (*Communicated by F. H. Taylor, F.R.E.S., F.Z.S.*)

NOTES AND EXHIBITS.

Mr. E. Cheel exhibited herbarium specimens in flower, and live plants in cultivation, of *Rupicola sprengelioides* collected by Dr. I. V. Newman and O. D. Evans near the Lookout, Burragorang, in December, 1934. The genus was originally described by Messrs. J. H. Maiden and E. Betche (these PROCEEDINGS, xxiii, 1898, 774) from specimens collected by J. H. Maiden and W. Forsyth near the southern edge of the King's Tableland in the Blue Mountains. Some seeds were forwarded to Kew (England) by Maiden in 1906, from which plants were raised; they flowered in April, 1911, and were illustrated in *Bot. Mag.*, Tab. 8438 (1912). The late Mr. E. Betche, when preparing the description, was doubtful as to the correct position on account of the anthers somewhat resembling those of Ericaceae, but the general characteristics being in agreement with those of Epacridaceae, it was classed in the latter family with which the author of the article in the *Botanical Magazine* agreed, but for some unknown reason omitted Betche's name as joint author. In *Kew Bulletin*, No. 7, 1910, p. 216, O. Stapf described a new species of *Epacris* under the name *E. breviflora*. It is figured by Hooker (*Bot. Mag.*, Tab. 3257, 1833) under the name *E. heteronema*, but is quite distinct from *E. heteronema* Labillardière, collected in Tasmania; through a slip, the name *breviflora* is listed as *brevifolia* by Maiden and Betche (*Census of New South Wales Plants*, 1916, p. 167).

Mr. Cheel also exhibited specimens of *Cryptocarya Meissneri* F.v.M., from a plant cultivated in the Botanic Gardens, which produced a few flowers in March last. It is figured by Maiden (*Forest Flora*, Pl. 130) from specimens collected at Port Macquarie in January, 1897, and Clarence River, 1875, but is not entered in the Catalogue of Garden Plants or represented in the National Herbarium; it was evidently planted during C. Moore's directorship of the Gardens. Specimens of the Common Barberry (*Berberis vulgaris* L.) from Bellbird, near Newcastle, together with a coloured illustration published in *English Botany*, Tab. 49 (1807), were exhibited for comparison. Several samples of this species have been submitted to the botanical staff at the National Herbarium for identification during the past year.

Mr. A. N. Colefax sent for exhibition two samples of Antarctic Plankton, one a heavy Diatom catch, and the other an equally heavy catch of zooplankton (Copepoda, Euphausids, etc.). These samples illustrate the extreme abundance of planktonic life in the cold Antarctic seas, and come from the large collection of hauls made by the "*Discovery*" in 1929–1930. The collection is being worked out at the Zoology Department, The University of Sydney.

Miss E. C. Pope exhibited the head of a specimen of the Cockney Bream, *Pagrosomus auratus*, which showed peculiar malformation of the mouth and jaws. The specimen was taken from Brisbane Water in January, 1936. The whole mouth has the appearance of having undergone twisting towards the right, and the upper jaw appears to lack several bones on this side of the mouth. A suggested explanation is that part of the upper jaw was torn away (probably by careless removal of a hook by some fisherman when the fish was very young) and the wound has healed up unevenly, causing the distortion shown. The fish had an otherwise normal appearance.

Mr. R. H. Anderson exhibited: (i) A specimen of *Codonocarpus cotinifolius*, "Horse Radish Tree", or "Mustard Tree". This is a fairly common tree in Western Australia, and also occurs in western New South Wales on red soils or sandy loams. The leaves and bark have a very pungent taste, so that it is not touched as a rule by stock or rabbits. It has been suggested that it might prove a useful species in helping to prevent soil drift and erosion in the interior in view of its avoidance by stock and free seeding habit. (ii) A specimen of *Oncinocalyx Betchei*, "Oncino Burr", a native plant which produces a burr injurious to wool. Recent information received from the Mandowa Shire Clerk indicates that it is spreading in the Hall's Creek area, about 15 miles east of Manilla. (iii) A specimen and plate of *Hakea Bakeriana*, an ornamental shrub with a limited distribution, being mainly confined to the Newcastle–Lake Macquarie district. It grows on poor sandy soil and should prove a useful ornamental shrub for such areas.

Dr. R. J. Tillyard referred to the recent discovery of a new Upper Triassic fossil insect bed at Mount Crosby, near Ipswich, Queensland. He exhibited six specimens of fossil insects from this bed, two being cockroaches, three Hemiptera and one a beetle elytron. Representatives of the Odonata, Neuroptera, Mecoptera and Diptera also occur. Ninety-three specimens were discovered in three days, so the fauna is evidently a rich one. The insects were fossilized in the bed of a running stream between two ridges of older Brisbane schist.

ORDINARY MONTHLY MEETING.

29th July, 1936.

Mr. C. A. Sussmilch, F.G.S., President, in the Chair.

The President announced that Mr. R. H. Anderson, B.Sc.Agr., had been elected to fill the vacancy on the Council caused by the death of Mr. A. H. S. Lucas.

The President offered the congratulations of members to Mr. R. N. Robertson, B.Sc., Linnean Macleay Fellow in Botany, on the award of a Science Scholarship of the Royal Commissioners for the Exhibition of 1851.

The President announced that the operation of the Wild Flowers and Native Plants Protection Act, 1927, has been extended for a further period of one year from 1st July, 1936.

The President reported that subscriptions to the David Portrait Fund to date amounted to £20 15s. 6d. The object of the fund is to obtain a portrait of the late Sir Edgeworth David, to be hung in Science House, and the total amount required is about £85.

The Donations and Exchanges received since the previous Monthly Meeting (24th June, 1936), amounting to 26 Volumes, 169 Parts or Numbers, 11 Bulletins, 7 Reports and 8 Pamphlets, received from 88 Societies and Institutions and 1 private donor, were laid upon the table.

PAPERS READ.

1. The Upper Palaeozoic Rocks in the Neighbourhood of Boorook and Drake. By A. H. Voisey, B.Sc.

2. Two new Australian Fleas. By Karl Jordan, Ph.D., F.R.S. (*Communicated by F. H. Taylor, F.R.E.S., F.Z.S.*)

NOTES AND EXHIBITS.

Mr. R. N. Robertson gave a short résumé of the present knowledge of stomatal movement in its relationships to the physiological processes of the leaf. The action of stomata as conservers of water was emphasized. The views of modern workers, including Scarth and Maskell, as to the cause of the movement were outlined. Mr. Robertson exhibited the apparatus with which he has been investigating the relation of the composition of the gases of intercellular spaces to the stomatal movement. Some results were shown and the difficulties of interpretation pointed out.

Mr. H. L. Jensen exhibited agar cultures of aerobic nitrogen-fixing bacteria (*Azotobacter*) from soils of different character; in some these organisms were absent, while in others an addition of a suitable energy material caused them to multiply and reach numbers of several hundred millions per gram of soil.

Dr. I. V. Newman exhibited photomicrographs of living material of *Acacia discolor* showing a method of protection of stigmas after pollination. The first was a crushed stigma with a fully germinated pollinium attached to it by the pollen tubes and covered by vaseline that had been placed on it 4½ hours after pollination (germination of pollen begins about 1½ hours after pollination). The second was a hand section of the ovary of the same carpel showing pollen tubes emerging into the cavity. The carpel was collected 24 hours after pollination. Pollination was done before the stamens extended and about 24–30 hours before the anthers would open. Emasculation is, therefore, not essential for genetical work of this method, and only a temporary protection between pollination and placing the vaseline is needed. (This work was carried out by means of a binocular magnifier granted for Dr. Newman's use by the Science and Industry Endowment Fund.)

Mr. A. N. Colefax sent for exhibition an apparatus for making drawings direct from a dissection, or other object, which he had recently constructed. It embodies a pantograph in which the tracing point is replaced by an adjustable tube at the base of which are crossed wires. The apparatus rests on a glass-topped table, the object being placed underneath on a subsidiary stage, which is well illuminated by four strip lights.

ORDINARY MONTHLY MEETING.

26th August, 1936.

Mr. C. A. Sussmilch, F.G.S., President, in the Chair.

Messrs. D. Gilmour and M. E. Griffiths were elected Ordinary Members of the Society.

The Donations and Exchanges received since the previous Monthly Meeting (29th July, 1936), amounting to 7 Volumes, 97 Parts or Numbers, 6 Bulletins, 5 Reports and 19 Pamphlets, received from 60 Societies and Institutions, were laid upon the table.

PAPERS READ.

1. The Diptera of the Territory of New Guinea. iv. Family Tipulidae, Part ii. By C. P. Alexander. (*Communicated by F. H. Taylor, F.R.E.S., F.Z.S.*)
2. Introductory Account of the Geology and Petrology of the Lake George District. By M. D. Garretty, B.Sc.

NOTES AND EXHIBITS.

Mr. E. Cheel exhibited specimens of a weed not previously recorded for Australia, collected at Garah in December, 1933, by Messrs. Halstead and O'Neill, and at Scone in March, 1936, by Mr. B. G. Millard. The plants are remarkably like the "Khaki Weed" (*Alternanthera echinata*) in general appearance but have been identified by the authorities at the Royal Botanic Gardens, Kew (England), as *Gomphrena dispersa* Standley. It is a native of Central America and the West Indies, and is also found in tropical and South Africa, though in the latter area it had been wrongly named *G. decumbens* Jacq.

Mr. Cheel also exhibited specimens of a grass collected by Mr. F. H. Taylor at Bulolo, New Guinea (alt. 2,300 ft.), classed in the genus *Themeda*, which is probably the species *T. triandra* Forsk. Specimens of what is regarded as *Themeda quadrivalvis* Forsk. (*Anthistiria vulgaris* Hack.), from Astrolabe Range, New Guinea, collected by F. H. Brown in June, 1898, together with specimens of the Australian Kangaroo Grass, *Themeda australis* (R.Br.) Stapf, together with four other distinctive forms or subspecies from other parts of Australia, were exhibited for comparison with the two species from New Guinea.

Mrs. Sherrard exhibited graptolites from two localities to the east of Yass in an area from which no fossils have previously been obtained, and which has been tentatively correlated with the Silurian. From the roadside on the way to Gundaroo, 12 miles to the east of Yass, about Portion 24, Parish of Morumbateman, were obtained *Climacograptus missilus* Keble and Harris, and *Diplograptus calcaratus* Lap. These are poorly preserved, but have been identified by Mr. R. A. Keble, Palaeontologist to the National Museum, Melbourne. In Portion 1, Parish of Mundoonen, 15 miles east of Yass, were obtained *Retiograptus pulcherrimus* Keble and Harris, ?*Leptograptus flaccidus* Hall, and ?*L. ascendens* Elles and Wood. These forms are typical of the Bolindian Beds of the Upper Ordovician Series, which make the uppermost zone of this series in Victoria, and prove that these beds near Yass, previously classed in the Silurian, should be moved down to the Upper Ordovician. The *R. pulcherrimus* is well preserved, and Mr. Keble remarks that its only other occurrence known to him, apart from the type locality on the Yarra Track, Victoria, is in Romsey in the same State.

Mr. F. H. Taylor exhibited, on behalf of Mr. David O. Atherton, Entomologist, Department of Stock and Agriculture, Atherton, larvae of a species of the family Blepharoceridae (Diptera). These larvae were found beneath a waterfall in the Little Mossman River, Queensland, about 60 miles north of Cairns. It is believed to be the first recorded instance of the family Blepharoceridae in Queensland.

ORDINARY MONTHLY MEETING.

30th September, 1936.

Mr. C. A. Sussmilch, F.G.S., President, in the Chair.

The Chairman announced that the Council is prepared to receive applications for four Linnean Macleay Fellowships tenable for one year from 1st March, 1937, from qualified candidates. Applications should be lodged with the Secretary, who will afford all necessary information to intending candidates, not later than Wednesday, 4th November, 1936.

The Donations and Exchanges received since the previous Monthly Meeting (26th August, 1936), amounting to 12 Volumes, 153 Parts or Numbers, 3 Bulletins, 1 Report and 9 Pamphlets, received from 73 Societies and Institutions, were laid upon the table.

PAPERS READ.

1. Studies in Australian Embioptera. i. Systematics. By Consett Davis, B.Sc.
2. The Adrenal Gland in New-born Mammals. By G. Bourne, D.Sc.

Mr. E. le G. Troughton delivered a lecturette: "Rarer Mammals—Their Past and Future."

NOTES AND EXHIBITS.

The Secretary, on behalf of Mrs. E. Coleman, communicated the following notes:

Note on Nest Hygiene of the White-plumed Honey-eater, Meliphaga (Ptilotula) penicillata. *By Edith Coleman.*

Opportunity of observing, at close range, the construction of nests and the brooding habits of various species of birds, and of witnessing methods of maintaining the perfect hygiene noted in the nests of certain Australian birds has been afforded by a garden wilderness, some two acres in extent, containing many native trees and shrubs. In this garden, as elsewhere in the suburbs of Melbourne, alien birds, such as the British Song Thrush and the Blackbird, are dominant. These are gradually ousting native birds, other than those that do not enter into food competition with them.

The non-competitive Honey-eaters, however, are holding their own in our gardens, and they are encouraged in my own by the planting of many trees and shrubs bearing nectariferous flowers. Four species frequent the garden throughout the year: the Spinebill (*Acanthorhynchus tenuirostris*), Regent (*Zanthomiza phrygia*), White-plumed (*Meliphaga penicillata*) and the Yellow-winged (*Meliornis novae-hollandae*). All of them nest here. In examining the nests of these Honey-eaters, after the nestlings had flown, I have always been impressed with their remarkably clean condition. Except for scale, they were as clean as when constructed. The same feature was noted in the nests of other species in the hills or along the coast. In December, 1935, I discovered that this surprising cleanliness is due to the remarkable precautions taken by adult birds to ensure perfect sanitation during the nestling stage.

In this district (Blackburn, Victoria) the Silver-leaf Stringy-bark (*Eucalyptus cinerea* var. *multiflora*) is a favourite nesting-site of the White-plumed Honey-eater (*Meliphaga penicillata*), probably because its slender, pendent branches offer safe anchorage for the basket nests. Swinging at the ends of branchlets they are practically inaccessible to cats or owls. The trees provide good, handy foraging in the scale-insects that infest them. Moreover, the flowering of the trees coincides with the brooding season of the Honey-eaters, and the flowers secrete abundant nectar.

In January, 1936, three of these cradles swung from one tree in my garden, within the space of a few feet. In one nest three nestlings were reared, and I was able to follow closely their development. The parent birds were very trustful. The male bird was at all times quite fearless, and, in spite of my proximity, fed the nestlings from the side of the nest facing the camera, placed within three feet of it. The female, a little alarmed by the click of a shutter, occasionally fed from the back of the nest, but she was at all times quite visible to me. In feeding, the parents did not rest on the nest, but perched on a twig, reaching down to the nestlings from a considerable distance. Large masses of scale-insects and nectar were fed. At no time were excreta allowed to reach the nest, but were taken by an adult bird as soon as voided. After feeding a nestling, a parent, more frequently the male bird, paused expectantly on his twig. If excreta were not at once voided, he touched the cloaca of the nestling he had just fed. At once it rose in the nest, lifted its wings, and the voided excreta were taken directly from the cloaca into the bill of the adult. Usually they were taken away from the nest. From my position I could not see whether they were dropped. Frequently they were swallowed at the nest. I saw many of the large white capsules carried away intact. It seemed remarkable that so large a faecal mass, partly fluid in content, held together only by a thin, filmy covering, should remain intact under even slight pressure of a bill. Dr. D. F. Thomson, however, has pointed out (*Proc. Zool. Soc. Lond.*, 1934 (1935), pp. 701–707) that the enclosure of faeces within a mucilaginous covering not only facilitates transport, but is an adaptation whereby faeces may be accumulated in the alimentary tract, and held for a considerable period. They are expelled only when peristalsis is stimulated by feeding. The faecal capsule of the Honey-eater appears to be considerably larger than that of the Butcher-bird nestling (*Cracticus torquatus*) shown in Dr. Thomson's photograph, although the Honey-eater is a smaller bird. Its size would doubtless be governed by the period of time during which the parent is collecting food. It is assumed that the collecting of nectar, pollen, and scale-insects would occupy longer than large insects, mice or birds, such as the Butcher-bird feeds to its young. Dr. Thomson states that removal by the adult bird of the faecal masses as they leave the cloaca of a nestling is, with certain exceptions, quite general among the Passeriformes, and cites eight examples among Australian birds. The present note adds another name to his list.

Nest Hygiene in Australia of the British Song Thrush, Turdus philomelus clarkei. *By Edith Coleman.*

The nest hygiene of the British Song Thrush provides a striking contrast with that of the Australian Honey-eater. In my garden many of these birds build every year. As nests are frequently placed close to a window, it has been possible to learn much concerning the habits of the Thrush.

Four clutches in one season are quite commonly reared by one pair of birds. Occasionally there have been five. First and third, second and fourth broods are often reared in the same nest. The nest is cleaned out, the sides are raised, and more mud is added to the interior. Twice (1933, 1934) I have seen a male bird renovating an old nest while his mate was still brooding nestlings. On one occasion (Dec., 1934), just after a thunderstorm, a male bird was cleaning out an old nest while the female was sitting on four eggs which she could not hatch. Then for some hours she sat on the edge of the nest. Often the male bird rested on the nest beside her, then returned to his work on the old nest. Then she left the eggs, and, next morning, I saw her revolving in the renovated nest. In this four more eggs were laid, and four nestlings reared. This was the second time in the same season that this pair of thrushes used an old nest. It is, however, a common practice of the British Song Thrush (in Australia) to save time in this way. In feeding, the parents rest on the edge of the nest. Excreta are voided directly into the nest or, as the nestlings grow, on to the sides of it. With these nestlings peristalsis was not always stimulated by feeding, but frequently took place during the absence of the parents. Sometimes one adult bird returned to the nest with food just as the other had fed the nestlings. Both then removed the excreta which appeared to have accumulated in the nest. Usually they were swallowed, often avidly.

The male thrush did not share the brooding, but, during the absence of the female, he perched on the edge of the nest. A few restless movements gave notice that the female wished to stretch her wings. If the male bird did not soon appear, she commenced to sing, softly at first, the notes increasing in strength until he returned. Then she slipped away and he stood on guard, often peering down at the eggs. I sometimes thought he turned them, but could not be sure of this. Not once did he leave the eggs, when incubation was nearly completed, until his mate returned. When tired, apparently, of his task he commenced singing, the notes increasing in volume until she returned, becoming imperative, I thought, if her absence were much prolonged. They ceased only when a sound announced her return. She dropped at once on to the eggs and he slipped away as silently and swiftly as she had done. I was thus able to satisfy myself that the female Thrush sings, though not so loudly as the male bird; that, in Australia, the British Song Thrush may rear four, even five, broods in one season, and that the same nest is frequently used for two broods.

ORDINARY MONTHLY MEETING.

28th October, 1936.

Mr. C. A. Sussmilch, F.G.S., President, in the Chair.

The Chairman reminded candidates for Linnean Macleay Fellowships, 1937–38, that Wednesday, 4th November, is the last day for receiving applications.

The Donations and Exchanges received since the previous Monthly Meeting (30th September, 1936), amounting to 20 Volumes, 428 Parts or Numbers, 4 Bulletins, 1 Report and 6 Pamphlets, received from 76 Societies and Institutions and 1 private donor, were laid upon the table.

PAPERS READ.

1. Notes on Australian Diptera. No. xxxvi. By J. R. Malloch. (*Communicated by F. H. Taylor, F.R.E.S., F.Z.S.*)

2. Problems in the Geology of New Caledonia (with Appendix by Germaine A. Joplin, B.Sc., Ph.D.). By H. I. Jensen, D.Sc. (*Communicated by Professor L. A. Cotton.*)

3. Studies in Australian Embioptera. ii. By Consett Davis, B.Sc.

4. Revision of Australian Lepidoptera. Oecophoridae. v. By A. Jefferis Turner, M.D., F.R.E.S.

Professor J. Macdonald Holmes delivered a lecturette entitled "Colour in the Australian Landscape", illustrated by Duofay colour films.

NOTES AND EXHIBITS.

Mr. E. Cheel exhibited specimens of a species of *Prostanthera* usually regarded as *P. incisa* var. *pubescens* F.v.M. A coloured drawing made by the late Mr. A. Forster from specimens collected at Hogan's Brush near Gosford in October, 1921, together with drawings made by Miss E. King of the leaf and floral characters of what is generally regarded as typical *P. incisa* R.Br., and the Hogan's Brush plants, shows that the two plants are distinct and that the latter is worthy of specific rank. Further investigations are being made with the object of tracing the original specimens of the var. *pubescens* F.v.M., recorded by Bentham (*Fl. Aust.*, v, 96), and of describing the plants more fully as a proposed new species.

Miss J. Vickery exhibited specimens of *Rulingia salvifolia* Benth. (Sterculiaceae), and *Boehmeria platyphylla* Don (Urticaceae) collected recently at Mt. Warning in the Murwillumbah district. Apparently these species have not previously been recorded from New South Wales and are not represented by any other specimens from New South Wales in the collection at the National Herbarium. They have, however, been collected at the Macpherson Ranges in Queensland, so that it is not surprising that they have now been obtained from similar districts in northern New South Wales.

Dr. I. V. Newman exhibited sixty-six seedlings (up to 20 cm. high) of *Acacia Baileyana* F.v.M., from seed taken from trees at two localities near Cootamundra, N.S.W. These localities were "A" and "J′", shown in Text-figure 2 of his paper, "Studies in the Australian Acacias. v." (These PROCEEDINGS, lx, 1935.) The seedlings exhibited showed no marked variation and are a good example of the total batch in this germination test, comprising 255 seedlings. Of the seedlings exhibited twenty were from three trees at Berthong (locality J′), one showing up to five pairs of pinnae, nine up to four pairs, nine up to three pairs, one up to two pairs. Of the 46 seedlings exhibited from two trees near the Big Sister Mt. (locality A) two showed up to five pairs of pinnae, fifteen up to four pairs, twenty-five up to three pairs, and four up to two pairs. All seedlings exhibited were hairy, but this may be only a juvenile character in some of them. There are in the whole test fifty-one seedlings from five trees at locality J′ and two hundred and four from five trees at locality A. None of them showed any marked variation. This evidence strongly supports the specific status of *Acacia Baileyana* and that the Cootamundra district is the natural habitat of the species.

ORDINARY MONTHLY MEETING.

25th NOVEMBER, 1936.

Mr. C. A. Sussmilch, F.G.S., President, in the Chair.

The President announced that the Council had reappointed Dr. I. V. Newman, M.Sc., and Miss Elizabeth C. Pope, B.Sc., to Linnean Macleay Fellowships in Botany and Zoology respectively for one year from 1st March, 1937, and had appointed Mr. H. F. Consett Davis, B.Sc., and Mr. A. H. Voisey, M.Sc., to Linnean Macleay Fellowships in Zoology and Geology respectively for one year from 1st March, 1937.

The Donations and Exchanges received since the previous Monthly Meeting (28th October, 1936), amounting to 19 Volumes, 85 Parts or Numbers, 8 Bulletins, 2 Reports and 15 Pamphlets, received from 64 Societies and Institutions and 2 private donors, were laid upon the table.

PAPERS READ.

1. The Diptera of the Territory of New Guinea. v. Family Tipulidae, Part iii. By C. P. Alexander. (*Communicated by F. H. Taylor, F.R.E.S., F.Z.S.*)

2. The Colour-Changes of Batoid Fishes. By Mervyn Griffiths.

3. Plant Ecology of the Bulli District. Part i. By Consett Davis, B.Sc.

4. Notes on the Occurrence of the Trichopeltaceae and Atichiaceae in New South Wales, and on their Mode of Nutrition, with a Description of a New Species of *Atichia*. By Lilian Fraser, M.Sc., Linnean Macleay Fellow of the Society in Botany.

NOTES AND EXHIBITS.

Mr. E. Cheel exhibited fresh specimens of the following species of *Leptospermum*, taken from plants cultivated at Ashfield:

Leptospermum citratum Challinor, Cheel and Penfold.

L. citratum var. *latifolium* (Garden origin).—Leaves twice the size of the original species.

L. odoratum Cheel.

L. floribundum Salisb.; *L. persiciflorum* Reichb.; *L. juniperinum* Sm.—These three species are listed as synonyms under *L. scoparium* by Bentham (*Fl. Aust.*, iii, p. 105) but are quite distinct from the *L. scoparium* of Forster, which is a native of New Zealand and is commonly known as "Manuka".

L. emarginatum Wendl.—Listed as a synonym under *L. flavescens* by Bentham but quite distinct from the three following forms, which were exhibited for comparison: *L. flavescens* Sm. (Typica); *L. flavescens* var. *microphylla* Benth.; *L. flavescens* var. with atro-cyanin pigment in the leaves and young shoots.

DONATIONS AND EXCHANGES.

Received during the period 31st October, 1935, to 28th October, 1936.)

(From the respective Societies, etc., unless otherwise mentioned.)

Aberystwyth.—*Welsh Plant Breeding Station, University College of Wales.* Bulletin, Series H, No. 14 (1936); "The Welsh Journal of Agriculture", xii (1936); "The Improvement of Grassland by Seeds and Manures", by Prof. R. G. Stapledon (being *Journal of the Farmers' Club, London,* Part 3, 1935).

Accra.—*Geological Survey Department, Gold Coast Colony.* Report for the Financial Year 1934-35 (1935).

Adelaide.—*Department of Agriculture of South Australia.* Bulletin, No. 313 ("Important Weeds of South Australia, Part 1", by G. H. Clarke) (1936).—*Department of Mines: Geological Survey of South Australia.* Annual Report of the Director of Mines and Government Geologist for 1934 (1935); Mining Review for the Half-years ended 30th June, 1935 (No. 62) (1935) and 31st December, 1935 (No. 63) (1936).—*Public Library, Museum and Art Gallery of South Australia.* 51st Annual Report of the Board of Governors, 1934-35 (1935).—*Royal Society of South Australia.* Transactions and Proceedings, lix (1935).—*South Australian Ornithological Association.* "The South Australian Ornithologist", xiii, 4-7 (1935-1936).—*University of Adelaide.* "The Australian Journal of Experimental Biology and Medical Science", xiii, 4 (T.p. & c.) (1935); xiv, 1-2 (1936).—*Woods and Forests Department.* Annual Report for the Year ended 30th June, 1935 (1935).

Albany.—*New York State Library, University of the State of New York.* New York State Museum Bulletin, Nos. 299, 300, 302, 303 (1934-1935).

Alger.—*Société d'Histoire Naturelle de l'Afrique du Nord.* Bulletin, xxvi, 6-9 (T.p. & c.) (1935); xxvi bis (Volume Jubilaire) (1935); xxvii, 1-5 (1936).—*Station d'Aquiculture et de Pêche de Castiglione.* Bulletin, 1933, 1-2 (T.p. & c.) (1934-1935); 1934, 1-2 (T.p. & c.) (1935).

Amsterdam.—*Koninklijke Akademie van Wetenschappen.* Proceedings of the Section of Sciences, xxxvii, 6-10 (T.p. & c.) (1934); xxxviii, 1-5 (T.p. & c.) (1935); Verhandelingen Afdeeling Natuurkunde, 2e Sectie, xxx, 1-4 (T.p. & c.) (1933); xxxi (complete) (1933); xxxii (complete) (1934); xxxiii, 1-2 (T.p. & c.) (1934).—*Nederlandsche Entomologische Vereeniging.* Entomologische Berichten, ix, 204-209 (1935-1936); Tijdschrift voor Entomologie, lxxviii, 3-4 (T.p. & c.) (1935); lxxix, 1-2, (1936).

Ann Arbor.—*University of Michigan.* Miscellaneous Publications of the Museum of Zoology, Nos. 26-30 (1935); Occasional Papers of the Museum of Zoology, Nos. 307-324 (1935); Papers of the Michigan Academy of Science, Arts and Letters, xx, 1934 (1935).

Athens.—*Zoological Institute and Museum, University of Athens.* Acta, i, 1-5 (1935-1936).

Auckland.—*Auckland Institute and Museum.* Annual Report, 1935-36 (1936); Records, i, 5 (1934).

Baltimore.—*Johns Hopkins University.* Bulletin of the Johns Hopkins Hospital, lvii, 3-6 (T.p. & c.) (1935); lviii, 1-6 (T.p. & c.) (1936); lix, 1 (1936); University Circular, N.S. 1935, 8-9 (1935) (exchange of University Circular concluded).

BANDOENG.—*Dienst van den Mijnbouw in Nederlandsch-Indie.* Bulletin of the Netherlands Indies Volcanological Survey, Nos. 72-74, T.p. & c. for Nos. 61-74 (Vol. iii), 1933-1935 (1935-1936); 75 (1936).

BARCELONA.—*Academie de Ciencies i Arts.* Memories, Tercera Epoca, xxv, 8-10 (1935).

BASEL.—*Naturforschende Gesellschaft.* Verhandlungen, xlvi, 1934-35 (1935).—*Schweizerische Naturforschende Gesellschaft.* Verhandlungen, 116. Jahresversammlung, 1935 (1935).

BATAVIA.—*Department van Economische Zaken.* Bulletin du Jardin Botanique, Serie iii, xiii, 3 (1935); "Treubia", vii, Suppl., Livr. 8 (T.p. & c.) (1936); xv, 2-3 (1935-1936).—*Koninklijke Natuurkundige Vereeniging in Nederlandsch-Indie.* Natuurkundig Tijdschrift voor Nederlandsch-Indie, Register, lxi-xc, 1901-1930 (1935); T.p. & c. for xcv (1935); xcvi, 1-3 (1936).—*Natuurwetenschappelijke Raad voor Nederlandsch-Indie te Batavia (Netherlands Indies Science Council).* Publication, Nos. 8-9 (November, 1935, and Mei, 1936).

BERGEN.—*Bergens Museum.* Arbok, 1935, 2 (T.p. & c.) (1936); 1936, 1 (1936); Arsberetning, 1934-35 (1935).

BERKELEY.—*University of California.* Bulletin of the Department of Geological Sciences, xxiii, 11, 13-15 (T.p. & c.) (1935); Publications, Botany, T.p. & c. for xvii (1932-1934); xviii, 2-4 (1935); xix, 1-4 (1935); Entomology, vi, 9-12 (1936); Physiology, viii, 8 (1936); Public Health, ii, 1 (1935); Zoology, T.p. & c. for xxxix (1933-1935); xl, 11-14 (T.p. & c.) (1935-1936); xli, 3-7 (1935-1936); Publications of the University of California at Los Angeles in Biological Sciences, i, 6 (1935).

BERLIN.—*Deutsch-Auslandischer Buchtausch.* "Flora", Neue Folge, xxix, 4 (T.p. & c.) (1935); xxx, 1-3 (1935-1936).—*Deutsche Entomologische Gesellschaft, E.V.* Deutsche Entomologische Zeitschrift, T.p. & c. for 1928 (1928); 1929, 1-5 (1929-1930); 1931, 4 (T.p. & c.) (1932); 1932, 1-3 and Beiheft (T.p. & c.) (1932-1933); 1933, 1-3 (T.p. & c.) (1933-1934); 1934, 1-2 (1934); 1935, 1-2 (1935); Mitteilungen, ii, 10 (T.p. & c.) (1931); iii, 1-10 (T.p. & c.) (1932); iv, 1-10 (T.p. & c.) (1933); v, 1-10 (T.p. & c.) (1934); vi, 5-10 (T.p. & c.) (1936).—*Zoologische Museum.* Mitteilungen, xxi, 1 (1935).

BERLIN-DAHLEM.—*Botanisch Garten und Museum.* Notizblatt, xii, 115 (T.p. & c.) (1935-1936); xiii, 116-117 (1936).—*Deutsches Entomologisches Institut.* Arbeiten uber morphologische und taxonomische Entomologie aus Berlin-Dahlem, ii, 3-4 (T.p. & c.) (1935); iii, 1-2 (1936); Arbeiten uber physiologische und angewandte Entomologie aus Berlin-Dahlem, ii, 3-4 (T.p. & c.) (1935); iii, 1-2 (1936); Entomologische Beihefte aus Berlin-Dahlem, ii (1935).

BERN.—*Naturforschende Gesellschaft.* Mitteilungen a.d. Jahre 1935 (1936).

BIRMINGHAM.—*Birmingham Natural History and Philosophical Society.* List of Members, 1936, and Annual Report for 1935 (1936); Proceedings, xvi, 6-7 (1935-1936).

BLOEMFONTEIN.—*Nasionale Museum.* Argeologiese Navorsing, ii, 2-4 (1935); Soologiese Navorsing, i, 1-2 (1935).

BOMBAY.—*Bombay Natural History Society.* Journal, T.p. & c. for xxxvii, pts. 3-4 (1935); xxxviii, 2 (T.p. & c. for xxxviii, pts. 1-2) (1935-1936); xxxviii, 3-4 (1936).—*Haffkine Institute.* Reports for the Years 1929; 1930 (1931, 1932).

BONN.—*Naturhistorischer Verein der Preussische Rheinlande und Westfalens.* "Decheniana" (comprising Verhandlungen und Sitzungsberichte), xci-xcii (1935).

BOSTON.—*American Academy of Arts and Sciences.* Proceedings, lxx, 3-10 (T.p. & c.) (1935-1936); lxxi, 1-2 (1936).—*Boston Society of Natural History.* Memoirs, ix, 1-2 (1935-1936); Proceedings, xl, 3-8 (T.p. & c.) (1934-1935); xli, 1-4 (1935-1936).

BRISBANE.—*Department of Agriculture.* Queensland Agricultural Journal, xliv, 5-6 (T.p. & c.) (1935); xlv, 1-6 (T.p. & c.) (1936); xlvi, 1-4 (1936).—*Department of Mines: Geological Survey of Queensland.* "Queensland Government Mining Journal", xxxvi, Nov.-Dec., 1935 (T.p. & c.) (1935); xxxvii, Jan.-Sept., 1936 (1936).—*Great Barrier Reef Committee*—Reports, iv, 2 (1936).—*Queensland Museum.* Memoirs, x, 5 (T.p. & c.) (1935); xi, 1 (1936).—*Queensland Naturalists' Club and Nature-Lovers' League.* "The Queensland Naturalist", ix, 6; x, 1 (1936).—*Royal Society of Queensland.* Proceedings, xlvii, 1935 (1936).—*Sub-Department of Forestry, Department of Public Lands.* Queensland Forest Service Bulletin, No. 12 (1936).

BRNO.—*Prirodovedecka Fakulta, Masarykovy University.* Spisy (Publications) (Botanical only), Cis. 222, 224 (1936); "Nanismy (Trpasliči Formy Rostlinné)", by R. Dvorák (1935).

BROOKLYN.—*Botanical Society of America.* American Journal of Botany, xxii, 8-10 (T.p. & c.) (1935) (Exchange discontinued).—*Brooklyn Botanic Garden.* "Genetics", xxi, 1-5 (1936).

BRUSSELS.—*Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique.* 102me Annuaire, 1936 (1936); Bulletin de la Classe des Sciences, 5me Série, xxi, 6-12 (T.p. & c.) (1935); xxii, 1-5 (1936).—*Musée Royal d'Histoire Naturelle de Belgique.* Bulletin, xi, 1-29 (T.p. & c.) (1935); Mémoires, Nos. 67-73, 2me Série, Fasc. 1-3 (1935-1936); Mémoires, Hors Série (Résultats Scientifiques du Voyage aux Indes Orientales Néerlandaises), ii, 17; iii, 17; iv, 11-12 (1935).—*Société Entomologique de Belgique.* Bulletin and Annales, lxxv, 7-12 (T.p. & c.) (1935); lxxvi, 1-5 (1936).—*Société Royale de Botanique de Belgique.* Bulletin, lxviii, 1 (1935).—*Société Royale Zoologique de Belgique.* Annales, lxv, 1934 (1935).

BUENOS AIRES.—*Sociedad Argentina de Ciencias Naturales.* Revista, "Physis", xii, 41-42 (1936).—*Sociedad Entomologica Argentina.* Revista, v, 1 (No. 21) (1932); vii (complete) (1935).

BUITENZORG.—*Nederlandsch-Indische Entomologische Vereeniging.* Entomologische Mededeelingen, i, 1-4 (1935); ii, 1-3 (1936).

CAEN.—*Société Linnéenne de Normandie.* Bulletin, 8e Série, vii, 1934-viii, 1935 (1935-1936); Mémoires, Nouvelle Série—Section Géologique, i, 2 (1935).

CAIRNS.—*North Queensland Naturalists' Club.* "North Queensland Naturalist", iv, 38-48 (1935-1936).

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LIST OF MEMBERS, 1936.

ORDINARY MEMBERS.

1927 *Albert, Michel François, "Boomerang", Elizabeth Bay, Sydney.
1929 Allan, Miss Catherine Mabel Joyce, Australian Museum, College Street, Sydney.
1905 Allen, Edmund, c/o Mulgrave Mill, Gordonvale, Queensland.
1906 Anderson, Charles, M.A., D.Sc., Australian Museum, College Street, Sydney.
1922 Anderson, Robert Henry, B.Sc.Agr., Botanic Gardens, Sydney.
1899 Andrews, Ernest Clayton, B.A., F.R.S.N.Z., No. 4, "Kuring-gai", 241 Old South Head Road, Waverley.
1932 Andrews, John, B.A., Department of Geography, Sydney University.
1927 Armstrong, Jack Walter Trench, "Callubri", Nyngan, N.S.W.
1912 Aurousseau, Marcel, B.Sc.

1913 Badham, Charles, M.B., Ch.M., B.Sc., Bureau of Microbiology, 93 Macquarie Street, Sydney.
1888 Baker, Richard Thomas, The Crescent, Cheltenham.
1919 Barnett, Marcus Stanley, 44 Fox Valley Road, Wahroonga.
1935 Beadle, Noel Charles William, 36 Anglo Street, Chatswood.
1907 Benson, Professor William Noel, B.A., D.Sc., F.G.S., University of Otago, Dunedin, N.Z.
1920 Blakely, William Faris, Botanic Gardens, Sydney.
1929 Boardman, William, Australian Museum, College Street, Sydney.
1935 Bourne, Geoffrey, D.Sc., School of Public Health and Tropical Medicine, Sydney University.
1923 Brough, Patrick, M.A., D.Sc., B.Sc.Agr., Botany School, Sydney University.
1921 Brown, Horace William, 871 Hay Street, Perth, W.A.
1924 Brown, Miss Ida Alison, D.Sc., "Caversham", 166 Brook Street, Coogee.
1911 Browne, William Rowan, D.Sc., Geology Department, The University, Sydney.
1932 Bryce, Ernest John, 47 Nelson Road, Killara.
1931 Burges, Norman Alan, M.Sc., 35 Wetherell Street, Croydon.
1920 Burkitt, Professor Arthur Neville St. George Handcock, M.B., B.Sc., Medical School, The University, Sydney.
1921 Burns, Alexander Noble, "Meringa", Fuchsia Street, Blackburn, Victoria.
1926 Buzacott, James Hardie, Meringa (private bag), via Cairns, North Queensland.

1901 Campbell, John Honeyford, I.S.O., M.B.E., Royal Canadian Mint, Ottawa, Canada.
1927 Campbell, Thomas Graham, Flat No. 4, 806 Military Road, Mosman.
1930 Carey, Miss Gladys, M.Sc., 32 Rawson Street, Epping.
1934 Carey, Samuel Warren, M.Sc., c/o Oil Search Ltd., 350 George Street, Sydney.
1905 Carne, Walter Mervyn, University of Tasmania, Hobart, Tasmania.
1903 Carter, Herbert James, B.A., F.R.E.S., "Garrawillah", Kintore Street, Wahroonga.
1936 Chadwick, Clarence Earl, B.Sc., 41 Hannam Street, Arncliffe.
1899 Cheel, Edwin, 40 Queen Street, Ashfield.
1924 Chisholm, Edwin Claud, M.B., Ch.M., Barellan, N.S.W.
1932 Churchward, John Gordon, B.Sc.Agr., Ph.D., Faculty of Agriculture, Sydney University.
1901 Cleland, Professor John Burton, M.D., Ch.M., The University, Adelaide, S.A.
1931 Colefax, Allen N., B.Sc., Department of Zoology, Sydney University.
1933 Coleman, Mrs. Edith, "Walsham", Blackburn Road, Blackburn, Victoria.
1908 Cotton, Professor Leo Arthur, M.A., D.Sc., Geology Department, The University, Sydney.
1928 Craft, Frank Alfred, B.Sc., 64 Boyce Road, Maroubra.
1925 Cunningham, Gordon Herriot, Ph.D., Department of Agriculture, Fields Division, Plant Research Station, P.O. Box 442, Palmerston North, N.Z.

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1934 Davidson, Harold James, 11 Melrose Street, Croydon Park.
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1936 Day, Maxwell Frank, 12 Arnold Street, Killara.
1934 Day, William Eric, 23 Galling Avenue, Strathfield.
1929 Deane, Cedric, A.M.I.E.Aust., "Cloyne", 6 State Street, Malvern, S.E.4, Victoria.
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1927 *Dixson, William, "Merridong", Gordon Road, Killara.
1921 Dodd, Alan Parkhurst, Prickly Pear Laboratory, Sherwood, Brisbane, Q.
1926 Dumigan, Edward Jarrett, State School, Toowoomba East, Queensland.
1920 Dwyer, Rt. Rev. Joseph Wilfrid, Bishop of Wagga, Wagga Wagga, N.S.W.

1932 *Ellis, Ralph, 2420 Ridge Road, Berkeley, California, U.S.A.
1930 English, Miss Kathleen Mary Isabel, B.Sc., March Street, Yass, N.S.W.
1914 Enright, Walter John, B.A., West Maitland, N.S.W.

1908 Flynn, Professor Theodore Thomson, D.Sc., Queen's University, Belfast, Ireland.
1930 Fraser, Miss Lilian Ross, M.Sc., "Hopetoun", Bellamy Street, Pennant Hills.
1911 Froggatt, John Lewis, B.Sc., Department of Agriculture, Rabaul, New Guinea.
1886 Froggatt, Walter Wilson, F.L.S., Young Street, Croydon.
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1935 Garretty, Michael Duhan, B.Sc., c/o J. H. H. Miller, Esq., Suva, Fiji.
1932 Gay, Francis Joseph, B.Sc., Glebe House, Reid, Canberra, F.C.T.
1936 Gilmour, Darcy, 325 Livingstone Road, Marrickville.
1936 Goerling, August, Marloo Station, Wurarga, Western Australia.
1912 Goldfinch, Gilbert Macarthur, University Club, 70 Phillip Street, Sydney.
1911 Greenwood, William Frederick Neville, F.L.S., F.R.E.S., c/o Colonial Sugar Refining Co., Ltd., Lautoka, Fiji.
1910 Griffiths, Edward, B.Sc., Department of Agriculture, Farrer Place, Sydney.
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1930 Heydon, George Aloysius Makinson, M.B., Ch.M., School of Public Health and Tropical Medicine, The University, Sydney.
1930 Holmes, Professor James Macdonald, Ph.D., B.Sc., F.R.G.S., F.R.S.G.S., Department of Geography, Sydney University.
1932 Hossfeld, Paul Samuel, M.Sc., c/o Deputy Administrator, Alice Springs, Central Australia.
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1932 Martin, Donald, B.Sc. c/o University of Tasmania, Hobart, Tasmania.
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1932 Messmer, Pearl Ray (Mrs. C. A.), Treatts Road, Lindfield.
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1930 Munch-Petersen, Erik, Ph.B., M.Sc. (Haunensis), M.I.F., Veterinary Research Institute, Story Street, Parkville, Melbourne, N.2, Victoria.
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1934 Newman, Florence Rewa Wear (Mrs. I. V.) (*née* Burton), B.A., Dip.Ed., "Whitehaven", 5 Llandilo Avenue, Strathfield.
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1912 North, David Sutherland, c/o Colonial Sugar Refining Co., Ltd., Broadwater Mill, Richmond River, N.S.W.

1920 O'Dwyer, Margaret Helena, B.Sc., Ph.D., Forest Products Research Laboratory, Princes Risborough, Aylesbury, Bucks., England.
1927 Oke, Charles George, 34 Bourke Street, Melbourne, C.1, Victoria.
1910 Oliver, Walter Reginald Brook, F.L.S., F.Z.S., D.Sc., F.R.S.N.Z., Dominion Museum, Wellington, C.1, New Zealand.
1927 Osborn, Professor Theodore George Bentley, D.Sc., F.L.S., Department of Botany, The University, Sydney.
1921 Osborne, George Davenport, D.Sc., Geology Department, The University, Sydney.

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1922 Perkins, Frederick Athol, B.Sc.Agr., Biology Department, University of Queensland, Brisbane, Q.
1921 Phillips, Montagu Austin, F.L.S., F.R.E.S., 57 St. George's Square, London, S.W., England.
1936 Pidgeon, Miss Ilma Mary, B.Sc., "Winslow", 57 Amhurst Street, North Sydney.
1920 Pincombe, Torrington Hawke, B.A., "Mulyan", Beta Street, Lane Cove, Sydney.
1934 Plomley, Norman James Brian, c/o Bank of New South Wales, Threadneedle Street, London, E.C.2, England.
1935 Pope, Miss Elizabeth Carington, B.Sc., 36 Kameruka Road, Northbridge.
1931 Pratt, Enid Mary, (Mrs. W.), (*née* Edmonds), M.Sc., Congregational Manse, Broken Hill.
1918 Priestley, Professor Henry, M.D., Ch.M., B.Sc., Medical School, The University, Sydney.

1929 Raggatt, Harold George, M.Sc., Geological Survey, Department of Mines, Sydney.
1924 Roberts, Frederick Hugh Sherston, M.Sc., Department of Agriculture and Stock, Animal Health Station, Yeerongpilly, Brisbane, Q.
1936 Roberts, Noel Lee, 24 Meredith Street, Homebush.
1932 Robertson, Rutherford Ness, B.Sc., 15 The Boulevarde, Lewisham.
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NOTES ON THE BIOLOGY OF *SCAPTIA AURIFLUA* DON. (DIPTERA, TABANIDAE).

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(Plate i; eleven Text-figures.)

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Introduction.

Although the early stages of many Tabaninae (*Tabanus* and *Haematopota*) have been discovered in other parts of the world, comparatively little is known of the Pangoniine genera. The larvae and pupae of a few species of the more specialized genera *Chrysops* and *Silvius* have been studied, but *Goniops chrysocoma* Osten-Sacken, which has been fully described by McAtee (1911), is the only generalized Pangoniine of which the breeding habits and early stages are known. Our knowledge of the immature stages of Australian Tabanidae is small, although the family is represented here by more than 250 species. The larvae of four species of *Tabanus* and one Pangoniine, *Silvius notatus* Ric., have been briefly described (Johnston and Bancroft, 1920; Hill, 1921). The discovery of the breeding grounds and early stages of the generalized Pangoniine, *Scaptia auriflua* Don., is, therefore, of considerable interest.

Scaptia Walk. is the dominant Australian Pangoniine genus, nearly fifty species being known (Ferguson, 1926). It is the Australian representative of that group of genera with short, broad, mostly hairy bodies, and with the third antennal segment eight-annulate, of which *Pangonia* (*s.l.*) may be taken as typical. *Goniops* Ald. also appears to belong to this group and, from the information available, seems to possess characters in common with some species of *Scaptia*. It is, therefore, not surprising that the larva and pupa of *S. auriflua*, described below, should show points of resemblance to those of *G. chrysocoma*.

The writer is indebted to Dr. I. M. Mackerras for the identification of the species, for information on the Tabanidae, and for assistance in the preparation of the paper.

The Habits of the Adult.

S. auriflua is a medium-sized, rather ornate species, of which White (1915) has given an adequate re-description. It is distributed along the southern and eastern highlands of Australia, from Tasmania and South Australia to southern Queensland, and is commonly found associated with flowering *Leptospermum* growing in swampy country at high altitudes. In January, 1935, the flies were plentiful on *Leptospermum* flowers on a small plain at the foot of Mt. Coree (4,600 ft.) near Canberra, and were also abundant on the flowers of another species of *Leptospermum* growing along Alpine Creek, Kiandra, and in a swamp near Yarrangobilly (5,000 ft.). Dr. Mackerras informs me that they were very common on flowering *Leptospermum* at Barrington Tops (4,500 ft.) in the summer of 1925. The flies remained resting or moving about on the flowers for considerable periods, and were not readily disturbed. They frequently rested beneath the flower clusters and among the inner parts of the bushes, with their lower surface uppermost, and were then not readily distinguishable in spite of their bright colouring. Both sexes were present in equal numbers. They were not seen to hover over or alight on the swamps, although other Tabanids, including *Scaptia ruficornis* Macq., had this habit.

Most species of *Scaptia* suck the blood of mammals, and the females are usually taken when attacking the collector; males are rarely seen. *S. auriflua,* however, made no attempt to bite, and has never been recorded as blood-sucking by other observers. It is most probable that both sexes feed exclusively on the nectar of flowers, although the mandibles of the female are not reduced, as they are in the primitive, non-blood-sucking genus *Pelecorhynchus.* Possibly *S. auriflua* sucks the blood of native animals, but no evidence of this was found.

Notes on the Life-History.

Goniops oviposits on the underside of leaves and guards the egg-mass for some days, buzzing loudly at intervals. The breeding habits and the egg-masses of *S. auriflua* have not been discovered, nor is there any evidence to suggest that it might possess similar peculiar habits.

The larvae of *S. auriflua* were discovered in the soil of a restricted area on a small mountain plain beside Mt. Coree (Plate i, fig. 1). The soil, the moisture content of which varied over the period when larvae were found, was never dry nor saturated; in general it was moderately damp. The larvae were just below the surface and frequently well up among the grass roots. They were present in the same situation whenever it was examined from October, 1934, to August, 1935. Many other areas in the locality were examined, but the larvae were not found anywhere else. The surface of the ground was covered with grasses and a small group of willows was close by (Plate i, fig. 2). Between the willows and Coree Creek, which was 65 yards distant, the ground was slightly lower and was covered with marsh grasses, being in places saturated. Since the first larvae found were full grown, it was assumed that they lived in the swamp and moved to higher ground to pupate, but this was found to be incorrect, when later search revealed larvae of all sizes. Moreover, none were found in the wetter soil.

On 7th October, full-grown larvae were present, associated with numerous Tipulid and some Stratiomyiid larvae.

On 13th and 14th October, full-grown larvae in the proportion of 1 to 50 Tipulids were present, the Tipulids being extremely plentiful.

On 11th November, a few large larvae were present, and most of the Tipulids had pupated.

On 17th February, half-grown larvae and no Tipulids were found.

On 24th March, larvae of various sizes from half to full grown and no Tipulids were present. The soil was at its driest.

On 23rd June, very small to nearly full-grown larvae were present, and Tipulids were again found in small numbers.

On 11th August, small to full-grown larvae were present and Tipulids occurred in fair numbers. The soil was wetter than it had ever been previously, due to the fact that snow had fallen to a depth of six inches or more a week earlier. The larvae were still very close to the surface.

Throughout the whole period, earthworms and cockchafer larvae were present in the soil. The *Scaptia* larvae were always contracted when found, probably due to being disturbed when the soil was turned over. They remained inert and never attempted to move away.

The first larvae collected were kept each in a separate jar of slightly moistened soil and supplied with Tipulid larvae as food. As the larvae were full grown and were not observed to feed, it was assumed that they were at the resting stage prior to pupation. They remained in this state for approximately two months (54 to 65 days) before pupating. The pupal stage lasted 15 to 24 days, and the flies emerged in December and January over a period of three weeks.

As the larvae showed no attempt to attack each other, several were later kept in each jar. Apparently most of the feeding is done in the winter, as larvae collected in March and June disposed of earthworms supplied to them, although actual feeding from a worm was only observed once. The *Scaptia* larva had pierced the worm near the middle and had its head buried in the body, part of which was sucked out. Tipulid larvae placed in the jars were later found damaged and flaccid, but feeding on these was not actually observed. Some larvae have been kept successfully in jars of soil and grass roots for five months. They can withstand starvation, and drying and hardening of the soil for six weeks without being affected. Larvae subjected to such conditions were contracted and darkened, but extended and became normal when placed in moist soil and given food.

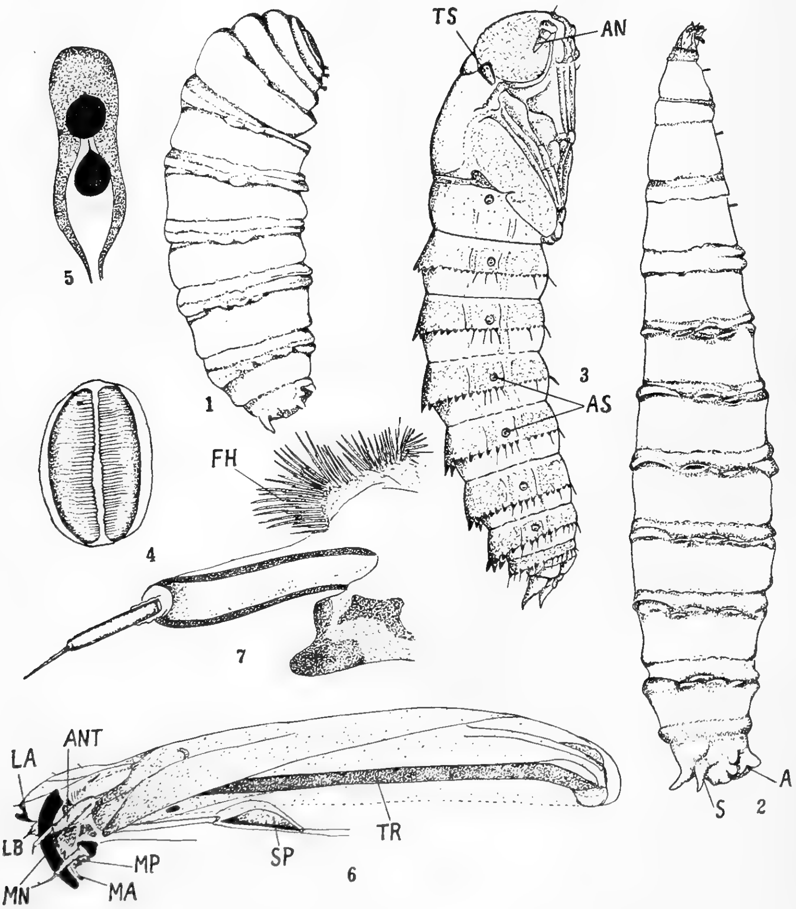
The full duration of the life cycle is not known, but the facts that adults are only on the wing for a limited period in summer, and that larvae in various stages of growth occur together, suggest that full development may take two, or even three, years.

The Larva (Text-figs. 1 and 2).

Larvae from 11 to 26 mm. in length were examined and, except for size, there was no difference in structure between these stages.

The following description is taken from a full-grown larva. The length of the larva when fully extended is 26 mm. The body is pointed anteriorly and, unlike most other Tabanid larvae, truncated posteriorly (Text-fig. 2). It is widest at the 3rd, 4th and 5th abdominal segments. The larva is capable of contracting to half its length when disturbed. When moving actively it has a leech-like shape, but takes on a short barrel shape when touched (Text-fig. 1), the girth increasing by about 2 mm.

As the pigment fades and alters in preserved specimens, the following description of the colour markings is from a live larva. Beneath the thick striated integument, which is itself practically colourless, is a layer of pigment broken up into patches. The pigment is a dark chocolate or purplish-brown, and varies in amount and extent with individual larvae, and with stages of growth. It is brightest in colour near the anterior end, and most continuous and intense on the dorsal surface of the last four abdominal segments. The patches where the pigment is absent are a pale yellowish colour, and it is only through these patches that parts of the internal organs are visible. The unpigmented patches are rounded or elongated-oval in outline. The lateral regions of the thoracic segments are devoid of pigment, and the junction between segments is colourless, except for an occasional spot between the posterior segments. Down the dorsum of the thoracic and first few abdominal segments there is a long narrow colourless area. On the ventral surface the yellowish patches are more extensive than the pigmented areas, which simply form a network of colour around them. The ventral surface of the eighth segment, and the parts surrounding the anus, are completely devoid of pigment. In general the arrangement of the pigment in this larva gives it a very characteristic mottled or spotted appearance.



Text-figs. 1-7.—*Scaptia auriflua.*
1.—Larva contracted, × 3·6. 2.—Larva extended, × 3·6; *a*, anus; *s*, spiracle. 3.—Pupa, × 3·6; *an*, antenna; *as*, abdominal spiracles; *ts*, thoracic spiracle. 4.—Posterior spiracle, × 80. 5.—Graber's organ, × 144. 6.—Head of larva, × 16; *ant*, antenna; *la*, labrum; *lb*, labium; *ma*, maxilla; *mn*, mandible; *mp*, maxillary palp; *sp*, salivary pump; *tr*, tentorial rod. 7.—Antenna, × 64; *fh*, flexible hairs.

With the exception of the head, the annulus of the first thoracic segment, and certain papillae on the eighth abdominal segment, the whole of the integument is strongly and evenly striated. Between adjacent thoracic segments is a broad annulus. The annulus of the first segment, which is immediately behind the head, is covered with close minute spines directed backwards. On the ventral surface of each thoracic segment are two groups of hairs situated one each side of the centre in the anterior third. Each is composed of four long, light brown setae arising from a common base. There is no division of the thorax into dorsal, lateral and ventral areas, beyond a slight curving of the striae in these regions. No trace of the anterior spiracles is visible on the thorax.

The integument on the posterior border of each abdominal segment is thickened, raised slightly, and somewhat irregularly folded. Just behind the anterior border of each segment the skin is raised all round and folded into a series of small prominences. Dorsally this forms a continuous ridge, slightly curved forwards. Laterally there is a series of small curved ridges with hollows between and among them, and ventrally there are two parallel ridges of integument, one being formed by the anterior border of the segment, and one by the fold behind it. The posterior borders of the segments are more prominent ventrally, making a series of three ridge-like pseudopods. On the ventral surface of each abdominal segment except the last there is a transverse series of six very delicate, colourless hairs in the anterior third.

The eighth segment is entirely different from the others. It is much shorter and does not bear a ring of projections. Two large pointed papillae arise from the dorsal surface at the posterior extremity and project backwards, upwards and outwards. Between them on the vertical face of the segment is the posterior stigma (Text-fig. 4). There is no indication of a siphon, the spiracle lying flush with the integument. It is elliptical in shape, consisting of a single narrow vertical slit with two raised chitinous lips, the edges being finely scalloped. Below the spiracle are two pairs of short rounded papillae. The anus on the ventral surface is surrounded by a fleshy ridge, which bears a pair of blunt papillae projecting downwards and backwards. The four papillae below the spiracles are striated and each bears a short, fine hair. The pointed dorsal projections and the anal ridge are finely rugose.

Graber's organ (Text-fig. 5) is very difficult to discern because of the heavy pigmentation in the posterior segments. It is never visible from the exterior, and can only be detected after the eighth segment is macerated and the pigment scraped out. The organ lies below the integument of the dorsal surface of the eighth segment just anterior to the pair of projections. It is rounded at the anterior end and tapered posteriorly. In the larvae examined, which were all more than half grown, there were only two bodies present. These were large, black and round, occupying most of the space in the sac, and arranged one in front of the other.

The head (Text-fig. 6).—The head capsule is very elongated, only the anterior fifth being visible when extended, the rest being enclosed within the thorax. Of the portion which is external, a smooth thin membrane which grows out from the thorax envelops the posterior half, the mouth parts projecting in front of this. The epicranium is a flat dorsal plate of smooth, brown chitin dividing into three arms anteriorly. The two outer projections curve round forming the lateralia, and the central arm continues forward into the rostrum. The chitin is darker along the sides of the epicranium, giving the effect of two stripes. Posteriorly the chitin of the dorsal plate becomes thinner and is produced into two lateral arms which curve downwards and fuse with the posterior extremities of the tentorial rods. At the base each of these epicranial arms is joined to the tentorial rod by a short curved bar. Just anterior to the basal membrane the head capsule is completed ventrally by a smooth, flat gular plate lying between the lateralia and extending forward to the posterior end of the labium.

The tentorium consists of a pair of dark brown, hollow chitinous rods, running the length of the head ventrally. These rods end anteriorly just behind the reduced buccal cavity, and take a downward sweep posteriorly to join the tips of the epicranial arms. They are each connected near the anterior end, behind the eye-spot, with the dorsal plate by a curving vertical bar. The eye-spots are small, dark, reddish masses lying internally beneath the lateralia just in front of the basal membrane, and not visible from the dorsal surface. The pharynx, which is chitinized for its whole length, runs below the tentorial rods anteriorly, and then between them, expanding slightly at the posterior end of the head.

The salivary pump lies posterior to the gular plate and below the ventral side of the head internally. It is large, chitinous, and saddle-shaped, having the concave surface uppermost. A duct running forward from its anterior end opens in the front of the labium. From its posterior end a duct runs back to the salivary glands. Valve structures are present in the organ where these ducts enter it.

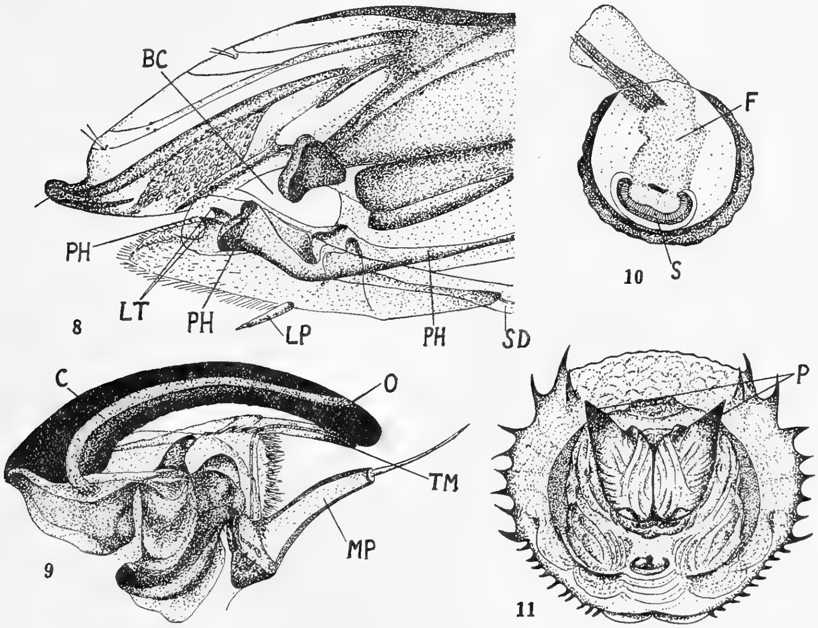
The antennae (Text-fig. 7) arise dorso-laterally from the lateralia, and consist of three segments, the basal one being very elongated, flattened and lying close against the head. Cameron (1934) and Isaac (1925) describe the antenna of Tabanid larvae as two-segmented, considering the apparent basal segment to be a flattened cephalic sclerite. Stone (1930), Boving (1924) and others state that the antenna is three-segmented. In *Scaptia auriflua* the large basal segment is clearly articulated with the head, and readily separated from it. The middle segment projects sideways and is considerably smaller than the basal one, whilst the apical segment is very narrow, pointed and setiform. Between the lateralia and rostrum the chitin is delicate and membranous. Near the base of the mandibles and between the antennae and rostrum on each side is a comb of fine hairs which are hidden when the mandibles are withdrawn. They correspond to the stiff brush of "piercing spines" (Isaac, 1925) in many Tabanids, but are much finer and less conspicuous.

Mouth Parts.—The anterior extremity of the head is occupied by the prominent mouth parts. Dorsally the rostrum ends in the laterally compressed labrum with its up-turned end. Ventrally the two pointed hairy lobes of the labium project forwards. Between these laterally are the large, conspicuous mandibles with their associated maxillae.

The labrum (Text-fig. 8) is narrow and blade-like, with a narrow, sharply up-turned tip composed of hard black chitin. A pair of small setae is present at the end, and two other groups of setae occur dorso-laterally. On the ventral surface and laterally in this region is a large area of close papillae, corresponding, no doubt, to the epipharynx. The labium (Text-fig. 8) is less chitinous than the labrum and does not project so far forward. It is bi-lobed and covered with fine hairs. At its base ventrally are a pair of elongated palps projecting forwards.

Dorsally it is fused with the anterior end of the pharynx, which is strongly chitinous in this region. A pair of lobes from the dorsal wall of the pharynx grow upwards to meet the ventral surface of the labrum, and associated with them is a pair of forwardly-directed, sharp, chitinous teeth arising from the labium. Isaac and Cameron both assert that these structures permanently close the mouth opening, cutting off the reduced buccal cavity from the exterior, the liquid food being taken in through the mandibular canal. This specialization of the labium and pharynx, and the structures connecting the labrum and labium in *Scaptia*, closely correspond with the condition described for *Haematopota pluvialis* by Cameron and *Tabanus rubidus* by Isaac. But in *Scaptia*, although the mouth appears to be closed by the dorsal pouch of the pharynx and the chitinous teeth of the labium, it is possible to separate the labrum and labium-pharynx, thus opening the mouth, by pushing the tip of the labrum upwards or by pressing from the buccal cavity forwards with a needle, none of the parts being torn or damaged in the process. It is quite possible that these parts are not capable of independent movement in the living larva, and the mouth is non-functional as in *Haematopota* and *Tabanus*. Projecting into the back of the buccal cavity is a pair of triangular masses connected with the tentorium.

The mandible (Text-fig. 9) is a strong, black, slightly curved tusk-like structure, with a blunt tip, and slightly expanded at the base where it is



Text-figs. 8-11.—*Scaptia auriflua*.
8.—Labrum and labium, × 52; *bc*, buccal cavity; *lp*, labial palp; *lt*, labial teeth; *ph*, pharynx; *sd*, salivary duct. 9.—Mandible and maxilla, × 52; *c*, canal; *mp*, maxillary palp; *o*, opening of canal; *tm*, tip of maxilla. 10.—Abdominal spiracle of pupa, × 64; *f*, felt chamber; *s*, slit. 11.—Posterior end of pupa, × 12 approx.; *p*, points of aster.

connected with the maxilla. The concave inner edge is finely serrated. There is an opening on the dorsal, convex surface a little behind the tip. This is the entrance to a canal which runs through the mandible and is continued through its base. Isaac states that it then continues as a membranous tube amongst the anterior sclerites of the head, until it ends in the pharynx. The mandible is more strongly developed and larger in proportion to the other mouth parts in *Scaptia* than in the Tabanid larvae described by other workers. The maxilla (Text-fig. 9) is composed of lighter chitin and works in unison with the mandibles. It is a fairly broad flat plate produced to a slender point anteriorly: the end of this projection is hard and black and extends a little beyond the mandible. The lower edge of the maxilla is heavily fringed with fine hairs. The maxillary palp arises near the outer posterior edge and is very large and conspicuous. The basal segment is a short triangular mass of heavy chitin. The second segment is large, cylindrical and well chitinized, whilst the apical segment is fine and slender.

The Pupa (Text-fig. 3).

The pupa is 19 to 22 mm. in length. When newly formed, the thoracic region and all the anterior end, except the eyes, are a creamy colour, and the abdomen is bright chestnut. The colour changes to a general light brown, and before emergence again darkens considerably, the eyes becoming greenish.

The frontal carina is a ridge of light brown, wrinkled chitin with a notch in the median line. Above the carina is a pair of slight prominences of wrinkled chitin, each bearing a fine bristle. Below the carina is a pair of small, but prominent projections placed close together in the median line, and lying between the eyes ventrally. Below and to each side of these is one fine bristle. The antennae are short and curved down over the eye. The thoracic spiracles are short and dark-brown, and do not project much beyond the dorsal surface. The wing sheaths just reach the fore border of the second abdominal segment.

Except for the first and last, the abdominal segments are all similar. The first to the seventh are divided into dorsal, lateral and ventral areas by smooth grooved lines. Each of these segments bears a conspicuous spiracle near the centre of each lateral area. The spiracle (Text-fig. 10) is a round mound with a strong chitinous rim which is incomplete anteriorly. Near the posterior edge of the mound is a curved spiracular slit, opening into a large felt chamber. Every segment except the first bears a girdle of spines near its centre. The part of the segment in front of the ring of spines is marked with a network of raised lines of darker brown than the general surface. The posterior half of the segment is finely rugose. The girdle of spines, which point backwards, is continuous. The spines are dark brown, thorn-like structures, and are largest and strongest on the dorsum, smaller in the lateral areas and very small ventrally. The lateral spines are produced into long, stiff, colourless setae. In the last segment the dorsal spines are absent, whilst all the rest bear setae. In the female pupa there is a median gap ventrally in the ring of spines on the last segment, whilst in the male there is no break in the ring.

The pupal aster (Text-fig. 11) which in all known Tabanid larvae, except *Goniops*, is a series of six large projections on the anal segment, consists of only two noticeable projections, the dorso-lateral pair. These are strongest and most outstanding in the male pupa. The ventral pair are reduced to two small knobs, and the dorsal pair are scarcely distinguishable.

Fig. 1.

Fig. 2.
Areas where larvae of *Scaptia* were found.

Discussion.

The structure of the larval head and mouth parts, the form of the respiratory organs, and the longitudinally striated integument are all characteristic features of immature Tabanidae possessed by *Scaptia auriflua.* The larvae and pupae of *S. auriflua* (which, as the species is very closely related to the genotype, *S. aurata,* may be taken as representative of the genus) and of *Goniops chrysocoma* can, however, be distinguished from all other known Tabanidae by the following characters:

> *Larva.*—The body does not taper at both ends; there is no siphon; Graber's organ is not visible.
>
> *Pupa.*—The aster is reduced to two large projections at the end of the terminal segment.

The common possession of these characters by two genera, one North American and the other Australian, justifies the suggestion that they may prove to be group characters, sharply distinguishing the "Pangonia" group of genera from the rest of the family. Other points in common between *S. auriflua* and *G. chrysocoma* are the general opaqueness of the integument, the replacement of the "piercing spines" by fine, flexible hairs, and the fact that, unlike most Tabanid larvae, they are found in comparatively dry situations. They, however, differ from each other in several particulars. *Goniops* has a characteristic club shape, whereas *Scaptia* is more elongate, although when moving along it sometimes assumes a long club form. Also *Scaptia* is strongly striate, whilst *Goniops* has no striae but is papillate. The pupae differ in shape and in the arrangement of the segmental spines.

These investigations suggest that the characters of the early stages will be found to throw more light on generic relationships in the Tabanidae than can at present be obtained from a study of the adults.

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EXPLANATION OF PLATE I.

1.—Small plain below Mt. Coree (4,600 feet) showing area where *Scaptia auriflua* larvae are found.

2.—Area on Coree plain where *Scaptia* larvae occur in the soil.

NOTES ON AUSTRALIAN DIPTERA. XXXV.

By JOHN R. MALLOCH, Washington, D.C., U.S.A.
(*Communicated by F. H. Taylor, F.R.E.S., F.Z.S.*)

(Nine Text-figures.)

[Read 25th March, 1936.]

Family TACHINIDAE.

Tribe RUTILIINI.

SENOSTOMA Macquart.

Townsend has recently published some notes on genotypes, including one dealing with *Senostoma variegata* Macquart which, he states, following Engel, is a synonym of *Diaphania testacea* Macquart.*

The name *Senostoma* will therefore replace *Prodiaphania* Townsend in our list of Australian Diptera, provided someone does not subsequently prove that this synonymy is erroneous.

I have already dealt briefly with the genus *Prodiaphania* in this series of papers (PROC. LINN. SOC. N.S.W., liv, 291, 1929), though I was at that time, and am even yet, uncertain of the exact identity of *testacea* Macquart. I accepted this name for what appears, from my material, to be the commonest species found in central Eastern Australia, particularly in the vicinity of Sydney, N.S.W., and only a careful examination of type material will prove whether I am correct or not.

The genus is not difficult to separate from its allies, the chief character being the very short palpi, which are not as long as the third antennal segment, all the other genera of the tribe having these organs much longer than the entire antennae.

I described one new species from Western Australia in my previous paper and distinguished one new variety of *testacea*, but it is very difficult to determine the exact status of some specimens on the basis of external characters, and a careful study of the genus in the field is required to check laboratory findings. There are, without doubt, several species involved, and below I present some additional data intended to facilitate the recognition of those now before me, though the question of synonymy is not attempted without access to the type specimens of certain old species.

This summary of results is based almost exclusively upon males submitted to me by various Australian correspondents.

In this study I have been compelled to make use of the male hypopygial characters to distinguish several species occurring in the eastern part of the continent and, as it is almost, if not quite, impossible to present in words a description that will give a brief but exact picture of these characters, I have

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* *Ann. Mag. Nat. Hist.*, vol. 9, 1932, p. 40.

figured them herein. I have found that the principal distinguishing characters are found in the structure and armature of the inferior forceps (dististyli), the superior forceps (cerci) being of very similar form throughout my series. The most remarkable feature consists of a more or less developed extension on the inner side at the base of each dististylus which is furnished with hairs or bristles and which is entirely concealed when the hypopygium is in its normal retracted condition. In the species that I have dissected there is no extension of the dististyli in one, and here I have a suspicion that the species may be out of place in *Senostoma*, though it lacks hairs on the edge of the narrow stripe above the lower squama (parasquamal tuft). The proboscis is not in such a position that the palpi are visible without difficulty, but I make them out to be small, so I retain the species in this genus, the other characters being in accordance with the generic criteria.

I present below a key to the species which I hope will prove of value in the identification of, at least, those now in hand. I believe it will be found that there are a number of other species in Australia, to which continent the genus at present appears to be confined.

Key to the Species.

1. Males 2
Females 9

2. Hind tibia with no posterodorsal submedian bristle 3
Hind tibia with one or more submedian posterodorsal bristles 4

3. Hind metatarsus with a series of dorsal setulose hairs that are longer than the greatest diameter of that segment .... *georgei* Malloch
Hind metatarsus with much shorter dorsal hairs; hypopygium as Figure 1 .... *biarmata*, n. sp.

4. Upper squama not extending more than two-thirds of the distance to apex of the lower one; wing with no dark transverse mark near base; hind femur with widely separated strong bristles on the entire extent of the anteroventral surface, and some on the basal half of the posteroventral surface; fourth tergite of the abdomen with apical bristles strong and widely separated, about as long as the exposed part of the tergite .... *cygnus*, n. sp.
Upper squama extending almost to apex of the lower one; wing normally with a dark transverse mark near base; hind femur with the anteroventral bristles on apical half only and none on the basal half of the posteroventral surface.. 5

5. Wing with no dark mark near base .... *testacea*, var. *claripennis* Malloch
Wing with a dark transverse mark near base 6

6. Inferior hypopygial forceps as in Figure 2, with a long heavily chitinized fork at base which projects forward and is usually concealed, the inner side of the fork with dense short dark brown hairs; hind metatarsus slender, with a series of fine bristly hairs above that are a little longer than its diameter .. *furcata*, n. sp.
Inferior hypopygial forceps either without a fork at base or, if forked, the inner branch much shorter, stouter, and furnished with longer hairs or bristles 7

7. Inferior hypopygial forceps with a stout basal process which is densely covered with long fine brown hairs (Fig. 3); hind metatarsus with short dorsal setulose hairs .... *testacea* Macquart
Inferior hypopygial forceps with comparatively few bristles or bristly hairs on a poorly developed basal prominence 8

8. Inferior hypopygial forceps with but few fine short hairs on dorsal surface of the exposed part (Fig. 4); hind metatarsus with the dorsal setulae not very strong and distinctly shorter than those on centre of the series on the anterodorsal surface of the hind tibia .... *victoriae*, n. sp.
Inferior hypopygial forceps with quite dense long bristly hairs on most of the dorsal surface of the exposed part (Fig. 5); hind metatarsus with strong bristly setulae on the dorsal surface that are about as long as those at centre of the anterodorsal surface of the hind tibia .... *regina*, n. sp.

9. Arista with its longest hairs not more than twice as long as its basal diameter; second visible tergite of abdomen with a pair of well developed apical central bristles; large species, about 18 mm. in length .... *georgei* Malloch
   Arista with its longest hairs more than three times as long as its basal diameter.. 10
10. Hind tibia with a well differentiated bristle in the anterodorsal series beyond the middle; aristae entirely dark .... sp. ?
   Hind tibia with the anterodorsal series of short bristles quite even, no outstanding one beyond middle; aristae black at base, yellowish beyond 11
11. Large species, at least 15 mm. in length .... *testacea* Macquart
   Smaller species, not more than 13 mm. in length ..... *regina*, n. sp.; *victoriae*, n. sp.

SENOSTOMA GEORGEI (Malloch).

PROC. LINN. SOC. N.S.W., liv, 292, 1929 (*Prodiaphania*).

I have before me three females which apparently belong to this species, despite the presence of a distinct bristle on the posterodorsal surface of the hind tibia beyond the middle. All agree in the characters given in the key, the very much shorter haired aristae and invariable presence of a pair of strong bristles on the apex of the second visible tergite at centre readily distinguishing them from others in the material before me. Length, 18 mm.

Localities: Mundaring, and Eradu, W. Australia.

SENOSTOMA TESTACEA Macquart.

Dipt. Exot., ii, pt. 3, 278, 1843; Suppl. iv, pt. 2, 1851, 193 (*Diaphania*); Malloch, PROC. LINN. SOC. N.S.W., liv, 1929, 292 (*Prodiaphania*).

This identification ought to be checked by an examination of the type specimen which is said to be in Paris though not seen by Townsend. I am unable to say why Townsend has elected to erect a tribe for the reception of four genera including this and *Chaetogaster*, naming it Senostomatini. These two genera have the suprasquamal hairs lacking, but his *Philippoformosia* has these hairs present, so it can not be upon that basis that the tribe was erected.

The present species is one of a group of five that are very similar in general coloration and structure. I have separated one, *biarmata*, from the others on the lack of a posterodorsal bristle near the middle of the hind tibia and, in addition to this character, the hypopygium is very distinct. The others are all rather alike, being of the same testaceous yellow colour on most of the head, the humeri, usually the apex of the scutellum, and extensively on the sides of the abdomen, the female having this last feature less pronounced.

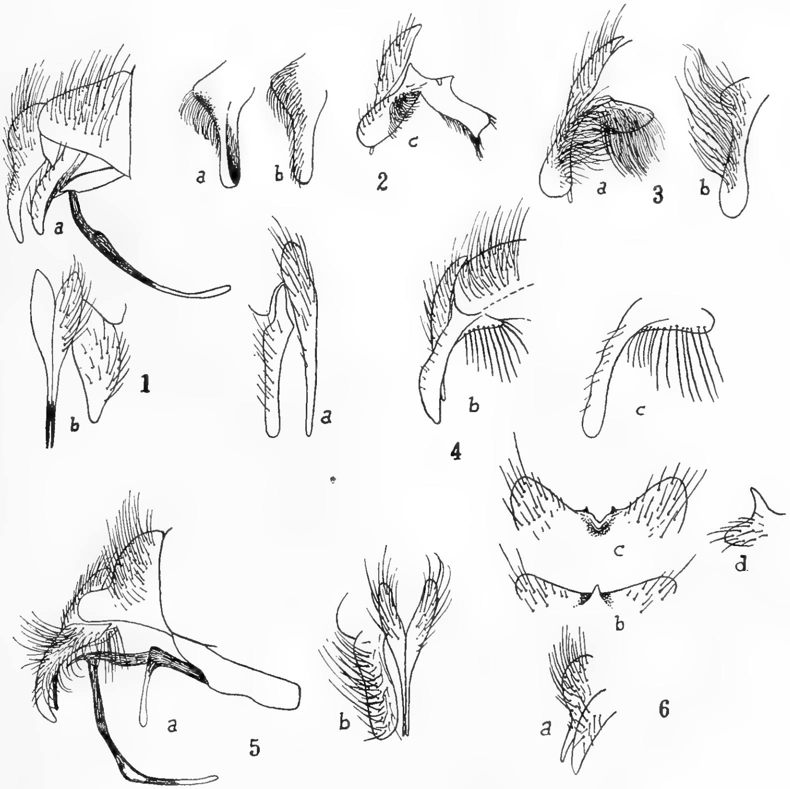
The wings are very distinctly shouldered and normally there is a conspicuous blackish-brown transverse mark near the bases. The sexes both have a complete series of short closely-placed setulae on the anterodorsal surface of the hind tibia which, in one species, at least in the female, has an outstanding bristle in it beyond the middle. It is noteworthy that in the females there is an irregular series of strong bristles on the anterior side of the mid femur which extends from the ventral surface at base upward to the anterior surface before middle, which series is present in no male now known to me. There is also usually on the hind femur in the females a more or less conspicuous series of several bristles on the basal half of the posteroventral surface, which is not found in any male but *cygnus*, and the bristles on the anteroventral surface of the same femur in the females are longer basally than apically, whereas in the males there are a number of long bristles on the apical third or more and none on the basal two-thirds.

The characters cited in the foregoing key to the species coupled with the figure of the hypopygium (Fig. 3) should serve to distinguish this species as that to which I assign the name. Length, 16–18 mm.

Habitat: Canberra, F.C.T.; Wentworth Falls, Sydney, Glenreagh, N. S. Wales; Eidsvold, Queensland.

SENOSTOMA VICTORIAE, n. sp.

A slightly smaller and rather darker species than *testacea*, most readily and reliably distinguished by means of the hypopygial structures of the male (Fig. 4*a*). The hind metatarsus has the dorsal hairs a little longer than in *testacea*, but



Text-figures 1-6.

Fig. 1.—*Senostoma biarmata*. *a*, male hypopygium from the side; *b*, same from behind, left side incomplete.

Fig. 2.—*Senostoma furcata*. *a*, inferior forceps from below; *b*, same from above; *c*, same from the side showing the basal process.

Fig. 3.—*Senostoma testacea*. *a*, inferior forceps from the side showing short densely haired basal process; *b*, same from above.

Fig. 4.—*Senostoma victoriae*. *a*, hypopygium left side from above; *b*, same in profile; *c*, inferior forceps of a possible variety.

Fig. 5.—*Senostoma regina*. *a*, hypopygium from the side; *b*, same from above, right side incomplete.

Fig. 6.—*Melinda minuta*. *a*, hypopygial forceps in profile; *b*, fifth sternite of male, ventral view; *c*, same more turned upward; *d*, apical process of same in profile.

they are much finer and shorter than the setulae on the anterodorsal surface of the hind tibia.

Habitat: Gisborne (holotype), Linga (paratypes), Victoria; and Buccleugh, N.S.W. The last specimen in the United States National Museum.

One female from Gisborne I refer here also.

A male from Mooroopu, N.S.W., in the United States National Museum has some long hairs on the sides of the prosternum and the dististylus as Figure 4*c*. This may be a distinct species, but I do not care to decide upon the basis of a single specimen in a genus which is rather markedly variable in the matter of hairing on various parts.

SENOSTOMA FURCATA, n. sp.

Similar in general colour and size to *victoriae*, differing markedly in the structure of the hypopygium as shown in Figure 2, the basal fork of the inferior forceps being the most developed in the genus as far as my material shows and the hairing on it the shortest and densest. The hind metatarsus is rather slender and has a series of rather widely separated setulose hairs on the dorsum that are not nearly as long or as strong as the anterodorsal series on the hind tibia. The anteroventral bristles on the hind femur are not as strong or as long as those of *testacea*. Length, 12–13 mm.

Habitat: Canberra, F.C.T., 16.xii.1928, holotype (M. Fuller); paratype, Galston, 2.i.1926, N.S.W. (L. Wood).

SENOSTOMA REGINA, n. sp.

Averaging a little smaller and of a more slender build than *furcata*, with the hypopygium as in Figure 5. The hind tibia has the anterodorsal series of setulae long and rather conspicuous, and the setulae on the dorsal surface of the hind metatarsus are almost equally long, while the tarsus is slightly thicker and shorter than usual.

Holotype ♂, and allotype, with a series of paratypes of both sexes, Eidsvold, Qld., December, 1922 (Mackerras). Four female paratypes, Marwood, near Mackay, Qld., January, 1924 (W. G. Harvey).

SENOSTOMA sp.?

Two female specimens belonging to this group are distinguished from any of the others by the presence, beyond the middle of the hind tibia, of a single outstanding bristle in the anterodorsal series of setulae. Apart from this character and their being darker coloured, there is nothing to distinguish them from *regina*, though it is very probable that they belong to a distinct species that may have good characters in the structure of the hypopygium for its recognition. Length, 12–13 mm.

Locality: National Park, Gundamain, N.S.W., January, 1926 (Mackerras).

SENOSTOMA BIARMATA, n. sp.

A larger species than *regina*, with much larger wings, but of the same general colour, with the abdomen largely testaceous and with a broad black dorsocentral vitta. The dark mark near the base of the wing is quite conspicuous and the shoulder is well developed, while the second section of the costa is about two-thirds as long as the third. The outstanding structures consist of the lack of a distinct posterodorsal bristle on the hind tibia, and the exceptional structure of the inferior hypopygial forceps which are much broader than usual in the genus (Fig. 1). Length, 16 mm.

Holotype, S. Australia, no other data (J. B. Cleland).

SENOSTOMA CYGNUS, n. sp.

A much darker species than any of those already dealt with, the occiput and posterior half of genae black, the genal hairs fuscous, the thorax shining black, with grey dust and four rather inconspicuous dark vittae, the scutellum reddish-brown; abdomen black, showing reddish to a greater or less degree according to the angle from which it is viewed, the surface grey-dusted, with a narrow dark central dorsal line and traces of lateral dorsal checkerings. Legs black, knees narrowly reddish. Wings brownish hyaline, without any trace of a transverse dark mark near base. Squamae brownish-yellow, the margin not darker, the upper one about two-thirds as long as the lower. Halteres fuscous.

Head as in the other species but the epistome more produced, and the aristae haired as in *georgei*, the longest hairs about twice as long as its basal diameter. Ocellar bristles short but evident, the inner marginal bristles on the orbits more distinct than usual, and the fine hairs carried downward on the parafacials to near level of apex of third antennal segment. Thorax more strongly bristled than in typical species of the genus, the dorsocentrals complete though not large, the sternopleurals 2 + 1, and the scutellum with 8 marginal and 2 discal bristles. Postalars 3. Legs shorter and stronger than in the other species, the bristles stronger, the hind femur with long widely-spaced bristles on entire extent of anteroventral surface, shorter apically, and some long bristles on basal half of the posteroventral surface; hind tibia with the usual anterodorsal series of closely-placed setulae that are not as erect as usual, two posterodorsal and two anteroventral bristles; hind tarsus normal, the basal segment without long dorsal setulae, the apices of all tarsal segments with longer bristles than usual. Wings without distinct shoulder, though more explanate than in typical Tachinidae, the venation normal. Abdomen ovate, more nearly circular in cross section than usual, the apical bristles on third visible tergite longer and stronger than usual. Hypopygium not dissected. Length, 12 mm.

Holotype, Swan River, W. Australia (L. J. Newman).

A most exceptional species in coloration and development of the bristling, the type of hind femoral armature being similar to that of females of the other species. I do not consider that it is entitled to removal from this genus.

RUTILIA Robineau-Desvoidy.

Acad. Sci. Paris, Mem. Sav. Étrang., ii, 319, 1830.

RUTILIA TRANSVERSA, n. sp.

♂. Very similar to *splendida* Donovan, differing essentially in having the upper postocular orbits brassy instead of silvery-white-dusted, and the abdomen with a broad green transverse band on the anterior half or more of the third and fourth segments which are divided on the centre of the dorsum by a black vitta of about their own width.

Head orange-yellow, occiput with a metallic-green sheen which is carried on to the genae posteriorly but becomes obsolete before attaining their anterior margins; frons, parafacials, and postocular orbits densely yellow-dusted, the upper part of the latter brassy and slightly checkered; face less densely dusted, centrally below shining; antennae and palpi orange-yellow; aristae fuscous; hairs on frons and upper half of parafacials fuscous, those on occiput and genae as well as on lower part of parafacials orange-yellow; postocular cilia black. Frons at vertex about one-third as wide as either eye; in *splendida* not more than one-fourth as wide as an eye, and the frontal orbits are narrower and less densely and shorter haired. The parafacials are wider and longer haired than in *splendida*. Thorax brilliant metallic-green, mesonotum with four black vittae, the central pair ceasing before midway from suture to hind margin, the sublateral pair a little longer. the humeri, two spots just in front of suture and large one behind suture as well as centre of the mesopleura dusted with white. Thoracic hairs all black, very dense and fine. Sternopleura black, with a green spot above. Abdomen coloured as thorax, second (first visible) tergite black in front and in centre, next two with a black apical fascia and central vitta, fifth with a black central vitta and very narrowly black in front and behind. Third tergite with a series of very short apical bristles, fourth with a much longer apical series; fifth not noticeable, depressed in centre at apex. In *splendida* there are usually no noticeable apical bristles on the third tergite. Legs black, bristled as in *splendida*. Wings as in *splendida*, the basal black mark very distinct. Squamae yellowish-white, the margin more noticeably yellow. In *splendida* the lower squama is brown or fuscous with darker margin, and the upper one much paler, almost white. Length, 13–14 mm.

Holotype and 2 paratypes, Swan River, W. Australia (J. Clark).

These male specimens more closely resemble the females of *splendida* than they do the male of that species because in the females the abdominal green fasciae are usually complete, while in the males they are almost invariably divided, the inner part being spot-like. In females of *splendida*, however, there is usually a constriction of the fascia on each side of the central black vitta where the break occurs in the other sex and there is no indication whatever of any constriction in the new species. In both species there are some black or fuscous hairs on either side near the anterior margin of the prosternal plate.

RUTILIA MICROPALPIS Malloch.

PROC. LINN. SOC. N.S.W., liv, 1929, 298.

I have before me four additional specimens of this species, two from National Park, N.S.W., one from Sydney, and one from Como, N.S.W., the last being one of the original localities. The specimen from Sydney is a female, the others are males.

RUTILIA LEPIDA Guérin.

Rev. Zool., vi, 1843, 268; Engel, *Zool. Jahrb.*, 50, 1925, 373.

A female specimen that I believe belongs to this species, though the pleural hairs are all black, has a puparium pinned with it. The general colour is brownish-black, and the form almost cylindrical, slightly tapered at each extremity, and the surface is quite coarsely transversely wrinkled. The spiracles are set in a deep terminal cavity and are of the same general form as I figured for *Chrysopasta elegans* Macquart in the previous paper in this series. Their general form is more regular in outline, not at all trifoliate and, though there are several slightly indicated raised lines, there is not a definite demarcation into separate plates; the separating line is also much narrower than in the other. Attached is a slip with the note "Bred from larva of beetle *Chlorobapta frontalis* Don". This note bears out my suspicion that the great majority of the Rutiliini will be found to be parasitic upon larger Coleoptera despite the record of *Chrysopasta* from nest of a Termite.

I have before me a number of additional specimens that I refer to *lepida*, from New South Wales localities: Manly, Sydney, Barrington Tops, Como, and Wentworth Falls, as well as one from Canberra.

Subgenus NEORUTILIA, n. subgen.

I am erecting a new subgenus for the reception of a single species which differs from the more typical forms of *Rutilia* in having the hind tibia without a well developed fringe of setulae or isolated strong bristles on the anterodorsal surface, and no posterodorsal bristle; and the section of the costa between the apices of the subcosta and the first vein subequal in length to that between the apices of first and second veins. For other distinguishing characters see the description of the species below, which is the subgenotype.

RUTILIA (NEORUTILIA) SIMPLEX, n. sp.

General colour bright metallic blue-green. Occiput, genae, and frontal orbits emerald-green, the colour of latter merging into violet on the upper anterior part of each parafacial; epistome metallic-green with violet reflections. Mesonotum emerald-green, with four narrow incomplete cupreous vittae, blue on posterior margin behind the bristles; scutellum emerald-green; pleura becoming more bluish below. No definite white dust, except on humeral angles. Abdomen a little darker than thorax, each segment with a blackish-blue apical fascia and similar dorsocentral vitta; no distinct white dusting present. Legs black. Wings hyaline, with the usual dark basal mark pale brown and very small. Squamae fuscous, with darker margins.

Head large, as wide as thorax; frons at vertex about one-tenth as wide as head, widened to anterior margin, the interfrontalia dark brown to black. Vertical bristles one pair; ocellars lacking; no proclinate orbitals but numerous fine black orbital hairs which cease about level of apex of second antennal segment; facial carina normal; third antennal segment not as long as distance from its apex to epistome; arista bare; palpi normal. Face, vibrissal angle, and upper part of genae, pale-grey-dusted, the dust on lower part of postocular orbits white, becoming obsolete about middle of eye, the orbit green above. All genal hairs short and dark, the beard pale. Thorax rather more flattened than usual, the scutellum noticeably flattened and triangular. Mesonotum with shorter hairs than usual, the bristling normal, except that there are eight or ten bristles in a transverse series in front of the scutellum and the marginal scutellars number about 22. All hairs black. Legs black, not very strong, hind tibia almost circular in cross section, the usual anterodorsal series of short bristles lacking, there being but short stiff hairs present that are visible only with a high magnification and at a certain angle. Wings not as large as usual, distinguished by the lengthened section between the apices of subcostal and first veins. Halteres fuscous. Length, 20 mm.

Holotype, Eidsvold, Qld., December 22.

I believe this species forms a sort of connecting link between the species that I placed in my Group 1 containing *formosa* Rob.-Desv. and its allies, and section 2 of Group 2 containing *regalis* Guérin and its allies, as formulated in my paper published in 1929 as part xx of this series. I have seen no species, however, in which the hind tibia is as here and the costal divisions are similar to those of *simplex*.

It is unfortunate that it is impossible to give a complete revision of the species of this genus at this time, as they are undoubtedly of considerable economic importance apart from their interest as taxonomic constituents. I still have a number of unworked specimens on hand, but lack of time has prevented me making as complete a survey of them as I would like to, and I have no assurance that such an opportunity will present itself within the immediate future.

Subgenus MICRORUTILIA Townsend.

Proc. Biol. Soc. Washington, xxviii, 1914, 23.

This subgeneric name will require to be used in place of *Senostoma* for that group of small species in which the sternopleura has 2 or 3 bristles, the hind tibia has one or more well developed bristles and usually a complete or partial fringe of setulae on the anterodorsal surface, and the arista is pubescent.

Townsend cited *minor* Macquart as his genotype when he described the group as a genus, but he had not seen the species. More recently (*Ann. Mag. Nat. Hist.*, ix, 1932, 39) he gave a few details of the type specimen which he saw in Paris, and this information leaves no doubt as to the identity of the concept. In this same paper he proposed the erection of *Prosenostoma* for the reception of *flavipes* B. and B. I can see no reason for this course, unless he considered that his examination showing only 2 sternopleural bristles justified it. I have examined some of the original specimens and several additional specimens of *flavipes*, and find that there are either 2 or 3 such bristles, the lower anterior one being variable in development, as usual in the genus where there are anterior bristles present.

Since the appearance of my paper in these PROCEEDINGS (liv, 1929, 305), in which I dealt with the group, I have received some additional material containing one new variety, which I briefly describe below.

RUTILIA (MICRORUTILIA) RUFICORNIS Macquart, *var.* CUPREIVENTRIS, n. var.

Differs from the typical form in having the four black mesonotal vittae much broader and more conspicuous and the abdomen more definitely coppery than green. In both sexes the genal hairs are all fulvous-yellow. The abdomen in the male is semi-diaphanous and coppery, with but faint greenish lustre, a dorsocentral black vitta that narrows from base to apex and becomes violet coloured on fifth tergite; in the female the general colour is reddish-coppery with golden to violet reflections, rarely greenish-tinged. The legs in both forms are black in the male, with the tibiae more or less brownish-yellow, while in the female they are fulvous to brownish-yellow, with black tarsi. Length, 11–13 mm.

Holotype ♂, allotype, and 8 paratype ♀, Barrington Tops, Feb., 1925, Allyn Range, on *Leptospermum* (S.U. Zool. Exped.).

CHAETOGASTER Macquart.

Dipt. Exot., Suppl. iv, 1850, 225.

I have already dealt with this genus in one of my papers in this series (these PROCEEDINGS, liv, 1929, 314), and now add some additional data and two species. Brauer and von Bergenstamm did not see Macquart's species, but recently Townsend has published some notes on it, having seen the type-specimen in Paris. His short list of characters agrees with those I have already cited and my identification of *violacea* is evidently correct.

The two species represented by males may be distinguished as below. I have females only of the other.

A. Mesonotum black, distinctly shining, with the usual grey dusting and dark vittae, mostly bluish to greenish tinged, the scutellum more distinctly violaceous; abdomen semidiaphanous basally on sides; darker centrally and apically, with reddish-violet suffusion on nearly the entire dorsum, the whitish dust not conspicuous, best seen when viewed from behind .... *violacea* Macquart

AA. Mesonotum dark metallic-green, with the same grey dusting and vittae as the genotype, scutellum concolorous, the violet tinge confined to extreme margins of both and very indistinct; abdomen entirely bright metallic-green, with quite faint whitish dusting basally .... *viridis*, n. sp.

CHAETOGASTER VIOLACEA Macquart.

Dipt. Exot., Suppl. iv, 1850, 225.

I have before me examples from New South Wales and Victoria.

CHAETOGASTER VIRIDIS, n. sp.

Smaller than *violacea*, 14 mm. in length, and differing markedly in colour as in above diagnosis. The frons is also slightly narrower, there are no distinct presutural acrostichals present, the abdomen has the erect hairs on centre of the third, fourth, and basal half of fifth, tergites much less developed, and the setulae on the lateral curves of the tergites much less developed though still stronger than in most other genera.

Holotype, Comboyne, N.S.W. (Chisholm).

CHAETOGASTER ARGENTIFERA, n. sp.

Shining metallic blackish-blue, with distinct silvery-white dusting which is most conspicuous on the sides of the third to fifth abdominal tergites.

Head brownish-yellow, occiput darkened from near lower margin, bluish-black on upper half, with whitish dust that is dense and almost silvery on the upper postocular orbits, frontal orbits brownish, with white dust that merges into the yellowish dust of the upper parafacials, the interfrontalia dark brown; antennae and palpi orange-yellow, the former the darker; aristae fuscous. Frons at vertex about one-fifth of the head width, rapidly widening in front, the interfrontalia not obliterated at narrowest point; vertex with four verticals which are not very long, the ocellar bristles fine, directed forward and slightly divergent; each orbit with a complete inner marginal series of incurved bristles, no reclinate upper, and two proclinate supra-orbitals, the area laterad of the bristles finely haired, both the bristles and hairs ceasing at level of antennal insertion. Parafacial in profile about as wide as length of eye and more than twice as wide as third antennal segment; gena almost as high as eye; vibrissal angle slightly produced, the epistome projecting beyond it, vibrissae well developed and with a series of setulae above them on lower third of facial ridges; face with the central vertical carina well developed, narrow. Antennae with third segment about 2·5 times as long as second, rounded at apex; arista distinctly pubescent. Palpi longer than antennae, dilated slightly at apices; proboscis with the apical section nearly as long as lower margin of head, and rather thin. Eyes bare.

Thorax blackish-blue, the mesonotum with quite dense white dust when seen from behind at a low elevation, and with the usual dark vittae very narrow in that light. Mesonotum with the dorsocentrals 3 + 4, acrostichals 1 + 2, and the prealar rather short; presutural lateral area with only 2 bristles. Mesopleura with centre densely silvery-white-dusted. Legs black, tibiae centrally more brownish. The femora not as noticeably attenuated apically as in the males. Wings hyaline, slightly infuscated near bases, veins fuscous, darker basally. Inner cross-vein oblique as usual, but a little beyond apex of level of subcosta instead of directly below it as in the males, the second costal division more appreciably shorter than first than in the males.

Abdomen broadly ovate, more distinctly metallic blue than the mesonotum, the sides of the third to fifth tergites showing silvery-white dust at apices that is carried to the extreme lateral edges below. The same tergites with discal and apical bristles centrally, the former rather variable, and without erect setulae on central line of dorsum. The tergites usually show a violet tinge on apices at the lateral curves. Squamae white, with narrow fuscous rim and fringe. Halteres fuscous. Length, 13 mm.

Holotype and one paratype, 25.2.1923, and 19.3.1922 respectively (G. Lyell). One specimen in rather poor condition differs slightly from the other two in the dusting of the fifth abdominal tergite, but I consider it is the same species.

Locality: Brisbane, Queensland, 12.12.1922, no collector's name on label.

In the other two species the wings are slightly brownish, with bright orange tinge basally on costa and the veins are also bright orange, which colour is also found in the squamae. It is also noteworthy that the presutural lateral area in the males has usually at least three, and generally four bristles in an oblique series running inward from the posterior to the anterior bristle. I have met with similar variation in the bristling of the different sexes in some other genera and do not consider this an important character for the separation of species, and certainly not a generic criterion.

MACROCHLORIA Malloch.

PROC. LINN. SOC. N.S.W., liv, 1929, 326.

This genus was erected for the reception of an Australian species, and below I describe a variety of the genotype.

MACROCHLORIA CALLIPHOROSOMA, var. RUFIPES, n. var.

Differs from the typical form in having the legs entirely brownish-red, the tarsi but slightly darker, and the abdomen usually distinctly violet-blue and not metallic greenish-blue. Length, 12–15 mm.

Holotype ♂, Toronto, N.S.W., April, 1920. Allotype, same locality, no date. Paratypes, Kosciusko, 21.ii.1926 (Nicholson); Deervale, January, 1921; Lansdowne, December, 1923; and two from Toronto, N.S.W.

Tribe ACTIINI.

ACTIA Robineau-Desvoidy.

Acad. Sci. Paris, Mém. Sav. Étrang., ii, 1830, 85.

I have already published in this series of papers a key to all the species of this genus known to me from Australia (these PROCEEDINGS, lv, 1930, 303). The new species described below is very similar to *darwini*, and I restrict the description to those characters in which it differs from that species.

ACTIA QUADRISETA, n. sp.

♀. Differs from *darwini*, to which it will run down in my published key, in being larger and stouter, in having the setulose hairs on the third wing-vein extending distinctly beyond the level of the outer cross-vein, and the postsutural dorsocentral bristles in four well developed pairs. Length, 5 mm.

Holotype, Nyngan, N.S.W., no date (J. W. Armstrong).

Family CALLIPHORIDAE.

POLLENIA Robineau-Desvoidy.

Acad. Sci. Paris, Mém. Sav. Étrang., ii, 1830, 412.

I have already described one species of this genus from Australia, and now am able to add two new species, which may be distinguished from each other as below.

Key to the Species.

1. Antennae and palpi orange-yellow, the latter slightly darkened at bases and the third antennal segment sometimes slightly darkened on upper margin; the fine hairs on sides of scutellum basally fuscous to black; male with the frontal orbits in front with more than one series of bristles, female with a number of long erect setulose hairs laterad of the inner marginal bristles on the orbits anteriorly; male hypopygium with the inferior forceps quite long and slender, their apices slightly spatulate; parafacials with black hairs; scutellum with six marginal and two discal bristles; hairs on postalar declivity black .... *hirticeps* Malloch

Antennae and palpi fuscous, third segment of former usually reddish at base; the fine hairs on sides of the scutellum basally mainly yellow; male with the frontal orbits anteriorly furnished with one inner marginal series of bristles and some intermixed long setulose hairs 2

2. Mesopleura with black hairs except on the hind margin amongst the bristles; parafacial hairs all black and setulose; antennae entirely black; scutellum with six marginal and two discal bristles; fore tibia with two posterior submedian bristles (♂) .... *nigrita*, n. sp.

Mesopleura with nearly all the discal hairs yellow; parafacial hairs yellow on at least the lower half; antennae with the third segment reddish at base; scutellum with eight marginal and usually more than two discal bristles; fore tibia with one posterior bristle beyond middle .... *stolida*, n. sp.

POLLENIA HIRTICEPS Malloch.

PROC. LINN. SOC. N.S.W., lii, 1927, 318.

I have before me a series of specimens which show that the antennae are usually entirely orange-yellow, rarely with the third segment browned above. The parafacial hairs are longer and stronger than in *stolida* and all black, while the frontal orbits in the male are much more densely bristled, with these in two or more series on most of the anterior third and the bristles weaker than those on the inner margin in *stolida*. The pleura are not as conspicuously yellow-haired as in that species, and the postalar declivity and the sides of the scutellum basally are black-haired. The hypopygial forceps are much more slender and more noticeably spatulate at apices than in *stolida*, and the first posterior cell of the wing is noticeably narrower at apex, sometimes practically closed.

Localities: Barrington Tops, Wentworth Falls (Dec., 1931), Blue Mts., and Sydney, N.S.W.

One small female from Sydney has only six marginal bristles on the scutellum, and the antennae appear shorter than usual.

POLLENIA STOLIDA, n. sp.

Very similar to *hirticeps*, but the antennae are black, with the apex of second and base of third segment reddish, the palpi are fuscous, the parafacials are partly yellow-haired, the postalar declivity and sides of the scutellum basally are also largely yellow-haired, the pale pleural hairs are golden-yellow and not yellowish-brown as in *hirticeps*, and instead of having the disc of the mesopleura fuscous haired it is golden-yellow-haired, while the hairs are finer and more crinkly.

Structurally the species are rather similar, though the frontal orbits are less densely bristled in the male and the inner marginal bristles anteriorly are much stronger than the outer lateral bristly hairs, and in the female there are no long rather erect setulose hairs laterad of the bristles as in *hirticeps*. The antennae are also a little longer, though this character is somewhat variable. The scutellum has usually eight strong marginal bristles and three or four discals. In the male the hypopygial forceps are stouter and shorter, with the apices of the inferior pair bluntly rounded. Length, 10 mm.

Holotype ♂, allotype, and 3 paratypes, Wentworth Falls, N.S.W., Dec., 1931 (F. H. Taylor).

There are two males and one female before me in which the parafacial hairs are entirely yellow and much finer than in the typical form. These may possibly represent a distinct species, but careful work will be required to establish their status.

Localities: Sydney (Dec., 1931) and Jenolan Caves, N.S.W.

POLLENIA NIGRITA, n. sp.

A smaller species than either of the other two, with entirely black parafacial hairs and antennae, the pale hairs of the thorax brownish-yellow and confined to the stigmatal region, the posterior margin of the mesopleura, the lower part of the pteropleura, and the basal part of the sides of the scutellum. The calyptrae are also paler than in the other two species, being greyish-white with yellowish margins as against yellowish-brown with darker margins.

Structurally rather similar to *stolida*, the frontal orbits narrower, each with a series of strong inner marginal bristles to well above middle and some much shorter lateral hairs; the parafacial hairs strong, setulose; scutellum with six strong marginal bristles and two discals. Abdomen more narrowly ovate than in *stolida*, the hypopygium concealed but evidently similar to those of the two other species in general structure. First posterior cell of the wing moderately wide. Length, 7·5 mm.

Holotype, Yaouk, N.S.W., about 3,500 feet altitude, Jan., 1931 (F. H. Taylor).

I believe that there will be a number of other species of this genus found in Australia, and to enable students of the group to make comparisons with my material, I am returning nearly all the specimens to Mr. Taylor so that they will be available in Australia.

One female has an egg protruding from the apex of the abdomen, so it appears that the species are oviparous. It will be of interest to discover what the larval habits of the genus are in Australia, as the nearest relative, *P. rudis*, of which we have information is an internal parasite of earthworms in Europe and North America.

MELINDA Robineau-Desvoidy.

Acad. Sci. Paris, Mém. Sav. Étrang., ii, 1830, 439.

MELINDA MINUTA Malloch.

PROC. LINN. SOC. N.S.W., liii, 1928, 328.

This species was inadvertently omitted from my revisional paper in Part xi of this series of papers (these PROCEEDINGS, lii, 1927, 299).

I now present figures of the hypopygial characters of the male, the remarkable spike-like process of the fifth sternite which is usually readily visible in dried specimens when the abdomen is viewed from the side being a good distinguishing character for the species.

I can now record the species from Perth, Narrogin, and Beaconsfield, W. Australia.

Family CHLOROPIDAE.

In March, 1934, Dr. O. Duda published a paper (*Arb. Morph. Taxon. Ent. Berl.-Dahl.*, vol. 1, No. 1, p. 39) in which he described a number of Australian species of this family. Included in the paper there is a key to the species of *Parahippelates* Becker, which I consider is properly a synonym of the European genus *Lasiopleura* Becker, also the record of an African genus from Queensland. Below I deal with some of the species in Duda's paper, and add one new species, making 104 Australian species in our list.

APROMETOPIS PUNCTIPENNIS Duda.

Op. cit., p. 56.

This species is referable to *Caviceps* Malloch, and may be distinguished from *flavipes* Malloch by the presence of a deep black almost round small spot situated on the costa at the apex of the second vein. The inner cross-vein is very distinctly basad of the middle of the discal cell and the outer cross-vein is almost three times its own length from the inner instead of not twice that length.

Becker described *Aprometopis* from Africa. He laid particular emphasis upon the lack of the frontal triangle as a generic character, which might be considered to some extent as justification for Duda's course in placing his Australian species in the same genus, but he also states that the flattened mesonotum and habitus are similar to those of *Eribolus* Becker, a genus that occurs in Europe and North America. The latter and *Aprometopis* are both slender insects, and the figure of the head of the latter given by Becker is radically different from that of the Australian genus, being distinctly longer than high, with the face in profile not as high as the eye at middle, and the orbits showing a series of distinct setulae that are not found in *Caviceps*.

I have before me two examples of *punctipennis* from Palmerston, N. Australia, the type locality, that belong to the same Museum as the type material.

Genus LASIOPLEURA Becker.

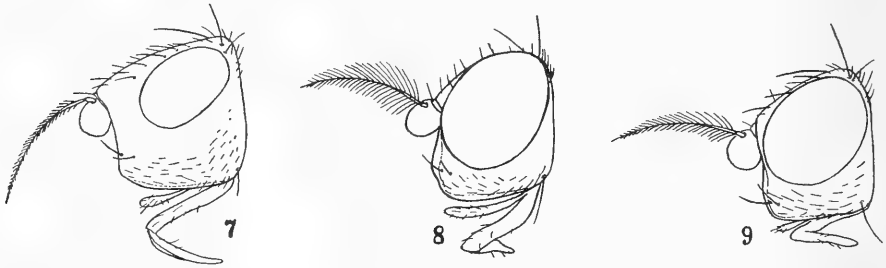
As noted above, this genus has previously been dealt with under the generic name *Parahippelates* Becker in this series of papers (PROC. LINN. SOC. N.S.W., lvi, 1931, 73). Before me now are three species from the Deutsches Entomologisches Institut in Berlin, from which collection Duda obtained the material for his paper referred to above. All three were unknown to me previously and had been set aside pending an opportunity to describe them, which course has been obviated by the appearance of Duda's paper. Some notes are presented below to make available to Australian students of the group data for the recognition of these species.

LASIOPLEURA CONOPSEA Duda.

Op. cit., p. 45.

A bright orange-yellow to fulvous yellow coloured species, with the mesonotum shining, a dark spot on the ocellar region, and most of the abdominal dorsum and the apical two segments of each tarsus brown.

The very high genae of this species, as shown in Figure 7, with the yellow genal hairs, and very short haired aristae, readily distinguish it from the next two dealt with below. The bristle at the lower angle of the back of the head is much less developed than in the other two. The mesonotal bristles are moderately strong, with the acrostichals quite distinct. The hind tibial spur is slightly shorter than the apical diameter of the tibia, but it is strong and slightly curved. The third section of the costa is about 1·5 times as long as the third, and the outer cross-vein is about twice its own length from the apex of fifth vein. The scutellum has normally more than two discal setulose hairs. Length, 4–5·5 mm.



Text-figures 7-9.
Fig. 7.—*Lasiopleura conopsea* Duda.
Fig. 8.—*Lasiopleura rufescens* Duda.
Fig. 9.—*Lasiopleura nigripila* Duda.

Cairns, N. Qld. (coll. Oldenberg; Deutsches Ent. Mus.). This is the type locality.

LASIOPLEURA RUFESCENS Duda.

Op. cit., 49.

This species is readily distinguished from any other known to me by the long hairs of the aristae, the longest of these being almost as long as the width of the third antennal segment. The hind tibial spur is curved and fully as long as the diameter of the apex of the hind tibia, and the wings are hyaline. Head in profile as Figure 8, the bristle at lower posterior angle strong and long. Frons in front orange-yellow, darkened on each side centrally. Thorax rather dull fuscous, more yellowish on pleura and apex of the scutellum. Mesonotum with the dorsocentrals and surface hairs rather short, the former consisting of one presutural pair and four pairs behind the suture, the disc with greyish dust and faint dark vittae. Scutellum with the basal pair of bristles shorter than the apical pair, and one pair of fine discal setulae. Legs testaceous, the femora and apices of tarsi more brownish. Second section of the costa about 1·25 times as long as third; outer cross-vein about 1·5 times as long as its own length from apex of fifth. Abdomen brown, slightly shining, the apices of the tergites paler and with grey dust. Length, 2·5–3·25 mm.

Palmerston,* N. Australia (coll. Oldenberg; D.E.I.). Type locality.

LASIOPLEURA NIGRIPILA Duda.

Op. cit., 48.

A paler species than the preceding one, with the general colour more like that of *conopsea*, though the mesonotum is darker. The setulae and bristles are

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* Darwin was substituted for Palmerston under Proclamation dated March 3, 1911, which appeared in the *Commonwealth Gazette*, No. 18, March 18, 1911. I am indebted to Mr. K. R. Cramp of the Royal Australian Historical Society, for supplying me with this information.—F.H.T.

black and much stronger than in *rufescens*, especially on the frons and mesonotum, the latter having four or more pairs of decussate acrostichals quite bristle-like and, though the dorsocentrals are similarly arranged, they are as strong as the notopleurals, which is not the case in *rufescens*. The longest hairs on the aristae are also distinctly shorter than in that species though longer than in *conopsea*, being about half as long as the width of the third antennal segment (Fig. 9). Length, 3–3·5 mm.

Palmerston, N. Australia (coll. Oldenberg; D.E.I.). Type locality.

LASIOPLEURA GRISEOVITTA, n. sp.

♂. Head orange-yellow, the frons anteriorly, the face, and genae in front paler and with slight white dusting; antennae and palpi yellow, aristae brown. The upper half of each frontal orbit is dull dark brown, the ocellar spot is fuscous, the triangle is yellowish-dusted though slightly shining, and all the hairs and bristles are black except on the palpi where most of the hairs are white. Frons with three pairs of orbital setulae, the usual bristles and some setulose hairs in centre. Profile much as in *nigripila*, but the epistome more produced, the genae higher, and the face not as evidently carinate in centre. Longest hairs on aristae hardly longer than its basal diameter. Proboscis rather stout, the labellae short and fleshy. Thorax fuscous to brown, slightly shining, the mesonotum with a broad central stripe of grey dust that extends over the dorsocentrals and is most pronounced in front, laterad of this the surface is quite dark brown; scutellum not as noticeably grey-dusted, yellowish on margin. Bristles and acrostichals well developed, the former 1+3, the acrostichals extending in front of the dorsocentrals; the short surface hairs very minute and inconspicuous. Scutellum with the disc flattened, four marginal bristles, the basal pair slightly the shorter, and no discal hairs. Notopleurals as usual 1+1. Legs tawny yellow, the sensory area on hind tibiae showing darker. Hind tibial spur rather strong, slightly curved, and about as long as the tibial diameter. Wings brownish hyaline, veins brown. Abdomen dark brown, shining, the hypopygium brownish-yellow and bulbous. Halteres brownish-yellow. Length, 3 mm.

Type, Mt. Molloy, Qld. (F. H. Taylor).

Type in the School of Public Health and Tropical Medicine, Sydney University. Representatives of the three preceding species will be sent to the Australian Museum.

Genus PRIONOSCELUS Becker.

Ann. Mus. Nat. Hung., ix, 1911, 99.

This genus was originally described from New Guinea material and is distinguished from most genera in the Oscinosominae by the thickened hind femora, which are furnished below with short spines, and the curved hind tibiae which have a short apical process. I have not seen the genus, but Duda has recorded one species from Australia, the place of record being the paper already referred to herein.

PRIONOSCELUS MAGNUS Becker.

Op. cit., 99.

Becker states definitely that this species has two small setiferous warts on the apex of the scutellum as in *femoralis*, but Duda says that there are no such warts present. The principal distinction, if Duda is correct, between the two species is then that in *magnus* the apex of the scutellum is unarmed and the palpi are black, while in *femoralis* there are two small setiferous warts at the apex of the scutellum and the palpi are red. Unfortunately, the two males he has recorded from Cairns appear to be intermediate between these forms, having the apex of the scutellum with two setiferous warts and the palpi black. His acceptance of *magnus* as the Australian species may be incorrect, but it would appear to be binding on us until more data are available.

In addition to the species listed above, Duda has described in his paper two species which he refers to *Gaurax*, both from Palmerston, N. Australia; they are *obscuripilus* and *pleuromaculatus*. I have not seen either species and, having no material in the genus from the type locality, can offer no data on their relationships.

CONTRIBUTIONS TO THE MICROBIOLOGY OF AUSTRALIAN SOILS. IV.

THE ACTIVITY OF MICROORGANISMS IN THE DECOMPOSITION OF ORGANIC MATTER.

By H. L. Jensen, Macleay Bacteriologist to the Society.

(Eleven Text-figures.)

[Read 29th April, 1936.]

Introduction.

The decomposition of the organic compounds which are continually added to soils under natural conditions, especially in the form of plant residues, is known to be due chiefly to the action of microorganisms, among which bacteria, actinomycetes and lower types of fungi are the most important. This process of decomposition results in the release of a part of the elements of the decomposed material as compounds suitable for plant nutrition (water, carbon dioxide, ammonia, nitrate, etc.) and in the accumulation of another part of the material as a slowly decomposing residue of various constituents collectively known as "humus". This "humus" is recognized as a natural constituent of most soils that carry a vegetation, and is of importance by affecting the physical properties of the soil as well as by acting as a carrier of plant food, especially nitrogen, which is gradually made available to the vegetation through the slow decomposition of the humus. The extent to which humus accumulates is known to depend largely upon the temperature relationships of the soil in question. Tropical soils, although carrying a luxuriant vegetation, are usually poor in humus, and in temperate climates Jenny (1928-31) has demonstrated an inverse relationship between the average annual temperature and the average content of organic matter and nitrogen in soils, which latter was found to increase 2 to 3 times for each 10° C. decrease in the mean annual temperature. Jenny explained these phenomena through the accelerating influence of increasing temperature on the decomposition processes in the soil according to the rule of van't Hoff. Following up this idea, Waksman and Gerretsen (1931) showed that although the rate of decomposition of straw as a whole increased markedly with the temperature, the rate of decomposition of the various constituents of the straw was not affected in the same manner by changes in temperature from about 7° C. to about 37° C. For instance, the resistant lignin was decomposed comparatively quickly at 37° C., but hardly at all at 7° C., and at this temperature (the lowest tested) there was a tendency to synthesis rather than to decomposition of proteid materials. In connection with this important contribution we shall make a brief survey of the present status of the problem of decomposition of organic matter in soil. Most of the work in this direction falls into two categories:

A. Decomposition of the soil's own organic matter ("humus").—In experiments on this subject, the evolution of carbon dioxide from the soil, either in laboratory or field experiments, has usually been used as an index of the decomposition.* In all experiments where the influence of temperature has been studied, the rate of carbon dioxide formation has been found to increase with the temperature, at least within the limits obtaining under natural soil conditions; important contributions in this respect are due to Russell and Appleyard (1917), Fehér (1929–35), and Leroux (1934). Counts of microorganisms (especially bacteria) have frequently been combined with the CO_2-determinations, and a parallelism has sometimes been observed. The bacteria have always been counted by the plate method or other cultural methods, and determinations of the total numbers of bacteria have not been made in such experiments, although it is known that the plate method reveals only a (mostly) small fraction of the total bacterial flora of soils (Conn, 1918; Winogradsky, 1925; Thornton and Gray, 1934). The importance of fungi under these conditions is not precisely known.

B. Decomposition of organic materials added to the soil.—Laboratory experiments in this direction are almost innumerable (for references, see Waksman, 1932) and have been undertaken from widely different points of view. A very large proportion of them are simple "ammonification"—or "nitrification"—experiments with nitrogenous materials used as fertilizers, in which only the accumulation of ammonia and/or nitrate is determined. In many other experiments, with definite chemical compounds as well as with complex materials, the rate of CO_2-formation or of disappearance of added compounds has been found, sometimes together with determinations of ammonia or nitrate and chemical analysis of the complex material undergoing decomposition. Such experiments have been carried out, not only with the complex soil microflora, but also with pure cultures of soil microorganisms. In many instances, counts of bacteria and fungi have been carried out by cultural methods, but determinations of the total numbers of bacteria in quantitative decomposition experiments are lacking, with the notable exception of a few recent contributions by Jacobs (1931) and Vandecaveye and Villanueva (1934*a*–*b*). Finally, a large number of experiments deal merely with the influence of addition of organic materials on the number and kinds of microorganisms in soil, without quantitative estimation of the rate of decomposition. On this field microscopic methods have been widely used in recent time, particularly through the studies of Conn (1917), Winogradsky (1925) and Cholodny (1930).

Among all these investigations we find comparatively few attempts to correlate the abundance of microorganisms with the intensity of destruction of organic matter, at least on a quantitative basis. Important steps in this direction are represented by studies on pure or mixed cultures of soil microorganisms (bacteria and protozoa) by Cutler and Crump (1929), de Telegdy-Kovats (1932), and Meiklejohn (1932). As to the fungi, they have been shown again and again to develop abundantly in soil to which decomposable organic matter has been added, and to be able to carry out many processes of decomposition as actively as the bacteria or the mixed soil microflora (see Waksman, 1932), but their quantitative importance under natural conditions in comparison with the bacteria still remains unknown. The influence of temperature on separate microbial processes (nitrification, nitrogen fixation, cellulose decomposition, etc.) has been studied extensively, but its influence on the decomposition of complex organic materials as a whole has received remarkably little attention, apart from the

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* Good and complete reviews of the literature on carbon dioxide production in soil are due to Waksman and Starkey (1924) and Leroux (1934).

work referred to above under (*A*) and the mainly biochemical contributions by Waksman and Gerretsen (1931), Norman (1931) and Shrikande (1934), and we have hardly any information at all concerning the influence of temperature on the number and kinds of microorganisms that arise when organic materials are added to the soil, or on the relation between the character of this microflora and the nature and intensity of the decomposition processes which it brings about.

In some preliminary experiments (Jensen, 1935) it was observed that, in soils with addition of organic materials, the bacteria and fungal mycelia generally developed most richly at lower temperatures, whereas the rate of CO_2-production increased with the temperature; correlations also appeared to exist between bacterial numbers, density of mycelium, and production of carbon dioxide. Since these results suggested a way of finding quantitative expressions for the activity of each group of microorganisms at different levels of temperature, the experiments were extended and placed on a broader basis. Two series of experiments were carried out. In the first, the rate of decomposition of the soil's own organic matter was estimated by determinations of carbon dioxide production at different levels of temperature from soils of different character, but without addition of any organic matter. In the second, similar determinations were made from soils with additions of three different organic materials. In both series, the rate of CO_2-evolution was compared with the results of periodical estimations of the density of mycelium by the Rossi-Cholodny method (Jensen, 1935) and the numbers of bacteria (including actinomycetes), which were determined by direct microscopic counting as well as on agar plates. The objection has often been raised against the method of direct counting, that these figures are of little value, since they include dead as well as living bacteria. This cannot be denied, but on the other hand Thornton and Gray (1934) pointed out that non-viable bacteria may produce chemical changes in their environment, although they are unable to multiply. This contention is undoubtedly well founded; there is ample evidence that bacterial cells incapable of reproduction may still show such fundamental biochemical activities as respiration (Cook and Stephenson, 1928; Ehrismann, 1933*), and proteolysis (Berghaus, 1908; Janke and Holzer, 1929–30; Moycho, 1933).

Methods.

Carbon dioxide production was measured by the method of Petersen (1926): a suitable quantity of moist soil, usually 50–60 gm., is placed in a cylindrical bag of copper wire gauze, approximately 3 × 12 cm., which by means of a nail and a piece of string is suspended under a rubber stopper that fits tightly into the neck of a flask of convenient size and shape (square, wide-necked reagent bottles of 600 c.c. capacity were used), containing a measured quantity of an approximately 0·05N solution of barium hydroxide. At intervals (usually 24 hours, or 2–3 days if the evolution of CO_2 is very slow) the amount of carbon dioxide liberated from the soil and absorbed by the baryta-water is determined by titration with standard oxalic acid and phenol-phthalein, similar flasks without soil serving as blanks. The results from parallel flasks usually agree within ± 4·0 per cent. In the Tables 1–4, the production of CO_2 is expressed as mgm. produced by 100 gm. of dry soil in 24 hours, unless otherwise stated. The flasks were placed

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* This author sums up the matter in the paradoxical sentence: "Die Atmung als solche ist kein Beweis für das Leben."

in incubators regulated to the desired temperatures and only removed for the brief periods (not more than 15–20 min., usually less) necessary to carry out the titrations and the manipulations involved in the determinations of microorganisms. The higher temperatures, 28 and 37° C., were obtained in ordinary incubators. For the lowest range of temperature an electric refrigerator was used; the temperature of this varied somewhat (from about 4° to about 8° C.) during the whole experimental period, but not more than 1–2° C. during each single experiment. A temperature of 14–16° C., with an average of 15° C., was obtained in an ice- and water-cooled incubator; occasional fluctuations to about 13° and about 17° C. took place, but only rarely and not for more than a day at a time. A few experiments were also carried out in a water-cooled incubator at 18–21° C.; during the colder part of the year, this could also be run at a temperature of 14–15° C.

To observe the development of fungal mycelium, a clean microscopic slide was inserted vertically in the soil in each bag (or in two of them, if more than two parallels were run) with its upper edge on a level with the surface of the soil, and renewed at intervals of 3–8 days. At the same time a weighed quantity of soil was removed from each bag for the bacterial counts. After drying and heat-fixation, the slides were stained after Gram, decolorized with alcohol or acetone (preferable for heavy clay soil), and counterstained with phenolic erythrosine. The density of mycelium was then estimated as previously described (Jensen, 1935): 400–500 microscopic squares of 65μ side-length, distributed as evenly as possible over the whole area of the slide, were examined, and the percentage of fields showing presence of fungal hyphae was calculated. The figures from parallel slides usually agreed within 10 per cent., except in the case of slides very poor in mycelium (less than 2 per cent.).

Direct counts of bacteria were made by the method of Thornton and Gray (1934): shaking of the soil with a suspension containing a known number of indigo particles, and determination of the ratio bacteria/indigo. Since only a small quantity of soil was available in most cases, the same soil suspension was used for both direct and plate counts: the soil was shaken for 4 minutes with sterile agar solution, making an initial dilution of 1:3 to 1:15, according to the number of bacteria to be expected in the soil. 1 c.c. of the suspension was removed and diluted further for preparation of the agar plates, whereupon 4 or 5 c.c. of the initial suspension was shaken for 1 minute with an equal volume of the indigo suspension. Rose bengale was found to give a better staining than erythrosine.

Plate counts were made on dextrose-casein-agar (dextrose, 2·0 gm.; casein, dissolved in dilute NaOH, 0·2 gm.; KH_2PO_4, 0·5 gm.; $MgSO_4$, 0·2 gm.; $FeCl_3$, trace; agar, 20·0 gm.; H_2O, 1,000 c.c. pH 6·5–6·7). The plates were incubated for 8 days at 27–28° C., except those from experiments at 4–7° C., which were incubated for 12 days at 16–18° C. All numbers of microorganisms, direct as well as plate counts, are expressed as millions per gm. of dry soil.

Nitrate was determined by the Devarda method, after boiling of the soil extract with sodium hydroxide and potassium permanganate, and ammonia was determined by the method of Bengtsson: repeated extraction of the soil with 0·5N potassium chloride solution, and distillation of the extract with magnesium oxide.

"*Organic matter*" (Table 1) is expressed as loss on ignition.

TABLE 1.

Chemical and microbiological characters and carbon dioxide production in soils without addition of organic matter.

Soil No.		Organic Matter %.	pH.	H_2O %.	At start of Experiment.			Mgm. CO_2 produced* in the first 24 hours at:			Total production of CO_2 in 10 days, in mgm.			Mgm. CO_2 produced per gm. of Organic Matter in 10 days at:		
					Direct Count.*	Plate Count.*										
						Bact.	Act.	15° C.	28° C.	37° C.	15° C.	28° C.	37° C.	15° C.	28° C.	37° C.
Group I: Sand soils	1	1·5	6·5	9·2	250	0·8	0·5	1·4	2·6	3·9	8·3	17·6	25·8	5·5	11·7	17·2
	2	2·1	5·7	9·0	500	4	3	2·0	—	7·7	32·8	—	76·9	10·6	—	36·6
	3	3·4	5·8	14·0	300	1	0·1	2·6	9·5	11·0	31·8	63·1	104·8	9·3	17·8	30·8
	4	5·8	6·7	17·0	2,560	134	5	6·3	16·1	21·9	50·1	119·2	148·9	8·6	20·6	25·7
Group II: Red to brown loam soils ..	5	3·4	6·0	17·0	1,360	22	5	3·7	7·9	12·2	60·2	98·0	136·3	17·7	28·8	40·1
	6	4·7	6·2	16·4	1,330	20	8	2·6	6·2	12·6	45·2	89·0	113·8	9·6	18·9	23·8
	7	22·4	6·1	34·6	2,180	237	3	9·5	19·6	32·6	52·8	111·3	208·6	2·4	5·0	9·4
	8	24·5	5·8	39·2	3,410	119	3	9·0	18·1	33·7	49·2	104·1	193·8	2·0	4·2	7·9
Group III: Grey to black loam soils ..	9	5·5	6·5	17·7	1,700	23	7	5·9	12·8	22·5	88·1	133·5	191·4	16·0	24·3	34·8
	10	5·7	6·8	15·3	1,940	84	9	4·1	6·7	10·6	23·2	38·4	62·8	4·1	6·8	11·1
	11	12·4	7·7	19·7	3,290	95	4	11·6	22·5	29·4	43·6	100·0	151·9	3·5	8·1	12·3
	12	14·5	6·9	24·6	2,360	31	2	4·9	8·5	13·2	30·9	63·7	114·1	2·1	4·4	7·9
	13	17·6	6·5	31·6	(*a*) 3,970	—	—	14·3	38·2	—	82·8	291·9	—	4·7	16·6	—
					(*b*) 3,115	161	13	—	—	46·8	—	—	388·0	—	—	22·0

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* In this and the following tables, numbers of organisms are expressed as millions per gram of dry soil, and production of CO_2 as mgm. CO_2 per 100 gm. dry soil in 24 hours, unless otherwise stated.

Part I.—Production of Carbon Dioxide and Numbers of Microorganisms in Soils without Addition of Organic Matter.

The following soils were used in this series of experiments:

I. *Sand soils*: 1.—Very light sand, poor in humus, under grass, Cooper Park, Sydney. 2.—Light sand soil, poor in humus, under bushes, same locality. 3.—Coarse, dark sand soil, poor in humus, under bushes, Rose Bay Heights, Sydney. 4.—Dark sand soil, fairly rich in humus, from garden, Richmond, N.S.W.

II. *Red to brown loam soils*: 5.—Heavy, red loam, rather poor in humus, from wheat field (good crop), Wagga, N.S.W. 6.—Red-brown loam, rather poor in humus, from pasture, Burragorang Valley, N.S.W. 7.—Heavy, red-brown loam, rich in humus, from lucerne field (good crop), Northern Tablelands, N.S.W. 8.—Heavy, red loam, rich in humus, from lucerne field (crop failing), same locality.

III. *Grey to black loams*: 9.—Heavy, grey loam, fairly rich in humus, from wheat field (poor crop), Wagga, N.S.W. 10.—Heavy, grey loam, fairly rich in humus, from experimental plots, School of Agriculture, Sydney University. 11.—Heavy, dark loam, rich in lime and humus, from flower bed, Sydney University. 12.—Heavy, dark loam, rich in humus, under grass, Sydney University. 13.—Heavy, dark loam, rich in humus, under trees, covered with heavy grass, Sydney University.

After air-drying and sieving, the soils were moistened to approximately two-thirds of their water-holding capacity, and kept for about one week at room temperature before starting the experiments. Germinating seeds that appeared during this period were carefully removed. The experiments were run in duplicate over a period of 10 days, with microbiological analyses after 4 days and at the end of the experiment. For the bacterial counts, 2 or 2·5 gm. soil was removed from each parallel flask and used as a composite sample. Slides for the determination of mycelium were placed in the soil on the first and renewed on the fourth day. Three temperatures were studied: 15° C., 28° C., and 37° C. The experimental results are reproduced in Tables 1–3. Table 1 shows, besides the reaction and the humus and moisture content of the soils, their initial numbers of bacteria, and the amounts of carbon dioxide produced during the first 24 hours and during the whole 10-day period.

The direct counts of bacteria, at start as well as after 4 and 10 days (Table 2), are of the same order as those found by Thornton and Gray (1934), whose work included only clay soils with 1,000 to 4,000 mill. bacteria per gm. The figures show no correlation with the soil reaction, but show a general, although by no means proportional, increase with increasing content of organic matter. The same is true of the plate counts, which, however, vary within much wider limits; their proportion (also in Table 2) is from about 0·3 to about 13 per cent. of the direct counts. Although several important groups of soil organisms (obligate anaerobes, nitrifying bacteria, certain types of cellulose-decomposing bacteria, etc.) cannot be counted by the ordinary plate method, it does not seem necessary to assume that the bulk of the bacterial population of the soil is represented by species which, as such, are unable to develop upon agar media. It has repeatedly been shown that even in what are generally considered "young" cultures the proportion of cells capable of developing into colonies may be as low as the proportion of plate to direct counts observed here (Beijerinck, 1909; Dorner, 1924; Wohlfeil, 1932; Ehrismann, 1933), and this proportion of "viable" cells may depend not only on the age of the culture and the kind of the organism, but also on the composition of the medium used for plate counting (Beijerinck, 1909), the nature of the diluent (Wohlfeil, 1932), and other factors.

The yields of carbon dioxide, in the first 24 hours as well as during the whole period, increase regularly with the temperature, being generally about twice as high at 28° C. as at 15° C., with a somewhat smaller increase when the temperature is raised to 37° C. There is at each temperature a marked parallelism between the direct counts of bacteria and the yields of CO_2 in the first 24 hours (see also Text-fig. 1). The total amounts of carbon dioxide increase somewhat, but very irregularly, with the content of organic matter, and the three last columns of the table show that the production of carbon dioxide per unit of organic matter generally decreases with increasing content of organic matter, i.e., the more humus there is present, the more slowly is it decomposed, as pointed out by Engel (1934); the very active soil No. 13, however, forms an exception to this rule.

Table 2 shows the counts of microorganisms and the densities of mycelium on the 4th and 10th days, and the corresponding yields of carbon dioxide in the previous 24 hours; the most important results are summarized in Table 3. The direct counts are very little influenced by temperature. In some cases, especially No. 4, there is a marked drop in the numbers after 4 and 10 days in comparison with the initial counts, but in general the changes are not of an order of magnitude different from the spontaneous fluctuations shown by Thornton and Taylor (1935) to occur in soil kept under constant conditions of moisture and temperature.* The plate counts follow the same general rule; a marked increase in bacteria, most rapidly at 37° C., is seen in the sand soils No. 1–3 and the loam soil No. 5. The actinomycetes, which never account for any very large proportion of the plate counts, do not seem to be affected by either the temperature or the time. Their mycelia were hardly ever seen in the drop-films for direct counting and were mostly not very conspicuous, although present, on the Rossi-Cholodny slides. Upon the whole, one does not get the impression that this group of organisms is of considerable importance in soil to which no decomposable material has recently been added (cf. Winogradsky, 1925). The development of fungal mycelium is strongest at 15° C. (in the sand soils equally so at 28° C.), and stronger in the sand soils than in the loams, particularly the red loams, which have also by plate counting been found very poor in fungi (Jensen, 1934). At 37° C. the growth of fungi is rather insignificant, except perhaps in the first 3 sand soils.

As on the first day, the yields of carbon dioxide increase markedly with the temperature, especially in the interval from 15° C. to 28° C., where they are approximately doubled. At each temperature, but particularly at 28 and 37° C., there is a significant correlation (Fisher, 1930) between direct counts and yields of carbon dioxide, as shown in Table 3 and Text-figure 1. On the other hand, the figures for density of mycelium show no correlation whatever with the CO_2-yields. Even when fungi are present in notable quantities, as in No. 2, they seem rather inactive, confirming the view of Winogradsky (1925), that these organisms do not partake in the breakdown of soil "humus". If we assume that the whole production of carbon dioxide is the work of the bacteria found by

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* In soils incubated for longer periods (up to 3 months) a marked drop in bacterial numbers, both by direct and by plate counts, was observed at 25 to 37° C., but not at 4 to 15° C.

TABLE 2.

Carbon dioxide formation and composition of microflora in soils without addition of organic matter.

Soil No.	Time. (Day.)	Temperature. (° C.)	Direct Count of Micro-organisms.	Plate Count.		Mycelium. %.	CO_2.	Efficiency.
				Bact.	Act.			
Group I.—Sand Soils.								
1	4th	15°	230	2	0·5	4·9	0·7	0·030
		28°	230	5	0·5	6·8	1·7	0·074
		37°	200	6	0·4	2·9	2·6	0·130
	10th	15°	290	4	0·4	9·8	0·5	0·017
		28°	290	7	0·4	3·7	1·3	0·045
		37°	240	3	0·4	4·6	2·3	0·096
2	4th	15°	680	4	0·1	20·9	2·6	0·040
		37°	630	19	(0)	4·4	7·0	0·111
	10th	15°	610	21	(0)	5·5	4·0	0·066
		37°	560	15	(0)	3·2	7·2	0·129
3	4th	15°	530	4	0·1	3·9	3·1	0·058
		28°	620	5	0·1	8·5	6·3	0·102
		37°	560	19	(0)	3·4	12·3	0·220
	10th	15°	710	21	(0)	4·7	3·6	0·051
		28°	680	8	0·1	5·8	4·7	0·070
		37°	550	15	(0)	0·6	8·7	0·158
4	4th	15°	1,400	83	5	2·9	5·5	0·039
		28°	1,360	70	6	8·0	14·3	0·107
		37°	1,170	59	6	0·3	15·8	0·136
	10th	15°	1,380	71	4	4·4	3·9	0·028
		28°	850	50	6	5·5	8·1	0·099
		37°	910	37	5	0·8	8·9	0·098
Group II.—Red to Brown Loam Soils.								
5	4th	15°	1,140	21	5	3·5	6·0	0·053
		28°	1,630	35	6	0·6	12·5	0·077
		37°	1,170	83	6	0·2	13·8	0·118
	10th	15°	1,740	56	6	0·8	7·8	0·045
		28°	1,590	75	6	(0)	12·1	0·076
		37°	1,600	88	6	(0)	11·1	0·069
6	4th	15°	1,560	25	5	0·8	5·9	0·038
		28°	1,370	31	6	(0)	10·4	0·076
		37°	1,320	22	7	0·3	15·1	0·114
	10th	15°	1,570	16	4	1·5	5·3	0·034
		28°	1,310	22	5	0·6	11·8	0·090
		37°	1,480	14	6	(0)	10·7	0·072
7	4th	15°	1,810	232	3	2·5	4·7	0·026
		28°	1,800	212	4	1·6	10·3	0·057
		37°	1,560	173	3	(0)	20·0	0·128
	10th	15°	1,790	184	5	10·3	4·4	0·025
		28°	1,910	197	4	0·6	9·3	0·049
		37°	1,810	127	4	(0)	17·4	0·096

TABLE 2.—*Continued.*

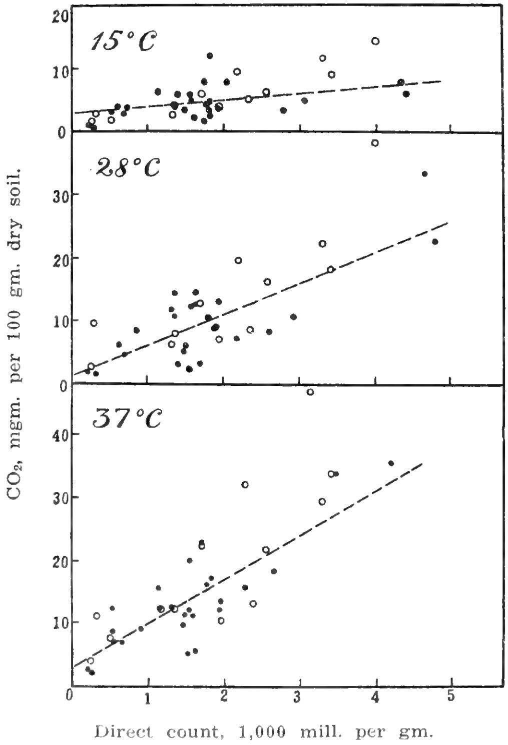
Carbon dioxide formation and composition of microflora in soils without addition of organic matter.—Continued.

Soil No.	Time. (Day.)	Temperature. (° C.)	Direct Count of Micro-organisms.	Plate Count.		Mycelium. %.	CO_2.	Efficiency.
				Bact.	Act.			
Group II.—Red to Brown Loam Soils.—Continued.								
8	4th	15°	3,050	98	4	0·2	4·9	0·016
		28°	2,940	107	4	(0)	10·5	0·036
		37°	2,640	72	4	0·3	18·4	0·070
	10th	15°	2,770	108	4	(0)	3·2	0·012
		28°	2,580	91	3	0·9	8·1	0·031
		37°	2,290	65	5	(0)	15·8	0·069
Group III.—Grey to Black Loam Soils.								
9	4th	15°	1,820	30	4	5·8	12·2	0·067
		28°	1,620	25	7	1·9	14·5	0·090
		37°	1,710	28	7	0·5	22·7	0·133
	10th	15°	2,040	44	6	3·3	9·9	0·048
		28°	1,930	42	7	0·5	13·0	0·067
		37°	1,740	98	8	0·3	16·9	0·097
10	4th	15°	1,620	77	8	0·3	2·2	0·014
		28°	1,380	75	9	2·8	3·1	0·022
		37°	1,620	68	9	(0)	5·5	0·034
	10th	15°	1,750	87	9	1·2	1·6	0·009
		28°	1,550	78	9	4·2	2·4	0·015
		37°	1,530	96	12	0·7	5·2	0·034
11	4th	15°	1,930	98	5	3·1	3·7	0·019
		28°	1,910	105	4	0·6	9·1	0·048
		37°	1,960	100	7	1·3	13·6	0·069
	10th	15°	1,810	86	5	1·0	3·2	0·018
		28°	2,170	84	5	1·4	7·1	0·033
		37°	1,950	85	5	0·6	12·1	0·062
12	4th	15°	1,490	34	3	3·6	3·3	0·022
		28°	1,500	35	3	1·1	5·9	0·039
		37°	1,540	33	2	(0)	12·0	0·078
	10th	15°	1,500	37	3	2·4	2·4	0·016
		28°	1,490	36	3	2·6	5·1	0·034
		37°	1,430	34	3	1·0	9·8	0·069
13	4th	15°	4,310	285	14	11·9	7·9	0·018
		28°	4,660	272	15	4·5	33·5	0·072
		37°	4,190	165	16	1·1	35·4	0·084
	10th	15°	4,380	275	18	7·3	6·2	0·014
		28°	4,770	250	21	2·5	22·5	0·047
		37°	3,470	191	19	1·4	33·9	0·098

TABLE 3.

Summary of results in Table 2.

	15° C.	28° C.	37° C.
Number of pairs of observations	26	24	26
Mean and standard deviation of direct counts..	1,690±1,030	1,760±1,114	1,530±916
Mean and standard deviation of CO_2 production	4·56±2·699	9·8±6·96	13·6±8·08
Correlation coefficient between direct count and CO_2	0·429	0·775	0·809
Regression coefficient $(\times 10^2)$ of CO_2 on direct count	0·112	0·484	0·714
Mean and standard deviation of efficiency of microorganisms in :			
Group I	0·041±0·0164	0·083±0·0244	0·135±0·0403
Groups II+III	0·027±0·0165	0·053±0·0232	0·083±0·0280
Total	0·032±0·0173	0·061±0·0264	0·099±0·0400



Text-figure 1.—Black dots: correlation between direct counts of bacteria on 4th and 10th day and yields of carbon dioxide in previous 24 hours. Regression lines corresponding to the equations:

15° C. : $y = 4{\cdot}56 + 0{\cdot}00112\ (x - 1690)$.
28° C. : $y = 9{\cdot}8 + 0{\cdot}00484\ (x - 1760)$.
37° C. : $y = 13{\cdot}6 + 0{\cdot}00714\ (x - 1530)$.

Circles: correlation between initial direct counts and yields of CO_2 in the first 24 hours.

direct counting, we may calculate the "efficiency" of the bacteria at the different levels of temperature as mgm. of carbon dioxide produced by 1,000 millions of bacteria in 24 hours. This "efficiency", shown in the last column of Table 2, varies from 0·009 to 0·067 at 15° C., from 0·015 to 0·107 at 28° C., and from 0·034 to 0·220 at 37° C. These figures, the means of which are given in Table 3, are of an order comparable with that of corresponding values found by Cutler and Crump (1929) and de Telegdy-Kovats (1932) in work with pure and mixed cultures of soil bacteria. The maximal efficiency observed here—0·220—corresponds to a daily CO_2-production about equal to the dry weight of the organisms concerned, since the dry matter of 1,000 mill. bacteria can approximately be estimated at 0·2 mgm. Table 3 also shows that the efficiency of the bacteria appears to be higher in the sand soils than in the loams, and the *t* test of Fisher (1930, p. 107) shows this difference to be significant at 28 and 37° C. This is probably due to the fact that the sand soils have lower bacterial numbers than the rest, and the efficiencies of bacterial populations will as a rule decrease with increasing density of the population (Cutler and Crump, 1929; de Telegdy-Kovats, 1932; Meiklejohn, 1932). The total plate counts (bacteria plus actinomycetes) do not show any correlation with the yields of carbon dioxide at 15° C.; although positive correlations exist at the higher temperatures, it does not seem that this fraction of the total microflora is the most important in biochemical respect. If the plate-counted organisms were alone responsible for all the carbon dioxide produced, their efficiency would at 15° C. vary from 0·17 (No. 10, 10 days) to 7·2 (No. 3, 4 days), at 28° C. from 0·27 to 12·1 (same soils), and at 37° C. from 0·48 (No. 10, 10 days) to 7·7 (No. 1, 10 days). These figures are not only rather erratic and without any clear relation to the temperature, but they also appear unreasonably high; for instance, an efficiency of 12·1 corresponds to a CO_2-production approximately 60 times the dry weight of the organisms, which exceeds the *maximal* rate of carbon dioxide production in a very young and actively multiplying culture of *Bact. coli* in peptone-water at 37° C., according to Mooney and Winslow (1935).* In the present case we are dealing with populations in comparative equilibrium and consisting of cells of all ages, where such enormous efficiencies would appear inconceivable.

The general results of this series of experiments may be summarized thus:

The rate of destruction of the soil's own organic matter ("humus") increases rapidly with increases in the temperature from 15° C. to 37° C. This is not due to any increase in the number of microorganisms, which are not significantly affected by the temperature, but to an increased metabolic activity of the organisms, among which the bacteria (and not merely the individuals capable of producing colonies on agar plates) are the most important. The total bacterial flora, as determined by microscopic counting, shows an average carbon dioxide production corresponding to approximately 16, 30 and 50 per cent. of the dry weight of the organisms in 24 hours at 15° C., 28° C., and 37° C. respectively (according to the total mean efficiencies in Table 3, and assuming that 1,000 mill. bacteria contain approximately 0·2 mgm. dry matter).

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* Mooney and Winslow estimated the maximal rate of CO_2-production by *Bact. coli* in peptone-water (after 1-2 hours at 37°) at 330 grams per hour per kilogram of bacterial substance; if it be assumed that the bacterial bodies contain 20 per cent. dry matter, this would correspond to a CO_2-production about 40 times the weight of dry matter in 24 hours.

Part II.—Decomposition of Organic Materials added to the Soil.

In these experiments, three kinds of organic materials were used: oats straw, as an example of a natural organic material poor in nitrogen; hay (mixture of young leaves and stems of grasses and white clover, from a grass lawn), as an example of a similar material richer in nitrogen; and fungal mycelium, as an example of a microbial substance synthesized and re-decomposed in the soil. The mycelium was produced by growing a common green soil *Penicillium* on a modified Czapek's solution, containing 5% saccharose, 0·5% $NaNO_3$, and 0·2% KH_2PO_4. After 6–8 days' growth at 28° C. the mats of mycelium were removed, washed several times with distilled water, dried and ground. The materials had the following elementary composition:

	In per cent. of air-dry material		
	Carbon*	Nitrogen	Ratio C/N
Straw	42·15	0·20	211 : 1
Hay	35·35	2·73	13·0 : 1
Penicillium-mycelium	51·8	3·52	14·7 : 1

The materials were used in a finely ground, air-dry condition, and were added to the following soils in quantities of 1 per cent., on the basis of air-dry soil:

1.—A "synthetic soil" made up from 80% pure sand, 18·5% pure kaolin, 1% calcium carbonate, and 0·5% ferric oxide. Small quantities of a suspension of garden soil were added, as an inoculum, to the water with which the soil was moistened. 2.—Garden soil, rich in lime and humus (same as No. 11 in the previous set of experiments), mixed with equal parts of sand. 3.—Acid sand soil (No. 2 in the previous experiments). 4.—Red loam (No. 5 in the previous experiments).

The following sets of experiments were run:

I. "Synthetic soil" + 1·0% straw + 0·1% $NaNO_3$ + 0·025% K_2HPO_4. 12·0% H_2O. Temp.: 6–8° C.; 18–21° C.; 28° C.; 37° C. Duration of experiment: 30 days.

II. Sand-mixed garden soil + 1·0% straw + 0·1% $NaNO_3$. 16·7% H_2O. Temp.: 14–16° C.; 28° C.; 37° C. Duration of experiment: 29 days.

III. Acid sand soil + 1·0% straw + 0·1% $(NH_4)_2SO_4$ + 0·03% KH_2PO_4. 9·5% H_2O. Temp.: 14–16° C.; 28° C. Duration of experiment: 19 days.

IV. "Synthetic soil" + 1·0% hay. 11·0% H_2O. Temp.: 5–6° C.; 14–16° C.; 28° C.; 37° C. Duration of experiment: 28 days.

V. Sand-mixed garden soil + 1·0% hay. 14·8% H_2O. Temp.: 14–16° C.; 28° C.; 37° C. Duration of experiment: 29 days.

VI. Acid sand soil + 1·0% hay. (*a*) 5·3%, and (*b*) 10·4% H_2O. Temp.: 19–21° C. Duration of experiment: 10 days.

VII. Red loam + 1·0% hay. 16·7% H_2O. Temp.: 14–16° C.; 37° C. Duration of experiment: 17 days.

VIII. "Synthetic soil" + 1·0% fungal mycelium. 11·0% H_2O. Temp.: 4–5° C.; 13–15° C.; 18–21° C.; 28° C.; 37° C. Duration of experiment: 28–40 days.

IX. Sand-mixed garden soil + 1·0% fungal mycelium. 14·4% H_2O. Temp.: 5–6° C.; 14–16° C.; 28° C.; 37° C. Duration of experiment: 28 days.

All experiments were run in triplicate, except Nos. III and VI (duplicate).

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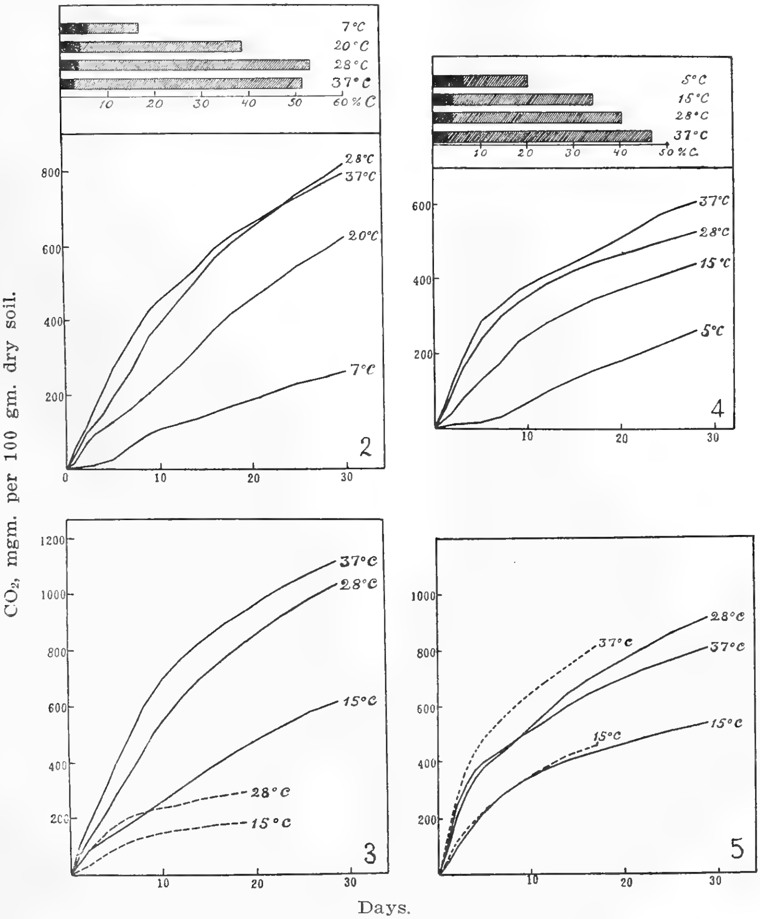
* Carbon determinations carried out by Miss M. Cogle, B.Sc., Department of Medicine (Medical Organic Chemistry), Sydney University.

The course of carbon dioxide evolution in the various experiments is shown in Text-figures 2–7. The curves are generally of the same type as in the experiments of Starkey (1924), Petersen (1926) and Waksman and Gerretsen (1931); at the lower temperatures they are mostly of the S-shaped type suggestive of an autocatalytic reaction (accumulation of respiring organisms). The stimulating influence of increased temperature is most pronounced in the interval from about



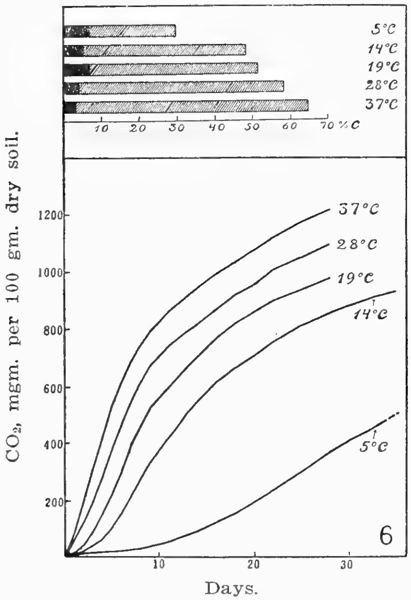
Text-figure 2.—Carbon dioxide production in "synthetic soil" with straw. Horizontal columns: percentage of carbon of added straw liberated as CO_2 at end of experiment. Black part of columns: percentage of carbon of straw present as bacterial substance at end of experiment.

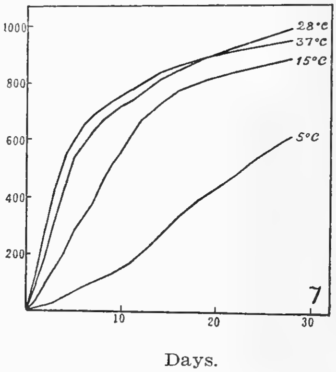
Text-figure 3.—Carbon dioxide production in sand-mixed garden soil with straw (continuous lines), and acid sand soil with straw (broken lines).

Text-figure 4.—Carbon dioxide production in "synthetic soil" with hay. Horizontal columns: percentages of carbon of hay liberated as CO_2 at end of experiment. Black part of columns: percentages of carbon of hay present as bacterial substance at end of experiment.

Text-figure 5.—Carbon dioxide production in sand mixed garden soil with hay (continuous lines), and red loam with hay (broken lines).

5° to about 15° C. (cf. Petersen, 1926, and Waksman and Gerretsen, 1931), whereas the increase from 28° to 37° C. has mostly little influence except in the early stages of the process. After 2–3 weeks the rate of CO_2-production is slowing down, rather suddenly at the higher and more gradually at the lower temperatures, and after 4 weeks the curves tend to run parallel (a marked exception to this rule is only seen in Experiment No. IX), i.e., the stimulating influence of temperature on the decomposition process is most pronounced in the early stages of the process, in agreement with the observations of Waksman and Gerretsen (1931). When this stage is reached, more organic carbon has been liberated as CO_2 at 28–37° C. than at the lower temperatures, i.e., a larger amount of organic material has been left as the slowly decomposing residue called "humus". This is most clearly seen in the experiments with "synthetic" soil, where all the carbon dioxide comes from the organic material added (see Text-figures 2, 4 and 6).





Text-figure 6.—Carbon dioxide production in "synthetic soil" with fungal mycelium. Horizontal columns: percentages of carbon of mycelium liberated as CO_2 at end of experiment. Black part of columns: percentages of carbon of mycelium present as bacterial substance at end of experiment.

Text-figure 7.—Carbon dioxide production in sand-mixed garden soil with fungal mycelium.

The results of the periodical microbiological analyses, together with the corresponding yields of carbon dioxide in the previous 24 hours, are found in Table 4, which also shows the total yields of carbon dioxide, with standard deviations.

The bacteria (as estimated by direct counting, therefore including spores and mycelial fragments of actinomycetes) are seen to multiply in all cases except in the acid soil in Exp. No. 3 (pH 5·4 at the start of the experiment), where the numbers are very low and hardly change significantly. At 4–7° C. the multiplication is very slow, but eventually the numbers exceed those at the higher temperatures

TABLE 4.

Composition of microflora and production of carbon dioxide in soils with additions of organic matter.

Experiment No.	Temperature. (° C.)	Time. (days).	Direct Count.	Plate Count.		Density of Mycelium. %.	Production of Carbon Dioxide.	
				Bact.	Act.		Observed.	Calculated.
I. "Synthetic soil" + straw.	6–7°	7	1,740	713	3	0·7	20·6	—
		14	2,010	1,496	3	1·2	6·9	—
		21	2,270	1,994	(0)	0·3	7·8	—
		30	2,510	1,823	(0)	0·8	6·3	—
		Total CO_2-production in 30 days: 262 ± 14·2 mgm.						
	18–21°	7	1,880	1,341	7	1·8	17·7	—
		14	1,830	994	17	21·0	25·9	—
		21	1,530	1,034	34	14·1	18·9	—
		30	1,710	852	28	3·9	17·7	—
		Total CO_2-production in 30 days: 625 ± 15·6 mgm.						
	28°	7	1,460	642	40	21·5	35·4	33·4
		14	1,270	591	63	12·3	27·6	21·3
		21	1,100	591	97	6·7	18·0	13·6
		30	1,640	605	63	2·4	18·1	12·9
		Total CO_2-production in 30 days: 823 ± 48·3 mgm.						
	37°	7	1,140	619	139	38·2	38·7	63·1
		14	1,040	552	242	4·3	21·2	7·5
		21	1,310	492	193	4·5	13·8	13·9
		30	1,210	520	128	1·0	14·0	6·3
		Total CO_2-production in 30 days: 796 ± 55·3 mgm.						
II. Sand-mixed garden soil + straw.	14–16°	4	1,750	754	5	17·8	23·5	15·0
		9	2,970	591	5	10·7	26·1	20·6
		15	2,310	544	4	27·8	22·7	23·3
		21	2,010	456	2	19·0	18·2	17·5
		29	1,650	—	—	8·4	12·3	10·4
		Total CO_2-production in 29 days: 617 ± 8·7 mgm.						
	28°	4	2,780	951	41	25·3	57·6	48·4
		9	3,010	706	22	8·7	58·4	31·6
		15	2,800	688	20	7·8	30·2	28·3
		21	2,720	525	17	1·0	24·8	22·2
		29	2,640	432	22	0·3	18·7	18·4
		Total CO_2-production in 29 days: 1,041 ± 3·0 mgm.						
	37°	4	2,060	564	66	17·4	75·6	52·2
		9	2,550	549	44	2·8	55·3	39·0
		15	2,390	343	31	1·7	26·8	33·5
		21	2,190	275	46	0·5	17·4	26·2
		29	1,760	180	23	0·2	15·8	13·3
		Total CO_2-production in 29 days: 1,125 ± 13·1 mgm.						

TABLE 4.—*Continued.*

Composition of microflora and production of carbon dioxide in soils with additions of organic matter.

Experiment No.	Temper-ature. (° C.)	Time. (days).	Direct Count.	Plate Count.		Density of Mycelium. %.	Production of Carbon Dioxide.	
				Bact.	Act.		Observed.	Calculated.
III. Acid sand soil+straw.	14–16°	6	520	—*	—	43·1	15·7	17·0
		12	550	—	—	19·4	4·6	7·3
		19	540	—	—	17·9	3·4	6·5
		Total CO_2-production in 19 days: 186±0·7 mgm.						
	28°	6	550	—	—	25·8	20·9	31·1
		12	730	—	—	7·1	6·2	11·0
		19	600	—	—	4·8	5·2	7·4
		Total CO_2-production in 19 days: 294±15·6 mgm.						
IV. "Synthetic soil"+hay.	5–6°	7	650	60	(0)	0·9	7·6	—
		12	2,620	747	(0)	7·0	14·2	—
		17	2,660	888	(0)	20·0	10·7	—
		22	1,590	547	3	21·0	9·2	—
		28	2,260	888	(0)	36·8	8·9	—
		Total CO_2-production in 28 days: 262±18·2 mgm.						
	14–16°	3	2,530	840	(0)	1·8	39·7	13·9
		7	2,430	1,708	(0)	16·1	24·3	20·4
		12	2,700	1,434	3	15·8	16·3	20·9
		17	2,010	712	9	16·6	11·0	16·5
		22	1,310	428	8	3·9	8·8	6·2
		28	1,450	275	4	4·4	8·0	7·0
		Total CO_2-production in 28 days: 444±22·3 mgm.						
	28°	3	2,790	858	1	17·3	57·0	37·9
		7	1,370	376	25	12·3	31·4	22·1
		12	1,180	638	28	2·6	16·2	9·4
		17	1,060	448	31	0·5	9·8	6·0
		22	1,220	410	28	0·2	7·8	7·0
		28	1,410	396	25	0·2	6·7	8·5
		Total CO_2-production in 28 days: 522±3·6 mgm.						
	37°	3	2,490	582	58	21·3	60·8	59·3
		7	1,360	456	94	2·8	21·2	8·6
		12	1,160	327	102	0·0	13·3	3·6
		17	860	198	102	0·0	10·8	(0)
		22	1,260	269	105	0·0	15·8	5·8
		28	1,070	205	90	0·2	7·7	1·8
		Total CO_2-production in 28 days: 608±10·1 mgm.						

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* Plate counting was impossible in this experiment because of abundant growth of fungi on the agar plates.

TABLE 4.—*Continued.*

Composition of microflora and production of carbon dioxide in soils with additions of organic matter.

Experiment No.	Temperature. (° C.)	Time.	Direct Count.	Plate Count.		Density of Mycelium. %.	Production of Carbon Dioxide.	
				Bact.	Act.		Observed.	Calculated.
V. Sand-mixed garden soil+hay.	14–16°	3	3,800	1,124	1	39·8	42·0	38·9
		7	2,590	932	38	34·9	30·2	28·2
		11	3,850	732	29	15·0	16·2	28·8
		16	3,190	613	20	21·5	10·9	26·8
		22	2,730	531	35	10·5	8·8	18·2
		29	2,210	435	29	2·4	6·8	11·9
		Total CO_2-production in 29 days: 536±6·0 mgm.						
	28°	3	3,420	850	53	43·5	84·1	74·4
		7	2,000	702	47	16·8	26·3	32·4
		11	3,740	631	59	25·6	30·5	56·3
		16	3,120	503	58	14·9	22·6	39·2
		22	2,230	533	45	20·7	17·8	38·6
		29	2,230	479	56	0·5	14·5	15·4
		Total CO_2-production in 29 days: 912±49·6 mgm.						
	37°	3	3,190	766	115	8·1	80·6	61·3
		7	1,730	556	171	1·8	22·4	19·0
		11	3,160	472	177	1·9	20·4	50·9
		16	2,550	547	185	2·2	21·4	37·9
		22	1,780	383	202	0·7	11·3	18·4
		29	1,990	298	164	0·4	10·2	22·5
		Total CO_2-production in 29 days: 803±17·0 mgm.						
VI. Acid sand+hay.	*a* 19–21°	4	2,420	527	2	58·8	44·2	—
		10	1,720	478	58	26·7	15·9	—
	b	4	3,030	558	(0)	32·5	40·3	—
		10	1,630	338	2	18·1	20·7	—
		Total CO_2-production in 10 days: *a*: 308 mgm.; *b*: 320 mgm.						
VII. Red loam+hay	14–16°	3	4,220	455	18	32·2	48·4	38·6
		7	2,730	337	6	43·3	25·5	32·7
		11	2,920	345	8	8·0	18·3	19·3
		17	2,530	352	11	22·6	12·2	22·6
		Total CO_2-production in 17 days: 460±6·7 mgm.						
	37°	3	3,260	377	36	27·4	112·1	92·9
		7	2,520	217	48	9·3	38·2	48·2
		11	2,300	208	47	4·4	25·8	35·8
		17	2,070	181	38	3·8	25·7	29·7
		Total CO_2-production in 17 days: 806±50·7 mgm.						

TABLE 4.—*Continued.*

Composition of microflora and production of carbon dioxide in soils with additions of organic matter.

Experiment No.	Temperature. (° C.)	Time.	Direct Count.	Plate Count.		Density of Mycelium. %.	Production of Carbon Dioxide.	
				Bact.	Act.		Observed.	Calculated.
VIII. "Synthetic soil"+fungal mycelium.	4–5°	8	510	89	1	2·0	3·8	—
		14	1,270	618	1	27·6	10·7	—
		20	1,850	1,455	1	15·6	17·5	—
		28	4,610	2,865	(0)	33·2	23·4	—
		40	3,540	3,781	3	27·2	12·8	—
		Total CO_2-production in 40 days: 561±34·2 mgm.						
	13–15°	4	1,070	301	1	13·3	22·3	5·4
		8	2,580	899	(0)	54·2	55·6	36·5
		14	3,290	2,410	14	52·9	39·4	40·7
		20	3,710	1,951	29	37·6	22·1	37·3
		28	2,170	957	23	10·2	15·0	15·3
		35	2,600	739	21	8·9	9·8	16·3
		Total CO_2-production in 35 days: 915±23·5 mgm.						
	18–21°	4	2,170	1,070	3	29·6	61·5	—
		8	2,070	1,730	14	67·0	67·1	—
		14	3,240	2,697	118	34·0	35·4	—
		20	2,000	2,354	124	24·6	18·0	—
		28	3,440	1,933	124	18·0	14·2	—
		Total CO_2-production in 28 days: 978±48·9 mgm.						
	28°	4	2,890	787	62	52·0	79·8	79·5
		8	2,520	2,052	199	27·8	61·5	49·1
		14	2,160	2,132	236	8·0	25·9	23·5
		20	1,590	1,815	152	8·0	24·3	19·0
		28	2,270	1,101	258	2·9	14·7	17·7
		Total CO_2-production in 28 days: 1,097±31·6 mgm.						
	37°	4	3,090	292	292	42·5	104·3	113·7
		8	2,600	2,011	275	15·8	59·0	60·2
		14	2,190	1,281	340	3·0	30·7	30·1
		20	1,520	730	343	1·5	20·4	13·7
		28	1,690	472	157	0·3	15·4	15·8
		Total CO_2-production in 28 days: 1,218±41·8 mgm.						
IX. Sand-mixed garden soil+fungal mycelium-	5–6°	3	1,320	52	0·3	0·3	11·4	—
		7	3,420	1,426	(0)	3·7	15·6	—
		11	4,680	1,811	(0)	13·9	20·3	—
		16	7,830	2,024	(0)	55·9	35·8	—
		22	6,050	2,446	14	76·6	25·2	—
		28	5,730	2,658	3	49·8	21·5	—
		Total CO_2-production in 28 days: 623±34·8 mgm.						

TABLE 4.—*Continued.*

Composition of microflora and production of carbon dioxide in soils with additions of organic matter.

Experiment No	Temperature. (° C.)	Time.	Direct Count.	Plate Count.		Density of Mycelium. %.	Production of Carbon Dioxide.	
				Bact.	Act.		Observed.	Calculated
IX. Sand-mixed garden soil+fungal mycelium—*Continued.*	14–16°	3	4,210	1,070	2	19·5	55·4	33·3
		7	3,770	1,180	51	64·0	51·2	48·8
		11	3,780	575	131	42·2	47·8	39·7
		16	3,160	493	141	26·3	21·5	28·6
		22	2,470	497	143	18·7	9·6	19·7
		28	2,160	—	—	13·2	8·0	16·2
		Total CO_2-production in 28 days : 890±15·4 mgm.						
	28°	3	4,340	947	199	41·8	128·0	79·4
		7	3,880	1,332	145	41·0	46·0	75·1
		11	4,070	1,199	88	13·5	21·5	45·1
		16	2,570	632	94	8·5	19·7	27·3
		22	2,050	599	96	13·9	14·4	29·3
		28	2,260	547	98	2·7	11·7	13·4
		Total CO_2-production in 28 days : 998±8·5 mgm.						
	37°	3	3,990	500	201	21·3	149·1	99·6
		7	2,250	400	359	13·3	36·4	48·5
		11	2,560	278	322	3·0	21·7	39·3
		16	1,830	224	308	0·8	12·0	19·8
		22	1,860	189	355	0·2	7·8	19·5
		28	1,920	187	356	0·7	6·4	21·5
		Total CO_2-production in 28 days : 959±9·2 mgm.						

Mean and standard deviation of direct counts at 4–7° C.	2,960± 2,039
,, ,, ,, ,, ,, ,, ,, ,, 13–16° C.	2,510±992·2
,, ,, ,, ,, ,, ,, ,, ,, 28° C.	2,220± 1,001
,, ,, ,, ,, ,, ,, ,, ,, 37° C.	2,050±730·9
Mean and standard deviation of density of mycelium at 4–7° C.	19·7±21·77
,, ,, ,, ,, ,, ,, ,, ,, ,, 13–16° C.	22·6±15·39
,, ,, ,, ,, ,, ,, ,, ,, ,, 28° C.	14·3±13·83
,, ,, ,, ,, ,, ,, ,, ,, ,, 37° C.	7·1±10·81
Mean and standard deviation of CO_2-production at 4–7° C.	14·5± 7·95
,, ,, ,, ,, ,, ,, ,, ,, 13–16° C.	22·5±14·77
,, ,, ,, ,, ,, ,, ,, ,, 28° C.	31·2±26·12
,, ,, ,, ,, ,, ,, ,, ,, 37° C.	34·4±33·01

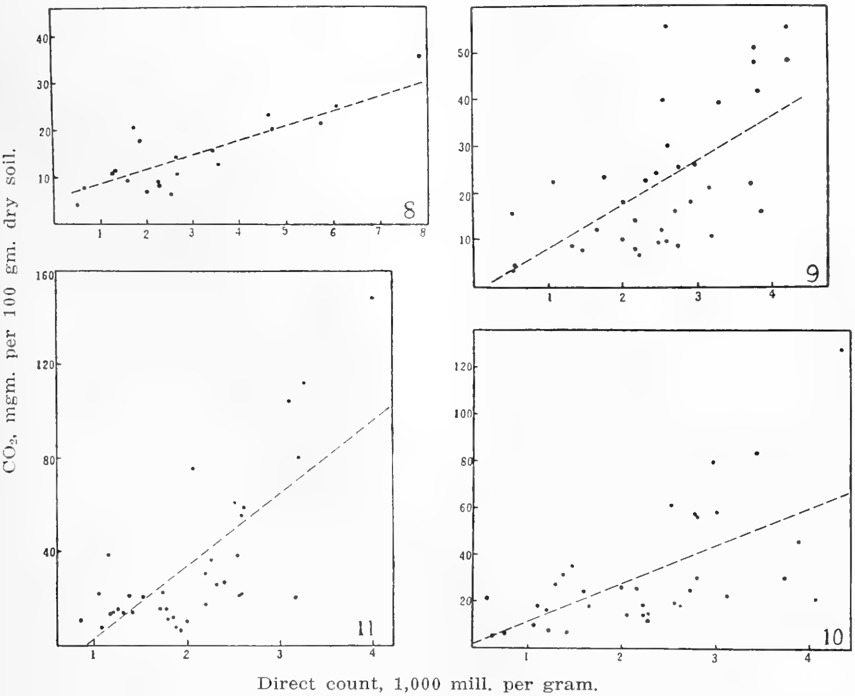
in the same experiment; this is especially the case in the experiments with mycelium. As the temperature increases, the multiplication becomes more rapid, but the numbers do not reach a higher level. The figures at 15° and 28° C. are not, on the whole, very different, and the same applies to the few results from 18–21° C. At 37° C. the numbers are, in the later stages of all the experiments, definitely less than those at the lower temperatures. What has been said of the direct counts generally applies to the plate counts of bacteria as well; here the reduction in numbers at the higher temperatures is very pronounced. This general rule: with decreasing temperature a slower multiplication, but eventually higher maximal numbers than at temperatures favouring rapid multiplication, agrees perfectly with observations on pure cultures by Gotschlich and Weigang (1895), Graham-Smith (1920) and Hess (1934). Vanderleck (1918) has shown in an interesting (but apparently often overlooked) contribution, that surprising numbers of bacteria may accumulate during a mild frost in soil containing undecomposed plant residues. The explanation for these phenomena would seem to be that the low temperature delays the death-rate of the organisms (and possibly also the rate of disintegration of the dead cells) more than the rate of reproduction (Loeb, 1908; Cohen, 1922).

As to the kinds of bacteria observed, a large proportion of white and yellow colonies of corynebacteria (*Cor. helvolum* or related forms) was seen on the plates from experiments with hay and fungal mycelium at 5° to 15° C.; at the higher temperatures they were less conspicuous. Spore-forming bacilli, often in fine long chains, were frequently seen on the Rossi-Cholodny slides at 15° C. in the early stages of the same experiments at 15° C. They showed the presence of endospores after 3 days (cf. Winogradsky, 1925, and Ziemiecka, 1935); after this time, free spores were often seen in the films for direct counting. The slides and films from experiments with straw showed the presence of slender, curved filaments of the *Cytophaga*-group and small, curved, gram-negative rods which might be representatives of the "*Cellvibrio*"-group, but these organisms did not seem to make a large proportion of the total microflora.

The actinomycetes are shown by the plate counts to be almost absent at 4–7° C. and to be very numerous at 28° C. and 37° C., especially in the experiments with fungal mycelium. Their numbers nearly always reach their maximum after the peak period of CO_2-production, and remain high when the carbon dioxide production has become very slow. Microscopically this group of organisms showed some interesting features. On the Rossi-Cholodny slides their vegetative mycelia appeared in great abundance after 3 to 7 days at 28° and 37° C. in soils with hay and fungal mycelium, but at later periods little more was seen of them. The films for direct counting showed surprisingly few actinomyces-hyphae, even in cases where they were richly represented on the Rossi-Cholodny slides, but in such cases the films often contained many long, irregular rods which might be fragments of actinomyces-mycelia; it seems that the filaments are easily broken up by preparation of the soil suspension, and thus become included in the direct counts. These phenomena indicate that the actinomycetes are of most importance in the earlier stages of the decomposition process, where they accompany and succeed the vigorous development of fungal mycelium (cf. Ziemiecka, 1935), and that their high numbers in later stages are mainly derived from spores, which may be without biochemical significance.

The fungi, like the bacteria, developed very slowly at the lowest range of temperature, but in some cases (experiment No. IX) they gradually became very abundant at this temperature. At higher temperatures the mycelia appeared earlier on the slides. As a whole they seemed to develop most richly at 15° and 20° C., reaching a maximum after 3 to 11 days and then receding. At 28° C., and particularly at 37° C., they tend to disappear quite rapidly after a brief period of vigorous growth in the first 3–7 days. At the latter temperature their maximal density is with few exceptions considerably less than at the lower temperatures in the same experiment. The periods of strongest mycelial growth generally coincide with the peak periods of carbon dioxide formation. This shows that the fungi are of chief importance in the early stages of intense decomposition of organic matter (cf. Waksman and Gerretsen, 1931, and Waksman, 1932), and that their period of activity is markedly shortened with increasing temperature.

The mere inspection of the figures gives only an imperfect idea of the relationships between yields of carbon dioxide, bacterial numbers, and densities of mycelium; a better picture may be obtained by calculation of the correlations between these three sets of values, as shown in Table 5. Text-figures 8–11 show definite linear correlations between the direct counts of bacteria and the yields of CO_2 at the different temperatures,* and similar types of scatter-diagrams are shown by the densities of mycelium and the yields of CO_2.



Text-figure 8.—Correlation between direct counts of bacteria and yields of carbon dioxide at 4-7° C. Regression line corresponding to the equation: $y = 14{\cdot}5 + 0{\cdot}003091\ (x - 2960)$.

Text-figure 9.—Correlation between direct counts of bacteria and yields of carbon dioxide at 13-16° C. Regression line corresponding to the equation: $y = 22{\cdot}5 + 0{\cdot}00941\ (x - 2510)$.

Text-figure 10.—Correlation between direct counts of bacteria and yields of carbon dioxide at 28° C. Regression line corresponding to the equation: $y = 31{\cdot}2 + 0{\cdot}0162\ (x - 2220)$.

Text-figure 11.—Correlation between direct counts of bacteria and yields of carbon dioxide at 37° C. Regression line corresponding to the equation: $y = 34{\cdot}4 + 0{\cdot}03088\ (x - 2050)$.

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* The few determinations at 18-21° C. were insufficient to show any significant correlations; these values have been omitted from the calculations.

TABLE 5.

Correlations between CO_2 production, numbers of microorganisms, and density of fungal mycelium.

	4–7° C.	14–16° C.	28° C.	37° C.
Total correlation coefficient between direct count and CO_2-production	0·774	0·636	0·621	0·716
Regression coefficient of CO_2-production on direct count, $\times 10^2$	0·3091	0·941	1·620	3·088
Partial correlation coefficient between direct count and CO_2, density of mycelium eliminated	0·600	0·565	0·413	0·643
Partial regression coefficient of CO_2-production on direct count, $\times 10^2$	—	0·709	0·797	2·22
Total correlation coefficient between density of mycelium and CO_2-production	0·640	0·614	0·773	0·726
Regression coefficient of CO_2-production on density of mycelium	0·234	0·586	1·46	2·217
Partial correlation coefficient between density of mycelium and CO_2, direct count eliminated	(0·238)	0·536	0·675	0·657
Partial regression coefficient of CO_2-production on density of mycelium	—	0·421	1·150	1·158
Correlation coefficient between direct count and density of mycelium	0·685	0·361	0·513	0·437
Number of pairs of observations	20	36	35	36
Correlation coefficient between CO_2-production and plate count (Bact. + Act.)	0·452	(0·325)	(0·273)	(0·180)

(Non-significant values are placed in parentheses.)

The simple correlation coefficients between direct count and carbon dioxide are in all cases significant (Fisher, 1930, Table V.A), and remain so when the density of mycelium is eliminated by calculations of the partial correlation coefficients. On the other hand the correlation between plate counts (bacteria + actinomycetes) and yields of CO_2 is barely significant at 4–7° C. and insignificant at the higher temperatures. The numbers of organisms capable of producing colonies on agar plates are thus clearly less significant than the direct counts as indices of the biochemical activity of the bacterial population. It is interesting to note that the ratio between direct and plate counts is, in all these experiments, and particularly in the "synthetic" soil, much closer (from about 1 to about 10) than in the previous experiments with soils without addition of organic matter.† This suggests that the zymogenic flora of bacteria and actinomycetes, which has arisen in these experiments, consists mainly of species capable of growth on agar plates, but that the fraction of viable individuals is not necessarily the most important in biochemical respect. This is in perfect agreement with the results obtained in the previous series of experiments.

Like the direct counts, the figures for density of mycelium show significant correlations with the CO_2-yields, and at all temperatures except 4–7° C. this correlation continues to exist when calculated as a partial correlation coefficient with elimination of direct counts.

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† Some experiments recorded by Jacobs (1931) seem to represent the only previous case where bacterial numbers have been determined both by direct and plate counting in soil with addition of a rapidly decomposable material (naphthalene). Here, too, the direct counts were only 2 to 3 times as high as the plate counts, but unfortunately the figures cannot be directly compared, since they were obtained from separate experiments.

The partial regression coefficients in Table 5 (calculated by means of the formulae given by Dawson, 1933) enable us in some measure to compare the effect of the bacteria and the fungal mycelia in the production of carbon dioxide. At 4–7° C., where the partial correlation between density of mycelium and yield of CO_2 is reduced below significance, the effects of the two groups of organisms cannot be separated simply, although it is obvious that their efficiency is much lower than at the higher temperatures. At 14–16° C. the partial regression coefficient $\times 10^2$ of CO_2 on direct count is 0·709; this means, that with constant density of mycelium the average daily yield of CO_2 per 100 gm. of dry soil increases with 0·709 mgm. when the number of bacteria increases with 100 mill. per gm.; expressed on the basis of 1 gm. of soil, this increase corresponds to an average production of 0·0709 mgm. CO_2 per 1,000 mill. bacteria in 24 hours, which we may regard as the average efficiency of the bacteria at this temperature. The corresponding partial regression coefficient of CO_2 on density of mycelium shows, similarly, that with constant numbers of bacteria the yield of CO_2 increases with 0·421 mgm. per 100 gm., or with 0·00421 mgm. per 1 gm. of soil, so that a quantity of mycelium corresponding to a density of about 17% produces on an average the same amount of carbon dioxide as 1,000 mill. bacteria per gm. of soil. In the cases where the growth of fungi is most abundant (50–64% density) their activity would thus seem to be about equal to that of the bacteria (3–4,000 mill. per gm.) present at the same time, but towards the end of the experiments their activity appears small in comparison with that of the bacteria. An exception is shown by the acid soil with straw (experiment No. III), where the fungi appear almost alone active, but in this soil the rate of CO_2-formation is very slow in comparison with the corresponding experiment (No. II) with alkaline soil, where large numbers of bacteria are present. In the same way we find from the partial regression coefficients at 28° C., that the average efficiency of the bacteria is 0·0797 mgm. CO_2 per 1,000 mill. bacteria, and that with constant bacterial numbers the yield of CO_2 increases with 0·0115 mgm. CO_2 per gm. soil per 1% increase in density of mycelium, i.e., 7% density of mycelium is approximately equal to 1,000 mill. bacteria per gm. soil. At this temperature the fungi seem to display their greatest activity, although their growth is usually less abundant than at 15° C. After 3 to 8 days their activity appears to exceed that of the bacteria very considerably; but after 3–4 weeks they have largely ceased to be of importance. Finally, at 37° C. the average efficiency of the bacteria is considerably increased (0·222 mgm. CO_2 per 1,000 mill. bacteria), and a density of 14% mycelium is approximately equal to 1,000 mill. bacteria per gm. This and higher densities are not very common, and only in a few cases (experiment No. I after 7 days, No. VII after 3 days, No. VIII after 4 days) does the activity of the fungi appear to exceed that of the bacteria (including actinomycetes, which are richly represented at this temperature).

It should here be pointed out that these calculations represent no more than a first attempt to estimate the relative importance of bacteria and fungi in the decomposition processes. The direct counts of bacteria include varying proportions of active and inactive cells (bacterial endospores, and large numbers of aerial spores of actinomycetes at the higher temperatures), and the method of estimating the density of mycelium is admittedly not ideal and leaves considerable room for improvement. Firstly, the number of fields showing presence of mycelium does not precisely indicate the amount of fungal protoplasm represented by these mycelia, owing to the very variable thickness (sometimes also number in each field) of the hyphae observed and, secondly, the slides were in contact with the soils for longer periods at the end than at the beginning of the experiments. But, even with these limitations, the method is felt to be a distinct improvement in comparison with the plate method. Improvements of the method (actual measurements of the hyphae, standardization of the time of incubation, etc.) may lead to more precise estimates.

In the last column of Table 4 are shown the amounts of CO_2 that would be expected to have been produced by the amounts of microorganisms observed. These values are calculated from the partial regression formula (Dawson, 1933):

$$X_1 - \bar{X}_1 = b_{12\cdot3}(X_2 - \bar{X}_2) + b_{13\cdot2}(X_3 - \bar{X}_3),$$

where X_1, X_2 and X_3 represent yields of CO_2, direct counts of bacteria, and densities of mycelium, respectively, $\bar{X}_1$, $\bar{X}_2$ and $\bar{X}_3$ the corresponding mean values (Table 4, bottom), and $b_{12\cdot3}$ and $b_{13\cdot2}$ the partial regression coefficients of CO_2 on direct counts and density of mycelium, respectively. In some experiments the agreement between expected and observed values is very close, but in most cases the observed values are in the beginning higher and at later stages lower than expected. This is obviously due to the fact that the bacterial counts, as seen in Table 4, tend to decrease much less rapidly than the rate of carbon dioxide production, i.e., the efficiency of the bacteria decreases with advancing time (cf. Meiklejohn, 1932, and Mooney and Winslow, 1935). In the later stages of the experiments at 37° C., where the mycelium has practically disappeared, we may calculate the efficiency of the bacteria as mgm. of CO_2 per 1,000 mill. bacteria in 24 hours in the same way as in Table 2; this calculation shows efficiencies of quite the same order as in the experiments with soils without addition of organic matter (for instance, 0·079–0·081 in experiment No. II after 21–29 days, 0·072–0·125 in experiment No. IV after 11–28 days) and much lower than the average efficiency indicated by the regression coefficients. A similar decreasing efficiency has been observed in cultures of fungi, where the rate of CO_2-production per unit of weight of mycelium is high in young stages where mycelium is being synthesized, but may become very low when the already-formed mycelium is merely being maintained (Noack, 1920; cf. also Mazé, 1902; Peterson, Fred and Schmidt, 1922; and Heukelekian and Waksman, 1925). This time-factor cannot in the present experiments be eliminated simply by treating the time as a fourth variant, because the regression of carbon dioxide formation on time is far from linear, particularly at 28° C. and 37° C.

The nitrogen transformation in some of the experiments is shown in Table 6. In the soils with hay and mycelium the production of nitrate, like that of carbon dioxide, increases with the temperature and is practically the same at 28° and at 37° C. The hay, with its narrower C:N ratio, has produced more inorganic nitrogen than the mycelium, the nitrogen-compounds of which do not appear to have been attacked at all after 4 weeks at 5° C., in spite of the abundant growth of microorganisms that took place in this experiment. The soils with straw show an analogous phenomenon: the actual amount of inorganic nitrogen consumed is rather constant at the different temperatures, but the amount of organic matter decomposed to carbon dioxide per unit of nitrogen consumed increases markedly with the temperature. This is in full agreement with the results of Norman (1931) who found the "nitrogen-equivalent" (parts of inorganic nitrogen immobilized per 100 parts of organic matter decomposed) higher at 20° C. than at 30–50° C. in decomposition experiments with straw. From a practical aspect this might indicate that the danger of exhaustion of available nitrogen by addition of straw or similar materials to the soil is graver in the colder than in the warmer seasons of the year.

TABLE 6.

Nitrogen transformations in soils with addition of organic matter.

Experiment.	NH_4–N.*	NO_3–N.*	Production (+) or Consumption (−) of Mineral N ($NH_4 + NO_3$).	mgm. C liberated as CO_2 per mgm. Mineral N consumed.
No. 2 (sand-mixed garden soil + straw and $NaNO_3$):				
At start of experiment	1·3	19·3	—	—
After 29 days at 14–16° C.	0·0	9·3	−11·3	14·9
,, ,, ,, ,, 28° C.	0·0	8·7	−11·9	23·9
,, ,, ,, ,, 37° C.	0·0	11·5	−9·1	33·9
No. 3 (acid sand soil + straw and $(NH_4)_2SO_4$):				
At start of experiment	16·8	4·0	—	—
After 19 days at 14–16° C.	11·3	3·8	−5·7	8·9
,, ,, ,, ,, 28° C.	11·7	3·7	−5·4	14·8
No. 6 (sand-mixed garden soil + hay):				
At start of experiment	1·3	5·4	—	—
After 28 days at 14–16° C.	0·8	9·3	+2·6	—
,, ,, ,, ,, 28° C.	0·0	11·6	+4·9	—
,, ,, ,, ,, 37° C.	0·8	13·2	+6·3	—
No. 8 (red loam + hay):				
At start of experiment	0·8	2·7	—	—
After 17 days at 14–16° C.	6·3	3·2	+6·0	—
,, ,, ,, ,, 37° C.	6·2	5·9	+8·6	—
No. 10 (sand-mixed garden soil + mycelium):				
At start of experiment	1·4	6·7	—	—
After 28 days at 5–6° C.	2·5	5·0	(−0·6)	—
,, ,, ,, ,, 14–16° C.	4·2	8·1	+4·2	—
,, ,, ,, ,, 28° C.	0·0	14·0	+5·9	—
,, ,, ,, ,, 37° C.	1·1	12·1	+5·1	—

* Mgm. per 100 gm. of dry soil.

CONCLUSIONS.

A general principle extends through all these experiments: the higher the temperature, the more organic matter is decomposed to carbon dioxide (and inorganic nitrogen-compounds) in proportion to the quantity of microorganisms acting; one might say that the metabolism of the total microflora becomes less economical as the temperature increases.* This explains partly the rapid destruction of soil organic matter in hot climates. At low temperatures (4–7° C.) the microorganisms develop slowly when organic matter is added to the soil, but owing to the preserving influence of the low temperature, their cell-material gradually accumulates to a greater extent than at higher temperatures, where the

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* The widening influence of increasing temperature upon the ratio of carbon liberated as CO_2 to carbon converted into bacterial substance is clearly seen in Text-figures 2, 4 and 6. The quantities of carbon in bacteria have been calculated on the assumption that 1,000 mill. bacteria on an average represent 0·2 mgm. dry matter with 50% carbon. To this must be added an unspecified amount of carbon present as fungal mycelium at 4-5° C., and as residues of previous generations of bacteria.

development of the organisms is more rapid, but not more extensive, and where the re-decomposition of the synthesized microbial matter becomes increasingly rapid. These facts have another important bearing on the problem of humus-accumulation. The proteid compounds synthesized at low temperature, according to Waksman and Gerretsen (1931), are obviously identical with the protoplasm of microorganisms that accumulate under these conditions. The lignins, which also accumulate at low temperatures (Waksman and Gerretsen, 1931), may combine with the proteins of the dead organisms (or with protein-like substances actually secreted by bacteria, according to Simola, 1931), thereby giving rise to those highly resistant ligno-protein compounds (Waksman and Iyer, 1933) that account for a very considerable part of the soil humus. According to what has just been said, these two sources of humus (lignin and microbial protein) will increase in quantity as the temperature decreases; and when they have been formed, their rate of decomposition will naturally increase with the temperature.

In cases where organic matter is being decomposed chiefly by fungi, it might be imagined that more protoplasm would be synthesized than where bacteria predominate, since the fungi are usually credited with a more economic type of metabolism than the bacteria (for references, see Kruse, 1910; Stephenson, 1930; and Waksman, 1932). The generality of this principle may, however, be doubted. A favourite test object in nutritional studies with fungi has been *Aspergillus niger* and related forms, which may convert one-half or even more of the consumed food-material into cell substance. Similar values were found by Heukelekian and Waksman (1925) in *Trichoderma* and *Penicillium*, but several other fungi seem to use their nutrients far less economically (Harter and Weimer, 1921; Peterson, Fred and Schmidt, 1922 (*Pen. glaucum* less economic than *Asp. niger*); Hochapfel, 1925). As to the bacteria, Rubner (1906) found *Proteus vulgaris* able to utilize up to 25% of the energy of the medium, whereas pathogenic bacteria were far less economical; this, however, could not be confirmed by Abt (1925), who found *Cor. diphtheriae* capable of utilizing some 30 per cent. of the energy of its nutrients. A utilization of sugar nearly as economical as in *Aspergillus* has been observed in *Myc. phlei* by Stephenson and Whetham (1923) and in other bacteria by Conn and Darrow (1935), whose experiments are particularly significant in regard to our problem, since they deal with a type of bacteria that represent a large proportion of the soil microflora. Even if the fungi as a whole synthesize somewhat more cell substance from a given quantity of nutrients than the bacteria, they do not actually seem to build up more protein, since they are generally much poorer in nitrogen. For instance, the data of Waksman and Diehm (1931), expressing the ratio of decomposed hemicellulose to assimilated ammonia-N in solution and sand cultures, do not show significant differences between fungi and aerobic bacteria (both studied in large numbers), although the ratio varied strongly within each group of organisms. Simola (1931) found cellulose-decomposing bacteria consuming nearly as much nitrogen in proportion to the amount of cellulose decomposed as *Trichoderma* and *Penicillium* according to Heukelekian and Waksman (1925), and Shrikande (1934) even found the nitrogen-equivalent (parts of inorganic nitrogen immobilized per 100 parts of organic matter decomposed) much higher with bacteria than with fungi in decomposition experiments with straw. There is thus no certain evidence that a decomposition of a given amount of organic materials by fungi would lead to the formation of more protein (and hence ligno-protein compounds) than a similar process brought about by bacteria under equal conditions.

SUMMARY.

A study was made of the rate of decomposition of organic matter in soil at different ranges of temperature in relation to the abundance of microorganisms present. The rate of decomposition was measured by the production of carbon dioxide. Bacteria (including actinomycetes) were counted both microscopically and on agar plates. The density of fungal mycelium was determined microscopically by means of the Rossi-Cholodny method.

In soils without extra addition of organic matter the carbon dioxide production was generally about 100 per cent. stronger at 28° C. than at 15° C., and about 50 per cent. stronger at 37° C. than at 28° C. The numbers of bacteria were not appreciably influenced by the temperature within a period of 10 days. Direct counts showed numbers from about 8 to about 300 times as high as plate counts. At each range of temperature there was a significant correlation between the daily yields of carbon dioxide and the directly counted numbers of bacteria, which appeared to be a better index of the activity of the bacterial flora than the plate counts. The growth of fungi was more extensive in sand soils than in loam soils, and was greatly restricted at 37° C. No correlation was found between the density of mycelium and the yields of carbon dioxide. The decomposition of the soil's own organic matter ("humus") seems to be carried out almost entirely by bacteria, and the accelerating influence of increasing temperature on this process is due to stimulation of the metabolic activity of the bacteria, but not to increased numbers of these organisms.

In soils with addition of undecomposed plant materials (straw, hay, fungal mycelium) the rate of carbon dioxide formation increased steeply with increases in temperature from about 5° C. to 37° C. This effect was most pronounced in the early stages of the decomposition process and at the lower ranges of temperature. In general the microorganisms tended to develop more slowly, but eventually to a greater extent, at lower than at higher temperatures, especially 37° C., where the vegetative growth of the fungi was generally very restricted and always confined to a brief initial period. Direct counts of bacteria (including actinomycetes) showed figures only 1–10 times as high as the plate counts. The numbers of actinomycetes increased strongly with the temperature. Significant correlations existed between the daily yields of carbon dioxide and the densities of mycelium, and between yields of carbon dioxide and directly counted numbers of bacteria, but not between yields of carbon dioxide and plate counts. The efficiency of the organisms decreased rapidly with advancing time. The fungi appeared to be important agents of decomposition during the earlier stages of the process, when the most intensive destruction of organic matter takes place. The figures suggested that, especially at 28° C., their carbon dioxide production may, even in alkaline soil, considerably exceed that of the bacteria; with advancing degree of decomposition they cease to be of importance. The decreasing rate of decomposition of added organic materials, together with the increasing accumulation of microbial substance, seems to offer a natural explanation for the increasing accumulation of "humus" with decreasing soil temperature.

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STUDIES IN THE AUSTRALIAN ACACIAS. VI.

THE MERISTEMATIC ACTIVITY OF THE FLORAL APEX OF ACACIA LONGIFOLIA AND ACACIA SUAVEOLENS AS A HISTOGENETIC STUDY OF THE ONTOGENY OF THE CARPEL.

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(Plates ii–v; fifteen Text-figures.)

[Read 29th April, 1936.]

Introduction.

Taking its origin in Goethe's (1790) "Versuch die Metamorphose der Pflanzen zu erklären", and regarded by Robert Brown (1840, p. 108) as generally accepted, the classical theory that the carpel is a modified leaf has held sway for more than a hundred years. In recent times criticisms ranging from modification to complete negation of the theory have arisen. So much speculation and assumption and criticism (of such speculations and assumptions) have been written about this subject, that the only excuse for adding to the literature is that there are new relevant facts to be recorded. In spite of frequent reference to the need for considering primordial stages and the ontogeny of the carpel, the literature shows few illustrations of these features, particularly of cellular details of the meristematic tissues concerned. In this paper I will describe and illustrate the origin of the floral organs in two species of *Acacia*, showing the relation of their primordial tissues to the tissues of the floral axis. The central interest will lie in finding the relation of the carpel primordium to the apex of the flower and in comparing its mode of origin with that of the other parts of the flower.

The two species, *Acacia longifolia* Willd. and *Acacia suaveolens* Willd., were given by Saunders (1929, pp. 225–7) as illustrations of the theory of Carpel Polymorphism (1925, etc.). I undertook an examination of them to test the objections to the theory based on the examination of *Acacia Baileyana* (Newman, 1933 and 1934). As the work progressed it became clear that important evidence was here available concerning other criticisms of the old theory of the carpel that were being raised by McLean Thompson (1929, 1931, 1932, 1934), Hamshaw Thomas (1931, 1934) and Victor Grégoire (1931). In none of the papers mentioned do the four authors support their theories by illustrating the cellular details of the ontogeny of the carpel and its relation to the apical meristems of the floral axis; and this is the type of evidence that will be presented in the following pages.

MATERIAL AND METHODS.

DESCRIPTION OF RELEVANT FEATURES OF THE SPECIES.

Acacia longifolia.

The flowers of *Acacia longifolia* are in cylindrical spikes. In the bud stage the only restriction is due to the tight packing of the young flowers on the axis of the spike. There is no marked distortion of the flowers. Each flower is in the axil of a bract which overlaps the bract of the flower next above so that in the very young condition the surface of the spike consists of the tips of the subtending bracts. The only distortion is that the flowers are elongated or flattened in the direction of their axis. The construction of this inflorescence makes it easy to orientate the material for sectioning, and to determine in microscopic examination how a flower lies with regard to the axis of the spike. There are four sepals and four petals. The stamens number approximately between 90 and 110. The single legume has ten or twelve ovules, in the young state is relatively small, and in the pod stage long, narrow and almost cylindrical. In rare cases, more than one legume has been seen in a flower; but the disposition of the sections was not such as to disclose the relationship of the legumes to one another or to the axis of the flower. The orientation of the legume to the axis of the spike appears to have no constancy. The foliage is of the phyllodineous type, with flat phyllodes having several parallel "nerves".

Acacia suaveolens.

The flowers of *Acacia suaveolens* are in globular heads borne in axillary racemes. The young racemes are enclosed in several large imbricate bracts, and the flower heads are subtended by bracts. In the bud these bracts so tightly clasp the young inflorescence and flower-heads that there is often a considerable distortion of the young flowers (Text-fig. 11). The bracts are deciduous at anthesis. There are no bracts subtending the individual flowers. Such an arrangement makes it impossible to orientate the material in sectioning, and often difficult to determine in microscopic examination how a flower lies with regard to the axis of the flower-head. There are five sepals and five petals, though sometimes six or four are found. The stamens number approximately between 60 and 80. The single legume has five or six ovules, in the young state is relatively massive, and in the pod stage flat, broad and short. The foliage is of the phyllodineous type, with flat phyllodes having one "nerve".

MANIPULATION OF THE MATERIAL.

All the material was fixed in a formalin–alcohol solution (50 c.c. absol. ethyl alcohol, 50 c.c. water, 6 c.c. commercial formalin). In the case of *A. suaveolens*, it was found necessary to dissect out as many bracts as possible. In the case of *A. longifolia* the young spikes were rolled and squeezed between the fingers and cut longitudinally, either down the middle of the axis or twice parallel with the axis. All material was thoroughly exhausted when put into the fixing fluid. After dehydration and clearing in either xylol or cedar-wood oil, the material was embedded in paraffin.

Serial sections were cut with a microtome, mostly at a thickness of 6μ (0·006 mm.), a few being cut at 4μ and 8μ. The block was usually cooled with ice and salt. This material was very hard, probably on account of the hardening of the tannin in the cells by the fixative. The consequent friction during cutting invariably generated static electricity that caused disruption of the ribbon as it left the edge of the knife. This was overcome by producing a high-frequency brush discharge around the material and knife (Batson, 1920, describes the method). The stain used, except where specified, was a triple stain comprising Safranin in 50% alcohol differentiated with 0·005% Light Green in 95% alcohol, a saturated solution of Orange G in clove oil and a saturated solution of Light

Green in clove oil. Immersion of the slides in water after the alcoholic safranin makes the final differentiation of the safranin much easier. There is no use in giving a schedule, because the times vary with both species and stage of development.

EXAMINATION OF THE MATERIAL.

The necessary details of the photography and drawing, together with the standardized annotations, are given in the "Notes on the Illustrations" (p. 85).

The first attempt to find the relation of the primordium of the legume to the apex of the flower was by means of scale models made of plasticene (modelling material). The models were made at a magnification of approximately 375 from series of sections 0·006 mm. thick. Sheets of plasticene were rolled to a thickness of 2·25 mm. (0·006 × 375), and on them were drawn, with the aid of the camera lucida, the outlines of the component sections of series through young flowers. The outlines being cut out and superposed in order, scale models of young flowers were built up.* Models were made of the portion above the sepals at different stages of development. After smoothing the surface and cutting off the petals level with the base of the outer stamens (except in Plate v, fig. 51) and cutting off some or all of the stamens, the models appeared as in Plate v, figures 51–59. They represent two critical stages from *Acacia longifolia* (58–59) and a complete series of stages from *Acacia suaveolens.* The additional stages for *longifolia* are represented by outline drawings (Text-figs. 1–5).

Description of the Evidence.

METHOD OF APPROACH.

In this description I will not use terms whose morphological or spatial significance could assume an interpretation of the legume or the carpel. The term "carpel" assumes an interpretation of the legume, the terms "legume" and "apex" (of the flower) have a spatial significance in the problem; therefore they will not be used.

In the succeeding section of the paper the evidence will be interpreted against the background of knowledge of the vegetative growing point found in recent literature. In the final section the criticisms of the classical theory will be discussed and an attempt made at a constructive contribution to the morphology of the carpel.

THE EVIDENCE.

External appearances.

The young floral axis is approximately cylindrical, with its upper portion nearly hemispherical. The appearance, from (and including) the insertion of the petals upwards at the time of the petal primordia,† is shown by a model of *suaveolens* (Plate v, fig. 51) and an outline of a section of a young flower with bract of *longifolia* (Text-fig. 1). Soon after this stage the outer part of the convex end of the axis develops into a "shoulder" leaving a central convex area, which I will call the "dome". On the "shoulder" the stamen primordia arise, beginning at its edge and in front of the sepals (not shown in the models) (Plate v, fig. 52 for *suaveolens* and Text-fig. 2 and Plate v, fig. 59 for *longifolia*).

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* Zimmermann (1928, p. 299) made a model by drawing on and cutting out cardboard, adding paraffin to the appropriate thickness, and sticking together the magnified sections thus made.

† See p. 67 for terminology.

The area of the "shoulder" becomes filled with the primordia of the stamens during whose early growth the dome becomes higher (Plate v, figs. 53–5 for *suaveolens* and Plate v, fig. 59 and Text-fig. 3 for *longifolia*). The next development appears to occur at a younger stage of staminal growth in *longifolia* than in *suaveolens*, i.e., the stage of Plate v, figure 55 is omitted in *longifolia*. The regular contour of the dome is obliterated by an ex-centric development that appears to affect about half—possibly more—of the circumference of its transverse projection, but does not extend across its vertical centre. The excrescence so formed has a crescent shape in vertical projection. This stage is represented for *suaveolens* by a model (Plate v, fig. 56) and for *longifolia* by the outline of a section at a slightly older stage (Text-fig. 4). During this development the surface of the dome develops a steeper slope. The crescentic excrescence continues its vertical growth (Plate v, figs. 57–8 and Text-fig. 5) and, above its insertion on the dome, extends its arms forward in parallel growth so that a definite groove is formed between them. The margins of this groove, by increase in thickness and slight curvature of the arms, are brought into close association. Having an idea of the "solid" appearance of the development of the flower to this stage, we can turn to the changes in the tissues, of which this is the outward appearance.

Internal Development of Tissues.

In *longifolia* it will be easy to trace the enlargement of the young developing flower, for, though it is closely shut in between its own bract and those of adjacent flowers, there is no great distortion of its shape. But in *suaveolens* the difficulty of determining the orientation of the section and the frequent, marked distortion (cf. Text-fig. 11 and Plate v, figs. 66–8) prevent a comparison of sizes in the younger stages. For the sepals, petals, and stamens, the description will not be carried further than the formation of the primordia.*

At the time the sepal initials are formed, the axis is about 0·125 mm. long in both species, and its breadth is approximately 0·075 mm. in *longifolia* and 0·1 mm. in *suaveolens*. The upper surface of the axis is convex, the degree of curvature varying considerably in *suaveolens* on account of the distortion. The three outer layers of cells appear to have been formed with regularity by anticlinal division walls which are generally straight. They have very large nuclei in proportion to their size, and the cytoplasm is very dense, with very little vacuolation, if any. Beneath these layers are from one to three layers in which the direction of division is at random, the nuclei are relatively small and the cytoplasm is increasingly vacuolated the further the cell is from the surface. This zone merges into the pith of large, much vacuolated cells with small nuclei. The walls of the vacuolating and vacuolated cells are curved.

In Plate ii, figure 1, of *longifolia*, the sepal primordia consist of a fold in the outer layer (increase by divisions with anticlinal wall formation) under which are cells, continuous with the second layer and some at least of which have been formed by divisions with periclinal walls. In the younger stage of *suaveolens*, shown in Plate iii, figure 19, the initial of the sepal is seen clearly as a fold in the outer layer under which divisions with periclinal walls have occurred in the second layer. There may be some contribution from the third layer.

The description of the formation of the petal initials would be a repetition of that given above for the sepal initials, except for relative differences in age of the initials illustrated. This stage is shown in Plate ii, figure 2 for *longifolia*.

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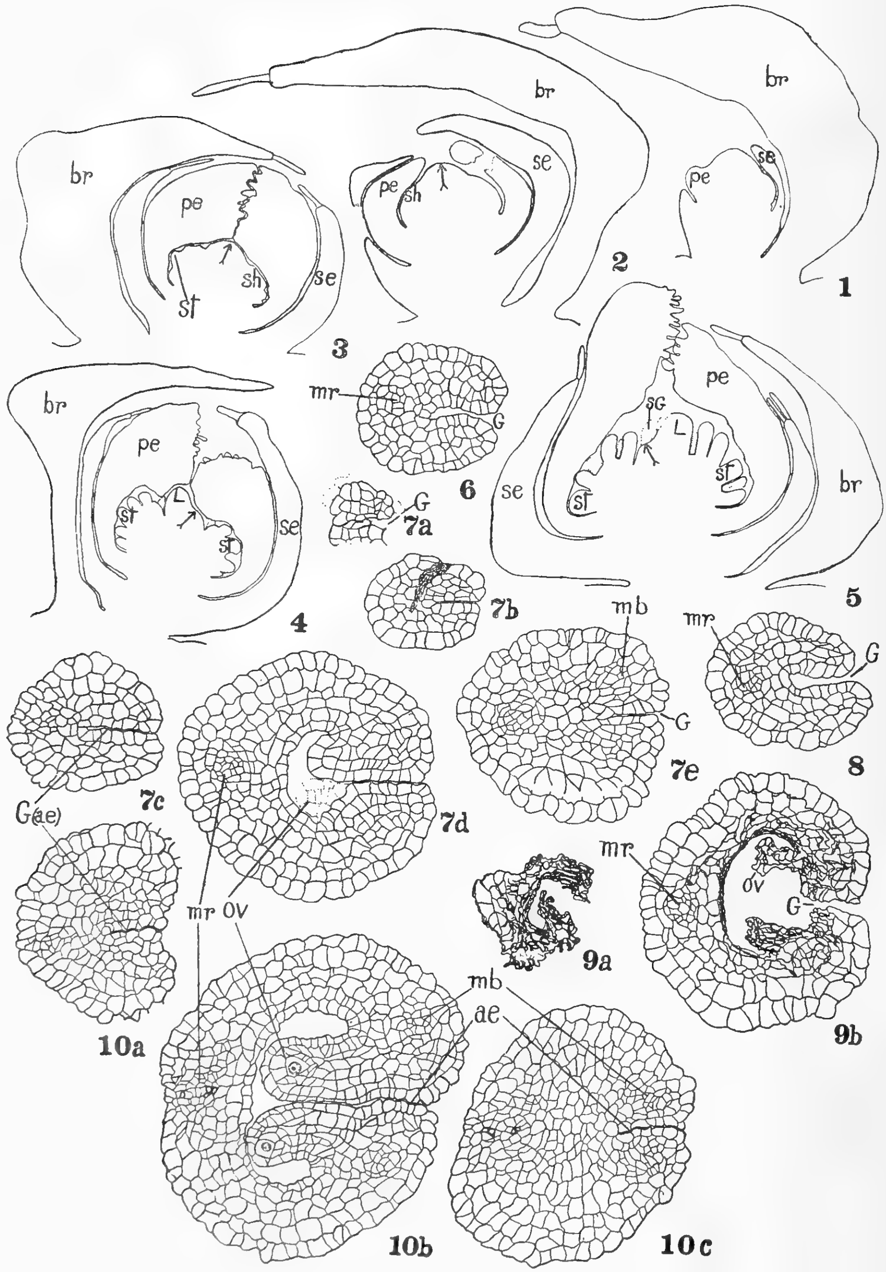
* See p. 67 for terminology.



Text-figures 1-10*c*.—*Acacia longifolia*. Magnification, × 80 for Figures 1-5, and × 160 for Figures 6-10*c*.

1-5.—Longitudinal sections of young flowers corresponding respectively with the models of *Acacia suaveolens* shown in Plate v, figures 51, 52, 54, (older than) 56 and 57. Note the hairs on the bracts, sepals and petals. The stages shown are: petal primordia (1), the "shoulder" (*sh*) before stamens (2), the stamen initials (3), the lateral ovule-

In the left-hand initial some of the cells appear to have been formed from the second layer by divisions with walls anticlinal to the *inclined* surface of the fold. Plate iii, figure 20 shows the petal initial in *suaveolens.* About this time the cells of the pith become greatly enlarged and begin to deposit globules of an unidentified substance which stains heavily with safranin and haematoxylin.

Examples of the distortion of the young developing flower of *suaveolens* are shown in Plate v, figures 66–68, in which the three zones of cell layers, based on nuclear and cytoplasmic conditions and direction of wall formation, can be clearly observed. These are at a later stage than that just described.

Still maintaining the three zones of tissue, the axis has about doubled its height above the level of insertion of the petal initials before they have made much growth. During the stages to be described in this paragraph the petals of *longifolia* become considerably larger than those of *suaveolens.* As the petals enlarge, divisions with periclinal walls begin to occur just above them in the second layer of the axis (Plate ii, fig. 3 and Plate iii, fig. 21). These divisions extend (Plate ii, fig. 4 and Plate iii, fig. 22) from the petals for about one-third of the distance over the convex upper surface of the axis (Plate ii, fig. 5 and Plate iii, fig. 23). In this way the shoulder is formed and the central dome is differentiated. The second layer of the dome is continuous with the second and third layers of the shoulder, and the third layer of the dome is continuous with the fourth layer of the shoulder (originally third layer of the axis). This fourth layer of the shoulder is becoming vacuolated and losing the regular shape of its cells.

In *suaveolens*, the last stage of shoulder formation is concurrent with the beginning of stamen formation. The stamen initials are formed on the shoulder and, except that the number of cells concerned in each initial is very much smaller, the same description applies to them as to the initials of the sepals and petals. A fold in the outer layer of the shoulder of the axis has, underneath it, cells derived from the second layer by periclinal wall-formation, some possibly by divisions in a fold of the second layer with walls anticlinal to the inclined surface of the fold (Plate ii, figs. 6–8, and Plate iii, figs. 23–26).

By the time the stamen initials have developed into primordia about four cells high, complete vacuolation has extended in the axis to the second or third layer of cells in the shoulder, i.e., to layers continuous with the second layer of the central dome. In the central dome itself there are still three layers of cells

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bearing organ (4) and the formation of the groove (5). Note the interlocking of the tips of the petals in 3. Compare these figures respectively with Plate ii, figures 2, 5, 7, 14 and 18.

6.—Transverse section, 0·1 mm. from the base of young organ, 0·18 mm. long before formation of the ovules.

7*a-e*.—Representing a series of 55 transverse sections of an ovule-bearing organ with primordia of the ovules. Sections are 6μ, the numbers represented being 2, 6, 11, 38 and 50, beginning from the tip. Tissue is crushed in one part of *b*. Note the continuation of the groove to the tip of the organ, and the ovules arising at the edges of the incurved arms of the groove.

8.—Transverse section about half-way up a sterile ovule-bearing organ from a flower of the same staminal development as that of Text-figures 7*a-e*.

9*a, b*.—Transverse sections from the base of the style and in the region of ovules in an organ whose ovules had attained about the development of those in Text-figures 10*a-c* before sterility set in.

10*a-c*.—Transverse sections of an ovule-bearing organ through the base of the style, middle pair of ovules and just below the loculus, at the stage of the mother cell. Compare *b* with Plate v, figure 76.

with non-vacuolated cytoplasm and large nuclei. Under these are one or two layers of intermediate vacuolation. The dome projects further than before and the cells of its second and third layers appear to have increased in length vertically to the surface with a slight distortion whereby the direction of their long axis approaches that of the axis of the flower. The maximum height attained by the dome is only about the thickness of the three outer layers of cells—between 0·025 and 0·03 mm. In both species there may be variations in the shape of the dome. In *suaveolens* they are derived from the general distortion of the young flower, already described (Plate iii, figs. 25–27). In *longifolia* the presence of the bract causes the petals to be pressed down on the growing axis, whereby some distortion of the dome occurs (Plate ii, figs. 7–8). The development of the dome appears to be due more to increase in cell size than to cell division; for the number of cells in each of the two outer rows is between about 15 and 18 before and after the increase (cf. Plate ii, fig. 6 with fig. 8, and Plate iii, fig. 24 with fig. 27). The diameter of the base of the dome shows almost no increase at this stage.

The next stage of development shows a fold in the outer layer of cells of the dome, occupying less than half of the outline of the dome in vertical section, and placed to one side of the vertical centre. The space beneath the fold is filled with cells derived from the second layer mostly by walls that appear to be periclinal (Plate ii, figs. 9–12 for *longifolia* and Plate iii, figs. 28–30 for *suaveolens*). This corresponds with the stage shown in Plate v, fig. 56. The radius of curvature of the central dome is much smaller than that of the young axis during the formation of the sepal, petal and stamen initials; and the cells of the second and third layers are elongated vertically in the central dome in contrast to those of the young axis. Remembering these differences, there is no fundamental divergence of the process just described from the mode of formation of the initials of the sepals, petals and stamens. The initial described last develops into the ovule-bearing organ.

If the foregoing description is true, *the mode of formation of the initials of each of the organs of these flowers is essentially the same.* The differences that exist are mainly concerned with the area of the surface of the axis that is involved, and the radius of the axis at the level concerned.

An examination of Plate ii, figures 3–8, and Plate iii, figures 21–27, shows that the dome first existed as the residue of the convex upper surface of the axis after the shoulder had been formed. Its increase in size (height) was by increase in size and negligible increase in number of cells. Its three outer layers of cells were continuous with the three outer layers of cells of the rest of the axis (before shoulder formation) and have the same protoplasmic characteristics. Its origin is in no way comparable with the origin of the initials of the floral organs below it; it is merely a part of the axis slightly extended by cell enlargement. The initial of the ovule-bearing organ having been formed, there remains a part of the dome not involved, and represented in median vertical section by a region having 8–10 cells in the outer layer (slightly more than half the number of cells in the original, full contour). With the formation of the last initial, the slope of the residual portion of the dome becomes steeper. If the axis of symmetry of the axial tissues of the young flower be followed to the upper surface, it will be seen to emerge in the centre of the dome; but after the formation of the last initial, there is an appearance as if this axis were bent away from the initial. The "flow" of cells from the apex of the large-celled pith emerges on the surface at about the seventh or eighth cell of the surface layer (in median L.S.) from the base of the dome opposite the initial, that is, at the original centre of the surface of the dome. This point is now slightly displaced by the formation of the initial of the ovule-bearing organ (cf. Plate ii, figs. 6–8 with figs. 9–12 for *longifolia*, and Plate iii, figs. 24–27 with figs. 28–30 for *suaveolens*. remembering the distortions).

The course of development of the sepals, petals and stamens beyond the formation of their primordia is not followed in this paper. The story of the residue of the dome is described below (p. 65). The development of the ovule-bearing organ will now be described to the stage where its general form and the manner of bearing ovules are clearly displayed.

When the initial of the ovule-bearing organ has developed into a primordium of four or six cells in height and six cells in thickness (Plate ii, figs. 13–14 for *longifolia*, and Plate iii, figs. 31–32 for *suaveolens*), the cells are densely cytoplasmic and have relatively large nuclei, as in the three outer layers of the axis in the previous stages. Passing down through the position of the original second and third layers of the dome, the cells have an increasing degree of vacuolation, an increase of size and relatively small nuclei. The large, irregular pith cells now extend to where was the centre of the base of the dome. To either side of this point there is a distinct difference in the organization of the cells. Those on the side towards the primordium are larger and slightly vacuolate, compared with those in the residue of the dome, except that a couple of vertical rows towards the centre of the base have retained the feature of relatively large nuclei. The residue of the dome has retained till now the disposition and appearance of its three (outer) layers; but there is a beginning of change with slight vacuolation. The increase in size of the cells on the side towards the primordium is accompanied by an orientation of their length, such that there is an appearance of a flow of tissue obliquely from one side of the tip of the pith into the primordium. The residue of the dome has the appearance of having been tilted about the outer edge of its base as a pivot by the increase in size of these cells.

It must be remembered that, on account of the small dimensions of the dome, if the fold that was the initial of the ovule-bearing organ were relatively long, it would be very much curved in the horizontal plane. When such an initial grows out as the primordium, it must assume a grooved form, opening towards the space above the residue of the dome. This feature is shown in the solid by Plate v, figure 58 for *longifolia*, and Plate v, figures 56–57 for *suaveolens*. In *longifolia* the approximation and final contact of the two arms of the grooved primordium occurs much more rapidly than in *suaveolens*; so that, whereas in some stages a section down the groove of *longifolia* will inevitably show one or other of the approximating surfaces, one or two sections can be cut down the groove of *suaveolens* without including either surface. It will be noticed also at this stage that, with the close crowding of the stamens, the space available for the longitudinal growth of the ovule-bearing organ causes it to grow in the vertical direction, and brings the arms of the groove down on to the upper part of the residue of the dome.

Stages in the development of the groove are illustrated in Plate ii, figures 15–18 for *longifolia*, and Plate iv, figures 33*a*–37 for *suaveolens*. During this development: (1) the region of complete vacuolation and irregular cells, i.e., the pith, extends in the residue of the dome to level of formation of the initial of the ovule-bearing organ; and (2) in the base of the primordium, vacuolation of the cytoplasm and the decrease in the nucleus/cell size-ratio has left a small central longitudinal zone of cells almost unaffected (Plate ii, fig. 16 for *longifolia*, and Plate iv, fig. 35 for *suaveolens*). Dense cytoplasm and relatively large nuclei are still maintained at the tip and on the arms of the organ. The aspect of these features as seen in transverse section is shown in the series of sections illustrated in Plate iv, figures 39*a–f* (cf. Plate ii, fig. 14), and Plate iv, figures 38*a–f* (cf. Plate iv, figs. 34*a–b*), for *longifolia* and *suaveolens* respectively. In each case the section shown in *d* passes through the upper part of the residue of the dome whose smaller cells can be seen on the right. Plate ii, figure 18, and Plate iv, figure 37, show a further stage in both species with a similar distribution of cellular differences as before, except that marked vacuolation and the reduction of the nucleus/cell size-ratio has now affected all of the residue of the dome, in some of whose outer cells there is a deposition of the globules that stain deeply with safranin and haematoxylin. The arms of the primordium of the ovule-bearing organ now extend over, and make contact with the upper surface of the residue of the dome. Their extent in the transverse plane is already much greater than when the initial was formed.

Neglecting the residue of the dome, we will follow further the development of the ovule-bearing organ. It extends at the stage shown in Plate ii, figure 18, and Plate iv, figure 37, about 0·09 mm. and 0·125 mm. respectively above the insertion of the adjacent stamens. Text-figures 6 (*longifolia*) and 12 (*suaveolens*) show transverse sections of the organ about half-way up when the heights are 0·18 mm. and 0·16 mm. respectively, the arms of the groove being now almost in contact. Further growth is such that the rate of increase is greater on the outside of the arms than on the sides nearly in contact. Consequent upon this, the margins of the grooved organ remain in contact and a central cavity is formed. Into this cavity the ovules arise as outgrowths from the margins of the groove. The two series of sections shown in Text-figures 7*a–e* for *longifolia* and 13*a–g* for *suaveolens* illustrate this point and show that the groove extends to the very tip of the organ and below the insertion of the ovules. The part of the adult organ that is extended for some distance above the ovuliferous region is a prolongation of the tip, though in passing upwards the grooved condition is soon lost. Sections made just above, at the middle of, and just below the ovuliferous region, at the stage of the megaspore mother cell, are illustrated for both species in Text-figures 10*a–c* and 15*a–c*. In both these last stages the appressed epidermes of the margins are clearly discernible on the right of the organ and the midrib on the left.

Four photomicrographs are submitted in confirmation of these drawings concerning the appressed epidermes. Plate v, figure 70, is of a longitudinal section through the margins of the organ when it is about 0·25 mm. long in *longifolia*. Plate v, figure 69*a*, is a similar photomicrograph for the organ when it is about 0·225 mm. long in *suaveolens*. Plate v, figure 77, is of a section (at the base of the ovuliferous region) in the series from which Text-figure 15 is taken, the line of the two appressed epidermes being clearly visible on the right side of the structure. Plate v, figure 76, is of the same section as Text-figure 10*b* and is a clear confirmation of the drawing. An interesting confirmation of the single curved structure of the ovule-bearing organ is derived from cases of sterility. In the flower from which Text-figure 8 was taken, the stamens were at the stage of those in the flower from which Text-figures 7*a–e* were taken. Text-figures 9*a–b* show degeneration that had set in about the stage of Text-figures 10*a–c* or a little earlier. Text-figure 14 is of *suaveolens* where sterility had set in before formation of the ovules (with degeneration). Occasionally the organ does not have the margins closed together, in which case the ovules are visible, as shown in Plate v, figure 69*b*, of *suaveolens* (length a little more than 0·25 mm.).

The single curved structure of the ovule-bearing organ can still be discerned at the time of fertilization. Plate v, figure 78, of *longifolia* clearly shows the appressed marginal epidermes to the right and the twin bundles of the midrib to the left, the ovules being inserted at the margins.*

As we return to a consideration of the residue of the dome, it must be realized that the great growth taking place in the ovule-bearing organ, and the difficulty of finding the perfectly median section with respect of two axes of possible obliquity, make the demonstration of that residue more difficult in later stages.

The oldest stage of the residues of the dome yet illustrated (Plate ii, fig. 18 for *longifolia*, and Plate iv, fig. 37 for *suaveolens*) shows the ovule-bearing organ extending for 0·09 and 0·125 mm. respectively above the insertion of the adjacent stamens. Plate v, figure 60, *a–b*, is from the stage in *longifolia* where that distance is about 0·2 mm., just before formation of the ovule initials. Some of the cells of the residue have a copious deposition of the substance that stains deeply with safranin and haematoxylin. Growth in this region appears to have been by cell enlargement only. The surface of the residue is now vertical or even leans outward, so that it has the appearance of being merely part of the surface of the pedicel or stipe of the ovule-bearing organ. The large cells of the pith, many containing the deep staining deposition, are seen to extend past the residue of the dome, between it and the mid-rib of the ovule-bearing organ. The corresponding figures (Plate iv, figs. 40–41) for *suaveolens* are from a slightly older stage when the ovule-bearing organ extends about 0·25 mm. above the insertion of the adjacent stamens. By this stage the ovule primordia have been formed. The same features just described can be observed here, except that there is not such a marked deposition of deep staining substance and the residue of the dome is not so far displaced from its original position. The upper part of the dome is "clasped" by the folded ovule-bearing organ in this species, so that its upper surface is less easily discerned in the later stages. This difficulty is illustrated in Plate iv, figure 42, of the stage of primary megasporogenous cells.

Two further stages are illustrated, about the times of the megaspore mother cell and the functional megaspore, in *suaveolens*. Comparing the earlier of these two stages (Plate iv, figs. 43–46, consecutive sections) with Plate iv, figures 40–42, it will be seen that much of the growth at the base of the ovule-bearing organ and all in the residue of the dome is by cell enlargement. The cells of the pith, some of them with the deeply-staining deposition, extend into the organ between its midrib and the residue of the dome. The lower part of the surface of the residue of the dome is now vertical (about 6 or 7 cells in the L.S.), the upper part (about 4 or 3 cells) is still curved and is "clasped" by the arms of the ovule-bearing organ. The slight mutual intrusions of the epidermal cells in this region make it difficult to follow the surfaces clearly, foreshadowing the almost complete obliteration of them, which is nearly accomplished by the stage of the functional megaspore (Plate iv, figs. 47–50). In this last stage, the tissue of the residue of the dome can still just be identified, though, had it not been

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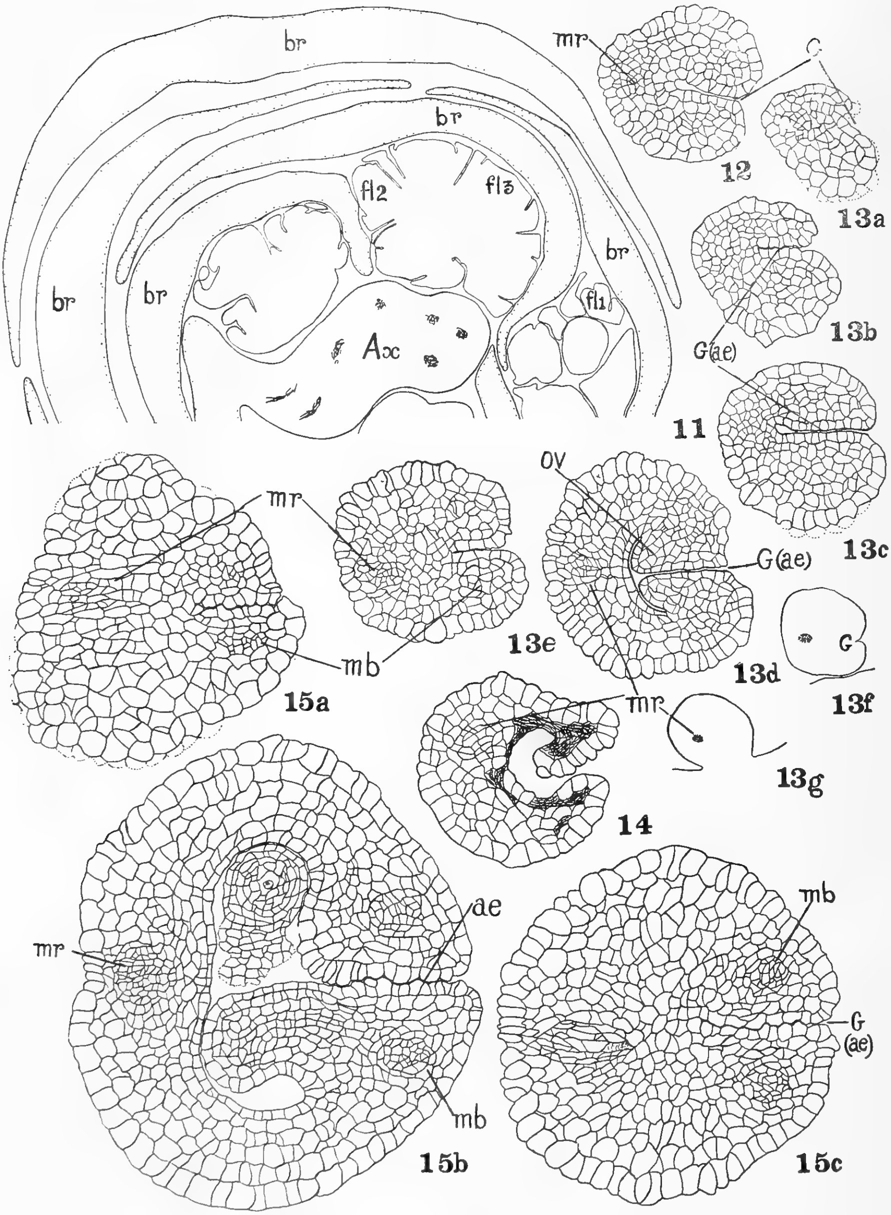
* Note that the twin bundles of the midrib are formed from a single primordium.



Text-figures 11-15*c*.—*Acacia suaveolens.*

11.—Transverse section of a little more than a longitudinal half of a raceme, showing the axis (*Ax*) giving off a pedicel of a flower-head to the left, sections of three flower-heads and several bracts. *fl*1-*fl*3 are flowers of which sections are shown in Plate v, figs. 66-68. This figure shows the tight packing of the raceme with the bracts and the resultant distortion of some of the flowers. Magnification, × 55.

12.—Transverse section about half-way up a young ovule-bearing organ of 0·16 mm. length, before the formation of the ovule primordia. Magnification, × 160.

traced from the beginning, it could not have been discriminated from the tissues of the base of the ovule-bearing organ. The disposition of the pith and the deposition in its cells in this stage are but continuations of the conditions in the earlier stage just described.

The development of the vascular tissue has not been followed far, but it is evident that the pith extends between the residue of the dome and the single pro-cambial strand of the early stages of the ovule-bearing organ (Text-figs. 6–7*e*, 12–13*g*, Plate v, figs. 60*a*–*b*, Plate iv, figs. 40–41). During the development of the ovules, pro-cambial strands are differentiated beneath them in the margins of the ovule-bearing organ (Text-figs. 10*a*–*c*, 15*a*–*c*, Plate v, figs. 76, 78 and fig. 77).

Though I have not traced the residue of the dome in *longifolia* beyond the stage shown in Plate v, figures 60*a*–*b*, this description is not thereby made appreciably incomplete, because at that stage the residue of the dome was situated further below the folded arms of the ovule-bearing organ, the later development of which could not complicate the description as in the case of *suaveolens*.

Interpretation of the Evidence.

INTRODUCTORY.

The foregoing description of some of the aspects of floral ontogeny in *Acacia suaveolens* and *Acacia longifolia* is made in order to provide a basis for the morphological interpretation of the legume, and to contribute to the morphological interpretation of the carpel. As Schüepp (1930, p. 339) says: all forms are produced by growth, and therefore morphology must always become more a story of formation (Bildungsgeschichte). Having described in detail the appearances of the different stages of that story, we now have to make an interpretation of them, remembering that the floral apex is a living, re-acting organization. It is, however, necessary for the sake of clearness to make some temporary restriction in the angle of approach to the subject. The description has, therefore, been made in terms of the histogenesis of an apical meristem giving rise to lateral organs. In the literature available to me I can find no such account of a floral apex, and very little reference in the citations. The aim of this paper is to use the histogenesis as a basis for interpretation, and not to make a detailed study of histogenesis in the floral apex. It has therefore been necessary to employ one of the methods of description already in use for the vegetative apex. The description I have given has been based on accounts of the apical meristem that are generalized and describe activity, rather than on those that are precise demarcations of tissue-areas and describe appearances.

Louis (1935, p. 92, footnote) defines his terminology for the early stages in leaf formation thus: "initium foliaire" is the very beginning of divisions that form a protuberance, "primordium foliaire" is still strongly meristematic, "ébauche foliaire" is the protuberance in differentiation. In the terms "initial",

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13*a*-*g*.—Representing a series of 40 transverse sections of an ovule-bearing organ with primordia of the ovules. Sections are 6μ, the numbers represented being 2, 4, 7, 21, 29, 30 and 34, beginning at the tip. Note the continuation of the groove to the tip of the organ, and the ovules arising at the edges of the incurved arms of the groove. Magnification, × 160 for *a*-*e*, and × 80 for *f*-*g*.

14.—Transverse section of a young sterile ovule-bearing organ that had not formed primordia of ovules. Magnification, × 160.

15*a*-*c*.—Transverse sections of an ovule-bearing organ at the stage of the mother cell, through the junction of style and loculus, the region of ovules and just below the region of ovules. Plate v, figure 77 is of a section through the base of the loculus of this organ. Magnification, × 160.

"primordium" and "young . . ." I have generally followed that system. (There are no sharp boundaries between the stages.)

The examinations made in this inquiry were directed primarily to tracing the initiation of the parts of the flower, and especially the relation of the legume to the apex. There is not enough detailed evidence collected to permit of much reference to the origin of the vascular tissue and the connection of the vascular strands of the floral parts with the axis.

References in the literature to the meristem of the floral apex* seem to be concerned mainly with physiology or the determination of time and conditions of flower formation for economic purposes. Klebs (1914) has shown experimentally that flower formation is related rather to quantitative seasonal differences in nutrition than to qualitative differences in the substances supplied to the growing apex. Schmidt (1924) records that in *Scrophularia* the meristematic layers lie more thickly at the apex at the time of flower formation. Priestly (1929, p. 63) suggests that the greater depth of meristem in flower buds is due to a greater thickness of cell walls and consequent increased water supply through them to the protoplasts; the thickness of the walls is possibly correlated with the relatively greater proportion of carbohydrates in the supplies to the apex at the time the flowers are being formed.† More closely placed to our present problem are the many papers on the formation of "fruit-buds" (e.g., Barnard and Read, 1932–3, references to literature), which appear to cover the ground required, but not in sufficient detail of description or illustration to give any information on the histological details of the floral apex. Such workers must have a great deal of material that would throw light on histogenetic problems of the floral apical meristem and on the morphology of the carpel.

So little work, then, has been done on the histogenesis of the floral apical meristem, that caution must be exercised in drawing conclusions in the absence of detailed and systematic examinations. This paper will have served a useful purpose if, in attempting to describe the floral in terms of the vegetative apical meristem, it calls attention to the great field of work here to be found in connection with morphological inquiry.

THE VEGETATIVE APEX AS A BACKGROUND FOR THE INTERPRETATION.

The Apical Meristem.‡

Structure.

We owe our knowledge of the structure of the cells of the apical meristem of the angiospermous shoot largely to Sachs (1882), Schmidt, Schüepp, and Priestly. Differing slightly in details, there is a general agreement among them that the cells occur in zones that are more or less sharply defined, and of various numbers of cell-layers. The outer zone is composed of regular, straight-sided, rectangular cells with relatively very large nuclei and dense, unvacuolated cytoplasm, which assume their shape on account of external pressure, having no internal (osmotic) pressure due to vacuoles (Priestly, 1928, pp. 4–6, and 1929, p. 55). There follows a zone of cells which, though still dividing as rapidly as

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* A paper by Grégoire (1931) is not included here, as it is a subject of criticism on account of the morphological conclusion. It is dealt with below (p. 79).

† In some species of *Acacia* (e.g., *Baileyana*) flower formation and vegetative growth appear to go on at the same time.

‡ I regret that Schüepp's monograph on the Meristem (1926) is not available to me in Sydney. I therefore ask to be pardoned if any of my deductions that follow appear to repeat existing discussions unnecessarily.

those in the outer zone, are in process of becoming vacuolated. Within and below is a zone of cells which, having attained vacuolation, are expanding by the intake of water into the vacuoles. The outer zone is described as "meristematic" (Priestly, 1929, p. 54), "typical" and "embryonic meristem" (Schüepp, 1917, p. 73, and 1926), and "tunica" (Schmidt, 1924). The almost complete predominance of divisions with anticlinal wall-formation, makes its one to about four layers of cells genetically distinct. The next zone has been described as "vacuolating dividing" (Priestly, 1929, p. 54) and "half-meristem" (Schüepp, 1917, p. 73, and 1926). The direction of the nuclear divisions in it is at random. The third zone is described as "vacuolating expanding" (Priestly, 1929, p. 54) and "lengthening tissue" (Schüepp, 1917, p. 73, and 1926). The last two zones comprise the "corpus" of Schmidt (1924).*

We must not expect these zones to be rigidly marked; for example, Foster (1935, p. 90) refers to occasional periclinal division-walls in the "tunica" of *Carya Buckleyi.* Priestly (1928, pp. 11, 12) points out that the definiteness of organization of the zones of the meristem depends on the rate of growth, degree of internal pressure (due to vacuolation and expansion of innermost zone) and breadth of the apex.

The description given of the structure of the meristematic tissues of the floral apex of *Acacia suaveolens* and *Acacia longifolia* are in general agreement with the terms outlined above. Before discussing the results of the activity of the vegetative apex, certain internal and external conditions affecting its operation will be pointed out.

According to Errera's law, new cell walls are formed in such a direction that they are of minimum area (Errera, 1886).† The truth of this was demonstrated by Giesenhagen (1909). It seems quite reasonable to consider with Zimmermann (1928, p. 313) that the function of the "corpus" (Schmidt, 1924), comprising the zones that are vacuolating and that are expanding (Sachs, Priestly and Schüepp), is the extension of the vegetative point, for the random direction of division walls (vacuolating zone) and the expansion of the cells by intake of water (expanding zone) will produce increase in volume (expressed mainly as increase in length). On the other hand, as many have pointed out, the outer zone, by its divisions with anticlinal wall formation, produces only increase in surface. Priestly (1928, pp. 10, 11) has suggested that the pressure set up by the vacuolation of the internal zones compresses the outer zone of fully meristematic, unvacuolate cells against the cuticle, so that, not only are they of a rectangular shape, but their long axis is parallel to the surface. The result is that the minimum area across which new walls can be formed is perpendicular to the surface of the growing point, thus instituting the difference between the zones of anticlinal and random direction of wall-formation. The growing point thus appears within itself to be differentiated as the expression of a system of pressures and tensions. The increase in surface of the outer zone is a direct result of the pressure due to increase in volume of the inner zones. There is a paradox here which will be explained further on.

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* In addition, Schüepp (1917, pp. 60-68) describes in *Helianthus annus* an apical group of initial cells that give rise to the two zones of meristematic cells. In the figures given by Priestly (1928, 1929), Priestly and Swingle (1929), Zimmermann (1928) and Louis (1935) I can recognize no such group.

† The term used in this reference is "average constant curve" (courbure moyenne constante).

Usually the apical region of the shoot, particularly when the apical cone is short, is closely surrounded by the young leaves, which have every appearance of being pressed against it. The lower part of the apical cone is in contact with the surface of the youngest leaves. Increase in volume of the cone would cause flattening of the outer layers of cells of that part of the apex. The consequent operation of Errera's law to produce anticlinal wall-formation would tend to emphasize the growth in surface along the faces of the existing leaves, that is, growth would be parallel with the surface of pressure. This may explain the origin of new leaves *between* the existing ones, where the conditions can favour divisions with periclinal wall-formation, and folding of the surface into the free space to accommodate the increase opposite the existing leaves. It seems, therefore, very reasonable for Schüepp (1917) to emphasize strongly that (following Sachs, 1894—with some modifications) the direction and growth of each meristem cell is consequent upon the form of the whole vegetative apex and upon its position in the apex (p. 61); and to conclude that the external differentiation of the vegetative apex is primary, and the inner differentiation consequent thereon and secondary. Though a reversal of existing ideas, this leads to a theory which may explain the progress of the vegetative point from an undifferentiated to a differentiated condition (p. 75).

We have now seen that it is possible to look for quite simple explanations of the external and internal differentiation of the vegetative apex. These simple explanations would not be all-inclusive;* they also assume the process of apical growth to be in progress; and there still remains the problem of how the process is started. However, the above ideas will serve as a useful check on interpretations that may be too rigid or artificial.

Activity.

It has already been pointed out that the manner of growth of the outer, "fully meristematic" (unvacuolated), cell-layers produces increase in surface of the apex, and that the manner of growth of the two inner zones produces increase in volume. It has been shown by Schüepp that the rate of division in the different meristematic layers is the same, regardless of the depth from the surface. He has calculated that such a condition will produce an increase in surface greater than that necessary for the increase in volume. The result is that the surface of the apical cone is thrown into folds which become the initials of the leaves (Schüepp, 1914, pp. 335–338; 1917, pp. 62, 64–68; 1930, p. 340). Priestly (1929, p. 62) supports this and points out that the layer(s) immediately under the fold are generally subject to divisions with periclinal wall-formation whereby they contribute to the primordium of the leaf. (See also Schüepp, 1930, p. 340). If the fold in the outer layer draws out the cells of the next layer(s) so that their long axis is perpendicular to the original surface of the apical cone, it is understandable why the division walls should be periclinal. One of the chief results of the process is that the leaves are formed from the two to four outer layers of the apex. Though he does not express it in terms of "folding", Zimmermann (1928, pp. 303, etc.) describes the origin of the leaves in *Hypericum uralum* from the four outer layers ("tunica" of Schmidt, 1924, and the "fully meristematic" zone of Priestly, 1929), by divisions with anticlinal wall-formation in the first and second layers and enlargement and divisions with periclinal wall-formation in the third and fourth layers.

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* I have not taken the physico-chemical conditions of the apex into consideration, as I have derived from my investigation no information thereon.

Two difficulties now arise. First, there is the paradox referred to above, namely: if the surface is increasing in excess of the volume, how can the outer layers be compressed between the cuticle and the expanding inner zone? The second difficulty is: if the meristematic layers are all growing equally fast, and therefore produce folds in the surface, why are these folds localized and not as rings round the apical cone?

It is a matter of observed fact that growth is not uniform over the whole circumference of an apex.* Priestly and Scott (1933, p. 242), speaking of the emergence of leaf primordia, have said: "In phyllotaxis the actual locus of a new emergence becomes very important. Unfortunately all that can be said is that every meristematic apex is apparently asymmetric and grows more rapidly at one point than at any other. This point becomes the centre of a new fold." Priestly (1929) and Griffiths and Malins (1930) have described a unit of shoot growth which does not occupy the whole of the circumference of the shoot. If this is associated with any form of spiral phyllotaxis, it requires a revolving segment of increased activity in the apical meristem, producing isolated folds by an intermittent movement. Schüepp (1914) has measured the period of this movement and found that it is rhythmic, with a time interval which is constant for any one organ of a species. This interval is the "plastochrone" (Askenasy, 1880, p. 76), which may be associated with movement of the segment in one or more spirals. Schüepp (1921) has worked out the geometrical relationships of different types of known leaf arrangements, assuming such a periodical raising of equal parts from the embryonal mass of the vegetative apex.

Thus the second difficulty is explained by the fact that, though the rate of meristematic activity is uniform in the meristem perpendicularly to the surface, it is not uniform parallel to the surface but is more intense in a restricted segment, subject to periodic fluctuation and displacement. The explanation of the first difficulty begins at the same point. For over most of the surface meristematic activity is not occurring at greatest intensity (if at all†). It seems reasonable to assume that the expansion due to vacuolation will not be subject to localization like the meristematic activity and will set up a more or less constant pressure, preparing the outer layers in the more slowly growing segment for the anticlinal wall-formation to follow.

There has been outlined above a mechanism of growth which is simple, and operates through internal and external conditions that do not require rigid and artificial definitions, but allow of a reasonable merging of processes and indefiniteness of structural zones. (Zimmermann, 1928, p. 342, concludes that the relationship of the layers of the apex to the leaf varies from case to case.) It is on such a basis that I have built the description in the earlier part of the paper, and upon which an interpretation thereof will be made later.‡

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* Cf. the nutation and circumnutation movements of apices.

† Absence of meristematic activity from a large segment of the apex would cause marked distortion which is not observed in every case. Activity at the very apex may be uniform (cf. Schüepp's group of initial cells, 1917, pp. 64-66) and the operation of the varying intensity of activity be confined to a region a little below the apex.

‡ Certain work on the processes of the vegetative apex should be mentioned here, though it is disregarded in the background for the interpretation made in this paper.

Schmidt (1924) has used the idea of an alternation of minimum and maximum area (minimalfläche and maximalfläche) during a plastochrone, so that the growing point increases during the interval from a minimum area to a maximum area, at the edge of which the initials of the new leaves arise, reducing the growing point to a minimum area again. Louis (1935) and Grégoire (1935*a*) have made strong use of this idea.

The Lateral Organs.

This inquiry does not follow the development of the lateral organs very far, and has little to disclose about their vascular connection to the stem. There seems to be general agreement that, as we pass down the young axis, we find that vacuolation takes place not only at the centre but at the periphery, leaving a ring of meristematic tissue ("pro-desmogène" of Grégoire, 1935*a* and *b*, and Louis, 1935) which becomes the locus of the procambium; though not necessarily all of it becomes procambium. It is also to be noted that this process of vacuolation leaves a zone of meristematic tissue extending from the axial ring into the meristematic tissue of the primordium of the leaf. (See Priestly, 1928, pp. 12–14, and 1929, p. 74, for the institution of the vascular connection.)

Louis' description (1935) of the tissues of the young leaf of several species, including *Syringa vulgaris* and *Arabis alpina*, is important for our purpose. The primordium is first evenly meristematic throughout its volume. Then, a little distance below the tip of the primordium, vacuolation begins on the ab-axial and ad-axial sides, leaving an arc of meristematic tissue joining the margins of the primordium and extended upwards to occupy the whole of the cross-section at the tip. Further vacuolation across this arc leaves meristematic tissue at the margins and in the centre of the young leaf. From the marginal meristems, the lamina is developed. The central meristem is the locus of formation of the pro-cambium.

Residual Apex.

As the vegetative shoot is theoretically of unlimited growth, the question of a residual apex does not arise in the investigations of its manner of growth. There is, therefore, no body of information against which to set the discussion of this question which must arise in considering the growth of the flower which is

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I have disregarded it because it seems to be really a description of the appearances only, whereas the ideas of Schüepp and Priestly, set out above, take us into the realm of explanation.

Grégoire (1935*a* and *b*) regards the leaf primordia as arising on "leaf foundations" (soubassements foliaires) developed on the vegetative cone as it increases from minimum to maximum area during a plastochrone; and that on account of this "foundation" the leaf grows vertically. This is described with illustrations by Louis (1935, pp. 99-123) for *Syringa vulgaris* and *Arabis alpina*, together with details of the shape of the cone at successively lower levels, including the "foundations". Using these terms, Louis finds it necessary to formulate two types of leaf initiation in the Dicotyledons: (1) Alternation of minimum and maximum area with the establishment of the leaf foundation, the general type; (2) The development of a lateral protuberance, in a few cases such as *Hippuris vulgaris* (pp. 126-130). Zimmermann has described in *Hypericum uralum* the histogenesis of the same phenomenon that Louis describes as "soubassement foliaire", without recourse to the terms used by Louis and Grégoire (Zimmermann, 1928, p. 303, etc.). It seems to me that Louis and Grégoire, in their interpretations, have failed to recognize that the pressure from within the apex and the restrictions imposed from without by the existing leaves will in a great degree determine the shape of the vegetative cone and the shape and direction of growth of the primordia. The recognition of these factors will obviate the necessity to formulate the two types of leaf initiation in the Dicotyledons, and will prevent what seems to me too rigid and artificial a description of the phenomena.

Support for the recognition of the influence of pressure by existing organs comes from Doak (1935), who refers to the bud scales of *Pinus* having a "*binding effect* upon the tissues within" (p. 24); and speaks of certain phases of evolution in *Pinus* where "Just as pressures within the compound bud *limited*, *shaped*, and *displaced* the sheath scales of the dwarf shoot, so the formation of the compound strobilus *limited, shaped* and *displaced* the sporophylls on the simple strobilus" (p. 43).

theoretically of limited growth. The following considerations have a bearing on the question.

If it is correct to consider with Zimmermann (1928, p. 313) that the vacuolating dividing cells and the expanding cells ("corpus" of Schmidt, 1924), have the function of extending the vegetative point, and with Priestly (1929, p. 69) that the vacuolating dividing cells characterize "that region of cell growth and activity which lays down the node and internode of the 'articulate' shoot organisation"; then, in a shoot of limited growth, it is in that region we must look for the beginning of an explanation of the limitations of growth.

Two other observations of vegetative apices are significant for the question of a residual apex. Schüepp (1914, pp. 332–3) studied growth curves in *Lathyrus latifolius* L., and suggested that the initial, rapid growth of the laterals, followed by slow growth, is due partly to diversion of material to the new ones, leaving a deficiency for those already formed. Priestly and Scott (1933, p. 242) consider that the early formation of pro-cambial cells is probably responsible for the fact that the leaf primordium grows more rapidly than the meristematic apex; and conclude (p. 266) that primordia, once formed, are competing centres of activity. Schüepp (1917, pp. 45 and 76) correlates the proportion of the vegetative cone involved in the formation of a lateral with the number of shoot parts growing at any one time (i.e., with the length of the plastochrone). In *Elodea*, where one-tenth of the apex is used up, many parts are growing at one time; but in *Mesembryanthemum pseudotruncatellum*, where nine-tenths of the apex is involved, only one or two parts are growing at the one time. In the latter case there is a long rest period. It is conceivable that if the growth rate of the apex were otherwise slowed down, the superposition of the rest period might cause such a delay that the extent of growth of the last-formed lateral might mechanically and/or physiologically prohibit further growth of the apex, before the completion of the rest period.

If meristematic activity occurs periodically in sectors disposed in a spiral manner on the growing cone, then, under the conditions just indicated, it seems reasonable to conclude that in a shoot of limited growth there must be a residual apex. No organ could be strictly terminal.

THE INTERPRETATION.

We come now to review the description given of the floral apex in *Acacia suaveolens* and *Acacia longifolia*, making an interpretation against the background of the foregoing discussion of vegetative apices. In this interpretation the term "carpel" will not yet be used. In examining the photomicrographs, allowance must be made for slight shrinkage in the fully meristematic cells.

The Apical Meristem.

The floral apex in both these species exhibits three zones of cellular condition: the fully meristematic zone with dense, unvacuolate cytoplasm, relatively large nuclei, rectangular cells and predominance of anticlinal wall-formation; the half-meristematic zone with the beginning of vacuolation, relatively large nuclei and random direction of division; and the vacuolating expanding zone without division but with enlargement of cells by intake of water into the vacuoles and with curved cell walls. That there is not complete regularity of direction of division in the outer zone is probably due to the apex being broad (Priestly, 1928, p. 12), with consequently less pressure to flatten the outer layers. Probably, it is also partly due to a lessening of the pressure on account of the diminishing expansion of the inner zones concurrent with the limitation of growth. This diminishing expansion of the inner zones is explained by the fact that the vacuolating dividing zone appears frequently to consist of one layer only, and rarely of more than two. If these expanding zones are normally the cause of growth in length, we are witnessing the limitation of that growth.

The Sepals, Petals and Stamens.

There is the regular formation of the initials of the sepals and petals by folding of the outer layer of cells and the projection into the fold of the next layer or two, mostly by divisions with periclinal walls.

The formation of the shoulder is an interesting variation from the growth of a vegetative apex. I doubt whether there is any special significance in it. A possible explanation is that the external restrictions of the growing petals cause them to compress tangentially the adjacent cells of the outer zone of the apex so that the operation of Errera's law results in divisions with periclinal wall-formation.

Although the formation of the stamens appears to follow the normal process of folding of the outer layer with periclinal wall-formation below it, there is to be sought a reason for the sudden change in the size of the folds compared with the initials of the sepals and petals. Is it due to a diminished size of the segment of meristematic activity? That here we have many parts growing together can be correlated with the fact that in the formation of any one of them only a very small fraction of the apical cone is used up. There is no evidence against their formation in spiral sequence. They are not formed simultaneously.

The Relation of the Legume to the Apex.

The formation of the shoulder leaves the central part of the apex as a small dome composed only of fully meristematic cells. By the time the stamen primordia are all formed, this dome, which is all that is left of the meristematic apex, has increased in size slightly. This increase, due almost entirely to cell enlargement, is laterally restricted by the growing stamens and the other parts of the flower so that the small apex is forced to extend vertically by elongation of its cells. As the vacuolating dividing zone does not extend into the apex, there is no means of producing a normal lengthening of it. At this stage the vacuolating dividing zone has almost been changed into the expanding zone. Apical growth has nearly ceased.

By the asymmetric incidence of meristematic activity, a lateral fold is formed in the outer layer of the apex; the lower layers protrude into the fold by divisions with periclinal wall-formation; and thus the initial of the legume is formed in the same manner as those of the other parts of the flower *and of vegetative leaves.* The small radius of the apex at the time causes the initial to have a strongly curved insertion, so that the primordium is curved from the beginning. The growth of the primordium is not just a vertical extension from its insertion on the apex. The meristematic tissue at the tip increases the length, and the meristematic tissues on the margins extend the breadth of the lamina of the legume. The legume is thus initiated and the plan of its structure differentiated in the same manner as for vegetative leaves. The spatial restriction to which it is subjected forces it into a vertical position. Excess growth in the abaxial part causes the marked curving which produces the close contact of the margins, whose appressed epidermes at later stages undergo a slight mutual intrusion which nearly makes them indistinguishable. The ovules are produced at the margins of the lamina of this leaf-like organ, the legume, which has been so folded that they develop into an enclosed space. Above the region of formation of the ovules the growth of the margins and the excess growth on the abaxial side diminish acropetally, so that the central cavity is continuous upwards with a closed groove which becomes merged into the surface of one side of the cylindrical style. The groove reappears at the tip of the style as the stigmatic surface, which is slightly depressed and laterally displaced.

After the formation of the initial of the legume, the residue of the apex (dome) passes from the fully meristematic condition to a condition of complete vacuolation without further meristematic activity (even in the early stages of the process). We have thus witnessed the suppression of the apex,* which is displaced laterally and overtopped by the developing legume. Slight mutual intrusion of the epidermes of the residue of the apex and of the lamina of the legume (where the two are in contact) makes it almost impossible to distinguish them in the later stages. At a period later than shown in this paper the residue of the apex would assume the appearance of being but a small part of the short stalk of the legume.

The relation between the early development of the legume and the suppressed apex has been demonstrated by a series of models made in "plasticene" (modelling material). These models were made differently from those described earlier. They were moulded by hand according to measurements of certain of the illustrations of *Acacia suaveolens* in this paper (see explanation of the Figures for identification). They are of the same magnification as those illustrations (approximately). White plasticene was used to represent the apex just before the formation of the initial of the legume, and the residue of that apex thereafter. Grey plasticene was used to represent the legume at all stages of development. These models were cut longitudinally so that the cut surface would present the same aspect as the illustrations upon which they were based. The complete models are shown in Plate v, figures 61–65. The cut models are shown in Plate v, figures 71–75, together with the originals from which their measurements were taken. The gradual displacement of the suppressed apex, and the clasping of its top by the base of the lamina of the legume, is clearly shown.

On the evidence brought forward in this paper, I can see no other conclusion than that the legume in the two species examined is a lateral laminar organ developed on an apex which is immediately suppressed; that the initiation and differentiation of the legume is not significantly different from those of a vegetative leaf; and that the ovules are formed on the margins of the lamina of the legume.

DISCUSSION.

INTRODUCTORY.

This histogenetic study of the floral apex and initiation of the floral appendages of *Acacia suaveolens* and *Acacia longifolia* has been designed to test recent criticisms and variations of the classical idea of the carpel as a modified leaf. The evidence presented herein is the cellular details of the meristematic activity of the floral apex that gives rise to the initials of the floral organs. In the case of the legume, the study is continued as far as the formation of the ovule primordia. This evidence shows clearly that (1) the legume takes its origin by the meristematic activity of cells occupying a lateral position on the floral

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* See above ("Residual Apex", p. 72) for possible causes.

apex; (2) the residue of the apex loses its meristematic activity, the apex thereby becoming suppressed; (3) the legume is a single, laminar structure which by incurving and adpression of its margins encloses a central cavity; (4) the ovules arise on the incurved margins of this laminar structure.

The work of Priestly and Swingle (1929) on regeneration has emphasized the fact that cells can resume the meristematic state long after they have lost it, if the appropriate conditions are set up. This obviously happens after fertilization, when the legume renews its growth. There is therefore no reason against renewed meristematic activity producing vascular tissue in the uppermost parts of the floral axis where there were no procambia at the time of formation of the legume primordium. It would then be easily possible for the pod to appear to receive the whole of the residual vascular cylinder after the exsertion of the androecium. The minuteness of the residual apex alone, before or after the renewed meristematic activity, might also cause this appearance. At the time the first procambia are formed in the primordium of the legume, the vertical distance is very small within which the level of their insertion is to be determined—in the cases of *Acacia suaveolens* and *Acacia longifolia* it is only about 50μ. Differences in level within such a distance may easily be obliterated or even reversed by the growth that takes place up to the stage of fertilization, and still more so after fertilization. It is reasonable, therefore, to regard a study of the vascular anatomy after the very earliest stages as being not competent to determine whether or not the legume is terminal. This is especially so if transverse sections only are used. (The same considerations would apply to any gynoecial structure under morphological interpretation.) Moreover, a multitude of the types examined can add no weight to any conclusions, if the manner of examination is not competent to reveal significant evidence.

In this paper I have studied ontogeny and meristematic activity. That is to say, a close series of stages of the coming into being of the parts concerned has been examined and illustrated with cellular details of the meristematic tissues involved. This study has led to interpretations different from some that are claimed to have as their basis an examination of ontogeny and meristematic activity, or that follow expositions of the necessity for such examinations (Grégoire, 1931, pp. 1288–9; Thomas, 1934, p. 177; Thompson, 1931, p. 75, and 1934, p. 7). The studies of these workers appear to me to lack the necessary closeness and earliness of the series of stages described, the presentation of cellular details of the tissues and the illustration of longitudinal sections. There is serious danger of calling "ontogeny" that which is not ontogeny because it includes so few truly early developmental stages and is not of sufficient detail.

For the reasons outlined above I have taken little notice of vasculation after the primordial stages, in this inquiry, and will not make much reference thereto in discussing the literature. The questions of the vascular anatomy of the legume will be found discussed with references to the relevant literature in papers by Parkin (1929), Eames (1931), Arber (1933), Bancroft (1935), Joshi (1935), etc., in addition to the four propounders of the theories I am discussing.

CRITICISM OF RECENT THEORIES.

We now come to consideration of the theories of the four workers mentioned at the beginning of this paper who oppose or modify the classical theory of the carpel. It is to be understood that I can only speak in so far as they refer to the legume—particularly the *Acacia* legume—or make reference to the carpel in general. There will not be a detailed comparison of the evidence produced in this paper with the evidence and conclusions given by these writers. But I will ask the reader to bear in mind the content and nature of the evidence presented herein and the remarks made above on the competence or incompetence of different types of evidence. The common elements of the different theories will be discussed together.

If the evidence, the interpretation, and the criticisms of types of evidence that have been given above are valid, then the following propositions are not true: (1) The legume is a terminal structure; (2) the legume is not a single folded structure; (3) the legume is not a foliar structure.

(1) *The legume is a terminal structure.*—This statement is made by Saunders (1929). She bases it on the claim (p. 225) that the "whole residual vascular cylinder in the Leguminosae is continued directly into the gynoecium". The evidence presented in support of this claim consists of transverse sections of well advanced legumes shown in outline, with no significant illustrations of cell detail. There are no longitudinal sections, no close series of early developmental stages nor an exposition of terminality being a necessary consequence of the whole residual vascular cylinder* entering the gynoecium. For *Acacia suaveolens* she produces no evidence on this question, because Figures 1–3 do not include the level of exsertion of the legume from the floral axis.

In making this statement, Thompson† (1929, pp. 16–17, etc., and 1931, pp. 11, etc., and 75—conclusion) appears to have regarded the "dome", that is, the remainder of the apex after the formation of the stamens, as the initiation of the legume. The evidence he presents (neglecting sectional views of adult flowers) consists almost entirely of outline drawings of serial transverse sections at various stages of development. The one longitudinal section illustrated is of *Acacia spadicigera*, and demonstrates clearly the necessity for the study of tissues (1931, fig. 63). The outline of the "gynoecium" in this figure is almost identical with the outline of the legume plus the residue of the apex shown in my Plate ii, figures 13–15, and Text-figure 4 for *Acacia longifolia* and Plate iii, figures 31, 32, 34*a* and 35 for *Acacia suaveolens.*

Grégoire (1931, pp. 1289 and 1294) makes the statement with regard to the carpel in general. His figures are very few and show no developmental series or details of tissues (see Postscript, p. 88).

Arber has discussed cases of leaves that are described as terminal (1930, pp. 301–2). One of these is that of *Gigantochloa* (1928, p. 184); but in the evidence presented there is the same lack of close developmental series and cellular detail of tissues. Attention is re-directed to the tentative argument made above that an organ cannot be terminal.‡

If the legume is not terminal, we expect to find some cases where the apex has not been suppressed. Such a case was found in *Acacia Baileyana*, where an apex had produced a young flower after the formation of the legume. The young

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* This question of the "whole residual vascular cylinder" is bound up with the conception of the unit of shoot growth. Cf. Griffiths and Malins (1930) and Priestly and Scott (1933).

† In a later paper (1934) Thompson propounds a theory which is incompatible with this, but he does not definitely withdraw his frequent and unequivocal statement of terminality of the legume made in the papers referred to here.

‡ See "Residual Apex" (p. 72). Also compare the idea of the unit of shoot growth (Griffiths and Malins, 1930, and Priestly and Scott, 1933).

flower had the appearance of growing out of the base of the legume (Newman, 1933, p. 154).

If the ontogenetic and histogenetic evidence presented in this paper is representative of the evidence that could be produced from other Leguminosae by similar methods of study, then the legume is a lateral organ. The legumes of *Acacia suaveolens* and *Acacia longifolia* are certainly lateral organs.

(2) *The legume is not a single folded structure.*—This proposition is part of Saunders' application of the Theory of Carpel Polymorphism to the Leguminosae (1925, p. 142, and 1929). Her statement that the legume consists of two carpels, one fertile and the other sterile, is incompatible with the ontogenetic and histogenetic evidence given herein* for *Acacia suaveolens* (illustrated by her, 1929, Figs. 1–3) and *Acacia longifolia* (referred to by her, 1929, p. 227). She illustrates with outline drawings of transverse sections (1929), except in two figures with cell detail, one of which (Fig. 79) shows the legume a single folded structure (the other does not bear on the point).

Grégoire (1924) regards the legume (of Papilionaceae) as not folded because he interprets its primordium as annular. In the cases described here the primordium is certainly not annular. The figure given by Grégoire is a transverse section of a legume long after the primordial stage. His objections to the single structure based on dehiscence have been met by the description of the pod of *Acacia Baileyana* (Newman, 1934, p. 238).

I can only conclude from the evidence presented herein that, if it is representative of what could be found by similar methods in other Leguminosae, then the legume is a single folded structure.† The legumes of *Acacia suaveolens* and *Acacia longifolia* are certainly single folded structures (similarly for *Acacia Baileyana*, Newman, 1933, pp. 153–6, and 1934, p. 238).

(3) *The Legume is not a foliar structure.*—In discussing the two preceding propositions we were dealing with descriptions of facts. The differences between the descriptions were due to differences in the methods of examination and presentation. This proposition introduces morphological interpretation, which is naturally influenced by our description of the facts, and consequently by the methods of examination and presentation.

Thomas (1931, pp. 660–2, and 1934, pp. 186-8 and figs. 12, 13A–C) has described the hypothetical evolution of the Angiospermous carpel from a cupular structure, beginning with a cupule like that of *Gristhorpia* (Caytoniales). He derives the follicle from such a form by fusion of two ovaries in such a way that the cupules became concrescent and, curving over, enclosed the ovules which were axial organs. In this process the last traces of the stem might be included on the side of the structure away from the ovules. From this hypothetical type he derives the legume. His comparative evidence (from present-day forms) in support of this hypothesis does not contain close ontogenetic series or illustration of cellular detail of tissues at the very earliest stages of development. The ontogeny of the legume presented in the present paper plainly shows the ovules to arise on the margins of a single folding laminar structure, a process incom-

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* Similarly for *Acacia Baileyana* (Newman, 1933, pp. 153-6, and 1934, p. 238).

† Thompson (1929 and 1931) has supported this view, though in a later paper (1934, p. 8) he seems to suggest a multiple structure, viz.: "Other forms of accepted carpel, such as the legume, likewise arise, singly or in series, by union of emergences from the sporogenous tissue of the axis." I cannot find where he has withdrawn the earlier view.

patible with a derivation such as suggested.† There is also incompatibility between the hypothesis and the ontogeny with regard to the stigma (cf. Thomas, 1934, fig. 13A–C).

Grégoire (1931, pp. 1288–9) says he will study: (1) the behaviour of the central part of the floral axis during formation of the carpel primordia, (2) the meristematic activity itself which originates the carpellary protuberances (ébauches), (3) the structure and activity of the floral meristem that produces carpel primordia compared with a vegetative cone concerned with the forming of leaves. He claims to find that (1) the centre of the floral apex forms or could form a carpel, (2) there are two distinct types of primordia, and (3) there are two distinct types of apical meristem. He concludes that the carpel is an organ *sui generis* and not a modified leaf (p. 1300). He does not show developmental series or cellular detail in illustration of his contentions. In the earlier part of this paper it has been shown in *Acacia suaveolens* and *longifolia* that (1) the legume is lateral to a suppressed apex, (2) the primordium of the legume arises similarly to those of vegetative leaves, (3) the structure and activity of the meristem of the floral apex is of a type known for vegetative apices (allowing for the limitation of growth).

The description of the legume as terminal and its interpretation as a phylloclade is made by Thompson (1929 and 1931). In a later publication (1934) he introduces a startling theory in which the accepted parts of the flower are discarded and replaced by emergences from a sporogenous axis (pp. 6–7). In reference to the legume he says (p. 8): "Other forms of accepted carpel, such as the legume, likewise arise, singly or in series, by union of emergences from the sporogenous tissue of the axis. . . . Whatever be their final state or form, they are here considered sporogenous phylloclades, in view of their origin from the sporogenous tissue of the axis. As they are enlarged, they carry with them portions of the original sporogenous tissue which may, locally, be sterilized. The sporogenous tissue carried by the phylloclades may be increased as growth proceeds. When ovules emerge from this sporogenous tissue, ovuliferous phylloclades are in being and not carpels, as commonly received." The evidence presented in the paper, which primarily deals with Scitamineae and Ranunculaceae, is largely diagrammatic and does not contain close developmental series, longitudinal sections or cellular details (except for one figure of an advanced stage). The detailed description of the developmental series with cellular detail of longitudinal sections given above for *Acacia suaveolens* and *Acacia longifolia* cannot be reconciled with that quotation.

It thus appears that the above theories, which deny foliar nature to the legume, are not compatible with the evidence of the ontogeny in *Acacia suaveolens* and *Acacia longifolia*. The evidence produced here is more detailed and of a more necessary type compared with the evidence shown in support of the theories referred to. It is compatible with the legumes of these two species (and by suggestion of all Leguminosae) being foliar structures.*

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† Joshi (1935) adversely criticizes Thomas's theory from the standpoint of anatomy. There is a reply added by Thomas.

* Judging from the description and figures given by Salisbury (1931, pp. 558-9, figs. 14-15 and Plate xviii, figs. 2-4) of the achene of *Ranunculus parviflorus* L., a close series of stages of development would show clearly the foliar structure with the ovule on the margin, though extreme reduction has caused the apparent axillary origin of the ovule.

POSITIVE IMPLICATIONS OF THE EVIDENCE.

We come now to attempt to assess the implications for morphological theory of the evidence and its interpretation that have been set forth in the foregoing pages. The enquiry began in order to investigate the claim that the legume of two species of *Acacia* is terminal and composed of two carpels, one fertile and the other sterile. In addition to determining those points in the negative, it has expanded into a description of the histogenesis of the floral apex in terms similar to those used by some writers in describing the meristematic activity whereby a vegetative apex gives rise to the emergences known as leaves. There are, therefore, two subjects for consideration. The first is the contribution to be made to the morphological understanding of the legume. The second is the contribution to be made to the morphological understanding of the flower.

It is clearly recognized that this discussion is of limited application, because only two species are examined, and the course of development is not traced far beyond the initiation of the primordia, except in the case of the legume. But there has been examined and illustrated, with cellular detail of close developmental series, the ontogeny of the floral apex, that is, the process whereby the undifferentiated (surface of the) floral apical meristem gives rise to the floral organs. It is claimed that such a study is the most essential requirement for morphological interpretation. Unfortunately, it seems to be very scarce in the literature of floral morphology.

The Legume.

It has been demonstrated that the legume is a single infolding laminar structure that arises laterally to the apex of the floral axis in a manner fundamentally similar to that of leaves on the vegetative apex, and that it bears ovules on the margins of the lamina. These facts are in harmony with the interpretation that it is a single carpellary structure of foliar nature. The final proof of the foliar nature would require more evidence than is provided in this investigation.

Foster (1935) finds a histogenetic difference between the foliage leaf and the cataphyll of *Carya Buckleyi* var. *arkansana* at a very early stage (0·09–0·1 mm. high) of the primordia, though they both arose from the same layers of the apical meristem. The difference lay in the distribution of the meristems within the primordia (pp. 101, 114, 124, 126). He refers (p. 88) to the conclusion of Schüepp (1929), that "differences in the distribution of types of tissue, and in the intensity and duration of their growth must form the basis for the difference between foliage leaves and bud scales". A comparison is therefore indicated of the distribution of the meristems in the legume with that in foliage leaves (of the same species especially). This aspect of the subject was only slightly examined by me, but the indication was that the distribution of meristems in the primordia of the legumes of *Acacia suaveolens* and *Acacia longifolia* correspond with that in the foliage leaves of a variety of species (of other genera) examined by Louis (1935).

A discussion of the morphology of the legume would be incomplete without consideration of the vascular anatomy. Saunders (1929) and Thompson (1929, 1931) have discussed it from points of view opposed to the monocarpellary interpretation of the legume. Eames (1931, with reference to the legume) and Arber (1933) discuss vascular anatomy and find in it support for the foliar nature of the carpel. These discussions are based on vasculation of the gynoecium at relatively advanced stages. There is, therefore, nothing in this paper with which to contrast them. It is to be noted, however, that the relative positions of the primordium of the midrib, the extension of the pith and the suppressed apex, together with the later origin of the primordia of the marginal bundles appear in keeping with a foliar interpretation.

After considering the facts of ontogeny described in this paper, and discussing them in relation to facts and ideas put forward by other workers, I can see no reason for doubting that the legumes of *Acacia suaveolens* and *Acacia longifolia* are of foliar nature; rather does the evidence support that morphological interpretation.

The Flower.

The ascription of a foliar nature to the legume, that is, to the monocarpellary gynoecium of the Leguminosae, immediately raises the question of the morphology of the flower. Is it a modified leafy shoot? This question has been discussed by many recent workers from various points of view. I will only add certain comments which arise out of the present study.

The special contribution of this paper to the subject is the description of the meristematic activity of the floral apex with cellular detail, and the comparison thereof with the similar activity of at least some types of the vegetative apex. It has been seen that there is fundamentally no difference between them, except the limitation of growth of the floral axis. The appendages are initiated in the same manner on vegetative and floral apices. In the floral apices of the two *Acacia* species we have seen the limitation of growth by the failure of formation of the vacuolating dividing tissue which is the tissue responsible mainly for the production of node and internode (Priestly, 1929, p. 69). Priestly and Swingle (1929, p. 27) refer to the work of Koch (1893) in which he showed that "in practically all trees and shrubs the new lateral buds arise some time after the leaf initials have appeared at the growing point, at a time when the internodal development taking place makes these axillary meristematic groups distinct in origin from the meristematic tissue crowning the apex". With the absence of activity to form the internode, it is understandable that buds would be absent from the axils of floral appendages.

The considerations which arise out of the study of the histogenesis of the floral apices of *Acacia longifolia* and *Acacia suaveolens*, taken in comparison with accounts given by other workers of vegetative apices, cannot be regarded as contrary to, but as favourable to the interpretation of the flowers of these two species as modified leafy shoots.

Summary and Conclusion.

In some recent criticisms and modifications of the classical theory of the carpel as a modified leaf there is little presentation of evidence from primordial stages or with cellular detail. This paper studies both these aspects in *Acacia longifolia* and *Acacia suaveolens* in an attempt to find the relation of the carpel primordium to the apex of the floral axis.

There is a description of the relevant features of the species, the methods of manipulation of the material and the methods of examination including the construction of plasticene models from serial sections.

The evidence is first presented without use of the terms "apex", "legume", or "carpel".

The description of the external appearance of the development of the young flower records the formation of a "shoulder" on the apex after the formation of the petals. This "shoulder" is the seat of origin of the stamens and leaves a central "dome" which becomes slightly accentuated and gives rise to the ovule-bearing organ on one side of it.

The description of the internal appearance of the development of the young flower begins with the formation of the sepal initials and passes in close stages to the production of ovules. Particular attention is given to the distribution of the types of meristematic tissues and the vacuolated tissue. Three zones are recognized: fully meristematic, vacuolating dividing, and vacuolating extending, the first being the outer zone of from two to four layers.

The sepals and petals arise as folds in the outer layer under which divisions take place in the second layer with periclinal wall formation. The shoulder arises in the second layer by divisions with periclinal wall formation, the activity not extending over the central third of the longitudinal sectional contour and thus instituting the "dome". The stamens arise on the shoulder in the same manner as the sepals and the petals.

The enlargement of the "dome" is almost entirely by increase in cell size, spatial restriction causing the enlargement to express itself as increase in height.

The ovule-bearing organ arises laterally on this "dome" in the same manner as the sepals, petals and stamens arose, namely, by folding of the outer layer with divisions with periclinal wall-formation in the cells of the second layer, below the fold. The smallness of the "dome" causes the initial of the ovule-bearing organ to have a curved insertion. Restriction of space brings the primordium of the ovule-bearing organ into an erect position. Its early growth is by meristematic activity of the apex and margins. It assumes the form of a groove whose margins meet and, by differential growth of the inner and outer surfaces, enclose a cavity. Into this cavity the ovules grow from the edges of the arms of the groove. The assumption of the erect position by the organ brings the lower surface of the arms of the groove into close contact with the upper surface of the residue of the "dome".

The growth of the base of the ovule-bearing organ displaces the residue of the "dome", which finally appears to be but a part of the surface of the short stalk of the ovule-bearing organ. The tissues of the residue of the "dome" can be traced through the stages of development at least as far as the stage of the functional megaspore, by which time there is a strong tendency to the obliteration of the distinction between them and the adjacent tissues.

Apart from notice of the procambia of the ovule-bearing organ little notice is taken of the vascular tissues. The pith extends between the procambium of the midrib of the ovule-bearing organ and the residue of the "dome".

The foregoing description was made in terms of the histogenesis of an apical meristem giving rise to lateral organs. Such a description of floral ontogeny could not be found in the literature available to me here.

As a background for the interpretation of the evidence presented in this paper there is a discussion of recent work on the meristematic activity of the vegetative apices in the Angiosperms. Emphasis is laid on the response of the apex as a living entity to the mechanical influence of the formed lateral organs. The asymmetric distribution of meristematic activity is discussed in relation to the limitation of growth, and an argument advanced for the impossibility of an appendage being terminal in origin, so that there must always be a residue of the apex.

The evidence is interpreted as being compatible with all parts of the flowers of these two species being modified leaves. The legume arises laterally on the apex, the histology of whose suppression is observed. The legume is a single laminar structure growing in a manner similar to some vegetative leaves and bearing the ovules on its margins. The interpretation is illustrated by a series of models moulded according to measurements made of certain photomicrographs, and displayed in conjunction with those photomicrographs.

There is a discussion of the type of evidence necessary for a basis of morphological conclusions that imply some kind of ontogenetic process.

Bound up with recent theories of Saunders—Carpel Polymorphism—(1925 and 1929), Grégoire (1931), Thomas (1931 and 1934) and Thompson (1929, 1931, 1932 and 1934) are the following propositions: (1) the legume is a terminal structure; (2) the legume is not a single folded structure; (3) the legume is not a foliar structure.

After discussion, bearing in mind the evidence produced in this paper and comparing its nature with that of the evidence shown in support of the above propositions, it is concluded that: (1) the legume is a lateral structure; (2) the legume is a single, folded structure; (3) the evidence is compatible with the legume being a foliar structure (certainty on this point requires a wider study than that made in this paper).

The positive implications of the evidence are reviewed, with the conclusions that there is no reason for doubting that the legumes of *Acacia longifolia* and *Acacia suaveolens* are of foliar nature, and that it is reasonable to interpret the flowers of these species as modified leafy shoots.

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Notes on the Illustrations.

All the drawings were made with the aid of the camera lucida, the magnifications being determined by direct measurement.

All the preparations from which the photomicrographs were made were stained with Safranin, Orange G and Light Green (except with Haidenhain's Iron Alum Haematoxylin for Plate ii, fig. 3, and Plate v, figs. 60*a, b*), giving red nuclei, golden cytoplasm and green walls. The source of light was a Philips' Tungsten arc lamp. The light was passed through Wratten F (red) and density filters, and the source focussed on the back lens of the condenser by which it was focussed on the object. The cover glass correction collar on the objective (and sometimes the tube length) was adjusted for each photograph. On account of this the magnifications vary slightly, so that they have been given in round figures for the photomicrographs. Panchromatic plates were used. All figures in the plates are photomicrographs except the photographs of models shown in Plate v, figures 51-59, 61-65 and 71-75.

A few special annotations are indicated in the explanations of the figures. The following annotations have been standardized and apply in all cases:

ae, appressed epidermes; (arrow) >——→, the original centre of the upper surface of the axis, i.e., for the description (pp. 58-67) the original centre of the "dome", and for the interpretation (pp. 67-75) et seq., the original centre of the apex of the flower; *bG,* inner limit of the groove; *br,* bract; *G,* groove; *L,* for the description the ovule-bearing organ, for the interpretation, et seq., the legume; *mb,* marginal bundle (or its procambium); *mr,* midrib (or its procambium); *ov,* ovule; *P,* pith; *pe,* petal; *se,* sepal; *sG,* surface of the groove; *st,* stamen.

EXPLANATION OF PLATES II-V.

Plate ii.—*Acacia longifolia.*

Photomicrographs of the whole or part of longitudinal sections of young flowers. Notice the distribution of the meristematic tissue. Magnification of all figures, × 240.

Fig. 1.—Shows sepals have arisen by cell division in second layer of the apex, under a fold in the outer layer.

Fig. 2.—Formation of the initials of the petals by cell division in the second layer of the apex, under a fold in the outer layer.

Figs. 3-5.—Stages in the formation of the "shoulder" (*sh*) by divisions with periclinal walls in the second layer of the apex except in the part represented by the central third of the sectional contour. The central part forms the "dome". Note the large-celled pith.

Figs. 6-8.—Origin of the initials of the stamens by cell divisions in the second layer under folds in the outer layer of the shoulder (*sh*). Variations in the shape of the apex (dome) and the axis. These figures are at slightly advancing stages. In 7, the section does not pass through any stamens on the right.

Figs. 9-13.—Progressive stages in the formation of the initial of the ovule-bearing organ (legume) on one side of the apex (dome) and by multiplication of the cells of the second layer with periclinal wall formation under a fold in the outer layer.

Figs. 14-18.—Development of the grooved structure of the primordium of the ovule-bearing organ (legume) which is forced into a vertical position by lack of space. The residue of the apex (dome) is displaced laterally and the arms of the groove extend above it, enclosing the original centre of the apex (dome). In 17 the section is slightly inclined to the plane of the groove and misses the midrib. (See Plate v, fig. 60*a, b*, for the next stage of *longifolia.*)

Plate iii.—*Acacia suaveolens.*

Photomicrographs of the whole or part of longitudinal sections of young flowers. Notice the distribution of the meristematic tissue. Magnifications of all figures, × 240.

Fig. 19.—Shows a sepal initial arising by cell division with periclinal wall formation in the second layer of the apex under a fold in the outer layer.

Fig. 20.—Shows initials of the petals formed by cell divisions in the second layer of the apex with periclinal wall formation, under a fold in the outer layer.

Figs. 21-23.—Stages in the formation of the "shoulder" (*sh*) by divisions with periclinal walls in the second layer of the apex, except in the part represented by the central third of the sectional contour. The central part forms the "dome". Stamen initials are already forming at the end of this process. The section for 22 is slightly displaced from the centre. Note the large-celled pith with the beginning of deposition of deeply-staining granules, which in the figures frequently appear as brightly shining bodies (red stain, red filter, panchromatic plates).

Figs. 24-27.—Origin of the initials of the stamens in the second layer of the "shoulder" (*sh*) under folds in the outer layer. 25-27 show the regularity of the layers of the apex (dome), although there has been distortion by external pressure in the cases of 25 and 26. In this species the dome is defined later than in *longifolia,* cf. figure 24 with figure 6 on Plate ii. In 26 the section does not pass through any stamens on the right.

Figs. 28-31.—Progressive stages in the formation of the initial of the ovule-bearing organ (legume) on one side of the apex (dome), by multiplication of the cells of the second layer with periclinal wall formation under a fold in the outer layer.

Fig. 32.—Section passes down the groove which is becoming pronounced. The groove is wider than in *longifolia* and requires more than one section to show its extent. Stage of development is about that of *longifolia* shown in Plate ii, figure 15. Displaced tissue is lying above the darkly staining cells of the pith.

Plate iv.

Figs. 33*a* to 38*f*.—*Acacia suaveolens.* Magnification, × 240.

Showing the grooved nature of the young ovule-bearing organ (legume) which is forced into a vertical position by lack of space. The residue of the apex (dome) is displaced laterally and the arms of the groove extend above it enclosing the original centre. Notice the distribution of the meristematic tissue.

Figs. 33*a, b*.—Two sections in a longitudinal plane inclined to the plane of the groove, so that 33*b* includes the edge of the base of one side of the groove. The inclination to the plane of the groove makes the slope of the residual apex appear less steep. These are the two outside of three consecutive sections. Age younger than that of stage shown in Plate iii, figure 32.

Figs. 34*a, b*.—Two longitudinal sections down the groove; they are the outside ones of four consecutive sections, 34*b* is encroaching on the arm of the groove. Older stage than 32.

Figs. 35, 36.—Two longitudinal sections down the groove; they are the outside ones of three consecutive sections. 36 includes the face of the groove. Older stage than 34*a, b*.

Fig. 37.—Longitudinal section down the groove and including one face of it. Older stage than 35, 36 and than the stage of *longifolia* shown in Plate ii, figure 18. Note the great increase in cell size compared with figures 35, 36.

Figs. 38*a-f*.—Transverse sections of a young ovule-bearing organ (legume) about the stage of figures 34*a, b*. The series represents twelve sections at 6μ, beginning at the tip, of which Nos. 1, 4, 6, 8, 10 and 12 are shown. Though the midrib is indicated in *d* and *e*, it has scarcely been initiated yet. Detailed comparison of this series with figures 34*a, b*, will show the correspondence of the distribution of the meristematic and vacuolating tissues. (The two organs appear reversed in aspect in these illustrations.) Note that the organ is grooved to the apex.

Figs. 39*a-f*.—*Acacia longifolia*. Magnification, × 240.

Transverse sections of a young ovule-bearing organ of about the stage of Plate ii, figure 14. The series represents ten sections at 6μ, beginning at the tip, of which Nos. 1, 3, 5, 6, 8 and 10 are shown. This series is of a stage younger than that shown for *suaveolens*. Comparison of this series with Plate ii, figure 14, will show the correspondence of tissues. (Organs reversed in aspect.)

Figs. 40-50.—*Acacia suaveolens*. Magnification, × 120.

Progressive and serial longitudinal sections of the central upper portion of the floral axis with the whole or part of the ovule-bearing organ (legume), showing the organ assuming an apparently terminal position with the lateral displacement, and suppression of the residue of the apex (dome), and the approach to obliteration of the boundaries between the upper part of the apex (dome) and the lower part of the arms of the groove, i.e., the lamina of the ovule-bearing organ (legume).

Figs. 40-41.—Consecutive sections showing the ovule primordia on the margin of one of the arms of the groove, and the demarcation between the lower part of the arm and upper part of the residue of the apex (dome). Same stage as Text-figure 13.

Fig. 42.—At the stage of the megasporogenous cell. Section is not truly vertical, hence the demarcation between the arm of the ovule-bearing organ (legume) and the upper part of the residue of the apex (dome) is not clear. It can be traced by the large cells of the hypodermis.

Figs. 43-6.—Consecutive sections at the stage of megaspore formation. The plane of section is not quite parallel with the plane of the groove. The maximum demarcation between the arms of the ovule-bearing organ (legume) and the residue of the apex (dome) would be underneath the junction of the arms. On account of the inclination of the plane of section, the four sections are needed to show the entirety of this line of maximum demarcation which can be followed from left to right in passing from figure 43 to 46. Away from this line there is some interpenetration of the cells of the two epidermes. The junction of these epidermes is shown in figure 43 by a dotted line. Note the extension of the dark staining deposition in the pith cells between the midrib and the residue of the apex (dome), and the bands of thickening on some of them.

Figs. 47-50.—Consecutive sections at the stage of the functional megaspore. As figures 43-46, except that the aspect is reversed and the line of demarcation is more easily traced by the more prominent hypodermis. Note the bands of thickening on some of the outer cells of the pith. By this stage it is only possible to identify the residue of the apex (dome) because of having traced it from the beginning.

Plate v.

Figs. 51-57.—Models of part of young flowers of *Acacia suaveolens* to show the development of the shoulder (*sh*) and the "dome" and the origin of the ovule-bearing organ from one side of the "dome". The explanation is in the text. The black dot is at the original centre of the apex (dome). All the stamens have been cut off in 56 and the central ones in 55 and 57. Except in 51, the petals have been cut off below the level of the stamens. The cards bearing the numbers have a width representing 50μ.

Figs. 58-9.—Models of part of young flowers of *Acacia longifolia*, showing the shoulder (*sh*), the "dome" and the young lateral ovule-bearing organ. Stamens have been cut off from the centre of 58. Black dot the original centre of the apex (dome). Explanation in the text. The cards bearing the numbers have a width representing 50μ.

Figs. 60*a, b*.—Consecutive longitudinal sections of a young ovule-bearing organ of *Acacia longifolia* at a stage just before the formation of ovule primordia. Shows the displacement of the residue of the apex (dome). The section is slightly inclined to the vertical. The line of demarcation between the lower part of the arm of the ovule-bearing organ (legume) and the upper part of the residue of the apex (dome) is still clearly discernible. The deeply staining deposition in the cells of the pith extends between the midrib and the residue of the apex (dome). Magnification, × 150.

Figs. 61-5.—Models showing the relation of the legume to the suppressed apex of *Acacia suaveolens*. White plasticene was used to represent the apex and grey plasticene to represent the legume. The models were made from measurements of illustrations as follows: 61 from Plate iii, fig. 27; 62 from Plate iii, fig. 30; 63 from Plate iii, fig. 31; 64 from Plate iv, figs. 35 and 36; and 65 from Plate iv, figs. 40 and 41, and Text-fig. 13.

Black dot represents the original centre of the apex. Explanation in text; see also Figs. 71-75 on this Plate. Magnification, × 96.

Figs. 66-8.—Longitudinal sections of young flowers of *Acacia suaveolens*, showing the regularity of the zonation of the tissues in spite of the distortion by the various compressions due to the pressure of the bracts and adjacent flowers (*fl*). These are photographs respectively of flowers 1, 2 and 3 in Text-figure 11, but not all from the same section. Magnification, × 150.

Figs. 69*a*-70.—Longitudinal sections of the ovule-bearing organ (legume) perpendicular to the plane of the groove and through the appressed margins, showing the appressed epidermes and portion of the upper part of the axis. 69*a*, of *Acacia suaveolens*, is at the same stage as Text-figure 13 and passes through the region about where the marginal bundles will form. 69*b* is of a similar stage of the same species as 69*a*, but the margins have not completely closed together, so that ovule primordia are exposed; a filament has been partly inserted into the open base of the organ. 70 is of *Acacia longifolia* at a stage slightly older than shown in Text-figure 6. Magnifications, × 120.

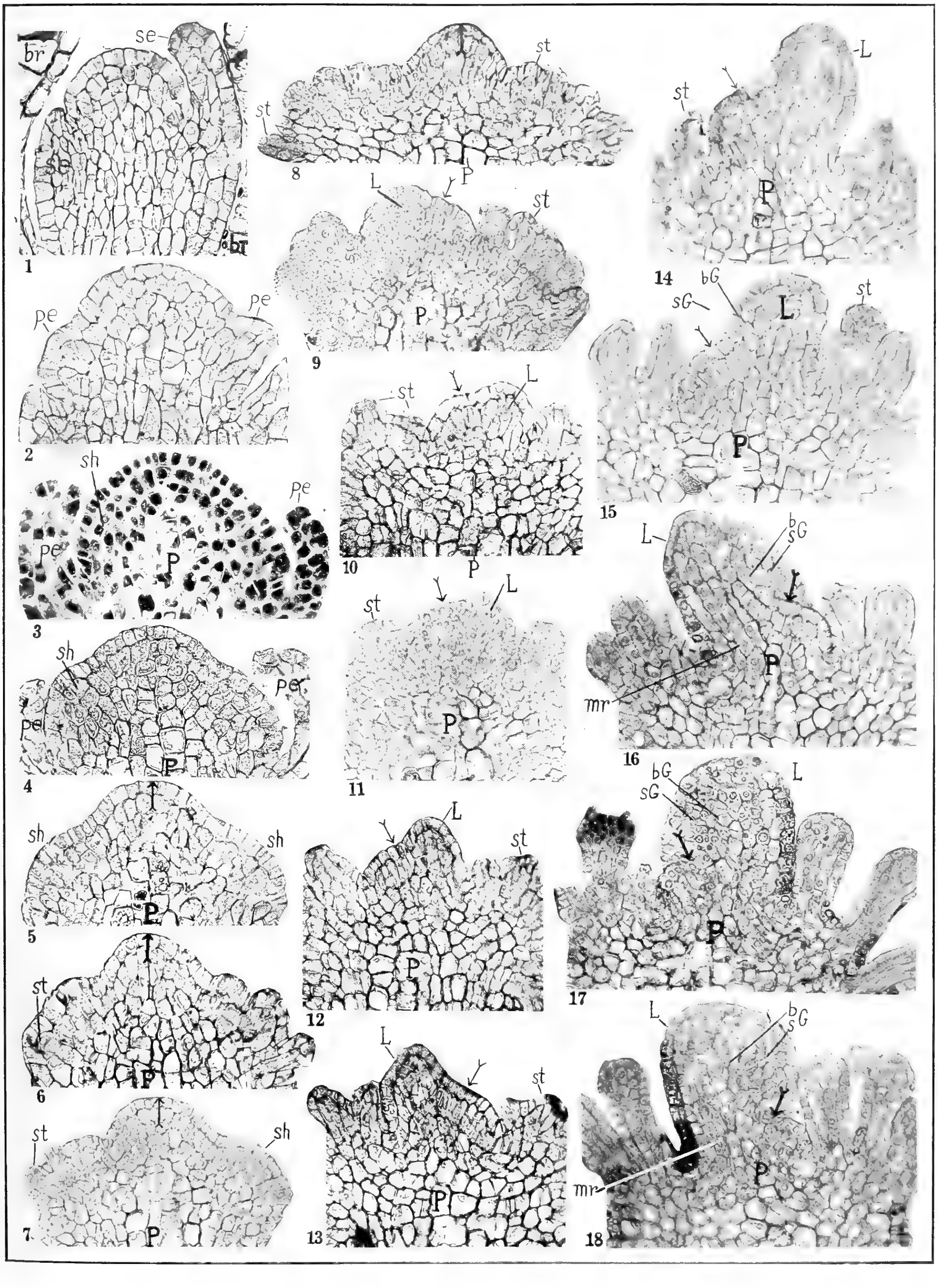
Figs. 71-75.—Correspond with 61-65 of *Acacia suaveolens*. The models are cut down longitudinally, the two halves of each opened out to show the disposition of the apex and legume in progressive stages of development. With each opened model is placed a copy of the photomicrograph from the measurements of which it was constructed. The photographs of the models have been brought to the same magnification as the photomicrographs. For the correspondence of the models and photomicrographs see the explanation of figures 61-65 on this Plate. A careful comparison of the distribution of the white (apex) and grey (legume) in the opened models with the cellular arrangement in the associated photomicrographs will demonstrate clearly the interpretation of the legume as lateral on a suppressed apex. The photomicrograph in 75 was reversed (cf. Plate iv, fig. 41) for ease of comparison. Magnification, × 240 for 71-4, and × 120 for 75.

Figs. 76-78.—Transverse sections of the ovule-bearing organ (legume) showing the appressed epidermes of the incurved margins. 76 is of *Acacia longifolia*, and is a photomicrograph of the section shown in Text-figure 10*b*. 77 is of *Acacia suaveolens* and is of a section of the base of the loculus of the ovule-bearing organ (legume) figured in Text-figure 15. 78 is of *Acacia longifolia* at about the time of fertilization, when the appressed epidermes of the incurved margins are still clearly to be seen. Magnifications, × 120.

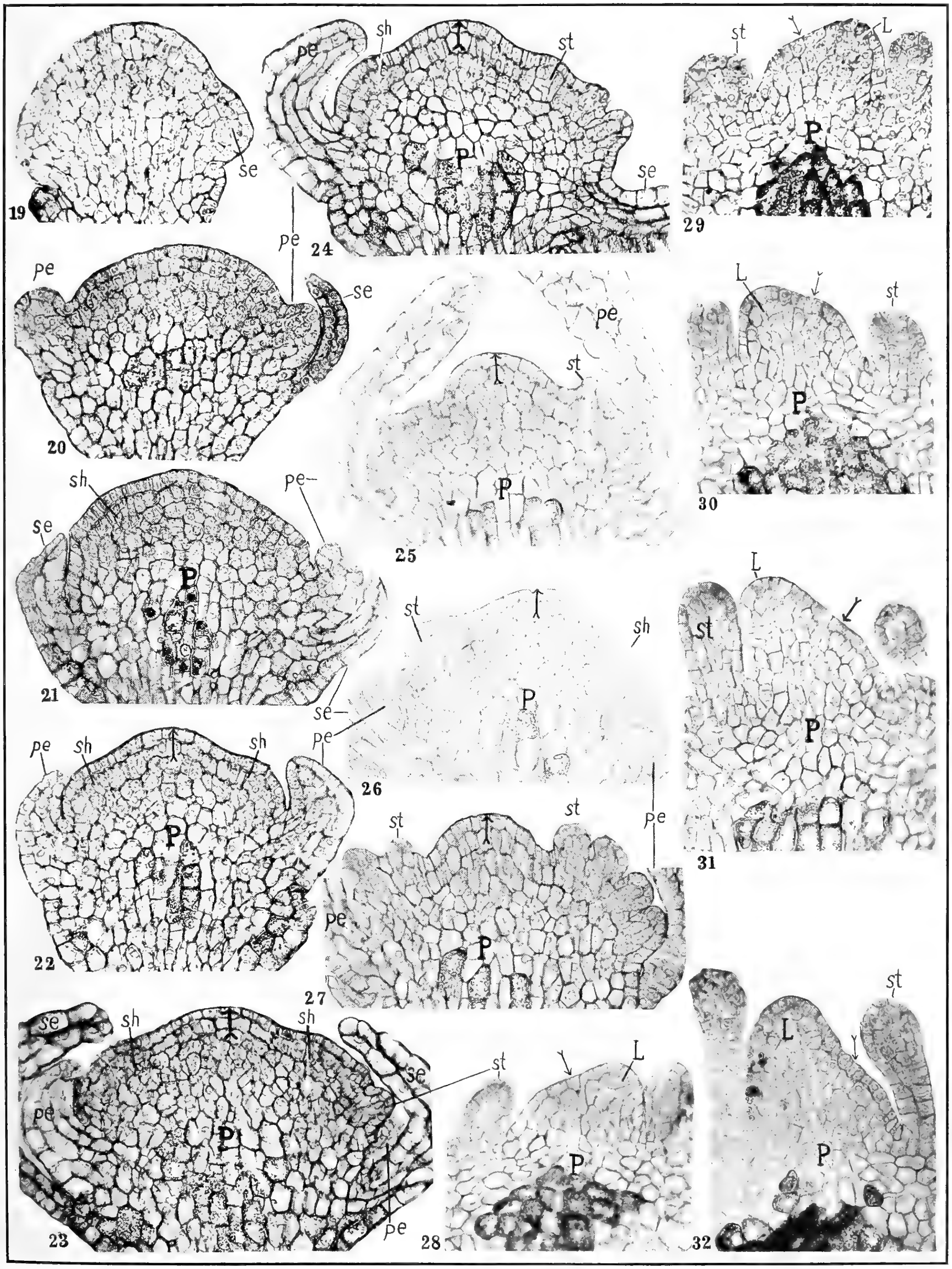
Postscript, added 22nd April, 1936.

After I had completed the foregoing paper, Professor V. Grégoire kindly sent me a reprint of a recent paper of his (Grégoire, 1935*c*) in which he shows cellular detail in illustrations of the floral apex of *Ranunculus scleratus* and the vegetative apex of *Lonicera periclymenon*. He points out (p. 299) that whereas the vegetative cone has a tunic enveloping a corpus furnished with an initial region that can cause elongation in growth, the floral summit has only a meristematic cloak ("Manchon") covering a mass of parenchyma and cannot grow in length. Discussing certain abnormalities in flowering described by Brieger (1935) in *Primula*, he attributes the presence or absence of sepals in different forms of proliferation to the difference in meristematic organization between vegetative and floral apices. Sepals are developed by the organization of a vegetative apex, from which there is a transition to the floral type of apex by the time of formation of the initials of the petals. It seems to me that the differences described by Grégoire are of a similar kind to those that I have described and attributed to limitation of growth.

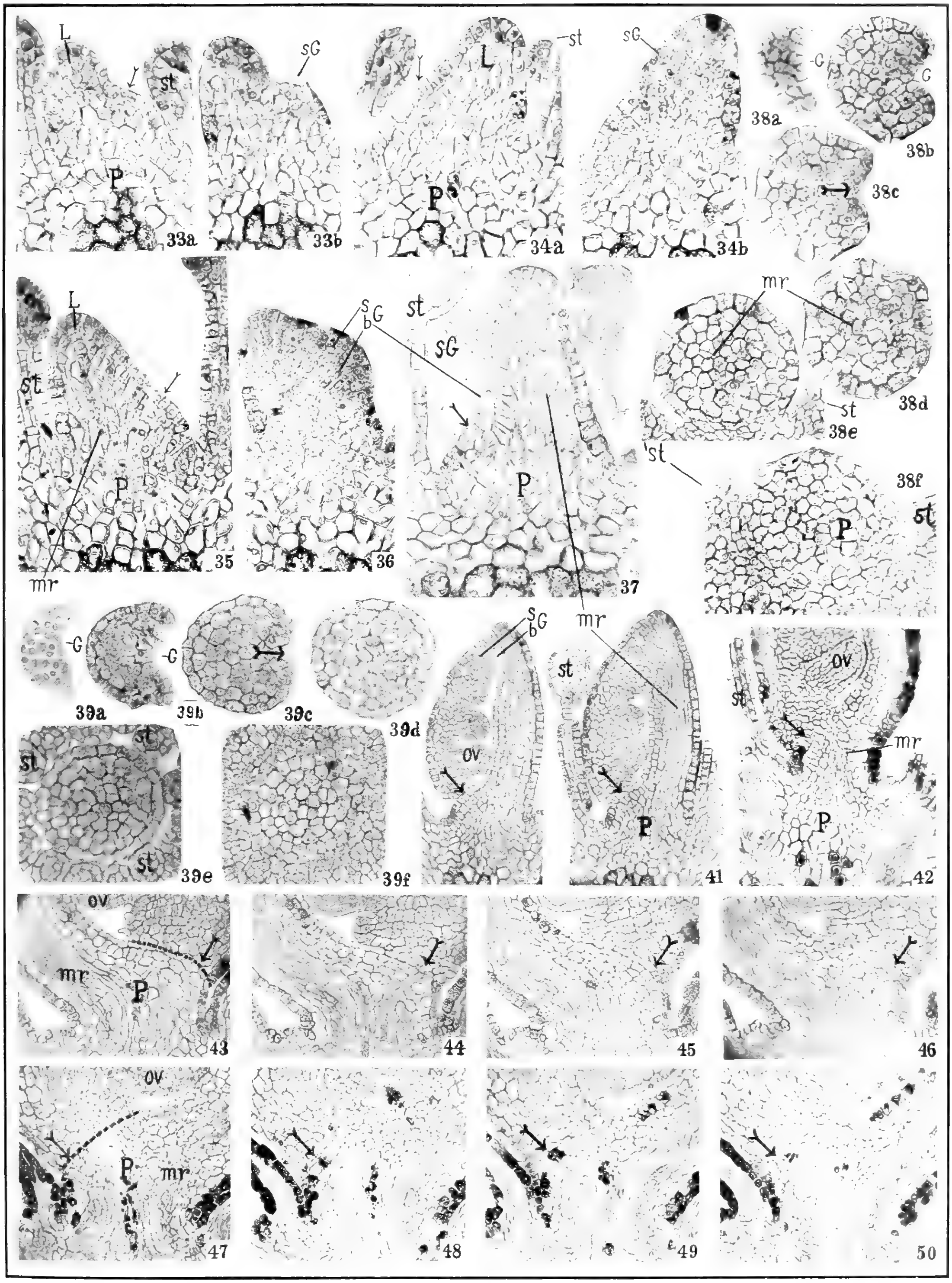
Finality in the interpretation of the flower will only be attained after very wide inquiry. In the meanwhile, it is well to emphasize that the classical interpretation is that the carpel is a *modified* fertile leaf and the flower a *modified* leafy shoot. A different appearance in the meristematic organization of the two forms of apex should, therefore, not be regarded as necessarily antagonistic to that interpretation.



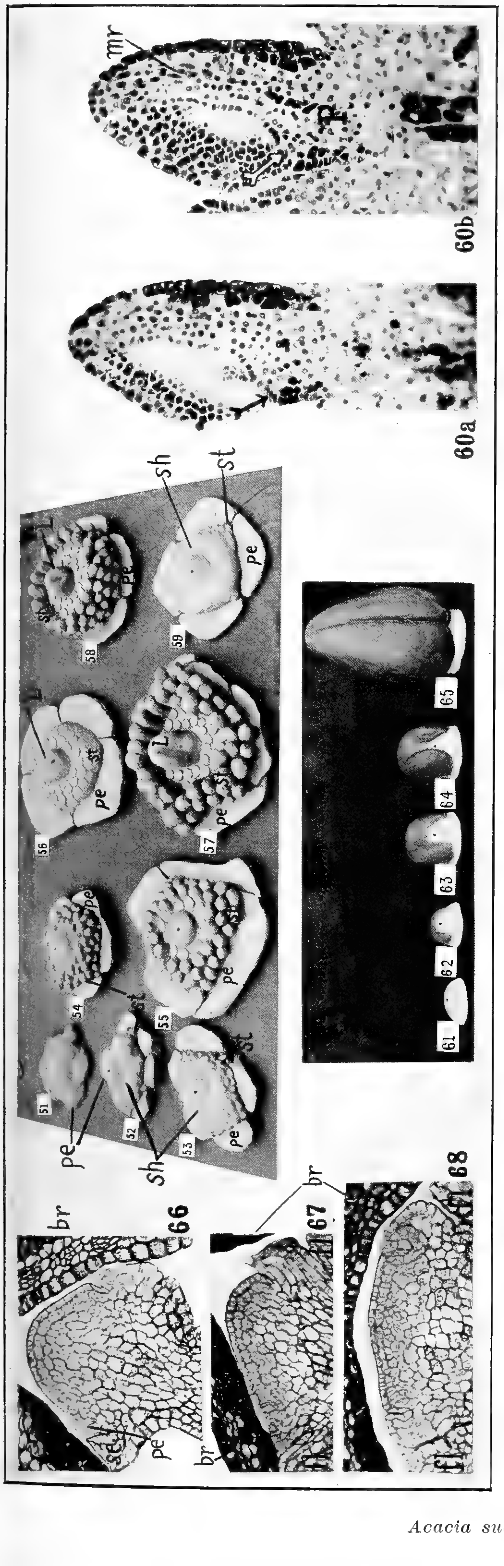
Acacia longifolia.—Longitudinal sections of young flowers.

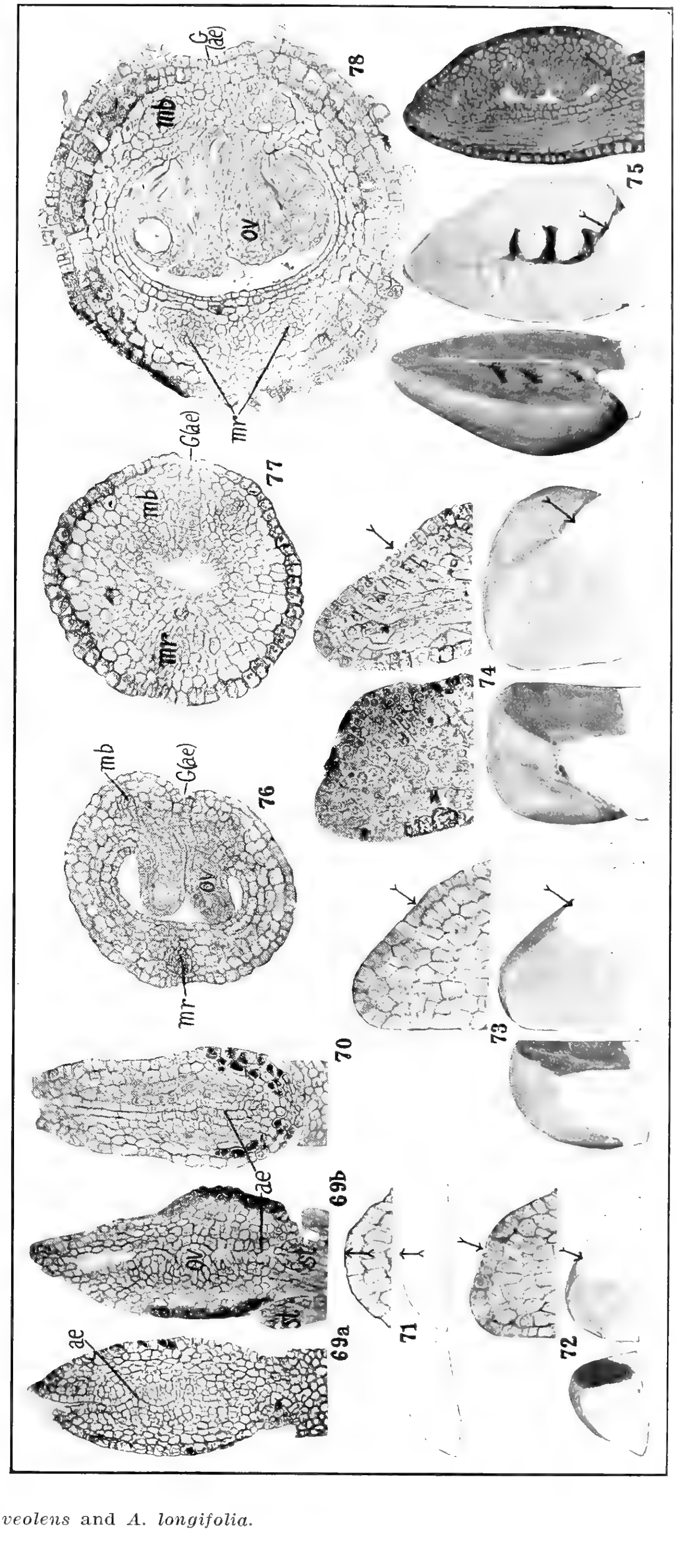


Acacia suaveolens.—Longitudinal sections of young flowers.



Acacia suaveolens (33*a*-38*f*; 40-50); *A. longifolia* (39*a*-*f*).





Acacia suaveolens and *A. longifolia.*

NOTES ON SARCOPHAGINAE IN INDIA AND AUSTRALIA.

By G. H. Hardy.

[Read 27th May, 1936.]

In his Revision of the Sarcophaginae of the Oriental Region, Mr. R. Senior-White (1924) considered that five species of *Sarcophaga* reach the Australian Region. It has become evident that specific relationships as then understood by that author need modification, and the relationship is one of groups, not species. It is due to the courtesy of Mr. Senior-White that I have been able to compare his reference collection of mounted genitalia taken from Indian species, finding there relationships that were not detected through the illustrations that he has hitherto published. I feel very grateful for the loan of this collection, for it has permitted me to gain an insight into various structures that otherwise may have taken years to acquire.

The assessment of the relationship between Indian and Australian Sarcophagas.

Before me are 25 species of *Sarcophaga* from Australia, 37 from India and Ceylon, and 1 from the Philippines. Amongst these 27 alliances are found, and it is possible further alliances have been overlooked or even a few species misplaced in *Parasarcophaga*, for the Oriental material is represented by genitalia only, one example for each of the 37 species. Also these, being mounted on slides, sometimes have their parts obscured, and it is not easy to reconstruct various structures that may have been overlapped by others. Nevertheless, I have concluded that 57% of the Indian, and 28% Australian species belong to subgenus *Parasarcophaga*, whilst a further 13% Indian species fall in groups containing 32% Australian species. The remaining 30% Indian and 40% Australian species are without mutual affinities recognized at present. The list is as follows:

Subgenus PARASARCOPHAGA.

(Australian.)	(Oriental.)
albiceps-group.	
omega J. & T., 1921; *gamma* J. & T., 1921.	***albiceps*** Meigen, 1826; *knabi* Parker, 1917; ***flavipalpis*** S.-W., 1924; *hirtipes* Wied., 1830; *orchidea* Bott.
misera-group.	
misera Walker, 1849; *kohla* J. & H., 1923; *eta* J. & T., 1921.	*dux* Thomson, 1868; *harpax* Parker, 1897; *scopariformis* S.-W., 1927; *tsushimae* S.-W., 1924.
peregrina-group.	
peregrina Desv., 1830.	*fuscicauda* Bott., 1912.
Miscellaneous.	
aurifrons Macq., 1846.	*aurifrons* Dol., 1856 (= *doleschalli* J. & T., 1921); *ballardi* S.-W., 1924; *khasiensis* S.-W.; *annandalei* S.-W., 1924; *kempi* S.-W., 1924; *walayari* S.-W., 1924; *caudagalli* Bott., 1912; *futuris* S.-W., 1924; *ostindicae* S.-W., 1924; *bambridgei* S.-W., 1925; *haemorrhoidalis* Meig., 1826.

Subgenus SARCOPHAGA (with propleura bare).

ruficornis-group.

kappa J. & T., 1921.	*ruficornis* Fab., 1794.

crinita-group.

omnia J. & H., 1923.	*crinita* Parker, 1917.

Subgenus ——— (with propleura hairy).

antilope-group.

alpha J. & T., 1921; *zeta* J. & T., 1921; *beta* J. & T., 1921; *furcata* Hardy, 1932.	*antilope* Bott., 1913; *henryi* S.-W., 1924; *flavinervis* S.-W., 1924.

impatiens-group.

impatiens Walker, 1849; *tryoni* J. & T., 1921.	*banksi* S.-W., 1924 (Philippines).

Miscellaneous.

(Propleura bare.) *depressa* Desv., 1830; *bancrofti* J. & T., 1921; *spinifera* Hardy, 1932. (Propleura hairy.) *epsilon* J. & T., 1922; *omikron* J. & T., 1921; *hardyi* J. & T., 1922; ? *fergusoni* J. & T., 1922; *littoralis* J. & T., 1922; *froggatti* Taylor, 1917; *alcicornis* Hardy, 1932.	(Propleura ??.) *melaneura* Meig., 1826; *gravelyi* S.-W., 1924; *pattoni* S.-W., 1924; *calcifera* Bott., 1912; *aspinata* S.-W., 1924; *haematodes* Meig., 1826; *falculata* v. *persicae* S.-W., 1924; *pusana* S.-W., 1924; *beesoni* S.-W., 1924; *talonata* S.-W., 1925; *orientaloides* S.-W., 1924.

As the propleural character of the Indian species is unrecorded, I am not able to group these under their respective subgenera, but I note that the posterior clasper has a subapical bristle on *pattoni*, *calcifera* and *talonata*, and a median bristle on *gravelyi* and *beesoni*. The others do not have any bristle apparent.

Key to genera of Australian Sarcophaginae.

1\. First radial vein bristly. Propleura bare. Three postsutural dorsocentral bristles. Posterior clasper with two bristles on the posterior half .... ? *Helicobia*
First radial vein bare 2
2\. Three postsutural dorsocentral bristles. Propleura bare. Posterior clasper without bristles .... ? *Blaesoxipha*
Four postsutural dorsocentral bristles. Propleura with hairs, or bare. Posterior clasper with bristles .... *Sarcophaga* Meig.

Key to species of Australian Sarcophaga.

1\. Propleura with hairs in abundance .... Subgen. ———. 14
Propleura bare, or at most with a limited amount of black bristly hairs confined to centre 2
2\. Posterior clasper with a pair of closely adjacent, rarely widely separated, subapical bristles .... Subgen. PARASARCOPHAGA. 3
Posterior clasper with bristles otherwise arranged .... Subgen. SARCOPHAGA. 9

Subgenus *Parasarcophaga*.

3\. Propleura with a few black bristly hairs in centre .... *peregrina* Desv.
Propleura entirely bare 4
4\. Anterior appendage in the form of a cup-shaped process arising from a stalk .... *albiceps*-group. 5
Anterior appendage otherwise formed 6
5\. Process of anterior appendage widely diverging .... *gamma* J. & T.
Anterior appendage compact, the process being short .... *omega* J. & T.
6\. With one or more rows of black bristly hairs behind postoculars 7
Without such bristly black hairs .... *misera* Walk.
7\. Anterior appendage with two pairs of foliaceous parts .... *kohla* J. & H.
Anterior appendage with only one pair of foliaceous parts 8
8\. Anterior appendage excessively long, projecting considerably beyond apex of sheath .... *eta* J. & T.
Anterior appendage normal in length, about as long as sheath .... *aurifrons* Macq.

Subgenus *Sarcophaga*.

9.	With three bristles spaced wide apart on posterior clasper	10
	With only one bristle on posterior clasper	11
10.	Genital segment red	*securifera* Vill.
	Genital segment black	*kappa* J. & H.
11.	Antennae red	*bancrofti* J. & T.
	Antennae black	12
12.	Bristle on posterior clasper placed subapically	*depressa* Desv.
	Bristle on posterior clasper placed basally	13
13.	With two rows of black bristly hairs behind postoculars	*synia* Hardy
	With one row of black bristly hairs behind postoculars	*spinifera* Hardy

Subgenus ———.

14.	With bristle on posterior clasper placed from the median to the subapical position	15
	With the bristle on the posterior clasper placed basally	26
15.	Anterior clasper bifid	*antilope*-group. 16
	Anterior clasper often with a large flange but not bifid	20
16.	Cleft of anterior clasper reaching base; apex of sheath at most bifid	17
	Cleft of anterior clasper not reaching base; apex of sheath trifid	18
17.	Filaments long and projecting	*alpha* J. & T.
	Filaments not to be detected	*zeta* J. & T.
18.	Second abdominal segment with a pair of median subapical bristles	*howensis* J. & H.
	Second abdominal segment without such bristles	19
19.	With the normal knob in membrane anterior to claspers	*beta* J. & T.
	Without such knob	*furcata* Hardy
20.	With the bristle on posterior clasper placed subapically	21
	With the bristle on posterior clasper placed in the median position	22
21.	Posterior clasper short and broad	*epsilon* J. & T.
	Posterior clasper long and slender	*omikron* J. & T.
22.	Anterior appendage with a hook-shaped process	23
	Anterior appendage without a hook-shaped process	24
23.	Both presutural and acrostichal bristles present	*impatiens* Walk.
	Only presutural acrostichals present	*tryoni* J. & T.
24.	Anterior clasper gently arched forwards	25
	Anterior clasper abruptly bent forwards	*alcicornis* Hardy
25.	Prescutellar acrostichals strong	*hardyi* J. & T.
	Prescutellar acrostichals absent, or at most very weak	?*fergusoni* J. & T.
26.	Both presutural and prescutellar acrostichals present	*littoralis* J. & T.
	Only presutural acrostichals present	*froggatti* Taylor

At present only about one-third of the species can be identified with any assurance from the female, although more than two-thirds have been allied by breeding, by capture *in copula* and by field observation. In cases where females have been associated with their respective males, an asterisk (*) has been placed in the following key. Further aid may be given when the species have a restricted distribution; for instance, *S. aurifrons* occurs abundantly in the south-eastern quarter of Australia, whereas *S. kohla* seems to be limited to Queensland. Similarly *S. hardyi* is not known from Queensland, so any females there that have the same recorded characters may be regarded as either the unknown females of *S. furcata* or of *S. ?fergusoni*. It seems probable that *S. tryoni* has a wider frons than that on *S. froggatti*, although this character may be obscure on bred specimens.

Very few of the females are to be recognized by superficial characters seen at a glance, but the red apex to abdomen on *securifera*, the red antennae on *bancrofti* and the quite distinct appearance of *S. littoralis*, with its very wide frons, lend themselves to ready recognition. *S. peregrina* may be readily isolated, its group of bristly hairs on the propleura being distinctive, but the mass of the species fall into two subgenera on the propleural character and may be further divided on certain bristle characters.

In 1927, J. R. Malloch (These PROCEEDINGS, lii, 334) suggested that certain unused characters, including the propleural one, might be used to ally sexes, but he overlooked the important point that the most closely allied species are generally difficult to recognize from females, and these are usually consistent in the characters he mentions. Malloch's suggestion does not seem very helpful for Australian forms, and I would suggest that characters he uses for specific recognition might be studied first for their value in group recognition. Again, Malloch's suggestion that the female genital segments might be used as specific indices apparently does not apply to Australian forms. When breeding these flies in numbers, I found that characters within the vagina may prove valuable, though not of use in practice. On freshly-emerged females, it is possible to extrude the vaginal skin and study the plates and depressions there, but I know no means of doing this once the integument becomes hardened.

Key enabling the sexes of some Australian species of Sarcophaga *to be allied.*

1. Genital segment red on both sexes. Propleura bare, male without, female with only prescutellar, acrostichals. Without black bristly hairs behind postoculars. (Introduced) .... **securifera* Vill.
   Genital segment black or brown on male, black on female 2
2. Propleura bare 3
   Propleura with hairs varying from 2-3 black bristly ones to moderately plentiful but confined to the central area. Only prescutellar acrostichals present. Two rows of black bristly hairs behind postoculars .... **peregrina* Desv.
   Propleura hairy, the hairs light-coloured and occupying all or most of the area .. 7
3. With one or more rows of black bristly hairs behind postoculars 4
   Without black bristly hairs behind postoculars 6
4. Both presutural and prescutellar acrostichal bristles present.
   Two rows of black bristly hairs behind postoculars .... **synia* J. & H.
   One row of black bristly hairs behind postoculars .... *spinifera* Hardy
   Only prescutellar acrostichals present 5
5. With two rows of black bristly hairs behind postoculars .... **aurifrons* Macq.; **kohla* J. & H.
   At most with only one row of black bristly hairs behind postoculars.
   Antennae red .... *bancrofti* J. & T.
   Antennae black .... **eta* J. & T.
6. Both presutural and prescutellar acrostichals present .... **omega* J. & T.; **kappa* J. & T.; **depressa* J. & T.; usually **gamma* J. & T.
   Only prescutellar acrostichals present .. **misera* Walk.; sometimes **gamma* J. & T.
7. With two rows of black bristly hairs behind postoculars .... **epsilon* J. & T.
   Without black bristly hairs behind postoculars 8
8. Both presutural and prescutellar acrostichals present 9
   Prescutellar acrostichals absent .... **tryoni* J. & T.; **froggatti* Taylor
9. With a pair of median discal bristles on second abdominal segment .. *howensis* J. & H.
   Without median discal bristles on second abdominal segment 10
10. Thorax with central stripe rather obscured. Head yellow only below. Frons of female unusually wide, nearly twice the width of an eye .... **littoralis* J. & T.
    Thorax with the central stripe normal. Frons of female normal. Head entirely yellow 11
11. Frons deeply golden .... **alpha* J. & T.; *zeta* J. & T.; **beta* J. & T.; **impatiens* Walker; *alcicornis* Hardy; **omikron* J. & T.
    Frons yellow .... **hardyi* J. & T.; ? *fergusoni* J. & T.; *furcata* Hardy

Subgenus PARASARCOPHAGA J. & T.

Originally I relied upon the presence of closely associated bristles placed subapically on the posterior clasper for the recognition of this subgenus, but apparently this character is variable for exotic species. Nevertheless, where the character does occur, it seems advisable to place the species in this subgenus and add thereto forms that appear to be obviously allied though without the character.

The Indian forms listed above under this subgenus include *ballardi* and *annandalei*, which species appear to have only one subapical bristle, whilst *ballardi*, *doleschalli* and *khasiensis* come near the *misera*-group. Another set of mutually related forms appears to be *annandalei*, *kempi* and *walayari*; and the relationship is obscure in regard to *caudagalli*, *futuris* and *ostindicae* unless the last be related to the *albiceps*-group; it is like *bambridgei* in being without an apparent bristle on the posterior clasper. Although *haemorrhoidalis* does not seem to belong to this subgenus, it is relegated there as it conforms to these bristle characters.

SARCOPHAGA MISERA group.

To the eighteen names already listed under this group, there is now added: *tsushimae* Senior-White, 1924, India.—The nature of the anterior appendage on this species shows a gradation between this group and certain species listed by me in the miscellaneous *Parasarcophaga.*

SARCOPHAGA MISERA Walker.

Sarcophaga ceylonensis Curran, *Amer. Mus. Novitates,* No. 375, 1929, 10 (nec Parker, 1923).

A record of this species from Victoria by Curran and his remarks suggesting the use of Parker's name for the Australian form, overlook the remarks on Parker's species published in 1927; these species are not identical specifically. Moreover, there seems to be no reason why Walker's name should not be used for the species which is not difficult to recognize from the female, and Major E. E. Austen has identified specimens by comparison with the type.

Subgenus SARCOPHAGA Meig.

There appear to be two groups in the Indo-Australian element, separable by the propleura being bare or hairy, and I am able to ascertain this character at present for the Australian species only. Those with the bare propleura, consisting of five species only, fall into relationship with the typical subgenus *Sarcophaga* as far as I am at present able to ascertain, and I have been able to ally two Australian species with exotic forms, suggesting group values.

SARCOPHAGA RUFICORNIS group (new group).

Forceps rather long and strongly bent at apex (as figured by Senior-White, not by Johnston and Hardy, whose figure was drawn from a different angle). The anterior and posterior claspers of almost equal length and the bristle on the latter placed subapically. The aedeagus has the inner process projecting beyond the sheath and the anterior appendage is short.

Two species: *ruficornis* Fabricius, 1794, India; *kappa* Johnston & Tiegs, 1921, Australia (*illingsworthi* Parker, 1922, Australia = *kappa*).

There can be no doubt concerning the alliance between these two species, for the structure of their genitalia is essentially the same. I have examined the structure on an Indian specimen having the organs exposed in the ordinary way, as well as the genitalia mounted by Senior-White.

SARCOPHAGA CRINITA group.

Hardy, *Australian Zoologist*, xiii, 1934, 52.

The Indian *crinita* does not have the minute indentation at the apex of the forceps; a basal flange covers the lower half of the anterior clasper, but this is not symmetrical on both sides; the clasper on one side of the aedeagus is as illustrated by Senior-White, i.e., almost furcate, but that on the other side is normal. Owing to the nature of the mounting, I am unable to ascertain if the bristle at the base of the posterior clasper is present, but there is a subapical bristle present, this being an addition that might be fortuitous.

From Manus, an island of the Mandated Territory of New Guinea, Mr. N. E. H. Caldwell secured a specimen of this group whose genitalia conform remarkably well with the figure given for *S. kankauensis* Baranoff, from Formosa.

SARCOPHAGA BANCROFTI J. & T.

Johnston and Hardy, PROC. LINN. SOC. N.S.W., xlviii, 1923, 122.

Hitherto the characters of this species have not been made out with assurance, but now a small series of specimens with well extracted genitalia has enabled me to ascertain the true characters. The figure given by Johnston and Hardy is moderately accurate. The forceps are broad, the claspers are of about equal length, and a median bristle occurs on the posterior one. The anterior clasper is strongly curved. The apex of the sheath terminates in a slender process along which the apex of both filaments lies protected and, when in their normal position, they are not easily detected as being structures apart from the sheath. The lobe is stout and the anterior appendage small with the tip curved, but not to the extent showing in the published figures.

It will be noted that the apex of the sheath is not split, as shown in the figures, but appears to be so because of the filaments occurring there. Also, it is suggested below that the type of *S. fergusoni* may prove to be identical with this species but confused with quite a different species standing under the same name. A conspicuous feature of *S. bancrofti* lies in the antennae being red, or yellow if very pale, instead of black.

Hab.—Queensland: Goondiwindi, 5 males, October and November, 1935. One specimen has the genitalia mounted on a cellulose slip in Canada balsam, displaying the various parts of the aedeagus.

Subgenus ———.

Those species that have the propleura covered with hairs come into this section; this character has not been taken into account, so far as I have yet ascertained, under named divisions standing as genera and proposed by various authors.

SARCOPHAGA ANTILOPE group.

Hardy, PROC. LINN. SOC. N.S.W., lii, 1927, 448.

To the six names that have been listed under this group must be added: *henryi* Senior-White, 1924, India; *flavinervis* Senior-White, 1924, India; *furcata* Hardy, 1932, Australia.

The little knob anterior to the claspers is missing on *furcata*, and I did not detect it on *henryi*. The anterior clasper is very shallowly bifid on *flavinervis*, which species has also a hook-shaped process suggesting an alliance with the *impatiens*-group.

SARCOPHAGA IMPATIENS group.

Hardy, *Austr. Zool.*, viii, 1934, 53.

To the two species placed under this group must be added: *banksi* Senior-White, 1924, Philippines.

The remarkable similarity of the genitalia of this species to those of the Australian *tryoni* suggests a close relationship, but there is no hook-shaped process on the anterior appendage and the claspers are comparatively small, the anterior one being without the flange. Nevertheless the bristle on the posterior clasper is in conformity with the group and the general features are similar.

SARCOPHAGA ? FERGUSONI J. & T.

Johnston and Hardy, PROC. LINN. SOC. N.S.W., xlviii, 1923, 124; fig. 1 only.

The type of *S. fergusoni* may be a specimen of *S. bancrofti*, for there is much to suggest this. Other specimens standing under the name apparently belong to a different subgenus and conform in genitalia to the figure given by Johnston and Hardy to supplement the drawing of the damaged genitalia on the type. Some new specimens before me have the form of genitalia corresponding to the latter figure, but show the anterior appendage full and rather broadly developed and without the curved apex. The apex of the sheath has, in addition, a pair of laterally spreading processes not shown in the figure. Moreover, the posterior clasper is twice as long as the anterior one and not like that drawn from the type which corresponds more closely to that on *bancrofti*. It is probable that Johnston and Hardy confused two species in the inferior material before them.

Hab.—Queensland: Goondiwindi, 2 males, November, 1935.

SARCOPHAGA OMIKRON J. & T.

Johnston and Hardy, PROC. LINN. SOC. N.S.W., xlviii, 1923, 120.

Most specimens hitherto collected are in inferior condition, but the present series shows the posterior clasper to be longer than the anterior, slender, well curved and with a subapical bristle.

Hab.—Queensland: Goondiwindi, October and November, 1935; 3 ♂, 4 ♀.

Genus BLAESOXIPHA Loew.

Blaesoxipha Loew, *Wien. Ent. Monatsch.*, v, 1861, 384.—*Locustivora* Johnston and Tiegs, *Proc. Roy. Soc. Queensland*, xxxiv, 1923, 187.

During the plagues of grasshoppers in the years 1934–1935, Mr. J. A. Weddell bred a parasite that is presumably identical with that described by Skuse, as the host is the same. This form, *Masicera pachytyli* Skuse, which Coquillet placed as a *Sarcophaga*, is apparently in no way generically distinct from other grasshopper parasites recorded under the generic name *Blaesoxipha*, and corresponds very well in its generic characters with those given by Lundbeck in his *Diptera Danica*. The two species known to me as occurring in Australia have most of their characters in common, but differ slightly in their genitalia. I have been unable to ally either of these with exotic species which have been adequately described during recent years, so they are probably indigenous forms and not introduced ones.

The following characters, unless otherwise stated, apply to both species.

Head: Only the inner vertical bristles present; ten frontals, the vibrissa and three facials, a second row of weak facials and a row of three bristles near the eye, nine orals. The postoculars have, below them, black bristly hairs that tend to form two further rows. One strong postvertical pair and a paired row of four further bristles extend behind the ocellar tubercle. *Thorax*: three humeral bristles, two posthumeral, four notopleural, two being very much reduced, one presutural, two supraalar, three intraalar, one being weak, one postalar, three presutural and three postsutural dorsocentrals, a paired row of acrostichals complete, the anterior pair and the posterior pair being well developed and the intermediate ones may also be more or less conspicuously developed but somewhat variable in this respect. Four pairs of scutellar bristles are strongly developed. Except for two large bristles above the coxae and the adjacent bristly hairs, the propleural region is bare. The mesopleural row is well developed and, in addition, further bristles may develop along the upper margin. A row of three sternopleurals and the pteropleural and hypopleural bristles are all normal. *Abdomen*: On the first segment laterally, there are three submarginals and about four discals arranged in two rows. The following segments each have a median pair of subapicals and laterally about five submarginals. *Legs*: the femora have the system of bristles conforming to that of *Sarcophaga*, but the hairs are invariably short. *Wings*: as in *Sarcophaga*, including the bristles on the vein R_{4-5}. *Terminalia*: the forceps taper more or less uniformly to the apex and are contiguous to the apex, i.e., they do not diverge apically as in *Sarcophaga*, but lie adjacent for their whole length. The forceps are without hairs, but bristles occur on a limited area giving a roughened appearance there. No bristle has been detected on the claspers, which are curved but otherwise simple. The anterior clasper is somewhat strongly curved and much broadened out on one species. The aedeagus has the two hinged segments as in *Sarcophaga*, but the apical one is much reduced and consists of a shaft, at the apex of which two small processes occur anteriorly, and then comes the sheath, simple in outline and partly enveloping the anterior appendage, which is also simple in outline and consists of a paired curved tapering part, blunt at the apex. The sheath and the anterior appendage lie closely adjacent to each other, and on one species the outline of the sheath is distended by the formation of flattened lobes, one at the apex slightly bent rearwards and one at each side tending still further to hide the anterior appendage.

Key to species of Blaesoxipha.

Anterior clasper about twice as broad at apex as at its narrowest part. Sheath of aedeagus with three rather small but well developed lobes, one at the apex and two at the sides .... *pachytyli* Skuse

Anterior clasper hardly broadened at apex. Sheath of aedeagus with lobes hardly if at all discernible .... *sp.*

BLAESOXIPHA PACHYTYLI Skuse.

Masicera pachytyli Skuse, *Agric. Gaz. N. S. Wales*, 1891, 251.—*Sarcophaga pachytyli* Coquillet, *Insect Life*, v, 1892, 22.—*Locustivora pachytyli* Johnston & Tiegs, *Proc. Roy. Soc. Queensland*, xxxiv, 1923, 187.

Hab.—New South Wales, Queensland, and probably widely distributed over other mainland States.

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Postscript, added 23rd May, 1936.—In a letter Dr. Boris Rohdendorf has kindly given me notes that tend to show where the above species come within his scheme of classification. There are two notes intimately connected with the above paper:

"The species *antilope* Bott. and other closely allied species must be referred to the genus *Chrysosarcophaga* Towns. 1932, type *superba* Towns. 1932, Solomon Isl., vide Baranov, 1934 . . ."

"The species *aspinata* S.W. is a *Blaesoxipha*."

AUSTRALIAN COLEOPTERA.

NOTES AND NEW SPECIES. NO. X.

By H. J. CARTER, B.A., F.R.E.S.

[Read 27th May, 1936.]

CUCUJIDAE.

There is considerable confusion, both in collections and catalogues, in the genus *Platisus*, largely due to an initial mistake by Lacordaire (Atlas, ii, pl. 21, fig. 11) in which, under the name *P. obscurus* Er., he figures the common New South Wales species *P. angusticollis* Reitt. This mistake was repeated by Olliff (These PROC., 1885, p. 210). The Junk Catalogue has another variation of it. As pointed out by Reitter, who knew Erichson's type, *P. obscurus* Er. is quite easily distinguished from his own two species by the toothed sides of the prothorax. There is no reason for the generic separation of *P. bicolor* Oll. (= *P.* (*Cucujus*) *coloniarius* Oll.).

The list should, I think, stand as follows:

PLATISUS Er.: (1) *angusticollis* Reitt. (syn. *obscurus* Lac. (*nec* Er.); (2) *coloniarius* Oll. (syn. *bicolor* Oll.); (3) *integricollis* Reitt.; (4) *moerosus* (*Ipsaphes*) Pasc.; (5) *obscurus* Er.

N.B.—Ipsaphes nitidulus Macl. = *Platycotylus inusitatus* Oll. It is also very near *Doliema spinicollis* Fairm., but, on a re-examination of the much begummed type, I cannot detect the spines that characterize Fairmaire's species. It is not a *Platisus*, as placed in the Junk Catalogue.

HYMAEA PARALLELA, n. sp. Text-fig. 1.

Elongate, oblong; mostly nitid black, oral organs, apex of pronotum and greater part of elytra red; sparsely pilose.

Head subtriangular, eyes very prominent—less acutely so than *H. succinifera* Pasc., tumid behind eyes, front coarsely punctate, the punctures tending to coalesce longitudinally; antennae long, perfoliate, 1 very stout, 2–8 piriform, 9–10 rounded and transverse, 11 oval, longer than 10. *Prothorax* longer than wide, convex laterally, apex produced in middle, anterior angles obsolete, base truncate, hind angles obtuse, sides slightly widest behind middle, with some lateral angulations; one near front, another, at widest part, marked by a pustule. Disk coarsely punctate, the punctures tending to coalesce, their intervals rugose; some widely placed pustules, two, near middle, slightly in advance of lateral pustules. *Scutellum* transverse, oval. *Elytra* distinctly wider than prothorax at base, shoulders rather square, sides parallel for the greater part; disk rather flat, striate-punctuate, the striae not well defined, the punctures large, round and close, the intervals very narrow and, in general, flat, here and there forming irregular raised lines—the 5th especially—and clothed with sparse, pale, upright hair; the black markings in rather irregular patches; of these, two oblique patches extend from beneath the shoulders to the 3rd interval near middle; a square patch behind these at middle and one or two ill-defined streaks near base. *Underside* nitid-black, everywhere closely and strongly punctate. *Dim.* 4 mm. long.

Hab.—Victoria: Warburton (F. E. Wilson).

A narrow, elongate species, without tubercles on the elytra. Two examples, including the holotype, in the South Australian Museum.

N.B.—*H. laticollis* Cart. was described as having "head placed vertically". This was due to the setting of the type example. A second example sent me has the head inserted quite as in *H. succinifera* Pasc. My species has been omitted from the Junk Catalogue though described in 1908. The 3 species may be distinguished as follows:

Hymaea.

1. Pronotum without tubercles .... *laticollis* Cart.
   Pronotum with tubercles 2
2. Elytral humeri with elongate tubercles .... *succinifera* Pasc.
   Elytral humeri without tubercles .... *parallela*, n. sp.

DASCILLIDAE.

EPILICHAS (?) NIGRINUS, n. sp.

Elongate-ovate; subnitid-black, antennae, underside and appendages red, legs testaceous.

Head: eyes large and prominent, antennae long and strongly serrated, 1 ovoid stout, 2 very small, 3–10 serrate, 3 and 10 smaller than the rest, 11 lanceolate. *Prothorax*: apex rounded, narrower than head, sides widest at base, nearly straight at basal fourth, thence sharply narrowed, and devolute to apex, margins only near base evident from above, disk uniformly, very minutely and densely punctate, and rather thickly pilose with short, upright hair. *Scutellum* large and oval. *Elytra* little wider than prothorax, sides nearly straight for two-thirds of length; striate, without defined punctures in striae, intervals nearly flat at middle, more convex at base and apex; very minutely punctate with feeble transverse strigae, surface closely pilose, underside impunctate and pubescent. Coxae approximate. *Dim.* 15 × 3½ mm.

Hab.—Victoria: Healesville (F. E. Wilson).

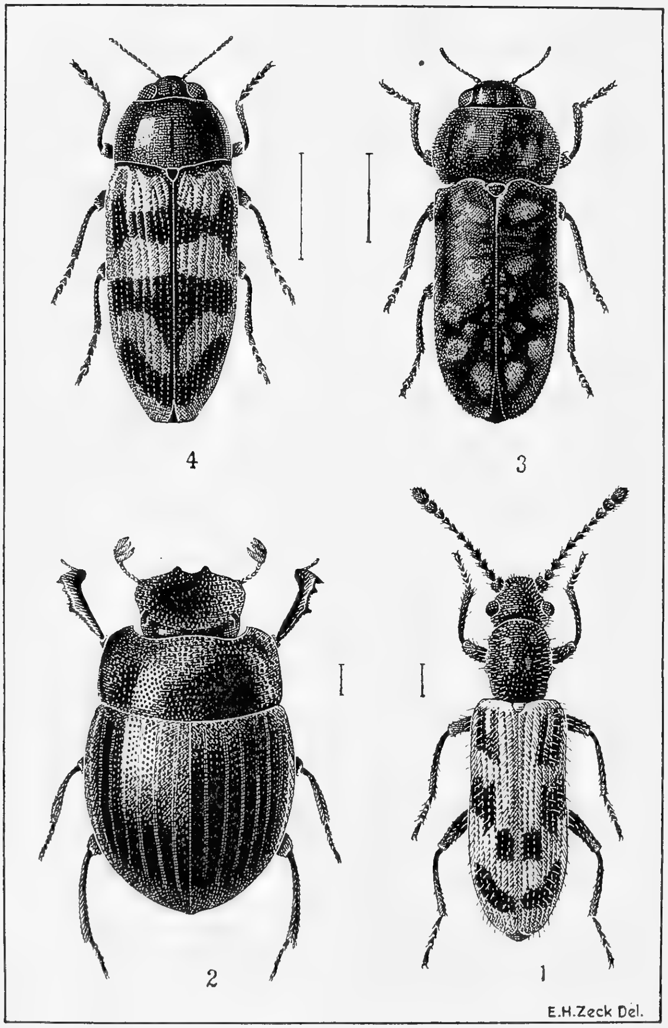
A single example taken by my friend is clearly allied to *E. serraticornis* Cart., from which it differs in colour, more elongate and less convex form and denser clothing. Holotype in Coll. Wilson.

SCARABAEIDAE.

PANELUS HOPSONI, n. sp. Text-fig. 2.

Ovate; piceous-black, sides of head, narrow margin of apical third of prothorax, also underside and legs red; antennae and palpi testaceous.

Head wide, basal two-thirds rounded, sides subangulately narrowed towards apex, clypeus bidentate, the triangular teeth limiting a circular excision; whole surface with close, round, cellulose punctures; antennae 10-segmented with trilamellate club. *Prothorax*: apex arcuate-emarginate, anterior angles subacute, sides lightly obliquely widened from base to apical third, thence abruptly narrowed to apex; posterior angles obsolete (rounded off); surface with round punctures larger and slightly less dense than on head. *Scutellum* none. *Elytra* widest at middle, each with six rows of finely impressed, geminate striae, without visible punctures; intervals flat and finely, not closely, punctulate, the two nearest suture sublaevigate. Tibiae carinate and bowed, the anterior tridentate at apex. Underside closely, not coarsely, punctate, the apical segment of abdomen with large punctures. *Dim.* 4¼ × 2¾ mm.



1.—*Hymaea parallela*, n. sp.
2.—*Panelus hopsoni*, n. sp.
3.—*Cisseis goerlingi*, n. sp.
4.—*Stigmodera* (*Castiarina*) *truncata*, n. sp.

Hab.—N.S.W.: Barrington Tops (H. J. Carter).

I took one example in rotting leaves in January, 1927, which I dedicate to the memory of John Hopson, the late naturalist of this region, whose help and friendship were delightful concomitants of a beautiful district. It is the largest of described Australian species, distinguished from *P. bidentatus* Wilson by the distinct geminate striae of its elytra. Holotype in Coll. Carter.

PANELUS POLITUS, n. sp.

Castaneous, highly polished, hind margins of prothorax infuscate, and parts of elytra feebly so, antennae testaceous.

Head shaped like the ace of spades (with a rounded base and a bidentate apex), the clypeal teeth acutely produced and a little recurved, their interspace triangular. Sides of head foliate and concave; surface finely, not closely, punctulate. *Prothorax* widely transverse and subrectangular, apex lightly bisinuate, base arcuate, sides nearly straight for basal three-quarters, thence abruptly and strongly narrowed to the widely obtuse and scarcely emarginate front angles; disk uniformly punctulate, the punctures much larger than on head. *Elytra* widely ovate and convex, with about six fine, but distinctly impressed, striae, the two nearest suture on each geminate (two very fine close striae, the rest single); intervals flat and apparently impunctate. Tibiae bicarinate and strongly arched externally, less arched internally, fore tibiae tridentate at apex. *Dim.* 3 × 2 mm. (approx.).

Hab.—N.S.W.: Dorrigo (W. Heron).

A species characterized by its polished and almost glabrous (even to the legs) surface, while the subfoliate head is peculiar. It is nearest to *P. pisoniae* Lea in colour and size, but differs in the more evident striae and laevigate intervals of elytra. *P. pisoniae* is also said to have bidentate front tibiae, but this may be sexual. I have a short note on it from the late A. M. Lea, as to its distinction from his species. Holotype in Coll. Carter.

A cotype of *P. pisoniae* Lea, sent for examination by Mr. Womersley, is less than 1¾ mm. long, more convex than *P. politus*, with clearly impressed punctate striae. The clypeal teeth are shorter, the head itself less elongate, the foliate sides obliquely revolute.

The five Australian species may be tabulated as follows:

Panelus.

1.	Elytra with geminate striae	2
	Elytra with single striae	3
2.	Posterior angles of prothorax obsolete, 4 mm. long	*hopsoni*, n. sp.
	Posterior angles of prothorax obtuse, 2 mm. long	*pygmaeus* Macl.; *arthuri* Blckb.
3.	Colour black, with red spots	*bidentatus* Wils.
	Colour red or castaneous	4
4.	Head gently concave, elytral striae faint	*pisoniae* Lea.
	Head concave at sides, elytral striae distinct	*politus*, n. sp.

PEDARIA INTERRUPTA, n. sp.

Black, nitid, antennae and tarsi reddish, upper surface sparsely setose, the setae short and bristly.

Head subvertical, very wide and flat, coarsely punctate, clypeus obtusely bidentate, with widely arcuate bay. *Prothorax*: apex and base subequally wide, the former lightly arcuate-emarginate, anterior angles slightly advanced and rounded, the arcuate base more or less parallel to apex, sides sinuate, with a light medial enlargement; disk with a few smooth prominent rugae, surrounded by irregular coarse punctures having a longitudinal tendency. A wide depression at middle of basal half, bounded by oblique rugae. *Elytra* rather squarely ovate, the suture forming twin carinae enclosing fine striae: on each elytron three rows of longitudinal pustules, these more elongate on inside row, smaller and more distant on outer rows; a well-defined costiform pustule near each shoulder; intervals between these rows containing two pairs of well-marked geminate striae, the striae becoming undulate towards apex. Whole underside (including front femora) very coarsely punctate, the mesosternum carinate, with two rows of very large transverse punctures on each flank, anterior tibiae tridentate, the three teeth rather wide apart, post tibiae widely triangular. *Dim.* 4 × 2·5 mm.

Hab.—Queensland: Benarkin (L. Wassell), Bundaberg (C. Bates).

Two examples in my cabinet differ from the two described Australian species (*geminata* Macl. and *alternata* Lea) by the elytral sculpture with its interrupted costae and the more strongly defined geminate striae. Holotype in Coll. Carter.

PEDARIA METALLICA, n. sp.

Nitid, head violet-bronze, prothorax and elytra dark blue, the former with metallic gleams, upper surface with short, sparse, bristly setae of a whitish colour, underside and legs coppery-bronze, glabrous, antennae pale red.

Head wide and rather flat, its basal two-thirds subparallel, thence obliquely narrowed to the bidentate clypeus, this with two triangular teeth, separated by an arcuate bay, surface coarsely punctate, with an undulate ridge traversing the forehead, clypeus and margins subhorizontal. *Prothorax* strongly transverse, apex nearly straight for the greater part, anterior angles advanced and acute, sides feebly rounded at middle, abruptly, arcuately, narrowed near front angle, widely rounded off behind, base arcuate; disk moderately convex and uneven, a wide, subtriangular depression having its apex at middle of base and bounded by wide, oblique, almost impunctate, rugae; the depression and lateral regions strongly and rather closely punctate, the medial apical half very sparsely and coarsely punctate. *Elytra* oblong-ovate, each with 8 pairs of geminate carinae, besides a pair of sutural carinae more widely separated than the rest, the 2nd and 4th intervals with setiferous punctures, the 3rd with one or two elongate pustules; setae more evident at sides and apex. *Metasternum* with sparse, foveate punctures at base and sides, abdomen and femora with close round punctures. Front tibiae with three well separated teeth at apex, hind tibiae widely triangular. *Dim.* 3½ × 2 mm.

Hab.—N.S.W.: Clarence River (Macleay Museum).

A single example in the Macleay Museum has no record of capture, except the printed locality label. It is clearly distinct from other described species, not only by its metallic surface, but by the elytral sculpture, with the well raised but fine geminate carinae. A second example, from Stanthorpe, Queensland (E. Sutton), sent for determination, is in the Queensland Museum. Holotype in the Macleay Museum.

The four recorded Australian species may be tabulated as follows:

Pedaria Castelnau.

1.	Colour black	2
	Colour metallic	*metallica*, n. sp.
2.	Elytra without pustules	*alternata* Lea.
	Elytra with pustules	3
3.	Elytral pustules small and round	*geminata* Macl.
	Elytral pustules elongate and costiform	*interrupta*, n. sp.

BUPRESTIDAE.

MELOBASIS IMPRESSA, n. sp.

Elongate-ovate; nitid, concolorous coppery bronze; somewhat explanate, more or less pubescent.

Head densely punctate, with smooth medial space terminating behind in a fine sulcus; sparse pubescence consisting of long silvery hair. Eyes large, moderately prominent. *Prothorax*: apex lightly, base more strongly bisinuate, widest behind middle, sides well rounded, narrowed to the acutely-produced anterior angles, a little sinuate before the subrectangular hind angles; disk finely and irregularly punctate, with silvery hair, sparse in middle, more dense at sides; a medial carina feebly indicated, an oval depression near each lateral margin behind middle. *Scutellum* rather small, nodulose (or subcarinate) in middle. *Elytra* slightly wider at shoulders than prothorax, sides subparallel on basal half, thence narrowed behind, subapical margins serrulate, extreme apices rounded, extreme border evident from above throughout; disk irregularly impressed and punctate, each with four large impressions, the first behind humeral angle, the second, transversely oval, premedial, a subelongate postmedial one and a lighter depression between the two former; the depressions bounded by light vermiculate rugosity; two more clearly defined, straggly costae extending from the postmedial impression to apex; everywhere variably punctate, the punctures in general round and distinct, those near suture showing a subseriate tendency. A sparse pubescence near shoulders and margins. Underside densely punctate, sparsely pubescent. *Dim.* 15 × 5 mm.

Hab.—Western Australia: Wurarga district (Mr. A. Goerling).

Four examples, sent by Mr. Goerling, of Marloo Station, Wurarga, show a species that is unique in sculpture, though deviating less from the normal than *M. abnormis* Cart. The elytra at first appear to have been slightly crushed by pressure, but the symmetry of the impressions disproves this. Holotype in Coll. Carter.

MELOBASIS WANNERUA, n. sp.

Convex, oblong; head, prothorax, underside and legs golden-green, elytra brassy, greenish at sides and base, tarsi and antennae blue.

Head densely, finely punctate, with indistinct short pubescence. *Prothorax*: apex and base subtruncate, base very feebly bisinuate; sides lightly, arcuately narrowed from base to apex, anterior angles obtuse, posterior subrectangular; disk very minutely punctate, finely strigose at sides; two shallow foveae in front of middle, medial line indicated only at base and apex. *Scutellum* small, depressed. *Elytra*: sides almost straight, apical third with margins denticulate; striate-punctate, intervals nearly flat, those near suture slightly rounded, the strial punctures irregular, the general surface transversely wrinkled, feebly concave near suture. *Prosternum* densely punctate near front, more sparsely behind, metasternum sparsely and finely punctate, abdomen closely and finely, the apical segment densely so and truncate at apex between two strong spines. *Dim.* 10 × 4 mm.

Hab.—Western Australia: Wanneru (H. W. Brown).

Two examples under examination, both ♂, show an approach to *M. derbyensis* Blkb. in colour and the striate-punctate elytra (rather uncommon in the genus). Mr. Clark has kindly compared it with the type of Blackburn's species, and the following distinctions are noted:

derbyensis Blkb.	*wannerua*, n. sp.
Head at eyes wider than base of prothorax; clothed with white recumbent hair.	narrower than base of prothorax; feebly pubescent.
Prothorax sides well rounded, and more elongate.	sides feebly rounded, less elongate.
Elytra strongly depressed at base.	scarcely depressed,
Colour golden-bronze throughout.	green, elytra brassy-green.

Holotype in Coll. Carter.

CISSEIS GOERLINGI, n. sp. Text-fig. 3.

Elongate, parallel; head coppery-bronze, pronotum opaque bluish, with lateral pubescence, elytra blue with white pubescent spots. Underside metallic bronze with green and metallic reflections.

Head very finely punctate, with shallow longitudinal sulcus at base, feebly pubescent. *Prothorax* convex, strongly transverse, widest at middle, apex lightly arcuate, base bisinuate, sides widely rounded, lateral carinae parallel for the greater part, meeting behind at a sharp angle, with a subobsolete, white pubescent vitta above carinae; disk finely, transversely striolate, with two circular depressions, with faint signs of white flocculence. *Scutellum* transverse, bronze. *Elytra* not as wide as prothorax at its widest part, and more than thrice as long; subparallel for the greater part, each separately, and rather widely, rounded at apex; subapical margins minutely serrulate, as also margins of abdomen. Disk with 6 large round, white pubescent spots and faint indications of a subapical pair; suture near base coppery. Segments of abdomen with white lateral impressions. *Dim.* 14 × 5·5 mm.

Hab.—Western Australia: Wurarga (Mr. A. Goerling).

Four examples examined. It belongs to my Section 1 (These PROC., 1923, p. 163), but is distinguished from all recorded species by its wide prothorax with elongate, parallel elytra narrower than prothorax. Holotype in Coll. Carter.

ANILARA SUBIMPRESSA, n. sp.

Oblong-oval; nitid bright bronze above, underside and appendages obscure bronze.

Head uniformly convex, eyes not prominent, widely separated, surface finely scalose-punctate. *Prothorax* transversely convex, apex and base nearly straight, the latter lightly bisinuate; widest in front of middle, sides here well rounded, thence arcuately narrowed to apex, behind nearly straight; disk finely punctate in middle, transversely rugose towards base, alveolate punctate at sides, a large depression near each side at middle. *Scutellum* elongate-ovate, punctulate. *Elytra* of same width as prothorax at base, feebly compressed behind shoulders, sides nearly straight for the greater part, widely, separately rounded at apex, subapical margins serrulate, abdominal margins more coarsely serrate; a subcostate impression originating at shoulders obliquely inclined inwards to basal third, thence gradually obsolescent, tending towards, but not reaching suture; a second short, subobsolete impression at base, between the former and scutellum; surface scalose-punctate, strongest at sides and apex. *Underside* finely alveolate punctate; *mentum* subrectangular, minutely, transversely striolate. *Dim.* 4–5 × 2 mm.

Hab.—Western Australia: Tammin (H. W. Brown).

Four examples sent are clearly distinct from *A. subcostatus* Blkb., the only other subcostate species, by smaller size, brighter colour, and finer sculpture. The undersides of the two are widely different, especially the mentum, which is granulose in *subcostatum*. Holotype in Coll. Carter.

STIGMODERA (CASTIARINA) TRUNCATA, n. sp. Text-fig. 4.

Elongate, oblong, rather flat. Head and pronotum dark greenish-bronze, elytra yellow with basal margin, two fasciae and preapical mark greenish-blue, the premedial fascia bifurcating laterally, its forward branch extending to basal margin at the shoulders, lateral margins sanguineous throughout. Underside and legs dark olive-green, with some bronze reflections.

Head finely punctate, with shallow medial sulcus. *Prothorax* widest at base, thence lightly and arcuately narrowed to apex; apex and base very lightly bisinuate, anterior angles unseen from above, hind angles subacute; densely and finely punctate on disk, with smooth medial line terminating behind in a small fovea. *Scutellum* subcordate, depressed in middle and impunctate. *Elytra* enlarged at shoulders, compressed behind them, apices truncate, the margins everywhere entire: striate-punctate, the seriate punctures round and regular, becoming smaller toward apex; intervals nearly flat and transversely wrinkled, those on lateral half finely and closely punctate. Prosternum strongly, metasternum finely punctate, abdomen rather densely clad with recumbent white hair. *Dim.* 14–15 × 5½ mm.

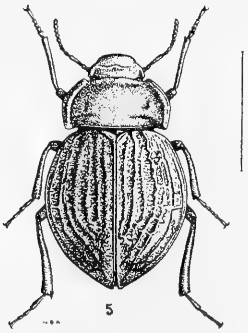
Hab.—Western Australia: Moore's River (H. W. Brown).

Mr. Brown still succeeds in finding new species of his favourite group in Western Australia. Two examples (one returned to its captor) belong to Section XIV of my tabulation (*Aust. Zool.*, 1931, p. 365) near *S. cupreoflava* Saund., but the dark parts more or less olive-green, the truncate apices and sanguineous sides of elytra readily separate it from its neighbours. In one of the examples the dark areas predominate, i.e. fasciae and preapical mark are wider. There is no external character to denote sex. Holotype in Coll. Carter.

TENEBRIONIDAE.

NYCTOZOILUS SUBSCULPTUS, n. sp. Text-fig. 5.

Widely ovate, convex; dull black above and below, tarsi with red tomentum beneath.



5

5.—*Nyctozoilus subsculptus*, n. sp.

Head rather closely and finely punctate; epistoma rounded in front and meeting antennal orbit at a wide angle, the latter subhorizontal, an elongate depression near base; antennae extending to base of prothorax, 3rd segment longer than 4–5 combined, 8–11 less enlarged than usual. *Prothorax* 4 × 8·3 mm., apex arcuate-emarginate, anterior angles subacute, base subtruncate, posterior angles obtuse, not produced, sides rather widely rounded without sinuation, widest near middle. Foliate margins wide and subhorizontal, with a very thin border, disk smooth, without distinct punctures, some undefined foveae near middle, and a slight transverse depression near base. *Scutellum* transversely triangular. *Elytra* widest behind middle, not much longer than wide (11 × 9½ mm.), a row of punctures within a subobsolete border, surface with vague costae, about four on each, connected by equally vague vermiculations, the suture slightly raised and nitid near middle. Abdomen strigose, the two apical segments finely punctate. *Dim.* 16 × 9½ mm.

Hab.—Central Queensland: Aramac district (Mr. F. Bradshaw).

A wide convex species that stands near *N. ruficornis* Cart. in my table of the genus (These Proc., 1925, p. 235). But the antennae and tarsi are black, or nearly so, while the elytral sculpture is less pronounced than in *ruficornis*, or indeed any other species before me. Holotype, K43425, in the Australian Museum.

PLATYPHANES PLANATUS, n. sp.

Oblong-oval; above varicolorous, dark green and purple intermingled, purple predominating on the pronotum and apical area of elytra; legs and underside dark red, antennae and tarsi pale red.

Head finely punctate, antennae short, segment 1 stout, 2 short, 3–4 subcylindric, 5–10 successively shorter and wider, 11 narrower than 10, oval. *Prothorax* 4½ × 8 mm., arcuate-emarginate at apex, angles advanced but widely rounded, base bisinuate, much wider than apex, posterior angles subrectangular, sides arcuately narrowed from base to apex, a narrowly raised margin, a little explanate near front angles, disk somewhat depressed, finely and rather closely punctate, without medial line or foveae. *Scutellum* large, triangular. *Elytra* (17 × 10 mm.) wider than prothorax at base, shoulders rounded, subparallel for the greater part; very finely striate-punctate, with about ten feebly marked striae, seriate punctures small, intervals quite flat, minutely punctate. Flanks of prosternum with fine longitudinal strigae, sides of metasternum strongly punctate, middle regions almost impunctate, basal segments finely strigose. *Dim.* 22 × 10 mm.

Hab.—Western Australia: Wurarga (Mr. A. Goerling).

A single example of this fine species is a rather close ally of the Queensland *P. chalcopteroides* Cart. in form and dimensions, but is readily separated by its much finer sculpture, the striae scarcely discernible except under a lens. Holotype in Coll. Carter.

ADELIUM HIRSUTUM, n. sp.

Oblong-ovate; dark violet-bronze, subopaque. Whole upper surface rather thickly clothed with long, dark, upright hairs.

Head coarsely, sparsely punctate, with a longitudinal sulcus on each side, extending from behind eyes to the clypeal suture. Antennae stout, segments more or less piriform, successively widening to apex, 11 unusually large and ovate, 3 as long as 4 and 5 combined. *Prothorax* rather convex, apex arcuate, anterior angles widely obtuse and depressed, base truncate, posterior angles obtuse, little but clearly defined by a small postlateral sinuation. Widest at middle, sides evenly rounded, without definite foliation; disk coarsely punctate, the round punctures closer and more regular than in *A. pilosum* Pasc., with a few smooth transverse raised spaces near middle. *Scutellum* smooth and nitid. *Elytra* wider than prothorax at base, shoulders rounded, sides very lightly arcuate; punctate-striate, the strial punctures large, round or oval, and closely set; intervals convex, the space between the seriate punctures also raised, intervals dotted with setae bearing long hairs. *Prosternum* with coarse, sparse punctures; post-intercoxal process subtruncate. *Dim.* 11 × 5 mm.

Hab.—N.S.W.: Wee Waa (? S. W. Jackson).

A single ♂ example, generously given me by Mr. H. Davidson, came from a collection, originally Mr. Jackson's, lately acquired by the former. It is a very distinct species belonging to Section 1A of my revision (These Proc., 1908,

p. 272) and readily separated from *A. pilosum* by smaller size, evenly rounded prothorax (subangulate in *pilosum*), the regular strial punctures of the elytra, and the more strongly pilose upper surface, this extending even to the head. The three pilose species, *A. barbatum* Cart., *A. pilosum* Pasc. and *A. hirsutum*, exhibit three degrees of hairiness, the first two sometimes needing a close examination to show this. Holotype in Coll. Carter.

BRYCOPIA BAROSSAE, n. sp.

Ovate; nitid-bronze, pilose above, appendages red.

Head rather coarsely punctate, clypeus rounded, eyes, from above, round and moderately prominent, antennae slender, segment 3 as long as 4–5 combined, 4–8 oblong-obconic, gradually widening, 9–10 subtriangular, 11 narrowly ovate, much longer than 10. *Prothorax* transverse, widest at middle, apex nearly straight, anterior angles sharply rectangular, base feebly, convexly arcuate, hind angles widely obtuse, sides with four subequal crenulations, forming angles, the widest part clearly angulate and setose within margin; disk coarsely setose-punctate, without medial line or defined foveae. *Elytra* much wider than prothorax at base, striate-punctate, the strial punctures round, diminishing in size towards apex, intervals lightly convex, irregularly punctulate-setose, a pale, upright hair springing from each such puncture. Legs rather thin, post tarsi having 1st segment shorter than the rest combined. *Dim.* 4–5 mm. long.

Hab.—South Australia: Barossa (A. H. Elston), also in Macleay Museum.

Three examples are before me. Two of these have long been in my cabinet, confused with *B. minuta* Lea. The third example is in the Macleay Museum. While superficially like *B. minuta* in size and form, it can be readily separated by (1) the pilose surface, (2) the elytral punctures round, more distant and smaller than the squarish, closer punctures of *B. minuta* Lea. Holotype in Coll. Carter.

BRYCOPIA BROWNI, n. sp.

Ovate; nitid-bronze.

Head coarsely punctate, antennae moniliform, the three apical segments subspherical, little wider than preceding. *Prothorax* widest behind middle, sides well rounded, strongly sinuate behind, anterior angles obtusely rounded off, posterior angles rectangular, disk coarsely and rather closely punctate, without any sign of medial sulcus. *Elytra* wider than prothorax at base, shoulders squarely rounded; striate-punctate, the striae deep and wide near suture, narrower towards sides, strial punctures large, round and rather close; intervals flat and clearly punctate, the 5th wider than the rest. *Dim.* 7 × 3·6 mm.

Hab.—? Queensland (H. W. Brown).

A single example given me some years ago by Mr. Horace Brown as from Queensland, but unlabelled, was erroneously placed with *B. cheesmani* in my cabinet, but may be distinguished from that species as follows:

cheesmani Cart.	*browni*, n. sp.
Colour, subnitid violet-bronze.	nitid brighter bronze.
Disk of pronotum, with medial sulcus.	not sulcate.
Prothorax widest at middle, sides feebly sinuate behind, hind angles obtuse.	widest behind middle, sides strongly sinuate behind, hind angles rectangular.
Intervals of elytra uniformly wide, strongly punctate.	5th interval wider than rest, intervals less strongly punctate.

Holotype in Coll. Carter.

BRYCOPIA DENTICULATA, n. sp.

Ovate; nitid-bronze, antennae and tarsi red.

Head strongly, rather closely punctate, clypeus rounded and bearing a few prominent setae; a long seta on each side in front of eye. Antennae rather long, extending to base of prothorax, segment 3 twice as long as 4, 4–8 subequal, moniliform, 9–11 of increasing size, 9–10 subtriangular, 11 oval, twice as long as 10. *Prothorax*: apex and base truncate, all angles obtuse, widest at middle, sides here strongly, subangulately widened, markedly sinuate behind, the sinuation starting from a denticulation, one or two other denticulations at margin, in number slightly varying in the five examples before me, one near middle bearing a prominent seta; lateral foliation narrow; disk uniformly and coarsely punctate, without sign of a medial line. *Elytra* ovate, slightly wider than prothorax at base, widest at middle, moderately convex, shoulders rather squarely rounded; striate-punctate, the punctures large on basal half, becoming smaller to apex; intervals flat and impunctate. *Prosternum* with a few irregular punctures at middle, more evenly and closely on the flanks, meso and meta sternum and abdomen sparsely, the apical segment densely punctate. *Dim.* 3–4 mm. long.

Hab.—Western Australia: King George's Sound (in Australian Museum).

Five examples bear a label of recent date, but the specimens have been for some time in the Museum. In my table it stands near *crenaticollis* Cart., which, however, is twice the size. *B. minuta* Lea has distinct pilose clothing, among other differences. *B. denticulata* is the sole representative of the genus in Western Australia. There are no evident sex characters. Holotype in the Australian Museum.

BRYCOPIA HARRISONI, n. sp.

Dark bronze above and below, widely ovate, glabrous, moderately nitid, antennae and legs dark, tarsi and palpi red.

Head coarsely, closely punctate, eyes large, moderately prominent, coarsely faceted; antennae moniliform and strongly pilose, segment 1 stout, 2 small, 3–6 subequal, 7–11 gradually enlarged, a pseudo 12th appearing like a small, pale nodule at apex of 11th. *Prothorax* convex, strongly transverse, widest at middle, apex and base truncate, sides widely and evenly rounded, anterior angles widely obtuse, posterior forming a subdentate rectangle, border near hind angle feebly crenulate; disk closely, evenly, rather finely punctate, a longitudinal depression on each side towards hind angle. *Elytra* slightly wider than prothorax at base, and less than twice as long, shoulders rather squarely rounded, striate-punctate, the striae defined, seriate punctures round, close and regular; intervals flat, finely and irregularly punctate. Epipleurae and sternal area strongly punctate, abdominal segments impressed at sides. *Dim.* 5½ × 2¾ mm.

Hab.—N.S.W.: Barrington Tops (Sydney University Expedition, 1925).

A single example has escaped notice till now. It is a short, wide species nearest *B. cheesmani* Cart. in general facies, but readily distinguished by the absence of a medial line on the pronotum (well marked in *cheesmani*), and the much finer striae and punctures, both seriate and interstitial, of elytra. Holotype in the Macleay Museum. In my table (These PROC., 1920, p. 247) it would follow *B. crenaticollis* Cart. thus:

9. Elytra concolorous, form convex.
    9*a*. Sides of prothorax strongly crenulate throughout .... *crenaticollis* Cart.
    9*b*. Sides of prothorax feebly crenate behind only .... *harrisoni*, n. sp.

BRYCOPIA MUSGRAVEI, n. sp.

Widely ovate; very nitid bronze above, antennae, palpi, legs and underside red, tarsi pale red.

Head coarsely, subsparsely punctate, antennae moniliform, segment 1 stout, 2 small, 3 longer than 4, 4–6 equal, 7–11 successively wider than preceding, 10–11 opaque, 11 much larger than 10. Eyes large, round and prominent. *Prothorax*: apex and base truncate, anterior angles widely obtuse (bluntly rounded at tip), widest before the middle, sides widely rounded, narrowed, but scarcely sinuate, towards the rectangular hind angles; border entire; disk rather sparsely and irregularly punctate, with some raised smooth areas here and there, the punctures round and generally smaller than on head, without foveae or medial sulcus. *Scutellum* small and inconspicuous. *Elytra* wider than prothorax at base, humeri rather squarely rounded, widest behind middle; striate-punctate, the striae rather deep, the seriate punctures large and round, separated by a space less than the diameter of one, intervals flat, the 3rd and 5th clearly wider than the 2nd and 4th, the latter with a single row of minute punctures, the wider intervals with, at least, 2 rows of punctures. *Prosternum* coarsely, *abdomen* finely punctate. *Dim.* 5 × 2½ mm.

Hab.—N.S.W.: Near Cutler's Pass, Williams River (A. Musgrave and T. G. Campbell).

A single example in the Australian Museum is named after the Museum entomologist who found it. It is very closely allied to the Tasmanian species *B. coelioides* Pasc. (= *diemenensis* Cart.), from which it differs in (*a*) more widely rounded sides of prothorax, (*b*) 3rd and 5th elytral intervals wider than rest (intervals uniformly wide in *coelioides* Pasc.). Holotype in the Australian Museum.

CISTELIDAE.

NOCAR SUTTONI, n. sp.

Widely ovate, convex; nitid black, antennae and legs piceous, feebly pubescent at sides of pronotum and elytra, also on abdomen.

Head finely punctate, antennal segments subconic. *Prothorax*: front angles widely rounded, base bisinuate, its angles acute; disk closely punctate. *Elytra* striate-punctate, the striae well marked, seriate punctures well defined, with transverse strioles overlapping intervals; these very lightly convex, clearly and closely punctate. Underside closely and distinctly punctate. *Dim.* 9 × 5 mm.

Hab.—Northern New South Wales: Rivertree (E. Sutton).

Five examples were sent as captured on *Angophora* flowers. It is nearest to *N. funereus* Cart. in colour and to *N. convexus* Macl. in size. The latter species is, however, brown with quite flat and excessively finely punctured elytral intervals. It is separated from *N. funereus* by (1) larger size, (2) piceous antennae and legs, (3) antennal segments more elongate, (4) elytral intervals lightly but clearly convex with stronger sculpture. Holotype in Coll. Carter.

CURCULIONIDAE.

ACANTHOLOPHUS SUTTONI, n. sp.

Elongate-ovate. Black, the inter-tubercle spaces with grey scalose clothing, appendages brown, underside nitid black, glabrous, save for fine, grey setae.

Head: rostrum narrower than head, dorsal surface widening to the front, the external ridges converging to the base of intercristal ridge, with two shallow foveae near base; supraorbital crests large, biramate, the anterior branch small and rather closely welded to the subconical posterior branch, the latter curved backward; intercristal ridge wide, well raised and continuous with anterior rami. *Prothorax* 5½ × 8 mm., apex sinuate, the medial area produced over head, disk with three transverse impressions extending to the median tubercles, ocular lobes prominent, median area flat, bounded by rows of six large rounded tubercles, the 6th (at base) small, the 4th triplicate and subconnected, lateral tubercles dentate, triangular (somewhat as in *A. marshami* Kirb., but more robust), the anterior tooth biramate, the anterior branch smaller; between the lateral teeth a small rounded tubercle evident below the plane of disk; a conical tubercle also on each side of apical lobe and some scattered granules on depressed area of disk. *Elytra* 16 × 10 mm., ovate, widest slightly behind middle, base truncate, wider than base of prothorax, apex widely rounded; disk with seven rows of tubercles, besides the less evident rows of punctures. Of the rows of tubercles, the 3rd, 5th and 7th contain those of larger size, those in 3rd and 5th rounded, in 7th conical; the 1st, 2nd, 4th and 6th rows contain smaller, round tubercles; between the regular rows a few irregular granulose tubercles also. Apical segments of abdomen finely punctate, the apical with a subgranulose margin. Tibiae without evident sexual character.* *Dim.* 25 × 10 mm.

Hab.—South Queensland: The Pyramids, Wyberba district (E. Sutton).

The largest species of the genus known to me, that I gladly name after its discoverer, the naturalist of the Stanthorpe region. It is one of the *marshami* group in Ferguson's table of the genus (These Proc., 1921, p. 26).

CERAMBYCIDAE.

Hesthesis plorator Pasc.—Typical examples of this have the elytral apices oblique. Two examples taken by Mr. F. E. Wilson at Woori Yallock, Vict., and an example from Ringwood, Vict., in my collection, have clearly truncate apices, though with the characteristic production at the sutural angle.

Coptocercus trimaculatus Hope, and *C. crucigerus* Hope, by a mischance, were transposed in my tabulation (These Proc., 1929, p. 130). *C. crucigerus* should appear in line with No. 8 on p. 130.

I wish to express my thanks to Mr. E. H. Zeck and Miss N. B. Adams for their drawings of the new species illustrated.

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* As the example in hand is probably ♀, this character awaits confirmation. A second example, recently sent by Mr. Sutton, is ♂ and has the intermediate tibiae with a subapical emargination.

A CHECK LIST OF THE NEW SOUTH WALES PTERIDOPHYTES.

By ALMA T. MELVAINE, Science Research Scholar of the University of Sydney.

[Read 27th May, 1936.]

There has been no comprehensive publication on the nomenclature of the Pteridophytes of New South Wales since the Census of 1916. Since then there have been some radical changes in our knowledge of the systematics of the Filicales, and some changes in nomenclature. These changes are embodied in this list, which is intended to cover all the past nomenclature of the Pteridophytes which has been in use in this State. Brief explanatory notes have been inserted where it has been considered necessary.

All the species listed are represented by New South Wales specimens in the National Herbarium, except where otherwise indicated.† Some of these may be represented by specimens whose localities are not given.

LYCOPODIALES.

LYCOPODIACEAE.

PHYLLOGLOSSUM Kuntze, in Mohl and Schlechtendal, *Bot. Zeit.*, 1843, 721.
**P. Drummondii* Kuntze, l.c. (M. & B.; C.)
LYCOPODIUM Rupp., Fl. Jen., 1718, 32.
L. Selago L., Sp. Plant., 1753, 1102.
L. varium R.Br., Prodromus, 1810, 165.
L. cernuum L., l.c.
L. densum Labill., Nov. Holl. Plant., ii, 1806, 1104.
L. clavatum L., l.c., var. *fastigiatum* Benth., Fl. Austr., vii, 1878. (*L. fastigiatum* R.Br.)
L. laterale R.Br., l.c., p. 165.
**L. carolinianum* L., l.c., p. 1104. (M. & B.; D.; C.)

SELAGINELLACEAE.

SELAGINELLA Beauv., Prodr. des familles de l'Aeth., 1805, 101.
**S. Preissiana* Spring, *Mem. Acad. Brux.*, 1842, 61. (M. & B.; C.)
S. uliginosa Spring, l.c., p. 60.
S. Belangeri Spring, l.c., 1849, 242.

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† Explanation of abbreviations:

*.—No specimens from New South Wales in the National Herbarium, Sydney.

B.—Recorded by Bentham, *Flora Australiensis*, 1878, but no specimens in the Herbarium.

M. & B.—Recorded by Moore and Betche, *A Handbook to the Flora of New South Wales*, 1893, but no specimens in the Herbarium.

C.—Recorded by Maiden and Betche, *A Census of New South Wales Plants*, 1916, but no specimens in the Herbarium.

D.—Recorded by Domin, *Beiträge zur Flora und Pflanzengeographie Australiens*, in *Bibl. Bot.*, Bd. XX, but no specimens in the Herbarium. Most of Domin's records for New South Wales were, however, taken from other authorities.

ISOETACEAE.

ISOETES L., Skanska resa, 1751, 420.

A species of *Isoetes* is recorded for New South Wales and there are specimens from the Victorian side of the Murray River in the National Herbarium. These plants are certainly not *I. Drummondii*, nor do they seem to conform to descriptions of any other species.

PSILOTALES.

PSILOTACEAE.

TMESIPTERIS Bernh., Schrad. Journ., ii, 1800, 131.

T. tannensis Bernh., l.c., including *T. elongata* Dang. and *T. lanceolata* Dang.

PSILOTUM Sw., Schrad. Journ., ii, 1800, 109.

P. nudum (L.) Griesb. in Veget. d. Karaiben, 1857, 130. (*P. triquetrum* Sw.; *Lycopodium nudum* L.)

FILICALES.

OPHIOGLOSSACEAE.

OPHIOGLOSSUM L., Gen. Plant., 1753, 503.

O. coriaceum A. Cunn. in Hk., Comp. to Bot. Mag., ii, 1836, 367. (*O. gramineum* R.Br.)

O. costatum R.Br. Prodr.

Some specimens of *Ophioglossum* collected by Mr. E. Cheel in the Orange district have been identified by him as *O. Prantlii* C.Chr. (*O. lanceolatum* Prantl, *O. vulgatum* var. *lanceolatum* Luerss., *O. vulgatum* var. *gramineum* Bailey) in PROC. LINN. Soc. N.S.W., 1924, with the proviso that this species may not be specifically distinct from *O. lusitanicum* Linn. The specimens are indistinguishable from the common Australian species *O. coriaceum* A. Cunn. which is the Australian counterpart of *O. lusitanicum*, having ovate to ovate-lanceolate sterile fronds.

O. pendulum L., Sp. Plant. ed. ii, ii, 1763, 1518.

BOTRYCHIUM Sw., Schrad. Journ. 1800^2, 1801, 8, 110.

B. lunaria (L.) Sw., l.c.

B. australe R.Br., Prodr., 1810, 164. (*B. ternatum* var. *australe* Domin.)

MARATTIACEAE.

ANGIOPTERIS Hoffm., Comm. Soc. Reg. Gotting., xii, 1793?, 29.

A. evecta Hoffm., l.c. Recorded in PROC. LINN. Soc. N.S.W., 24, 1909, 367.

OSMUNDACEAE.

TODEA, Schrift. Akad. Erfurt., 1802, 14.

T. barbara (L.) Moore Ind., 1857, cxix. (*Osmunda barbara* Thunb.)

LEPTOPTERIS Presl, Suppl. Tent. Pterid., 1845, 70.

L. Fraseri (Hk. and Grev.) Presl, l.c. (*Todea Fraseri* Hk. and Grev.)

SCHIZAEACEAE.

LYGODIUM Sw., Schrad. Journ., 1800^2, 1801, 106.

L. scandens (L.) Sw., l.c.

SCHIZAEA Sm., *Mem. Acad. Turin*, v, 1793, 419.

S. bifida Willd., Schrift. Akad. Erf., 1802, 30.

S. dichotoma (L.) Sm., l.c., p. 422, t. 9. The var. *Forsteri* is recorded by Domin (*Bibl. Bot.*, Bd. xx, p. 207) as occurring in New South Wales, but he states that he himself has not seen true specimens from Australia.

S. fistulosa Labill., Nov. Holl. Pl. Ins. Sp., ii, 1806, 103.
S. rupestris R.Br., l.c., p. 162.

MARSILEACEAE.

MARSILEA L., Gen. Plant., 1753, 799.
M. angustifolia R.Br., l.c., p. 167. Recorded in PROC. LINN. SOC. N.S.W., 30, 1905, 374.
M. Brownii A.Br., *Monatsber. Ak. Berl.*, 1863, 418. (*M. quadrifolia* Benth., non L.)
M. Drummondii A.Br., *Linnea*, 25, 1853, 721.
var. *Nardu* Benth. impl., Fl. Austr., vii, 1878, 674. (*M. Nardu* A.Br.)
M. exarata A.Br., *Monatsber. Ak. Berl.*, 1870, 732.
M. hirsuta R.Br., l.c., 167.

PILULARIA.
**P. Novae-Hollandiae* A.Br., l.c. (B.; C.). (*P. globulifera* Benth., non L.)

GLEICHENIACEAE.

GLEICHENIA Sm., l.c.
G. circinata Sw., l.c., p. 107.—This species was originally described by Swartz in 1801 from a limited number of specimens. Robert Brown, in 1810, from a larger supply of material, discarded Swartz's species as insufficiently described (charactere haud conveniente), and described three species of *Gleichenia*: *G. microphylla*, *G. rupestris*, and *G. speluncae* (l.c., p. 161). Of these, *G. microphylla* is apparently synonymous with *G. circinata* but more carefully defined; it is frequently given as a variety of *G. circinata* (v. Domin, e.g.). *G. rupestris* is a glabrous form without the hirsute rachis of Swartz's species and has fronds which are glaucous below. *G. speluncae* is described as "frondibus furcatis . . . lobis semiovatis planis membranaceis subtus glaucis, capsulis 3–4 exsertis". In the National Herbarium, Sydney, the only specimens which agree with this description are a few fronds which are membranous and only once or twice forked. They appear to be juvenile fronds of Brown's *G. rupestris*. Thus the specimens may be classified as *G. circinata* which has priority despite its imperfect description, and Brown's *G. rupestris* which is worthy only of varietal rank.
var. *rupestris* Benth. impl., Fl. Austr., vii, 1878, 697.
G. dicarpa R.Br., l.c., p. 161.
G. flabellata R.Br., l.c.
G. flagellaris (Bory) Spreng. Syst., iv, 1827, 25. (*G. laevigata* (Willd.) Hk.) Recorded in PROC. LINN. SOC. N.S.W., 34, 1909, 366.
G. linearis (Burm.) Clarke, *Trans. Linn. Soc.*, ii, Bot. i, 1880, 428. (*G. dichotoma* Hk.; *G. Hermanni* R.Br.)
PLATYZOMA R.Br., l.c.
P. microphyllum R.Br., l.c.

HYMENOPHYLLACEAE.

TRICHOMANES L., Sp. Plant., ii, 1753, 1907.
**T. omphalodes* (Vieill.) C.Chr., Ind. Fil., 1906, 646. (*T. peltatum* Bak.) (C.)
**T. Bauerianum* Endl., Prodr. Fl. Norf., 1833, 17. (*T. apiifolium* Presl; *T. meifolium* F.v.M., non Bory.) (B.; D.; C.; M. & B.)
T. digitatum Sw., var. *calvescens* Benth. impl., l.c., p. 12. (*T. calvescens* V.d.B.; *Hymenophyllum Cattlettii* C. Moore.)

**T. humile* Forst., Prodr., 1786, 84. (M. & B.; C.)
T. javanicum Bl., Enum., 1828, 224.
T. parvulum Poir., Encycl., viii, 1808, 64.
T. rigidum Sw., Prodr., 1788, 137.
T. venosum R.Br., Prodr., 1810, 159.
T. vitiense Bak., *Journ. Linn. Soc.*, ix, 1866, 338.
HYMENOPHYLLUM Sm., *Mem. Acad. Turin*, v, 1793, 418.
H. australe Willd., Sp. Plant., 5, 1810, 527. (*H. javanicum* Spreng.)
H. bivalve (Forst.) Sw., Schrad. Journ., 1800^2, 1801, 99. Recorded in Wing's *Southern Science Record*, June, 1883.
H. flabellatum Labill., Nov. Holl. Plant., ii, 1806, 101. (*H. nitens* R.Br.)
H. marginatum Hk. and Grev., Ic. Fil., 1829, i, t. 34. Recorded in PROC. LINN. SOC. N.S.W., 8, 1884, 469, and 37, 1912.
H. pumilum C. Moore, Hk. and Bak. Syn. Fil., 1874, 464.
H. rarum R.Br., l.c., p. 159 (*H. lucens* C. Moore).
H. tunbridgense (L.) Sm., in Sowerb. Engl. Bot., 1794, t. 162.
H. peltatum Poir. Recorded in PROC. LINN. SOC. N.S.W., 1916.

SALVINIACEAE.

AZOLLA Lam., Encycl. meth., i, 1783, 343.
A. filiculoides Lam. var. *rubra* Diels. (*A. rubra* R.Br.).
A. pinnata R.Br., l.c., p. 167.

DICKSONIACEAE: Subfamily DICKSONIEAE.

CULCITA Presl.
C. dubia (R.Br.) Maxon, *Journ. Wash. Acad. Sci.*, 12, 1922, 458. (*Davallia dubia* R.Br.; *Dicksonia dubia* Gaud.; *Sitolobium dubium* Brack.; *Balantium dubium* (R.Br.) Copel.)
DICKSONIA L'Her., Sertum anglicum, 1788, 30.
D. antarctica Labill., Nov. Holl. Plant., ii, 1806, 100. (*D. Billardieri* F.v.M.)
D. Youngiae C. Moore, *Proc. Hort. Soc.*, also in Hk. and Bak. Syn. Fil., 1874, 461.

Subfamily DENNSTAEDTIINAE.

DENNSTAEDTIA Bernh., Schrad. Journ., 1800^2, 1801, 124.
D. davallioides (R.Br.) Moore, Parker's Cat., 1858. (*Dicksonia davallioides* R.Br.; *Davallia dicksonioides* F.v.M.)
HYPOLEPIS Bernh., Schrad. neu Journ., 1^2, 1806, 34.
H. tenuifolia (Forst.) Bernh., l.c.
H. punctata (Thunb.) Mett. (*Dryopteris punctata* (Thunb.) C.Chr.; *Polypodium punctatum* Thunb.; *Phegopteris punctata* Mett.) The transfer of this species and the next to *Hypolepis* from *Polypodium, Dryopteris*, etc., is already widely accepted. Anatomical features are definitely in accord with a Dicksonioid relationship, and the species are only superficially similar to the Polypodiums and Dryopteroid ferns with which they have commonly been classified.
H. rugulosa (Lab.) J.Sm., *Bot. Mag.*, lxxii, 1846, Comp. 8. (*Dryopteris punctata* subspecies *rugosula* C.Chr.; *Phegopteris punctata* var. *rugulosa* v. Alder v. Rosenberg; *Polypodium rugosulum* Labill.; *Phegopteris rugulosa* Fée; *Phegopteris rugosula* Mett.)

CYATHEACEAE.

ALSOPHILA R.Br., Prodr., 1810, 158.
A. australis R.Br., l.c.

A. Cooperi F.v.M., Fragm., v, 1866, 117. (*A. excelsa* R.Br. var. *Cooperi* C. Moore, Hbk. Fl. N.S.W., 1893, 505, as a synonym.)

A. Leichhardtiana F.v.M., l.c., 1865, 53.

A. Loddigesii Kuntze, *Linnea*, 20, 1847, 7; Bak. Syn. Fil., 458.

CYATHEA Sm., *Mem. Acad. Turin*, v, 1793, 416.

C. Lindsayana Hk., Sp. Fil., 1865, 25.

POLYPODIACEAE: Subfamily DAVALLIOIDEAE.

DAVALLIA Sm., l.c., p. 414.

D. pyxidata Cav., Descr., 1802, 278.

NEPHROLEPIS Schott., Gen. Fil., 1834, t. 3.

N. cordifolia (L.) Presl, Tent. Pterid., 1836, 79. (*Aspidium cordifolium* Sw.)

ARTHROPTERIS J.Sm., Hk. f., Fl. N.Z., ii, 1854, 43.

A. Beckleri Mett., Novara Exp. Bot., i, 1870, 213. (*Aspidium ramosum* var. *eumundi* Bailey.)

A. obliterata (R.Br.) J.Sm., Cat. Cult. Ferns, 1827, 62. (*Aspidium ramosum* Palis.)

A. tenella (Forst.) J.Sm., Hk. f., Fl. N.Z., ii, 1854, 43. (*Polypodium tenellum.*)

LINDSAYA Dryand., J.Sm., *Mem. Acad. Turin*, v, 1793, 413.

L. cuneata (Forst.) C.Chr., Ind. Fil., 1906, 392. Recorded in PROC. LINN. SOC. N.S.W., 1886, 929.

L. dimorpha Bailey, Hbk. Queensland Ferns, 1874, 19.

**L. incisa* Prentice, *Journ. Bot.*, 1873, 295. (M. & B.; D.; C.)

L. linearis Sw., Schrad. Journ., 1800^2, 1801, 78.

L. microphylla Sw., l.c., p. 79. Including var. *gracilescens* Domin.

Subfamily PTEROIDEAE.

PTERIDIUM Gleditsch, Scolopi. Flora Carniolica, 1760, 169.

P. aquilinum (L.) Kuhn., v. Deck. Reisen, iii^3, Bot. ii, 1879. Including var. *pseudocaudatum* Domin and var. *aequipinnulum* Domin. (*Pteris aquilina* L.)

HISTIOPTERIS (Agardh.) J.Sm., Hist. Fil., 1875, 295.

H. incisa (Thunb.) J.Sm., l.c. (*Pteris incisa* Thunb.)

PTERIS L., Hort. Cliff., 1737, 443.

P. longifolia L., Sp. Plant., ii, 1753, 1074. (Including var. *brevipinna* Domin.)

P. umbrosa R.Br., Prodr., 1810, 154.

P. tremula R.Br., l.c. (*P. arguta* F.v.M., non Ait.)

P. tripartita Sw., Schrad. Journ., 1800^2, 1801, 67. (*Pteris marginata* Bory.)

P. comans Forst., Prodr., 1786, 79. Including *P. Endlicheriana* Agardh.

**P. ensiformis* Burm., Fl. Ind., 1768, 230. Recorded, without specific locality, by Domin; doubtful.

ACROSTICHUM L., Gen. Plant., 1737, 785.

A. aureum L., Sp. Plant., ii, 1753, 1069. The old subfamily Acrosticheae has been clearly shown to be composite in nature and many of its original constituents have been removed. Developmental studies of this and other species of *Acrostichum* show that the genus is unmistakably a Pteroid derivative. The soral condition of the "Acrosticheae" has been attained by loss of the indusium and soral spread in most of the subfamilies of the Polypodiaceae, but nearly all those which show the Acrostichoid state give evidence, in their other features, of their true relationships. In *Acrostichum* itself, the sporangia do not originate simultaneously all over the surface but, like the Pteroid ferns, begin their development marginally, spreading towards the centre.

Subfamily GYMNOGRAMMOIDEAE.

This is a composite subfamily comprising Schizaeoid and Osmundaceous derivatives, centred around the old genus *Gymnogramme.* The group includes a large percentage of the old subfamily Pterideae, which have been shown to conform to an Osmundaceous or Schizaeoid, exindusiate type, rather than to the bi-indusiate Dicksonioid type from which originated the Davallioid and Pteroid ferns. A true indusium is phyletically absent, but the leaf margin is often membranous and recurved over the sorus in imitation of this structure.

The chief superficial distinguishing features between genera of this group, such as *Pellaea*, and Pteroid ferns, is the consistent occurrence of hard dark, often polished, petioles and rachides.

CERATOPTERIS Brongn., *Bull. Soc. Phil.*, 1821, 186.

C. thalictroides (L.) Brongn., l.c.—This species has usually been separated from the Polypodiaceae because of its somewhat irregular sporangial characters. These are marked irregularities of the annulus, and great variations in spore output, both of which features are typical of primitive ferns in general, and are seen in a small group of rather rare ferns classified with *Ceratopteris.*

ANOGRAMMA Link, Fil. Sp., 1841, 137.

A. leptophylla (L.) Link, l.c. (*Grammitis leptophylla* Sw.)

ADIANTUM L., Gen. Plant., 1737, 782.

A. aethiopicum L., Syst. Nat., ed. x, ii, 1759, 1329.

A. formosum R.Br., Prodr., 1810, 155.

A. diaphanum Bl., Enum., 1828, 215.

A. hispidulum Sw., Schrad. Journ., 1800^2, 1801, 82.

A. affine Willd., Sp. Plant., v, 1810, 448. *A. Cunninghami* Hk. is apparently synonymous with this species, though Christensen separates them. He states that *A. affine* occurs only in New Zealand, while *A. Cunninghami* is common to Australia, New Zealand and several of the Pacific islands. In New Zealand, however, the two are not separated (Cheeseman, Hbk. Fl. N.Z., 1914), and the distinction, which is based on the glaucous or non-glaucous character of the pinnules, is unsatisfactory, since all intermediate states of glaucousness are found.

The var. *intermedium* Benth. is excluded: the distinction (length of indusia) is not valid. There is almost no difference between length and breadth in most of the indusia, nor is the difference, where it exists, constant.

PELLAEA Link, Fil. Sp., 1841, 48, 59.

P. falcata (R.Br.) Fée, Gen. Fil., 1850, 129. (*Pteris falcata* R.Br.) The variety *nana* Bailey is excluded. Many plants in different localities have been examined and, though a few extremes are separable, the characters of tufted rhizome and close or overlapping pinnae, which distinguish the variety, are by no means constant. One finds all combinations of the two characters, which seem to be a feature of the habitat.

P. paradoxa (R.Br.) Hk., Sp. Fil., ii, 1858, 135. Including var. *normalis* Domin, l.c. (*Pteris paradoxa* Bak.)

DORYOPTERIS J.Sm., *Journ. Bot.*, iii, 1841, 404.

D. concolor (Langsd. and Fisch.) Kuhn., v. Deck. Reisen, iii^3, 1879, Bot. 19. (*Pteris concolor* Langsd. and Fisch.; *Pteris geraniifolia* Raddi.)

CHEILANTHES Sw., Syn. Fil., 5, 1806, 126.

C. tenuifolia (Burm.) Sw., l.c., 1806, 129, 332. The variety *Sieberi* Benth. impl. is excluded: the character of an almost erect rhizome is quite inadequate as a distinguishing feature. The species has its leaves crowded on the rhizome, so that a short rhizome gives a tufted appearance; most of the rhizomes examined are short, and apparently slow growing.

NOTHOLAENA R.Br., l.c., p. 145.

N. Brownii Desv., Prodr., 1827, 220. (*N. vellea* R.Br.; *Cheilanthes vellea* F.v.M.)

N. distans R.Br., l.c., 146. (*Cheilanthes distans* A.Br.)

Subfamily DRYOPTEROIDEAE.

CYSTOPTERIS Bernh., Schrad. neu. Journ., 1^2, 1806, 5, 26.

C. fragilis (L.) Bernh., l.c. (*Woodsia laetivirens* Prentice.) Although the true systematic position of this fern is by no means certain, it is usually included in the section Woodsieae of Dryopteroid or Aspidioid ferns, and will be classified here until a better position can be assigned to it.

DRYOPTERIS Adans., Fam. des Plant., ii, 1763, 20.

D. decomposita (R.Br.) O. Kuntze, Rev. Gen. Plant., ii, 1891, 812. (*Aspidium decompositum* R.Br.) Including *D. lanciloba* var. *glabella* Benth. impl. This is the reference given in Maiden and Betche's Census, though Bentham does not mention the name *glabella*. (*D. glabella* (A. Cunn.) C.Chr.)

D. acuminata (Lowe) Watts, PROC. LINN. SOC. N.S.W., 41, 1916, 380. The variety *cristata* Watts, l.c., is excluded; *D. acuminata* has a tufted rhizome, but the type specimen of the variety has a creeping one, with its leaves much closer together than on the typical creeping rhizomes of *D. decomposita* and *D. queenslandica*. This, however, is a common feature of the early stages of tufted rhizomes, and the cristate character of the fronds is almost certainly an aberrant one: no further crested fronds could be found in the same locality, though several similar rhizomes were unearthed.

D. tenera (R.Br.) C.Chr., l.c., p. 297. (*Aspidium tenerum* Spreng.)

**D. setigera* (Bl.) O. Kuntze, l.c., p. 813. (*Aspidium tenericaule* Thw.; *A. uliginosa* Kuntze.) (M. & B.; B.)

D. queenslandica Domin, *Bibl. Bot.*, Bd. xx, p. 44. (*D. Baileyii* Maiden and Betche; *Polypodium aspidioides* Bailey.) Maiden and Betche were undoubtedly right in referring this species to *Dryopteris*, and in requiring a name other than that already used for an American species (*aspidioides*), but this alteration had already been effected by Domin, three years prior to the publication of the Census of Maiden and Betche.

D. gongylodes (Schkuhr) O. Kuntze, l.c., p. 811. (*Aspidium unitum* Sw.)

D. parasitica (L.) O. Kuntze, l.c. (*Aspidium molle* Sw.)

D. truncata (Poir.) O. Kuntze, l.c., p. 814. (*Aspidium truncatum* Gaud.)

**D. prolifera* (Retz.) C.Chr., l.c., p. 286. (*Polypodium proliferum* Presl.) (B.; M. & B.; C.)

POLYSTICHUM Roth., Röm. Mag., 2^1, 1799, 106.

P. aculeatum (L.) Schott., Gen. Fil., 1834, ad. t. 9. (*Aspidium aculeatum* Sw.) The plants of this species vary tremendously in the degree of scaly development, and of proliferation from the frond. A large collection from all over the State shows a degree of constancy in the type from any one ecological situation, a fact which indicates that the variations are probably due to habitat. The number of buds formed on the frond varies too with environmental conditions, as the cultivation of wild plants will readily show. A specimen from Robert Brown's collection, which he named *P. proliferum*, is nearly glabrous, and bears a single bud near the apex of the frond. One rarely finds plants without any buds, and all are apparently capable of proliferation when conditions are favourable. Maiden and Betche's varieties (the species *P. proliferum* and *P. vestitum* of Diels and Christensen) are therefore excluded.

P. aristatum (Forst.) Presl, Tent. Pterid., 1836, 83. (*Aspidium aristatum* Sw.)

*var. *carvifolium* Maiden and Betche. (*P. carvifolium* (O. Kuntze) C.Chr.) (C.)

P. adiantiforme (Forst.) J.Sm., Hist. Fil., 1875, 220. (*Aspidium capense* Willd.; *A. coriaceum* Sw.)

P. hispidium (Sw.) J.Sm., *Journ. Bot.*, iv, 1841, 195. (*Aspidium hispidium* Sw.)

Subfamily ASPLENIOIDEAE.

ATHYRIUM Roth., Röm. Mag., 2^1, 1799, 105.

A. umbrosum (Ait.) Presl, Tent. Pterid., 1836, 98. (*Asplenium umbrosum* J.Sm.)

var. *semidivisum* E. C. Chisholm, PROC. LINN. SOC. N.S.W., lix, 1934, 143.

A. humile Watts, PROC. LINN. SOC. N.S.W., 41, 1916, 380. The name is included here until further material can be found. It is highly probable that the type specimen is a juvenile frond of *Diplazium japonicum* Beddome.

DIPLAZIUM Sw., Schrad. Journ., 1800^2, 1801, 61.

D. maximum (Don) C.Chr., l.c., p. 235. (*Asplenium maximum* Don.)

D. japonicum (Thunb.) Beddome, Supplement to the Ferns of Southern India, etc., Madras. There has always been some doubt as to the occurrence of this species in New South Wales, owing to a description from a doubtful specimen in Bentham's Flora Australiensis, but recent collections from several localities in the North Coast district have confirmed the original record.

ASPLENIUM L., Gen. Plant., 1737, 783.

A. nidus L., Sp. Plant., ii, 1753, 1079.

A. attenuatum R.Br., Prodr., 1810, 150.

var. *multilobum* F.v.M., Fragm., v, 1866, 131.

A. flabellifolium Cav., Descr., 1802, 257.

A. trichomanes L., Sp. Plant., ii, 1753, 1080.

A. obtusatum Forst., Prodr., 1736, 80. (*A. marinum* F.v.M., non L.)

var. *difforme* Benth. (*A. difforme* R.Br.)

A. adiantioides (L.) C.Chr., Ind. Fil., 1906, 99. (*A. falcatum* Lam.) The var. *caudatum* Benth. impl. is excluded; it is given specific rank by van Rosenburg in Malayan Ferns (1908), where it is distinguished by the position of the higher sori which are "sub-parallel and nearly close to the costa, occupying the lower part of the veins". In *A. adiantioides* they are "erecto-patent, and not sub-parallel to the costa". In the New South Wales specimens at least, the variety is not constantly separable.

**A. Hookerianum* Col., Tas. Journ., ii, 1884, 169. (B., doubtful.)

**A. praemorsum* Sw., Prodr., 1788, 130. (*A. furcatum* Thunb.) (B.; C.)

A. bulbiferum Forst., Prodr., 1786, 80.

A. flaccidum Forst., l.c.

PLEUROSORUS Fée, Gen. Fil., 1850–52, 179.

P. rutifolius (R.Br.) Fée, l.c., p. 180. (*Grammitis rutifolia* R.Br.; *Gymnogramme rutaefolia* Hk.)

Subfamily BLECHNOIDEAE.

BLECHNUM L., Sp. Pl., ii, 1753, 1077.

B. cartilagineum Sw., Syn. Fil., 1806, 114, 312. Including the four varieties of Domin: var. *normale*, var. *appendiculatum*, var. *tropicum*, var. *woodwardioides*.

B. serrulatum Rich., *Act. Soc. Hist. Nat. Paris*, i, 1792, 114.

B. Patersoni (R.Br.) Mett., Fil. Lips., 1856, 64, t. 4. Including var. *normale* Domin (*Lomaria elongata* var. *Cunninghamiana* Hk.), and var. *elongata* (Bl.) Domin. (*Lomaria Patersoni* Spreng.)

B. discolor (Forst.) Keyserling, Polyp. et Cyath. Herbarii Bungeana, 1873, 66. (*Lomaria discolor* Willd.) Including var. *normale* Domin, var. *nudum* Domin, var. *bipinnatifidum* Domin.

B. lanceolatum (R.Br.) Sturm., Enum. Pl. Crypt. Chil., 1858, 25. (*Lomaria lanceolata* Spreng.)

B. penna-marina (Poir) Kuhn, Fil. Afric., 1868, 92. (*Lomaria alpina* Spreng.)

B. capense (L.) Schlecht., Adumbr. Fil., 1825, 34, t. 18. (*Lomaria capensis* Willd.; *L. procera* Spreng.) Including var. *Gregsoni* Watts. Exact localities for the many varieties which he has set up are not given by Domin. The New South Wales specimens, though very variable, cannot be separated into constant varieties, with the exception of var. *laevigatum* (*Blechnum capense* subspecies *laevigatum* Domin), which has Blechnoid and not Lomarioid fertile fronds.

var. *laevigatum*, nov. comb.

B. fluviatile (R.Br.) Lowe, Salom. Nom., 1883, 115. (*Lomaria fluviatilis* Spreng.)

DOODIA R.Br., Prodr., 1810, 151.

D. aspera R.Br., l.c. (*Woodwardia aspera* Mett.)

D. caudata (Cav.) R.Br., l.c. (*Woodwardia caudata* Cav.) The variety *media* Benth. (*D. media* R.Br.) is inseparable from the species, which varies tremendously. Bentham himself, who transferred Brown's species to varietal rank, notes that he can find no difference other than size, and that intermediate specimens are numerous.

var. *Atkinsoniae* nomen nudum.—Woolls refers in his Flora of Australia, without description, to this plant (from Kurrajong), which has apparently never been described. Betche, on an herbarium sheet, notes that . . . "the variety *Atkinsoniae* is . . . worthy of specific rank". There are no specimens in the National Herbarium bearing the name *Atkinsoniae*. It should, therefore, be deleted from a list of New South Wales ferns.

D. maxima J.Sm., *Bot. Mag.*, 72, 1846, Companion, p. 27. (*D. blechnoides* A. Cunn. *Woodwardia aspera* var. *blechnoides* F.v.M. impl.)

Subfamily DIPTEROIDEAE.

This subfamily has been separated by Bower (The Filicales, vol. iii, p. 200), and in it he has placed the genera *Cheiropleuria*, *Platycerium* and *Pleopeltis* (Malayan species), adding a note that probably many species of *Polypodium*, and especially *Cyclophorus*, would eventually be placed in the group. The constituent genera are shown to be derivatives of a *Dipteris* type, probably of Gleicheniaceous ancestry. They are superficially characterized by a reticulate venation of the *Anaxetum* type, and by simple, bifid or not highly divided leaves. They are always ex-indusiate. Below are included the New South Wales species of *Pleopeltis* (*Polypodium*) which conform generally to the characters of the subfamily, and also the single species of *Drynaria* which is found in this State.

PLEOPELTIS Humb. et Bonpl., Pl. aequinoct, Paris, 1805–1818.

P. Brownii (Wickstr.) Fournier, *Bull. Soc. Fr.*, 16, 1869, 424. (*Polypodium Brownii* Wickstr., *Polypodium attenuatum* R.Br.)

P. pustulata (Forst.) Moore, Ind. Fil., 1857.

P. diversifolia (Willd.), nov. comb. (*Pl. Billardieri* Moore; *Polypodium diversifolium* Willd.).—The complicated synonymy of these two species has caused much confusion. The solution of the problem is clearly given by Domin (l.c.), who summarizes the situation as follows: the two species *Polypodium pustulatum* and *P. scandens*, set up by Forster in 1786, were only one species. In 1806 Labillardière described a plant from Tasmania which he said was identical with Forster's *P. scandens*, but he expressed doubt as to the validity of Forster's two species. However, Labillardière's plant, which he called *P. scandens*, was certainly different from Forster's species: it was described again in 1810 by Willdenow as *P. diversifolium*, and in the same year by Robert Brown as *P. Billardieri*. Domin says that, if Forster's names are synonymous, and *scandens* is therefore deleted from the genus as a specific name, then Labillardière's *P. scandens* must have precedence (for the Tasmanian plant), and Willdenow's *P. diversifolium* and Brown's *P. Billardieri* are synonyms of it. C. Christensen considers that *P. diversifolium* Willd. was the first true name for this species and, as this name is now generally in use, it has been adopted here. Christensen and Domin have adopted *P. pustulatum* Forst. for the other species. Unfortunately both Bentham, and Moore and Betche used the name *scandens*, now generally regarded as a synonym. Thus a reversal of the nomenclature in use in this State becomes necessary: *Polypodium pustulatum* of the Flora Australiensis (also of Bailey, Moore and Betche, etc.) must become *P. diversifolium* Willd., and *P. scandens* Forst. of Bentham, Bailey, etc., must become *P. pustulatum* Forst. Since their characters are those of the Dipteroid ferns and not of the true Polypodiaceae the generic name *Pleopeltis* has been adopted.

CYCLOPHORUS Desv., *Berl. Mag.*, v, 1811, 300. (*Niphobolus* Kaulf.)

C. serpens (Forst.) C.Chr., Ind. Fil., 1906, 201. (*Polypodium serpens* Forst.)

C. confluens (R.Br.) C.Chr., l.c., p. 198. (*Polypodium confluens* R.Br.)

DRYNARIA (Bory) J.Sm., *Journ. Bot.*, iv, 1841, 60.

D. rigidula (Sw.) Beddome, Ferns Brit. Ind., 1869, t. 314. (*Polypodium rigidulum* Sw.)

HYMENOLEPIS Kaulf., Enum Fil., 1824, 146.

H. spicata (L. fil.) Presl, Epimeliae botanicae, 1849, 159. (*Acrostichum spicatum* L.)

PLATYCERIUM Desv., Prodr., 1827, 213.

P. bifurcatum (Cav.) C.Chr., l.c., p. 498. (*P. alcicorne* Desv.)

P. grande (A. Cunn.) J.Sm., *Journ. Bot.*, iii, 1841, 402.

Subfamily POLYPODIEAE.

A systematic study of the Ferns such as Bower has undertaken in The Filicales, vols. i, ii, and iii, shows clearly that species of *Polypodium* which are commonly classified in the subgenus *Eu-Polypodium* are not closely related to species such as are included in this list with the Dipteroid ferns, though they are usually classified together in the subfamily Polypodieae. Only two species of the subgenus *Eu-Polypodium* occur in New South Wales, and it seems justifiable to include these as true members of the old subfamily Polypodieae.

Polypodium L., Gen. Plant., 1753, 784.

P. Billardieri (Willd.) C.Chr., l.c., p. 513. (*P. australe* Mett.) Maiden and Betche used the name *P. australe* Mett. in preference to *P. Billardieri*, in order to avoid confusion, though they recognized that *P. Billardieri* had priority.

**P. grammitidis* R.Br., Prodr., 1810, 147. (C.)

In the making of this list the collections of Pteridophytes in the National Herbarium, Sydney, have been invaluable. I wish to express my thanks to Mr. Cheel, of the Herbarium, who placed the collections at my disposal, and to Professor Osborn, of the Department of Botany, Sydney University, for advice and helpful criticism.

CONTRIBUTION TO A KNOWLEDGE OF PAPUAN TIPULIDAE (DIPTERA).

By CHARLES P. ALEXANDER, Massachusetts State College, Amherst, Mass., U.S.A.

(*Communicated by Frank H. Taylor, F.R.E.S., F.Z.S.*)

(Seven Text-figures.)

[Read 24th June, 1936.]

The material included in the present paper is chiefly from the mountains of the Central Division of Papua north of Port Moresby, and was collected by Mr. K. J. Clinton of the School of Public Health and Tropical Medicine, The University of Sydney. The collection contained eight species, six being described as new. The subgenus *Paramongoma* is recorded for the first time from Papua. I express my very sincere thanks to Professor Harvey Sutton, Director of the School of Public Health and Tropical Medicine, for submitting this material to me for study. All types and uniques are preserved in the collection of the School.

LIMONIINAE.

LIMONIINI.

LIMONIA (LIMONIA) LONGEANTENNATA, n. sp. Figs. 1, 3.

Size small (wing, ♂, 4 mm.); general coloration of thorax dark brown, the praescutum more reddish-brown; femora yellow, with a narrow, subterminal, dark ring; wings with a uniform brown tinge, the stigma very small, subcircular in outline; male terminalia with the basistyle armed at tip with three groups of modified setae; dististyle profoundly divided into a dusky clavate outer lobe and an oval inner lobe that is produced into a slender spinous point.

♂. Length about 3·5 mm.; wing, 4 mm.; antenna about 2·7 mm.

Rostrum black, about one-third the length of remainder of head; palpi black. Antennae (♂) of unusual length for a member of this subgenus, being only a little shorter than the entire body, black throughout; flagellar segments long-cylindrical, with short glabrous apical pedicels; terminal segment subequal in length to the penultimate, strongly narrowed and pale at apex. Head grey, more silvery-grey on front; eyes large, rather broadly contiguous on vertex.

Pronotum dark brown. Mesonotal praescutum more reddish-brown, somewhat darkened behind; scutal lobes dark brown, the median area and the scutellum more testaceous-brown; mediotergite dark brown. Pleura uniformly dark brown, the dorso-pleural region and meron somewhat brighter. Halteres dark brown, the base of stem narrowly pale. Legs with the fore coxae darkened, the remaining coxae more yellowish; trochanters yellow; femora yellow, with a narrow subterminal dark ring, the actual tip a little narrower, yellow; tibiae and tarsi brown; claws small. Wings (Fig. 1) with a uniform brown tinge; stigma very small, subcircular in outline, darker brown; veins brown, macrotrichia conspicuous, black. Venation: Sc_1 ending shortly before midlength of the long Rs, Sc_2 at tip; free tip of Sc_2 and R_2 in transverse alignment; m a little longer and more arcuated than basal section of M_3; m-cu just beyond fork of M; anal veins parallel for almost the entire length of 2nd A.

Abdominal tergites dark brown, the basal sternites more yellowish-brown; terminalia obscure yellow, the outer lobe of dististyle more infuscated. Male terminalia (Fig. 3) with the tergite, *9t*, large, the caudal margin gently emarginate, the low, broad, lateral lobes with long, conspicuous setae. Basistyle, *b*, short, the ventro-mesal lobe conspicuous, at apex armed with three groups of spines and setae, including a low mass of tubercles shortly before apex, an outer apical lobe set with long setae, and an inner apical row of four flattened black fasciculate setae. Dististyle, *d*, single, produced into a long clavate lobe, with very long erect setae; main body of style elongate-oval, at apex drawn out into a straight, slender, spinous point. Mesal-apical lobe of gonapophysis, *g*, a long flattened blade, the apex obtuse.

Holotype, ♂, Onoba, Papua, altitude about 2,000 feet, July, 1935 (K. J. Clinton).

The present fly is readily distinguished from similar small species of the subgenus by the unusually elongate antennae of the male, pattern of the femora and, especially, the structure of the male terminalia.

LIMONIA (LIBNOTES) ONOBANA, n. sp. Fig. 4.

General coloration obscure yellow, the praescutum with a black median stripe that spreads out in front to cover the humeral and lateral portions of the sclerite; halteres yellow; femora obscure yellow, the tips very narrowly clearer yellow, the fore femora with a narrow brown subterminal ring; wings tinged with yellowish-grey, margined with dusky, cells C and Sc more infumed; Sc_1 ending just before fork of Rs; Rs gently arcuated; m-cu just beyond one-third the length of cell 1st m_2; anal veins slightly convergent at bases; abdomen black.

♂. Length about 6·5 mm.; wing, 7·5 mm.

Rostrum and palpi black. Antennae black, the outer segments a little paler; flagellar segments oval, with short apical pedicels; terminal segment elongate, about one-half longer than the penultimate. Head dark grey.

Pronotum black. Mesonotal praescutum with the ground-colour obscure yellow, with a median black stripe that is widened in front and extends laterad across the humeral and lateral portions of the sclerite, restricting the ground-colour to broad sublateral areas; at about midlength of the segment, the black stripe sends cephalad a small lateral point or spur, isolating a linear ground dot on either side of the midline; scutum with the median area yellow, the lobes black; scutellum black, paler basally, the parascutella yellow; mediotergite dark, the cephalic portion paler. Pleura obscure yellow, the propleura and a narrow longitudinal stripe across the anepisternum and pteropleurite to and including the pleurotergite, blackened; fore coxae and a small vague area on sternopleurite darkened. Halteres pale yellow throughout. Legs with the fore coxae darkened, as described; remaining coxae obscure yellow; trochanters obscure yellow; fore femora obscure yellow, with a very narrow, brown, subterminal ring, the yellow apical portion a trifle broader than the ring; middle and posterior femora obscure yellow, becoming a little darker outwardly, but without distinct dark annuli, the tips narrowly clearer yellow; tibiae and tarsi yellowish-brown, the terminal tarsal segments blackened. Wings tinged with yellowish-grey; cells C and Sc more infumed, passing into brownish-yellow outwardly; bases of cells R, M, Cu and 1st A slightly darkened; a narrow dusky border around the wing, somewhat more extensive on the apical portions; a tiny cloud at origin of Rs; stigma small, oval, darker brown; veins dark. Venation: Sc relatively short, Sc_1 ending just before fork of Rs, Sc_2 at tip of Sc_1; Rs gently arcuated; free tip of Sc_2 and R_2 in transverse alignment; inner ends of cells 2nd M_2 and M_3 in transverse alignment; m-cu just beyond one-third the length of cell 1st M_2; anal veins slightly convergent at bases.

Abdomen black, the terminalia only a little brightened. Male terminalia (Fig. 4) with the tergite, *9t*, relatively narrow apically. Basistyle, *b*, long and slender, the ventro-mesal lobe basal in position, provided with long coarse setae. Dorsal dististyle a short curved blackened horn, the tip acute. Ventral dististyle, *vd*, a small oval lobe, with long setae; rostral blade long and conspicuous, pale, compressed, at apex narrowed into a small spinous point.

Holotype, ♂, Onoba, Papua, altitude about 2,000 feet, July, 1935 (K. J. Clinton).

By Edwards's key to the species of *Libnotes* (*Journ. Fed. Malay St. Mus.*, 14, 1928, 74–80) the present fly runs more or less directly to *Limonia* (*Libnotes*) *trifasciata* (Edwards) of the Federated Malay States, a very different fly. The peculiar structure of the male terminalia is somewhat as in an otherwise entirely distinct species to be described, in a later paper of the series, from Kavieng, New Ireland.

LIMONIA (LIBNOTES) CLINTONI, n. sp. Fig. 2.

General coloration grey; praescutum with a brownish crossband behind the anterior margin, together with two comma-shaped brown spots beyond midlength of the sclerite; fore legs entirely black; wings faintly tinged with yellow, sparsely patterned with brown; free tip of Sc_2 in virtual transverse alignment with R_2; abdomen dark brown, the terminalia brownish-black.

♂. Length about 11 mm.; wing, 15 mm.

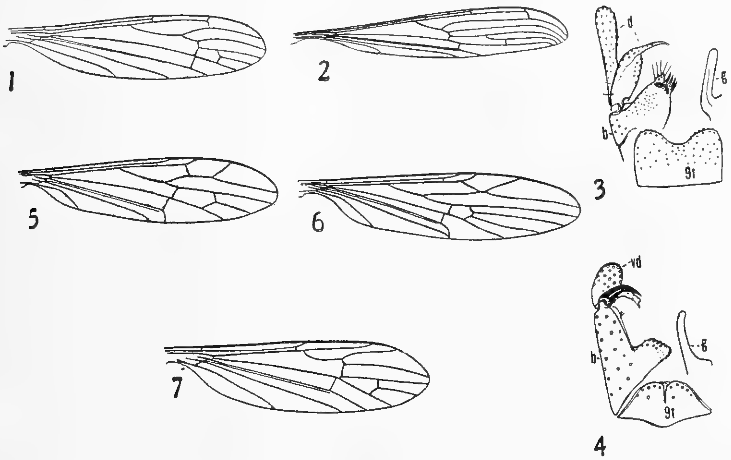
Rostrum brownish-black; palpi black. Antennae with scape black, pale at base; pedicel brownish-yellow; flagellum yellow; flagellar segments long-oval, the longest verticil of each subequal in length to the segment; terminal segment about one-fifth longer than the penultimate. Head light grey; anterior vertex reduced to a very narrow strip that is only a little wider than the diameter of a single ommatidium.

Pronotum reddish-brown, darker on posterior border. Mesonotal praescutum chiefly greyish-pruinose, with a brownish crossband behind anterior margin, continued backward across the humeral and lateral borders to the suture; a pair of intermediate brown dashes, shaped like commas, placed just beyond midlength of praescutum; scutum whitish, the lobes with more greyish centres; scutellum and mediotergite whitish, the latter with a brownish-black lateral line, widened posteriorly. Pleura whitish-grey, with narrow, broken, dark brown, longitudinal lines on anepisternum and pteropleurite, and again across fore coxae and ventral sternopleurite. Halteres with stem yellow, its base infuscated, the knob blackened. Legs with the coxae whitish, the fore coxae marked as above described; trochanters whitish; fore femora entirely black; middle and hind femora brown basally, passing into black at or near midlength; all tibiae and tarsi black; vestiture of legs relatively short and inconspicuous, short and spinous on femora, longer and more appressed on distal segments. Wings (Fig. 2) long and narrow, faintly tinged with yellow, the costal cells more saturated; a restricted dark pattern that is confined to the veins and distributed as small areas as follows: Arculus; origin of Rs; at intervals along cord; outer end of cell 1st M_2; tip of Sc_2 and R_2; at distal ends of veins M_4, Cu_1, 1st A and 2nd A; veins bright yellow, black in the clouded areas. Venation: Free tip of Sc_2 lying immediately basad of R_2, so as to appear virtually in alignment with it; cell 2nd M_2 about one-third longer than cell M_3; m-cu just beyond one-fifth the length of lower face of cell 1st M_2; anal veins convergent basally.

Abdomen dark brown, the basal tergites darker laterally, the intermediate ones further darkened medially at base; terminalia small, brownish-black; sternites paler.

Holotype, ♂, Onoba, Papua, altitude about 2,000 feet, July, 1935 (K. J. Clinton).

This interesting and very distinct *Libnotes* is named in honour of the collector, Mr. K. J. Clinton. It belongs to the *notata* complex of species, being most readily distinguished from all described allies by the extensively blackened legs.



Figures 1-7.

b, basistyle; *d*, dististyle; *g*, gonapophysis; *t*, tergite; *vd*, ventral dististyle.

1. *Limonia* (*Limonia*) *longeantennata*, n. sp., venation.
2. *Limonia* (*Libnotes*) *clintoni*, n. sp., venation.
3. *Limonia* (*Limonia*) *longeantennata*, n. sp., terminalia.
4. *Limonia* (*Libnotes*) *onobana*, n. sp., terminalia.
5. *Trentepohlia* (*Paramongoma*) *lucrifera*, n. sp., venation.
6. *Trentepohlia* (*Mongoma*) *longisetosa*, n. sp., venation.
7. *Gonomyia* (*Lipophleps*) *jurata*, n. sp., venation.

ERIOPTERINI.

TRENTEPOHLIA (PARAMONGOMA) LUCRIFERA, n. sp. Fig. 5.

General coloration of thorax uniformly brownish-yellow; antennae with scape yellow, pedicel and flagellum brown; legs pale brownish testaceous; wings pale yellowish-grey, unmarked; veins pale; macrotrichia of veins very reduced in number; R_{2+3+4} subequal to R_{3+4} alone, both a little longer than R_2.

♀. Length about 3·8 mm.; wing, 3·7 mm.

Rostrum and palpi brownish-yellow. Antennae with the scape yellow; pedicel and flagellum brown; flagellar segments suboval, the verticils short. Head brownish-yellow.

Mesonotum and pleura almost uniformly brownish-yellow, without distinct markings. Halteres pale. Legs with the coxae and trochanters yellow; remainder of legs pale brownish testaceous, the tarsi a little paler, dirty white. Wings (Fig. 5) pale yellowish-grey, unmarked; veins pale. Macrotrichia of veins virtually lacking, there being two or three on vein R_1 near stigmal region and two or three scattered trichia on distal section of vein R_5. Venation: R_{2+3+4} subequal to R_{3+4}, both a little longer than R_2; cell 1st M_2 elongate, exceeding vein M_{1+2} beyond it; m-cu just before fork of M; distal section of Cu_1 subequal to m-cu and about equal to the space along wing-margin between veins Cu_1 and 1st A.

Abdominal tergites brown; sternites paler brown.

Holotype, ♀, Onoba, Papua, altitude about 2,000 feet, July, 1935 (K. J. Clinton).

Trentepohlia (*Paramongoma*) *lucrifera* is allied to species such as *T.* (*P.*) *banahaoensis* Alexander, *T.* (*P.*) *chionopoda* Alexander and *T.* (*P.*) *pusilla* Edwards, differing from all in the venation, especially the subequal veins R_{2+3+4} and R_{3+4}, the latter exceeding in length vein R_2 alone.

TRENTEPOHLIA (MONGOMA) LONGISETOSA, n. sp. Fig. 6.

General coloration dark brown; legs brownish-black, the outer tarsal segments paling to dirty yellow; tarsi short, especially the posterior pair in male; all femora with short spines at base; wings strongly tinged with dusky; costal fringe (♂) long and conspicuous; vein R_3 oblique, cell R_2 at margin exceeding one-half the extent of cell R_3.

♂. Length, 5·5–6 mm.; wing, 6–7 mm. ♀. Length, 6·5–8 mm.; wing, 6·5–8 mm.

Rostrum and palpi black. Antennae black throughout; flagellar segments subcylindrical; longest verticils subequal in length to the segments. Head brownish-black.

Thoracic dorsum and pleura uniformly dark brown, the dorsopleural region and pronotum even darker in colour. Halteres dusky. Legs brownish-black, the outer tarsal segments paling to dirty yellow; tarsi short, especially the posterior tarsi in male (femora, 8 mm.; tarsi, 5·3 mm.), which are much shorter than the femora; femora with several (12–15) short black spines at base. Wings (Fig. 6) with a strong dusky tinge, the wing-tip narrowly more darkened in outer radial field; stigma small and inconspicuous; cells C and Sc more yellowish-brown; veins brownish-black. Costal fringe (♂) unusually long and conspicuous, exceeding in length the width of cell 1st M_2 at base; in female, costal fringe dense but short and normal. Venation: Basal section of R_5 relatively long, exceeding two-thirds of Rs; R_{2+3+4} gently sinuous, exceeding Rs; vein R_3 much more oblique than in *brevipes*, cell R_2 at margin exceeding one-half the extent of cell R_3; R_{3+4} only about one-third to one-half R_2; cell 1st M_2 short, the veins and cells beyond it correspondingly lengthened.

Abdominal tergites and terminalia brownish-black; sternites brown, the caudal borders of the segments narrowly darkened.

Holotype, ♂, Maini, Papua, altitude about 6,300 feet, July, 1935 (K. J. Clinton). Allotopotype, ♀. Paratopotypes, 4 ♂, ♀. Paratypes, 1 ♂, 1 ♀, Kone, Papua, altitude about 5,000 feet, July, 1935 (K. J. Clinton).

By my key to the regional species of *Trentepohlia* (PROC. LINN. SOC. N.S.W., lx, 1935, 66), the present fly runs to *Trentepohlia* (*Mongoma*) *brevipes* Alexander (New Britain, New Guinea), which shows several features in common, as the darkened femora and tibiae and the shortened tarsi, but is very different in the pattern and venation of the wings and in the short costal fringe of the male sex. In the long costal fringe of the male, the present fly agrees with *T.* (*M.*) *costofimbriata* Alexander (New Britain), a species with entirely different leg-pattern.

TRENTEPOHLIA (PLESIOMONGOMA) NOVAE-BRITTANIAE Alexander.

PROC. LINN. SOC. N.S.W., lx, 1935, 66–67.

1 ♀, Maini, Papua, altitude about 6,300 feet, July, 1935 (K. J. Clinton).

TRENTEPOHLIA (TRENTEPOHLIA) PICTIPENNIS Bezzi.

Philippine Journ. Sci., xii, D, 1917, 115.

Inawi, Papua, July, 1935 (K. J. Clinton).

GONOMYIA (LIPOPHLEPS) JURATA, n. sp. Fig. 7.

General coloration of mesonotum dark grey, the scutellum light yellow, with a dark spot medially at base; antennae with pedicel large, bright orange; mesopleura dark brown, scarcely variegated by brighter; knobs of halteres dusky; legs black; wings with a strong brown suffusion, the costal border narrowly yellow; macrotrichia of veins numerous; Sc_1 ending opposite origin of Rs; abdomen black.

♀. Length about 4·5 mm.; wing, 4·2 mm.

Rostrum and palpi black. Antennae with scape obscure orange; pedicel enlarged, bright orange; flagellum black throughout; flagellar segments oval, the outer ones more elongate-oval; terminal segment shorter than the penultimate. Head grey.

Pronotum above obscure brownish-yellow, the pronotal scutellum brighter yellow. Mesonotal praescutum and scutum dark grey, the pseudosutural foveae dark; humeral and lateral portions of praescutum not or scarcely brightened; scutellum light yellow, with a darker median spot at base; mediotergite grey. Pleura dark brown, scarcely variegated by brighter. Halteres obscure yellow, the knobs dusky. Legs with the coxae yellowish-brown; trochanters a little brighter; remainder of legs black. Wings (Fig. 7) with a strong brownish suffusion; cells C and Sc yellow. Macrotrichia of veins relatively abundant, including a series on distal two-thirds of vein 1st A and a few on outer end of vein 2nd A. Venation: Sc_1 ending opposite origin of Rs, Sc_2 close to its outer end; Rs long, arcuated; basal section of vein R_5 long, approximately one-half r-m; m-cu shortly before the fork of M.

Abdomen black, the bases of the terminalia brownish-black; cerci horn-yellow.

Holotype, ♀, Onoba, Papua, altitude about 2,000 feet, July, 1935 (K. J. Clinton).

Gonomyia (*Lipophleps*) *jurata* is generally similar to species such as *G.* (*L.*) *fijiensis* Alexander and *G.* (*L.*) *kertesziana* Alexander, yet is very distinct in all details of coloration, especially of the legs, wings and abdomen.

A REDESCRIPTION OF *SOLOMYS* (*"MUS"*) *SALAMONIS* RAMSAY.

By Ellis Le G. Troughton, C.M.Z.S.*

[Read 27th May, 1936.]

It is of interest to note of the "New species of *Mus* from the Island of Ugi, Solomon Group", described in the Proceedings for 1882 by E. P. Ramsay, then Curator of the Australian Museum, that not only was it the first indigenous rat reported from the group, but actually the second species of non-chiropterous mammal to be recorded as well, although a remarkably varied murine and chiropterous fauna has since been listed from the Solomons.

Representatives of the only marsupial inhabitant, a geographical race of Cuscus (*Phalanger orientalis breviceps* Thomas), and the first collection of bats, had previously been obtained during the voyage of 'H.M.S. *Herald*' in 1855 by the famous naturalist John Macgillivray, and Dr. F. M. Rayner, who presented the material to the British Museum.

Apparently the next definite attempt at collecting in the group occurred some twenty-five years later, when, by courtesy of the naval authorities, Alexander Morton, then assistant taxidermist at the Australian Museum, accompanied the punitive expedition on board 'H.M.S. *Cormorant*', despatched in 1881 to investigate tragic happenings in the Solomons.

An excellent collection of birds included striking novelties described in the Proceedings for 1882, in which Morton also supplied interesting "Notes on the Cruise" and wrote concerning collecting on Ugi Island, near San Christoval in the south-eastern extremity of the group, that "Mammals were very scarce, an opossum, *Cuscus orientalis*, the species common throughout the islands, and a Rat, an undescribed species of *Mus*, being the only species obtained".

In reviewing the important collections of mammals sent to the British Museum by the late C. M. Woodford, C.M.G., following his arrival in the Solomons in 1886, Oldfield Thomas repeatedly misquoted the locality of *Mus salamonis* as being Florida Island, although it is perfectly clear from Ramsay's title and description, as well as Morton's account, that Ugi was the type locality. The implied uncertainty of habitat, coupled with the impossibility of deciding its generic affinities from the brief description, therefore led to the species being generally regarded as of doubtful authenticity.

Although the holotype skin unfortunately disappeared many years ago, careful examination of the "old collection" crania in the Museum resulted in the discovery of the holotype skull, the identity of which is definitely established by comparison with Ramsay's illustrations. The description of the hairless tail showed the animal to be of the arboreal *Uromys* type, and the cranial features now prove it to belong to the closely allied genus *Solomys*, originally provided by Thomas (*Ann. Mag. Nat. Hist.*, (9) ix, 1922, 261) for his *Uromys sapientis* from Ysabel

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* Contribution from the Australian Museum.

Island, east central Solomons. Also included in the genus is a third species, *S. salebrosus* Troughton (*Rec. Austr. Mus.*, xix (5), 1936, 341–354) recently described from Bougainville Island at the north-western extremity of the group.

It is indeed satisfactory to confirm the status of this interesting species, described in the PROCEEDINGS more than fifty years ago, and to amplify its description in accordance with the needs of modern mammalogy.

SOLOMYS SALAMONIS Ramsay.

Mus salamonis Ramsay, PROC. LINN. SOC. N.S.W., vii, 1882 (1883), p. 43, Pl. ii (v), figs. 1–7. Ugi Island.

Diagnosis.—A pale, grizzled, "light ashy grey", rather harshly furred animal, with the termination of palate and the bullae and other features quite typical of *Solomys.* Differing from the allied forms by its smaller size, decidedly broader and straighter margined interorbital region, and smaller tympanic bullae. Habitat: Ugi Island, near San Christoval, south-eastern Solomons.

External characters.—According to Ramsay, "General colour of the fur, of a light ashy grey, somewhat grizzly, and pencilled with black, the base of the hair mouse colour, the tips almost white: long black hairs extending about half an inch beyond the fur, which is slightly harsh to the touch; the tail bare, scaly; the whiskers long, blackish; the ears small, inside grey, on the outside covered with minute hairs."

Holotype skull.—Compared with a topotypical skull of *S. sapientis*, possessing all features regarded as typical of the genus, though the narrowing of the mesopterygoid fossa anteriorly is less marked, with a corresponding reduction of the palatal emargination, and the bullae are relatively smaller, less inflated, and more transparent. Interorbital region comparatively broad and straight-sided, the margins not markedly concave as in *sapientis*, or sinuous as in *salebrosus.* Palatal foramina distinctly smaller in the slightly larger skull, and decidedly constricted in their anterior third instead of evenly bowed as in the topotype *sapientis.* Zygomatic plate wider, and broadly convex instead of straight in profile, the upper edge more rounded but not projecting above as in Ramsay's figure.

Dentition.—Size and pattern of upper molars quite as in the allied forms, but the lower series differing unusually in being longer and much heavier than the upper row, the greater width being most evident in m_3, the greatest width of which is 2·9, against 2·6 mm. in the specimen of *sapientis*, while the posterior lamina is 2·1 against 1·6 mm. and obviously larger, giving the lower row a broadly angulate appearance posteriorly.

Dimensions of holotype, male.—In spirit, vide Ramsay: Head and body 216; tail 224; pes 44·3; ear, from top of head, 13 mm.

Skull: Greatest length 49; basal length 43·8; zygomatic breadth 28·1; interorbital width 8·9; nasals 17·8 × 5·3; palatal length 25·9; palatal foramina 6·2 × 2·8; upper molar row 10·4; width of m^1 3; lower row 10·5; bulla, length 5·9, breadth, including meatal tubercle, 6·4 mm.

Holotype.—Skull only in existence, registered No. A.11257 in the Australian Museum. Collected about May, 1881, by Alexander Morton, Assistant Taxidermist to the Museum, on Ugi Island, off the northern coast of San Christoval in the Solomons group.

Comparison with allies.—The description has been amplified in comparison with *sapientis* because of its intermediate range. Although it is quite possible that examination of a series of skins of *salamonis* might tend to link superficially the three forms, specific distinction is most advisable at present and appears fully justified by the cranial and dental differences.

Various dimensions indicate that *salamonis* is the smallest form, with smaller and less inflated bullae than either ally, while the interorbital region is comparatively much broader and has almost straight margins, instead of them being evenly concave as in *sapientis*, or sinuous as in *salebrosus*. It agrees with *sapientis* in having the tail longer than the head and body, instead of averaging shorter as in *salebrosus*, but differs from *sapientis* in the comparatively much heavier lower molar row.

Remarks.—The members of this genus are apparently the Solomons representatives of the large arboreal *Uromys* of the Aru Islands, New Guinea, and north-eastern Queensland. The habits are evidently similar, as *U. caudimaculata* of the mainland has been reported to knock down and gnaw coconuts in the Cairns district, while Mr. N. S. Heffernan, when District Officer at Ysabel Island, observed of *S. sapientis* that "the big and large-toothed rats, called 'Vanete' by the natives, are wonderfully active and must be almost entirely arboreal as they crack the Ngali (Canarium) nuts and gnaw the coconuts, and are found in trees felled by the natives who eat them".

The habits of *S. salamonis* are doubtless the same, and it is fortunate, in view of the large and varied rat population of the group, that the dense vegetation which led to the development of many arboreal forms in the Solomons may also prevent them affecting the food supplies of the natives, as various species are reported to be doing in parts of New Guinea.

THE STRUCTURAL GEOLOGY AND PETROLOGY OF AN AREA NEAR YASS, NEW SOUTH WALES.

By KATHLEEN SHERRARD, M.Sc.

(Plates vi–vii; nine Text-figures.)

[Read 24th June, 1936.]

A study of the geology of the neighbourhood of Yass was undertaken to determine the nature of the igneous rocks, and their relationship to the sediments. In addition, it was hoped to find a zone fossil to enable correlation to be made with rocks of other districts.

The area studied comprises the whole or portion of the parishes of Hume, Yass, Warroo, Boambolo, Bowning, Derringullen and Nanima; Shire of Goodradigbee; Counties of King, Murray and Harden.

The town of Yass is situated on the Yass River, a tributary of the Murrumbidgee. It is 1,620 feet above sea-level, on the Southern Highlands of New South Wales, 198 miles by rail, south-west of Sydney. A short branch line connects the town with the Sydney-Melbourne railway line. It is 33 miles by road, north-west of Canberra.

About 50 square miles has been studied in detail, stretching from the town for 7 miles south, and from a north and south line through the town, for 3 miles east and 3 miles west. The remainder of the 120 miles shown in the sketch map (Text-fig. 9) has been examined cursorily.

PREVIOUS LITERATURE.

Jenkins (1878*a*) described the igneous and sedimentary rocks of Yass and the surrounding country. He separated the fossiliferous beds into lower (Yass beds) and upper (Hume beds) horizons, subdividing these further. He classed Yass and Hume beds within the Silurian formation, separating them from the Murrumbidgee limestone. He noted the absence of graptolites. Later (1878*b*) he described trilobites collected by himself. David visited Yass (1882) shortly after joining the Geological Survey. He mapped the area and noted the geological structures. Mitchell, in two early papers (1886, 1888), dealt principally with the geology of Bowning, describing a synclinal structure there, and the fossil content of the beds. He refers to the presence of graptolites "from mica sandstones in the Lower Trilobite bed on the east side (i.e., of the syncline), and in shaly sandstones on the west side in the Great Shale bed". In later papers (1919–1923) he describes trilobites and brachiopods from the district.

Geology owes a debt to Mr. A. J. Shearsby for his study (1911) of the geology and palaeontology of the district. His descriptions and map cover a wide area and systematize the previous observations. As well as his published work, his knowledge and guidance are always at the service of inquirers. Harper (1909), dealing principally with the area afterwards submerged by the Burrenjuck dam, referred to the Yass porphyry, which is considered of Post-Devonian age.

Mann (1921) regarded the igneous rocks at Yass as intrusive on account of the presence of contact-breccias. Etheridge (1894–1917) described fossils from many parts of the area, and several other short references are to be found (Cotton, 1923; Wilkinson, 1876).

PHYSIOGRAPHY.

A parallelism is to be noted in the physiographical features of the area shown on the map (Pl. vii), three ridges running approximately NNW.–SSE., with two intervening valleys, being the most pronounced features. On the eastern ridge is situated the Douro Trigonometrical Station, and on the second are the Laidlaw and Racecourse Stations. These names have been used in writing of the localities. The third is referred to as the Euralie–Warroo ridge, Euralie homestead and Warroo Trigonometrical Station being situated on it. The eastern valley, viz., that between Douro and Laidlaw ridges, is occupied by the town of Yass, the main street of which, Cooma Street, occupies the lowest ground and was formerly alongside a water-course flowing into the Yass River. The westerly valley is drained by two tributaries of the Yass River, Booroo Ponds Creek and Reedy Creek, which are fed by drainage from Laidlaw and Euralie–Warroo ridges. The Yass River has cut a passage across the ridges, but not before it was greatly deflected by them. Pronounced swingings to the north mark the river's course, when it first meets each ridge, and only after some distance of northward flow has a westerly course been carved, along which the river has the nearly vertical sides of a young stream. Across the softer beds of the valley between Laidlaw and Euralie ridges, the Yass River pursues the low-banked straight course of a mature stream. Differential erosion is responsible for the ridges. It will be shown that they mark the outcrop of coarse-grained igneous rocks, while the valleys have been carved in softer sedimentary rocks. Coarse gravel deposits in places, above the present river, mark levels of its former course. Alluvium has been deposited by the tributaries to Reedy Creek and Booroo Ponds Creek at points where their flow has been slackened by arrival on the relatively flat ground where sandy shales outcrop, after descent from higher land, as in Portions 16, the western part of 18, and southern 15, Parish of Hume. The course of Warroo Creek is checked by hard igneous rocks in Portion 62, Parish of Boambolo, and alluvium has been deposited, which here, as elsewhere, masks the geology. The lower course of Reedy Creek is marked by rather high, open banks rising to about 50 feet above the valley.

GENERAL GEOLOGY.

(*Note.*—The numbers, as S.53, refer to specimens and thin sections in the author's collection.)

a. Igneous Rocks and Tuffaceous Sediments.

The junctions between the different rocks of the area lie along more or less parallel lines, on account of their conformability. They are folded into a geosyncline with a pitch to the north-west. Igneous rocks are either interbedded or intrusive along bedding-planes. Transgressive intrusion plays but a minor part. With one or two possible exceptions, all rocks belong to the Upper Silurian system. The oldest members of the synclinal structure are exposed beside the river immediately north-east of Laidlaw Trigonometrical Station, where a fine-grained, quartz-rich, highly micaceous, black tuff, 20 feet wide, dips WSW. at 20 degrees. This bed underlies a finer, more iron-stained type, which has a steeper dip in the same direction. A thin section of this rock can hardly be distinguished from a felspathic mica sandstone, although it is probably of tuffaceous origin, since all its fragments are angular. Poorly preserved specimens of *Orthoceras* occur within it. A similar micaceous sandstone, rich in *Leperditia shearsbii* Chapm. (1909), on the same line of strike outcrops in Portion 100, Parish of Yass, and in a section on the opposite bank of the Yass river in Portion 14, Parish of Yass, described by Shearsby (1911) and regarded by him as the type section of the Yass beds, or lower member of the Upper Silurian rocks of the district. The section is about half a mile downstream from the railway bridge. The beds here are richly fossiliferous with *Ceratioceras*, *Cycloceras*, *Leperditia*, *Pterinea*, *Spirifer*, *Barrandella*, etc. Closely comparable lithologically and stratigraphically with these is a bedded rock (S.27) outcropping in Douro Creek, Portion 22, Parish of Hume. Tuffs and thin limestone bands are intercalated in some of these sections, and calcium carbonate has percolated into some of the tuffs, for example, into that exposed in a rock cutting on the Hume Highway, 1½ miles east of Yass. Well marked bands of limestone, striking at 7 degrees, outcrop in Portions 107 and 108, Parish of Yass. This is a porous rock of a fragmental nature, with broken corals, quartz grains and fragments of tuff. Almost the whole of the low-lying Rifle Range in Portion 8, Parish of Hume, is covered by limestone, in places strongly contorted, apparently by the neighbouring porphyry intrusion.

Overlying the series of fine tuffaceous sediments with intercalated limestone, near Laidlaw Trigonometrical Station (Text-figure 5), occurs a coarse-grained grey igneous rock, whose fragmental nature is not apparent until it is examined in thin section. In a hand specimen the rock resembles a porphyry, but it proves to be a coarse crystal tuff (Pirsson, 1915), with large angular fragments of quartz and felspar, some of which fractured in place before consolidation of the rock (*see* Petrological Descriptions). The fractured edges of adjoining fragments in some cases undoubtedly match, and would interlock if they could be brought into contact (Text-figure 6). The same feature has been detected in the "porphyroides" of the French and Belgian Ardennes (Poussin and Renard, 1876, 1897), and is also noted in the quartz-porphyry tuffs of the Yass District; it is discussed below. Coarse crystal tuff covers a large part of the area, being found in Portions 100, 103, 106, Parish of Yass, and in Portions 18 and 20, Parish of Hume, as well as in the Parishes of Boambolo and Warroo. The rock outcropping along a narrow ridge through Portions 45, 49, 53 and 57, Town of Yass, SSE. of Laidlaw Trigonometrical Station, though perhaps better described as a volcanic grit, is regarded as of similar origin. By the conversion of its matrix into secondary silica, the volcanic grit passes into quartzite, for example in the rifle range in the east of Portion 8, Parish of Hume, near the border of the quartz-porphyry. The relationship of coarse crystal tuff, volcanic grit and quartzite to quartz-porphyry tuff will be discussed later.

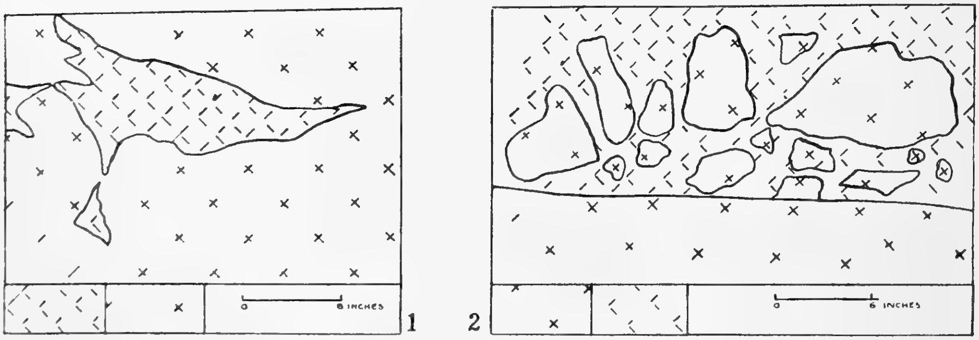
The fossils collected near Yass by Shearsby (1911) from coarse-grained igneous rocks, hand-specimens of which resemble porphyries, probably occurred in rocks of this type, and the presence of fossils further supports the theory of their pyroclastic origin.

The crystal tuffs, etc., junction with porphyry along a nearly straight north-west and south-east line, running parallel to the strike of the sediments, and passing through a point 150 yards north-east of Laidlaw Trigonometrical Station. The porphyry is a grey and white coarse-grained rock, easily to be confused with the crystal tuff, until examined in thin section, when it proves to be a normal quartz-porphyry with a devitrified ground-mass (*see* Petrological Descriptions). Careful collection and examination in thin section of specimens every twenty-five yards north-east of Laidlaw Trigonometrical Station has failed to disclose any rocks with texture transitional between that of crystal tuff and porphyry. A sharp junction separates the types (Text-figure 5). Hexagonal jointing has developed in the porphyry, an exposure in a rock pavement showing traces of well-marked joints bearing at 75 degrees, 195 degrees and 315 degrees. On the edge of a steep slope to the river, 50 yards north-east of Laidlaw Trigonometrical Station, porphyry columns 7 feet high and 2 feet in diameter are exposed. In a quarry within the golf links, in Portion 8, Parish of Hume, columnar development is also found.

Xenoliths of tuff, fine- and medium-grained, several inches in diameter, are not uncommon in the porphyry, and are regarded as being due to dislodgment by the porphyry during its intrusion.

Ten yards to the west of Racecourse Trigonometrical Station, the porphyry has suffered devitrification (Harker, 1909; Shand, 1927; Tyrrell, 1926) so intense as to have become almost a quartzite. (S.477; *see* Petrological Descriptions.) This is the furthest extension to the south-east of the Laidlaw ridge porphyry. To the north-west the outcrop trends across the Yass River, which has cut a passage through porphyry from Portion 108, Parish of Yass, to Portion 97, Parish of Yass. From Portion 97 a line running roughly south-east marks the junction of porphyry with tuffs. The intrusion of the porphyry is pictured as having taken place in the manner of a sill, since its junctions on both sides with neighbouring bedded strata run nearly parallel with their strike, viz., north-west and south-east.

Evidence of the period at which the intrusion of the porphyry took place has not been obtained. Its mineral contents ally it with the interbedded tuffs of the area, and it has undergone devitrification to about the same extent as they. These circumstances suggest that the intrusion took place shortly after the laying down of the tuffs. The river has exposed, in Portion 97, Parish of Yass, the junction between the porphyry and a fine-grained rock (Text-figures 1, 2). The conclusion that the fine-grained rock is intrusive into the porphyry seems inescapable. It occurs in masses up to 18 by 6 inches in cross-section, and is also seen in thin strings, about half an inch in width and 30 to 40 feet long, ramifying through the porphyry in all directions. These veinlets are generally dark-blue-grey in colour, though some are red. Thin quartz-veins are also present. For a



Text-figs. 1, 2.—Relations between quartz-porphyry and fine-grained rock in Portion 97, Parish of Yass.

width of 100 feet, the exposed face of the porphyry contains these inclusions. The porphyry is finely jointed here, joint-planes being only half an inch apart in places, and the rock is rotten. The fine-grained material is a dense, blue homogeneous material, suggesting a chert. Extremely fine and even-grained, in thin section it is nearly isotropic, though small rectangular fragments of secondary quartz can be discerned and minute mica flakes are arranged as though along bedding-planes. In places, mica flakes are concentrated in strings at right angles to the bedding-planes. With a high-power objective, a devitrified mass of spherulites, probably all of secondary quartz, can be detected. This material may have been intruded into the solid porphyry, which caused its very rapid cooling and solidification as a glass, and it has subsequently become devitrified. It is also possible that movements along the junction of porphyry and the fine-grained material have formed a kind of fault-breccia, causing the squeezing of the fine-grained rock into the porphyry. A sharp junction separates normal porphyry from that associated with the fine-grained material (Text-figures 1, 2). Whatever the origin of the breccia-like rock, it seems that the thin string-like veins must be intrusive. The microscopic character of this fine-grained material is similar to that of rocks from the Parish of Boambolo described below (S.101 and S.577), which have been classified, though somewhat doubtfully, as fine tuffs. In this connection, however, it is noteworthy that Cox and Wells (1920), writing of the Lower Palaeozoic rocks of North Wales, state "the true rhyolites of Mynydd-y-Gader bear an extraordinary resemblance to tuffs". Benson (1915) has described an intrusion of a tuffaceous breccia at Tamworth, N.S.W., of a grain-size, however, coarser than the intrusive material described here.

To the south-west, the porphyry of the Laidlaw ridge is succeeded by fine- to medium-grained tuffs, about 1,000 feet in thickness. The best section is exposed by the Yass River, upstream from Hatton's Corner, in Portions 94 and 97, Parish of Yass, where the dip is 15 to 30 degrees WSW. In the direction of dip, tuffs outcrop for an average width of 800 yards and vary in texture, but the mineral constituents remain uniformly quartz, altered felspar, chloritized biotite and iron oxide set in a devitrified groundmass. Texturally, three main divisions may be distinguished: medium-grained (type 1), bedded or banded (type 2), and fine-grained (type 3). Tuffs from all over the area have been grouped according to these divisions. Type 2 includes tuffs whose bedding traces are sometimes only detected with the aid of the microscope. These, and indeed most rocks of Type 2, are probably variants of types 1 or 3, local pressure having caused re-orientation of the minerals with their long axes parallel. In other parts of the area, rhythmic banding appears to be due to periodic variations in the nature of the deposit, for example, in a road-cutting in Portion 7, Parish of Warroo. Fine-grained tuff (type 3) adjoins the Laidlaw ridge porphyry to the south-west and is overlain by medium-grained tuff (type 1), which in turn underlies bedded tuff (type 2) (Text-figure 3). A fractured face of type 3 is exposed in the municipal quarry in the south-east of Portion 8, Parish of Hume, 150 yards south of Racecourse Trigonometrical Station, where doubtful traces of fossils may be found. About 50 yards to the west of the quarry the tuff is intensely devitrified, showing geodes of agate and chalcedony. Normal devitrification has probably been reinforced by invasions of siliceous solutions along the junction of tuff and porphyry (Harker, 1909; Shand, 1927; Tyrrell, 1926). In places this type of tuff is spotted, the spots being centres of advanced devitrification. The spots are sometimes visible to the naked eye, sometimes only in thin section (S.420).

The medium-grained tuff (type 1) overlying type 3, outcrops for 600 yards across the dip. A tributary to Black Bog Creek exposes a 20-foot section of this tuff dipping west at 10 degrees. It is grey when fresh, as in Portion 8, Parish of Hume, near the boundary of Portion 111, Parish of Yass, or in the bed of the Yass River, where it contains narrow veins of red siliceous material. Its outcrop is interrupted by a coarse agglomerate, which forms two persistent bands standing six to nine inches above the level of the tuffs and running parallel to their bedding. The bands are of low boulders and are about 40 feet apart. Each band is about 10 yards wide and strikes SSE. The bands are continuous across much of Portion 8, Parish of Hume, and may be followed across Portion 94, Parish of Yass, nearly to the Yass River, and in the opposite direction nearly to the municipal quarry. At the south-west corner of the rifle range, in Portion 8, Parish of Hume, the band of agglomerate widens out considerably into a circular area about 25 yards in diameter. Mr. Shearsby has traced agglomerate into Portion 55, Parish of Yass, north of the Yass River (personal communication).

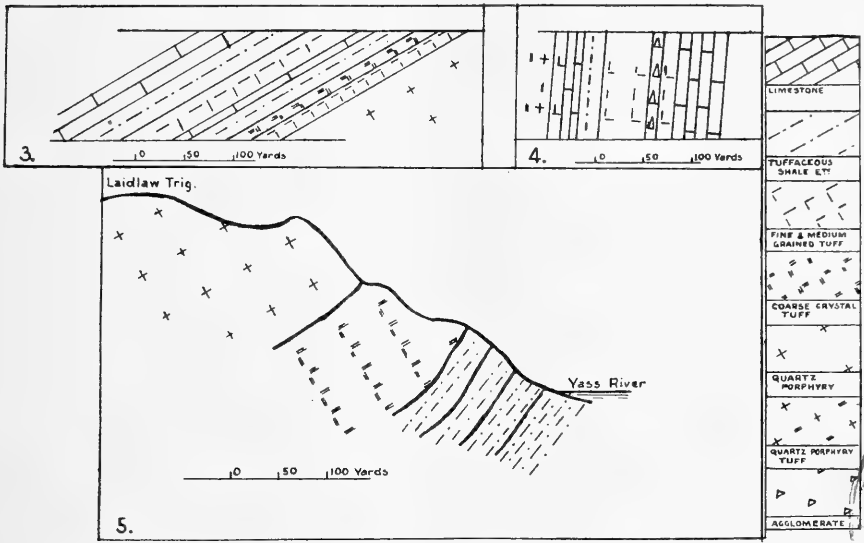
The fragments making up the agglomerate are of fine (type 3) and medium tuff (type 1) up to half an inch across. The rock is an interbedded pyroclastic rock, and for some miles follows the bedding of the tuffs and is not transgressive. It has been deposited after a period of intense explosive activity.

Another interruption in the deposition of medium-grained tuff (type 1) in Portion 8, Parish of Hume, is shown by a restricted outcrop of coarse crystal tuff similar to that found north-east of Laidlaw Trigonometrical Station, but here containing limestone fragments, which occurs 100 yards west of the south-west corner post of the rifle range. It is probably connected with a much weathered volcanic conglomerate outcropping in the bank of the Yass River, in Portion 97, Parish of Yass, 50 yards from the boundary of the porphyry, where it is clearly interbedded with tuffs (Text-figure 3). Another small outcrop of coarse crystal tuff occurs within the rifle range.

The sequence of tuffs in Portion 8, Parish of Hume, is brought to a close by the bedded tuff (type 2), which can be seen dipping at 10 degrees SW., conformably below limestone in the bed of Yass River, near the junction of Portion 8, Parish of Hume, with Portion 94, Parish of Yass, and also in the bed of Booroo Ponds Creek, about half a mile south-east of its junction with the Yass River.

Agglomerate does not outcrop across the valley along which the Wee Jasper Road now runs; indeed, the absence of such a competent bed may explain the development of a valley between the ridges capped by agglomerate, for agglomerate can be traced again south-east of the junction of the Wee Jasper and Gums Roads, Portion 14, Parish of Hume, where it strikes SSE., parallel to the strike of the tuffs. It accompanies a suite of tuffs similar to those in Portion 8, Parish of Hume. No section is exposed, but a traverse ENE. from the corner of the Wee Jasper and Gums Roads shows that the agglomerate is interbedded with the medium-grained tuff (type 1), beneath which fine tuff of type 3 outcrops. The fine tuff overlies coarse crystal tuff, whose direction of strike is the same as that of the coarse crystal tuff to the north-east of Laidlaw Trigonometrical Station, and they are lithologically similar. Included among the tuffs on this traverse are some which have undergone such intense devitrification that they are now almost pure quartz. It is considered that silica solutions percolating between bedding planes, or along concealed strike fault planes, have accelerated the devitrification process in these cases.

No porphyry is exposed in this traverse. Sir Edgeworth David noted (1882) that the Laidlaw porphyry does not outcrop south of Racecourse Trigonometrical Station.



Text-figs. 3, 4.—Sequence of rocks exposed by the Yass River in Portion 94, Parish of Yass (Fig. 3), and Portion 64, Parish of Warroo (Fig. 4).

Text-fig. 5.—Ideal section from Laidlaw Trigonometrical Station to the Yass River, Portions 112 and 113, Parish of Yass.

The country east of Gums Road is well grassed, and outcrops are poor. Along the junction of Portions 17 and 18, Parish of Hume, east of Gums Road, fine tuff (type 3) is succeeded by coarse crystal tuff, dipping WSW. at 20 degrees. Agglomerate is not exposed here. To the south, Portion 148, Parish of Boambolo, and adjoining portions are covered by a green, dense tuff, with a smooth surface and waxy lustre, dipping NNW. at 15 degrees. The rock is extremely fine-grained and intensely devitrified, perhaps best described as a chert or hälleflinta (Harker, 1919). It is, indeed, doubtful if this rock was originally a tuff, but since, in the hand-specimen, it resembles the undoubted tuffs of Portion 202, Parish of Warroo, and of the municipal quarry, in spite of the greater devitrification visible in a thin section, it is described here as a fine tuff belonging to type 3 (S.101, S.577). Agglomerate lithologically identical with those previously described, and with a dip varying between W. and NNE., separates the fine tuff from a bedded tuff of type 2, which, in turn, overlies coarse crystal-lithic tuff (S.155), containing remarkable elliptical xenoliths of pink crystal tuff of a type which can be matched in outcrops elsewhere in the area, notably near the 7-mile post on the Wee Jasper Road. The matrix of the crystal-lithic tuff is the normal crystal tuff familiar north-east of Laidlaw Trigonometrical Station. In Portion 108, Parish of Boambolo, remarkable tors, 10 feet high, are formed of this rock, and it caps a bold hill in Portion 90, Parish of Boambolo.

The Euralie-Warroo ridge forms the western limb of the geosyncline, of which the rocks of the Laidlaw Ridge are the eastern members, and the structure of which will be described later. Approaching the ridge from the east the rock sequence of the eastern limb in Portion 8, Parish of Hume, is passed over in the reverse order (see Geological Sketch Section, Plate vii). A conformable series made up of a blue-grey slate (regarded as the indurated equivalent of the Barrandella shales, described below), a resistant limestone, lithologically exactly similar to the Bowspring limestone (described below), and a medium-grained tuff (type 1 or 2), all dipping at 100 degrees ENE., is passed over in travelling from east to west in Portion 64, Parish of Warroo (Text-figure 4). This dip is regarded as due to local overfolding or faulting, because slightly to the north in Portion 148, Parish of Warroo, the limestone is dipping at 75 degrees ENE., and to the south, in Portion 60, Parish of Warroo, the medium-grained tuff and agglomerate dip to the north-east at 40 degrees, and at 60 degrees ENE., in Portion 15, Parish of Boambolo. Agglomerate interrupts the tuff sequence at Euralie, as elsewhere in the area. It is lithologically similar on the Euralie ridge to other outcrops, standing up in a resistant low wall which runs parallel to the strike of the tuffs. The repeated association of this rock in conformity with the same tuff sequence is a strong argument for a similar origin for all, that is a pyroclastic origin for the agglomerate. Cuttings on the Goodhope Road, immediately west of the Euralie turn-off, and on the bank of Yass River, east of the junction with Euralie Creek, expose a tuff of type 3 underlying agglomerate, followed by a medium-grained tuff (type 1) with interbedded thin bands of limestone and sandstone (Text-figure 4).

At the Yass River, in Portion 64, Parish of Warroo, near the junction of Euralie Creek, the sequence of fine- and medium-grained tuffs is succeeded by a coarse-grained crystalline rock, which seems best described as a quartz-porphyry-tuff. It differs materially from the porphyry of the Laidlaw ridge, but resembles the crystalline rock forming a fringe on the east of the area, and is discussed with it later.

To the south of Euralie, the sequence of fine- and medium-grained tuffs is succeeded by coarse crystal tuff, similar to the rock so named elsewhere in the area, and quite distinct from the quartz-porphyry-tuff of Euralie. Coarse crystal tuff forms the Warroo Trigonometrical Station ridge and extends in a direction generally south-south-east from Portion 213, Parish of Warroo. Quartzite outcrops in Portions 59, 64, 103 and 147, Parish of Warroo, are considered to have developed from coarse crystal tuff by devitrification intensified by the attack of siliceous solutions (*see* Petrological Descriptions).

The Douro ridge, on the east of the area, is formed of a coarse-grained quartz-porphyry which, like that of the Laidlaw ridge, meets sediments (tuffaceous sandstones) along its western border in a line parallel to the strike of the sediments, and so is regarded as having been intruded between bedding planes. Xenoliths of tuff, the coarse crystal and the bedded varieties, are not uncommon in the porphyry. Along their junction, both porphyry and tuffaceous sediments have been intensely devitrified and acted upon by siliceous solutions. Porphyry outcropping in Portion 24, Town of Yass, and bedded tuff in Portion 47, Town of Yass, have been converted to chert. In Portion 32, Parish of Hume, the porphyry and banded tuff are almost completely silicified. The process is less complete in Portion 21, Parish of Hume, 300 yards north of the Hume Highway, where the otherwise normal Douro porphyry, grey and coarse-grained, contains large patches (4 inches in diameter) of chalcedonic silica enveloping primary quartz and altered plagioclase crystals. A strip about a quarter of a mile wide running generally north-west and south-east along the margin of the porphyry has been affected. The invasion of siliceous solutions seems to have been the last phase of the intrusion of the Douro porphyry, affecting the western margin of the porphyry itself as well as the adjoining tuffaceous sediments. The parallelism of this line of intrusion to the strike of the sediments is considered to be due to the intrusion, as a sill, of the Douro porphyry between the bedding planes of the tuffs and tuffaceous sediments. The passage of siliceous solutions along bedding-planes, or possibly along concealed strike-fault planes, accounts also for the replacement by silica of some of the corals in the Bowspring limestone, near Hatton's Corner, and for the occurrence of quartz crystals, sometimes double-ended, half an inch in length in the tuffaceous grits in Portion 45, Town of Yass.

Fresh specimens of the Douro porphyry can be obtained in a quarry 150 feet above the left bank of the Yass River about half a mile up-stream from the Hume Highway bridge in the town, at a point called Hibernia Crescent (Shearsby, 1911). It is a coarse-grained, greyish-green rock, rich in quartz, and contains xenoliths of quartz-grit up to fifteen inches across. This quartz-grit is related to coarse crystal tuffs outcropping nearby, notably the volcanic grit of Portions 45, 49, 53 and 57, Town of Yass. The xenoliths were probably displaced by the porphyry during its intrusion between bedding-planes of the tuffs. Porphyry outcropping in Portion 21, Parish of Hume, half a mile north of the Hume Highway, also shows large included fragments of fine bedded tuff (type 2).

Forming a fringe on the east of the area, the rock outcropping in Portions 23, 24, 26, 27 and 30, Parish of Hume, and from Portions 6 to 16, Parish of Nanima, suggests, like the Euralie "porphyry", a normal quartz-porphyry in the hand-specimen, but an examination in thin section reveals differences. Though phenocrysts of idiomorphic quartz, plagioclase, chlorite and apatite bring the rock into line with the porphyries, small irregularly-shaped quartz and felspar fragments are packed so closely between the phenocrysts that the interstitial ground-mass is reduced to a minimum. Some of the quartz phenocrysts are shattered, the fragments remaining close together, with mere threads of interstitial ground-mass between them (Text-figure 7).

The name "quartz-porphyry-tuff" has been adopted to describe this type. They are vividly recalled, when reading descriptions of the rocks of the Belgian and French Ardennes by Ch. de la Vallée Poussin and A. Renard (1876, 1897). These rocks, previously known as "porphyroides", the authors say, are composed of crystals of felspar, which are cracked, broken and rounded off on the angles, and of crystals of quartz with corroded borders and seldom idiomorphic. They have so little cement as to have almost a granitic texture except that crystals have such poorly defined contours. They say, further, "it is noticeable that adjacent fragments have belonged to the same crystal", and that fragmentation is so general that the rocks must be clastic. The authors put forward the alternative hypotheses that the minerals composing these rocks were either of volcanic origin, and were projected directly into sea-water, fracturing on impact; or that they are the disintegrated products of a rock attacked by atmospheric agents, and are still *in situ*. T. G. Bonney (1885) considers these rocks of the French Ardennes to have been lavas, and ascribes the present fragmental condition of their mineral components to devitrification. Though both are composed mainly of quartz, plagioclase and chlorite, the crystal tuffs of the Yass district differ from quartz-porphyry-tuff in being composed of mineral grains, all of which have been corroded or worn by attrition, since none show crystal outlines. They are packed even more closely than in the quartz-porphyry-tuff, so that the proportion of crystals to matrix is higher. Felspar is greatly altered and unidentifiable, while comparatively fresh in the quartz-porphyry-tuff, and secondary minerals, such as calcite, are common in crystal tuff. The constituents of the crystal tuffs may have come from the same source as those forming the quartz-porphyry-tuffs, but they have undergone considerable weathering before consolidation, while those of the quartz-porphyry-tuff consolidated without so much intermediate weathering.

The outcrops of both tuffs show parallel strikes, and crystal tuff in Portion 18, Parish of Hume, is conformable in dip and strike with Upper Silurian limestone. It has been shown already that lithologically similar crystal tuff in Portion 112, Parish of Yass (i.e., NE. of Laidlaw Trigonometrical Station), is interbedded with fossiliferous Upper Silurian sediments. It is concluded, therefore, that the quartz-porphyry-tuff, like the crystal tuff, is Upper Silurian in age.

A belt of igneous rock which covers most of Portions 25 and 28, Parish of Hume, and Portions 7, 8, 71 and 72, Parish of Boambolo, is composed of a tuffaceous type, which differs from the quartz-porphyry-tuff in having a marked flow structure, and a higher proportion of ground-mass to phenocrysts. It is described as a rhyolite-tuff. The direction of the elongation of the outcrop is almost a direct south-south-eastern continuation of the Laidlaw porphyry, whose outcrop was interrupted at Racecourse Trigonometrical Station, but no evidence has been found to connect them. It seems likely that the rhyolite-tuff is also interbedded with the Upper Silurian rocks, but it is also possible that it is connected with the Devonian rocks to the south of this area.

b. Sedimentary Rocks.

The sedimentary series forms an elliptical enclave bounded by the igneous rocks already described. The sedimentary rocks and the tuffs are conformable where junctions are observable at Hatton's Corner and near Euralie.

The sedimentary series, ushered in by the Bowspring Limestone at Hatton's Corner, has been described by Shearsby (1911), who gave the name to the limestone. This limestone, about 300 feet thick, conformably overlies bedded tuff and outcrops across about 250 yards horizontally, its dip increasing from 10 to 30 degrees SW. It is crystalline and fragmental, the fragments often being in the form of elliptical boulders, about 3 inches along their greatest diameter, which are almost in contact. At Hatton's Corner, a cliff of the limestone, 90 feet high, is exposed, and is made up of alternate rows, each about 3 inches wide, of grey-blue ridges formed of such boulders, separated by less resistant material. A freshly-broken specimen has a brecciated appearance, while fossil fragments are exposed on a weathered surface.

Four hundred yards of shales, named "Barrandella" by Etheridge (1904), succeed the Bowspring limestone, dipping 10 degrees WSW., the bed being about 250 feet thick. They are compact, blue-grey, indurated, micaceous shales. They break with a semi-concave fracture, and show no sign of a slaty cleavage, nor trace of close bedding planes. The abundant *Barrandella* is preserved in almost transparent calcite with a pearly lustre.

Lithologically, the Barrandella shales vary only slightly from the sandy shales which overlie them. These are somewhat coarser in grain and contain more iron. Occasionally a greater concentration of iron has caused the formation of a pronounced ridge, on the weathered surface of which a rich fauna has been preserved, especially fragments of *Dalmanites*. Both types of shale break up along closely-set, somewhat curved joint-planes after exposure to the atmosphere for any length of time, when it is difficult to obtain a specimen larger than one cubic inch, except from beds with a high iron content. The sandy shales outcrop for about 2 miles across the dip, that is, to the south-west, and for a considerable distance to the south-east and north-west. They are occasionally interrupted by thin bands of limestone, which may represent conformable inliers of the underlying limestone. Indeed, a synclinal fold can be observed in the Bowspring limestone on the north bank of the Yass River, about Portion 148, Parish of Yass, near Hatton's Corner. What evidence of dip is available supports this view, notably in the case of the limestone outcropping at the 5-mile post on the Wee Jasper Road (see Map, Plate vii), which is probably the locality referred to by Etheridge (1894, 1907) as Old Limekilns Ridge. Concealed strike faulting, however, may have caused the repetition. The Yass River has exposed a series of anticlines and synclines in the sandy shales (see Pl. vii). The angle of folding becomes steeper westward, until, near Reedy Creek, a cliff face shows dips up to 80 degrees, as well as fracture (Pl. vi, fig. 11).

Highly dipping folds continue west of Reedy Creek, the strata exposed in the banks of the Yass River being nearly vertical, while the rock has become indurated to slate. Just before reaching the junction of Euralie Creek and the Yass River, a limestone band is crossed, as has already been described. This limestone is regarded as being the Bowspring limestone thrown up in this place by synclinal folding. It dips ENE. at 100 degrees or WSW. at 80 degrees, tuff outcropping to the WSW. An overfold must be postulated if this limestone is the Bowspring bed, and with almost vertical folding, an overfold may be expected, though faulting may intervene. The limestone outcrop is twice crossed by the Yass River at Euralie, striking across Portion 144, Parish of Yass, and being met again in Portion 103, Parish of Warroo, on the left-hand bank, while immediately to the east is shale (Barrandella, also thrown up by the syncline) striking NW. and with an almost vertical dip. The fossils recorded by Shearsby (1911) from limestone at Euralie, and by Etheridge (1907) from limestone and shale in Portions 53, 126 and 161, Parish of Yass, and from Portion 103, Parish of Warroo, which are all close by, give forms nearly identical with those from the Bowspring limestone and the Barrandella shales at Hatton's Corner, lending palaeontological support to the hypothesis of the synclinal fold.

Strong folding has been traced along Booroo Ponds Creek in Portion 7. Parish of Hume, and in cuttings along the Goodhope Road, such as about 5·1 miles from Yass, where folding and fracturing of the strata may be seen, and in the bed of Reedy Creek at the Goodhope Road. Along the Wee Jasper Road, cuttings expose comparatively low dips.

In Portion 62, Parish of Boambolo, near its junction with Portion 15, shafts have been sunk to exploit galena-bearing quartzites, dipping SW. at 60°. They are succeeded to the south-west by shales, with *Favosites*, *Mucophyllum crateroides*, *Atrypa reticularis*, *A. pulchra*, *Stropheodonta conica*, *Barrandella*, etc., regarded as the equivalent of the Barrandella shales, which give place in turn to a limestone, lithologically similar to the Bowspring type. The occurrence of a fault has been tentatively suggested to account for the sudden change of dip found about 400 yards to the south-west, where fine tuff (type 3) and agglomerate dip at about 60 degrees to the north-east in Portion 15, Parish of Boambolo. The presence of galena lends support to the postulation of a fault plane, which would provide an avenue for the mineral vapours.

Mitchell (1886) recorded a synclinal structure, with axis beneath Bowning Hill, illustrating it by a geological section. His west-dipping strata are exposed in Sharpening Stone Creek in Portions 7 and 8, Parish of Yass, while strata dipping 40 degrees east may be seen in Portion 94, Town of Bowning. Along the railway line between Bowning and Binalong, about Portion 146, Parish of Bowning, soft shales rich in brachiopods also dip at 40 degrees east. Beds exposed in the cutting near Bowning railway station are dipping 85 degrees east, and those exposed in Bowning Creek near the railway line have a practically vertical dip also. This synclinal structure is regarded as a continuation to the north-west of the Yass geosyncline (Text-fig. 9).

Stratigraphical Horizon.

The discovery of graptolites not far from Yass (Sherrard, 1934) has made possible the correlation of this locality with other Silurian areas. *Monograptus*? was recorded by Shearsby (1911). Mitchell (1886) also makes a brief reference to the collection of "graptolites from mica sandstones in the Lower Trilobite bed on the east side" (i.e., of the syncline) "and in shaly sandstones on the west side".

In the course of the present work, graptolites have been found in Portion 34, Parish of Derringullen, to the west of the road to Boorowa, 7 miles north-west of Yass. The fossils occur in a fine-grained felspathic sandstone, probably of tuffaceous origin. It forms a prominent ridge, 200 feet above the road, and is lithologically similar to the sandy shales found to the west of Hatton's Corner in ridges of which *Dalmanites* and other forms have been preserved. Indeed, the graptolite-bearing strata are believed to be extensions to the north-west of these sandy shales, since both overlie the same series, viz., the Barrandella shales. The Barrandella shales form the bed of Limestone Creek, a quarter of a mile to the east of the graptolite-bearing strata, and are richly fossiliferous, as Shearsby (1911) has recorded. Going eastward from Limestone Creek, Bowspring limestone, tuffs and porphyry are passed over, as at Hatton's Corner (Text-fig. 9).

In Portion 34, Parish of Derringullen, *Monograptus* is very common, and is associated with brachiopods, remains of both being found on the same slab of sandy shale. The specific determinations of Monograptidae have been made under the direction of Mr. R. A. Keble, Palaeontologist to the National Museum, Melbourne, who generously gave the writer the benefit of his extensive experience.

The following forms have been identified: *Monograptus vomerinus* Nich., *M. flemingii* Salt., *M. dubius* Suess, *M. vulgaris* Wood, *M.* cf. *nilssoni* Barr., *M. colonus* Barr., var. *compactus* Wood.

These forms indicate Zones 26 to 33 of Elles and Wood (1913), from which it is inferred that this bed and its continuation at Hatton's Corner are equivalents of the beds at the base of the Lower Ludlow division and at the top of the Wenlock division of the Upper Silurian of Britain. The equivalent bed in Victoria is the Yarravian, as defined by Thomas and Keble (1933).

The writer hopes to have the opportunity of publishing full descriptions of these forms later.

Slabs with brachiopods and graptolites on the same surface have also been submitted to Mr. Keble, and the following identifications made:

Atrypa fimbriata (?)	is	associated	with	*Monograptus vomerinus*
A. reticularis L. sp.	„	„	„	*M.* cf. *nilssoni*
Chonetes melbournensis Chapm.	„	„	„	*M. vomerinus*
C. bipartita	„	„	„	*M.* cf. *nilssoni*

Nucleospira australis McCoy is associated with *M. vulgaris*
N. australis „ „ „ *M. flemingii*
N. australis „ „ „ *M. vomerinus*
Meristella sp. „ „ „ *M. vulgaris*
Meristella sp. „ „ „ *M. dubius*
Meristella sp. „ „ „ *M. vomerinus*
Barrandella linguifera Sby.
  var. *Wilkinsoni* Eth. fil. „ „ „ *M. dubius*

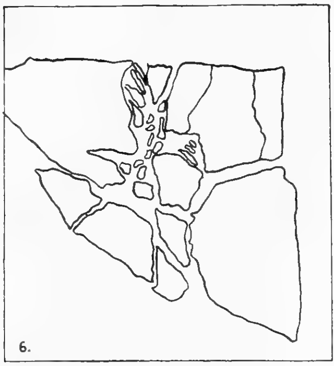
The association of graptolites with brachiopods of the class Articulata in arenaceous deposits is unusual. Ruedeman (1934) notes the association of small, primitive Inarticulata with graptolites in black, carbonaceous shales, while such an association in such shales has been described by the writer (1929).

PETROLOGICAL DESCRIPTIONS.

Quartz-porphyry.—The Laidlaw ridge quartz-porphyry (S.389; Pl. vi, fig. 1) is a coarse-grained grey and white rock composed of white felspathic crystals, some of which are idiomorphic, transparent quartz grains, and some black idiomorphic ferro-magnesian crystals. It is not uncommon for the black crystals to stand out from a broken surface so as to be detachable whole. Xenoliths of fine-grained material are frequent. In thin section, the phenocrysts of quartz are found to be much cracked and so much corroded that crystal boundaries are seldom perfect. The large hypidiomorphic plagioclase crystals are about $Ab_{60}An_{40}$, while some are zoned, and are slightly clouded by alteration. There are also some smaller plagioclases, and idiomorphic green biotite flakes somewhat chloritized. Accessory minerals include apatite, some galena and probably rutile. The fine-grained ground-mass making up about two-thirds of the rock consists of a devitrified mass of intergrown felspar and quartz showing spherulitic structure, with minute chlorite flakes.

This rock is referred to as "normal quartz-porphyry" throughout the paper. The porphyry in the neighbourhood of the Douro Trigonometrical Station differs somewhat. Its colour is greenish and it contains few white felspars. In thin section, devitrification of the ground-mass is seen to be more intense than in the Laidlaw rock, while the proportion of ground-mass to phenocrysts is nearly 1:1. Large apatite crystals show remarkable inclusions of rutile along cleavage planes intersecting at 120 degrees (S.10).

Quartz-porphyry-tuff.—These rocks are coarse in grain and greyish-green in colour. Mineral phenocrysts and fine-grained xenoliths stand out well. Thin sections show closer packing of the phenocrysts than in the porphyry. Small, angular or rounded grains of quartz and felspar are packed between large, hypidiomorphic, corroded and cracked quartz crystals, prismatic felspars of composition about $Ab_{60}An_{40}$, and flakes of chloritized biotite. Apatite is common, generally containing rutile inclusions along cleavage planes. Sphene is rare. The strongly devitrified ground-mass, showing spherulitic structure, occupies not more than 10–20% of the area. Traces of flow-structure are not uncommon. In places, the character of the broken edges of adjoining pieces of quartz shows unmistakably that they originally belonged to one quartz crystal, which must have fractured on the impact when it came to rest after violent extrusion (Text-figure 7). Typical of this tuff is the rock outcropping in Portion 23, Parish of Hume, at the intersection of the Hume Highway and the road from Yass to Canberra (S.169; Pl. vi, fig. 2). A further example occurs on the Euralie ridge, where specimens have been collected from Portion 62 (S.143) and 115 (S.604), Parish of Warroo. The rock of Portion 6, Parish of Nanima, is also typical (S.173).



6.

7.

8.

Text-fig. 6.—Fractured quartz crystal in coarse crystal tuff (S.220), Portion 100, Parish of Yass. Drawn with camera lucida. × 25.

Text-fig. 7.—Fractured quartz crystal in quartz-porphyry-tuff (S.173), Portion 6, Parish of Nanima. Drawn with camera lucida. × 25.

Text-fig. 8.—Quartz crystal with corroded and jagged outline from rhyolite-tuff (S.572), Portion 71, Parish of Boambolo. Drawn with camera lucida. × 25.

Rhyolite-tuff.—The rock of the narrow igneous tongue stretching south from Portion 25, Parish of Hume, has been described as a rhyolite-tuff, from the fluidal texture of its ground-mass. In a hand-specimen it differs only slightly from a quartz-porphyry or from a quartz-porphyry-tuff. Pink and cream felspar, glassy quartz and black ferro-magnesian minerals are the phenocrysts set in a greyish-green ground-mass. In addition chalcedonic patches about 1 inch in diameter are not infrequent. In thin section, the quartz fragments are seen to be of the most remarkable outline, corrosion having carved out re-entrant angles in their edges, leaving them serrated and jagged (Text-fig. 8; Pl. vi, fig. 3). The felspar is intensely altered to sericite and kaolin, and cannot be more exactly identified. Chlorite occurs in flakes, parallel to, and across the cleavage, calcite sometimes penetrating between cleavage laminae. Galena and apatite are accessories. Small angular pieces of quartz and felspar are packed between the larger fragments of these minerals. Flow-structure is pronounced in the ground-mass. Some lithic fragments are present. The ground-mass when fluid has taken a course around some of the phenocrysts, corroding them. The ground-mass is highly devitrified, now consisting of an intergrowth of secondary quartz and felspar spherulites. The chalcedonic patches observed in a hand-specimen are due to local greater devitrification, which has formed larger spherulites. S.572 from Portion 71, Parish of Boambolo, shows these characters (Pl. vi, fig. 3).

Devitrified Porphyries.—In some cases, intense devitrification has practically converted porphyry into chalcedony, chert or quartzite (Harker, 1909; Shand, 1927; Tyrrell, 1926). An intermediate stage is seen in Portion 21, Parish of Hume, 400 yards north of the Hume Highway, where more than half the ground-mass of the porphyry is chalcedonic (S.449). In thin section, the rock is like a normal quartz-porphyry, except that the secondary quartz in the ground-mass is coarse enough to be seen with a low-power objective. The chalcedonic portions are nearly opaque. In Portion 24, Town of Yass, the porphyry (S.387) has become chertified. In thin section, it is a mosaic of secondary quartz, with a few primary quartz grains, and iron-oxide skeletons of what have been biotite crystals. Solution channels, now filled with secondary quartz, traverse ground-mass and mineral grains alike. A rock in Portion 32, Parish of Hume, like quartzite in a hand-specimen, is identical with chertified porphyry (S.63) in thin section. The same applies to the chalcedonic type found 10 yards due west of Racecourse Trigonometrical Station (S.477).

Correlation of types described.—It is noticeable that the types, quartz-porphyry, quartz-porphyry-tuff and rhyolite-tuff have all the same mineral composition. All contain much quartz, the felspar where fresh enough for identification is in each case about $Ab_{60}An_{40}$, while the ferro-magnesian constituent is always chloritized biotite. Apatite is well represented in all. They differ, however, in texture. It seems probable that all originated from the same magma, and that their differences are due to different methods of extrusion or intrusion.

Coarse crystal tuff.—Fresh hand-specimens of this rock in some cases, for instance north-east of Laidlaw Trigonometrical Station (S.393), are difficult to distinguish from a porphyry, though in some cases the crystal tuffs are more like grits. They are grey-green in colour, weathering to a honey-yellow, and contain conspicuous grains of glassy quartz, opaque white felspar and a dark ferro-magnesian mineral. In thin section, the close packing of the quadrangular and triangular quartz and clouded felspar grains at once distinguishes these rocks from porphyry. Smaller fragments of the same minerals and of chlorite fill interstices. Calcite grains are common in some, though not found in all the tuffs. Apatite and chalcopyrite are also present in small amount. The scanty and nearly opaque matrix is secondary quartz. These rocks correspond closely to the definition of crystal tuff proposed by Pirsson (1915) and those described by Wells (1925) from North Wales. Rocks S.73, nine miles from Yass on the Wee Jasper Road, Portion 1, Parish of Boambolo; S.77, seven miles from Yass on the Goodhope Road, Portion 177, Parish of Warroo (Pl. vi, fig. 4); and S.239, Portion 18, Parish of Hume, are all typical crystal tuffs (Text-fig. 6).

Crystal-lithic tuff.—This rock is a special case of the coarse crystal tuff, since it contains rounded fragments of coarse and fine tuffs, as well as quartz and felspar crystals, in a matrix identical with that of the coarse crystal tuffs. The rock so formed is very resistant, forming tors in Portion 108, Parish of Boambolo (S.155). In thin section, though not in the hand-specimen, a resemblance to the agglomerates may be noted.

Volcanic grits.—The quartz-grits which form a conspicuous ridge to the north-west and south-east of Portion 45, Town of Yass (S.483), are composed of rounded quartz grains and an occasional iron-oxide cube, the whole being poorly cemented by an earthy paste. In thin section, the quartz grains are found to be sub-quadrangular, often due to attrition against one another, being sometimes in contact without the interposition of cement. The quartz grains, like those in the crystal-tuff outcropping nearby on the Wee Jasper Road (S.26), show numerous gaseous inclusions. The scanty matrix is of secondary quartz, felspar and calcite. These grits are crystal tuffs, in which quartz is present in greater proportion than is usual with the Yass crystal tuffs. It has also suffered greater wear. They recall the volcanic grits of the Lower Palaeozoic series of North Wales (Cox and Wells, 1920).

Quartzites.—Closely related to these grits are the quartzites or silicified grits found in Portion 8, Parish of Hume, immediately west of the middle of the rifle range (S.488), and in Portion 103, Parish of Warroo (S.157) and elsewhere. The slightly greater development of secondary quartz as a cement marks the only difference between the volcanic grits and these quartzites, whose origin is no doubt similar. The action of siliceous solutions is probably responsible for the difference between the quartzites and the grits. The cracks, strains and inclusions in the quartz of the quartzite (S.157) from Portion 103, Parish of Warroo, are also too much like those in the quartz of the Euralie agglomerate (S.126) from Portion 64, Parish of Warroo, to admit of doubt as to their similar provenance.

Agglomerates.—These fragmental rocks are almost identical throughout the area. They contain quadrangular green to brown pieces of tuff, one-quarter to one-half an inch across, set in a matrix, which also contains glassy quartz and earthy felspar grains. The pieces of tuff are almost in contact. A weathered surface is rough and pitted. In some cases the matrix is more highly silicified than in others (S.229 from the junction of Gums and Wee Jasper Roads, Portion 14, Parish of Hume). The agglomerates might be described as coarse lithic tuffs. Their character is uniform, although outcrops are widespread, and they have not been observed to be transgressive relatively to the interbedded tuffs, indeed they are everywhere conformable to them. In thin section, the lithic fragments are seen to be of fine tuff (type 3) and medium tuff (type 1), comparable with tuffs outcropping elsewhere in the area. S.182, for instance, from Portion 8, Parish of Hume, near Hatton's Corner (Pl. vi, fig. 6) contains fragments comparable with the medium tuff, S.204, an outcrop of which occurs in Portion 8, Parish of Hume, near the junction with Portion 111, Parish of Yass, as well as fragments comparable with the fine tuff, S.5, from the municipal quarry. As well as tuff, large angular quartz grains and altered felspar fragments are found in the devitrified matrix.

Medium Crystal Tuffs (Type 1).—This term has been used to describe a series of tuffs in the area, whose grain-size is about equal to that of table sugar, though they frequently contain scattered larger quartz grains. Their colour varies from grey to pink.

In thin section, the often nearly opaque ground-mass is found to be completely devitrified. It contains angular grains of primary and secondary quartz, and occasionally of weathered felspar and calcite. The last is regarded as detrital, though in some cases it may be an alteration product from felspar. Nodular lumps of interlocking crystals of secondary quartz and felspar are present in some of these tuffs, and may even be detected as white spots in the hand-specimen. They represent centres where devitrification has been greater than in the remainder of the rock. An example of a medium tuff (Type 1) is from Portion 8, Parish of Hume, immediately south of Portion 111, Parish of Yass (S.204; Pl. vi, fig. 7).

Banded or Bedded Tuff (Type 2).—These vary in colour from greenish-yellow to blue-black, while in grain-size, varieties of bedded tuffs are found to correspond to both medium and fine types (Types 1 and 3) among the non-bedded tuffs. A bedded structure is not always visible in the hand-specimen, but in thin section the long axes of rectangular or triangular grains of quartz, prisms of felspar and thin mica flakes are seen to be in a parallel arrangement within a devitrified matrix. There are tuffs with coarse mineral grains in bands about half an inch in width in the bed of the Yass River beneath the Bowspring limestone, in Portion 94, Parish of Yass (S.33), and tuffs of stages intermediate between that and the tuff at the intersection of the Goodhope and Euralie Roads, Portion 7, Parish of Warroo, where minute mineral grains are arranged in bands one-tenth of an inch wide (S.281). In the finer-grained tuffs, the bedding-planes are marked by colour banding (S.281; Pl. vi, fig. 8) or by small, discontinuous mica flakes (S.261). In the finer varieties the proportion of matrix to mineral grains is higher than in the coarser.

It is probable that this group includes tuffs whose bedding or banding is the result of two different causes. Either pressure has been the major cause, resulting in the parallel rearrangement of the mineral grains, as in S.33, from Portion 94, Parish of Yass, or slow settlement of fine particles has taken place under quiet conditions of accumulation as in Portion 7, Parish of Warroo (S.281).

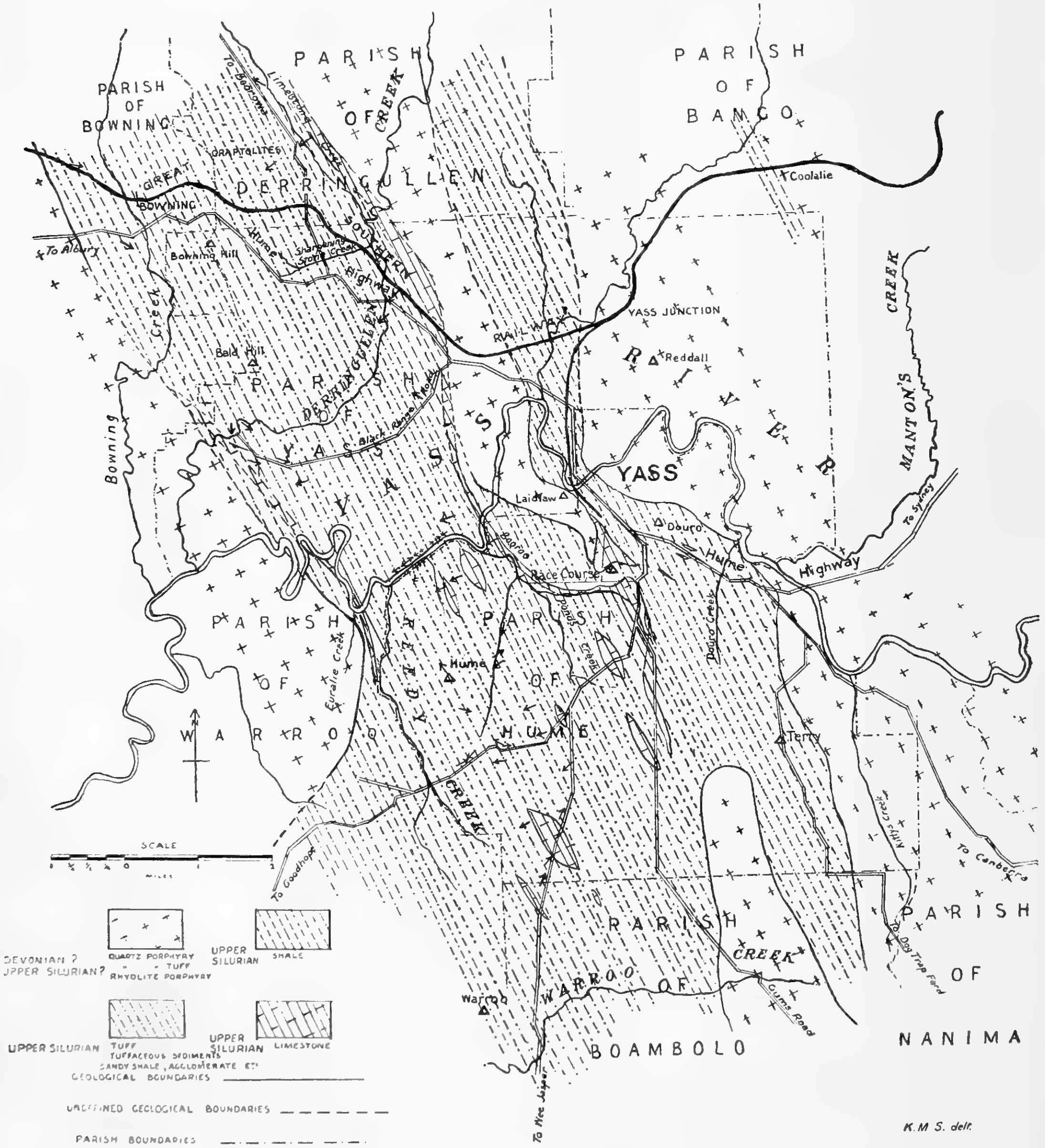
Fine-grained tuff (Type 3).—In Portion 202, Parish of Warroo (S.2), this type is a dense yellowish-green rock, with earthy cream-coloured spots. In thin section, minute angular fragments of quartz and felspar are seen, set in an iron-stained ground-mass composed of nodular lumps of secondary quartz almost in contact, a few being quite large. These are the spots seen in a hand-specimen and are centres of greater devitrification than the rest of the rock. Bedding planes are roughly marked by discontinuous shreds of mica. The matrix between the devitrified lumps is nearly isotropic. A similar tuff (S.129) from the junction of the Yass River and Euralie Creek contains numerous large quartz and calcite grains (Pl. vi, fig. 9). The dense green, homogeneous, waxy-lustred rock of Portion 148, Parish of Boambolo, and adjoining portions (S.101, S.577) resembles the matrix of S.2, the minerals being distinguishable only with the high-power objective, with which may be seen secondary quartz. Tiny, brown-mica flakes, showing a rough parallelism, mark the bedding. The material contained within porphyry, beside the Yass River in Portion 97, Parish of Yass (Text-figures 1 and 2), in thin section closely resembles these types (S.624; Pl. vi, fig. 10).

Limestones.—The limestones are crystalline and coloured bluish-grey on a fresh surface. A brown weathered surface may show ribbon-shaped rock fragments, coral remnants or cavities from which fossils have been detached. A thin section shows their fragmental character, all organic remains are broken, and angular quartz-grains, sometimes large, are common. Pieces of tuff are also occasionally included. Recrystallization of calcite is observable.

Sandy shales.—The sandy shales are homogeneous, greenish-brown dense rocks with rare mica flakes. Examination with the microscope shows the quartz grains to be angular, often in contact along one side, with a micaceous, ferruginous or calcareous cement. The quartz grains are all small. In rocks standing out as ridges, such as that which contains graptolites in Portion 34, Parish of Derringullen (S.379), they are larger than in the rock of Portion 14, Parish of Hume, east of Wee Jasper Road (S.714).

SUMMARY.

A series of conformable beds of Upper Silurian age is described, one of the uppermost containing graptolites typical of beds at the junction of the Lower Ludlow and the Wenlock divisions of the Upper Silurian of Britain and corresponds with the Yarravian of Victoria. The series includes tuffaceous and sedimentary members and, subsequent to deposition, was folded unevenly, steeper dips resulting in the western portion of the area. A geosyncline was formed about a north-west and south-east axis, with a pitch to the north-west. In places intense folding has been relieved by faulting. Porphyry was intruded between bedding planes subsequently, though evidence of the exact time of intrusion has not been obtained. The age of the porphyry is considered to be but little later than the deposition of the sediments and it is greatly devitrified.



Text-fig. 9.—Geological Sketch-map of the Yass and Bowning districts, showing position of the graptolite-bearing beds.

Invasion of siliceous solutions along bedding-planes followed the porphyry, causing a greater intensity of devitrification in their neighbourhood, and the development of quartz crystals. Mineral vapours followed, resulting in the deposition of galena, etc.

Outcrops of rhyolite-tuff may represent a Devonian deposit connected with outcrops south of this area, or may be interbedded with the Upper Silurian series.

Lastly, alluvium was deposited by several streams, while high-level gravels mark alterations in the course of the Yass River.

Acknowledgements.

The writer is indebted to Professor L. A. Cotton, M.A., D.Sc., of the Sydney University, for his kind assistance and advice during the course of this work, and for the facilities granted her for study at the Geological Department of the Sydney University. She also wishes to thank Assistant-Professor W. R. Browne, D.Sc., of the Sydney University, for the help he has given her, and Mr. R. A. Keble, of the National Museum, Melbourne, for his guidance in the determination of graptolites. Mr. A. J. Shearsby, of Yass, has also aided her with his intimate knowledge of the Yass District, which assistance she wishes to record here with thanks.

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EXPLANATION OF PLATES VI-VII.

Plate vi.

1.—Quartz-porphyry, Laidlaw Trigonometrical Station, Yass (S.389), showing corroded quartz, altered plagioclase and mica set in a devitrified ground-mass. Crossed nicols. × 6½.

2.—Quartz-porphyry-tuff, Junction, Hume Highway and Canberra-Yass Road (S.169), showing large corroded and cracked quartz crystals, felspar prisms and chips of quartz and felspar between them. Crossed nicols. × 6½.

3.—Rhyolite-tuff, Portion 71, Parish of Boambolo (S.572), showing jagged outline of quartz grains, quartz and felspar chips, and flow structure in ground-mass. Ordinary light. × 6½.

4.—Coarse crystal tuff, Portion 177, Parish of Warroo (S.77), showing quartz, felspar and chlorite grains nearly in contact. Ordinary light. × 6½.

5.—Crystal-lithic tuff, Portion 90, Parish of Boambolo (S.155), showing fragments of coarse and fine crystal tuffs, quartz and felspar grains. Ordinary light. × 6½.

6.—Agglomerate, near Hatton's Corner, Portion 8, Parish of Hume (S.182), showing fragments of different varieties of tuff, quartz grains, etc., in a highly silicified matrix. Ordinary light. × 6½.

7.—Medium-grained crystal tuff (Type 1), Portion 8, Parish of Hume (S.204), showing quartz fragments, some fractured, patches of secondary quartz resulting from devitrification. Ordinary light. × 6½.

8.—Banded tuff (Type 2), Portion 7, Parish of Warroo (S.281). Ordinary light. × 2.

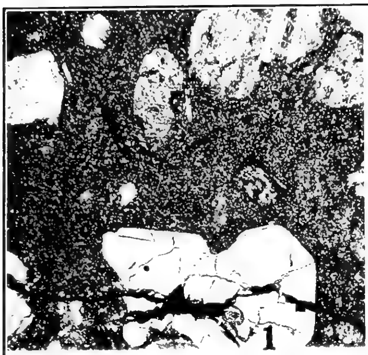
9.—Fine-grained tuff (Type 3), Euralie, Portion 64, Parish of Warroo (S.129), showing xenocrysts of quartz, altered felspar and calcite, strings of brown mica-flakes. Ordinary light. × 6½.

10.—Fine-grained tuff (?) within porphyry, Portion 97, Parish of Yass (S.624), showing small mica flakes intermittently marking bedding-planes, with strings of larger flakes crossing at right angles. Ordinary light. × 6½.

11.—Folded and faulted sediments in the bank of Yass River, near the mouth of Reedy Creek.

Plate vii.

Geological Sketch-map and Section of the Yass district.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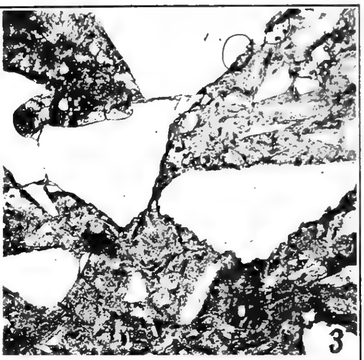
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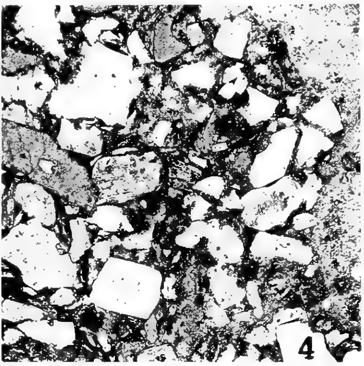
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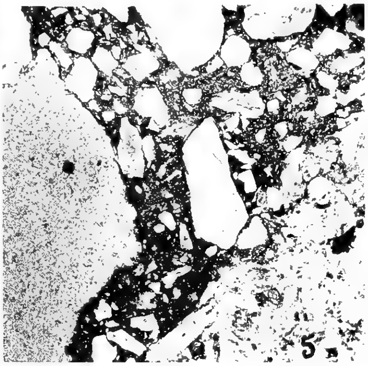
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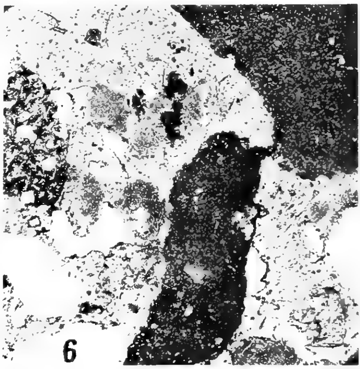
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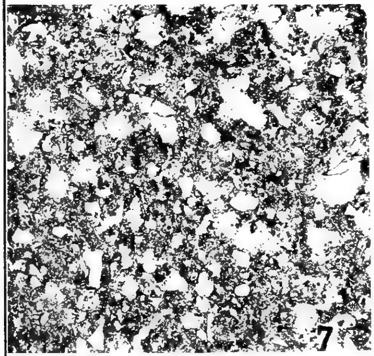
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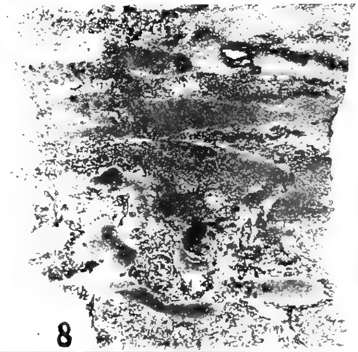
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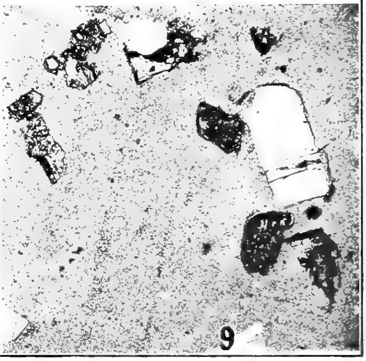
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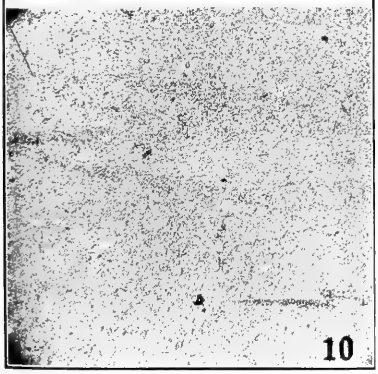
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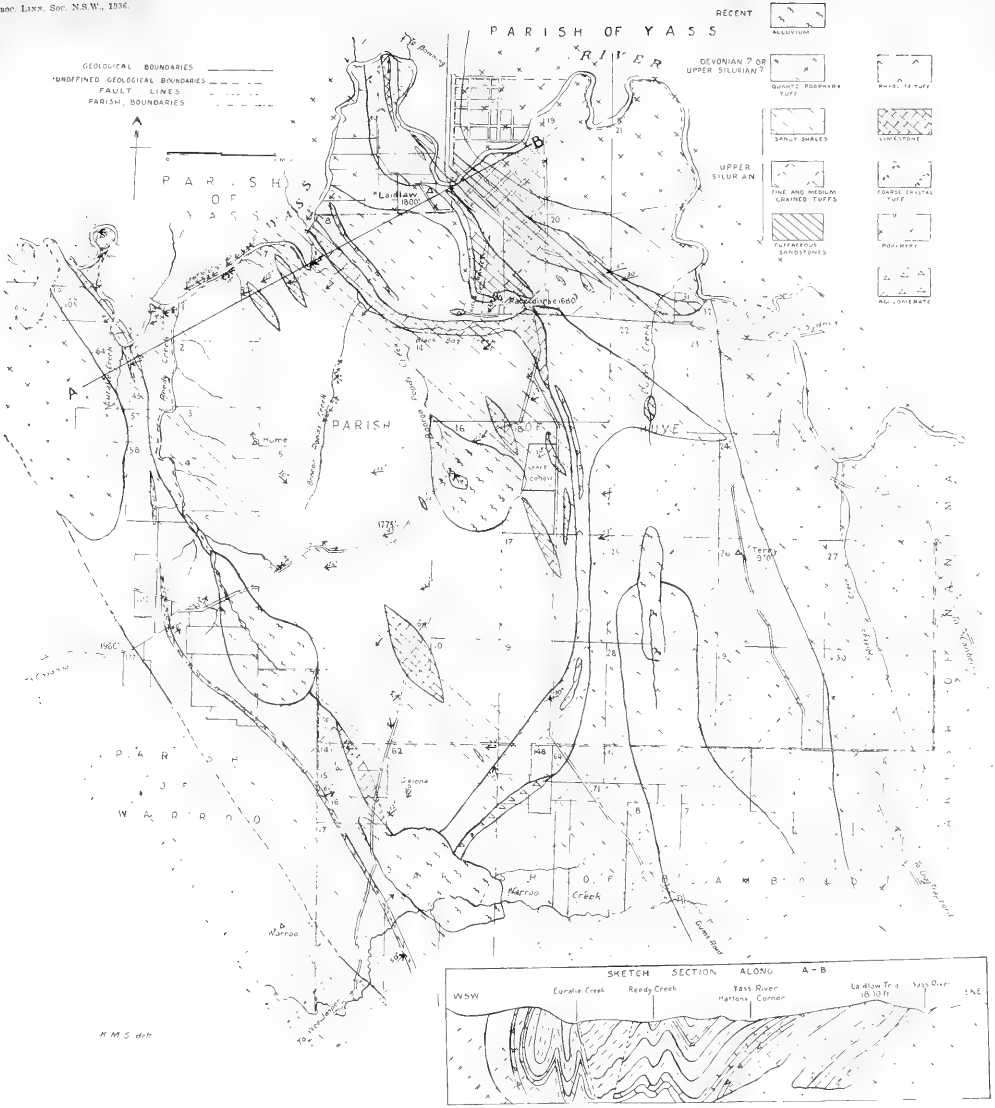
Rocks from Yass District.



Geological Sketch-map of the Yass district.

A COMPARISON OF THE RYDAL AND HARTLEY EXOGENOUS CONTACT-ZONES.

By Germaine A. Joplin, B.Sc., Ph.D., Department of Geology, University of Sydney.

(One Text-figure.)

[Read 24th June, 1936.]

Introduction.

In dealing with the exogenous contact-zone at Hartley (Joplin, 1935) it was pointed out that the Upper Devonian (Lambian) Series at Hartley could probably be correlated with rocks of similar age at Rydal. Thus, in discussing the incipient metamorphism at Hartley, it was assumed that the original sediments were similar to well-defined types at Rydal.

It may now be shown that this assumption was correct, as there is a very close parallelism between the hornfelses of both aureoles.

It is not proposed to describe the Rydal aureole exhaustively, but merely to place on record certain similarities with the exogenous contact-zone at Hartley. Possibly, if further field studies were undertaken and further material examined microscopically, other assemblages might be revealed; but as Rydal lies only about 10 miles from Hartley, as the sedimentary series is similar and as the Rydal granite represents only another part of the great Hartley–Bathurst bathylith, it seems unlikely that any very notable dissimilarities will be found. The writer feels confident that further study of the Rydal aureole would reveal other assemblages that have been described from Hartley.

The Primary Hornfelses of Hartley and Rydal.

Sixteen primary hornfels types were recognized in the Hartley aureole and eleven of these have been discovered at Rydal, as well as one assemblage which has not been met with at Hartley.

The hornfelses were collected along the Bowenfels Road on the south-eastern side of Cox's River Bridge and in the old and new railway cuttings north of Sodwalls. As the Rydal types are exactly similar to those of Hartley, it is not proposed to repeat detailed descriptions of the assemblages, but a comparison of the two aureoles is made in the following table, from which it will be seen that, as at Hartley, the Rydal aureole is characterized by a "wet" medium-grade metamorphism.

Primary Assemblage.	Hartley.	Rydal.
1. Andalusite-cordierite-biotite	+	+
2. Andalusite-biotite-orthoclase	+	—
3. Cordierite-quartz	+	+
4. Cordierite-plagioclase	+	+
5. Plagioclase-biotite	+	+
6. Amphibole-plagioclase-biotite	+	+
7. Amphibole-diopside-plagioclase-biotite	+	+
8. Amphibole-diopside-plagioclase	+	+
9. Amphibole-plagioclase	—	+
10. Diopside-plagioclase	+	+
11. Plagioclase-diopside-epidote	+	+
12. Plagioclase-diopside-wollastonite	+	—
13. Diopside-grossular-wollastonite	+	—
14. Vesuvianite-diopside	+	—
15. Wollastonite-diopside	+	—
16. Sandstone Hornfels	+	+
17. Grit	+	+

The Absence of Certain Primary Assemblages at Rydal.

Reference to the above table will show that the andalusite-biotite-orthoclase assemblage has not been met with at Rydal. Only one example of this type was recorded at Hartley; this was found as a boulder and has never been met with *in situ*. It is, therefore, not a prominent type, and it is not surprising that it has not been discovered at Rydal, especially in view of the fact that the study of this aureole is incomplete.

Again it will be noted that no assemblages containing wollastonite occur at Rydal. In dealing with the Hartley aureole it was pointed out that such assemblages were developed only at short distances from the contact. At Rydal, so far as the present writer is aware, the calcareous beds (*Spirifer*-bearing quartzites) do not outcrop closer than 800 yards from the contact, and the rocks contain quartz and calcite, which Eskola (1922) has shown to be a low-temperature assemblage.

Finally, the vesuvianite hornfels appears to be absent from Rydal, but in the Hartley aureole this was recorded from a single locality and it might be found at Rydal if more detailed work were carried out.

Metasomatism.

As at Hartley, greisenization, or the development of white mica, is common in the sandstone hornfelses and in the cordierite- and andalusite-bearing assemblages at Rydal.

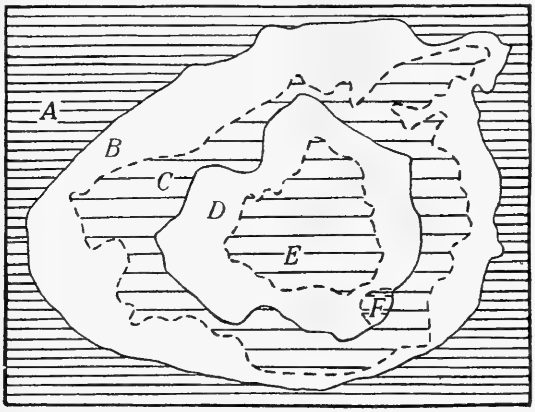
The development of andradite, prehnite, scapolite, etc., which was noted in many parts of the Hartley aureole, appears to be absent at Rydal, and this may be explained again by the fact that the more calcareous types do not occur very close to the contact.

Zoned Calcareous Nodules near Sodwalls.

A "purple-hornfels" with light calcareous patches occurs at the junction of the old and new railway lines on the Rydal side of Sodwalls at a distance of about 600 yards from the contact. The patches may be scattered through the body of the rock, but they are often concentrated on certain horizons and, though sometimes irregular in shape, are usually flattened ellipsoids. They vary in size from half an inch to about two inches in length, and show a rude zoning.

Examined microscopically, the well-defined zones are seen to consist of different mineral assemblages, and the less-defined ones are due to the relative abundance of a certain mineral in a given assemblage (see Text-fig. 1).

The "purple-hornfels" (Joplin, 1935) which encloses the calcareous bodies consists for the most part of biotite, quartz, and plagioclase, but a little amphibole is usually present and this becomes more abundant, together with calcite, in the immediate vicinity of the calcareous body.



Text-fig. 1.

A.—Biotite-plagioclase-amphibole-quartz assemblage.

B.—Plagioclase-amphibole-quartz-sphene assemblage with plagioclase > amphibole.

C.—Amphibole-plagioclase-sphene assemblage with a little quartz and amphibole > plagioclase.

D.—Plagioclase-amphibole-sphene assemblage with plagioclase > amphibole.

E.—Amphibole-calcite-sphene assemblage.

F.—Amphibole-sphene-iron ore.

The separate nodules show a good deal of variation in the order of the different zones, but consist mainly of the amphibole assemblages listed in the above table. Diopside may or may not be present.

Text-figure 1 is a diagram of one such nodule, and a critical examination of this indicates that the centre is richer in lime, and that this gradually decreases outwards, that magnesia attains local abundance in certain zones but is present throughout, that alumina is absent in the centre but occurs in the outer zones where silica also becomes prominent. The last oxide, in the form of quartz, is something of an anomaly, as it has been found in large irregular grains with calcite and amphibole in the centres of some of the nodules.

The junction between the biotite-bearing and biotite-free assemblages is very sharply defined and, as may be seen by reference to Text-figure 1, another well-marked junction occurs between an amphibole-rich and an amphibole-poor plagioclase-amphibole-sphene zone.

The origin of these bodies is somewhat obscure. Ward (1912) and Waterhouse (1916) have described calcareous patches and veins in shaly rocks in Tasmania, and they postulate addition from the magma; but the mode of occurrence, the frequent concentration of the nodules on a definite horizon, and the zoning make it difficult to explain the origin of the Rydal bodies in this way.

Twenhofel (1926) states that calcareous concretions are very common in claystones, and it seems likely that the nodules were concretions in the original tuffaceous silt which is now represented by the "purple-hornfels".

As regards the zoning, two alternative explanations suggest themselves, either that there was reaction between the concretion and the enclosing rock during metamorphism, or that the original concretion was laminated concentrically.

It is unlikely that much diffusion would take place at such a distance from the contact and, moreover, sharply defined beds of calcareous and purple hornfelses occur elsewhere and these can be shown to correspond to the *Spirifer*-bearing quartzites and soft purple shales of Mt. Lambie (Joplin, 1935, p. 19). Furthermore, the zones do not show a gradual transition, as might be expected if diffusion took place during metamorphism.

It seems likely, therefore, that the nodular concretions had an original concentric lamination and that each layer represents different admixtures of calcite and clay (Twenhofel, 1926, p. 503). The nodules may have been built up around fossils, but as no structure remains this point is obscure.

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THE UPPER PALAEOZOIC ROCKS IN THE NEIGHBOURHOOD OF BOOROOK AND DRAKE, N.S.W.

By A. H. VOISEY, M.Sc.

(Plate viii; one Text-figure.)

[Read 29th July, 1936.]

The object of this paper is to describe the rocks outcropping in the Drake and Boorook Districts in north-eastern New South Wales and to place the fossil zones in their correct positions in the sequence.

A short stay was made at Rivertree during February, 1934. Tabulam and Drake were visited during June and July, 1934. In January, 1936, the Boorook and Crooked Creek fossil beds were examined and their relationship to the Drake volcanic formations was established beyond doubt.

The geological sketch-map (Pl. viii) is not accurate in detail, but serves to indicate the fossil localities, and, roughly, the areas occupied by the series into which the strata have been divided. The mapping of the units within the series has unavoidably been left until a later date. Mr. E. C. Andrews (1908) said of the area: "It is a difficult area to map accurately, *i.e.*, in which to supply a connected sequence of geological events. Instead of containing several strong lines of rock junctions, whose succession in time might thus be readily grasped, it consists of a mass of insignificant and overlapping lava flows, sandwiched in with which are certain fossil beds. Dense jungle growths are common, which still further complicate mapping work."

He, however, did map the rocks around Drake, and his map may be considered typical of the whole area occupied by the volcanic beds.

Previous Literature.

E. C. Andrews (1908) detailed the history of the area, reported the discoveries of fossils and described the past mining activities. He also discussed the general characteristics of the ore deposits and their probable origin. This report, so far as the writer is aware, is the only record of geological field-work in the area which comes within the scope of this paper. J. B. Jaquet (1896) reported on the Lunatic Goldfield but did not deal with the general geology. Many references to Drake are to be found in literature, notably by Browne (1929), David (1932), Richards and Bryan (1923, 1924), Sussmilch (1935) and Walkom (1913). These writers have confined themselves to discussions based upon the work of Andrews (1908).

STRATIGRAPHY.

The Upper Palaeozoic strata between Boorook and Tabulam are bounded by granite on the east, west and south. Both granite and sediments are overlain in places by Jurassic rocks belonging to the Clarence Series.

The older beds have been divided into two main Series, the Emu Creek Series which is, in all probability, Carboniferous in age, and the Drake Series, which is probably Permian. The latter has been subdivided into a Lower and an Upper Division. The Lower consists chiefly of lavas, agglomerates and tuffs, and the Upper of tuffs, mudstones, and occasional lava flows, and characteristically possesses prolific fossil horizons.

Andrews (1908) observed that the Drake mudstones and tuffs (Upper Division) were younger than the volcanic beds (Lower Division), but he referred the latter to two distinct periods, "an older consisting mainly of rhyolites and a younger mainly of andesites".

While no definite divisions are likely to hold throughout the area, owing to the discontinuity of most of the beds, an arbitrary boundary has been fixed between the Lower and Upper Divisions. This boundary is indicated on the map and sections, but it must be emphasized that it is only approximate. It does not mark any great change in the nature of the deposits, but separates a zone which is prolific in fossil remains from one in which fossils are less numerous owing to the greater amount of volcanic material, chiefly lava, which makes up the sequence. No fossils appear to have been found in Andrews' older volcanics (lower part of Lower Division).

The relationship between the Emu Creek Series and the Drake Series has not been established beyond doubt, but the dark mudstones and tuffs belonging to the former seem to dip beneath the Drake volcanic rocks in the south-western corner of the Parish of Jenny Lind and also in the northern part of the Parish of Antimony. However, the outcrops are poor, and insufficient time was available to determine this point, important though it is. In spite of this admission of doubt, from field evidence alone the greater age of the Emu Creek Series may be accepted with slight reservation. The palaeontology is sufficient to clinch the matter.

The northward extent of the Emu Creek Series was not investigated far beyond Emu Creek, but the beds continue at least to Pretty Gully.

The following table shows the succession of beds which has been established:

Age.	Name of Series.	Rock Types.	Estimated Thickness in Feet.	Correlation.
Recent		Alluvium and creek gravels.		
Jurassic	Clarence Series.	Conglomerates, sandstones, and shales with fossil wood.		Walloon Series.
Permian	Drake Series.			
	Upper Division	Fossiliferous mudstones and tuffs, with some lava flows in lower portion.	2,000 +	Silverwood Fault-Block Series, and Lower Bowen Volcanics.
	Lower Division	Lavas, agglomerates, breccias and tuffs, with some fossiliferous beds.	5,000 +	
Carboniferous ..	Emu Creek Series.	Dark rhythmically-bedded mudstones and tuffs with lighter-coloured sandy beds.	Very thick, but no estimate made.	Neerkol (?) Series.

CARBONIFEROUS.

Emu Creek Series.

It must be made clear that the tuffs, sandstones, and conglomerates belonging to the Emu Creek Series are lithologically and palaeontologically quite distinct from the rocks belonging to the Drake Series, and must not be confused with them. Andrews (1908) appears to have recognized this, for he says: "The fossiliferous slates at Drake had been observed to be gently folded only. Towards Jump-Up, however, the strata possessed a vertical dip; thence to Pretty Gully the dip fell to 40°. Thus a tangential thrust from the east was suggested, unless the Drake rocks proper should be decidedly younger than the Pretty Gully series."

The name "Pretty Gully Series" would be retained for the Jump-Up beds but for the fact that the present writer did not visit Pretty Gully, and does not feel justified in using this name. Moreover, Andrews did not define the Pretty Gully Series further, and did not discuss the rocks. Hence the name "Emu Creek Series" will be used for the beds outcropping around Jump-Up Hill, although it is probable that the Pretty Gully beds could be correlated with them.

The lowest units of the series which were examined outcrop near the junction of Kangaroo Creek and Emu Creek, and consist of dark-grey indurated tuffs, fine in grain and rhythmically bedded with tuffaceous sandstones and occasional thin bands of conglomerate. All members of the series are hard and, in many places, intensely mineralized.

The fine-grained tuffs grade into dark grey mudstones and all the members bear witness to the fact that they are water-sorted; the pebbles in the conglomerate bands are well rounded and water-worn. The coarser beds are generally lighter in colour than the mudstones and tuffs, and are subordinate to them.

A horizon with remarkably prolific Fenestellidae outcrops on a spur between Kangaroo Creek and Emu Creek. The whole slope is strewn with fragments of rock crammed with the polyzoans. The material is a very hard, silicified light-blue to greyish-blue mudstone, highly impregnated with pyrites throughout. Its appearance is far different from the Fenestellidae mudstones of the Drake Series.

Only one specimen of *Spirifer striata* was found amongst the *Fenestella* and crinoid stems. My attention was drawn to this horizon by Miss Dorothy Smith and Mr. Arthur Smith of Cheviot Hills Station.

Probably overlying this Fenestellidae horizon by a couple of hundred feet is the Jump-Up Hill fossil horizon from which Andrews and the writer have collected a number of forms. These will be listed and discussed later.

The fossils are preserved in mudstone and fine-grained sandstone, probably tuffaceous, and are most abundant in the road cuttings ascending the hill. Many can be obtained in Jump-Up Creek. The beds are not nearly so indurated or so mineralized as those in the vicinity of the Fenestellidae horizon, but they are nevertheless very hard. The fresh sandstone is bluish-grey in colour, but weathers to a light-brown. The rocks are somewhat disturbed in the vicinity of Jump-Up Hill but the overlying beds continue with a general westerly dip of about 60° for at least 3 miles up Emu Creek. Although faulting may have caused some duplication, there is no doubt that a great thickness of rhythmically-bedded mudstone and sandstone overlies the Jump-Up horizon.

Near the boundary of the parishes of Antimony and Callanyn, the creek exposes a peculiar agglomerate. It contains irregular fragments of fine bluish-grey tuff set in a tuffaceous matrix. This rock is interbedded with tuffs similar to the fragments it contains.

It is in this locality that lava flows occur and seemingly overlie the west-dipping Emu Creek beds. Although an examination was made the actual contact was not found.

Permian.

Drake Series.

(*a*) Lower Division.

The magnificent suite of volcanic rocks outcropping around Drake has been partly described by Andrews (1908). Detailed petrological work on the numerous rock types is most desirable, but the writer had not the time necessary for this, so has very little to add. Andrews (1908, p. 11) writes: "The lavas of the Drake district present a difficult problem as regards detailed sequence of events. They are studies in minutiae. Frequently, within the limits of a 10 or 20-acre block, as many as a dozen rock sub-types may be found."

He has divided the volcanic beds into two groups: "(*a*) One productive of whitish to grey felsites, purple and green lavas, tuffs and breccias, and practically devoid of stratification planes. (*b*) A younger one, productive of blue and purple agglomerates, breccias, lavas and tuffs deposited on a sinking sea floor."

This division is upheld from a descriptive point of view, but there seems to be no need to make the break very significant. Andrews, himself, suggests that his older series may represent (1) the actual sites of small vents or (2) masses thrown out of neighbouring small vents. No evidence contributing to the problem was collected, but the detailed map given by Andrews is sufficient to show that his opinions are backed by much field-work and are worthy of consideration.

No records of fossils from the older volcanic beds have been found, and this is hardly surprising, since they are made up of so much lava and agglomerate. Stratification is much more marked in the younger volcanic beds than in the older, and the marine fossils found in the tuffs and mudstones between lava flows and agglomerates show that most were laid down under water.

Andrews submits the following list of fossils from Drake:

Martiniopsis subradiata var. *deltoidea* Eth. fil.
Fenestella sp.
Strophalosia jukesii Eth. fil.
Productus undatus ?.
Spirifer stokesi Konig.
Zaphrentis sp.
Stenopora (dendroid form).
Trachypora wilkinsoni Eth. fil.
Hyalostelia.
Entolium.
Modiola.
Aviculopecten (new sp.).
Orthoceras.

Knowing that most of the beds around Drake belong to the Lower Division of the Drake Series, one feels justified in considering that these fossils may be referred to the younger volcanic portion of the sequence.

Fragmental fossil remains, including *Monilopora*, *Trachypora*, Fenestellidae, crinoid ossicles, and Spiriferaceae, were found in the tuffs and mudstones outcropping in Girard Creek, about three miles west of Cheviot Hills Station. These sediments are interbedded with most spectacular agglomerates containing angular to sub-angular blocks, chiefly of felsite lava, up to nearly two feet across.

Several thousand feet of these tuffs and agglomerates, with occasional lava flows, are exposed between Cheviot Hills and Crooked Creek. At the top of this succession is a unit, about 200 feet thick, which, though an agglomerate at the base, passes upwards into a green tuff resembling an andesitic lava. The gradual change in texture from fragments more than a foot across to minute particles in the top-most portion may be traced.

Overlying this horizon is a mudstone bed full of *Trachypora wilkinsoni*. This has been taken as the base of the Upper Division of the Drake Series in this locality.

Andrews described the Girard Creek beds thus: "In many cases a conglomerate bed will contain numerous angular and subangular blocks; or, again, a conglomerate mass will pass gradually into an agglomerate. Here, commingling of two processes is evidenced—in shallow water agglomerates have been primarily thrown out, where probably the sea reduced the mass to a conglomerate; oftentimes, however, the imposition of fresh agglomerate deluges checked the process of pebble formation. Redistribution with partial to complete rounding by waves of breccias and agglomerates intermittently discharged from volcanoes is most probably the origin of the great majority of such rock masses."

Another section of the younger volcanic beds which was measured at Boorook ascending the hill between the ruins of the treatment plant on the Cataract River and the old Boorook township site, gives the following sequence:

(In descending order.)	Approx. thickness in feet.
Trachyte and trachytic tuff	100
Agglomerate	50
Trachyte	40
Felsite and felsite-breccia	100
Grey felsite	30
Felsite-breccia	30
Pink felsite	40
Agglomerate	20
Green trachyte	100
Volcanic breccias and agglomerates	200
Grey trachyte	100
	810

These are overlain by the Upper Division of the Drake Series. The Cataract River has only cut down as far as the grey trachyte, so that the underlying beds are not exposed in this locality. According to Andrews, however, the Cataract flows through felsite-breccias and lavas for miles downstream and the banks are high and almost impassable.

It is not possible to give a reliable figure for the thickness of the volcanic beds. A most conservative estimate, based on the section from Crooked Creek down Girard Creek to a point about two miles north-east of Cheviot Hills Station, is about 5,000 feet. The lower members of the Series have not been located definitely, though the lavas in the north-east of the Parish of Antimony must be among them. It is of importance to determine whether the volcanic rocks are underlain by marine fossil beds and also a *Glossopteris* horizon, as is the case at Silverwood.

(*b*) Upper Division.

Fossiliferous mudstones, tuffs and quartzites inter-bedded with breccias, agglomerates and occasional lava-flows follow conformably upon the main volcanic beds of the Lower Division of the Drake Series. The diminution in the amount of volcanic material and the greater development of the fossiliferous marine sediments are the characteristic features of this portion of the sequence. Eventually, the volcanic beds pass into mudstones which have a thickness exceeding 1,000 feet. As the rocks overlying the mudstones were not examined, it is not known whether the vulcanism continued after the deposition of these beds.

A specimen section measured down a spur leading into Sawpit Gully, Boorook, is as follows:

(Descending order.)	Approx. thickness in feet.
Massive dark-grey mudstones	1,000
Fossiliferous mudstones (Zone "D")	200
Felsite-lava	20
Coarse tuffs and breccias	100
Mudstones and cherts (Zone "C")	100
Felsite-breccias and coarse tuffs	100
Coarse breccia	10
Coarse tuffs with quartzite bands (Zone "B")	100
Fenestellidae mudstone (Zone "A")	20
Agglomerate	10
Fenestellidae mudstone (Zone "A")	50
Breccias and coarse tuffs	100
	1,810

The above thicknesses are approximate only and the units vary greatly throughout the district. The fossils collected from each bed will be given, but it is probable that most of the forms range throughout the above section. Collecting could only be carried on for a very short time, and numerous additions will be made to the lists when further work is done.

Immediately overlying the breccias and tuffs which form the basal unit of the above section is a band of calcareous mudstone crammed with fossils, chiefly Fenestellidae and crinoids. This is Zone "A" and contains *Zaphrentis* sp., *Martiniopsis subradiata* and *Spirifer* sp. (F36370–1 Australian Museum Collection); *Trachypora wilkinsoni* and *Monilopora* cf. *nicholsoni* appear to occur low down in the Upper Division in the Crooked Creek locality, but the sequence was not examined in any detail there.

The Fenestellidae mudstone is bluish-grey in colour when fresh, and is very tough. During decomposition it becomes buff-coloured and friable. The rock is made up of layers of fossils alternating with sediment. Weathering gives a concertina-like appearance to the outcropping blocks. An agglomerate with included rock fragments up to two inches across splits the Fenestellidae mudstone and the overlying bed is similar to that below (Zone "A").

Fossils are present, even in the coarse tuffs which follow, but, in the main, are fragmental, except in the quartzite and mudstone bands which are interbedded with these. They are mainly pectens and are so numerous that, in places, the quartzite is entirely made up of shells which have been replaced by silica. They include *Deltopecten subquinquelineatus* McCoy sp., *Aviculopecten sprenti* Johnston, and *Aviculopecten englehardti* Etheridge and Dun. *Fenestella* sp., *Protoretepora ampla* Lonsdale (?) and crinoid stems are also present in Zone "B" (Specimens F36367–9, Australian Museum Collection).

Felsite breccias and tuffs overlie the pecten horizon and then comes a most prolific fossil bed, a calcareous mudstone (Zone "C") containing:

Aviculopecten englehardti Eth. and Dun.
Aviculopecten cf. *flexicostatus* Mitchell.
Aviculopecten sp.
Productus (?) *brachythaerus.*
Taeniothyris subquadrata.
Crinoid stems.
Zaphrentis sp.
Fenestella sp.
Stenopora tasmaniensis Lonsd. (?).
Myonia carinata Morris.
Myonia (?) *corrugata* Fletcher.
Martiniopsis subradiata.
Strophalosia cf. *gerardi* King (?).
Strophalosia cf. *jukesi* Eth.

(Specimens F36344–F36366 Australian Museum Collection.)

Strophalosia is one of the commonest fossils in this zone and certain sections of the beds are made up almost entirely of this shell. In some parts the dendroid *Stenopora* is dominant and in others, *Fenestella.*

Coarse tuffs with fragmental fossils follow, and above these a felsite-lava flow outcrops.

On top of the felsite is a calcareous mudstone band (Zone "D") containing:

Monilopora cf. *nicholsoni* Eth.
Trachypora wilkinsoni Eth. fil.
Crinoid stems.
Fenestella sp.
Astartila sp.
Calyx plate of crinoid (*Cyathocrinus*?).
Strophalosia gerardi.

(Specimens F36329–31, F36335–43 Australian Museum Collection.)

The two corals are most numerous and they were used in tracing the bed along the ridge for about a mile, as they could be seen from a distance in the fragments of rock strewn over the surface. The lowest 200 feet of the mudstone, which makes up the rest of the section, contain numerous fossils, mainly corals, but the higher beds are practically devoid of them—only a few crinoid ossicles being found. The mudstone becomes less calcareous and more massive and compact. It is a dull black in colour and very fine-grained, for the most part, but is slightly more sandy in its lower portions. This sandy rock is lighter in colour, but has a blotchy appearance owing to the presence of dark irregularly-shaped inclusions. After several hundred feet, through which there is some variety in texture and colour, the mudstone becomes more uniform and apparently devoid of lamination and bedding planes. It is rather cherty and some harder parts give rise to falls in the creeks running west from the hills, but generally outcrops are poor. The beds are easily traced because they decompose to a characteristic yellow soil containing fragments of the crumbling rock.

This mudstone represents a complete change in the nature of the sedimentation. All through the underlying beds volcanic material is the main component right to the lowest part of the Drake Series that was examined. There is no important structural break, however, as the tuffs may be seen to pass upwards into the mudstone and fossils similar to those in the tuffs ascend well into the unit.

Fossils have been obtained in the hills bordering the granite for several miles north of Boorook. They also occur on the eastern side of the Cataract River and at Red Rock, where Mr. E. C. Andrews collected *Aviculopecten englehardti.* Between Crooked Creek and the stock route, the following forms were obtained:

Crinoid stems (*Phialocrinus*?).
Trachypora wilkinsoni Eth. fil.
Zaphrentis gregoriana De Kon.
Monilopora cf. *nicholsoni* Eth.
Cladochonus cf. *tenuicollis* McCoy.
Aviculopecten englehardti Eth. and Dun.
Fenestella sp.
Spirifer sp.

(Specimens F36324–8 Australian Museum Collection.)

These come from similar beds to those at Boorook as described above. Andrews (1908) records these additional types from somewhere along Crooked Creek:

Stenopora (small dendroid form).
Fenestella fossula Lonsd.
Fenestella internata Lonsd.
Fenestella sp.
Protoretepora (n. sp.).
Penniretepora grandis McCoy (De Kon.).
Hyalostelia.
Productus subquadratus Morris.
Martiniopsis subradiata Sby.
Spirifer vespertilio G. Sby.
Aviculopecten squamuliferus Morris.
Aviculopecten elongatus McCoy (De Kon.).
Stutchburia compressa Morris (?).

These fossiliferous beds undoubtedly continue for many miles to the north into the Rivertree District. It will be interesting to see whether the *Eurydesma cordata* recorded by Andrews from that locality comes from strata which can be correlated with some part of them.

Plumbago Creek Series.

Limestone, interbedded with hard slates and cherts, outcrops beside Plumbago Creek, just north of the point where the main road between Tabulam and Drake crosses the stream. The general strike of the series is north-north-west and the dip is west-south-west at about 60°. The invading granite cuts obliquely across the strike.

The limestone has been marmorized by the adjacent granite and no fossil remains were identified from it. The other sediments have been converted to hornfelses in places and are hardened elsewhere. Black slates contain fossils resembling *Pachydomus* but not definitely determinable. Breccias and tuffs related to those found around Drake are present, so it is probable that the Plumbago Creek Series will be connected in some way to the Drake Series. It has been kept separate because no limestone was found anywhere else and the northward extensions of it and the associated rocks were not followed far enough to connect them with any known beds.

JURASSIC.

Clarence Series (Walloon?).

The Clarence Series between Tabulam and Casino consists of conglomerates, grits, sandstones and shales with plant remains. A basal conglomerate is well exposed by the road cuttings just west of Tabulam Bridge. The water-worn pebbles are arranged in lenticular bands in sandstones and grits. Much of the material may be identified, as it has been derived from the Upper Palaeozoic rocks.

The beds appear to be estuarine in origin. This belief is strengthened by the fact that numerous fossil tree-trunks were found in the overlying sandstones and grits to the east of Tabulam. Their occurrence is reminiscent of those at Warwick, Queensland, and it is possible that both are on the same horizon.

The age of the series is probably Jurassic and equivalent to the Walloon Series of Queensland. There has been an overlap of these beds on the lower members of the Mesozoic suite (David, 1932).

INTRUSIVE ROCKS.

The Granites.

The map (Plate viii) shows that the Upper Palaeozoic rocks are intruded by granite both to the east and west of Drake. The eastern mass is overlain by the Clarence Series, but the western forms the high plateaus of New England. The granite makes poor outcrops around Boorook Station, and only the aplitic dykes which traverse the main rock were examined. One such dyke is found near the Station yards.

More than twenty different phases of the granite were collected from the Stanthorpe and Rivertree Districts (D.R. 3339 to D.R. 3358). For further details with regard to the New England Granites, see Andrews (1903).

PALAEONTOLOGY.

Emu Creek Series.

Andrews (1908) records the following fossils from Jump-Up Hill:

Strophalosia, sp. ind.
Productus subquadratus Morris.
*_Spirifer_ cf. _lata_ McCoy.
Spirifer sp. nov.
Spirifer cf. _strzeleckii_ Morris.
*_Reticularia_ cf. _lineata_ Martin.
*Fenestellidae.
Aviculopecten cf. _mitchelli_ Eth. fil and Dun.

(* Carboniferous type.)

The above were considered by Mr. W. S. Dun to be a mixture of Upper Marine and Lower Marine forms.

The writer collected two sets of fossils, one being given to the Australian Museum and the other to the University of Sydney. From the first, Mr. Fletcher has identified the following forms:

Cladochonus tenuicollis McCoy (?).
Strophalosia gerardi King (?).
Spirifer striata.
Spirifer pinguis (?).
Spirifer vespertilio.
Reticularia lineata.
Fenestella sp.
Stutchburia cf. _compressa._
Aviculopecten ptychotis McCoy sp.
Aviculopecten cf. _pincombei_ Mitchell.
Aviculopecten sp.
Phillipsia collinsi Mitchell.
Crinoid stems.

(Specimens registered F36372–F36379 Australian Museum Collection.)

Mr. Fletcher adds the following note:

"In the Jump-Up Hill beds, two pygidia and a thorax of _Phillipsia_ cf. _collinsi_ Mitchell were identified, with _Spirifer striata_ and _Spirifer pinguis._ These are Carboniferous forms and when taken with the Carboniferous types recorded by Mr. E. C. Andrews, it would appear that the facies of the Jump-Up Hill beds would be rather Carboniferous than Permian. In the same beds _Stutchburia compressa_ is found, but this genus probably extends into the Carboniferous. _Aviculopecten ptychotis_ is also a Carboniferous species."

From the second collection, Dr. Ida Brown recognized the _Phillipsia_ and _Cladochonus tenuicollis_ as Carboniferous forms and showed the collection to Dr. F. W. Whitehouse, who has kindly supplied this information: The fossils belong to "a fauna equivalent to that found in the Neerkol Series of Queensland. From that fauna few species have been described. The types of spiriferids, productids and fenestellidae agree well with the Queensland types.

"In the collection the following genera are represented: _Cladochonus, Fenestella, Pustula, Spiriferina, 'Spirifer'_ (spp. mult.), _Schizophoria, Retzia_ (?), _Modiomorpha, Aviculopecten_ and _Phillipsia._

"The Neerkol Series is known in Queensland at Stanwell, Cannindah and Mt. Barney."

He is also of the opinion that the fauna is newer than the _Amygdalophyllum_ horizon.

It is generally agreed, therefore, that the Jump-Up Hill horizon is of Carboniferous age. Mr. Dun's view that the beds were Permo-Carboniferous was probably influenced by the collections from adjacent areas occupied by the Drake Series.

Exact correlation of the Emu Creek Series with other areas will have to be made later by those acquainted with the Queensland Carboniferous beds. The writer has held the view that it might be Neerkol, and this has been strengthened considerably by Dr. Whitehouse's remarks.

J. H. Reid (1930) advocated an Upper Carboniferous age for the Jump-Up Hill beds on the evidence of the fossils collected by Andrews. It is hoped that the additional forms which have been collected will be of assistance in the determination of the exact age of the Series.

Though Fenestellidae zones are not uncommon in Carboniferous and Permian areas, the presence of the prolific band near Jump-Up Hill lends more support to a correlation with the Neerkol beds.

The writer is still opposed to the inclusion of any part of the Kempsey or Silverwood beds in the Neerkol, and consequently cannot agree to placing any of the beds belonging to the Drake Series there (Voisey, 1934*a*, 1935).

Drake Series.

Taken as a whole the fossil fauna of the Drake Series is as follows:

Cladochonus cf. *tenuicollis* McCoy.
Trachypora wilkinsoni Eth. fil.
Monilopora cf. *nicholsoni* Eth.
Zaphrentis gregoriana De Kon.
Cyathocrinus (?).
Phialocrinus (?).
Protoretepora ampla Lonsdale (?).
Fenestella sp.
Fenestella fossula.
Fenestella internata.
Penniretepora grandis.
Hyalostelia.
Stenopora tasmaniensis Lonsdale (?).
Strophalosia gerardi.
Strophalosia cf. *jukesi* King (?).
Martiniopsis subradiata var. *deltoidea* Eth. fil.
Spirifer spp. mult.
Spirifer stokesi Konig.
Spirifer vespertilio.
Productus undatus (?).
Taeniothaeris subquadrata.
Productus brachythaerus.
Myonia carinata Morris.
Myonia (?) *corrugata* Fletcher.
Stutchburia compressa.
Astartila sp.
Deltopecten subquinquelineatus McCoy sp.
Aviculopecten sprenti Johnston.
Aviculopecten englehardti Eth. and Dun.
Aviculopecten cf. *flexicostatus* Mitchell.
Aviculopecten squamuliferus Morris.
Aviculopecten elongatus McCoy (De Kon.).
Hyalostelia.
Entolium.
Modiola.
Orthoceras.

All these forms were found in, or above the volcanic rocks, so must be above the *Glossopteris* horizon which occurs below the Volcanic Beds at Silverwood, if correlation between the lavas is accepted.

Conclusive proof of the existence of prolific *Monilopora* cf. *nicholsoni* and *Trachypora wilkinsoni* beds at the top of the Series definitely overlying the volcanic beds, has an important bearing on the interpretation of the Silverwood fault-blocks. (Richards and Bryan, 1924; Reid, 1930; Voisey, 1935.)

It is unfortunate that a *Eurydesma cordata* horizon was not found in the Boorook-Drake Districts, but, if the views of the writer are correct, this should be discovered below the Volcanic Series (Voisey, 1935).

In a broad sense the Silverwood Fault Block Series, the Drake Series and the Macleay Series are correlated with one another and all are considered to be Lower Permian in age.

Structural Geology.

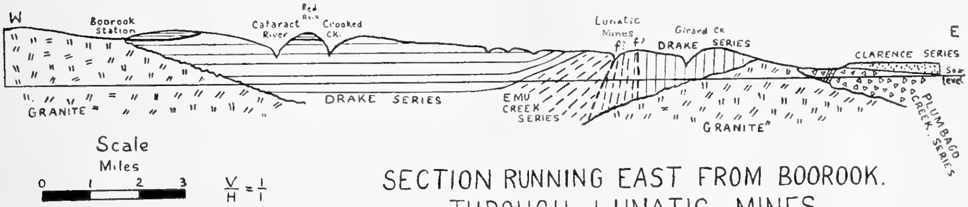
The Upper Palaeozoic strata are generally horizontally disposed or slightly undulating between the western granite and Drake, but between Drake and Tabulam they have been folded and faulted. In the Drake Series near Tea-Tree Creek, a vertical position has been attained. At the bridge where the road crosses the Creek, the unconformable junction of an outlier of the Clarence Series with the volcanic beds may be seen.

The folding has been roughly on a north-north-west, south-south-east axis.

The old Boorook township site is in the core of a syncline which pitches towards the north. It is a very gentle fold. The beds on the limbs of the syncline dip into the hill at angles generally about 5°. The northward pitch is demonstrated by the outcrop of the mudstones. This is roughly V-shaped, widening to the north.

Wherever rocks belonging to the Emu Creek Series have been seen they are steeply folded, but this may be because the disturbed zone happens to include them. Nevertheless, the conformity of the Emu Creek Series and Drake Series is open to doubt.

Going westward from Jump-Up Hill along Emu Creek the beds dip west at angles between 40° and 60°, but here and there they are much faulted.



SECTION RUNNING EAST FROM BOOROOK. THROUGH LUNATIC MINES.

A parallel might be drawn between the Drake and Kempsey Districts. In both cases there are areas of intense folding of Upper Palaeozoic beds to the east and gently folded beds to the west. It seems that pressure came from an easterly direction. The marginal beds yielded to the force and, by collapsing, allowed it to expend itself on them, thus protecting the strata to the west.

The New England granite was intruded into the Drake rocks after the folding had taken place. It cuts across the strike of the beds. This was some time before the Jurassic sediments were deposited, for these rest upon planed-down granite surfaces. That the diastrophism occurred between Middle Permian and Jurassic times is thus proved, but in all probability it marked the close of the Palaeozoic Era (David, 1932).

Richards and Bryan (1924) offered the suggestion that the "Permo-Carboniferous" fossils collected in the Drake District might have been obtained from isolated fault blocks let down into Devonian strata, the structures then resembling those at Silverwood. However, no rocks remotely related to the Silverwood Series (Devonian) were found in the area examined and the volcanic units were found to be continuous for many miles.

The sediments belonging to the Clarence Series formerly covered a much greater area west of their present boundary, but they have been removed by erosion. An outlier at Kettle's Lift remains, and this is being worn away rapidly.

The beds dip easterly at a very low angle and form the western rim of the Clarence Basin.

PHYSIOGRAPHY.

Boorook and Drake are situated on the eastern fall of the New England Tableland near the head-waters of the Clarence River.

The Cataract River collects Boorook Creek, Crooked Creek, and numerous tributaries as it flows northward from Sandy Hills to Rivertree, where it joins the main stream. The Clarence turns southward and eventually reaches Tabulam where it collects the drainage from Drake which enters it by means of Plumbago Creek and the Timbarra River.

The dissection which has occurred may be judged by the steep fall of the country from Tenterfield just west of the Main Divide to Tabulam. The heights are: Tenterfield, 2,831 feet; Drake, 1,650 feet; Tabulam, 410 feet.

Between Tenterfield and Boorook high granite hills rise to over 3,000 feet and continue northwards as the Boonoo Boonoo Heights. East of Boorook Station the creek falls into the Cataract which flows through narrow gorges carved out of the resistant lavas of the Drake Series. Both this river and its tributary, Crooked Creek, are aptly named. Travelling is difficult through this region, but access may be had by means of tracks which follow the more gentle spurs.

The response of the sub-horizontal rocks to rapid erosion is the main feature of the physiography, and both the Clarence Series and the Drake Series (in part) may be studied in this connection. The Clarence Series occupies the lower regions, and cliffs are formed where the hard sandstone beds alternate with softer slates. These are common on all sides but the east, as the dip of the units in this direction is sufficient to give rise to a dip-slope. As a great deal of the country has been cleared, these sandstone bluffs make conspicuous features as they rise above the undulating grassy areas and usually a number of trees remain on them. Sometimes two bands may be seen in the one hill.

The big difference in resistance to erosion between the lavas and sediments of the Drake Series has led to the development of benches round the hills.

As the streams have cut down into the Lower Division, the fossiliferous beds of the Upper Division occupy the ridges between the valleys. The natural contouring of the highlands by means of these resistant bands is somewhat obscured by the thick vegetation. Along the stock route between Sandy Hills and Drake, one goes from terrace to terrace. On some of these terraces, outliers of the overlying bed form small hills. One unit in particular, an agglomerate from the top of the Lower Division of the Drake Series, gives rise to such outliers since it is underlain by a resistant tuff band.

Between Cheviot Hills and Emu Creek the topography is neither so interesting nor is its evolution so clear. Outcrops are poor, and in the north the rocks are similar in type and dip steeply. Here deep gullies, tending to conform with the strike, lead into the main creek and the spurs fall steeply into them.

In the south-eastern corner of the area the old granite surface upon which the Clarence Series was laid down has been re-exposed during recent times and the streams are at work cutting downwards into it.

The sequence of events leading up to the formation of the present topography is similar to that of the whole coastal region, and the matter has been discussed elsewhere. (Craft, 1933, etc.; Andrews, 1903; Voisey, 1934).

GEOLOGICAL HISTORY.

Marine mudstones, sandstones and conglomerates were deposited, during Carboniferous times, in a sea which had its location in the position now described as north-eastern New South Wales. Rhythmic deposition was a characteristic feature of this thick series of rocks.

With the beginning of Permian times, vulcanism broke out and volcanoes which were situated in the region about Drake poured lavas over the sea-floor.

Tuffs and mudstones were laid down between the lava-flows and in these sediments the remains of marine animals were preserved. Eventually the activity of the volcanoes declined, and a thick deposit of mudstone was spread over the sea floor.

Pressure from the east affected the sediments, some of which yielded under the strain, fracturing and folding taking place in some areas; but the western portions were protected and remained practically horizontal. The invasion of the rocks by granite followed, metamorphosing them and introducing the auriferous, cupriferous and argentiferous quartz-reefs. Uplift and subsequent erosion led to the exposure of the granite and the reduction of the area to comparatively level country over which an inland sea transgressed during Jurassic times. Fresh-water conglomerates, sandstones and shales were laid down, and among them were preserved the logs and plant remains washed in by the rivers.

Eventually the sea receded and uplift brought the Clarence Series under the influence of erosive forces which reduced Eastern Australia practically to sea-level, leaving only a low divide. Basalts were poured out over this surface. Uplift occurred at the end of the Tertiary Era and subsequent erosion has led to the development of the present-day topography.

CONCLUSION.

The most outstanding results obtained from the field-work in the Drake and Boorook districts are as follows:

(1) The Drake volcanic beds have been separated from the Jump-Up Hill beds and the basis for such separation has been given.

(2) Suites of fossils were collected from each series and arranged in their correct stratigraphical positions.

(3) The relationship between the Boorook and Drake rocks was determined beyond doubt.

(4) A zone extraordinarily rich in *Trachypora wilkinsoni* and *Monilopora* cf. *nicholsoni* was proved definitely to overlie the volcanic beds of the Drake Series.

It is hoped that the data collected will be useful to palaeontologists and to future workers in a most fascinating locality.

Acknowledgements.

I desire to thank Dr. Ida Brown, of Sydney University, Mr. Fletcher, of the Australian Museum, and Dr. F. W. Whitehouse, of Queensland, for their notes upon the fossils. I am indebted also to Messrs. T. Hodge-Smith and R. O. Chalmers for their capable work in cataloguing the material which I have given to the Australian Museum.

Geological work at Drake, Boorook and Tabulam has always been a pleasure—largely because of the help and hospitality given to me by numerous residents. My grateful thanks are due to them, especially to the following: Mr. and Mrs. Arthur Smith of Cheviot Hills, Mr. and Mrs. Clarence Smith of Boorook, Mr. and Mrs. Hunter Smith of Drake, Mr. G. Purvis Smith of Sandy Hills, Rev. Schmitzer and Mr. and Mrs. Fergusson of Tabulam.

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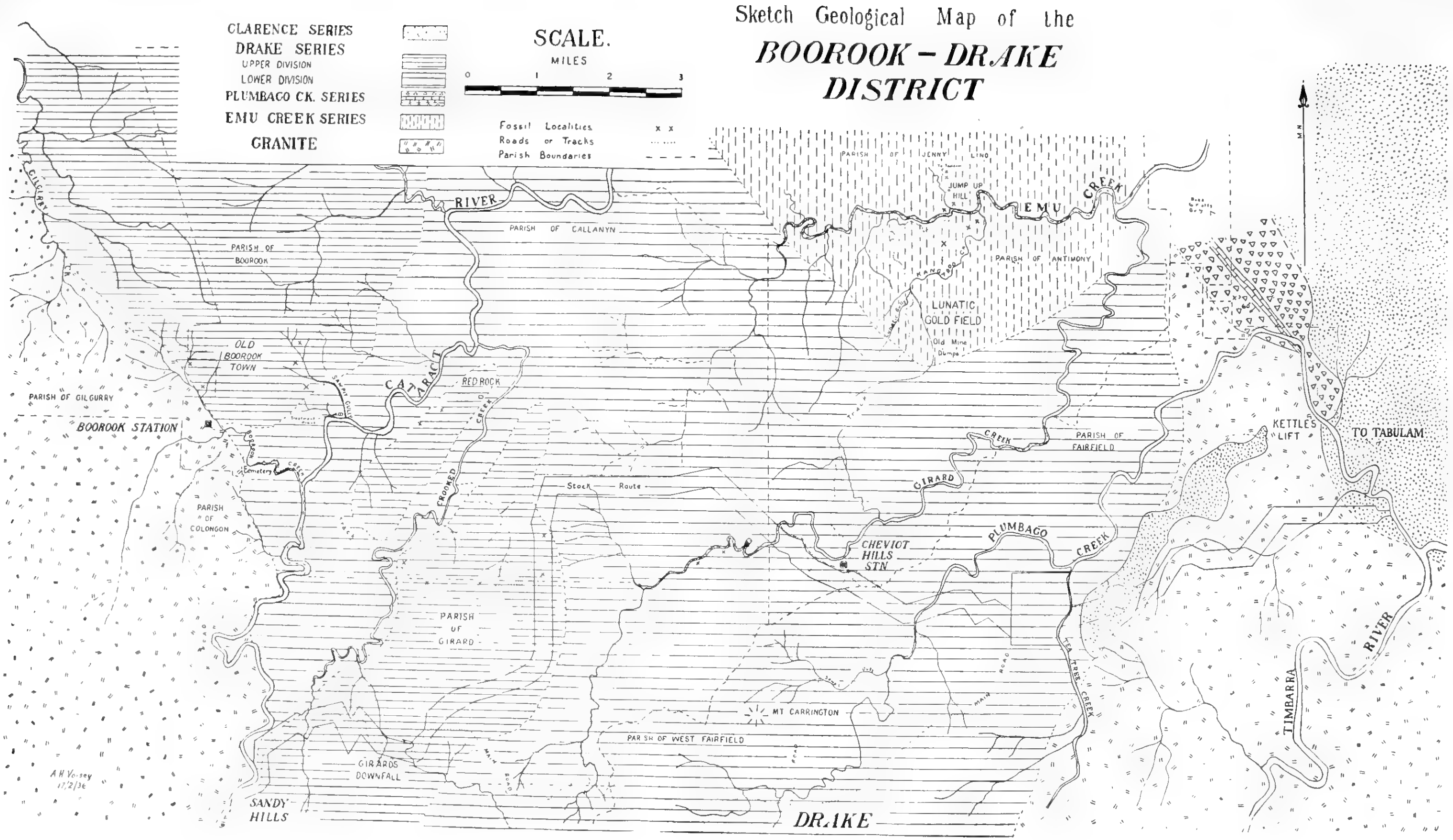
EXPLANATION OF PLATE VIII.

Geological sketch-map of the Boorook-Drake district.


Sketch Geological Map of the
BOOROOK – DRAKE
DISTRICT
CLARENCE SERIES
DRAKE SERIES
UPPER DIVISION
LOWER DIVISION
PLUMBAGO CK. SERIES
EMU CREEK SERIES
GRANITE
SCALE.
MILES
0
1
2
3
Fossil Localities
x x
Roads or Tracks
Parish Boundaries
M N
PARISH OF JENNY LIND
JUMP UP HILL
EMU CREEK
PARISH OF ANTIMONY
KANGAROO CK
LUNATIC GOLD FIELD
Lunatic Gully
Old Mine Dumps
60°
RIVER
PARISH OF CALLANYN
PARISH OF BOOROOK
GILGURRY CK
OLD BOOROOK TOWN
PARISH OF GILGURRY
BOOROOK STATION
BOOROOK CREEK
Cemetery
SAWPIT GULLY
Treatment Plant
CATARACT
RED ROCK
CROOKED CREEK
PARISH OF COLONGON
Stock Route
TRACK
PARISH OF GIRARD
GIRARDS DOWNFALL
SANDY HILLS
ROAD
MAIN ROAD
GIRARD CREEK
CHEVIOT HILLS STN
PLUMBAGO CREEK
PARISH OF FAIRFIELD
TRACK
MT CARRINGTON
PARISH OF WEST FAIRFIELD
TEA TREE CREEK
DRAKE
KETTLES LIFT
TO TABULAM
TIMBARRA RIVER
A.H. Voisey
17/2/36

THE DIPTERA OF THE TERRITORY OF NEW GUINEA. IV.

FAMILY TIPULIDAE. PART II.*

By CHARLES P. ALEXANDER, Massachusetts State College, Amherst, Mass., U.S.A.
(*Communicated by Frank H. Taylor, F.R.E.S., F.Z.S.*)

(Seventeen Text-figures.)

[Read 26th August, 1936.]

The materials included in this instalment are chiefly from the mountains of north-eastern New Guinea, the majority from Edie Creek, where they were collected by Mr. Frank H. Taylor. Additional materials were sent to me by Mr. Taylor and Professor Harvey Sutton, collected by Mr. Norman Ferguson and Dr. E. A. Holland, and forming a valuable addition to our knowledge of the Tipulidae of this little-known area. All types and uniques are preserved in the collection of the School of Public Health and Tropical Medicine, the University of Sydney. As before, I express my very sincere thanks to the Director of the School of Public Health, Professor Harvey Sutton, and to my very good friend and co-worker, Mr. Frank H. Taylor, for this continued co-operation in studying the Tipulidae of the Territory of New Guinea.

The rich collections studied herewith add no fewer than nine generic and subgeneric groups to those hitherto known from the Territory, of which *Dolichopeza*, s.s., *Helius*, s.s., and *Eurhamphidia*, are included here. A number of the large and conspicuous autochthonous Australian genera of the subfamily Tipulinae that might reasonably be expected to extend their range into New Guinea remain undetected and, in the light of the collecting done by Mr. Taylor, it may be expected that most of these, at least, do not occur within the Territory. Such genera, as *Clytocosmus*, *Platyphasia*, *Plusiomyia* and *Ptilogyna*, with branched antennae, and *Leptotarsus* and *Semnotes*, with the antennae simple and reduced, include the largest and most conspicuous crane-flies within the Australian faunal limits.

TIPULINAE.

TIPULA (PAPUATIPULA) LEUCOSTICTA Alexander.

Tipula leucosticta Alexander, *Philippine Journ. Sci.*, liv., 1934, 444–446.—*Tipula* (*Papuatipula*) *leucosticta* Alexander, *ibid.*, lvii, 1935, 114–115.

Known hitherto only from Bogadjim (Stephansort), Astrolabe Bay, north-eastern New Guinea, collected 30th March, 1900, by Biró. Two females, Kavieng, New Ireland, 31 January–14 February, 1934 (F. H. Taylor).

NEPHROTOMA FLAVOPOSTICATA, n. sp. Text-figs. 1, 7.

Mesonotal praescutum yellow, with velvety-black stripes, the median one plumbeous on central portion; scutellum black; pleura orange, unmarked; legs black, the posterior tibiae (♂) or middle and hind tibiae (♀) broadly yellow on

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* Continued from These PROCEEDINGS, lx, 1935, 51.

central portion; wings strongly tinged with blackish, cell Sc and stigma darker; abdomen (♂), including terminalia, almost uniformly blue-black.

♂.—Length, 12–13 mm.; wing, 10–11 mm. ♀.—Length, 13·5–14 mm.; wing, 11·5–12 mm.

Sexes feebly dimorphic in colour.

♂. Frontal prolongation of head orange, the dorsal surface and conspicuous nasus black. Antennae black, the apex of scape a little reddened; antennae of moderate length, if bent backward extending to just beyond root of halteres; flagellar segments moderately incised. Head orange, without occipital brand.

Pronotum orange. Mesonotal praescutum yellow, with three velvety-black stripes, the median one with posterior half and central portion of anterior half more plumbeous in colour; lateral stripes straight; scutum yellow, the lobes chiefly velvety-black; scutellum blackish-plumbeous, margined laterally with more velvety-black, the parascutella yellow; mediotergite yellow, on posterior third with a plumbeous area that is narrowly bordered with black. Pleura orange, the pleurotergite more yellowish-orange. Halteres black. Legs with the coxae orange; trochanters yellow; femora black; fore tibiae black; mid-tibiae light brown, the base and apex blackened; posterior tibiae bright yellow, blackened at both ends; all tarsi black. Wings (Fig. 1) with a strong blackish tinge, cell Sc and stigma darker brown; veins brown. Stigma with only five or six trichia. Venation: Sc_2 ending shortly beyond origin of Rs; cell M_1 very short-petiolate to narrowly sessile.

Abdomen uniformly black, with bluish reflexions; the paratype from Maini shows restricted yellowish areas on bases of tergites two to four. Male terminalia (Fig. 7) relatively small. Ninth tergite, *9t*, produced medially into two flattened divergent ear-like points; a blackened stub at each outer lateral portion of tergite. Both dististyles darkened; inner style, *id*, with a very low dorsal crest; apical beak unusually slender. Gonapophyses appearing as tiny oval pale plates, subtending the base of aedeagus.

♀. Similar to male, differing as follows: Antennae shorter; scape and pedicel brown. Halteres somewhat paler in colour. Legs with both middle and hind tibiae yellow on central portions. Abdomen with basal two tergites and basal four sternites obscure yellow, the outer segments more blackened. In the Maini paratypes, the amount of pale colour is somewhat more restricted.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor). Allotopotype, ♀, in copulation and carded with type. Paratopotypes, 1 ♂, 1 ♀; paratypes, 1 ♂, 2 ♀, Maini, altitude about 6,300 feet, July, 1935 (K. J. Clinton).

Nephrotoma flavoposticata is readily distinguished from the other described regional species of the genus by the coloration of the posterior tibiae. The nearest allies are various members of the *melanura* group, especially *N. dimidiata* (de Meijere) and *N. fumiscutellata* Alexander.

NEPHROTOMA KAVIENGENSIS, n. sp. Text-fig. 8.

General coloration yellow; occipital brand not indicated; pronotum orange-yellow; mesonotal praescutum with three black stripes that are confluent or virtually so, the median stripe velvety-black on cephalic portion, the posterior three-fourths nacreous, polished; lateral stripes velvety-black, extended laterad to margin of sclerite; scutellum black; wings greyish; stigma small, dark brown; abdomen with basal six segments orange, the posterior borders of the segments narrowly and evenly darkened; subterminal segments black; male terminalia with beak of inner dististyle slender, spinous; gonapophyses bispinous at tips;

caudal margin of eighth sternite produced medially into a narrow compressed point.

♂. Length about 12 mm.; wing, 10·5 mm.

Frontal prolongation of head fulvous, unmarked; palpi pale brown. Antennae (♂) of moderate length, if bent backward extending to the wing-root or approximately so; scape and pedicel orange; flagellum brownish-black; flagellar segments moderately incised, with verticils that are shorter than the segments. Head fulvous-orange, the occipital brand not differentiated; a vague dusky cloud on anterior vertex adjoining the inner margin of eye; vertical tubercle entire or virtually so.

Pronotum orange-yellow. Mesonotal praescutum with three black stripes, the polished black laterals virtually confluent with the broad median vitta, the latter velvety-black on anterior fourth, the remainder of stripe polished nacreous; outer stripes continued laterad to margin, restricting the yellow ground-colour to humeral triangles and narrow lines adjoining the suture; scutum yellow, each lobe with a velvety-black area; scutellum velvety-black, parascutella yellow; mediotergite yellow, with an oval nacreous area at posterior border. Pleura and pleurotergite yellow, the anepisternum and sternopleurite vaguely marked with pale reddish-yellow. Halteres yellow, the base of knob infumed. Legs with the coxae and trochanters yellow; femora obscure brownish-yellow; tibiae brown; tarsi black. Wings with a greyish tinge; prearcular region and cells C and Sc more yellow, the latter cell slightly deeper in colour; stigma small, oval, dark brown; veins dark. Stigmal trichia about fifteen in number. Venation: Cell M_1 very short-petiolate.

Abdomen with basal six segments orange, the posterior borders very narrowly ringed with brownish-black, the bands uniform in width or virtually so; outer segments black; terminalia more brownish at tip. Male terminalia (Fig. 8) with the tergite, *9t*, extended caudad into two submedian spinous points. Outer dististyle, *od*, with the apical point relatively short. Inner dististyle, *id*, with the terminal beak a slender sclerotized spine; a low dorsal crest. Gonapophyses, *g*, terminating in two acute spinous points. Eighth sternite, *8s*, sheathing, the median portion produced caudad into a narrow point, on ventral portion strongly compressed; surface of sternite with long coarse black setae.

Holotype, ♂, Kavieng, New Ireland, 4 February, 1934 (F. H. Taylor). Paratopotype, ♂, 11 February, 1934.

This fly is allied to species such as *Nephrotoma dimidiata* (de Meijere), *N. melanura* (Osten Sacken) and *N. speculata* (de Meijere). It differs from all described forms in the pattern of the praescutum and the structure of the male terminalia, notably of the inner dististyles, gonapophyses and eighth sternite.

DOLICHOPEZA (DOLICHOPEZA) TAYLORIANA, n. sp. Text-figs. 2, 9.

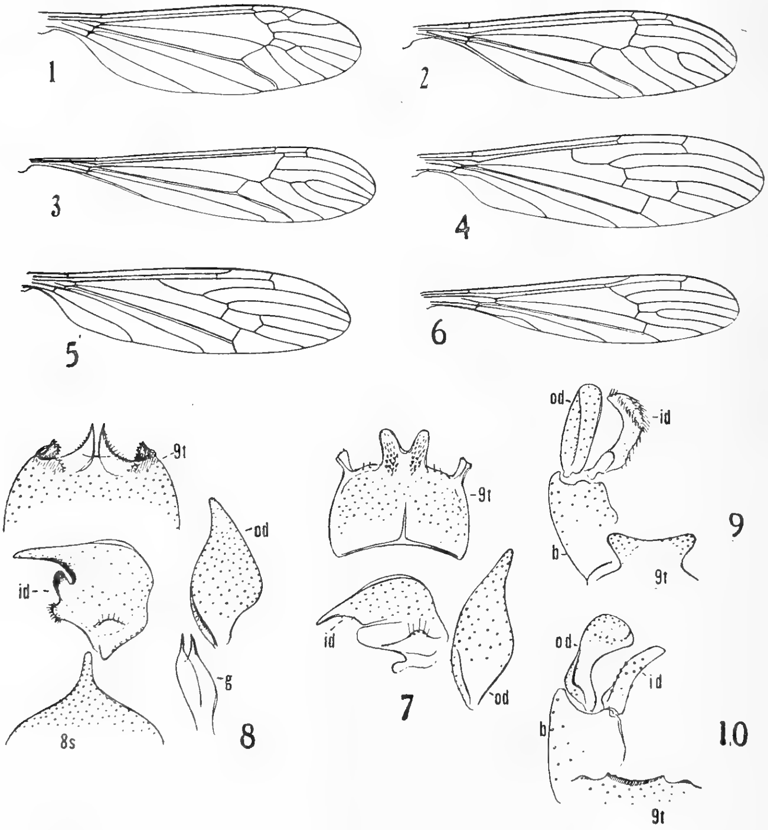
General coloration of mesonotal praescutum dark brown, the humeral region yellow; a transverse, dark brown girdle on mesepisternum; legs with genua, tips of tibiae, and all but proximal portions of basitarsi, white; wings with a weak brown tinge, conspicuously patterned with darker brown on cord and outer longitudinal veins; anterior cord oblique, with Rs lying most distad; Sc_2 opposite Rs; cell 2nd A narrow; male terminalia with the tergite produced laterad into triangular darkened lobes.

♂.—Length, 9·5–10 mm.; wing, 11–11·5 mm. ♀.—Length, 11–12 mm.; wing. 12–12·5 mm.

Frontal prolongation of head yellow above, darkened laterally; palpi dark brown. Antennae with the scape yellow, pedicel white; flagellum black; antennae

(♂) of moderate length, if bent backward extending about to base of abdomen; flagellar segments long-cylindrical, gradually decreasing in length outwardly, the terminal segment oval, about one-third the penultimate; verticils of intermediate segments much shorter than the segments themselves. Front yellow; vertex light brown.

Pronotum darkened medially, paling to yellow on sides. Mesonotal praescutum with an intermediate pair of stripes that become darker and nearly confluent behind, similarly fusing with the very extensive lateral darkenings; humeral region extensively light yellow; scutal lobes extensively dark brown, the



Text-figs. 1-10.

1. *Nephrotoma flavoposticata*, n. sp., venation.
2. *Dolichopeza (Dolichopeza) tayloriana*, n. sp., venation.
3. *Dolichopeza (Dolichopeza) percuneata*, n. sp., venation.
4. *Limonia (Libnotes) hollandi*, n. sp., venation.
5. *Limonia (Libnotes) consona*, n. sp., venation.
6. *Limonia (Pseudoglochina) procella*, n. sp., venation.
7. *Nephrotoma flavoposticata*, n. sp., male terminalia, details.
8. *Nephrotoma kaviengensis*, n. sp., male terminalia, details.
9. *Dolichopeza (Dolichopeza) tayloriana*, n. sp., male terminalia.
10. *Dolichopeza (Dolichopeza) percuneata*, n. sp., male terminalia.

(Symbols: *b*, basistyle; *g*, gonapophysis; *id*, inner dististyle; *od*, outer dististyle; *s*, sternite; *t*, tergite.)

cephalic portion, adjoining the suture, paler; scutellum testaceous-yellow in middle, darker posteriorly and on sides; mediotergite infuscated. Pleura yellow, with a transverse dark brown girdle occupying the anepisternum and sternopleurite, being a continuous extension of the lateral praescutal stripes; pleurotergite similarly darkened. Halteres moderately long, the stem dusky, the extreme base more greenish; knobs blackened. Legs with the coxae and trochanters yellow; femora brown to brownish-black, the tips narrowly white to greenish-white, preceded by a more intensely blackened area; tibiae black, the bases narrowly white, the amount subequal to the femoral brightening, the tips more extensively whitened, very narrowly so on fore tibiae, more extensive on posterior tibiae where nearly the distal sixth is involved; fore and middle basitarsi blackened on proximal portion, the outer half or more yellowish-white; posterior basitarsi almost entirely white, the proximal fourth or fifth infuscated; outer tarsal segments white or greenish-white. Wings (Fig. 2) with a weak brown tinge, patterned with darker brown, more conspicuously so at the stigma and as broad seams on both anterior and posterior cords; outer radial and medial veins more narrowly seamed with brown; veins brownish-black. Holotype with a series of about thirty macrotrichia in cell R_5, not evident in the remainder of type series. Venation: Anterior cord oblique, but not as markedly so as in *percuneata*, n. sp.; Sc_2 ending opposite Rs; outer medial forks of moderate depth; m-cu gently arcuated, about one and one-half times its length before the fork of M; cell 2nd A narrow.

Abdominal tergites obscure yellow, the bases and apices of the segments dark brown, the latter more broadly so; sixth tergite more uniformly darkened; sternites and terminalia more uniformly obscure yellow. Male terminalia (Fig. 9) with the tergite, *9t*, produced laterad into triangular darkened lobes, the caudal margin entire, gently emarginate. Both dististyles only feebly sclerotized, the apex of inner style, *id*, densely hairy.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor). Allotopotype, ♀. Paratopotypes, 1 ♂, 1 ♀.

I take very great pleasure in dedicating this handsome crane-fly to Mr. Frank H. Taylor, who collected the majority of the new and rare Tipulidae discussed in the present report. The nearest ally is *Dolichopeza* (*Dolichopeza*) *percuneata*, n. sp., which differs conspicuously in the venation and pattern of the wings, and in the structure of the male terminalia. Both species find their only near described allies in the eastern Australian fauna, since no member of the typical subgenus had been discovered west of Papua in the Austro-Malayan islands, their place being taken by other subgeneric groups of *Dolichopeza* that have evidently been derived from the Oriental faunal region, as *Eunesopeza* Alexander, *Mitopeza* Edwards and *Nesopeza* Alexander. The presence of macrotrichia in cell R_5 of the wing of the holotype specimen of the present fly and not in the remainder of the type-series is distinctly puzzling, since macrotrichia in the wing-cells of other species have been found to be relatively constant both in number and distribution.

DOLICHOPEZA (DOLICHOPEZA) PERCUNEATA, n. sp. Text-figs. 3, 10.

General coloration of mesonotum brownish-black; pleura yellow, with a transverse brownish-black girdle covering the anepisternum and sternopleurite; legs black, the genua very narrowly white, the tips of all tibiae somewhat more broadly so; tips of basitarsi and succeeding tarsal segments snowy-white; wings unusually narrowed at base; *Rs* very short, lying far distad of the other elements of the anterior cord; medial forks deep; cell 2nd A very long and narrow; male hypopygium with the outer dististyle expanded at apex into an obtuse spatulate head.

♂.—Length about 8 mm.; wing, 9 mm.

Frontal prolongation of head brownish-yellow; palpi brownish-black. Antennae black, the scape and pedicel a trifle paler; flagellar segments cylindrical, the verticils shorter than the segments. Head with the front yellow, the vertex more castaneous, the posterior orbits darker.

Pronotum brownish-black above, yellow on sides. Mesonotal praescutum brownish-black, the humeral region of the yellow ground-colour; median region of praescutum a little paler behind; scutal lobes brownish-black posteriorly, much paler in front, adjoining the suture; posterior sclerites of notum brownish-black, the scutellum paler on anterior portion. Pleura yellow, the anepisternum and sternopleurite brownish-black, a direct continuation of the lateral portions of the praescutum, forming a conspicuous transverse girdle; pleurotergite dark brown. Halteres very long and slender, black. Legs with the coxae yellow; trochanters testaceous; femora black, the tips very narrowly snowy-white; tibiae black, the extreme bases white, the tips more broadly so, the amount subequal on all legs or somewhat narrower on the mid-tibiae, including one-eighth or less of the segment; tarsi dusky, the outer ends of basi-tarsi and the remaining tarsal segments snowy-white. Wings (Fig. 3) unusually narrowed at base into a petiole; strongly tinged with brown, the prearcular field and cells C and Sc more yellowish-brown; stigma small, darker brown; a very narrow and restricted brown seam on anterior cord; veins brownish-black. Venation: Rs unusually short, transverse, lying far distad, some distance beyond Sc_2, delimiting the proximal end of stigma; cord unusually oblique, the fork of M lying most basad; outer medial forks deep; m-cu about one-half its length before fork of M; cell 2nd A long but reduced to a narrow strip.

Abdominal tergites black, with a yellow ring at near midlength of the individual segments, this subequal to or a trifle narrower than the blackened base and apex of the segment; subterminal sclerites and terminalia more uniformly blackened; sternites more extensively light yellow, the incisures narrowly darkened. Male terminalia (Fig. 10) small and with few distinctive features, other than the dististyles. Ninth tergite, *9t*, with the caudal margin narrowly blackened. Outer dististyle, *od*, expanded at apex into an obtuse spatulate head. Inner style, *id*, shorter, more narrowed outwardly, the tip obtuse, the basal three-fourths with long, coarse setae.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor).

By Skuse's table to the Australian species of *Dolichopeza* (PROC. LINN. SOC. N.S.W., (2) 5, 1890, 60), this fly runs to *Dolichopeza* (*Dolichopeza*) *annulipes* Skuse. It is somewhat more closely allied to *D.* (*D.*) *dorrigensis* Alexander and *D.* (*D.*) *kurandensis* Alexander, of eastern Australia. The nearest ally is undoubtedly *D.* (*D.*) *tayloriana*, n. sp., as discussed under that species. The venation, with Rs lying far distad, and with the cord unusually oblique, is somewhat suggestive of that found in the genus *Scamboneura* Osten Sacken, and marks the extreme condition in this venational peculiarity so far discovered in the genus *Dolichopeza*.

MEGISTOCERA FUSCANA (Wiedemann).

Nematocera fuscana Wiedemann, *Dipt. Exot.*, 1, 1821, 29. 1 ♂, Salamaua, New Guinea, 16 December, 1933 (F. H. Taylor).

LIMONIINAE.

LIMONIINI.

LIMONIA (LIMONIA) EXPEDITA, n. sp. Text-fig. 11.

General coloration of mesonotal praescutum reddish-brown, with a dark brown median stripe; pleura reddish-brown, with a narrow blackish longitudinal stripe; halteres chiefly blackened; legs black, the femoral bases brightened; wings with a brownish tinge; stigma oval, darker brown; costal fringe (♂) long and conspicuous; cell M_2 open by the atrophy of m; abdominal tergites black; male terminalia deeply notched medially; dististyle single, produced into a curved blackened spinous point.

♂. Length about 4·2 mm.; wing, 5 mm.

Rostrum obscure yellow; palpi black. Antennae black throughout; flagellar segments oval, with short glabrous apical pedicels. Head grey, lighter on front.

Pronotum dark brown above, paler laterally. Mesonotal praescutum high and gibbous, reddish-brown, with a dark brown median stripe, the lateral stripes paler and ill-defined; scutum reddish-brown, the centres of the lobes darkened; scutellum brown, darker posteriorly; mediotergite dark brown. Pleura reddish-brown, with a narrow blackish longitudinal stripe extending from the fore coxae to the abdomen, passing beneath the root of halteres. Halteres pale basally, the distal portion of stem and the knobs blackened. Legs with the fore coxae blackened, the remaining coxae and all trochanters reddish-yellow; femora obscure yellow basally, passing into black at near midlength; tibiae and tarsi black. Wings with a brownish tinge; stigma oval, darker brown; veins black. Costal fringe (♂) long and conspicuous, though sparse. Venation: Sc long, Sc_1 ending about opposite three-fourths the length of Rs, Sc_2 some distance from the tip of Sc_1, the lattter about one-half longer than r-m; free tip of Sc_2 and R_2 both pale and in transverse alignment; basal section of R_{4+5} long, exceeding one-half the length of Rs; cell M_2 open by the atrophy of m; m-cu just before fork of M; anal veins gently convergent at bases.

Abdomen with tergites and terminalia black; sternites obscure yellow, the incisures dusky; terminal segments more uniformly darkened. Male terminalia (Fig. 11) with the tergite, *9t*, profoundly notched medially, the lateral lobes glabrous, darkened, their tips obtuse. Basistyle, *b*, with the ventro-mesal lobe very low and stout. A single dististyle, *d*, from a swollen pale base, the distal half narrowed into a curved blackened spine, the tip acute, the surface with scattered setae and setulae, including one spinous bristle at near one-fourth the length that may be homologous with the usual spines of the rostral prolongation found throughout the genus. Gonapophyses, *g*, with the mesal-apical lobe very broad and flat, pale, the apex irregularly obtuse.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor).

The type-specimen is in very indifferent condition, both wings being badly torn. The species is so distinct that its recognition will be simple. It is the only species of the subgenus *Limonia* so far described from the Australasian region in which cell M_2 of the wings is open by the atrophy of m, rather than by that of the basal section of vein M_3. In the Oriental fauna, various members of the *pacata* group, such as *pacata* Alexander, *pacatella* Alexander, and others, possess this character.

LIMONIA (LIBNOTES) HOLLANDI, n. sp. Text-figs. 4, 12.

General coloration obscure yellow, conspicuously patterned with brownish-black and black; antennae black throughout; tips of femora narrowly blackened;

wings weakly tinged with brown, sparsely patterned with darker brown; Rs very strongly arcuated, perpendicular at origin or nearly so; cell 1st M_2 elongate, with m-cu at near midlength; m and basal section of M_3 subequal; anal veins convergent at bases; male terminalia with the dorsal dististyle present as an acute rod; rostral prolongation of ventral dististyle broadly flattened, produced into a slender apical point; gonapophyses with mesal-apical lobe slender, the margin with microscopic denticles.

♂.—Length about 6·5–6·7 mm.; wing, 6–6·5 mm. ♀.—Length about 7 mm.; wing, 7 mm.

Rostrum and palpi black. Antennae black throughout; flagellar segments (♂) short-oval, the first subglobular, the outermost more elongate; terminal segment a little exceeding the penultimate, pointed at tip; apices of flagellar segments glabrous but not constricted into necks; longest verticils subequal in length to the intermediate segments. Head dark grey, the occiput and posterior vertex with a velvety-black area; anterior vertex reduced to a linear strip in both sexes.

Pronotum dark brown, more or less pruinose. Mesonotal praescutum brownish-yellow, with a broken brownish-black pattern, the usual three stripes narrow, especially the median one, the laterals confluent at their anterior ends with the median vitta, isolating two linear strips of the ground-colour on posterior half of sclerite before the suture; lateral and humeral portions of praescutum similarly darkened; scutum pale medially, the lobes darker, more intensely blackened along their mesal edges; scutellum black, the parascutella a little paler; postnotum almost uniformly darkened. Pleura brownish-yellow, striped longitudinally with blackish, including a more dorsal area across propleura and anepisternum, and a scarcely separated line across the dorsal sternopleurite and ventral meron; ventral sternopleurite clearer yellow. Halteres obscure yellow at base, the outer portion dusky, the extreme tip more yellowish. Legs with the coxae pale, the fore coxae a trifle darkened; trochanters yellow; femora obscure brownish-yellow, the tips narrowly but conspicuously blackened, the amount subequal on all the legs, the dark apex preceded by a very narrow, scarcely evident, clearer yellow ring; tibiae brownish-yellow, the tips very narrowly darkened; tarsi brownish-yellow, passing into black. Wings (Fig. 4) weakly tinged with brown, restrictedly patterned with slightly darker brown; cells C and Sc more brownish-yellow; the dark areas include arculus, origin of Rs, cord, outer end of cell 1st M_2, and the small stigma; wing-tip and longitudinal veins very narrowly and insensibly seamed with brown; veins dark, paler in costal region. Venation: Sc moderately long, Sc_1 ending opposite r-m, Sc_2 at tip; Rs short and very strongly arcuated at origin, being perpendicular or virtually so; free tip of Sc_2 and R_2 in transverse alignment; m-cu at near midlength of the long cell 1st M_2; m and outer deflection of M_3 subequal; anal veins slightly convergent at origin.

Abdomen bicolorous, the tergites brownish-black, the bases of the individual segments narrowly yellow; sternites obscure yellow, the dark colour vaguely shown on the outer segments; pleura variegated with darker; eighth segment (♂) obscure yellow; terminalia brownish-yellow. Male terminalia (Fig. 12) with the caudal margin of tergite, *9t*, gently emarginate, the lateral lobes low and obtuse, with strong setae. Ventromesal lobe of basistyle, *b*, simple. Dorsal dististyle, *dd*, a strong chitinized rod, the tip acute. Ventral dististyle, *vd*, deeply bilobed, the outer lobe dusky, with conspicuous setae; inner lobe consisting of the broadly flattened rostral prolongation which is extended into a long slender point, the entire prolongation pale yellow. Gonapophyses, *g*, with mesal-apical angle long and straight, the inner edge with very acute microscopic denticles. Ovipositor with cerci very slender, the tips acute.

Holotype, ♂, Kavieng, New Ireland, 16 February, 1934 (Dr. E. A. Holland). Allotopotype, ♀, carded with type. Paratopotype, ♂.

This very distinct crane-fly is named in honour of the collector of the type series, Dr. E. A. Holland. The species is most generally similar to *Limonia* (*Libnotes*) *perkinsi* (Grimshaw), widely distributed in the Pacific Islands, differing notably in the coloration, venation, and structure of the male terminalia.

Limonia (Libnotes) obliqua (Alexander), var.

Libnotes obliqua Alexander, *Rec. South Australian Mus.*, ii, 1922, 232.

1 ♂, 1 ♀, Bulolo, New Guinea, altitude 2,200 feet, 26 December, 1933 (F. H. Taylor).

The problem of specific distinction is well shown in the present pair of individuals (vide papers by the writer: Proc. Linn. Soc. N.S.W., lx, 1935, 60–61; *Revue Suisse de Zoologie*, 43, 1936, 89).

Limonia (Libnotes) solomonis (Alexander).

Libnotes solomonis Alexander, *Ann. Mag. Nat. Hist.*, (9) xiii, 1924, 39.

Recorded from several Pacific Islands (Solomons, New Britain, Santa Cruz, Reef Islands). Pondo, New Britain, 28 November, 1933 (F. H. Taylor).

Limonia (Libnotes) consona, n. sp. Text-figs. 5, 13.

General coloration of thorax brownish-black, the humeral region of praescutum obscure yellow; femora black, the tips narrowly and abruptly yellow; tarsi paling to light brown; wings greyish-yellow, the ground almost concealed by an extensive brown pattern that appears as crossbands and seams to the veins; basal section of R_{4+5} about one-half Rs; cell 1st M_2 relatively small, about one-half the length of cell 2nd M_2; m-cu beyond midlength of cell 1st M_2; male hypopygium with the ventral dististyle large and fleshy, the rostral prolongation with two very unequal spines, the inner one reduced to a seta.

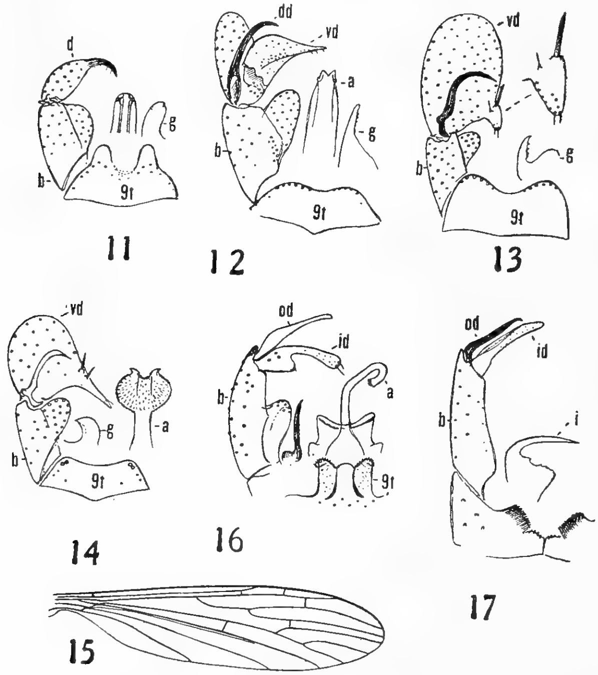
♂.—Length about 9·5 mm.; wing, 11 mm.

Rostrum dark brown; palpi brownish-black. Antennae black; flagellar segments long-oval; verticils shorter than the segments. Front dusky; posterior portions of head grey; anterior vertex reduced to a linear strip.

Pronotum brownish-black. Mesonotum brownish-black, the humeral region of praescutum obscure yellow, the remainder of the sclerite entirely occupied by a dorsal black shield; median region of scutum and scutellum obscure yellow. Pleura brownish-black, including the dorso-pleural membrane. Halteres dusky, the knobs more infuscated. Legs with the coxae dark brown; trochanters obscure testaceous yellow; femora black, the tips narrowly and abruptly yellow, the amount subequal on all legs; tibiae black; tarsi paling to light brown; claws with a long slender spine at near midlength. Wings (Fig. 5) with the ground-colour greyish-yellow, almost covered by extensive brownish clouds and cross-bands, including a broad area crossing the basal cells beyond arculus; a second band at level of origin of Rs, not involving cells C or Sc; broad areas along cord and outer end of cell 1st M_2; most of cells beyond cord suffused, variegated only by small diffuse areas of the ground; cells C and Sc chiefly yellow; stigma small, short-oval, darker brown; veins brown. Venation: Sc_1 ending opposite or just beyond r-m, Sc_1 a short distance from tip; free tip of Sc_2 in virtual alignment with R_2; basal section of R_{4+5} about one-half Rs; cell 1st M_2 relatively small, about one-half cell

2nd M_2; m-cu beyond midlength of cell 1st M_2, longer than distal section of Cu_1; anal veins gently divergent.

Abdominal tergites, including terminalia, brownish-black, the extreme bases of the intermediate segments pale; sternites a little brightened. Male terminalia (Fig. 13) with the tergite, *9t*, moderately notched, the setae of the lateral lobes almost all marginal. Basistyle, *b*, much smaller than the ventral dististyle, with normal small ventromesal lobe. Ventral dististyle, *vd*, large and fleshy, its rostral prolongation stout, with two spines of very unequal size, the outer one a strong black spike, the inner spine basal in position, reduced to a mere seta. Gonapophyses, *g*, with the inner margin of the mesal-apical lobe irregularly serrulate.



Text-figs. 11-17.

11. *Limonia* (*Limonia*) *expedita*, n. sp., male terminalia.
12. *Limonia* (*Libnotes*) *hollandi*, n. sp., male terminalia.
13. *Limonia* (*Libnotes*) *consona*, n. sp., male terminalia.
14. *Limonia* (*Thrypticomyia*) *spathulifera*, n. sp., male terminalia.
15. *Orimarga* (*Orimarga*) *papuicola*, n. sp., venation.
16. *Helius* (*Eurhamphidia*) *auranticolor*, n. sp., male terminalia.
17. *Helius* (*Eurhamphidia*) *melanosoma*, n. sp., male terminalia.

(Symbols: *a*, aedeagus; *b*, basistyle; *d*, dististyle; *dd*, dorsal dististyle; *g*, gonapophysis; *i*, interbase; *id*, inner dististyle; *od*, outer dististyle; *t*, tergite; *vd*, ventral dististyle.)

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor).

Limonia (*Libnotes*) *consona* is a large, striking species that requires no comparison with any of the numerous regional forms so far described. By

Edwards' key to the species of *Libnotes* (*Journ. Fed. Malay St. Mus.*, 14, 1928, 74–80), the fly runs to *L.* (*L.*) *montivagans* (Alexander), of Java, an entirely different species.

LIMONIA (DICRANOMYIA) SORDIDA (Brunetti).

Dicranomyia sordida Brunetti, *Fauna Brit. India, Dipt. Nematocera*, 1912, pp. 382–383.

Widespread throughout the Oriental Region. The present material is definitely referable to *sordida* rather than to the allied *illingworthi* (Alexander), characteristic of the Pacific Islands.

Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor). Maini, Papua, altitude about 6,300 feet, July, 1935 (K. J. Clinton).

LIMONIA (THRYPTICOMYIA) ARACHNOPHILA (Alexander).

Dicranomyia (*Thrypticomyia*) *arachnophila* Alexander, *Philippine Journ. Sci.*, xxxiii, 1927, 301.

Recorded from the Philippines and New Britain. Numerous specimens of both sexes, Salamaua, New Guinea, 21 August, 1935 (Norman Ferguson).

Mr. Ferguson furnished notes of unusual interest relating to the habit of these flies of resting and dancing on spiders' webs and long strands of spiders' silk. Similar habits in this same species had been discussed by the writer in an earlier paper (l.c., xxxiii, 1927, 299), but in the present instance, instead of only a few individuals being involved, Mr. Ferguson states that many hundreds of individuals were encountered.

In this material of *arachnophila*, the wing-tips are slightly infumed, but not so markedly so as in *apicalis* (Wiedemann), *fumidapicalis* (Alexander) and *spathulifera*, n. sp. The male terminalia lacks the two especially modified elongate setae at the outer lateral angle of the ninth tergite, and the conformation of the rostral prolongation and its spines is distinctive of the present fly.

LIMONIA (THRYPTICOMYIA) SPATHULIFERA, n. sp. Text-fig. 14.

General coloration dark plumbeous-grey; proximal fifth of basitarsi blackened; wings hyaline, the cells beyond cord very strongly infumed; Sc_1 ending a short distance before origin of Rs; m-cu at near three-fifths the length of cell 1st M_2; abdomen black, the basal segment brown; male terminalia with the aedeagus expanded at apex into a subcircular oval spatula, the surface provided with numerous setae.

♂.—Length, 5–5·5 mm.; wing, 6–6·3 mm. ♀.—Length, 5–5·5 mm.; wing, 6–6·2 mm.

Rostrum and palpi black. Antennae relatively elongate, black; flagellar segments long-oval, with short pedicels and very long verticils. Head dark grey.

Pronotum and mesonotum almost uniformly dark plumbeous-grey. Pleura heavily grey pruinose, the sternites more testaceous. Halteres with base of stem yellow, the outer end and knob blackened. Legs with the coxae and trochanters testaceous-yellow; femora black, the bases restrictedly paler; tibiae black; tarsi snowy-white, the proximal fifth of basitarsi black, the amount of the latter subequal on all legs. Wings hyaline, the cells beyond cord very strongly infumed; stigma long-oval, even darker brown; veins black. Venation: Sc relatively long, Sc_1 ending a short distance before origin of Rs, the distance on costa about as long as the basal section of vein M_{1+2}; free tip of Sc_2 far before R_2, R_1 alone exceeding m-cu; m-cu at near three-fifths the length of cell 1st M_2.

Abdomen black, only the basal tergite and sternite brown. Male terminalia (Fig. 14) with the tergite, *9t*, transverse, the caudal margin gently emarginate, each side with five setae, of which two are much stronger and placed close together. Basistyle, *b*, with ventro-mesal lobe unmodified. Ventral dististyle, *vd*, with the spines separated, the more basal from a low tubercle, the outer sessile. Aedeagus, *a*, at apex expanded into a subcircular to transversely oval spatula of thin membrane, this set with numerous setae, all of which are directed mesad and caudad.

Holotype, ♂, Admiralty Group, Lombrum, Manus Island, 19 February, 1934 (F. H. Taylor). Allotopotype, ♀, carded with type. Paratopotypes, 2 ♂, 2 ♀, on cards.

The most similar described species is *Limonia* (*Thrypticomyia*) *fumidapicalis* (Alexander), of north-eastern Australia. This has the wing-tip much less strongly darkened, Sc longer, with Sc_1 ending opposite the origin of Rs, and with the details of structure of the male terminalia quite distinct. The peculiarly dilated apex of the aedeagus is different from that of all other species of the subgenus so far discovered.

LIMONIA (PSEUDOGLOCHINA) PROCELLA, n. sp. Text-fig. 6.

General coloration of mesonotum dark brown, with a more brownish-yellow median line; a broad, pale yellow, longitudinal stripe across pleura, the ventral sternopleurite and meral region dark; tibiae white, with a single, relatively narrow, dark ring at near midlength; wings whitish subhyaline, the stigma conspicuous; Sc relatively long, Sc_1 ending distinctly beyond fork of Rs; medial fork deep; m-cu approximately its own length beyond fork of M; cell 2nd A narrow; abdominal segments bicoloured.

♂.—Length, 5·5–6·5 mm.; wing, 5·8–6·8 mm. ♀.—Length, 6–6·5 mm.; wing, 6–6·5 mm.

Rostrum and palpi brownish-black. Antennae black; flagellar segments oval, with very short, glabrous, apical pedicels; verticils about as long as the segments. Head light brown.

Pronotum pale brownish-yellow. Mesonotum brownish-yellow down the central portion, the sides darker, the praescutum a little more intensely coloured in front and laterally. Pleura chiefly pale brownish-yellow, the ventral sternopleurite and meral region brownish-black. Halteres dusky, the knobs even darker. Legs with the coxae darkened; trochanters obscure yellow, the fore pair darkened; fore femora yellow, very narrowly darkened at base, the tip a little more extensively so; middle femora dusky on basal half, outwardly paling to whitish, the tips narrowly blackened; posterior femora almost uniformly blackened, the tip a little more intense; all tibiae snowy-white, with a single, relatively narrow, darkened ring at near midlength; tarsi white. Wings (Fig. 6) whitish subhyaline, unmarked except for the oval, dark brown stigma; veins brown. Venation: Sc relatively long, Sc_1 ending some distance beyond fork of Rs, in cases extending to just before the level of r-m; Sc_2 opposite origin of Rs or nearly so; medial fork deep; m-cu beyond the fork of M, the distance variable, usually approximately equal to the length of the vein itself; distal section of Cu_1 a little longer than m-cu; cell 2nd A narrow.

Abdominal tergites bicolorous, dark brown, the caudal portions of the segments obscure yellow; lateral borders of second tergite darkened; sternites obscure yellow, the outer segments restrictedly darkened subapically; terminalia small, dusky.

Holotype, ♂, Kavieng, New Ireland, 14 February, 1934 (F. H. Taylor). Allotopotype, ♀, carded with type. Paratopotypes, 12 ♂, ♀, 10–16 February, 1934 (Taylor and Holland).

The nearest ally is *Limonia* (*Pseudoglochina*) *kobusi* (de Meijere) of Java and Sumatra, which differs in the coloration of the thorax and in the wing-venation, especially the less oblique cord, longer Sc, and slightly narrower cell 2nd A. Both species agree in having a single narrow tibial ring and with m-cu some distance beyond the fork of M.

LIMONIA (PSEUDOGLOCHINA) EVANESCENS, n. sp.

Antennae (♂) relatively long; flagellar segments with glabrous apical necks, the main body of the segments with long dark pubescence; tibiae white, with a single, nearly evanescent, dark ring at near midlength; wings with Sc_1 ending shortly before the fork of M; m–cu at or close to the fork of M; abdominal tergites bicolorous; sternites and terminalia uniformly yellow.

♂.—Length about 5·5 mm.; wing, 5 mm.

Rostrum and palpi testaceous brown. Antennae relatively elongate, much longer than in *procella*, n. sp.; flagellar segments oval to long-oval, with long conspicuous glabrous apical pedicels; surface of segments with a dense conspicuous erect pubescence that is only a little shorter than the verticils; in *procella*, the pubescence of the flagellar segments is short and relatively inconspicuous. Head dark.

Pattern of mesonotum not readily discernible in unique type because of method of mounting, but apparently much as in *procella*. Pleura chiefly pale, dark brown on the ventral sternopleurite. Halteres dusky, the knobs darker. Legs with the fore femora white, narrowly dark brown at both ends; mid-femora dusky on basal half, the outer half paling to white, the tips narrowly darkened; posterior femora infumed, the central area somewhat more brightened; tibiae white, with a very narrow, scarcely indicated, pale brown ring at near midlength, this being so faint as to be virtually evanescent; tarsi white. Wings subhyaline, unmarked except for the small, oval, dark brown stigma; veins brown. Venation: Sc relatively short, Sc_1 ending just before the level of the fork of M; medial fork of moderate depth; m-cu at or very close to fork of M, shorter than the distal section of vein Cu_1; cell 2nd A relatively narrow but long.

Abdominal tergites dark brown, the caudal borders narrowly brownish-yellow; sternites and terminalia uniformly yellow.

Holotype, ♂, Admiralty Group, Lombrum, Manus Island, 19 February, 1934 (F. H. Taylor).

The nearest regional ally is the type of the subgenus, *Limonia* (*Pseudoglochina*) *pulchripes* (Alexander) of northern Queensland, distinguished by the leg-pattern and details of venation. In the present fly, the dark tibial ring is so pale and narrow as to be nearly lacking.

ORIMARGA (ORIMARGA) PAPUICOLA, n. sp. Text-fig. 15.

General coloration light grey, the praescutum and scutum scarcely variegated by darker grey; knobs of halteres moderately infuscated; wings subhyaline, unmarked; macrotrichia of outer radial and medial veins abundant; free tip of Sc_2 far before R_2; Rs and R_{2+3} subequal; R_{1+2} about twice R_2 alone; abdomen brownish-black.

♀.—Length about 7 mm.; wing, 5·8 mm.

Rostrum grey; palpi brownish-black. Antennae black, the scape pruinose; flagellar segments oval, gradually decreasing in length outwardly. Head grey.

Pronotum and mesonotum uniformly light grey, the praescutum and scutum scarcely variegated by darker grey. Pleura dark grey. Halteres white, the knobs moderately infuscated. Legs with the coxae dark, heavily pruinose; trochanters pale brown; remainder of legs broken. Wings (Fig. 15) subhyaline, unmarked; veins pale. Macrotrichia of veins relatively abundant, including complete series on outer radial and medial veins, with about 25 on R_3; 30 on distal section of R_{4+5}; 40 on distal section of M_{1+2}; and 35 on distal section of M_3; no trichia on Rs, main stems of M or Cu, or either anal vein. Venation: Free tip of Sc_2 far before R_2, the distance approximately one-half longer than the latter vein; Rs and R_{2+3} subequal; R_{1+2} about twice R_2 alone; M_{3+4} a little shorter than M_4; m-cu about opposite two-thirds to three-fourths the length of Rs; cell 2nd A relatively long and wide.

Abdomen brownish-black, including the bases of the ovipositor; cerci dark brown.

Holotype, ♀, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor).

The only described regional species of *Orimarga* with which this fly may be profitably compared is *Orimarga* (*Orimarga*) *hypopygialis* Alexander (Celebes). The latter differs in coloration and, especially, in the details of venation, including the strongly angulated Rs, loss of the free tip of Sc_2, longer R_{1+2}, deeper cell M_3 and position of m-cu.

HELIUS (HELIUS) ANAEMICUS Alexander.

Helius (*Helius*) *anaemicus* Alexander, *Philippine Journ. Sci.*, xlix, 1932, 254–255.

Hitherto known from the Loochoo Islands, Formosa, Luzon and Mindanao, in all cases at low altitudes. Two male specimens, Kavieng, New Ireland, 16 February, 1934 (Dr. E. A. Holland). A wing of one of the specimens shows abnormal venation. By existing keys, the fly runs to *Helius* (*Helius*) *unicolor* (Brunetti), a very different species.

HELIUS (EURHAMPHIDIA) AURANTICOLOR, n. sp. Text-fig. 16.

General coloration light orange, the terminal abdominal segments black; head grey; halteres pale throughout; legs obscure yellow, the outer ends of the tibiae and tarsi paling to white; wings tinged with yellow, the veins very pale; a conspicuous pale brown cloud extends from the stigma along the anterior cord to the fork of M; male terminalia with the dististyles apical in position.

♂.—Length about 4 mm.; wing, 4·6 mm.

Rostrum about equal in length to remainder of head, brown; palpi darker brown. Antennae short, pale brown throughout; flagellar segments long-oval; verticils much exceeding the segments. Head light grey; anterior vertex about as wide as the rostrum.

Pronotum and mesonotum entirely light orange, unmarked. Halteres pale throughout. Legs with the coxae and trochanters pale orange-yellow; femora obscure yellow; tibiae a trifle darker, especially the posterior legs, the outer ends and tarsi paling to white; genua not brightened. Wings with a yellowish tinge, variegated only by an oblique, pale brown cloud extending from the stigma along the anterior cord to the fork of M; veins very pale yellow, a trifle darker in the clouded area. A few macrotrichia on outer ends of veins R_{4+5}, M_{1+2} and M_3. Venation: r-m a little less than its own length before the fork of Rs; cell 1st M_2 large, its inner end lying proximad of other elements of cord; m shortened; m-cu about its own length beyond fork of M.

Abdomen obscure yellow, the seventh to ninth segments, inclusive, black; more basal tergites vaguely darkened medially on basal ring. Male terminalia (Fig. 16) with the basistyle, *b*, slender, terminating in a small glabrous blackened point; dististyles apical in position; outer style, *od*, extended into a long point; inner style, *id*, with a conspicuous incision at near midlength, delimiting a conspicuous basal lobe.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor).

Helius (*Eurhamphidia*) *auranticolor* is very different from the other described species of the subgenus in the light orange colour of the thorax, in conjunction with the patterned wings.

HELIUS (EURHAMPHIDIA) MELANOSOMA, n. sp. Text-fig. 17.

General coloration polished black; mesonotal praescutum strongly arched; knobs of halteres darkened; legs dirty white, the tarsi clearer; snowy-white; wings strongly tinged with grey, the stigma dark brown, conspicuous; abdomen bicoloured, black, the posterior borders of the intermediate segments broadly pale.

♂.—Length, 4·8–5 mm.; wing, 5–5·2 mm.

Rostrum longer than remainder of head, black; palpi black. Antennae black throughout, about one-half longer than the rostrum. Head black, sparsely pruinose.

Pronotum and mesonotum polished black, the praescutum very strongly arched. Pleura polished black, the dorso-pleural membrane pale. Halteres white, the knobs infuscated. Legs with the fore coxae blackened, mid-coxae infuscated, posterior coxae yellow; trochanters obscure yellow; remainder of legs chiefly dirty white, the femora and tibiae somewhat more obscure than the snowy-white tarsi; terminal tarsal segments darkened; genua vaguely brighter than the adjoining parts of the femora and tibiae. Wings rather strongly tinged with grey, cells C and Sc weakly infumed; prearcular region whitish; stigma oval, darker brown, conspicuous; veins brown. Costal fringe relatively long and conspicuous. Venation: Sc_1 ending just before level of r-m, Sc_2 at its tip; r-m variable, from about its own length to nearly twice this distance before the fork of Rs; m-cu beyond midlength of cell 1st M_2.

Abdomen conspicuously bicoloured, black, the caudal borders of segments two to six, inclusive, broadly pale; subterminal segments and terminalia black. Male terminalia (Fig. 17) with the sternite bearing blackened cushions on either side of midline, these densely set with microscopic setulae. Basistyle, *b*, slender. Outer dististyle, *od*, terminating in a simple, gently curved point; inner style, *id*, longer. Interbasal plates, *i*, produced into long straight spines.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor). Paratopotype, ♂.

Helius (*Eurhamphidia*) *melanosoma* is readily distinguished from all other described regional allies by the polished black colour of the body and by the wing-pattern.

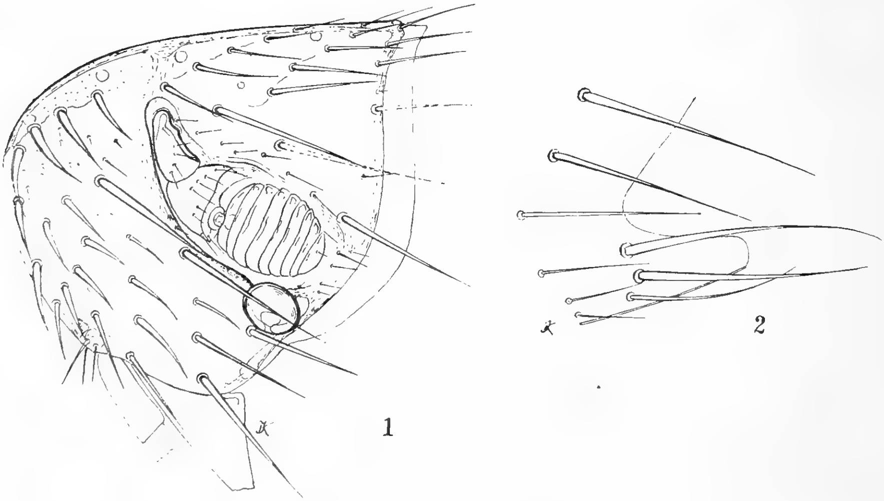
TWO NEW AUSTRALIAN FLEAS.

By Karl Jordan, Ph.D., F.R.S.
(*Communicated by F. H. Taylor, F.R.E.S., F.Z.S.*)

(With two Text-figures.)

[Read 29th July, 1936.]

The fleas here described were submitted to me for study by Mr. Frank H. Taylor, School of Public Health and Tropical Medicine, University of Sydney, to whom I tender my best thanks. The *Xenopsylla* is particularly interesting, as it is a connecting link between the fleas known as *X. hawaiiensis* Jord. 1932 and *X. vexabilis* Jord. 1925. The series of Queensland specimens sent by Mr. F. H. Taylor leaves no doubt in my mind that *hawaiiensis* (Sandwich Is.), *meseris* (Queensland) and *vexabilis* (Franklin Is., South Australia) are subspecies of one species.



Text-figs. 1, 2.—*Stivalius molestus*, n. sp.

Xenopsylla vexabilis meseris, n. subsp.

This Queensland race is characterized as follows: Chaetotaxy as in *X. hawaiiensis*, i.e., bristles more numerous, especially on abdominal sternites, than in *X. v. vexabilis*; the numbers being (on the two sides together):

On sternite:	III.	IV.	V.	VI.	VII.
X. v. meseris ♂	7-9	8-9	8-10	7-10	9-11
X. v. vexabilis ♂	6	6	6	6	6
X. v. meseris ♀	9-10	9-10	10	10	13
X. v. vexabilis ♀	6	7	8	8	8

Bristles on outer surface of sternite VIII of ♂ (on one side) from stigma downwards in *X. v. meseris* 16–21, in *X. v. vexabilis* 13. Bristles on outer surface of tergite VIII of ♀ (on one side), inclusive of marginal ones, in *X. v. meseris* 25–28, in *X. v. vexabilis* 19.

Modified Segments.—♂: as in *X. v. vexabilis*, the membraneous ventral margin of process P of clasper does not extend to middle, whilst in *X. v. hawaiiensis* at least half the ventral margin is membraneous. ♀: spermatheca as in *X. v. vexabilis*, smaller than in *X. v. hawaiiensis*, but its head shaped as in some specimens of that subspecies.

Hab.—Queensland: Ingham, Nov., 1935, on *Rattus culmorum*, collected by Dr. Baldwin; a series of ♂ and several ♀.

STIVALIUS MOLESTUS, n. sp. (Figs. 1 and 2).

Females only. Near *St. rectus* J. & R. 1922 (Queensland) and *St. mordax* J. & R. 1922 (New Guinea), but differs in the head and tail-end. Pale vertical margin of frons (fig. 1) longer than in the two allied species, the head resembling in shape the head of a male rather than of a female; the pale portion of the frontal margin about one-fourth longer than the more strongly chitinized dorsal portion (which ends at the slight dorsal incrassation above the antennal groove). Sternite VII (fig. 2) sinuate as in the allied species, but the sinus less deep, the two large subapical bristles below the sinus being placed vertically below the deepest point of the sinus, whereas in both *St. mordax* and *St. rectus* they are placed farther back on the ventral lobe. Tergite VIII apically sinuate as in other species, the lobe above the sinus as in *St. rectus*, but more rounded.

Hab.—Queensland: Ingham, November, 1935, on *Rattus culmorum*, collected by Dr. Baldwin; 7 ♀.

INTRODUCTORY ACCOUNT OF THE GEOLOGY AND PETROLOGY OF THE LAKE GEORGE DISTRICT.

PART I. GENERAL GEOLOGY.

By M. D. Garretty, B.Sc., late Science Research Scholar and Deas-Thomson Scholar of the University of Sydney.

(Plate ix; one Text-figure.)

[Read 26th August, 1936.]

Scope of Paper.—This paper deals with the General Geology of about 170 square miles of country between Spring Valley and Bungendore, and eastward to Tarago, on the eastern side of Lake George, on the Southern Tableland of New South Wales. A second paper will deal with the Petrology of the area. The work was done partly in 1934 as Deas-Thomson Mineralogy Scholar, a thesis embodying the results being presented as portion of the work for an Honours Degree in that year. During part of 1935 the mapping was continued with the aid of a Deas-Thomson Research Scholarship, and a Science Research Scholarship of the University of Sydney. Owing to his unexpected departure for Fiji, the writer was unable to extend the field examination of some of the more interesting occurrences, but feels that the chances of continuing it in the near future are sufficiently remote to warrant the publication of the results thus far obtained.

The accompanying map (Pl. ix) is based on the parish maps issued by the Department of Lands. To facilitate reference in the text, a grid system has been incorporated. Numbers in brackets refer to specimens, a suite of which is being lodged in the Museum of the Department of Geology at Sydney University.

Previous Records.—Practically the only references to the geology of the neighbourhood are contained in "The Limestone Deposits of N.S.W." (Carne and Jones, 1919), and the "Report on the Federal Territory" (Mahony and Taylor, 1913). Both these deal with the limestone deposits. On the physiographical side, the origin of Lake George has been discussed at some length by Taylor (1907), and several brief references occur in various recent papers by Craft (1928–33).

Acknowledgements.—The writer wishes to record his appreciation of the constant advice, and friendly and encouraging criticism given freely throughout the work by Dr. W. R. Browne. He also desires to acknowledge the practical hospitality of the residents of the district, and in particular that accorded by Mr. and Mrs. W. Overend, of Mount Fairy, and Mr. D. White, of Willeroo Station.

Summary.—Owing to the general absence of fossils and lack of suitable exposures, a definite chronological scheme cannot be given, but the general succession is briefly as follows: The Mount Fairy Series, of shales, phyllites, limestones, tuffs, and minor igneous zones, has, in common with an associated series of amphibolites, been injected by gneissic granite, accompanied by strong folding, and the formation of hybrid or contaminated types. The amphibolite series may possibly be a remnant of an older igneous mass than the shales, which are Silurian. A group of Devonian rocks, including Middle and probable Upper

Devonian, overlies unconformably the Mount Fairy Series and gneissic granite. Following an epi-Devonian period of igneous injection, erosion supervened until the outpouring of Late Tertiary lavas took place.

THE MOUNT FAIRY SERIES.

This name is given to a group of rocks covering an extensive area in the southern and eastern parts of the district. Shales form the chief rock type, but phyllites, sandstones, tuffs, limestones, and minor intrusions also occur, some of which are certainly of Silurian age, and all may well be.

Sedimentary Types.

The dominant rocks are sediments, ranging from fine shales through sandy shales to grits. They are usually brownish-yellow in colour, but in places white, brown, grey, and chocolate shales occur, as in a creek (H.13)* two miles north of Sally Trigonometrical Station. Black slaty and cherty phases do not occur in general, but are fairly well developed in a limited area between about G.10 and E.13. They would seem to be related in some way to the proximity of the main granite mass of the lake. The possibility should not be overlooked that they may belong to an older system, perhaps even Ordovician. Fossils were not found.

So far no definite fossils have been found in the Mount Fairy shales. In the Cookbundoon–Goulburn region numerous graptolitic remains have recently been found (Naylor, 1935) in beds of similar aspect. On Fairy Meadow Creek, between the Public School site and the railway line (J.5), deformed radiolaria occur in a dark cherty band among the shales. A similar rock from Sandhills Creek in southern J.4 contains better preserved types. The bands, a few inches thick in the shale series, contain identifiable *Spumellaria* and *Nasselaria*, in which the centrosphere is visible in some cases. Radiolaria also occur in a slate inclusion in one of the "intrusive tuffs" from Fairy Meadow Creek and probably are abundant in the adjacent rock.

Occasional zones of a more phyllitic character occur in the shales in the main area of the Mount Fairy Series. These could not be shown to bear any constant relation to visible occurrences of granite, but may reflect its presence below the surface. There are also phyllites and mica schists in that part of the area in which the amphibolites and hornblende schists occur in mass, near Red Hill. These occur as bands (intercalated or xenolithic?) in the amphibolite series, and also as xenolithic bands in the granite. On the map they are indicated by the same symbol as the normal Silurian beds, but they are easily recognized, since they occur well away from the main shale series.

Lithologically, these rocks appear to be more highly metamorphosed than the rocks of the Mount Fairy Series which, in addition to shales, includes slates, sericite-chlorite-schists, schistose grits, and the like. The Red Hill phyllitic group has not reached the biotite stage of regional metamorphism, but is still in the chlorite zone, into which the rocks of the Mount Fairy Series fall. Both types have suffered maximum stress, indicated by shearing and fracture, and this to a later time than that of the crystallization of the granite (q.v.). We must then compare them as purely regionally altered types, when the difference in maximum metamorphism amounts at most to a temperature difference wholly within the chlorite zone. This, especially in view of the apparent greater heating effects of the granite near the lake, as shown by the effects on the basic rocks, does not seem sufficient justification in itself for placing the phyllites in an older series. Further discussion of the age really turns upon the interpretation given to the

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* Grid reference to map.

amphibolite series of Red Hill, as being (*a*) bedded volcanics or pyroclastics, of Silurian or, less probably, older age; (*b*) epi-Silurian gabbro, comagmatic with the granite; (*c*) epi-Ordovician gabbro. This is discussed elsewhere. Here it may be said that should (*c*) be correct, the phyllitic series must be pre-Silurian, while in the other cases it could, and probably would, be Silurian.

Pyroclastic Types.

Pyroclastic types are not conspicuous members of the series. A hard dark band (1594) in the shales on Sandhills Creek near Emu Flat Creek was sectioned to see whether radiolaria might not be present. The rock is an extremely fine-grained quartz-tuff; radiolaria are wanting. Probably such tuffs, in narrow bands, are common in the series. About one mile west of the Tarago-Willeroo crossroads, in I.11, a small outcrop of banded rock (1951) occurs. In hand-specimen there is often a contortion of certain bands (only), reminiscent of the contorted varves of the Seaham district, and probably due to the same cause, namely, slumping in the soft sediments. Moreover, slides show that there is unmistakably a cycle of deposition of the type found in varves. Layers of coarser and limonite-rich material pass gradually into finer ones, to end abruptly at the commencement of another coarse band. The bands vary in width from 1 mm. to 0·3 mm. The writer is of the opinion that this rock is the consolidated product of very fine showers of volcanic ash, settling in water. The intervals between showers, though not long, were sufficient to allow of the settling of the finer ash which would remain suspended in the water for some time. An opportunity has since occurred of examining certain rhythmic tuffs in northern Viti Levu, Fiji, and an analogous structure has been observed to be not uncommon in these latter types. Unfortunately the field-relations of the Tarago occurrence are somewhat obscure, but there does not appear to be any reason to doubt that it forms part of the Mount Fairy Series.

Igneous Types.

Associated with the Mount Fairy Shales there is developed, along Merigan Creek and the railway line in eastern J.9 and J.10, a group of hypabyssal and possibly pyroclastic types. There is not much evidence on which to decide whether these are interbedded, intrusive, or both in part. Time did not allow of very detailed mapping, but it appears probable from the field relations that some at least of the felsite is in the form of one or more interformational sills or laccoliths. Owing to alteration, the origin of the rocks is rather obscure, but tuffs, felsites, rhyolites, and even obsidians probably occurred. These will receive more detailed treatment in Part II.

In north-western K.11 chiefly, there is a series of igneous and pyroclastic rocks. They are possibly related to the Devonian occurrences just to the north, but on the other hand their field relationship to the Mount Fairy Series suggests that they form part of this series. The boundary is steeply inclined to the strike of the shales on the southern margin of the group, but there is no evidence suggesting faulting, nor is there any distinction in elevation between them. Possibly the igneous types, which are acid, were very viscous and built up an elevated structure without much lateral extension, to be surrounded by shales. The chief types are quartz and felspar porphyries, tuffs, and a coarse rhyolite-breccia, all now much altered.

"Intrusive Tuffs."

Chiefly on Fairy Meadow Creek and Sandhills Creek there is a development of rather anomalous types. Concordant in general with the shales and slates, and yet showing in places minor signs of transgression, there are rocks which in thin section appear to be of clastic origin. Field-evidence cannot indicate much beyond the transgressive relation, and thin sections are in a measure unsatisfactory on account of a certain amount of silicification and albitization that has occurred. In Fairy Meadow Creek, 14 chains above the junction with Sandhills Creek, K.5, a rock (1716) of this nature occurs, with a number of xenoliths or fragments of slate embedded in it. On the same creek, half a mile above the junction, another (1715) shows a quite definitely transgressive relation to the sediments, but a section shows characters suggestive of a clastic or brecciated origin. Other quite definitely intrusive examples occur on these creeks, tongues of the rock cutting across the shales, and including detached fragments of the wall material.

Rocks exhibiting these peculiar features occur elsewhere in the Silurian of the State. However, a recent summary of their occurrence and characters (Browne, 1929, pp. xv-xvi) renders further notice here unnecessary. Not much fresh light on their origin can be shed by the study of the material from this district.

Limestones.

The limestones of the Mount Fairy Series occur in a belt of isolated outcrops covering several square miles, and exposed chiefly by Sandhills and Fairy Meadow Creeks, to the south-east of Mount Fairy (Mahony and Taylor, 1913; Carne and Jones, 1919, p. 286). Considerable interest attached to the main deposit—the only one considered in detail by these authors—on account of its proximity to the Federal Capital, and a proposal to make use of it for cement for the chief buildings of Canberra.

The limestone occurs in two belts trending meridionally, and with disconnected outcrops. The more eastern of these (K.4) passes through Swampy Creek. The other, narrower but more elongated, runs northwards along Sandhills Creek and then up Fairy Meadow Creek.

The *eastern belt* includes outcrops up to 22 chains in width. The main mass, cleft by Swampy Creek, occurs on the southern side of Sandhills Creek, but another series of outcrops occurs to the north of the latter stream. The general strike of the limestone of this belt is a little west of north, and the dominant dip is high to the west. The limestone is massive and jointed; nevertheless the writer found a number of places where intercalated shales gave reliable dips, though considerable variations occur. One determination near the eastern edge of the main mass, rendered certain by the presence of both shale and fossil bands, gave a strike of 355° and a dip westerly at 65°, and others, somewhat similar, were obtained. Variations may be seen, particularly near the stream at the northern end of the main mass. A determination, strike 115°, dip southerly at 45°, was succeeded just to the south by a strike of 140° and dip of 60° to the south-west, with a regular gradation between. These dips may indicate subsidiary transverse pitching folds in the main flexure of the limestone, or may be taken as contributory evidence of the existence of large-scale faulting.

Faulting in the associated shale series is very common. Some of the faults are normal, while many are thrusts. Often the throw is indeterminate, but in many cases it is of a small order. Faulting also occurs in the limestone, and there is evidence of the existence of at least one major fault. The latter, perhaps influencing the dip anomalies mentioned above, seems, while not clearly defined, to run from west-south-west to east-north-east along and past the northern edge of the main limestone mass. Such faults as this would need to be plotted and taken into account in any exhaustive examination of the limestone masses for economic purposes.

The *western belt* occurs about 30 chains to the west of the eastern. It is much narrower, having only about one-third the maximum width of outcrop of the eastern belt. The outcrops are disconnected, and occur chiefly along Fairy Meadow Creek to Mount Fairy and beyond. A reddish soil which is probably terra rossa occurs in a hollow at the railway line where the surveyed road crosses it in portion 21, Parish of Merigan, a little north of Mount Fairy (J.6). This would be a continuation of the western belt almost directly due north for about a quarter of a mile from the Mount Fairy Public School masses. The length of the belt is thus a few chains short of two miles. Some of the limestone masses on this belt show good stratification, especially those near the school site (J.5–6). One of these shows an excellent exposure of crumpled limestone, indicating fairly considerable depth of cover during folding. The limestone of this belt is given by Carne and Jones as striking N. 10° W., and dipping E. 10° N. at 65°. However, one determination gave a westerly dip of 30° for the limestone on Sandhills Creek near Fairy Meadow Creek.

The boundaries of the limestone outcrops are sometimes quite clear, as on the downstream side of the main mass on Sandhills Creek, but most of those elsewhere, except in creeks, are obscure. Near Mount Fairy and at the lower junction on Sandhills Creek, the gradation by intercalated bands into shales is easily seen; there is no sign of a faulted or eroded junction. The associated sediments are similar to the Silurian beds elsewhere in the district, with some exceptions. There is a greater proportion of coarser beds. Fine and coarse grits and tuffs are associated with the shales west of the limestone belts, and some carbonaceous shales also occur. The rocks actually in contact with the limestone on the west are shales, and between the two belts there are reddish shales. Downstream from the eastern belt, typical shales again occur at the junction, but some chains further down a more siliceous assemblage is found, of quartzites, shales, and phyllites.

Fossils are not numerous in the limestone, and even when they do occur, well preserved and identifiable specimens are rare. They are best developed at the extreme eastern edge of the main mass, on the creek. Forms collected include *Favosites* (several types, massive and dendroid, probably including *F. gothlandicus*); a large *Syringopora* and smaller fossils of the same type; numerous crinoid stems and ossicles. Professor L. A. Cotton has found* a thick band of *Conchidium* (*Pentamerus*) *knightii* in one of the tunnels which were excavated for the purpose of ascertaining the extent of the limestone. The fossil was also found in one of the caves. It links the limestone with other similar ones at Marulan and elsewhere, being considered a restricted form. The limestone was considered by the late Mr. W. S. Dun to be indubitably of Upper Silurian age, and there seems no evidence to the contrary.

The question, however, arises as to the age of the western belt, since it is the eastern one which contains the above fossils. Fossil traces were found in the western belt, but not well enough preserved for identification. In favour of the limestones being of similar general age, we have the very similar strikes and degree of dolomitization of the two belts. The apparent gradation in each case into the shales between indicates continuous sedimentation. Moreover, the occurrence of a similar sequence of two belts, one thick, and the other narrow.

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* Personal communication.

or a succession of thin beds, at Bungonia, Marulan, and Windellama, is significant. These are all Upper Silurian, as is the main belt on Sandhills Creek, and their existence is not inconsistent with the suggestion that the western belt on Sandhills Creek is likewise of Upper Silurian age.

A series of large caves exists in the main limestone mass, but they were not explored. As there cannot be caves below stream level, any of importance are likely to be confined to the eastern belt. The weathering of the limestone is of the orthodox type. The characteristic terra rossa is present in many places, though largely washed off by sheet erosion.

The suitability of the limestone for cement making has been considered by the Federal Government, more especially in connexion with the building of the Federal City. Two reports issued (Mahony and Taylor, 1913; Parl. Papers, 1916) contain information on this subject. Analyses, plans, cement tests, and tonnage estimates are given. Tunnels more than 200 feet in length have been driven into the main mass, which has been contour surveyed. Quite recently the dolomitic portion of the deposit has been opened up. The rock is being used by Hoskins' Iron and Steel Works at Port Kembla, presumably for lining furnaces.

Conditions of Deposition.

The dominance of shales in the series indicates the general prevalence of quiet sedimentation in water free from violent or persistent currents. Some reliable conclusions may be drawn from consideration of lithological features.

The very widespread occurrence of the Mount Fairy shales requires for its explanation the postulation of a sea of considerable area. That this was marine, in part at least, is shown by the association of radiolaria and of limestone beds. However, study of the rocks cannot fail to convince one of the applicability of Barrell's generalization that such seas in past geological time may have been wide, but certainly were not deep (Barrell, 1917). The intercalation, at intervals, of beds of fine sandstone, and even occasional grits, points either to continued shallow-water deposition or to an inconveniently rapid oscillation of the strand line. The limestones also contribute to this conclusion, inasmuch as corals flourish at a depth not greater than about 120 feet. A somewhat more subtle significance lies in the frequent occurrence in the shales and fine sandstone of miniature current-bedding. Good examples occur on a creek (southern part of F.4) tributary to Dry Creek, and also on Sandhills Creek at a number of places in J.3 and J.4. The deposition within the limit of occasional current action is obvious. But whereas currents may stir sediments at quite considerable depth, these must have been stirred at very small depth. For the thinness of the current-bedded bands (half an inch or less) requires very feeble currents, acting not far from the surface. At a greater depth stronger currents would have to be present, and these would have scoured out channels in the fine sediment, and could not have failed to stir feet of the muds, rather than a centimetre.

Signs of cycles in the sedimentation, and also in the contemporaneous vulcanicity, are common. On a large scale, we have the alternation of sandstones and shales. At Rocky Point, also, rhythmic banding of a large order of magnitude is very well shown in numerous exposures. There is some doubt about the correlation of the isolated Rocky Point mass with the Mount Fairy Series, on account of this banding, and also because of the indurated and rather more arenaceous type of sediment. Alternation of limestone and shale bands in the creek near Mount Fairy (J.5–6) is very regular. The distinct rhythm displayed by banding in the varve-like tuffs from I.11 has been commented upon already.

In a number of places the periodic banding in the shales or sandstones is very pronounced, and invites investigation with a view to possible determination of the nature or period of the cycle, as has been done by Gilbert and others. On Dry Creek in F.3 is such an exposure, and another is in a measurable position in the creek bed at Mount Fairy near the railway line. Alternations are excellently exposed in the slates on Taylor's Creek where it turns from north to west (G.9). The average thickness of the bands is about one-third of an inch. On Sandhills Creek, J.4, the average thickness of the bands, which are very well shown, is half an inch and three inches respectively. At the same place there is also a rhythm, of magnitude decreasing upwards from 18 inches to a fraction of an inch, of bands with strongly marked current-bedding, and laminated white shale beds between. The thicker current-bedded bands are not simple, but multiple, again illustrating the feebleness of the current action, even though prolonged more than usual. The picture conveyed to the imagination is one of unsettled conditions of deposition, periodical in incidence, but of waning intensity.

Palaeogeography and Climatology.

The palaeogeography of the Mount Fairy Series is somewhat obscure. At present it is not easy to state the bounds of the area over which rocks of this age outcrop. The Upper Silurian sea apparently was not deep, but was undoubtedly extensive. The limestones may point to the possible existence of a shore line to the east of Mount Fairy, though there is no reason to doubt that, in such a palaeozoic shallow-water sea, coral reefs could flourish far from land. The presence of volcanic rocks and, to a less extent, of pyroclastics, in the Tarago area suggests active volcanoes near the land, or perhaps on it. But such outpourings could quite easily have originated in submarine eruptions, a view which is indeed favoured by the occurrence of extensive deuteric alteration in them and by the abundant occurrence of these types of rock in the Silurian of the Cooma-Canberra region.

Climatic conditions in Upper Silurian time represented by the Mount Fairy Series were evidently moderate. The limestones indicate warm seas, for a time at least. It may be suggested that the clouds of volcanic ash emitted from time to time may have exercised a pronounced temporary cooling, as has often been urged by advocates of certain climatic theories, and has been indicated by modern instrumental observations by Abbott and others.

Structure of Mount Fairy Series.

It seems difficult to come to any other conclusion than that the Mount Fairy Series has been closely folded into a series of almost isoclinal overfolds, with axial planes dipping west. On seeing, throughout the district, numerous instances of this close folding—folds with a wave length of a few yards and even less—it does not seem reasonable to assume, on consideration of the uniform nature of the beds, that the close folding is but local, especially in view of the total absence of any evidence of the existence of more open folding. Excellent illustrations of the isoclinal folding may be seen in the following exposures: Emu Flat Creek, in north-eastern I.3, where the validity of the subsidiary corrugation test for anticlines and synclines finds an excellent demonstration; on Sandhills Creek numerous sections illustrate the close folding, as in south-western J.4 and north-western J.3; at the Mount Fairy Railway bridge, and in the cutting about 400 yards south of it (both in J.5), where the close folding may be seen; the big bend in Taylor's Creek in G.9—a storehouse of illustrations of various features of the Mount Fairy Series—shows the close folding to advantage, and also its discrepant attitude to the cleavage.

The almost invariable dip to the west, both of bedding and of schistosity, is strong evidence in favour of isoclinal folding, especially in view of the very variable amount of dip, precluding one large simple fold with corrugations. Exceptions with regard to both bedding and schistosity dip do occur, but are rare. An easterly dip of beds is to be seen near the bend of the road in K.12, and also on the Bungendore road just south of the area shown in the map. These anomalies are easily explained as the accidental exposure of the short east-dipping limbs, or as a local, rather more open, folding.

If close folding be such an essential feature as is thought, there must have been considerable crustal shortening due to pressure (from the west, see Hobbs, 1914). It is likely that the isoclinal folds dipping west form part of the one limb of a huge synclinorium (or anticlinorium); following the mechanical principles involved, the folds probably represent part of the eastern limb of a synclinorium, and the beds to the west of Lake George, with a large proportion of easterly dips,* could represent the western limb. Another result of the isoclinal folding is that it is quite impossible to form any idea, with data now available, of the thickness of the Mount Fairy Series.

Exposures showing the close folding of the shales also indicate a considerable pitch for the folds. A dominant direction of pitch cannot be given from the data known. One effect of the pitch is to modify to some small extent the observed values of strike and dip. The general strike is north or a little west of north. But considerable variations, partly along lines of shear, occur, up to 45° and even 80°. Darwin ("Geological Observations", p. 251) mentions the dominant northerly strike. No definite relation could be seen between the local strike of the shales and the boundaries of the granite, though the latter is, in general, concordant. Occasional belts of silicification occur in the shales, and run parallel to the strike. This is probably due to the penetration by magma and magmatic waters along these lines (see under "Gneissic Granite", below).

Geological Age.

Evidence of the age of the extensive Mount Fairy Series is as yet indirect and inconclusive. The shale series has not so far yielded fossil remains. Reasons have been given already for placing the Mount Fairy Limestones in the Upper Silurian. The eastern belt is interbedded with sediments on the eastern side; its western boundary is indefinite. The western belt is interbedded, as may be seen near Mount Fairy. There is no evidence that these limestones have faulted junctions with the shales. It seems fairly certain from this point of view that, so far as stratigraphical continuity is maintained, the Mount Fairy Series is of Upper Silurian age. An unconformity is later described between the Mount Fairy Series and a Middle Devonian Series, indicating the pre-Devonian age for the former as a probability. The granites which inject the Mount Fairy Series form what Billings has termed a synchronous batholith, and reasons are later

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* Personal observations by writer.

given for regarding them as probably of epi-Silurian age; in this case there is a strong presumption that the sediments are of Upper Silurian age, in part at least.

Conclusions based on lithology will always remain open to criticism, but due consideration of it must often be of service. In the present case, there can be no doubt that the lithological criteria are sufficient to place the Mount Fairy Series as pre-Devonian, as shown by comparison with nearby Devonian types—the coarse Middle and Upper Devonian of the Tarago–Goulburn district, and the Lower Devonian volcanics of the Murrumbidgee area. The great dissimilarity of the shales to Devonian rocks of this part of the State is paralleled only by the closeness with which they resemble the characteristic type of the Upper Ordovician and Silurian of the surrounding region.

From a consideration of the foregoing factors, the writer has concluded that the Mount Fairy Series is certainly pre-Devonian, and probably Upper Silurian in age, though there is a possibility that it is, in part, of Lower Silurian age. Lower Silurian rocks have recently been described from the neighbourhood by Naylor (1935).

DEVONIAN.

Rocks of Devonian age occur on Woolowolar Ridge, and its northerly extension across the road towards Tarago. Briefly, the succession consists of limestones, at and near the base, followed by a thick series of red beds, and then by shales, sandstones, felsites, and porphyries in alternating fashion. The general structure appears to be a syncline pitching to the south, probably with one or more cross fractures.

Limestones.

The chief outcrops were mapped as well as practicable. Some of them are mentioned by Carne and Jones (1919). Outcrops occur to the north and south of the road-cutting in K–L.12; this mass is about 60 yards by 150 yards, elongated east and west. Two rather irregularly exposed outcrops occur on the hill about half a mile north of this one, and a small one some chains south of the creek. Further exposures were found in the large tributary creek in northern K.12, interbedded with shales and other sediments.

Dips are easily obtained in the main mass, both in the creek and the road-cutting. The strike is N.20° W., and the dip westerly at 20–25 degrees and more. Bedding is well developed, and accentuated by intercalated shale bands. Dips in the next northerly outcrops are not obvious, but some of the limestone in the more easterly of the two outcrops is bedded, in the bank of the creek. The strike obtained, N. 5° W., with westerly dip, accords with the observation of Carne and Jones. Along the tributary creek the limestone bands and calcareous shales were found to strike from 90° to 150°, dips varying from north at 60° to south-west at 25–51°. These latter beds are apparently part of a series of sediments, fairly closely folded, and of steep pitch.

Fossils were sparingly present in the larger deposits. The chief forms found were *Favosites* sp. and *Receptaculites ?australis*; these were obtained from the smaller of the two outcrops in north-eastern K.12. The presence of *Receptaculites* indicates that the limestone is probably of Middle Devonian age, since in New South Wales this fossil is characteristic of the Middle Devonian, though it is also found sparingly in the Upper Silurian. Confirmatory evidence of the age of the Tarago limestones is to be found in their probable continuation northwards at Lake Bathurst, where they are quite fossiliferous in places, and brachiopods of Devonian aspect occur.

Red Beds.

The Red Bed Stage comprises a thick series of boulder beds and tuffs outcropping as a horseshoe-shaped exposure to the south of Tarago. The deposit varies from a very coarse boulder rock, with individuals up to three feet in greatest diameter, to a fine-grained rock with grainsize less than one millimetre. The boulders are well rounded, and are chiefly of much altered aphanitic acid rocks. A detailed search was made for scratched or faceted pebbles such as would suggest ice or fluvio-glacial action, but none was found. The large boulders are well seen in the section along Merigan Creek, K.11. Splendid sections are also to be seen in some of the gorges on the western side of Woolowolar Ridge. One of these is deeply incised into the mass, K.10, and the gorge walls give an impressive idea of the magnitude of the deposit, which is possibly one of the finest conglomerates to be seen in the State.

There is not only no positive evidence that the beds are fluvio-glacial, but there is definite circumstantial evidence against it. The underlying limestone has its connotations, though of course there may have been a time-break between it and the conglomerates. Moreover, there is no evidence of Devonian refrigeration in the State—or continent—as far as the writer is aware. The red colour of the beds has also certain climatic implications, as will be seen below, and these do not include excessive cold. The finer material is at least dominantly pyroclastic; the boulders are rounded, occur in more or less separate beds, and may or may not be of pyroclastic origin. The most appropriate name for the rock is probably tuffaceous conglomerate.

The brilliant red coloration of the Red Bed Stage is a striking characteristic. Red beds are often referred to as indicating in some vague way that the rocks were formed under arid conditions—presumably on the precedent of the red sands at present forming by exsudation in some deserts. Dorsey (1926) has shown that the redness is not due to a relatively high iron content, nor yet only to the presence of ferric iron-oxide—the form in which it is usually present in sediments. The question, he points out, really turns upon the state of hydration in which it is present, which may vary from $2Fe_2O_3.3H_2O$ to Fe_2O_3. The latter (haematite) is red, while each of the four hydrates has another colour. As pointed out also by Tomlinson (1916), the conditions necessary to produce the dehydrated ferric oxide need not coincide with those undergone by the rock at any stage. For this oxide, once formed, is stable, and may be deposited as sediment under totally different conditions. The chief factors in the production of the anhydrous oxide are time (it being slowly spontaneous) and heat (by which it is accelerated). Dorsey shows that optimum conditions are found "not in deserts—which are practically never red—nor in semi-arid climates, but in warm, moist, heavily forested regions similar to the tropical and sub-tropical areas of the earth today".

Dorsey states that, once formed, the red colour is permanent unless the oxide be chemically reduced. From this and field evidence he deduces that red beds are best formed under continental or freshwater conditions, the reducing effect in marine deposits being inhibitive. This makes the question of the occurrence of limestone with the Red Beds at Tarago an interesting one. Tomlinson remarks that where limestones do occur with red beds they are nearly, or quite, barren of fossils. This is also true of the only limestone at Tarago actually seen to underlie the Red Beds, but the few fossils which do occur in it are sufficient to indicate its marine origin. There may have been a time break between the limestone and red beds, and deposition of the latter under continental conditions, after uplift. Again, possibly the violent current carrying the boulders, or the rapid showering of ash and boulders—depending on the precise origin—was sufficient to cause the local suspension of true marine reducing conditions.

Mapping of the Red Bed Stage south of the road shows the outcrop to have a horseshoe shape, with the apex to the north, on the road. The western limb thins out and disappears, and the eastern one does likewise at about the same latitude. Dips could not be obtained on the eastern limb, owing to the weathered outcrops. At the apex, the beds are crushed and shattered, and dips meaningless. In the western limb, good exposures enable dips to be read from bands of finer or coarser material. The dips thus obtained are of doubtful general value. Some were to the east, but others were to the west. Evidence of contortion, crushing, and close folding in cuttings shows that the dips would be expected to vary in this way. More reliance should be placed on the obvious connotations of the relation of outcrop to contour, which make it unreasonable to consider the structure as other than a syncline pitching to the south. This pitch makes it seem likely that the Red Bed Stage continues as a sub-surface mass some distance further south than shown on the map. The effect would be that of the spreading out in plan of the superincumbent quartzites and other rocks. Possibly there has been transverse faulting of the structure about along the line of the Tarago road-cutting, with probable uplift of the structure to the north. In the section, the Red Beds are indicated as being folded in a syncline, with minor folding or corrugation of the whole. Owing to the absence of what may be taken as a general dip, and to the presence of minor folding and possibly strike-faulting, it is difficult to assess the probable thickness of the Red Bed Stage. The greatest normal width of outcrop, on the north-western side, is 24 chains. From this the maximum thickness would be, with a dip of 30°, about 800 feet, and with a dip of 70°, 1500 feet.

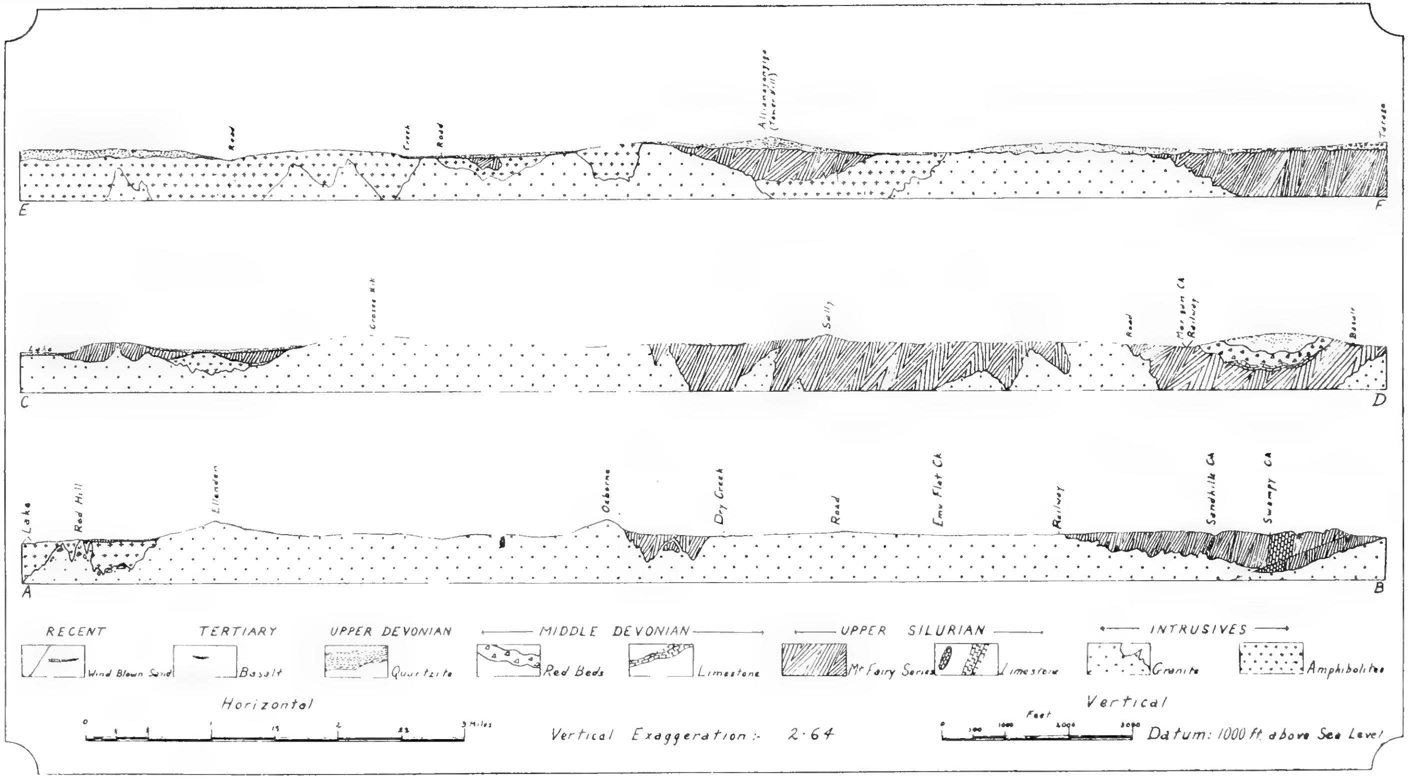
The Red Bed Stage must be either Middle or Upper Devonian in age. The apparent structural continuity with the limestone supports a Middle Devonian age, since there are reasons for believing an unconformity to separate the Middle and Upper Devonian in this region. Similar rocks, though not with the abundance of large boulders, occur associated with the limestone of Middle Devonian age at Lake Bathurst; they also occur underlying the white quartzites of Memorial Hill, Goulburn.

Felsites, Quartzites, etc.

Overlying the Red Bed Stage in the synclinal trough there occurs a series of felsites and porphyries, with quartzites and slates. The slates are both black and grey. The quartzites weather into boulders which much resemble those weathered out from the red beds after the haematite coating has been removed, and have thus rendered the mapping of the latter difficult in places. The felsites and porphyries appear to be flows interbedded with the sediments. With regard to structure, these rocks present difficulties which are not easily overcome. Dips are obtainable only on the western slope of the ridge, and have a dominant westerly nature. If the beds be truly conformable with the Red Beds, they should be expected to partake of the synclinal structure. Either the synclinal structure is very asymmetrical, or the two series are unconformable. The felsite-quartzite

Text-figure 1.

Sections drawn along the lines shown in the map (Plate ix). The thickness of the wind-blown sand is probably considerably exaggerated. The folding of the Silurian and Devonian systems, and the sub-surface boundaries, are diagrammatic only, as is also the faulting in the limestone of section A-B. In section C-D, the Upper Devonian is shown as resting conformably upon the Middle Devonian Red Beds and Limestone, though possibly there may here be an unconformity, as discussed in the text.


Road
Creek
Road
Allianoyonyiga (Tower Hill)
Tarago
E
F
Lake
Crosse Hill
Sally
Road
Mor bun Ck
Railway
Basalt
C
D
Lake
Red Hill
Ellenden
Osborne
Dry Creek
Road
Emu Flat Ck
Railway
Sandhills Ck
Swampy Ck
A
B
RECENT
Wind Blown Sand
TERTIARY
Basalt
UPPER DEVONIAN
Quartzite
MIDDLE DEVONIAN
Red Beds
Limestone
UPPER SILURIAN
Mt Fairy Series
Limestone
INTRUSIVES
Granite
Amphibolites
Horizontal
0
1
15
2
25
3 Miles
Vertical Exaggeration :- 2·64
Vertical
Feet
0
500
1000
2000
3000
Datum: 1000 ft above Sea Level

group shows close resemblances to Upper Devonian rocks in the surrounding region which have been studied by the writer. The suggestion of an unconformable relation of Upper to Middle Devonian is supported by the recent work of Dr. Ida A. Brown (1932).

To the north of the Tarago road-cutting, olive-coloured shales, quartzites, and calcareous shales occur interbedded with the limestones (see above). It is not clear whether these rocks are of Middle or Upper Devonian age. The limestones are not fossiliferous here, but it is to be expected that they are related to the nearby *Receptaculites* beds. Besides these beds associated with the limestone bands, there is also an extensive series of felsites and quartzites to the north and west of Tarago. In the railway cutting north of Tarago, the folding of the beds is well seen. The general strike is 135°, and the overfolds pitch to the north-west, and have axial planes dipping to the south-west; the general dip of the beds is north-east at about 60° in the central part of the cutting. In the northern part of the cutting there is a dominant south-westerly dip; here an interbedded felsite band is followed by shales, and then quartzites. Further west, in the neighbourhood of Tarago Trigonometrical Station, felsites, tuffs, and quartzites occur.

To the west of Tarago, a prominent range of mountains trends west-north-west through Tower Hill, and turns northwards to pass to the east of Spring Valley; another branch follows around the northern shores of Lake George. This range consists practically entirely of massive white quartzites, in places standing up in conspicuous walls. There is little sign of structure in these quartzites, and very few dip or strike determinations could be made. The few which were made gave no predominant trend for the rock. In the north-western corner of the map there is a greater tendency for brown and yellow shales to accompany the quartzite.

These quartzites are regarded as of Upper Devonian age by lithological analogy with other rocks in the neighbourhood, such as the Goulburn quartzites. Their strong overlapping of the Mount Fairy Series and the gneissic granite, well seen on the map, also supports this view.

Relation of Devonian to Silurian.

Unfortunately, exposures showing this relation directly are scarce. No clear indication may be seen in the Tarago district, although consideration of the Devonian synclinal structure—for the Middle Devonian at least, which may itself be unconformable beneath the Upper Devonian—and the isoclinal folding of the Silurian, indicates unconformability. It is probable that the Middle Devonian lies unconformably upon the Silurian. The case for the Upper Devonian, if this be granted, must follow immediately. Independent evidence is to be found in the overlapping mentioned above, and the irregular lower surface of the quartzites to be found along the north-eastern foreshores of Lake George.

TERTIARY TO RECENT.

The deposits of this age are of minor importance. They comprise basalt, lateritic beds, and various soils.

Basalt.—A patch of basalt occurs 13½ chains to the west of the Tarago–Boro Road, L.11. It forms a capping to gravels with predominant quartz and quartzite pebbles. In turn, a layer of ironstone caps the basalt. The latter is about 20 feet in thickness, and occurs on a flank of the wide valley which runs northwards to join Mulwaree Creek to the south of Tarago. The mass is seen to separate two minor creeks flowing into this meridional valley; it seems likely that the flow filled the course of a lateral valley to the main stream, covering the gravels therein, and causing the diversion of the drainage. There are no field criteria by which a definite age may be assigned to the basalt, other than that it is later than the underlying gravels. A similar degree of uncertainty holds with regard to these. Microscopical evidence indicates the similarity of the rock to the group of "Plateau Basalts" of this State (Browne, 1933), which are probably the most common type of Tertiary extrusive on the Central and Southern Tablelands.

Lateritic types.—A deposit of lateritic rock, a few chains square, in L.11, is probably to be related to the former presence of basalt; similar basalt occurs nearby. In H.13 also, and surrounding areas, patches of ferruginous material occur associated with gravels and white quartzite. Here again, these types are no doubt due to the action of a former covering of basalt, silicifying and impregnating with iron the underlying rocks.

The occurrence of a thin layer of ferruginous material on the surface of the bedrock of many streams is of interest; this coating, which may have a pisolitic structure, is often overlain by many feet of alluvium. There is evidence that the deposition was not confined to any period of the Tertiary, but that it is even going on at present. Favour is not found with the idea that it is due to leaching of the underlying rocks. The simplest explanation of the occurrence, which resembles that of a viscous fluid flowing down the bare rock channel, is that the material has come in solution from above. Surface water sinking through the alluvium dissolves out some of the iron and carries it to the bedrock, down along which it percolates as a sub-surface stream, depositing the iron again among the gravels as it goes.

Gneissic Granite.

Under this heading are included not only the typical gneissic granite found in the vicinity of the Lake, but also those variants of it, such as felsites and porphyries, which occur as well.

General Occurrence.

As seen on the map, the gneissic granite outcrops chiefly as a large, more or less elongated body in the central part of the area. Omitting the alluvium and Devonian quartzites, the western boundary of the gneissic granite on the map may be taken as the eastern boundary of Lake George. On the eastern side the granite is bounded by the Mount Fairy Series. In the latter series many exposures of the granite are uncovered, as to the south-west of Tarago. The general elongation of the part of the bathylith exposed is a little west of north.

Nature of the Bathylith.

The gneissic character of the rock is more pronounced on the western side than to the east. On the eastern side there is also a greater tendency for the occurrence of masses of porphyry and felsite associated with the granite. The general elongation of the granite-mass corresponds with the direction of average strike of the Mount Fairy Series. Apophyses and tongues from the main mass also have this trend. The foliation of the gneiss is likewise predominantly parallel to this general direction, with minor deviations. On the other hand the relation "the banding or foliation (of the gneiss) being parallel to the boundary of the intrusion" (Browne, 1931, p. 115) implied or expressed by many workers, is not at once apparent here. But the bathylith has only just begun to be uncovered, as is shown elsewhere, and variations in the topography produce marked changes in the boundaries. The foliation actually is approximately parallel to the solid (as opposed to surface) boundaries. There is reason for believing that ridges such as Governor's Hill, D.7, and Osborne Ridge, F.4, represent the original shape of the roof of the bathylith, and the walls are thus, here, at least, steep.

Although the bathylith in general conforms to the average strike of the shales, I have stated above ("Mount Fairy Series") that it is by no means usual for the strike and dip of the shales to accord with the boundary of the nearby igneous rock. Indeed, as may be seen from the map, especially in H.8, the strike of the shales is frequently distinctly oblique to the contact. It was found that the tendency for this to occur was greatest near the more felsitic phases of the intrusive mass, and especially well marked where apophyses of felsite or porphyry have insinuated themselves into the sediments. These facts were interpreted as indicating a decrease in the power of penetration of the magma as the emplacement of the bathylith progressed. The magma, forced up along an axis of structural weakness, was at first able to soften and absorb without deformation the folded shales, but later on, as the injection neared completion, the magma was unable to carry this out so effectively. Instead, it resorted to a forcible thrusting aside of the sediments, exhibiting a determination to displace, if not to absorb, them. It is possible that in these later phases we have an example of the transition from bathyliths of the synchronous type to those of subsequent type (see below). Since the preparation of the map and manuscript for this paper, the writer has noted with interest the description by Mayo (Mayo, 1935) of similar thrusting effects in the Sierra Nevada, California.

The occurrence of felsitic phases of the granite is interesting, as it does not seem to be usual in bathyliths of this type. As stated above, they are more prominent to the east, but it was not practicable to map them separately from the granite. No doubt they were injected somewhat later than the more coarsely crystalline granite, but before the cessation of regional stresses. In support of this may be quoted the occurrence of the felsites as dykes cutting the granite. An example is an east to west dyke, five to six feet across, of banded felsite (1588) with marked flow structure, seen especially well on weathered surfaces, in I.5. Again, on Dry Creek, felsite veins and plugs cut the laminated granite. The aplites and pegmatites, when they occur, are also distinctly later than the granite. Pegmatite was not seen to cut the country rock at any place.

Using the criteria recently enunciated (Browne, 1931) for distinguishing synchronous from subsequent bathyliths, the present example in the main may be placed in the former category, except for the possible transition noted above. With the proviso that but little pegmatite is present, the occurrence accords with each of the criteria given for this group, and not with any of those for the subsequent group.

The main folding of the Mount Fairy Series is inexplicable other than as having antedated the intrusion of the magma. On the other hand a large body of facts could be assembled to show the continuance of stress until after the completion of the crystallization of the rock. The petrographical and field evidence both point to this.

Xenoliths.

Xenoliths are common in the granite, and they are of several different kinds.

Blocks of slate rifted off from the roof have become engulfed in the magma. For the most part these do not differ petrographically from the country rock. Assimilation is not seen in progress. Xenoliths found near the margins are found to be undeorientated, and it would appear that the remarks of various writers on the oriented inclusions of related bathyliths apply to the more or less marginal ones. Slate xenoliths well away from the margins of the mass were found in general to show considerable rotation from the usual limits of strike of the massive slates.

A dark porphyritic rock occurs as xenoliths in several places, as on Dry Creek in G.4. The white phenocrysts in the rock stand out on weathered surfaces; they are of heavily sericitized plagioclase. Sulphides of two colours occur, the more brassy being better crystallized. In thin section the rocks show alteration of the felspar, and change of augite to hornblende.

Irregularly distributed through the granite, over most of the area, dark xenoliths occur which vary from uralitized dolerites to epidiorites and even schistose types. Most of them contain a good deal of sulphide. Some of those near the main amphibolite mass of Lake George show resemblances to it. Others, while they must have been dolerites, are of obscure origin. The distribution, and examination of the outcrops of the rocks leave little doubt as to their occurrence as xenoliths.

Spring Valley Granite.

In the vicinity of Spring Valley, in the extreme northern section of the map, is shown the southern part of a granite-mass extending to the north. It is bounded for the most part by amphibolites of the Red Hill type. Owing to interruption of the work, this granite was not followed far to the north. While it may be a further extension of the gneissic granite just described, there is also a possibility that it may be younger. In handspecimen the granite is of a massive type in comparison with the Lake George material. There is a large granite bathylith extending from the Goulburn-Gunning road southwards through Wologorong and Tarago Lagoon, and it is possible that the Spring Valley occurrence may be a still further southerly extension of this. In a thesis presented at Sydney University in March, 1935, this was regarded as being of Upper Devonian (Kanimbla) age.

The Amphibolite Series.

Under this head are included rocks of several modes of field occurrence, and also rocks of greatly differing constitution. To the north and east of Lake George these basic types occur as a meridional belt extending from Spring Valley to Bungendore. Further exposures occur to the east of this, along the Willeroo–Tarago road. The rocks are for the most part intimately associated with the gneissic granite, and in part form hybrid types with it. The numerous dark crystalline xenoliths to be found almost anywhere in the granite-gneiss are in many cases undoubtedly derived from the amphibolite masses.

The larger outcrop near the north-western corner of D.4 is typical of the hornblende-schist group. The rocks have the appearance of a bedded group (see strike and dip direction on map). Hornblende-schists, some of which contain clouded felspars, epidote, and porphyroblastic felspars, form the chief type, but hybrid zones and zones of more massive amphibolite also occur. These will be described in more detail in Part II.

The more massive and less obviously banded part of the basic series is best illustrated by reference to specimens from the area about Red Hill, C.6. Some of the types here are very similar to those occurring in D.4 mentioned above, but others of them are not. Hybridization has been fairly extensive, and all gradations into gneissic granite are to be found in the field. Tongues of progressively lighter or darker coloured material weave their way, with indefinite margins, among the slightly less acid or basic host.

The area of amphibolites shown on the north-eastern foreshores of Lake George, just west of Kenny's Point, contains types which are again in intimate relation to the granite-gneiss, and which differ considerably from the rocks occurring at Red Hill. Augen structure is common in the amphibolites. Cores of augite are sometimes seen within the amphiboles. There is here also much evidence in the field of absorption of blocks of the more basic rock in the later granitic types of magma.

To the north and east of the Kenny's Point group, further large masses of the amphibolite series are met with. These are not so variable as those just discussed, however, and are dominantly fine-grained hornblende-schists.

It is rather difficult to decide what was the origin of the members of the amphibolite series. On the one hand, we have the evidence of field structure and occurrence, and that of the microscopic examination of slides, to indicate that the rocks of D.4 especially have their origin in bedded igneous rocks or basic tuffs. On the other hand, most of the occurrences other than those in D.4 appear to have commenced with massive basic igneous rock, suggested by the Red Hill types, for example. The microscopical evidence indicates also that there was a first period of regional metamorphism, converting the rocks into various kinds of hornblende-schists. The chief question is to reconcile these. It may be that the greater part of the mass was originally an igneous intrusion of gabbroic nature, and that the more sheet-like southern portion was due to the development of sills or dactylitic intrusions into the country rock at the extremity.

The age of the amphibolite series cannot be definitely stated. It may be considered as an epi-Silurian intrusion probably comagmatic with, and heralding the injection of the gneissic granite. According to this view, the phyllitic group of the Mount Fairy Series near Red Hill would be explained as occasioned by the additional heat supplied by the gabbro during the regional metamorphism which must have closely followed the latter, but preceded the granite; the latter follows from the consideration that the strain effects of the granite-gneiss are not sufficiently strong to suggest that the same stresses could have formed the hornblende-schists. However, the facts pointing to the amphibolites being older than the Mount Fairy Stage form a more convincing assemblage. In the first place the pronounced regional metamorphism which they have undergone strongly suggests their having been involved in an earlier strong orogeny—of the type believed to have closed the Upper Ordovician in this part of the State. The phyllites and mica-schists of Red Hill may not really belong to the Mount Fairy Series at all, but to an earlier group. An epi-Ordovician age for these basic rocks would also supply an analogy to the rather similar basic rocks found further south in the Bungendore–Cooma region. The presence of hybrid gradations between the amphibolites and granite-gneiss certainly would seem to favour their having been injected in fairly quick succession, leaving little time for the earlier rock to cool off. But the fact remains, that the basic rock must have completely solidified and been regionally metamorphosed before the intrusion of the granite, seeming to make residual heat of little importance. Moreover, the influence of the heat content of a rock mass on its absorption by a later mass is at present an unknown quantity. Earlier ideas required the supply of a considerable amount of heat to effect absorption. Bowen has shown this to be erroneous, on theoretical grounds, and the recent considerable amount of study given to cases of extensive assimilation and contamination seems to minimize its importance.

Summing up, it appears that the most likely age of the original basic intrusions forming the amphibolite masses of the Lake George District is epi-Ordovician.

MINOR IGNEOUS INTRUSIVES.

Basic Rocks of Lower Crisps Creek.—Outcropping in Crisps Creek, K.12, twelve to twenty chains above the road bridge is a group of diabasic rocks, which appear to cut the sedimentary series as dykes trending 295°. They can be followed a couple of chains up the hill on the north bank in places. On the south they are obscured by rapid weathering; there is an outcrop in a small road-cutting, but none shows at the surface. Some of the rock includes fragments of the surrounding slate. The intrusion (1858) is about five feet wide, and is typical.

Thin sections show the rocks to belong perhaps to the quartz-dolerite group. Carbonation and albitization have taken place; the augite is in many cases represented by quartz, chlorite, and carbonate. The dykes appear perhaps to have a relation to numerous quartz-dolerite dykes occurring in the Shoalhaven Valley, which are of post-Devonian and probably pre-Kamílaroi age. All that can be said for the Tarago dykes is that they are post-Silurian.

Quartz-dolerite, Reedy Creek.—As with the dykes just mentioned, this is probably to be related to the Shoalhaven quartz-dolerites, which the writer intends to describe in a future paper. It occurs as a dyke twenty feet wide cutting the Mount Fairy Shales in Reedy Creek, K.4, about 30 chains below the main mass of limestone. A dyke of quartz-porphyry occurs two chains higher up, but there does not seem to be any connexion between them. The rock resembles in thin section the quartz-dolerite dykes of Crisps Creek.

Composite dyke, Sandhills Creek.—The types involved here are dolerite, aplite, and porphyritic dolerite, again showing features characteristic of the quartz-dolerite group. In north-western J.3, on Sandhills Creek, a dolerite dyke about 20 feet wide cuts the Mount Fairy Shales in an east-to-west direction. The dyke contains a sub-central band, two to three feet thick, of aplite. The relation of this to the parent dyke is not clear, but it appears that it split the latter after its intrusion, after the manner of composite intrusions. A few yards downstream large blocks of a porphyritic dolerite were found. Although not actually found *in situ* in the dyke, it is very probable that it is an associated type, and is here grouped with it.

Tachylytic basalt.—Specimen 1548 was collected in the railway cutting in south-eastern G.4. It shows the contact of aplite and tachylytic basalt. Thin sections show clearly that the aplite is intruded by the basalt. The rock is an intrusive basic type which, from its freshness, is probably no older than Devonian at most, since it shows no sign of the epi-Silurian diastrophism, and the felspars are quite fresh; possibly it is as recent as Pliocene. The rock may be related to a doleritic type (1552) from G-H.4. It is in the form of an inverted V, in the granite, the outcrop being an inverted V in the cutting wall, and two parallel bands in the floor. Possibly the shape is related to the joint system of the granite. This "dyke" trends at 40°. No slide is available.

Hornblende-epidote Rock.—This is an unsatisfactory type. In the southern part of I.4, in a tributary of Emu Flat Creek, basic rocks occur as bands a few feet thick, apparently interbedded with the Mount Fairy Shales. They are represented by specimens 1668 and 1669. Slides show that the rock consists of brown, with some bluish-green, hornblende in idiomorphic grains; associated with radiating epidote. This is a peculiar type, and no clues are known as to its origin.

Emu Flat Creek Dolerites.—A number of melanocratic rocks occur on Emu Flat Creek and nearby, in I.4. It is difficult to say definitely whether these are intrusions or xenoliths in the granite, since they are exposed only in the stream channel, and the critical junctions were largely covered. One of the masses contains coarse porphyritic phases, and is also intimately cut by an aphanitic type, which distinctly intrudes the granite as well, sending out tongues and seeking out the joint planes. On the other hand, at the old road crossing an exposure of basic rock more resembles a large xenolith. Moreover, this rock is distinctly more altered and different in thin section from the others. Very probably it is a xenolith while the others are dyke-rocks.

Physiography.

While the details of physiographic structure to be found in many regional settings are also to be found in the Lake George District, the discussion of the physiographic history of the area on modern lines can be satisfactorily dealt with only when treated as portion of a much larger unit. Broadly speaking, we may regard the Tarago to Bungendore area as an example of internal drainage—demanding some special explanation—superimposed on the conditions which must previously have obtained at the main divide between the coastal and western drainage systems. Discussion of this peculiar condition is left to a later paper, as it involves a much larger area than that dealt with in this paper.

Outcrop and Contour.—Much of the diversity of topographical detail is directly related to the geological structure. Prominent hills and ridges abound, and can in most instances be correlated with the nature of the rock. The steep hilly country to the south of the Tarago–Willeroo road occurs largely in slates, as do the surrounding flatter parts. However, the slates here have been considerably indurated by the granite close beneath. Intensely silicified bands are followed exactly by the minor ridges. The eminences of Sally Trigonometrical Station and Mount Ellenden (Governor's Hill) present slopes reaching 45°. (These slopes are quite stable in the present cycle of erosion, and most of them have a soil mantle.) The Sally group of hills consists of slates, but they have been indurated, and much impregnated by silica and iron. The ridges of Governor's Hill and Osborne Trigonometrical Station are composed of hard granite-gneiss. The marked elongation of these is probably due to the gneissic structure of the rock. The ridge of Osborne Trigonometrical Station is bounded on the east by low-lying slate country; on the west the change in topography is not so marked, as igneous rock, though of less massive type, continues. The hard flanks of Governor's Hill are bounded on the west by a soft amphibolite-slate complex, and on the east by jointed felsitic rocks. Possibly, also, the present surface represents fairly closely the original roof of the bathylith.

The Woolowolar Ridge, south of Tarago, is part of a long ridge running north to near Goulburn. Near Tarago at all events it shows all the signs of being due to differential erosion. It is built of resistant quartzites and felsites, and bounded on the east by weathered granite, and the west by soft shales. The rugged range running from Tarago to Spring Valley and along the north of Lake George, apparently owes its elevation to the same cause. As pointed out elsewhere, the chief rock type involved is a dense quartzite; where this gives way to granite or amphibolite, there is at once a change to lower ground.

Gullying.—A characteristic feature of the landscape is the extensive gullying which has gone on. An impressive picture of the apparently rapid erosion that has taken place is seen by standing in G.4 and looking westwards to Osborne Ridge, when a whole hillside seared with many gashes is viewed. The best example is perhaps in G.5, on Wright's Creek, which is here quite impassable, presenting vertical banks 20 feet high. Numerous observations, such as the occurrence of ox skulls in the alluvium banks, and the crossing of gullies by surveyed map roads, indicate that the gullying took place since white occupation, and during the last century. Deforestation at once comes under suspicion. However, such gullying was found to occur in places well away from any killed timber, gradually engulfing the vegetation. It may be that the rapid erosion at present occurring is not wholly to be attributed to deforestation, but is only affected in degree thereby. Whether the cause is a difference in annual rainfall, season of maximum precipitation, rate of precipitation, etc., is not clear. Bearing on this, Craft (1935) has just published the results of relevant observations on the Upper Murray Valley.

Aggradation of Low-lying Areas.—Many of the smaller streams in their lower courses pursue channels now very ill-defined, though the older parish maps show them clearly. Apparently this aggradation is of recent occurrence, and to be correlated with the extensive gullying noted above. Wright's Creek, D.4, shows both features very well. In many cases where the alluvium thus deposited has been later again cut into by the stream, regular alternations of coarse and fine beds occur.

Wind-blown Sand.—At various places along the eastern shore of the lake, considerable areas of a fine white quartz-sand with rounded grains occur. Notable among these are the large flats of the Currandooly and Willeroo Stations. These accumulations are especially found opposite breaks in the higher land on one or both sides of the Lake. The sand is economically valuable, supplying a constant flow in the streams, ample scope for wells, and much arable land. The sand is evidently wind-borne, and probably derived, in the last instance, from the lake bed.

Economic Geology.

Mention has been made above of the economic bearing of the deposits of limestone, dolomite, wind-blown sand, and alluvial flats of the district. Of importance also are the weathered granite or saprolite, much used as a road-surfacing material, and the soft shales, which have been used for brick-making.

Occasional pyritic replacements of the Mount Fairy Series have occurred near exposures of the granite. One such, a little south of the Tarago–Willeroo road, has been prospected by several deep shafts. At Currawang, there occurs a zone of mineralization of the amphibolite series, in which there has been considerable deposition of copper sulphides. The workings could not be examined, though there is evidence of a good deal of activity in the past, the ore being smelted locally. The surrounding areas of amphibolite show more pyrites as disseminated grains than is usual (see Carne, 1908, p. 341).

In portion 21, Parish of Mulwaree, and about one mile south-west of Tarago Trigonometrical Station, is a deposit of barytes, replacing limestone. This limestone is evidently a small outcrop to be grouped with the other Devonian limestones of the vicinity. Specimens of the limestone in all stages of replacement by the barytes may be obtained. The deposit does not appear to be very extensive. It is not possible to say whether the deposit is a groundwater replacement or is to be attributed to one of the nearby granites.

Geological History.

The earlier part of this history is rather vague. Probably earliest among those rocks of which we have knowledge were the gabbroic antecedents of the amphibolites, perhaps injected into a shale series now represented by the Red Hill phyllites; regional metamorphism converted these to amphibolites and hornblende-schists, and phyllitic types, respectively. Following extensive denudation, a shallow marine Upper Silurian (and possibly Lower Silurian) geosynclinal basin of considerable dimensions received muds and sands with considerable regularity

—a regularity displayed also by the occasional mild storms. At times, possibly far from land, coral reefs flourished, apparently at least twice. Occasional volcanic vents, on the shoreline or in the water, or both, emitted lavas which, in places, became interbedded with the sediments. Some of these, at least, seem to have been injected among the muds on the sea floor. Very regular emissions of ash took place at times. At the close of the Silurian, an orogeny ensued which compressed the rocks in the geosyncline into close folds; it was before this compressional movement had ceased that injection of granitic magma took place, insinuating itself among the bands of sediment, and also partaking of the impressed directional structures; movement had not ceased when the granite-gneiss had solidified.

Probably during the Lower Devonian, erosion was taking place on a considerable scale. The Middle Devonian saw shallow submergence of the land in another basin, and coral reefs again flourishing. Then followed, after an uncertain period, the ejection of coarse pyroclastic material, succeeded by some shale, flows of felsite, and finally a considerable thickness of sandstone. At some stage between the formation of the Middle Devonian reefs and the end of the deposition of the sandstone, there probably occurred a period of folding—the late Middle Devonian folding. Next occurred the intrusion of another granite, this time during tensional rather than compressional conditions, and at the close of another orogeny—the Kanimbla epoch—which folded the Devonian rocks and further dislocated the older ones, the sandstones were converted to quartzites. At some period later than this occurred the injection of most of the minor intrusives of the area—notably those of the quartz-dolerite kindred.

Erosion supervened, and has continued to the present day. In all probability the major stream-pattern of this part of the State was established as far back as the Triassic, but the internal drainage of the Lake George Basin is a later feature. Towards the end of the Tertiary, outpourings of basaltic lava covered a limited portion of the area. Probably at this stage the sand accumulations had begun to form, but these may be later than the Kosciusko Epoch, especially if this be related to the formation of Lake George. The Kosciusko Epoch did not leave any distinguishing marks on the area, except in so far as it may have affected the drainage of the region as a whole.

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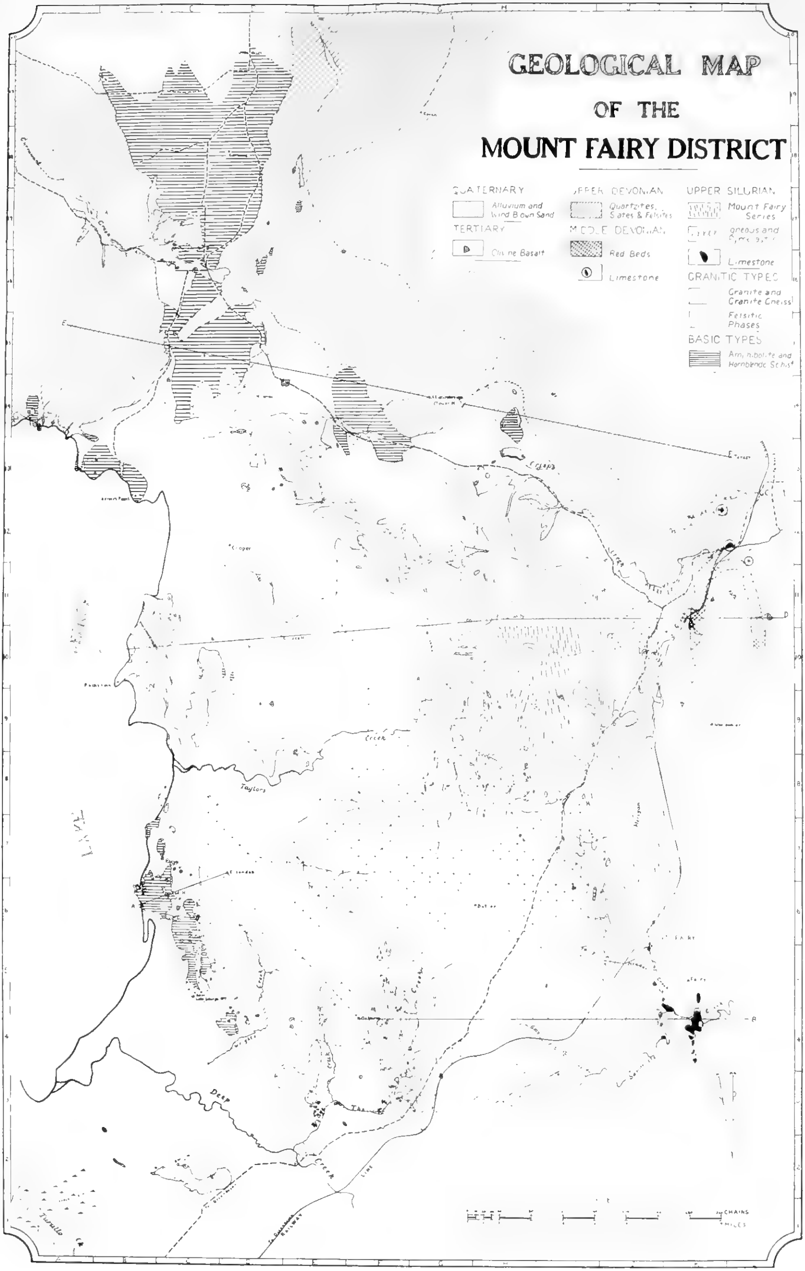
GEOLOGICAL MAP
OF THE
MOUNT FAIRY DISTRICT
QUATERNARY
Alluvium and Wind Blown Sand
TERTIARY
Olivine Basalt
UPPER DEVONIAN
Quartzites, Slates & Felsites
MIDDLE DEVONIAN
Red Beds
Limestone
UPPER SILURIAN
Mount Fairy Series
Igneous and
Limestone
GRANITIC TYPES
Granite and Granite Gneiss
Felsitic Phases
BASIC TYPES
Amphibolite and Hornblende Schist
Creek
Taylors
Creek
Deep
Creek
Creek
Railway
Line
Cooper
Fairy
CHAINS
MILES

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EXPLANATION OF PLATE IX.

Geological Map of the Mount Fairy District. The heavy line around Lake George is the surveyed boundary of the Lake George Parish, as given by maps of the Lands Department; the actual topographic boundary is slightly at variance with this. The wavy lines shown in certain portions of the Mount Fairy Series and the granite-gneiss represent zones of silicification. A-B, C-D, E-F, are section lines (see Text-figure 1).

Arrows indicate strike and dip of beds; square brackets, strike and dip of schistosity; crossed strike line shows vertical schistosity.

Charles Hedley

CHARLES HEDLEY.

1862–1926.

(*Memorial Series, No. 5.*)*

(With Portrait.)

Charles Hedley, one of the most celebrated of Australian naturalists and a world authority on Conchology, was born at Masham, Yorkshire, 27th February, 1862. He was the second son of Canon T. Hedley, a distinguished scholar and a Fellow of Trinity College, Cambridge.

On account of his delicate health, Hedley's school life was limited to about four years at Eastbourne College, which he attended with his two brothers, Herbert and Cyril. At this school it was the custom to offer each year a prize for the best collection in some branch of natural history, and Hedley was awarded the prize for a collection of shells, which shows that his taste for conchology was manifested at an early age. At the close of his school career Charles and his younger brother Cyril were taken by their parents to the Riviera, where during winter they lived at Mentone and in summer at St. Martin Lautosque in the Alpes Maritimes. While at Mentone Hedley amused himself collecting shells, and one day, while thus employed, he observed a stranger who seemed to be similarly engaged. Hedley entered into conversation with the stranger, who turned out to be G. F. Angas, a well-known Australian conchologist, who had at one time been Secretary to the Australian Museum, Sydney. At this time Hedley had no thought of emigrating to Australia and no premonition that he himself would one day be a distinguished member of the Australian Museum staff.

At Mentone he purchased a book on land shells written by A. Moquin-Tandon, and to the reading of this work he attributed the stimulus which launched him on his career as a conchologist.

Hedley was a life-long sufferer from asthma, and in search of a more genial climate he left England in 1881 for New Zealand, intending to prosecute sheep-farming. He found the climate of New Zealand too damp for his health, and in September, 1882, came to Sydney, where he met Dr. George Bennett, Dr. J. C. Cox, Mr. John Brazier, and other well-known naturalists. From Sydney Hedley went west to Hay, in the hope that an inland climate would be beneficial, but his expectations were not realized, and he next journeyed to Queensland, living first at Nerang and later on Stradbroke Island, Moreton Bay, where he took up an oyster lease. He found that he enjoyed the best health when living close to the sea, and for the rest of his life, except for brief intervals of travel, he resided near the Australian coast.

In 1884 he took up fruit-growing at Boyne Island, Port Curtis, where he obtained material for his first published paper, "Uses of some Queensland Plants" (*Proc. Roy. Soc. Queensland*, v, 1888, 10–13). Here, when driving in a sulky, he met with an accident and fractured his left arm. This was badly set and it was

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* It is much regretted that unforeseen circumstances were responsible for the delay in preparation of this Memorial.—Ed.

found necessary to break the bone and re-set it, which left him with a shortened and partially disabled arm. Finding that he could no longer undertake any laborious work, he left Boyne Island in 1888, and for about two years he resided in Brisbane, where he occupied himself in collecting and doing voluntary work at the Queensland Museum. On 1st January, 1889, he was appointed an officer of the Queensland Museum, and in May of the same year he was elected a member of the Linnean Society of London.

While at the Queensland Museum Hedley met Sir William Macgregor, Administrator of British New Guinea, who was preparing to return to that island, and offered to accompany him in order to investigate the land shells. Macgregor demurred, remarking, "Yon land is no place for a sick mon". Later, in 1890, he invited Hedley to form one of his party, an invitation which was joyfully accepted, and he was thus given the opportunity of visiting that fascinating region and penetrating to some unexplored parts.

While Macgregor visited the Louisiade Archipelago, Hedley, with one companion, remained at Milne Bay, where he made important collections. He afterwards travelled overland to meet Macgregor on his return to Port Moresby, and the Administrator was so impressed by the young man's courage, resourcefulness, and energy, that he offered him a magistracy in Papua. But by this time Hedley had definitely set his mind on a scientific career and the flattering offer was declined. An attack of malaria forced him to return to Brisbane, where he proceeded to study the shells he had collected in Papua. Finding, however, that his work was hampered by lack of adequate collections and of library facilities, he resigned his post at the Queensland Museum and, towards the end of 1890, removed to Sydney which, at that time, was the home of a coterie of enthusiastic conchologists. Sydney became his home until his death.

On 1st April, 1891, Hedley commenced work at the Australian Museum as Assistant in charge of land shells, and on 1st January, 1896, he succeeded Brazier as conchologist. He was now fairly launched on his career as a conchologist, and a long succession of important papers attest his ability, industry, and versatility. On 20th December, 1908, he became Assistant Curator, and, on the death of Robert Etheridge, Junior, in January, 1920, he was appointed Acting Director, until, on 14th February, 1921, he became Principal Keeper of Collections. He resigned this post on 30th March, 1924, to become Scientific Director to the Great Barrier Reef Committee, a position he occupied until his death. In August, 1926, he had returned to his home in Sydney and was happily preparing to attend the Third Pan-Pacific Science Congress in Tokyo, when he contracted a cold; more serious illness followed, and he died on 14th September. His remains were cremated, and his close friend, Mr. E. C. Andrews, conveyed his ashes to Queensland, where, in the presence of the Australian delegates to the Congress, they were scattered on the waters near the Great Barrier Reef, which he knew and loved so well, and the fauna of which he had done so much to elucidate.

Hedley's earliest writings were concerned mainly with land shells. His memorable paper on the Land Mollusca of New Guinea was published by this Society (Proc. Linn. Soc. N.S.W., (2), vi, 1891, 67–116; 685–698) and illustrated by a fine series of pen and ink drawings; for Hedley was a skilful delineator, and his accurate and artistic illustrations greatly enhanced the value of his scientific writings. Hedley was at first more interested in molluscan anatomy than in systematic conchology, but after his appointment on the staff of the Australian Museum he became more and more drawn to taxonomic work. For this he needed works of reference, and he spared no pains to accumulate an extensive library of conchological literature, drawing freely on his private income to enrich the Museum library which, consequently, has a magnificent collection of books and papers on the subject, including numerous rare works which can not be found in many scientific libraries of much greater size. At this time, too, Hedley began the preparation of a card catalogue of all publications dealing with Australian Mollusca; this grew through the years until it formed a complete guide to the literature and a most useful instrument for research. This catalogue, which on his death was presented to the Museum by Mrs. Hedley, is so comprehensive that one marvels that he could find the leisure to compile it; for the work was done mainly in unofficial hours, showing how completely Hedley was absorbed in scientific work to the exclusion of other interests.

Gradually Hedley became well equipped for research on Australian Mollusca, and with characteristic energy and determination he attacked the great work of disentangling the confused synonymy of many forms, rehabilitating specific names, preparing adequate illustrations for many unfigured species, and clearing up many obscure points of identification and nomenclature. He thus established a solid foundation for further research, and did most useful work in compiling lists of the marine shells of Queensland, New South Wales, and Western Australia, besides assisting in the preparation of other lists. For New South Wales Hedley listed 1,200 species, every form being well figured and its scientific history fully elucidated. His output of papers on systematic conchology was very large, as evidenced by the list of his publications appended. Of these one of the largest and most important was his monograph on the Australian Turridae (*Rec. Austr. Mus.*, xiii, 1922, 213–359), illustrated by more than 200 fine figures.

Though perhaps the Marine Mollusca bulked most largely in Hedley's writings, his early interest in the land and freshwater shells never abated and, just prior to his retirement from the staff of the Australian Museum, he was engaged on an illustrated monograph of the Land Mollusca of Eastern Australia. He had reviewed the literature, many drawings were completed, and certain groups had been revised, but with much reluctance the project was relinquished and the notes already prepared were embodied in his last conchological paper, "Some Notes on Australian Land Shells" (*Austr. Zoologist*, iii, 1924, 215–222).

Hedley was greatly interested in the investigation of the continental shelf of Australia and the deeper waters beyond. Since the visit of the "*Challenger*" in 1874, no one had dredged in depths greater than about one hundred fathoms round the Australian and New Zealand coasts, but Hedley attacked depths as great as 800 fathoms and made many interesting and valuable discoveries; he himself investigated the deep-sea shells resulting from these enterprises (*Rec. Austr. Mus.*, vi, 1905–07, 41, 211, 283, 356). This deep-sea work was largely financed by Hedley himself, who was ever ready to draw on his private purse, if by so doing he could contribute to the advancement of scientific investigation.

The Mollusca obtained by the F.I.S. "*Endeavour*" were submitted to Hedley and described in a series of Reports published by the Federal Government.

Another subject which had a strong fascination for Hedley was the formation and the life of coral reefs. This was stimulated by his participation in the expedition to Funafuti organized by the Royal Society of London in 1896. During his stay of two and a half months on the atoll, Hedley amassed a large collection, particularly of invertebrates and ethnological objects, and made many valuable scientific observations. The results were published by the Trustees of the Australian Museum (*Mem. Austr. Mus.*, iii, 1896–1900), to which Hedley contributed the general account and the sections on Mollusca and Brachiopoda, and on Ethnology, a subject of which his knowledge was considerable. He made many trips to the Great Barrier Reef of Queensland, and in collaboration with Mr. (now Professor) T. Griffith Taylor he propounded a theory of the formation of atolls by the action of the prevailing winds (*Rept. Austr. Ass. Adv. Sci.*, 1907 (1908), 397–413). On his appointment as Scientific Director to the Great Barrier Reef Committee he commenced a systematic investigation of the corals, and had assembled a large collection and much detailed information when this work was ended by his lamented death.

Hedley was greatly attracted by the problems presented by the Antarctic, and the relations of its fauna to that of the lands to the north. For twenty years or more he pondered over these problems and, in 1912, contributed an important paper at a meeting of the Linnean Society of London ("The Palaeogeographical Relations of Antarctica", *Proc. Linn. Soc. Lond.*, Session 124, 1911–12, 80–90). In this paper Hedley crystallized his views regarding the southern origin of many forms of life now found in Australia and elsewhere. Previous to this he had had the opportunity of describing the Antarctic Mollusca gathered by the Shackleton Expedition of 1907–1909, and he later investigated and described the Mollusca of the Australasian Antarctic Expedition of 1911–14, led by Dr. (now Sir) Douglas Mawson.

Hedley was greatly interested in the distribution of Mollusca and other forms of life, and his important contributions to the study of zoo-geography made his name widely known to others than conchologists. One of his earliest essays on this subject was "The Range of *Placostylus*: a Study in Ancient Geography" (PROC. LINN. SOC. N.S.W., (2), vii, 1893, 335–339; reprinted *Ann. Mag. Nat. Hist.*, (6), xi, 1892 (1893), 435–439), in which he deduced ancient land-connections from the distribution of this large and striking terrestrial mollusc. This was followed by articles on the relation of the fauna and flora of Australia to those of New Zealand, the faunal regions of Australia, a zoo-geographic scheme for the Mid-Pacific, and others. Hedley's contributions to this fascinating subject would entitle him to an honoured place in the scientific world even though he had written nothing else.

Hedley was a seasoned traveller and an indefatigable collector, and undertook many expeditions, mostly at his own expense. He had visited New Guinea, the Gulf of Carpentaria and the islands in Torres Strait, and had an intimate knowledge of the Great Barrier Reef and of many Pacific islands. In his later years he was able to indulge his desire to see more distant lands and paid visits to Alaska and East Africa. He was very anxious to see South America and the Himalayas, but his death at a comparatively early age left this desire unfulfilled.

Hedley would face any danger or hardship if by so doing he was enabled to attain his object. Mr. E. C. Andrews who, in 1901, accompanied him on a trip to the North Queensland coast, writes as follows of their experiences: "So thoroughgoing were his naturalistic instincts that he examined every plant and animal of promise in the area visited, especially in connection with its adaptation to its environment. To this work he devoted himself whole-heartedly day and night. If the coral reefs were submerged he prosecuted his examination of them waist and shoulder deep. . . . No mountain was too high or too densely clothed with jungle for him to scale; no swamp, infested with mosquitoes, snakes and crocodiles, prevented him from using it as a short cut in his work. Once on the Outer Barrier Reef off Green Island he was almost cut off by the high spring tides, and sharks were swimming freely over the reef before he was rescued. . . . The roughest and plainest fare and accommodation he accepted cheerfully, if only thereby he was enabled to visit some distant and choice gathering ground. In the jungle along the Johnston River he found an aboriginal bark canoe. To see it was to covet it for the Museum collection, but to secure it meant the taxing of the accommodation on the tiny 26-footer. Hedley solved the problem by sleeping in it, making a bed of the bare ribs of this harsh receptacle. Perhaps in these adventures the dominant note struck, as it appeared to his companions, was his unfailing cheerfulness, unselfishness, consideration for the comfort of his comrades, and his indefatigable energy in the promotion of Museum work."

In appearance Hedley was striking and handsome, six feet in height, with a spare and wiry frame. As a young man he wore only a moustache, but later he grew a beard, and it is thus that he will be remembered.

He was so completely wrapped up in his scientific work that he had few hobbies, the principal being a penchant for long walks and mountain climbing. He was a tireless pedestrian, and nothing gave him more pleasure than a long foot journey through the Australian bush. Those who had the privilege of accompanying him on some of his rambles retain a delightful memory of his pleasant companionship. For, in spite of his devotion to scientific work, he had very high social gifts and was a fluent and entertaining conversationalist, and a polished and courteous man of the world. He had a well stocked mind, for not only was he an accomplished zoologist, he also had a sound knowledge of botany and ethnology, and, particularly in his later years, he turned with enthusiasm to the subject of geology, to which he made some original contributions. He was a close observer of nature and had the faculty of illuminating any subject in an inimitable manner, enlivening his discourse with anecdote and flashes of humour, so that the way seemed shorter and blistered heels were forgotten.

Enough has been said to indicate the wide scope of Hedley's work and the versatility of his genius, but his services to science did not end with his own researches and publications and his many productive collecting trips. He inspired others with his own enthusiasm, and by example and precept he spurred them to put forth their best efforts. Thus his spirit still lives and animates many who were fortunate enough to have his friendship and warm encouragement. He had a genius for detecting promise in younger men, and their subsequent achievements justified his insight and gave him the greatest gratification. "Did I not pick winners?" he would say, with a genial and delighted smile.

He was a writer of delightful and lucid prose, and some of his papers contain passages of great beauty. No better example could be cited than his peroration to his article on the Palaeogeographical Relations of Antarctica: "In the long perspective of past time Antarctica appears to fade and form like a summer cloud, now extending a limb, now shedding it, now resolving into a continent, now dissolving into an archipelago. At present it lies dead and cold under its white winding-sheet of snow. By the light of the magician's lamp we watch the summer of the cycles dawn. The glow of life returns, the ice mask melts, green spreads a mantle. At last a vision comes of rippling brooks, of singing birds, of blossoming flowers, and of forest glades in the heart of Antarctica."

A fine example of the wide sweep of his knowledge and his charm of style is afforded by his Presidential Address to the Royal Society of New South Wales (*Journ. Roy. Soc. N.S.W.*, xlix, 1915, 1–77), in which he dealt in a masterly manner with the shore ecology of the Sydney district.

The high esteem which Hedley enjoyed among his fellows is evidenced by the honours he received during his lifetime. He was a Fellow of the Linnean and Malacological Societies of London, a Corresponding Member of the Zoological Society of London and of the Academy of Sciences of Philadelphia, and an Honorary Member of the Royal Societies of Victoria, Queensland, South Australia, and Western Australia. Shortly before his death he was elected a Fellow of the New Zealand Institute. He was a Past President of the Linnean, Royal, Royal Zoological, and Naturalists' Societies of New South Wales, and in 1909 he was President of Section D (Biology) of the Australasian Association for the Advancement of Science. In 1916 he was awarded the David Syme Prize for Scientific Research, and in 1925 he received the Clarke Memorial Medal of the Royal Society of New South Wales.

C.A.

LIST OF PAPERS BY CHARLES HEDLEY.

(Compiled by Tom Iredale.)

1888.

Uses of some Queensland Plants. *Proc. Roy. Soc. Qld.,* v, 1888, 10-13.

A List of the Land Shells Recorded from Queensland. *Proc. Roy. Soc. Qld.,* v, 1888, 45-70.

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THE ADRENAL GLAND IN NEW-BORN MAMMALS.

By Geoffrey Bourne, D.Sc., Australian Institute of Anatomy.

(Plate xi; twenty Text-figures.)

[Read 30th September, 1936.]

For this work the adrenals of the following species were examined: (1) Two new-born specimens of *Equus zebra*; (2) one new-born *Ursus maritimus* (Polar Bear); (3) one young specimen (a few weeks old) of *Arctocephalus doriferus* (Seal); (4) one late fœtus of *Delphinus delphus* (Dolphin); (5) one ten-inch pouch-embryo of *Dendrolagus bennettianus* (Tree Kangaroo); (6) one ten-inch pouch-embryo of *Macropus giganteus* (Kangaroo); (7) one four-inch female and one five-inch male pouch-embryo of *Macropus ruficollis*; (8) one young female specimen of *Macropus agilis*.

The two young zebras were obtained by courtesy of the Zoo authorities in Western Australia, and other glands described were obtained from preserved specimens in the possession of the Australian and National Museums, and the Western Australian Museum.

As a result of the imperfect fixation of the glands in the museum specimens, accurate details regarding the cells could not be given, but it was possible to distinguish the various zones and to make some degree of comparison with other forms.

Fixation and Staining.

The adrenals of the zebras were removed and divided into various sections. One portion was placed in 10% formalin for two days, then washed, imbedded, and sectioned. The sections were stained by the haemalum-eosin method.

Other sections of the zebra adrenal were treated in various ways. A portion was fixed in formalin for 24 hours; frozen sections were treated with Scharlach R and Sudan III to demonstrate fats and lipoids, and then mounted in glycerine jelly. Another portion was treated with osmium tetroxide (osmic acid) to test for the presence of unsaturated fat. In addition a portion of one gland was fixed in a mixture of 3% potassium bichromate 2 parts, 1% chromic acid 2 parts, and 2% osmic acid 1 part, for twenty-four hours, then placed in 2% osmic acid for four days at 30° C. (Kolatchev's method); the resulting sections demonstrated the Golgi apparatus.

For mitochondria another piece of gland was placed in the above fixative for twenty-four hours, washed, mordanted for six days in 3% potassium bichromate, washed, and sectioned. The sections were stained by the classical acid-fuchsin-picric-acid method.

The Staining of the Vitamin C.

Of two further pieces of gland, one was placed in the present author's modification of Giroud and Leblond's acetic acid silver nitrate mixture for two hours in the dark and kept at room temperature. Another piece was placed in acetic acid gold chloride for a similar time and under identical conditions. The composition of the silver nitrate solution was 2% silver nitrate with 5 c.c. of glacial acetic acid added to each one hundred cubic centimetres of the silver nitrate solution. The gold chloride solution was of a similar strength. The results obtained by these two methods were identical.

Treatment of Museum Specimens.

The adrenals removed from museum specimens were spirit-preserved. They were washed in distilled water for 48 hours, treated with 10% formalin for a further 48 hours, washed with distilled water for 24 hours, and were then dehydrated and sectioned. The sections were stained by the haemalum-eosin method as for the fresh adrenals.

Previous Work.

Hill (1930) described the microscopic and macroscopic appearances of the adrenal glands in young and adult specimens of Primates, Carnivores and Ungulates. He found that a foetal cortex was present in those specimens of young Primates which he examined, and stated that in young Carnivores and Ungulates the main mass of the gland was composed of cells which were morphologically similar to those of the "foetal cortex" of Primates.

The "foetal cortex" might be called an enlarged boundary zone between cortex and medulla. It is present in the human foetus and in the very young of both sexes, and was discovered in 1911 by Elliott and Armour. Starkel and Wegrzynowsky, Kern, and Thomas published on the same subject at about the same time. This cortical zone is not found in any other mammals lower than the Primates, and its absence from the human foetal adrenal in cases of anencephaly has led certain authors to claim a relationship between brain development and the presence of the "foetal cortex". It is of interest in this connection that the "foetal cortex" is only present in the adrenal gland of such members of the mammalian order as show a distinct advance in cerebral development over the members of the other orders.

The presence of large quantities of lipoid in both brain and adrenal gland may be a factor of some significance, but the "foetal cortex" is sometimes almost devoid of lipoid or may contain only relatively small amounts. Cooper (1925) mentions that at times the cortical cells may show marked reduction of lipoid, but she points out that as lipoidal material is apparently concerned with the development of the central nervous system and the sexual gland, therefore "it seems reasonable to expect the suprarenal body, which is presumably an important source of lipoidal material, to produce large amounts of this substance at those periods of life when the development of the sexual organs and the nervous system is greatest, namely, at puberty. Ordinary histological examination of the gland appears to support this presumption . . ."

Hill has published a summary of the more important papers dealing with the development of the adrenal gland in various animals, e.g., Jackson, 1913; Donaldson, 1919; Dewitsky, 1912, on rats; Elliott and Tuckett, 1906, on guinea-pigs; Lucas-Keene and Hewer, 1927, on the human adrenal; and Howard-Miller, 1927, on the X zone of the adrenal in mice. The animals examined by Hill include new-born Carnivores (kittens, leopard cub, pups, bear cub), Ungulates (lambs, pigs, goats and foetal hippopotami and calves), and Primates (Pithecoid monkeys, Macaques and Lemurs).

The Adrenals of New-Born Specimens of Equus zebra.

The adrenals in both specimens were elongated, smooth, rounded bodies of a light colour and were in each case attached intimately to the antero-mesial borders of the corresponding kidneys (Fig. 1). The sizes were: Left adrenal, 12 mm. long, 3 mm. antero-posterior thickness, and 3·5 mm. wide. Left kidney, long axis 40 mm., width 25 mm., and dorso-ventral thickness 15 mm. The gland was attached to the kidney by a plentiful investment of connective tissue which anchored it firmly in position.

On section, the gland showed a thin outer rim of cells and a more voluminous medullary part. Just beneath the capsule was a striking zone of elongated dark-staining cells which were arranged side by side with the long axes parallel to the capsule, and these cells formed columns which bent round through 180 degrees at the capsule and returned to the main body of the cortex.

The major portion of the cortical rim was made up of large cells with big vesicular nuclei as described by Hill for other Ungulates. Hill, however, found, beneath the capsule, a zone of small, darkly-staining cells not oriented in any glomerular fashion, and he comments that even in a three-weeks-old pig he is not able to find any glomerular arrangement of these cells. The young zebra adrenal, then, is an exception to the Ungulates examined by Hill in that, even at birth, a definite zona glomerulosa is present.

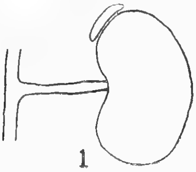
Near the glomerular zone the cortical cells with vesicular nuclei have scattered among them cells of similar size but with much more chromophillic nuclei. As the central medullary portion is more closely approached, these cells gradually become fewer and fewer and, closer to the medullary portion, large cells with very vesicular, weakly-staining nuclei make their appearance. Thus in a stained section of the gland we obtain a gradation of shading from the darkly-staining glomerular region to the lightly-staining medullary portion. This is shown very well in Plate xi, fig. 1.

The cells of this cortical rim were not oriented in any particular direction. This differs from the arrangement in the adrenals of the animals examined by Hill, in which he found the cortical cells arranged in short columns radiating from the centre of the gland.

The boundary zone between the cortical rim and the medullary portion is rather well defined and, although tongues of cortical material penetrate into the medullary portion, they are well marked off from the central or medullary region of the gland.

Immediately within the cortical portion were groups of very large cells with a pale-staining cytoplasm and very large, somewhat vesicular nuclei. They were in some cases isolated, but where they occurred near the cortical rim they were aggregated into groups with the long axes of the cells parallel with one another and at right angles to the boundary line. They were separated from the cortical rim by a single layer of flattened fibroblasts. These cells constituted the true medullary cells (Fig. 3). In addition to these, there were numerous other cells of a smaller size with vesicular, but more intensely staining nuclei and light-staining cytoplasm. These were scattered through the medullary portion of the gland and were very similar in nature to cortical cells. In addition, large cells with a much more deeply staining nucleus were present and numerous cells similar to those described near the boundary zone were found scattered through the so-called medullary portion. Also, there was a goodly admixture of large well-formed fibroblast cells with typical oval nuclei. The so-called medulla of this gland is thus a mixture of cortical elements and medullary elements and the gland may be described as consisting mainly of cortex, as Hill has found for other Ungulates.

Hill regards the main mass of the cells in the Carnivore and Ungulate adrenals as being similar to those of the "foetal cortex" of Primate adrenals. The foetal cortex, however, is, as Hill mentions, a zone which subsequently degenerates and takes no part in the formation of the adult cortex. No signs of degeneration have been observed in the zebra adrenal by myself, or by Hill in the adrenals of non-Primate animals examined by him. In the human foetal cortex, however, degeneration products, in the form of numerous melanin granules, have been found to be present, as a number of authors have observed.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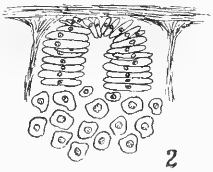
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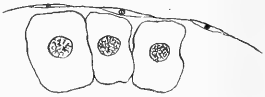
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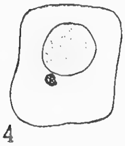
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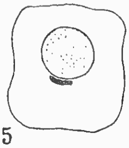
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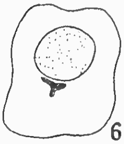
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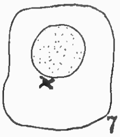
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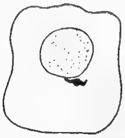
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Fig. 1.—Relationship of the left adrenal to the left kidney in the new-born *Equus zebra*. × ½.

Fig. 2.—Arrangement of cells in the zona glomerulosa in *Equus zebra*. × 500.

Fig. 3.—Arrangement of medullary cells at boundary between cortex and medulla in *Equus zebra*. × 1,750.

Figs. 4, 5, 6, 7, 8.—Golgi apparatus in the cells of the adrenal of the new-born *Equus zebra*. Fig. 4, a cell from the cortical rim; Figs. 5 to 8, cells from the central portion of the gland.

In Ungulates, Hill has shown that the foetal cells modify directly into the cells of the adult adrenal without any degeneration. I have not been able to obtain a series of zebra adrenals to confirm this fact.

The young zebra adrenal showed a paucity of lipoidal material in nearly all of its cells. Unsaturated fat also was found to be very rare in most of them (osmium tetroxide test).

A number of cortical cells showed the presence of two or three globules of lipoid enclosed in a small area which stained intensely black with osmium tetroxide, thus indicating the presence of unsaturated fat. This was also observed in occasional cells of the adrenal of the flying Phalanger (*Petaurus breviceps*) and may indicate that one of the substances associated with the elaboration of the lipoid droplets may be unsaturated fat. The presence of grey granules in some of the cells indicated the presence of fat of a higher degree of saturation. Mitochondria were found to be present in all the cells and were observed to be typically granular and to be scattered amongst the lipoidal globules (where present), but there did not appear to be any association between them and the lipoid droplets. No filamentous mitochondria were observed in any of the cells. This result (granular mitochondria) is in accord with the work of the previous authors on the adrenal gland. Pleknik (1902) and Bonnamour (1902) have found granular fuchsinophilic material, which they regarded as mitochondria, in the cells of the adrenals of various animals. Mulon (1910) found rod-shaped mitochondria in the zona glomerulosa cells of the guinea-pig adrenal. Rogoff (1932) quotes Seecof as having found the mitochondria of the adrenal to occur most commonly in the form of minute rounded granules, taking the rod-shaped and filamentous form only very infrequently.

Golgi Apparatus.

All the cells of the zebra adrenal showed the presence of a Golgi apparatus. In the cells of the cortical rim it was of a very compact nature and appeared to be composed of a sphere with numerous internal anastomosing branches (Fig. 4). This was the only type of apparatus found in the outer region, and no signs of hypertrophy of the apparatus as described by the present author in the adrenals of other animals was observed. This is in agreement with the suggestion (Bourne, 1934) that the Golgi apparatus is associated with the production of the lipoid droplets in the cortical adrenal cells, for here, where there are very few lipoid droplets, the Golgi apparatus is quite small and appears inactive. In the central portion of the gland the Golgi material, in some cells, was of the form just described and in others it showed a greater variety of forms (Figs. 5–8). Although the shape of the apparatus varied in these cells, it may be seen that it was still compact and showed no signs of hypertrophy.

Vitamin C.

The material presumed to be vitamin C was found to be aggregated chiefly in the central part of the gland and in the inner part of the true cortex. The zona glomerulosa and the outer portion of the zona fasciculata gave no reaction with either of these techniques, so it is probable that reduced vitamin C is absent from this portion of the gland (Pl. xi, fig. 2). Giroud and Leblond (1934) have found the adrenals of adult rats and guinea-pigs examined by them to contain no vitamin C in the zona glomerulosa, but they found it to be present plentifully in the zona reticularis and the zona fasciculata. The form taken by the vitamin was identical in the two techniques, that is, finely granular, with a slight tendency towards perinuclear condensation. The granules were found to be solid, not hollow as in the adrenals of a human foetus examined by the author. The fact that the outer portion of the glands gave no reaction with silver nitrate is not absolute proof that the vitamin is absent from this region, as Harris (1933) has found that in some cases the regions which do not stain with silver nitrate actually contain varying quantities of the reversibly oxidized vitamin, but he considers a positive result with silver nitrate a definite indication of the presence of the vitamin.

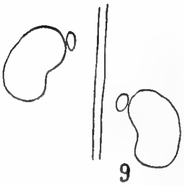
Ursus maritimus.

The adrenals of a new-born polar bear were examined. The glands were found to occupy the antero-mesial borders of the corresponding kidneys and showed a regular oval shape in transverse section. The surfaces were quite smooth and were covered by a thick loosely-investing capsule. The relations of the glands with the corresponding kidneys are shown in figure 9.

In section (Fig. 10) the glands did not appear to possess a definite medulla. There was an outer peripheral, denser, rim of cells and the main body of the gland appeared to be composed of mixed cortical and medullary elements. The peripheral cells showed in parts the structure of a zona glomerulosa.

Arctocephalus doriferus.

A young specimen a few weeks old was examined. The glands were elongated, and possessed a thick but loosely-investing capsule. The surfaces of the two adrenals were smooth. Both glands were situated on the anteromesial borders of the corresponding kidneys to which they were firmly attached (Fig. 13). The capsule sent practically no trabeculae into the interior of the gland. The cortex was fasciculated and there was a small zona glomerulosa and a small zona reticularis (Fig. 14). Thus, even at this early age in the seal, the typical adult structure of the gland is present. In 13-day-old members of the Carnivora vera, Hill found a zona glomerulosa and an incipient zona fasciculata to be present.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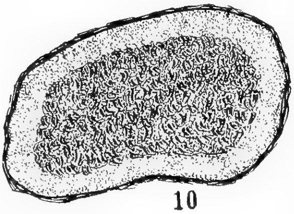
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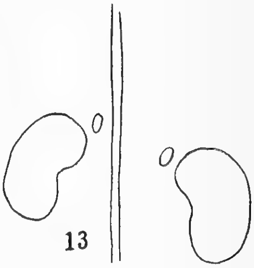
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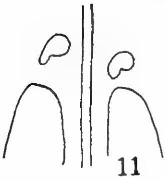
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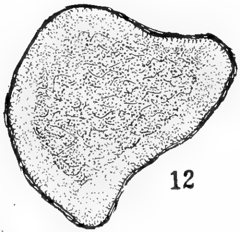
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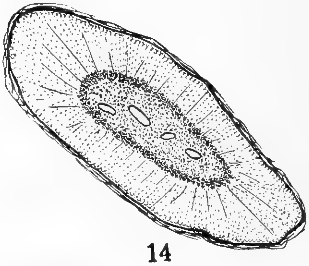
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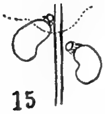
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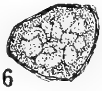
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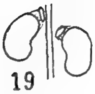
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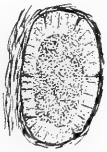
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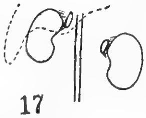
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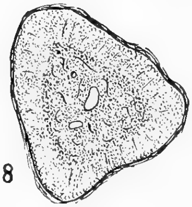
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Fig. 9.—Relation of the adrenals to the kidneys in *Ursus maritimus* (new-born). × ½.

Fig. 10.—The thin cortical rim surrounding a central portion containing mixed medullary and cortical elements. Portion of the cortical rim may be seen to possess a zona glomerulosa. × 5.

Fig. 11.—Position of adrenals in *Delphinus delphus.* × ¼.

Fig. 12.—Thin cortical rim with well defined zona glomerulosa. × 4.

Fig. 13.—*Arctocephalus doriferus.* Position of adrenals. × ¼.

Fig. 14.—Adrenal of young *Arctocephalus doriferus,* showing the three typically differentiated zones of the adult gland. × 5.

Fig. 15.—*Macropus ruficollis.* Position of adrenals. × ¼.

Fig. 16.—*Macropus ruficollis.* Showing strands of cortical material penetrating the medulla. Pouch-embryo. × 4.

Fig. 17.—*Macropus giganteus.* Position of adrenals. × ¼.

Fig. 18.—*Macropus giganteus.* Partly differentiated adrenal of pouch-embryo, showing zona glomerulosa. × 4.

Fig. 19.—*Dendrolagus bennettianus.* Position of adrenals. × ¼.

Fig. 20.—*Dendrolagus bennettianus.* Adrenal of pouch-embryo, showing slightly fasciculated cortical rim. × 3.

Delphinus delphus.

A late foetus was examined. Each gland was placed cranially to the corresponding kidney and was intimately attached to the dorsal body-wall (Fig. 11). The surface of the gland was smooth, though the shape was irregular. The cortex was rather difficult to distinguish from the medulla, and there was a typical thin rim of cells surrounding the gland, which stained much more intensely than the deeper portions. A zona glomerulosa was present also in this animal. The central region, as in the previous animals examined, was composed of mixed cortical and medullary elements (Fig. 12).

The pouch-young of three Marsupials of the family Macropidae were examined. In all three the adrenals were situated typically on the antero-mesial borders of the corresponding kidneys, and their surfaces were quite smooth (Figs. 15, 17, 19).

Dendrolagus bennettianus.

The adult gland of this Marsupial possessed a well-defined broad cortex, together with a rather imperfectly formed zona glomerulosa. In a 10-inch male pouch-embryo (Fig. 20), the cortex was in the form of a thin rim which possessed a slight degree of fasciculation and an indistinct zona glomerulosa. A number of trabeculae extended through the cortex and cut off portions of this region of the gland into separate islets of cells. The central portion of the gland contained both cortical and medullary elements as in the young Eutherian adrenal. The central cells were irregularly arranged.

Macropus giganteus.

A 10-inch pouch-embryo showed an adrenal with but a thin rim of cortex which was, however, definitely fasciculated and possessed a well-defined zona glomerulosa. The central portion again contained mixed cortical and medullary elements (Fig. 18).

Macropus ruficollis.

Four- and five-inch female and male pouch-embryos were examined. The cortex was composed of a rim of completely undifferentiated cells irregularly arranged. Some of the cells in this region, however, were arranged in strands and some of these strands entered the medulla to form a network, in the meshes of which the medullary cells lay in groups. This condition is quite primitive (Fig. 16).

Macropus agilis.

A young female specimen possessed adrenals which showed a thin differentiated cortex and a well-defined voluminous medulla which contained chiefly medullary and only a few occasional cortical cells.

Summary.

Hill's work on the adrenal glands of young Carnivora and Ungulates has been supported by the examination of other members of the same orders. In addition, it appears that the adrenals of members of the Metatheria Macropidae also pass through a stage comparable with that of the adrenals of the non-Primate Eutherian Mammal.

A similar stage may be seen in the adrenals of the Porpoise (*Delphinus delphus*). A young seal (*Arctocephalus doriferus*), however, possessed an adrenal in which a definite differentiated cortex was present, thus constituting a difference from the adrenals of members of the Carnivora vera, examined by Hill.

Acknowledgement.—I am very much indebted to Mr. L. Glauert, Curator of the W.A. Museum, to Mr. E. Le G. Troughton and Dr. C. Anderson of the Australian Museum, Sydney, and Mr. D. Mahony and Mr. C. W. Brazenor of the National Museum, Melbourne, for making available preserved specimens for some of this work.

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EXPLANATION OF PLATE XI.

Figure 1.—Section through adrenal of new-born *Equus zebra*. The thin rim of cortex with definite zona glomerulosa may be easily distinguished. × 80.

Figure 2.—Vitamin C in the adrenal gland of the new-born *Equus zebra*. The absence of the stain from the outer portion of the cortical rim may be easily noted. × 80. (Gold chloride method.)

New-born *Equus zebra*.—1. Section through adrenal; 2. Vitamin C in adrenal gland.

STUDIES IN AUSTRALIAN EMBIOPTERA.

PART I. SYSTEMATICS.

By Consett Davis, B.Sc.
(*From the Zoology Department, Sydney University.*)

(Forty-three Text-figures.)

[Read 30th September, 1936.]

Introduction.

The Embioptera represent an order in which some doubt still exists regarding internal anatomy, embryology, and general bionomics; moreover, certain sclerites are of doubtful homology, particularly the cercus-basipodites, and the relation of the genital aperture of the male to the ninth and tenth sternites is obscure.

With regard to internal anatomy, the earlier reports (e.g., Grassi and Sandias, 1896; Melander, 1903) are incomplete and conflicting; and although a report has been published more recently by Mukerji (1927), this description is of a different family from that to which the Australian forms belong. Certain details (e.g., of ovariole structure) have not yet been examined. With regard to embryology, three late stages have been described by Melander (1903), but this is the only work on the subject yet published. The bionomics of several foreign species have been detailed (e.g., Imms, 1913), but the life-cycles, feeding habits, and general ecology of the Australian species are almost completely unknown.

It is evident, therefore, that there is need for a considerable amount of research on all these aspects. Since, however, the two species most abundant near Sydney are undescribed, while previous descriptions of the third common species lack details of the diagnostic characters of greatest importance (the male terminalia), it is necessary to deal with the systematics of the order before proceeding to more general questions.

Except in the remarkable instance recorded by Froggatt (1905) of huge numbers of Embioptera occurring at the refinery of the Colonial Sugar Refining Company at Pyrmont—an occurrence recorded again for 1913 by Friederichs (1923)—this order has never been regarded as common in New South Wales. However, search in the field locally has revealed that three species are both widespread and abundant. The descriptions of species from other States are based on material forwarded by Mr. L. Glauert, of the Western Australian Museum; Mr. A. Tonnoir, of the Division of Economic Entomology, C.S.I.R., Canberra; Mr. J. Clark, of the National Museum, Melbourne; Mr. H. M. Hale, of the South Australian Museum, Adelaide; Dr. R. J. Tillyard; and Mr. F. H. Taylor. Certain species from the East Indies were kindly forwarded by Dr. Lieftinck, of the Zoological Museum, Buitenzorg, for examination. My thanks are due to all of these, and to those who have collected material locally; in the latter case, acknowledgement is made when dealing with the species concerned.

All the Embioptera yet discovered in Australia belong to the family Oligotomidae, in which the venation is more specialized and reduced than in the Embiidae. Some of the Australian forms, more especially some of those here described as new, must be regarded as being amongst the most specialized and advanced in the whole order. The absence of the primitive Embiidae suggests that the order reached Australia late in evolutionary history, probably from the Indo-Malayan region.

As far as practicable, the instructions laid down by Ferris (1928) have been adhered to in specific descriptions. The females are all so similar that, although certain species can be recognized one from another, no exact determination of the species can be made from the female alone. In consequence, the female is described fully only in the first species dealt with, and in subsequent species only points of special importance are mentioned. The females described have been taken in association with males of the species stated, and no records have been admitted where there was any possibility of more than one species living in the situation examined.

I follow Ferris's interpretation in designating an allotype female where the male only was known to the original author, and vice versa. Others of the series from which such an allotype has been selected have been designated para-allotypes.

All measurements were made with a calibrated ocular micrometer; this was also used continually in the preparation of diagrams, to ensure correct proportions and magnifications. The measurements, although made accurately, must not be taken with too much emphasis; they serve as an indication rather than a mathematically certain statement. The averages have been calculated from as large a series as was available, but in a few cases this was strictly limited. With regard to upper and lower limits, in such a variable group one must always be prepared to find an individual lying outside the limits here stated, which are laid down merely on material to hand. Total lengths are especially deceptive, as the reading varies according to whether the abdomen is extended or telescoped, especially with the female before and after oviposition. All measurements of total length, head length, and ratios, are exclusive of wings, cerci, antennae and palps. Ratios have been calculated from averages for the series concerned.

Since the colour varies greatly with the time since the final ecdysis, an attempt has been made to give data of mature and fully darkened specimens in all cases.

Family OLIGOTOMIDAE.

With regard to the males, the chief family criterion is the reduced venation, neither R_{4+5} nor M being branched in either wing. When the species is wingless, it must be referred to its family on other characters: the left hemitergite of abdominal segment 10 bears a process, and the left cercus-basipodite is present as a distinct process.

As Friederichs (1914) has already noted, the weakness of certain veins in the wing, although a reliable family character for foreign species, does not hold for all Australian species. This character is discussed below under the consideration of genera within the family.

The females of the family Oligotomidae can be distinguished from those of the family Embiidae by the reduced first abdominal sternite.

It becomes necessary to separate certain Australian species from the genus *Oligotoma*, and therefore a diagnosis of *Oligotoma* sens. str. is appended below. This diagnosis, besides excluding the local species, for which new genera are erected in this paper, also excludes satisfactorily the species of the North American genus *Anisembia* Krauss.

Genus OLIGOTOMA Westwood, 1836.

Trans. Linn. Soc. Lond., xvii, 1836, 373.—Genotype, *O. saundersi* Wwd., 1836, loc. cit.

To this genus, in the limited sense, are assigned those Oligotomidae in which the right hemitergite of abdominal segment 10 of the male is produced backwards from its outer margin to a long, straight or slightly sinuous process, at least three times as long as broad, and the second segment of the left cercus is subcylindrical, at least three times as long as broad, and distinctly sutured off from the first segment. When wings are present in the male (as is usual), the veins R_{4+5}, M, and Cu_{1a} are obscure, being represented by little more than pigment-bands.

Absence of wings is apparently a character of no generic significance, being convergent. Thus, within the genus *Oligotoma* sens. str., there is described below a species with the type form possessing a winged male, and with geographic subspecies in which the male is wingless. The species *Anisembia texana* (Mel.) has winged and wingless males occurring in the same colony, as also has one of the species described below under a new genus. Other forms are also wingless, e.g., the genus *Monotylota*, family Embiidae.

OLIGOTOMA GURNEYI GURNEYI Frogg., 1904. Figs. 1, 11, 18, 25, 32.

O. gurneyi Froggatt, PROC. LINN. SOC. N.S.W., 1904, pp. 672-673.

Concerning this species, Friederichs wrote (1914, p. 243): "Whilst in Sydney I had the opportunity of examining the type (male) of Froggatt's Australian Embiid. . . . It is a dry specimen without an abdomen. The neuration characterises it as an Oligotoma. . . . The (unforked) posterior portion of the radial ramus is only well-developed at its proximal end, the remaining part being only faintly indicated. The same is true of the median and the cubitus. The eye as seen from above is almost circular (as in Enderlein's figure of *O. saundersi*). It is possible that it may be one of the cosmopolitan species (*saundersi* or *latreillei*), but a reliable identification of this specimen is obviously out of the question."

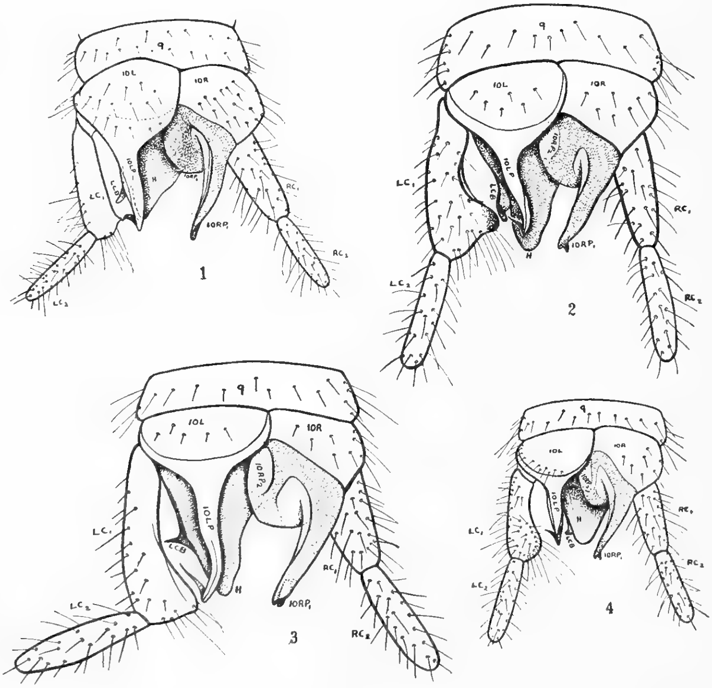
Zeck (1930) described and excellently figured a specimen (♂) taken near Sydney (the type locality) as *O. gurneyi* Frogg. This identification did not rest on a comparison with the type, and the terminalia were not figured in detail. This specimen has since been lost.

From a comparison of material taken around Sydney and elsewhere with the type (in which the head characters are still quite distinct) and with Friederichs's remarks, it can be stated with certainty that the material is *O. gurneyi* Frogg.; and that Zeck's description was of this species. The additional data are given below with Mr. Zeck's permission. Since other subspecies are described, the name becomes *O. gurneyi gurneyi* Frogg.

♂. *Length*, 7·6–11·3 mm., av. 9·2 mm. Head:thorax:abdomen in the ratio 10:22:30 (lengths). *Colour*: Dorsally, the sclerites are rich golden-brown, the mesoscutum and metascutum slightly paler, the head with darker symmetrical tracery, the eyes black. Ventrally, the colour is slightly paler, especially abdominal sternites 1–8. Intersegmental membranes cream. Wings with veins bordered by broad bands of pale brown. *Head* (Fig. 18): Length, 1·23–1·76 mm., av. 1·49 mm. Ratio of length to maximum breadth 10·0:8·2. Broadest at eyes, lateral margins slightly convex and convergent posteriorly, smoothly rounded at posterior limit. Eyes prominent, reniform. *Antennae*: Maximum number of segments observed, 21;

maximum total length, 4·5 mm. Four basal segments with lengths typically in the ratio 3:2:5:3. Distalia subcylindrical with rounded extremities (Figs. 25*a*, *b*).

(*Note.*—It is unusual to find an Embiopteron with the complete number of antennal segments on both sides. This fact has been noted by Friederichs (1906) and Mukerji (1927). The former explains the loss of antennal segments by supposing that a predatory insect or spider occasionally seizes the antenna projecting from the gallery in which the insect lives, whereupon it darts backwards, losing portion of its antenna. Mukerji gives the explanation that the antennae are occasionally nibbled by individuals of the same species, and figures an alimentary canal containing several antennal segments. Whatever the true cause, the descriptions here given include the greatest number of segments observed in the material available; it is impossible to say whether this corresponds in all cases to the complete number, as the last remaining segment rounds itself off at the subsequent ecdysis. In some cases, where specimens have a high and equal number of segments to each antenna, it is probable that this represents the complete number.)



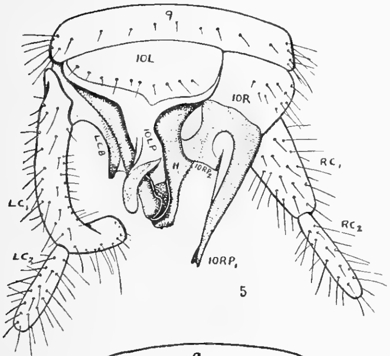
Figs. 1-10.—Terminalia of males of Australian Oligotomidae, viewed dorsally. (× 25.) 1.—*Oligotoma gurneyi gurneyi* Frogg. 2.—*O. gurneyi* Frogg. *centralis*, nov. 3.—*O. gurneyi* Frogg. *spinulosa*, nov. 4.—*O. gurneyi* Frogg. *subclavata*, nov. 5.—*O. tillyardi*, nov. 6.—*O. glauerti* Till. 7.—*O. latreillei* (Ramb.). 8.—*Notoligotoma hardyi* (Fried.). 9.—*N. nitens*, nov. 10.—*Metoligotoma reducta reducta*, nov.

Fig. 6*a*, termination of 10 LP, *O. glauerti* Till. (× 63); fig. 7*a*, termination of 10 RP$_1$, *O. latreillei* (Ramb.) (× 63).

9, ninth tergite; 10 L, 10 R, left and right hemitergites of tenth abdominal segment; 10 LP, process of 10 L; 10 RP$_1$, 10 RP$_2$, outer and inner processes of 10 R; LC$_1$, LC$_2$, first and second segments of left cercus; RC$_1$, RC$_2$, first and second segments of right cercus; LCB, RCB, left and right cercus-basipodites; H, hypandrium or sub-genital plate; HP (HP$_1$, HP$_2$), appendages of H; A, structure probably representing aedeagus.

Mouthparts: The mandibles are the only part showing considerable variation throughout the order, and are of some use as systematic criteria. In this species (and all the subspecies within it) the mandibles are very typical (Fig. 32): each with a semicircular concavity about half-way down the inner margin, the left with three, the right with two fairly sharp teeth distally. The genus *Aposthonia* was erected by Krauss (1911) and confirmed by Friederichs (1934), the main generic character being the mandible structure, as described for the above species. The species with which these authors were dealing was *A. vosseleri* Krauss, related to *O. gurneyi* Frogg. on other characters also. However, the male terminalia and other characters for these species are so close to the genotype of *Oligotoma* that it seems incorrect to propose a genus on such small differences. I am therefore demolishing the genus *Aposthonia*; if every species of *Oligotoma*, which differed from the genotype by as little as do *O. vosseleri* (Krauss) and *O. gurneyi* Frogg., were placed in a separate genus, the result would be a number of genera monotypic or nearly so, and the natural relationships of the species at present placed in the genus *Oligotoma* would be masked.

Thorax: Prothorax with sides diverging slightly posteriorly, and with a small rectangular area separated off by a slight transverse groove, one-quarter of the length from the anterior margin ("apotom" of Enderlein). Meso- and metathorax with triangular scuta and lateral sclerites. *Legs* normal for the order, the first segment of the fore tarsi dilated, the second legs slender, the hind femora noticeably swollen, the hind tarsi with one bladder ventrally on the first and second segments ("sohlenbläschen" of Verhoeff). *Wings*: Forewing, length 6·7–9·3 mm., av. 7·6 mm.; breadth 1·7–2·3 mm., av. 1·9 mm. Hindwing, length



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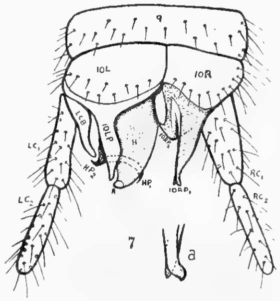

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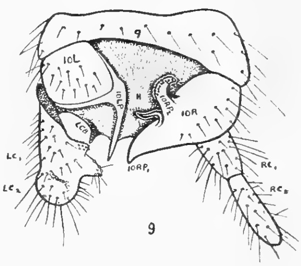

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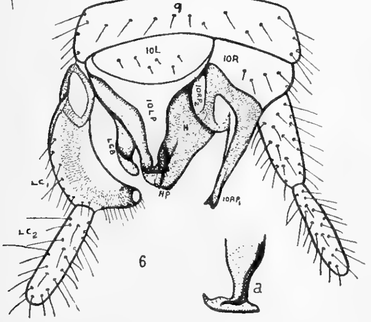

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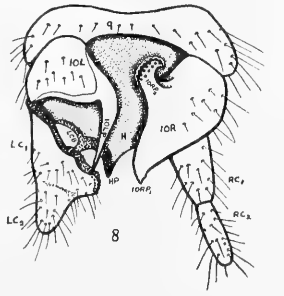

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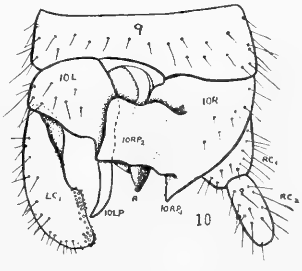

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5·3–7·5 mm., av. 6·1 mm.; breadth 1·6–2·3 mm., av. 1·8 mm. Venation characteristic of the genus. *Abdomen*: First seven segments, viewed dorsally, subequal; eighth slightly shorter, ninth only one-half as long as first and slightly asymmetrical; tenth as long as first.

Terminalia (Fig. 1): Tenth tergite divided longitudinally to left and right hemitergites (10 L, 10 R respectively). 10 R produced backwards and inwards from its outer margin to a long, thin, slightly sinuous process (10 RP_1), heavily chitinized, tapering distally but ending smoothly. Inner margin of 10 RP_1, anteriorly, curving inwards to overlie a second flap-like process, 10 RP_2 (median plate of Mukerji, 1935, p. 2, fig. 1e, *mp.*), more heavily chitinized medially. First segment of right cercus (RC_1) subcylindrical, arising from a vestigial annular cercus-basipodite (RCB) lateroventrally to 10 R; second segment (RC_2) also subcylindrical. Left hemitergite produced distally to a dagger-shaped process (10 LP), curving slightly to the left and bearing distally a small hook directed forwards and downwards. First segment of left cercus (LC_1) clavate, produced on the inner side, near its distal end, to a small blunt process; second segment (LC_2) subcylindrical. Ventrally (fig. 11) the subgenital plate or hypandrium (H) is produced backwards and slightly to the left to a broad blunt termination, the extremity of which is only weakly chitinized. Right margin of free portion of H slightly sinuous. Left cercus-basipodite (LCB) well developed, fused to the left margin of H for the greater part of its length, but curving outward distally to a smoothly-tapered termination.

The hypandrium undoubtedly includes the ninth sternite, but whether or not it consists of other structures fused thereto (e.g., valves of the tenth sternite) cannot at present be definitely stated.

♀. *Length*, 9·1–11·1 mm., av. 10·0 mm. Head:thorax:abdomen in the ratio 10:23:40. *Colour*: Dorsally, sclerites dark brown with reddish tinge, shiny, with a paler central line in the abdominal region indistinctly merging into the general colour. Eyes black, intersegmental membranes cream. Abdominal sternites 1–7 pale brown, remainder darker; abdominal pleurites 1–7 as elongated dark bars of chitin laterally. *Head*: Length, 1·28–1·44 mm., av. 1·37 mm. Ratio of length to maximum breadth 10·0:8·4. Lateral margins very slightly convergent posteriorly, smoothly rounded behind. Eyes small. *Antennae*: Maximum number of segments observed, 19; maximum length, 2·7 mm. Segments shorter than corresponding segments of ♂, the combination moniliform.

The thicker and more ovoid antennal segments of *O. vosseleri* (Krauss) gave Friederichs his other point of differentiation between *Oligotoma* and *Aposthonia*; but, as he states himself, the difference is not marked enough to be very significant.

Mouthparts normal for the order, the mandibles showing none of the modifications found in the ♂. *Thorax*: Pronotum similar to that in the ♂; mesoscutum subrectangular, broadest just behind anterior margin, thence tapering slightly. Metascutum with lateral margins convex, widest at about one-third its length from the posterior margin. *Legs* as in the ♂ but stouter. *Wings* absent as in all ♀ Embioptera. *Abdomen*: First three tergites subequal, the next three each slightly longer, the seventh as long as the first, the eighth a little shorter; the ninth only half as long as the first, the tenth slightly longer, subtriangular. Tenth sternite divided longitudinally to two subtriangular valves. Small annular cercus-basipodites present. Gonopore a transverse slit between eighth and ninth sternites.

Habitat.—Sydney, N.S.W., W. B. Gurney, 6-10-02 (holotype ♂); Exeter, N.S.W., N. J. B. Plomley, 26-4-35 (homotype ♂) and 6-6-35 (allotype ♀, para-allotype ♀ and homotype ♂♂); Eastwood, N.S.W., L. Gallard, 1934 (homotype ♂♂); Callubri, via Nyngan, N.S.W., J. Armstrong, 16-10-34 (homotype ♂♂) and 1-9-35 (homotype ♂ and para-allotype ♀); Tallong, N.S.W., A. Simpson, 26-5-36 (homotype ♂ and para-allotype ♀); Melbourne, Vic., F. A. Singleton, 23-6-26 (homotype ♂); Gippsland, Vic., date and collector unrecorded (National Museum collection) (homotype ♂); Ferntree Gully, Vic., J. Clark, 31-5-36 (homotype ♂); Bulnarring, Vic., A. D. Butcher, 31-5-36 (homotype ♂); Launceston, Tas., V. V. Hickman, 29-6-30.

Situation.—Most commonly in galleries in rough bark or old fence-posts; occasionally in dendroid lichens growing on bark. Winged males occasionally taken at light. One specimen has been taken in the nest of the ant *Colobopsis gasseri* Forel, in a log.

Distribution of Types.—Homotype ♂ (plesiotype) on slide, homotype ♂ and allotype ♀ in alcohol, Macleay Museum, Sydney University. Homotype males and para-allotype females forwarded to the British Museum; the Australian Museum, Sydney; and the Western Australian Museum, Perth. Homotype males forwarded to the National Museum, Melbourne; the South Australian Museum, Adelaide; the C.S.I.R. collection, Canberra; the Cawthron Institute, Nelson, N.Z.; and the Zoological Museum, Buitenzorg,* Java. The damaged holotype male is in the C.S.I.R. collection, Canberra.

OLIGOTOMA GURNEYI AGILIS Frogg., 1904.

Oligotoma agilis Frogg., PROC. LINN. SOC. N.S.W., 1904, pp. 673-674.

O. agilis was described by Froggatt from a female, probably immature. The holotype is a dry, carded specimen in fair condition, but lacks, of course, any good specific characters. This specimen was taken under granite boulders on the hill behind the students' quarters, Experiment Farm, Wagga, N.S.W. Recently I was able to collect a long series from the southern aspect of this hill, amongst dead, fallen foliage under boulders; there were no Embioptera on the northern aspect.

There can be no doubt that this series belongs to the same species as Froggatt's specimen. When reared to maturity, they proved to be a wingless species—approximately thirty males were taken, none with any sign of wings or wing-buds. The colour is slightly darker than in *O. gurneyi gurneyi* Frogg., but the terminalia and other characters are identical. *O. agilis* is therefore reduced to the status of a geographic subspecies, the following being its diagnosis:

♂. *Length*, 9·7–11·2 mm., av. 10·5 mm. Head:thorax:abdomen in the ratio 10:24:35. *Colour*: Dorsally, head and thoracic sclerites chocolate-brown, abdominal sclerites slightly paler. Ventrally, head and thoracic sclerites chocolate-brown, abdominal sclerites lighter, except 6, 7, 8, and 9 (9 = hypandrium, very dark). Leg segments chocolate-brown. Inter-segmental membranes cream. *Head*: Length, 1·41–1·62 mm., av. 1·55 mm. Ratio of length to maximum breadth, 10·0:8·6. Eyes slightly less prominent than in *O. gurneyi gurneyi* Frogg. *Antennae*: Maximum number of segments observed, 15; maximum length, 3·9 mm. Segments as in *O. gurneyi gurneyi* Frogg. *Mouthparts* as in *O. gurneyi gurneyi* Frogg. ♂. *Thorax and legs* as in the female of *O. gurneyi gurneyi* Frogg. *Wings* absent. *Abdomen and terminalia* as in *O. gurneyi gurneyi* Frogg. ♂.

♀. *Length*, 9·5–11·1 mm., av. 10·4 mm. Head:thorax:abdomen in the ratio 10:26:36. *Colour* as in the male, the terminal abdominal sternites likewise being darker than the rest. *Head*: Length, 1·41–1·62 mm., av. 1·48 mm. Ratio of length to maximum breadth, 10·0:9·0. *Antennae*: Maximum number of segments observed,

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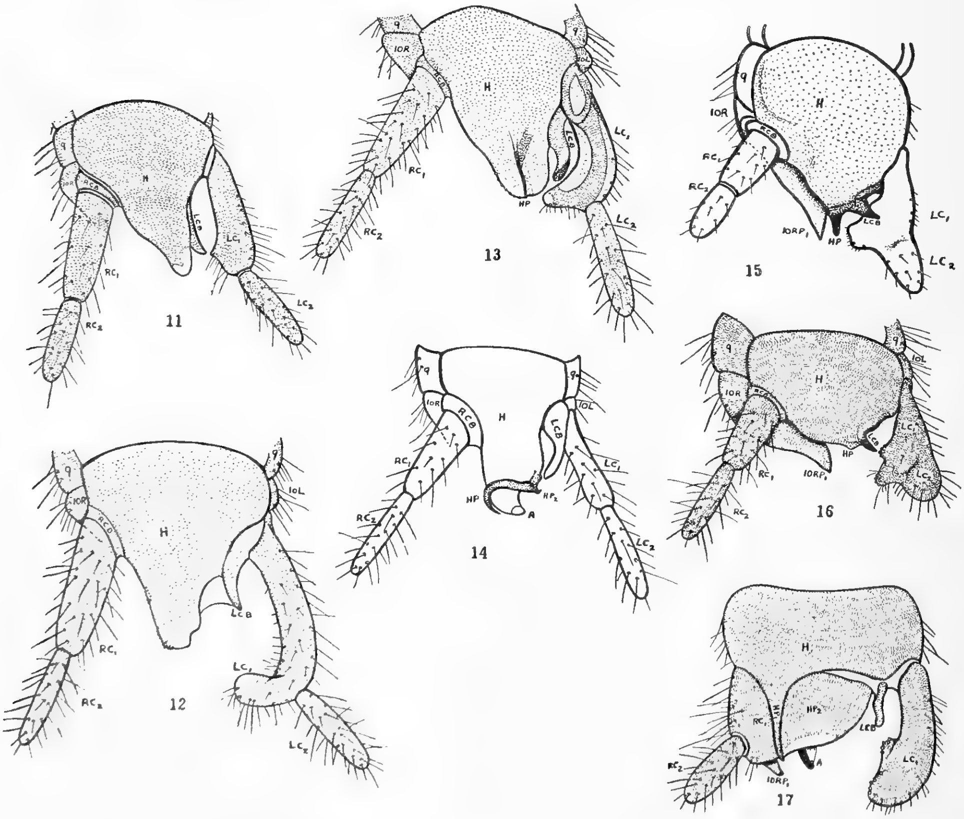
* See postscript at end of paper.

19; maximum length, 3·2 mm. The remaining characters are as in the female of *O. gurneyi gurneyi* Frogg.

Habitat.—Granite hill behind students' quarters, Experiment Farm, Wagga, N.S.W., W. W. Froggatt, 1904 (holotype ♀); the author, 12-2-36 (coll.), 20-3-36 et seq. (matured) (allotype ♂, long series of para-allotype ♂ and homotype ♀).

Situation.—Froggatt's specimen is recorded as being taken amongst granite boulders. The author's specimens were mostly taken in galleries among dead grass and *Callitris* foliage between granite boulders, while a few were in galleries in the bark of *Callitris* trees, close to the ground.

Distribution of Types.—Allotype ♂ on slide, para-allotype ♂ and homotype ♀ in alcohol, Macleay Museum; para-allotype males and homotype females forwarded to the British Museum, the National Museum, the Australian Museum, the Western Australian Museum, and the South Australian Museum; para-allotype males forwarded to the Cawthron Institute and the Zoological Museum, Buitenzorg. Froggatt's holotype female is in the C.S.I.R. collection, Canberra.



Figs. 11-17.—Terminalia of males of Australian Oligotomidae, viewed ventrally, certain dorsal structures omitted. (× 25.)

11.—*Oligotoma gurneyi gurneyi* Frogg. 12.—*O. tillyardi*, nov. 13.—*O. glauerti* Till. 14.—*O. latreillei* (Ramb.). 15.—*Notoligotoma hardyi* (Fried.). 16.—*N. nitens*, nov. 17.—*Metoligotoma reducta reducta*, nov.

Lettering as in Figs. 1-10.

Note.—Specimens taken in 1913 at Pyrmont, N.S.W., at the store of the Colonial Sugar Refining Co., were referred by Friederichs (1923) to what was then *O. agilis* Frogg., the reason being that the species appeared to have a wingless ♂ or a wingless form of the ♂, and was different in colour from *O. gurneyi* Frogg., and that only these two species were then known from New South Wales.

Although the form known then as *O. agilis* Frogg. has since been shown to be a wingless subspecies of the other then-known species, I am not inclined to agree with Friederichs, in view of the wide spatial and ecological difference between Pyrmont and Wagga. If Friederichs's assumption, that the Pyrmont specimens included a wingless form of male, be correct, it is more likely that they belonged to one of the wingless species described below from near Sydney.

The point can only be cleared up by collecting mature males from the Pyrmont locality. I recently searched this without success, possibly because of the season. The locality seems very favourable for Embioptera, because (1) there are numerous steam-outlets, so that the general temperature and humidity are high, (2) there are great quantities of raw sugar lying about, accumulated on floors, rafters and posts, and Embioptera have been observed to eat sugar readily in captivity.

OLIGOTOMA GURNEYI Frogg. HILLI, n. subsp.

This subspecies, from near the Cotter Reservoir, F.C.T., is, like the last, wingless; and the male terminalia are identical also. It is differentiated from *O. gurneyi agilis* Frogg. mainly on colour, size and head-length:breadth ratio. The characters of differential importance are given below.

♂. *Length*, 6·4–8·7 mm., av. 7·7 mm. Head:thorax:abdomen in the ratio 10:17:29. *Colour*: Dorsally, sclerites deep, rich brown, head very dark, pronotum darker than rest of body. Paler areas mid-dorsally on meso- and metathorax and abdomen; terminalia darker. Somewhat paler ventrally (except head and subgenital plate). Intersegmental membranes cream. *Head*: Length, 1·17–1·50 mm., av. 1·37 mm. Ratio of length to maximum breadth, 10·0:6·9. *Antennae*: Maximum number of segments observed, 19 (specimens with 18 segments on each side were common); maximum length, 4·6 mm.

♀. *Length*, 7·5–11·7 mm., av. 9·5 mm. Head:thorax:abdomen in the ratio 10:29:43. *Colour* as in the ♂, the eighth sternite dark laterally, and the ninth and tenth sternites dark throughout. *Head*: Length, 1·07–1·27 mm., av. 1·17 mm. Ratio of length to maximum breadth, 10·0:8·2. *Antennae*: Maximum number of segments observed, 19 (specimens with 18 segments on each side were common). Maximum length, 2·8 mm.

Other characters of both sexes as in *O. gurneyi agilis* Frogg.

Habitat.—Near Cotter Reservoir, F.C.T., G. F. Hill, 8-8-29 (holotype ♂, paratype ♂♂ and ♀♀); the author, 13-2-36 (immature); R. V. Fyfe and the author, 30-5-36 (allotype ♀, long series of paratype ♂ and ♀).

Situation.—In galleries under stones, among the roots of grasses and of the fern *Cheilanthes tenuifolia*, and lichens.

Distribution of Types.—Holotype ♂ on slide, allotype ♀, paratype ♂♂ and ♀♀ in alcohol, Macleay Museum. Paratype males and females forwarded to the British Museum, the National Museum, the Australian Museum, the Western Australian Museum, the South Australian Museum, the C.S.I.R. collection, the Cawthron Institute and the Zoological Museum, Buitenzorg.

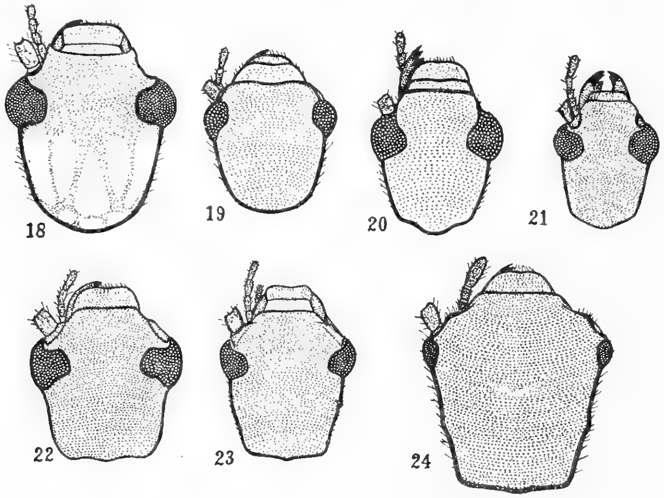
I am naming this subspecies after Mr. G. F. Hill, its discoverer.

OLIGOTOMA GURNEYI Frogg. CENTRALIS, n. subsp. Fig. 2.

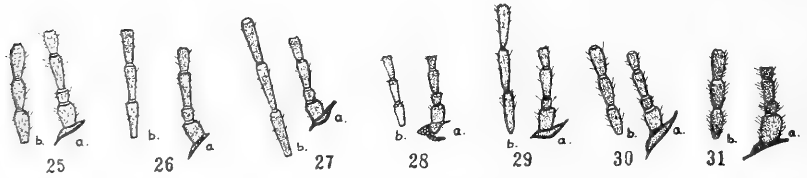
This geographic subspecies is erected for certain specimens (♂) taken in localities in Central Australia. It differs slightly from *O. gurneyi gurneyi* Frogg.

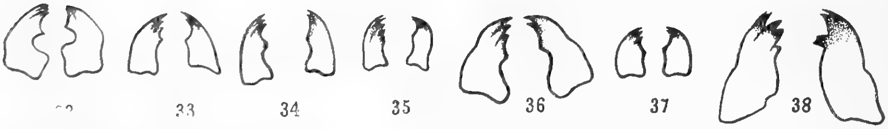
in characters of the terminalia, as well as in colour and generally larger size. The significant characters are given below.

♂. *Length*, 9·5–12·7 mm., av. 11·4 mm. Head:thorax:abdomen in the ratio 10:26:34. *Colour*: General coloration pale golden-brown, eyes black. *Head*: Length, 1·41–1·76 mm., av. 1·62 mm. Ratio of length to maximum breadth, 10·0:8·3. *Antennae*: Maximum number of segments observed, 17; maximum length, 3·2 mm. *Wings*: Forewing, length 7·4–9·9 mm., av. 8·9 mm.; breadth



Figs. 18-24.—Heads of males of Australian Oligotomidae, dorsal view. (× 20.)
18.—*Oligotoma gurneyi gurneyi* Frogg. 19.—*O. tillyardi*, nov. 20.—*O. glauerti* Till. 21.—*O. latreillei* (Ramb.). 22.—*Notoligotoma hardyi* (Fried.). 23.—*N. nitens*, nov. 24.—*Metoligotoma reducta reducta*, nov.





Figs. 25-31.—Antennal segments of males of Australian Oligotomidae. *a*, four basal segments; *b*, typical distalia. (× 20.)
25.—*Oligotoma gurneyi gurneyi* Frogg. 26.—*O. tillyardi*, nov. 27.—*O. glauerti* Till. 28.—*O. latreillei* (Ramb.). 29.—*Notoligotoma hardyi* (Fried.). 30.—*N. nitens*, nov. 31.—*Metoligotoma reducta reducta*, nov.

Figs. 32-38.—Mandibles of males of Australian Oligotomidae, dorsal view. (× 20.)
32.—*Oligotoma gurneyi gurneyi* Frogg. 33.—*O. tillyardi*, nov. 34.—*O. glauerti* Till. 35.—*O. latreillei* (Ramb.). 36.—*Notoligotoma hardyi* (Fried.). 37.—*N. nitens*, nov. 38.—*Metoligotoma reducta reducta*, nov.

1·8–2·5 mm., av. 2·1 mm. Hindwing, length 6·4–8·5 mm., av. 7·6 mm.; breadth 1·8–2·5 mm., av. 2·1 mm. *Terminalia* (fig. 2): The process 10 RP_1, instead of being smoothly tapered distally, ends in two closely-approximated points. The left cercus-basipodite is bluntly rounded distally, and the free portion projects upwards. The first segment of the left cercus has the process on the inner side more anteriorly placed than in *O. gurneyi gurneyi* Frogg., so that the segment has an altogether different appearance, with a considerable distance between the process and the junction with the second segment.

All other characters as in *O. gurneyi gurneyi* Frogg. ♂.

♀. Unknown.

Habitat.—Macdonnel Downs, Central Australia, 8-30, S. Australian Museum Expedition (holotype ♂ and paratype ♂♂); Alice Springs, Central Australia, Sir Douglas Mawson, 11-27 (paratype ♂).

Situation.—Winged males taken at light.

Distribution of Types.—Holotype ♂ and paratype ♂♂ (slides), South Australian Museum; paratype males, Macleay Museum, British Museum, and Western Australian Museum.

Variations.—Winged males from Lucindale, S.A., F. Secker, 1912, and Adelaide, S.A., A. M. Lea, 28-5-29 (taken at light), agree with the above examples in most points. While the left cercus-basipodite is similar to that of the typical Central Australian forms, the first segment of the left cercus approaches rather more closely to the East Australian *O. gurneyi gurneyi* Frogg., and the termination of the outer process of the right hemitergite of the tenth abdominal segment (10 RP_1), which ends smoothly in the East Australian form, and in two approximated points in the Central Australian form, is in these specimens intermediate.

A small series taken at Julia Percy Id., Victoria, by the McCoy Society Expedition, 2-36 (under stones), contained one mature male. This specimen had genitalia similar to the males from Lucindale and Adelaide, but was wingless (like the subspecies *agilis* Frogg. and *hilli*, nov.), and in colour approached more to the subspecies *agilis* Frogg. than to the subspecies *centralis*, nov. The females in association with this male were very similar to those of *O. gurneyi agilis* Frogg.

These specimens are regarded as intermediates between the geographic subspecies *gurneyi* Frogg. and *centralis*, nov., pending the discovery of more material.

OLIGOTOMA GURNEYI Frogg. SPINULOSA, n. subsp. Fig. 3.

This subspecies, erected for specimens (♂) from Western Australia, is of the same general appearance as the last subspecies described, but is slightly more variable in size, and has small but important differences in the male terminalia distinguishing it from the last subspecies and from *O. gurneyi gurneyi* Frogg. Points of systematic distinction are given below.

♂. Length, 8·7–13·8 mm., av. 11·1 mm. Head:thorax:abdomen in the ratio 10:21:23. *Colour*: Deep golden-brown, eyes black. *Head*: Length, 1·69–2·26 mm., av. 1·91 mm. Ratio of length to maximum breadth, 10·0:8·5. *Antennae*: Maximum number of segments observed, 20; maximum length, 4·2 mm. *Wings*: Forewing, length 8·2–10·0 mm., av. 9·1 mm.; breadth 2·0–2·5 mm., av. 2·3 mm. Hindwing, length 6·7–8·5 mm., av. 7·6 mm.; breadth 2·0–2·5 mm., av. 2·2 mm. *Terminalia* (Fig. 3): The process 10 RP_1, as in the last subspecies, ends in two closely-approximated points. The process 10 LP is slightly thinner and more sinuous than in the previous subspecies, and the small hook at the end of 10 LP is considerably longer, thinner, and more sinuous. The left cercus-basipodite is fused throughout, as far as its posterior limit, to the hypandrium, and near the posterior end gives off at right angles a sharp free spine projecting to the left. The first segment of the left cercus is different from that in *O. gurneyi gurneyi* Frogg. in that it is produced inwards from the junction with the second segment more markedly, the inward process being more distally placed.

All other characters as in *O. gurneyi gurneyi* Frogg. ♂.

♀. Unknown.

Habitat.—Morgan's, nr. Mt. Margaret, W.A., per L. Glauert, 10-33 (holotype ♂ and paratype ♂♂); Lake Violet, East Murchison District, per L. Glauert, 10-27 (paratype ♂).

Situation.—The specimens from Morgan's were taken swarming after rain, the Lake Violet specimen was taken at light.

Distribution of Types.—Holotype ♂ on slide, paratype ♂ in alcohol, Macleay Museum; paratype males forwarded to the British Museum, the Australian Museum, and the Western Australian Museum.

OLIGOTOMA GURNEYI Frogg. SUBCLAVATA, n. subsp. Fig. 4.

This subspecies is erected for some very interesting specimens (♂) taken in North Australia. The smaller size, and noticeable differences in the terminalia, differentiate it clearly from the other subspecies. The diagnostic characters are given below.

♂. *Length*, 6·4–7·5 mm., av. 7·2 mm. Head:thorax:abdomen in the ratio 10:23:31. *Colour*: General coloration yellowish-brown (including the broad bands beside the wing-veins). Eyes black. *Head*: Length, 0·75–1·12 mm., av. 1·02 mm. Ratio of length to maximum breadth, 10·0:7·6. *Antennae*: Maximum number of segments observed, 16; maximum length, 3·2 mm. *Wings*: Forewing, length 5·1–5·5 mm., av. 5·4 mm.; breadth 1·3–1·4 mm., av. 1·4 mm. Hindwing, length 4·3–4·6 mm., av. 4·4 mm.; breadth 1·3–1·4 mm., av. 1·4 mm. *Terminalia* (Fig. 4): The process 10 RP_1 ends in two closely-approximated points. The left cercus-basipodite is very similar to that of *O. gurneyi gurneyi* Frogg., but somewhat blunter distally. The process 10 LP is somewhat broader than in *O. gurneyi gurneyi* Frogg., but the hook at the distal end is identical. The greatest difference lies in the first segment of the left cercus; in all the previous subspecies this has some inwardly-directed process, but here the segment is thickened distally, but rounded off.

All other characters as in *O. gurneyi gurneyi* Frogg. ♂.

♀. Unknown.

Habitat.—Daly Waters, North Australia, F. H. Taylor, 1-11-34 (holotype ♂ and paratype ♂♂); Anthony's Lagoon, North Australia, F. H. Taylor, 5-11-34 (paratype ♂).

Situation.—Winged males taken at light.

Distribution of Types.—Holotype ♂ on slide, paratype ♂ in alcohol, Macleay Museum; paratype males forwarded to the British Museum and the Western Australian Museum.

Note.—This subspecies is the closest of all the subspecies to the East Indian species *O. vosseleri* (Krauss). The latter is well figured by Silvestri (1912, fig. 6). The differences of importance are (1) *O. vosseleri* (Krauss) lacks the terminal hook at the extremity of the process 10 LP, which is, on the contrary, present in all subspecies of *O. gurneyi* Frogg.; (2) the left cercus-basipodite in *O. vosseleri* (Krauss) (*c* in Silvestri's figure) is more distinct from the hypandrium, being free practically throughout and curved outwards to a point distally.

It is probable that *O. gurneyi* Frogg. *subclavata*, nov., is the most primitive of the six subspecies, and that the species originated in the North, differentiating as it radiated from that centre.

Key to the subspecies of Oligotoma gurneyi *Frogg.* (♂).

1. First segment of left cercus roundly club-shaped .... *subclavata*, nov.
   First segment of left cercus produced to a process on the inner margin 2
2. Left cercus-basipodite fused along its inner margin to the hypandrium, and at its posterior extremity produced outwards to a sharp spine; hook at end of process of left hemitergite of tenth abdominal segment long and very thin .. *spinulosa*, nov.
   Left cercus-basipodite not as above; hook of process of left hemitergite shorter and thicker 3
3. Outer process of right hemitergite of tenth abdominal segment ending in two closely-approximated points; left cercus-basipodite broadly rounded at posterior end and produced upwards .... *centralis*, nov.
   Outer process of right hemitergite and left cercus-basipodite both smoothly tapered at posterior extremity 4
4. Winged .... *gurneyi* Frogg.
   Wingless 5
5. Length of specimens in series examined 6·4-8·7 mm., av. 7·7 mm.; average ratio of head-length to head-breadth 10·0 : 6·9 .... *hilli*, nov.
   Length of specimens in series examined 9·7-11·2 mm., av. 10·5 mm.; average ratio of head-length to head-breadth 10·0 : 8·6 .... *agilis* Frogg.

Note.—It seems, for the present, wise to consider the six types as geographic subspecies, although some might consider that the last three described deserve specific status. Whether *O. gurneyi agilis* Frogg. and *O. gurneyi* Frogg. *hilli*, nov., are true geographic subspecies, or merely local varieties of *O. gurneyi gurneyi* Frogg., will only be shown by the examination of more material from other localities.

OLIGOTOMA TILLYARDI, n. sp. Figs. 5, 12, 19, 26, 33.

♂. *Length,* 7·4–9·7 mm., av. 8·9 mm. Head:thorax:abdomen in the ratio 10:22:30. *Colour*: Golden-brown, the head slightly darker, eyes black. Wing veins bordered with broad pale-brown bands. *Head* (Fig. 19): Length, 1·31–1·48 mm., av. 1·40 mm. Ratio of length to maximum breadth, 10·0:7·8. Broadest at the eyes, the lateral margins slightly convex and convergent behind. Eyes reniform, prominent. *Antennae*: Maximum number of segments observed, 19; maximum length, 4·6 mm. Basal four segments (Fig. 26*a*) with lengths typically in the ratio 4:2:6:5. Distalia elongate, narrowest at proximal end, sides slightly diverging and relatively straight (Fig. 26*b*). *Mouthparts* normal, mandibles (Fig. 33) somewhat slender; the left with three sharp distal teeth directed slightly inwards, and a blunt tooth on the inner margin behind these; the right with two distal teeth, and basal to these on the inner margin a concavity with a blunt tooth posterior to it. *Thorax*: Structure similar to that of *O. gurneyi gurneyi* Frogg. ♂. *Legs* as in *O. gurneyi gurneyi* Frogg. ♂. *Wings*: Forewing, length 7·5–8·5 mm., av. 7·9 mm.; breadth 1·9–2·0 mm., av. 2·0 mm. Hindwing, length 6·1–7·2 mm., av. 6·7 mm.; breadth 1·9–2·0 mm., av. 1·9 mm. Venation characteristic of the genus. *Abdomen*: Except for the terminalia, as in *O. gurneyi gurneyi* Frogg. ♂.

Terminalia (Fig. 5): Tenth tergite divided longitudinally to left and right hemitergites (10 L, 10 R respectively). 10 R produced backwards and inwards from its outer margin to a long, thin, straight process (10 RP_1), heavily chitinized and terminating in two closely-approximated points. Inner process (10 RP_2) similar to that in *O. gurneyi gurneyi* Frogg., somewhat blunter. First segment of right cercus (RC_1) subcylindrical, arising from a vestigial annular cercus-basipodite (RCB) placed latero-ventrally to 10 R. Second segment (RC_2) subcylindrical, thinner than RC_1. Left hemitergite produced distally to a process (10 LP) terminating in a forcipate structure, the inner tooth sharply pointed and heavily chitinized, the outer lobe blunt and more membranous, and projecting somewhat dorsally; both lobes curved in towards each other distally. First segment of left cercus (LC_1) curved inwards considerably from junction with second segment (LC_2), the distal, inner extremity somewhat flattened. LC_2 subcylindrical. Ventrally (Fig. 12), the hypandrium (H) projects backwards, with convergent lateral margins, to a blunt termination with two angles. Minute nodules distally and on right-hand margin of H. Left cercus-basipodite (LCB) lying along left-hand margin of H proximally, curving out distally to a free, tapered termination.

♀. Unknown.

Habitat.—Morgan's, nr. Mt. Margaret, W.A., per L. Glauert, 10-33 (holotype ♂ and paratype ♂♂).

Situation.—Swarming after rain.

Distribution of Types.—Holotype ♂ on slide, paratype ♂ in alcohol, Macleay Museum. Paratype males forwarded to the British Museum, the Australian Museum, the Western Australian Museum, the South Australian Museum, the C.S.I.R. collection, the Cawthron Institute and the Zoological Museum, Buitenzorg.

I am naming this species in recognition of the work done by Dr. R. J. Tillyard on the Western Australian Embioptera.

Note.—The forcipate termination to the process of the left hemitergite is a character convergent to the Embiid genus *Rhagadochir.* In one specimen of *O. tillyardi*, nov., a small, rounded body was found between the lobes of the forceps; this probably represented a spermatophore.

OLIGOTOMA GLAUERTI Tillyard, 1923. Figs. 6, 13, 20, 27, 34.

Journ. Proc. Roy. Soc. W. Aust., ix, pt. i, 1923.

This species has been well described by Tillyard (l.c.). Whilst transferring the holotype ♂ and a paratype ♂ from deteriorated glycerine jelly mounts to balsam, I was able to examine the terminalia critically in comparison with those of other Australian species. Certain measurements were also made to bring the description into line with those of the other species. The following description is given with Dr. Tillyard's permission.

♂. *Length*, 9·5–10·0 mm. Head:thorax:abdomen in the ratio 10:24:34. *Colour*: Golden-brown, eyes black, wing-veins bordered with pale brown. *Head* (Fig. 20): Length, 1·44–1·49 mm. Ratio of length to maximum breadth, 10·0:7·8. *Antennae*: Maximum number of segments observed, 21; maximum length, 7·5 mm. Four basal segments with lengths typically in the ratio 4:2:5:4 (Fig. 27*a*). Distalia (Fig. 27*b*) longer than those of any other Australian species. *Mouthparts* normal, mandibles (Fig. 34) slender, similar to those of *O. tillyardi*, nov., but with the blunt basal tooth of the left mandible bilobed. *Thorax and legs* as in *O. gurneyi gurneyi* Frogg. ♂. *Wings*: Forewing, average length 8·8 mm., average breadth 2·2 mm.; hindwing, average length 7·5 mm., average breadth 2·2 mm. Venation characteristic of the genus. *Abdomen*: Except for the terminalia, as in *O. gurneyi gurneyi* Frogg. ♂.

Terminalia (Fig. 6): Tenth tergite divided longitudinally to left and right hemitergites (10 L, 10 R respectively). 10 R produced backwards and inwards from its outer margin to a long, thin, straight process terminating in two closely-approximated points, the right-hand point placed somewhat dorsally to the left. Inner process (10 RP_2) almost identical with that of *O. gurneyi gurneyi* Frogg. First segment of right cercus (RC_1) subcylindrical, arising from a vestigial annular cercus-basipodite (RCB) lateroventral to 10 R. Second segment (RC_2) subcylindrical, thinner than first. Left hemitergite produced backwards to a narrowing process (10 LP) with sinuous margins, terminating in an anchor-like hook (Fig. 6*a*). First segment of left cercus (LC_1) curving inwards strongly from junction with second segment (LC_2) and ending in a blunt, round termination. LC_2 subcylindrical. Ventrally (Fig. 13), the hypandrium is produced backwards to a rounded termination, with a median longitudinal chitinous structure (HP), probably a spine, posteriorly, but not projecting. To the left of HP there is a trace of a membranous structure, possibly tubular, which may represent the aedeagus. Minute nodules at posterior extremity of right-hand margin of H. Left cercus-basipodite (LCB) fused proximally to anterior part of left margin of H, but distally curving upwards and inwards to a bluntly-rounded termination.

♀. Unknown.

Habitat.—Milly Milly Stn., Murchison River, W.A., L. Glauert, 26-5-22 (holotype ♂ and paratype ♂♂).

Situation.—Taken at light.

Location of Types.—The holotype ♂ is in the Western Australian Museum, and a paratype ♂ in the Macleay Museum.

OLIGOTOMA LATREILLEI (Rambur), 1842. Figs. 7, 14, 21, 28, 35.

Embia latreillei Rambur, *Hist. nat. Neur.*, 1842, p. 312.

This tropicopolitan species is recorded from several localities in Queensland. As it is somewhat variable throughout its extensive range, the complete description is appended for the Australian examples.

♂. *Length*, 6·6–8·3 mm., av. 7·5 mm. Head:thorax:abdomen in the ratio 10:20:34. *Colour*: Pale-brown, head a little darker, eyes black. Wing-veins bordered with broad bands of pale-brown. *Head* (Fig. 21): Length, 1·23–1·39 mm., av. 1·30 mm. Ratio of length to maximum breadth, 10·0:7·7. Eyes prominent; sides of head converging slightly posteriorly, rounded off at back. *Antennae*: Maximum number of segments observed, 20; maximum length, 3·5 mm. Four basal segments with lengths typically in the ratio 3:2:4:3 (Figs. 28*a*, *b*). *Mouthparts* normal, mandibles (Fig. 35) slender, the left with two narrow, sharp teeth distally, then two fairly sharp teeth, and behind these a slight bilobed projection, on the inner margin; right mandible with two sharp teeth distally and a slight projection behind these on the inner margin. *Thorax and legs* as in *O. gurneyi gurneyi* Frogg. ♂. *Wings*: Forewing, length 5·1–6·6 mm., av. 5·5 mm.; breadth 1·3–1·6 mm., av. 1·4 mm. Hindwing, length 4·3–5·3 mm., av. 4·6 mm.; breadth 1·3–1·5 mm., av. 1·4 mm. Venation characteristic of the genus. *Abdomen*: Except for the terminalia, as for *O. gurneyi gurneyi* Frogg. ♂.

Terminalia (Fig. 7): Tenth tergite divided longitudinally to left and right hemitergites (10 L, 10 R respectively). 10 R produced backwards and inwards from its outer margin to a long, thin, slightly sinuous process (10 RP_1) distally curving slightly to the right to a blunt termination, to the left of which is a small pointed process. It is in this termination of 10 RP_1 (Fig. 7*a*) that variations occur in examples from other localities; the present examples resemble specimens examined from New Caledonia and the Dutch East Indies, and are fairly close to the figure given by Enderlein (1912) of an example from Formosa. Inner process of 10 R (10 RP_2) very similar to that in *O. gurneyi gurneyi* Frogg. Left hemitergite produced backwards to a dagger-shaped process, lacking any terminal appendage. Right and left cerci each composed of two subequal, subcylindrical segments (RC_1, RC_2, LC_1, LC_2); the former arising from a vestigial annular cercus-basipodite (RCB) lateroventral to 10 R, the latter from a free cercus-basipodite (LCB) proximally separating LC_1 from the hypandrium, and distally curving round to a blunt termination. Ventrally (Fig. 14) the hypandrium (H) narrows posteriorly and curves to the left; its distal extremity is weakly chitinized, and appears to end in a tubular structure, probably an aedeagus (A). A spiral, heavily chitinized process (HP_1) is attached to the left-hand margin of H near its distal extremity, and curves under H, then upwards and round; at the base of HP_1 a minute hook (HP_2) is given off towards the left.

♀. As yet unrecorded from Australia. Specimens from Noumea, New Caledonia (A. M. Lea, date unrecorded), taken in association with a male referred to this species, are in general colour reddish-brown, and of the following dimensions: Length, 7·7–8·1 mm., av. 7·9 mm. Head:thorax:abdomen in the ratio 10:20:31. Head-length, 1·24–1·30 mm., av. 1·28 mm. Ratio of head-length to maximum breadth, 10·0:8·0. Maximum number of antennal segments observed, 20; maximum length, 1·9 mm.

Australian localities.—Brisbane, Q., Dr. R. J. Tillyard, 10-15; Townsville, Q., F. H. Taylor, 1928; Camooweal, Q., F. H. Taylor, 9-11-34 (♂).

Situation.—Winged males taken at light, or occasionally swarming in the daytime.

Distribution of Material.—Identified males in the Macleay Museum, and forwarded to the National Museum and the Western Australian Museum. In the South Australian Museum are identified specimens (♂, ♀) from Noumea, New Caledonia.

Key to the Australian species of Oligotoma (♂).

1. First segment of left cercus subcylindrical; process of left hemitergite of tenth abdominal segment dagger-shaped, and with no hook or other appendage distally .... *latreillei* (Ramb.)
   First segment of left cercus noticeably clavate; process of left hemitergite with an appendage at the distal extremity 2
2. First segment of left cercus not curved inwards to any great extent from the junction with the second segment; process of left hemitergite terminating in a simple spine produced forwards and downwards .... *gurneyi* Frogg.
   First segment of left cercus curved, produced inwards a considerable distance from the junction with the second segment; termination of process of left hemitergite not as above 3
3. Process of left hemitergite terminating in a forcipate structure ...... *tillyardi*, nov.
   Process of left hemitergite terminating in a simple anchor-like process .. *glauerti* Till.

Genus NOTOLIGOTOMA, n. gen.

Genotype, *Notoligotoma hardyi* (Friederichs) 1914.

Oligotoma hardyi Friederichs, *Rec. W.A. Mus. and Art Gall.*, Vol. 1, pt. 3, 1914.

This genus is proposed for the above species and a species, described later, which agrees closely with it. The diagnosis is as follows: Australian Oligotomidae with the second segment of the left cercus greatly reduced, less than twice as long as wide, and not distinctly divided from the first segment, which carries minute nodules; left cercus-basipodite fused intimately with hypandrium; right hemitergite of tenth abdominal segment massive and subtriangular, lacking any long, thin, backwardly directed process as in *Oligotoma*, but with a dorsal process directed forwards and bearing nodules. Left hemitergite produced backwards from its inner margin to a narrow, dagger-shaped process. Veins R_{4+5}, M and Cu_{1a} in the wings (when present) less obscure than in *Oligotoma*.

All the above characters refer to the males only.

Hind tarsi in both sexes with two minute bladders ("sohlenbläschen") on the first segment and one on the second segment.

This genus is convergent to the genus *Anisembia* Krauss (1911) with species from Texas, Mexico and California. It is structurally differentiated by the form of the process of the right hemitergite in the male, and by the number of tarsal bladders.

NOTOLIGOTOMA HARDYI (Fried.), 1914. Figs. 8, 15, 22, 29, 36.

Oligotoma hardyi Fried., 1914, l.c.

Friederichs's types (♂) have been lost. The species has been re-described well by Tillyard (1923), and from his description I have been able to identify material from localities in Western Australia, Queensland and New South Wales. In association with the last named was a female which has been designated allotype, and described here.

♂. Length, 8·8–11·0 mm., av. 9·5 mm. Head:thorax:abdomen in the ratio 10:21:24. Colour: Pale golden-brown, eyes black; wing veins bordered by broad pale-brown bands. *Head* (Fig. 22): Length, 1·49–1·76 mm., av. 1·65 mm. Ratio of length to maximum breadth, 10·0:8·4. Sides relatively straight, somewhat convergent, and posteriorly rounded off rather sharply. Eyes reniform, prominent. *Antennae* (Figs. 29*a*, *b*): maximum number of segments observed, 19; maximum length, 4·3 mm. Basal four segments with lengths typically in the ratio 3:2:5:3. *Mouthparts* normal, mandibles (Fig. 36) large, the left terminating distally in three incurved teeth, behind which, on the inner side, is a blunt projection and then a definite concavity; the right similar, but with two instead of three teeth distally. *Thorax*: Structure similar to that in *Oligotoma gurneyi gurneyi* Frogg. ♂. *Legs* normal, but with the hind tarsi possessing two minute bladders ventrally on the first segment and one on the second. In specimens of the genus *Oligotoma* examined there was only one such bladder distally on each of the first two hind tarsal segments. *Wings*: Forewing, length 7·9–10·9 mm., av. 9·8 mm.; breadth 1·9–2·8 mm., av. 2·4 mm. Hindwing, length 6·4–9·6 mm., av. 8·4 mm.; breadth 1·8–2·7 mm., av. 2·3 mm. Disposition of veins typical of the family, but with more cross-veins, and with the veins R_{4+5}, M and Cu_{1a} less obscure than in the genus *Oligotoma*. *Abdomen*, except for the terminalia, as in *O. gurneyi gurneyi* Frogg. ♂.

Terminalia (Fig. 8): Tenth tergite divided longitudinally to left and right hemitergites (10 L, 10 R respectively). 10 R subtriangular, massive, the distal vertex (10 RP_1) projecting backwards and inwards; a hook-like process (10 RP_2) arises dorsally about half-way along the inner margin of 10 R, and curves over, upwards and forwards, and bears minute nodules. Right cercus of two subcylindrical segments (RC_1, RC_2), and arising from a vestigial annular cercus-basipodite (RCB) lateroventrally to 10 R. Left hemitergite subtriangular, and produced backwards from the inner margin to a dagger-shaped process (10 LP). Left cercus very typical, clavate, the first segment (LC_1) produced inwards to a blunt process, and bearing minute nodules along the inner margin; second segment (LC_2) not sutured off, but represented by a subconical projection on the distal and outer margin of LC_1. Ventrally (Fig. 15), the hypandrium (H) is a large plate, rounded behind, but with a narrow, heavily-chitinized, finger-shaped process (HP) projecting upwards from the centre of the distal margin. Left cercus-basipodite (LCB) intimately fused to H, curving away from it distally to another finger-shaped process, adjacent to HP, pointing outwards, and heavily chitinized.

♀. Length 11·8 mm. Head:thorax:abdomen in the ratio 10:31:45. *Colour*: Head red-brown with darker tracery dorsally; body sclerites red-brown with paler mottling; intersegmental membranes cream. Legs red-brown, antennal segments golden-brown, eyes black. *Head*: Length, 1·37 mm. Ratio of length to maximum breadth, 10·0:8·8. Structure typical of that in female Oligotomidae. *Antennae*: Maximum number of segments observed, 19; maximum length, 2·4 mm. Segments much shorter than in the male. *Mouthparts* normal. *Thorax*: "Apotom" fairly distinctly divided off from rest of pronotum. Mesoscutum and metascutum with sides convex, each widest at a distance from the front equal to about one-third of its length, the metascutum narrowing rather markedly behind its widest point. *Legs* as in the male, somewhat stouter. *Abdomen and terminalia* normal.

Habitat.—Perth, W.A., 6-12 (Friederichs's types, ♂); Caversham, W.A., 6-15, C. Kerruish, per L. Glauert (♂); Castle Hill, nr. Townsville, Q., 3-9-22, G. F. Hill (♂ and immature); Callubri, via Nyngan, 21-7-35, J. Armstrong (♂, allotype ♀).

Situation.—The Western Australian specimens were taken at light, the Townsville specimens in galleries under stones, and the Nyngan specimens in galleries in rough bark.

Distribution of Material.—Identified males in the Macleay Museum and forwarded to the British Museum, the National Museum, the Australian Museum, the Western Australian Museum, the South Australian Museum, the C.S.I.R. collection and the Cawthron Institute. Allotype ♀ in the Macleay Museum.

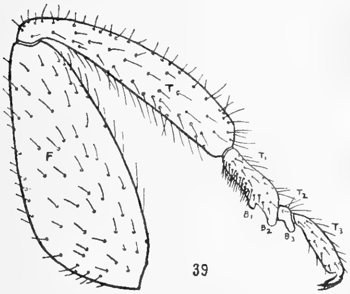
NOTOLIGOTOMA NITENS, n. sp. Figs. 9, 16, 23, 30, 37, 39–41.

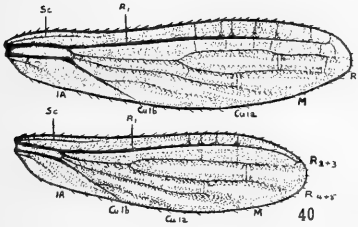
This species has a dimorphic ♂, winged and wingless forms occurring even in the same colony. Except for the presence or absence of wings and consequent modification of the thoracic sclerites, no significant difference can be observed between these forms in size or any other character.

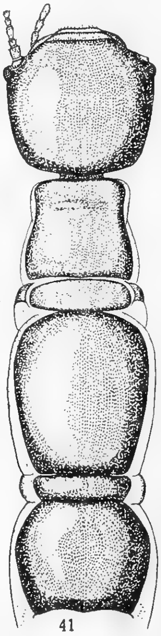
Length, 6·4–10·7 mm., av. 9·1 mm. Head:thorax:abdomen in the ratio 10:22:32. *Colour*: Black, very shiny; wings when present with veins bordered by broad bands of very dark grey. *Head* (Fig. 23): Length, 1·00–1·53 mm., av. 1·38 mm. Ratio of length to maximum breadth, 10·0:6·9. Broadest at the eyes, the lateral margins converging thence posteriorly, slightly sinuous. Eyes comparatively small. *Antennae*: Maximum number of segments observed, 23; maximum length, 5·9 mm. Basal four segments (Fig. 30*a*) with lengths typically in the ratio 3:2:5:3. Distalia (Fig. 30*b*) subcylindrical, smoothly rounded. *Mouthparts* normal, mandibles (Fig. 37) small and stout, the left with three inwardly-directed teeth distally and basad to these a blunt projection; the right similar but with only two distal teeth. *Thorax* (winged ♂): Pronotum with "apotom" fairly distinct, the groove representing the narrowest point, the broadest point at the posterior margin. Mesothorax and metathorax with subtriangular scuta and lateral sclerites. (Wingless ♂): Pronotum similar to winged ♂. Mesoscutum subrectangular, broadest at about one-third of its length from anterior limit, thence tapering slightly posteriorly. Metascutum subrectangular, broadest at one-quarter of its length from the posterior limit. *Legs* as in *N. hardyi* (Fried.), the hind femora more incrassate, the hind tarsal bladders more pronounced (Fig. 39). *Wings* (when present) (Fig. 40): Forewing, length 4·0–7·0 mm., av. 5·9 mm.; breadth 1·0–1·6 mm., av. 1·4 mm. Hindwing, length 3·5–5·7 mm., av. 5·0 mm.; breadth 1·0–1·6 mm., av. 1·4 mm. Otherwise as in *N. hardyi* (Fried.). *Abdomen*, except for terminalia, normal.

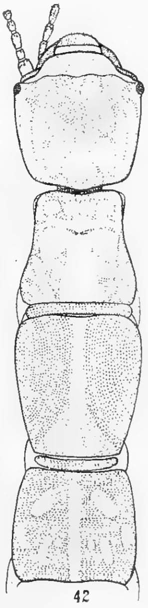
Terminalia (Figs. 9, 16): Similar in general structure to those of *N. hardyi* (Fried.). Just distal to the process 10 RP_2 is a small slender spine, placed ventrally on 10 R and projecting inwards. The process HP is not nearly so pronounced or heavily chitinized. The left cercus is very typical, the first segment (LC_1) subtriangular, and with minute nodules at the distal apex and on a small tooth on the inner margin just behind the apex. The second segment (LC_2) is more or less spherical, arising from the distal part of LC_1, and separated therefrom only by a slight narrowing, and not by any suture.

♀. Length, 6·9–12·5 mm., av. 9·7 mm. Head:thorax:abdomen in the ratio 10:27:36. *Colour*: Dorsally, the whole a deep umber-brown, very shiny, especially mesoscutum and metascutum. Antennae, palps, legs and cerci tending to golden-brown. Body sclerites, ventrally, somewhat paler. Intersegmental membranes cream. *Head*: Length, 1·07–1·55 mm., av. 1·33 mm. Ratio of length to maximum breadth, 10·0:8·4. *Antennae*: Maximum number of segments observed, 23; maximum length, 3·7 mm. Segments short and rounded, the combination moniliform. *Mouthparts* normal. *Thorax*: As in *N. hardyi* (Fried.) ♀; the metascutum









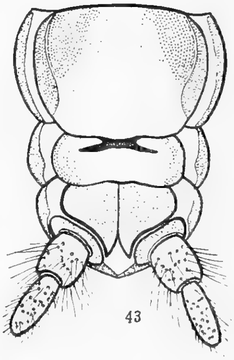


Fig. 39.—Hind leg of *Notoligotoma nitens*, nov. ♂. (× 25.) F, femur; T, tibia; T_1, T_2, T_3, tarsal segments; B_1, B_2, B_3, tarsal bladders (sohlenbläschen).

Fig. 40.—Right fore- and hind-wings of *Notoligotoma nitens*, ♂. (× 6⅔.) Standard lettering for venation.

Fig. 41.—Dorsal view of head and thorax of ♀ *Notoligotoma nitens*, nov. (× 12½). (Note: The head is tilted slightly forwards, exaggerating the ratio of breadth to length.)

Fig. 42.—Dorsal view of head and thorax of ♀ *Metoligotoma reducta reducta* nov. (× 12½.)

Fig. 43.—Ventral view of last three abdominal segments of ♀ *Metoligotoma reducta reducta*. (× 25.)

is widest at about one-third of its length from anterior limit, thence converging noticeably posteriorly (Fig. 41). *Legs* as in the ♂. *Abdomen and terminalia* normal.

Habitat.—Sylvania, N.S.W., the author, 29-10-34 (holotype winged ♂) and 11-8-35 (allotype ♀ and paratype ♀♀); Mortlake, N.S.W., Froggatt Collection, 24-10-09 (paratype wingless ♂); Kenthurst, N.S.W., L. Gallard, 15-9-17 (paratype winged ♂); Carlton, N.S.W., E. C. Hall, 18-7-31 (paratype winged ♂); Neutral Bay, Sydney, N.S.W., G. Dun, 5-33 (paratype winged ♂); Dee Why, N.S.W., R. V. Fyfe, 21-10-33 (paratype wingless ♂); Myall Lakes, N.S.W., N. J. B. Plomley, 24-8-34 (paratype winged ♂); Elanora Heights, N.S.W., the author, 7-10-34 (paratype winged and wingless ♂♂); Eastwood, N.S.W., L. Gallard, 1934 (paratype winged and wingless ♂♂); Sherbrooke, N.S.W., Miss G. Rodway, 27-8-35 (paratype winged ♂, and ♀); Wogamia, via Nowra, N.S.W., Miss G. Rodway, 29-8-35 (paratype winged and wingless ♂♂, and ♀); Sublime Point, nr. Austinmer, N.S.W., A. Simpson, 16-4-36 (paratype ♀♀); Austinmer, N.S.W., the author, 9-8-32; Galston, N.S.W., the author, 20-9-34; Killara, N.S.W., M. Day, 7-10-34; Gloucester, N.S.W., H. Davidson, 14-10-34; Bamarang, N.S.W., Miss G. Rodway, 12-2-35.

Situation.—This species is found most frequently forming galleries in the rough bark of certain trees (e.g., *Casuarina torulosa*, and various Eucalypts) or in old fence-posts. It is also found amongst the lichen *Cladonia* on rocks, and in similar situations. The winged males are sometimes taken at light.

Distribution of Types.—Holotype ♂ (winged) on slide, paratype wingless ♂ (morphotype) in alcohol, paratype wingless ♂ on slide, allotype ♀ in alcohol, Macleay Museum; paratype males and females forwarded to the British Museum, the National Museum, the Australian Museum, the Western Australian Museum, the South Australian Museum, the C.S.I.R. collection, the Cawthron Institute, and the Zoological Museum, Buitenzorg.

Note.—The male figured by Tillyard (1926, p. 120) as *Oligotoma gurneyi* Frogg. is not of that species, but apparently *N. nitens*, nov.

Key to the Species of Notoligotoma (♂).

Second segment of left cercus subconical; process to hypandrium slender and heavily chitinized; colour golden-brown	*hardyi* (Fried.)
Second segment of left cercus more or less spherical; process to hypandrium short, blunt, and not very heavily chitinized; colour black, shiny	*nitens*, nov.

Genus Metoligotoma, n. gen.

Genotype, *Metoligotoma reducta reducta*, nov.

Wingless Oligotomidae, the males having the left cercus clavate and one-segmented, and furnished with minute nodules on the inner surface; the first segment of the right cercus reduced to a broad base for the accommodation of the second segment; the left hemitergite produced backwards from its inner margin to a slender, sinuous process; the right hemitergite subtriangular and with a foliaceous dorsal process; and the left cercus-basipodite a small free sclerite.

Both sexes have two minute bladders placed ventrally on the first segment of the hind tarsi, and one bladder on the second segment.

METOLIGOTOMA REDUCTA REDUCTA, n. sp. et subsp. Figs. 10, 17, 24, 31, 38, 42, 43.

♂. *Length* 6·7–10·9 mm., av. 8·4 mm. Head:thorax:abdomen in the ratio 10:14:19. *Colour*: To the naked eye the general colour appears to be dull black. Under the binocular the body sclerites are seen to be very dark brown rather than true black; head black; cerci, intersegmental membranes, and near the joints of antennae and legs cream; antennal and tarsal segments deep golden-brown. *Head* (Fig. 24): Length, 1·81–1·97 mm., av. 1·92 mm. Ratio of length to maximum breadth, 10·0:8·3. Minutely punctate, broadest at the eyes, lateral margins running back thence, almost straight, to the posterior angles, and converging sharply. Eyes relatively very small. *Antennae*: Maximum number of segments observed, 20; maximum length, 3·7 mm. Basal four segments (Fig. 31*a*) subcylindrical, somewhat variable, but with the lengths typically in the ratio 5:2:4:2. Distalia (Fig. 31*b*) more rounded. *Mouthparts* normal, mandibles (Fig. 38) massive, the left with two sharp points distally, two blunter teeth inside these, and a small blunt tooth immediately posterior to them. Right mandible with two sharp points distally and a bilobed tooth on the inner margin a little behind the apex. *Thorax*: Pronotum with sides almost straight, and broadest at posterior end. "Apotom" not very distinctly divided off. Mesoscutum subrectangular, broadest at about one-third of its length from anterior limit; sides convex. Metascutum also subrectangular, with convex sides, and broadest at about one-quarter of its length from posterior limit, thence converging slightly. None of the thoracic nota as broad as the head. *Legs* normal, the fore femora somewhat incrassate, the hind femora greatly swollen; hind tarsi with two bladders ventrally on the first segment, one on the second. *Wings* absent. *Abdomen*: First seven segments, viewed dorsally, subequal; eighth tergite slightly shorter; ninth tergite only half as long as first; tenth segment a little longer than ninth.

Terminalia (Fig. 10): Tenth tergite divided longitudinally to left and right hemitergites (10 L, 10 R respectively). 10 R subtriangular, the distal apex pointing downwards and inwards (10 RP_1). From near the inner margin of 10 R there arises a foliaceous process (10 RP_2) projecting to the left and slightly upwards, but in a more or less horizontal plane; 10 RP_2 subrectangular, somewhat corrugated, not heavily chitinized. First segment of right cercus (RC_1) attached above to lateroventral part of 10 R, below to outer margin of hypandrium; no cercus-basipodite present. RC_1 reduced to a base, broader than long, for the accommodation of the second segment (RC_2), which is subcylindrical. Left hemitergite subtriangular, the inner margin produced backwards to a slender, slightly sinuous process (10 LP), heavily chitinized; proximal part of 10 LP overlapped by 10 RP_2. Between 10 L and 10 R, just distal to the ninth tergite, there appear to be several small chitinous plates connecting the proximal parts of 10 L and 10 R. Left cercus (LC_1) one-segmented, arising lateroventrally from the body of 10 L; clavate, the distal part of the inner margin forming a blunt face bearing many minute teeth. Left cercus-basipodite (LCB) a small, slender, free sclerite, between the base of LC_1 and the left margin of the hypandrium; LCB ending bluntly. Ventrally (Fig. 17), the hypandrium (H) is produced from its right-hand margin to a long, pointed process (HP_1), not free, for the right-hand margin is attached to RC_1, and the inner margin to another sclerite (HP_2) which fills up the concavity between H and HP_1. HP_2 subtriangular. Dorsal to the plate HP_2 and projecting between it and the dorsal sclerites is a subconical structure (A) probably representing the aedeagus; the right-hand margin of A is chitinized, the rest membraneous. *Note*: Both 10 RP_2 and LCB are somewhat variable.

♀. Length, 12·0–13·0 mm., av. 12·4 mm. Head:thorax:abdomen in the ratio 10:24:40. *Colour*: Head golden-brown with darker tracery; pronotum deep golden-brown, with paler areas (as in Fig. 42). Mesoscutum and metascutum and abdominal tergites dark brown at lateral borders, ranging through golden-brown to a longitudinal cream central line. Sclerites of leg and antennal segments golden-brown, the former paler near the joints. Intersegmental membranes cream. Ventrally, the body sclerites are pale-brown to cream, the thoracic sclerites, abdominal pleurites 2–7, and lateral margins of abdominal sternites being darker than the rest. *Head*: Length, 1·60–1·71 mm., av. 1·65 mm.; ratio of length to maximum breadth, 10·0:8·4. Structure normal for the family. *Antennae*: Maximum number of segments observed, 14; maximum length, 2·3 mm. Segments shorter than in the ♂, distalia more or less spherical, the combination moniliform. *Mouthparts* normal. *Thorax and legs* as in the ♂, the widest point of the mesoscutum slightly more anteriorly placed. *Abdomen and terminalia* normal (v. Fig. 43).

Note.—Females taken at Austinmer, N.S.W., in association with typical males, were smaller and darker than in the above description. They were mature, and in most cases guarding eggs, so that the bodies were shrunk subsequent to oviposition. The following details of this series are given:

Colour: Dorsally, dark brown, no head pattern; trace of pronotal pattern and mid-dorsal longitudinal line. Eyes black. Ventrally, sclerites pale brown with darker areas, especially on eighth sternite. Legs dark brown, paler near joints; membranes cream. Length, 7·7–8·4 mm., av. 7·9 mm. Head:thorax:abdomen in the ratio 10:18:25. Head-length, 1·33–1·60 mm., av. 1·47 mm. Ratio of head-length to maximum breadth, 10·0:8·2. Maximum number of antennal segments observed, 15; maximum antennal length, 2·4 mm.

Members of this series have not been designated paratypes. It is probable, however, that the females of this species are more variable than the first description implies.

Habitat.—Elanora Heights, N.S.W., M. Day, and D. Waterhouse, 16-9-34 (holotype ♂ and paratype ♂♂); N. J. B. Plomley, 18-12-34 (paratype ♂) and 27-5-35 (paratype ♂); Jooriland, Burragorang Valley, N.S.W., the author, 1-1-33 (paratype ♂, allotype ♀ and paratype ♀♀); Austinmer, N.S.W., the author, 30-9-34 and 23-8-36 (paratype ♂♂); coll. 1-3-36, matured 1-4-36 et seq. (paratype ♂♂, and ♀♀); Myall Lakes, N.S.W., N. J. B. Plomley 24-8-34 (paratype ♂); Mt. Tambourine, Q., W. H. Davidson, 1-9-24; Tomat Falls, nr. Wollondilly River, N.S.W., the author, 23-8-34; Springwood, N.S.W., and Lawson, N.S.W., D. Waterhouse, 1-10-34; Mittagong, N.S.W., D. Lee, 30-7-35; Lower Burragorang Valley, N.S.W., R. T. Walker, 6-36.

Situation.—In the mat formed by *Polypodium serpens*, *P. confluens*, or *Dendrobium linguiforme*, growing on rock faces; also amongst dead leaves, especially in the mat formed by fallen *Casuarina* needles.

Distribution of Types.—Holotype ♂ on slide, paratype ♂♂ on slide and in alcohol, allotype ♀ in alcohol, Macleay Museum; paratype males and females forwarded to the British Museum and the Western Australian Museum; paratype males forwarded to the National Museum, the Australian Museum, the South Australian Museum, the C.S.I.R. collection, the Cawthron Institute and the Zoological Museum, Buitenzorg.

METOLIGOTOMA REDUCTA INGENS, n. subsp.

This subspecies is divided off on account of its great size and paler colour. The significant characters are given below; the remaining characters are the same as for the respective sexes of *M. reducta reducta*, nov.

♂. *Length*, 12·0–14·2 mm., av. 12·8 mm. Head:thorax:abdomen in the ratio 10:15:18. Head-length, 2·93–3·41 mm., av. 3·26 mm. Ratio of head-length to maximum breadth 10·0:8·2. Maximum observed number of antennal segments, 13; maximum antennal length, 3·8 mm. *Colour*: Head dark-brown, eyes black; dorsally, body sclerites dull brown, with paler pattern on prothorax and pale mid-dorsal line on mesoscutum, metascutum and abdominal tergites; ventrally, body brown, abdominal sternites, especially hypandrium, darker than the rest. Legs and antennae golden-brown, intersegmental membranes cream.

♀. *Length*, 14·4–18·7 mm., av. 15·8 mm. Head:thorax:abdomen in the ratio 10:21:31. Head-length, 2·13–2·67 mm., av. 2·41 mm. Ratio of head-length to maximum breadth, 10·0:8·0. Maximum number of antennal segments observed, 18; maximum antennal length, 3·3 mm. *Colour*: Head golden-brown with dark-brown tracery. Remaining parts as in the ♂, the abdominal sternites around the genital aperture dark.

Habitat.—Black Mountain, nr. Canberra, F.C.T., R. V. Fyfe, 25-1-35 (holotype ♂, allotype ♀, paratype ♂♂ and ♀♀); the author, coll. 13-2-36, matured 27-3-36 (paratype ♀♀), and coll. 29-5-36 (paratype ♀♀).

Situation.—Amongst dead, fallen Eucalypt leaves, forming a moist, decaying mass on the ground.

Distribution of Types.—Holotype ♂ on slide, paratype ♂ and allotype ♀ in alcohol, Macleay Museum. Paratype ♂ and ♀ forwarded to the Western Australian Museum, and paratype females forwarded to the British Museum, the National Museum, the Australian Museum, the South Australian Museum, the C.S.I.R. Collection, the Cawthron Institute and the Zoological Museum, Buitenzorg.

Key to the Subspecies of Metoligotoma reducta, *nov.* (♂).

Length of specimens in series examined, 6·7-10·9 mm., av. 8·4 mm.; head-lengths of specimens in series examined, 1·81-1·97 mm., av. 1·92 mm.; colour to the naked eye dull-black .... *reducta*, nov.

Length of specimens in series examined, 12·0-14·2 mm., av. 12·8 mm.; head-lengths of specimens in series examined, 2·93-3·41 mm., av. 3·26 mm.; colour to the naked eye brown .... *ingens*, nov.

Key to the Australian Genera of the Family Oligotomidae (♂).

1. Second segment of left cercus distinctly separated from first by a clear suture, subcylindrical, more than three times as long as thick; right hemitergite of tenth abdominal segment produced backwards from its outer margin to a process, straight or slightly sinuous, at least three times as long as broad (e.g., Fig. 1, 10 RP_1). Hind tarsi with less than two bladders on the second segment. Winged or wingless .... *Oligotoma* Westwood

   Second segment of left cercus reduced or absent; process of right hemitergite not as above. Hind tarsi with two bladders on the second segment 2

2. Second segment of left cercus reduced in length, less than twice as long as thick, and not separated from first segment by a distinct suture; first segment of right cercus subcylindrical, longer than thick. Winged or wingless .. *Notoligotoma*, nov.

   Second segment of left cercus absent; first segment of right cercus reduced, broader than long. Wingless .... *Metoligotoma*, nov.

Relationships of Australian Species.

(The following discussion refers to the males.)

Although the members of the genus *Oligotoma* are less specialized in most characters than those of the genera *Notoligotoma* and *Metoligotoma*, the latter two genera could not have been derived directly from *Oligotoma*, since they possess a very different and rather more generalized right hemitergite.

Taking, then, a hypothetical Oligotomid lacking the outer process to the right hemitergite characteristic of the genus *Oligotoma*, we can on the one hand reach, from such an ancestor, the simplest of members of the genus *Oligotoma* (such as *O. latreillei* (Ramb.)), and, on the other, such genera as *Notoligotoma* and *Metoligotoma*.

From a generalized species of *Oligotoma* the three autochthonous Australian species of this genus are derived chiefly by various modifications of the process of the left hemitergite (terminating in *O. gurneyi gurneyi* Frogg. and subspecies in a simple hook, an advance on the Sumatran *O. vosseleri* (Krauss), in which it lacks any terminal process; in *O. glauerti* Till. in an anchor-like appendage; and in *O. tillyardi*, nov., in a forcipate structure convergent to that in the Embiid genus *Rhagadochir*). Concomitant with this is the development of the first segment of the left cercus; from the primitive subcylindrical type, the inner process is developed (as in the series *O. gurneyi* Frogg. *subclavata*, nov., *O. gurneyi gurneyi* Frogg., and *O. gurneyi* Frogg. *spinulosa*, nov.), and becomes greatly exaggerated in *O. glauerti* Till. and *O. tillyardi*, nov. Other minor differences, as in the left cercus-basipodite, also supervene.

On the other hand, the development of the genera *Notoligotoma* and *Metoligotoma* is marked chiefly by the reduction or loss of the second segment of the left cercus, present as a small, unsutured protuberance in *Notoligotoma*, but completely lost in *Metoligotoma*. This loss is convergent to that in the genus *Anisembia*, and is a continuation of the process by which the more generalized recent Embioptera with two-segmented cerci on both sides developed from their Permian ancestors with many-segmented cerci on both sides. The reduction or loss of the second segment of the left cercus in *Notoligotoma* or *Metoligotoma* can likewise be traced in ontogeny, when it is gradually resorbed in the last ecdysis, the penultimate instar possessing normal cerci with two subcylindrical segments on both sides. In *Metoligotoma*, the first segment of the right cercus is also reduced.

In both these genera, the hind tarsi develop an extra bladder. *Metoligotoma*, however, is probably not derived directly from *Notoligotoma*, as its right hemitergite has an altogether different form of process, and its left cercus-basipodite is more primitive.

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Postscript, added 27th August, 1936.—Since the completion of this paper, information has been received from Dr. Lieftinck that the Embioptera which were forwarded to the Zoological Museum, Buitenzorg, Java, have now been transferred to the Museum of Natural History at Leyden, Holland.

STUDIES IN AUSTRALIAN EMBIOPTERA.

PART II. FURTHER NOTES ON SYSTEMATICS.

By CONSETT DAVIS, B.Sc.
(*From the Zoology Department, Sydney University.*)

(Plate xii; seven Text-figures.)

[Read 28th October, 1936.]

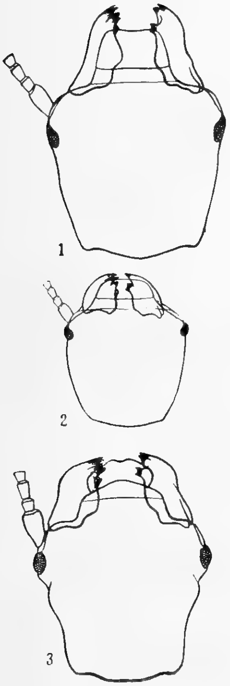
Since the completion of the first paper of this series (Davis, 1936), two interesting new species have been discovered. Since material of both of these species is being used for anatomical and embryological study, it is necessary to describe them forthwith. This paper is accordingly to be regarded as supplementary to the former paper, and the prefatory remarks to, and methods used in, that paper apply here also.

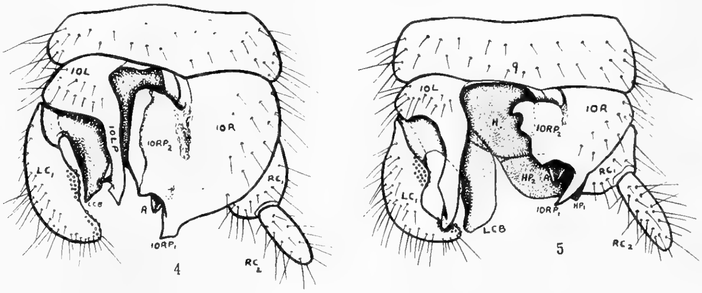
Genus METOLIGOTOMA Davis.

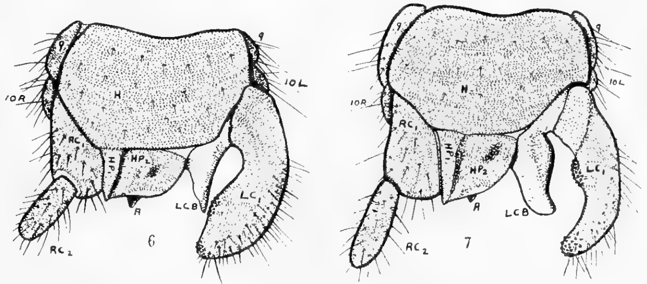
METOLIGOTOMA PENTANESIANA, n. sp. Figs. 1, 2, 4, 6.

♂.—*Length* 6·3–9·7 mm., av. 8·0 mm. Ratio head:thorax:abdomen, 10:16:22 (lengths). *Colour*: Living specimens appear dull greyish-brown to the naked eye. Details of the colour of preserved specimens are as follows: Head deep golden-brown with darker symmetrical tracery, eyes black. Sclerites of thorax and abdomen, dorsally dark brown, paler symmetrical pattern on pronotum, paler mottling on mesoscutum and metascutum, and paler mid-dorsal line in abdominal region (as in *M. reducta reducta* m., ♀). Ventrally, sclerites brown with paler areas, especially on anterior abdominal sternites; hypandrium very dark brown. Segments of antennae, legs and cerci golden-brown. Intersegmental membranes cream. *Head*: Length 1·40–2·12 mm., av. 1·69 mm. Ratio of length to maximum breadth 10·0:8·1. The variation in head-structure in adult males is interesting, some (fig. 1) having the head with almost straight lateral margins, converging posteriorly, as in *M. reducta reducta* m., ♂; in others (fig. 2), the lateral margins of the head are noticeably convex, and rounded off posteriorly, as in adult females of the family—that is, the larval form is fairly closely retained. Mature males with larviform heads have been noted very rarely in *M. reducta reducta* m. and *M. reducta ingens* m., but in this species the occurrence is frequent. *Antennae*: Maximum number of segments observed, 18; maximum total length, 3·6 mm. Four basal segments with lengths typically in the ratio 5:2:3:2; distalia subcylindrical, margins straight and diverging distally. *Mouthparts* with mandibles similar to those of *M. reducta reducta* m., ♂: the left with two sharp, inwardly-directed teeth distally, two blunter teeth behind these, and posterior to them a blunt process on the inner margin; the right with two fairly sharp distal teeth, directed inwards, and a bilobed tooth behind these on the inner margin (fig. 1). In males with head-structure approaching larviform, the mandibles are intermediate between those described above and those present in the immature stages (fig. 2). *Thorax*, *legs and abdomen* (except terminalia) as in *M. reducta reducta* m., ♂. *Wings* absent.

Terminalia (figs. 4, 6): Tenth tergite divided longitudinally into left and right hemitergites (10 L, 10 R respectively). 10 R and its processes 10 RP$_1$, 10 RP$_2$, similar in general form to those in *M. reducta reducta* m., but with 10 RP$_1$ terminating more bluntly, and 10 RP$_2$ of different form, the left-hand part being only very weakly chitinized. Segments of right cercus (RC$_1$, RC$_2$) as in *M. reducta reducta* m.; 10 L small, and giving rise to a process (10 LP) from the posterior limit of its inner margin. 10 LP sinuous, somewhat slender, ending bluntly, and giving off dorsally a sharp spine, directed towards the left, near its posterior extremity. Left cercus (LC$_1$) one-segmented, with minute nodules at its posterior extremity and on a rounded protuberance half-way along its inner margin. Left cercus-basipodite (LCB) projecting backwards between base of LC$_1$ and hypandrium to a tapered point; LCB membraneous except along its outer margin. Right cercus-basipodite wanting. Hypandrium (H) and its







Figs. 1-3.—Dorsal view of heads of adult males, showing mandible structure. × 12½. 1. *Metoligotoma pentanesiana*, nov., fully developed head; 2. *M. pentanesiana*, nov., head capsule of mature male retaining larviform features; 3. *M. extorris*, nov.

Figs. 4-5.—Dorsal view of male terminalia. × 25. 4. *M. pentanesiana*, nov.; 5. *M. extorris*, nov.

Figs. 6-7.—Ventral view of male terminalia, certain dorsal structures omitted. × 25. 6. *M. pentanesiana*, nov. 7. *M. extorris*, nov.

(9. Ninth abdominal tergite; 10 L, 10 R, left and right hemitergites of tenth abdominal segment; 10 LP, process of 10 L; 10 RP$_1$, 10 RP$_2$, outer and inner processes of 10 R; RC$_1$, RC$_2$, first and second segments of right cercus; LC$_1$, one-segmented left cercus; LCB, left cercus-basipodite; H, hypandrium; HP$_1$, HP$_2$, appendages of H; A, membraneous structure possibly representing aedeagus.)

appendages (HP_1, HP_2) as in *M. reducta reducta* m. Between HP_2 and 10 RP_2 there projects a conical, membraneous structure, chitinized medially (A); this may represent the aedeagus, but appears to be placed further dorsad than usual for this structure, so that it may belong morphologically, not to the aedeagus, but to the right hemitergite.

♀.—*Length* 8·0–10·6 mm., av. 9·4 mm. Head:thorax:abdomen in the ratio 10:19:27. *Colour*: Living specimens appear dark brown, without the greyish hue seen in the male; and there is more of the cream intersegmental membrane in evidence. In detail, preserved specimens have the same coloration as the male, somewhat paler, and the sternites around the genital aperture are very dark brown. *Head*: Length 1·47–1·82 mm., av. 1·69 mm. Ratio of length to maximum breadth, 10·0:8·5. Structure normal for the family. *Antennae*: Maximum number of segments observed, 16; maximum total length, 2·6 mm. Segments as in *M. reducta reducta* m., ♀. *All other characters* as in *M. reducta reducta* m., ♀.

Habitat.—Most northerly of the Five Islands, near Port Kembla, N.S.W., the author, 2.8.36 (paratype ♂) and 13.9.26 (holotype ♂, allotype ♀ and long series of paratype ♂ and ♀).

The island on which the insects were collected is an isolated trachy-andesite mass, more than a mile from the shore. The portion of the island not subject to wave action is approximately 100 yards in diameter (Pl. xii, fig. 1).

Situation.—Forming galleries under and between stones, among dead vegetation (especially of *Enchylaena tomentosa* and *Mesembryanthemum aequilaterale*), and among the fleshy stocks of the herb *Plectranthus parviflorus*.

Disposition of Types.—Holotype ♂ (in clove oil), allotype ♀ and paratype ♂ (in alcohol), Macleay Museum, Sydney University. Paratype males and females forwarded to the British Museum, the Australian Museum, the National Museum, the South Australian Museum, the Western Australian Museum, the C.S.I.R. collection, the Cawthron Institute and the Leyden Museum.

METOLIGOTOMA EXTORRIS, n. sp. Figs. 3, 5, 7.

♂.—*Length* 11·4–14·1 mm., av. 12·5 mm. Head:thorax:abdomen in the ratio 10:17:23. *Colour*: Head black, tergites of thorax and abdomen dark brown, the pronotum with paler symmetrical pattern, the mesoscutum and metascutum with a paler median line fading out in the abdominal region. Ventrally, sclerites brown with paler areas, especially in the abdominal region. Hypandrium very dark brown; segments of legs golden-brown, of cerci and antennae dark brown. Intersegmental membranes cream. *Head* (fig. 3): Length 2·23–2·77 mm., av. 2·51 mm. Ratio of length to maximum breadth, 10·0:7·9. Eyes small, but prominent for the genus; behind the eyes the lateral margins of the head expand in another protuberance, then converge to the posterior limit, where a fairly sharp angle is formed on each side. *Antennae*: Maximum number of segments observed, 18; maximum total length, 4·1 mm. Four basal segments with lengths typically in the ratio 5:2:3:2; distalia as in the previous species. *Mouth parts* with mandibles (fig. 3) having teeth disposed as in the previous species. *Thorax, legs and abdomen* (except terminalia) as in *M. reducta reducta* m., ♂. *Wings* absent.

Terminalia (figs. 5, 7): Disposition as in *M. reducta reducta* m. and *M. pentanesiana*, nov., with the following points of difference: (1) The process 10 RP_1 is slender and smoothly tapered; (2) the process 10 RP_2 is of different shape, and the left-hand margin, weakly chitinized, has a crenulate appearance; (3) the process 10 LP, simple in *M. reducta* m. and subspecies, and bearing a prominent spine in *M. pentanesiana*, nov., has a slight dorsal projection near its termination. 10 LP is somewhat stouter than in the other species, and 10 L smaller; (4) the left cercus (LC_1) curves in distally to a finger-shaped process, bearing minute nodules; minute nodules are also present on a rounded protuberance on the inner margin of LC_1; (5) the left cercus-basipodite (LCB) is a very large membraneous structure, running back to a rounded extremity. LCB chitinized only along its outer margin.

♀.—*Length* 9·4–15·0 mm., av. 12·2 mm. Head:thorax:abdomen in the ratio 10:23:35. *Colour*: Head golden-brown with dark brown symmetrical tracery. Tergites of thorax and abdomen dark brown, pronotum with golden-brown symmetrical pattern, mesoscutum and metascutum with paler mottling, abdominal tergites with a pale mid-dorsal line. Ventrally dark brown with paler areas; abdominal sternites 1–7 dark only at lateral margins, abdominal pleurites dark brown. Sternites 8 and 9 dark throughout. Segments of antennae, legs and cerci golden-brown; intersegmental membranes cream. *Head*: Length 1·53–2·12 mm., av. 1·79 mm. Ratio of length to maximum breadth, 10·0:8·0. Structure normal for the family. *Antennae*: Maximum number of segments observed, 18; maximum total length 3·1 mm. Segments as in *M. reducta reducta* m., ♀. *All other characters* as in *M. reducta reducta* m., ♀.

Habitat.—Brush Island, near Ulladulla, N.S.W., the author, 6.9.36 (holotype ♂, allotype ♀, paratype males and females). Brush Island (Pl. xii, figs. 2, 3) is a doleritic mass, approximately half a mile in length, less than half a mile from the mainland at Murramarang Point, some twenty miles south of Ulladulla.

Situation.—Forming galleries amongst dead vegetation, particularly inside the hollow stems of dead plants of *Tetragonia expansa*.

Disposition of Types.—Holotype ♂ (in clove oil), allotype ♀ and paratype ♂ (in alcohol), Macleay Museum. Paratype males and females forwarded to the British Museum, the Western Australian Museum and the National Museum.

Key to the Species of Metoligotoma (♂).

1. Left cercus finger-shaped distally (fig. 5) .... *extorris*, nov.
   Left cercus not as above 2
2. Process of left hemitergite of tenth abdominal segment simple .... *reducta* m.
   Process of left hemitergite of tenth abdominal segment with a prominent dorsal spine .... *pentanesiana*, nov.

Discussion.

The species *Metoligotoma extorris* and *M. pentanesiana* are interesting from the point of view of evolution; both apparently represent species formed under the influence of isolation by some form of orthogenesis (in the literal sense, that is, not implying any directive force).

Both islands have been separated from the mainland by erosion of sedimentary rocks lying between, and it is probable that a large part of the fauna and flora is relict from the time of separation.

The environment is similar in each case, though varying slightly from that on the mainland.

The developments of the process of the left hemitergite of the tenth abdominal segment are particularly important, when we remember that this process has developed a forcipate appendage twice within the order by convergence (*Rhagadochir* spp., *Oligotoma tillyardi* m.). The spine developed in *M. pentanesiana* appears to be the initiation of a similar structure, but as yet it would appear to have no functional importance, as in *O. tillyardi* m., so that an explanation of its development by selection would be incorrect.

Reference.

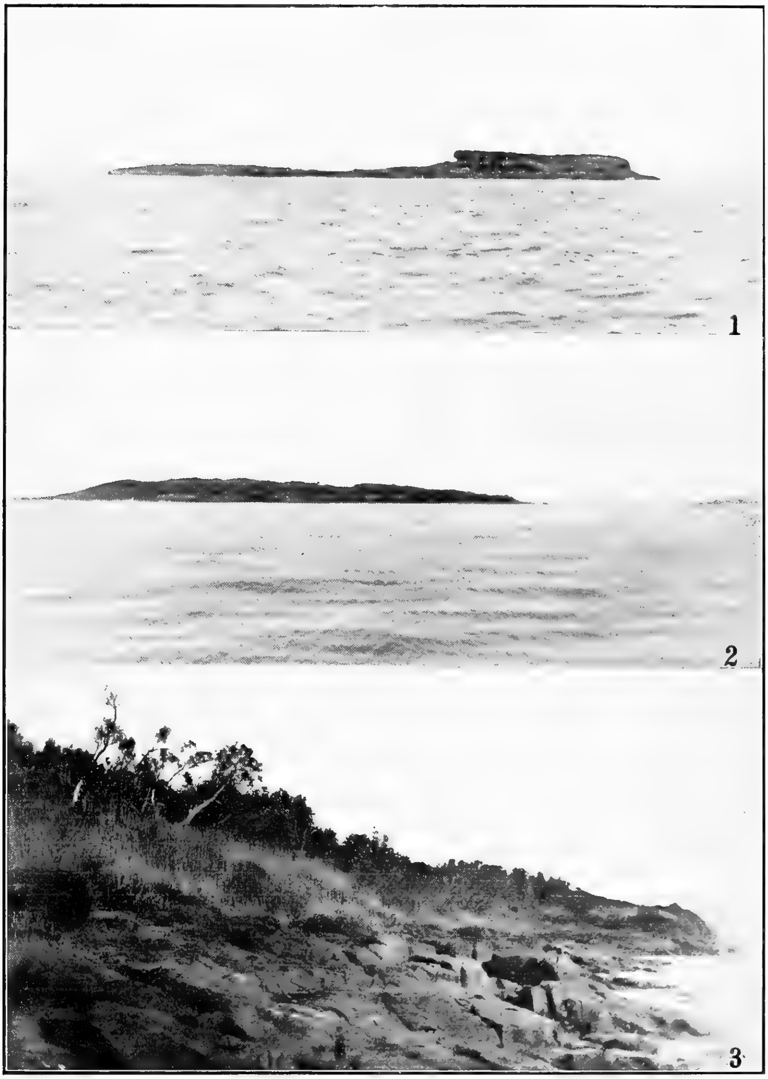
DAVIS, C., 1936.—Studies in Australian Embioptera, Part I: Systematics. PROC. LINN. SOC. N.S.W., Vol. lxi, p. 229.

EXPLANATION OF PLATE XII.

Fig. 1.—Most northerly of the Five Islands, off Port Kembla, N.S.W.

Fig. 2.—Brush Island and Murramarang Point, near Ulladulla, N.S.W.

Fig. 3.—Situation on Brush Island where *Metoligotoma extorris* occurs.



1.—Most northerly of the Five Islands, off Port Kembla.
2, 3.—Brush Island, near Ulladulla.

NOTES ON AUSTRALIAN DIPTERA. XXXVI.

By John R. Malloch, Arlington, Virginia, U.S.A.
(*Communicated by Frank H. Taylor, F.R.E.S., F.Z.S.*)

(Four Text-figures.)

[Read 28th October, 1936.]

The paper now presented furnishes descriptions of two remarkable Australian Diptera regarding the family location of which there is at least an element of doubt. I have long deferred dealing with them because of my intention to present a comprehensive synoptic key to the so-called acalyptrate Diptera, and these and other confusing species have been largely responsible for a protracted delay in bringing my paper to completion. I am now publishing the descriptions as a step towards the elimination of the problem of the family status of the two Australian species.

Family Asteiidae.

Without going into the question of the distinctness of this group from the Drosophilidae, I provisionally place herein the new genus described below.

Nothoasteia, n. gen.

Generic characters.—Wing venation much as in *Liomyza* Macquart, but the outer cross-vein is lacking and the sixth vein is well developed though incomplete (Fig. 1). Head wider than thorax, flattened, the frons broad, eyes elongate (Fig. 2); antennae with the third segment broken off in type, probably short and rounded at apex; frontal bristles weak, one vertical on each side rather noticeable, the ocellars not distinguishable; eyes stiff short-haired. Thorax slender, slightly convex above, the humeri tumid, with one short bristle and some hairs; notopleurals short; scutellum short, but both it and the posterior part of the mesonotum so much damaged by the pin that exact details can not be ascertained. Legs moderately long and strong, with no distinct bristles, rather numerously haired.

Genotype, the following species.

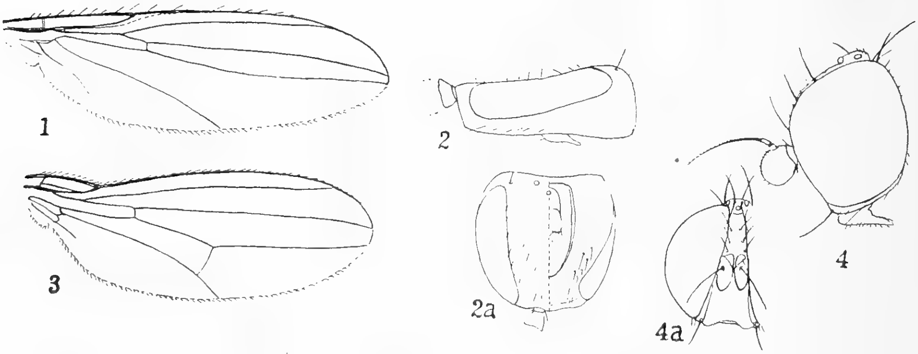
Nothoasteia platycephala, n. sp. Figs. 1, 2.

Head testaceous yellow, frons darkened above and with grey dust on the dark part, the orbits yellow, vertex brown, darkest at ocelli; hairs yellow. Thorax yellow, the mesonotum shiny black and slightly grey-dusted; scutellum apparently black. Legs entirely yellow. Wings hyaline, veins pale. Abdomen largely destroyed, but dark at base, the sex of the specimen indeterminable. Halteres cream-coloured.

Head as in Figures 2 and 2*a*, distinctly wider than thorax, partly abraded so that exact details of the bristling can not be given. The flattened and widened form is different from that of any genus of Asteiidae known to me, the only approach to it being found in a Hawaiian genus that differs in having the second wing-vein much shorter and in other details. Humeri quite prominent, prosternal plate small. Legs with numerous pale hairs and no bristles, all femora rather thick, the hind pair distinctly longer than their tibiae. Wings narrow, rather pointed, costa to apex of fourth vein, with some fine costal hairs (Fig. 1). Length, 2·5 mm.

Type, Brisbane.

It is possible that careful search on the inner sides of windows, and especially those of outhouses, will produce specimens of this interesting species, and so provide material for a thorough examination of features not preserved in the damaged type specimen.



Figs. 1-2*a*.—*Nothoasteia platycephala.* 1, wing; 2, head in profile; 2*a*, head from above on left, from below on right.

Figs. 3-4*a*.—*Waterhouseia cyclops.* 3, wing; 4, head of male in profile; 4*a*, head from in front, incomplete.

Family ANTHOMYZIDAE.

My reason for placing the new genus described below in this family is that the wing venation and presence of vibrissae appear to associate it most closely with this group. The extremely narrow frons, however, sets the genus apart, and several other characters, such as the markedly convex mesonotum, serve to distinguish it from any genus known to me. I admit that the assignment to Anthomyzidae is tentative and subject to rectification upon discovery of the female, as that sex may provide characters that will throw a new light upon the relationships.

WATERHOUSEIA, n. gen.

Generic characters.—Distinguishable from any acalyptrate genus by the remarkable structure of the head (Fig. 4), the eyes covering almost the entire sides, and the frons in front of the ocelli reduced to not more than one-sixth of the head-width, widening gradually to anterior margin. The bristles consist of three pairs of orbitals, the ocellar pair, four verticals, the inner pair much longer than the outer, and a divergent pair of postverticals. The vibrissae are well developed, the eyes are extremely short haired, the proboscis is short and fleshy, and though the palpi do not show in the type specimen they are no doubt present. The arista is subnude. Thorax highly arched, with the following bristles: 1 humeral, 2 notopleurals, 1 presutural, 1 supra-alar, 2 postalars, 2 or 3 pairs of dorsocentrals, 4 scutellars, and 2 sternopleurals. Postscutellum well developed.

Legs normal. Wing as Figure 3. Abdomen elongate, slender, cylindrical, the hypopygium small.

Genotype, the following species.

WATERHOUSEIA CYCLOPS, n. sp. Figs. 3, 4.

Male.—A shiny black species, with the mesonotum dull black, the venter of abdomen and the tibiae and tarsi brownish-yellow, wings slightly smoky, veins black, halteres with yellow stalks and black knobs.

Head as wide as thorax, occiput excavated in centre above, face almost flat; genae linear, parafacials invisible in profile (Fig. 4); frons very narrow (Fig. 4*a*). Mesonotum much elevated, with many decumbent stiff black hairs. Scutellum bare except for the 4 marginal bristles. Legs shrunken in type, the fore femora apparently with series of well developed bristles on the anterodorsal and posteroventral surfaces, the hind femur with an outstanding bristle on anterior surface beyond middle, mid legs broken off; preapical tibial bristle lacking. Wings as Figure 3. Length, 3 mm.

Type, Blue Mts., N.S.W., 15.4.1922 (Ferguson). In Health Dept. collection.

The genus is dedicated to Dr. G. A. Waterhouse in recognition of his assistance in presenting several of this series of papers to the Society.

Corrigendum.

In "Notes on and Descriptions of New Species of Australian Diptera", by John R. Malloch, *Australian Zoologist*, viii, pt. ii, 1935, p. 87, the reference to *Ichthyomyia* de Meijere, *Tijdschr. v. Ent.*, lviii, 1913, 382, should read *Ichthyomyia* de Meijere, *Nova Guinea*, ix, Zoolog., Livr., iii, 1913, 382.

PROBLEMS IN THE GEOLOGY OF NEW CALEDONIA.

By H. I. **Jensen**, D.Sc.

(With a note on the petrology of a small collection of schists, by
Germaine A. Joplin, B.Sc., Ph.D.)
(*Communicated by Professor L. A. Cotton.*)

(One Text-figure.)

[Read 28th October, 1936.]

Introduction.

New Caledonia was so named by Captain Cook because of the resemblance of its east coast to the west coast of Scotland, rugged mountains and deep fiords lining the coast. New Caledonia is a country whose mountainsides are deeply indented with hollows, furrows, ravines and deep valleys.

Geological Constitution and Physiography.

The geological constitution of New Caledonia causes its physical features to possess a unique character. Excepting the north-eastern portion of the island, which is intensely metamorphosed, most of New Caledonia is composed of serpentine and Mesozoic sedimentary rocks, mingled with andesitic lavas and breccias of an easily decomposable nature.

The serpentines which form high mountains and ranges are largely untimbered, probably because of the high magnesia content of the soil, though the lower slopes composed of serpentine rubble are often covered with a dense scrub of wattle (a species of *Acacia* locally known as '*guiac*'), and of she-oak (a species of *Casuarina* locally termed '*bois de fer*').

The andesitic soils are lightly timbered with tea-tree (*Melaleuca* sp. locally known as '*niouli*') and this timber grows more thickly and is the dominant wood on the sedimentary formations. However, in the alluviated valleys in the niouli (tea-tree) country we often find dense scrubs similar to those of north Queensland rivers, in which many of the trees seem to be close allies of those occurring in Queensland scrubs. On the high plateaux in many parts there are scrubby valleys in which the kauri pine flourishes. Yet, generally speaking, the natural vegetation is extremely monotonous, especially as the settled parts of the island consist mostly of the fertile sedimentary and volcanic areas in which the forest is almost entirely one of paper-bark tea-tree (niouli). Of course today much of this country is variegated with introduced plants, amongst which guava, lantana, and sida-retusa figure largely.

It would seem that the whole island must have been inundated with lavas and submerged beneath the ocean in late Mesozoic times, so that all vestiges of early plant and animal life were destroyed, and later, upon re-emergence, it is probable that the seeds of hardy plant species have been carried on driftwood from Australia and from the Solomon Islands in the early Tertiary to initiate the present flora. The animal life supports the same supposition. There were no mammals, nor marsupials, in New Caledonia before the voyage of Captain Cook, and only one small reptile, a little lizard, the ancestors of which also might have arrived on pieces of driftwood.

Geological History.

The island of New Caledonia is a remnant of a once continuous continent, the Melanesian plateau, which extended westwards to Eastern Australia and New Guinea, and south perhaps to New Zealand. Its separation from these lands was not, like the destruction of Atlantis, an affair of the geological yesterday. It dates back to the Mesozoic period. Since then the whole island has been under the sea, has been inundated with lavas, partly submarine, partly terrestrial, has been overturned, folded, plicated and faulted by great convulsions and earth movements, and re-elevated by forces which had their origin in titanic pressures emanating from the ocean depths to the east.

It seems most reasonable to suppose that the hinge line dividing the essentially oceanic Pacific trough from the submerged, collapsed and foundered Australia–Melanesian plateau passed, in early Mesozoic times, along the great volcanic line, which runs through New Zealand, White Island, Tonga, the New Hebrides and Solomons to New Guinea. New Caledonia was the scene of marine transgressions in the Mesozoic, during which Triassic and Cretaceous sedimentary rocks were laid down, with interludes of land conditions during which the coal beds were formed. The siliceous sandstones and aluminous shales of these periods must have been derived from continental rocks such as granite, or sedimentary rocks derived from granite. They were laid down in shallow water under oscillating conditions, as shown by coal-beds in them. The limestones of these periods are also of such a nature as to suggest shallow-water conditions. The contemporary lavas, tuffs, breccias and agglomerates are mostly andesitic, therefore neither truly oceanic nor truly continental; occasionally thin sheets and dykes of trachyte occur in them.

Fossils are not usually abundant, but do occur in abundance in a few places. Even then they are usually very crushed as a result of earth-movements and are not often identifiable as regards species. Yet the early French geologists, Garnier, Heurteau and Pelatan, succeeded in identifying a fair number and definitely found several species identical with those of the Triassic and Cretaceous of New Zealand. Indeed, New Zealand, both in its sedimentary and volcanic sequence, is much akin to New Caledonia, but New Caledonia has undergone the more intense subsequent earth-movements.

The Mesozoic sediments of New Caledonia have all been strongly folded. In the southern half of the island it is easily seen that the folding becomes rapidly more intense as we proceed from west to east towards the edge of the serpentine, near which overfolding and plication are common. The serpentine intrusions were apparently the cause of the pressure and thrust movements producing the folding, as well as of a considerable amount of faulting, crush and shearing.

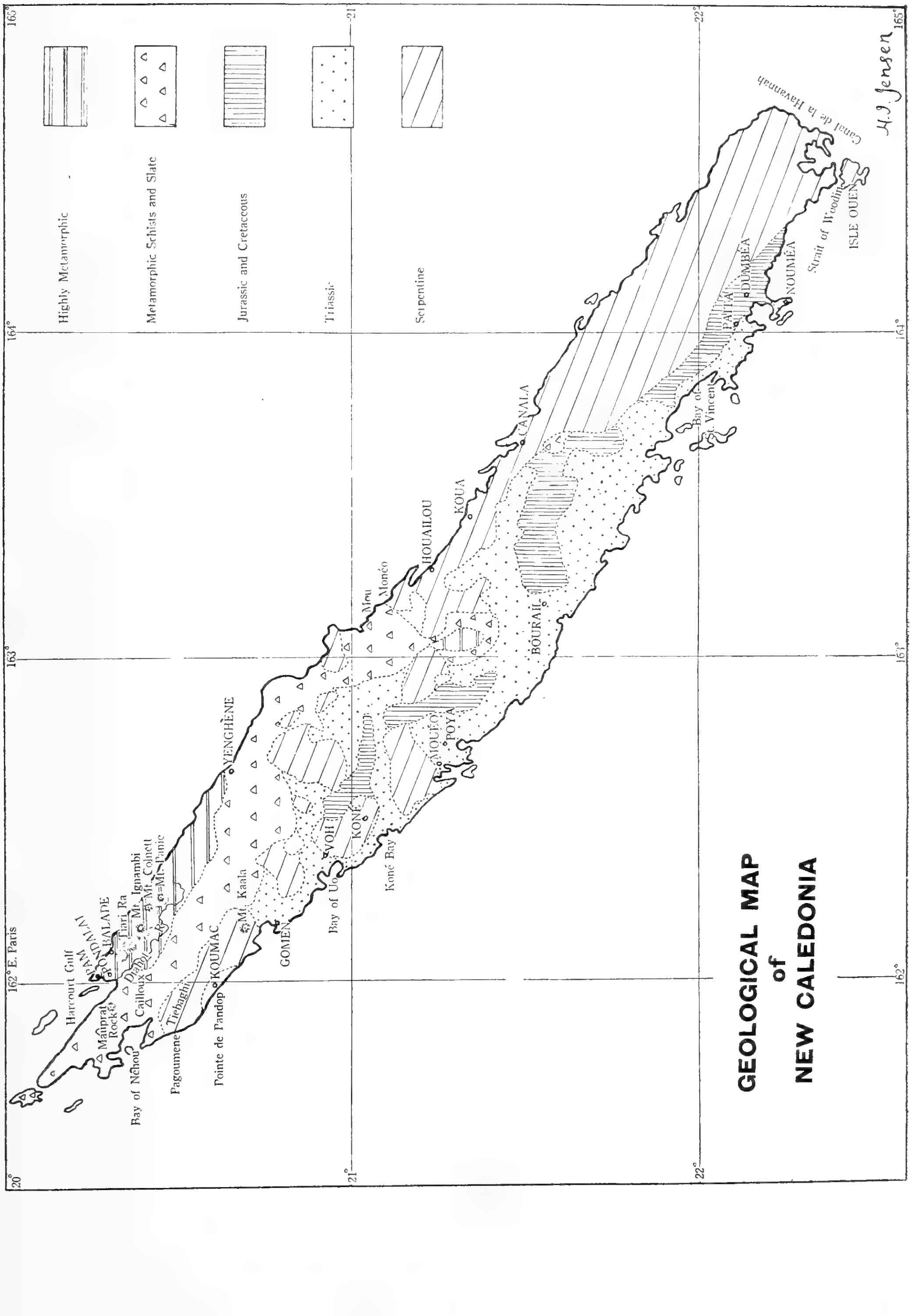
The dip seldom remains constant in direction or angle for any great distance. For example, Noumea is built on andesitic lavas, tuffs, breccias and sedimentary rocks of Jurassic–Cretaceous age. The southern suburbs are partly on sandstone and limestone moderately folded. East of the town there are high hills composed of volcanic tuffs, breccias, agglomerates and conglomerate, the latter containing a mixture of andesite, sandstone, limestone, chert and shales. The volcanic tuffs and breccias near the north end of the town about the railway station dip to the south-south-west at a regular angle of about 30°. The same series under the Catholic Cathedral at the south end of the town dips north-east at steep angles—from 45° to 70°—and the beds are frequently plicated and contorted by crush. The breccias and tuffs east of the town change frequently in dip, the road-cuttings showing numerous minor folds. The most regular bedding that I have noticed in New Caledonia was in the Bourail district, where the Mesozoic rocks dip eastwards near the west coast, then change to westerly dip which prevails to a few kilometres east of Bourail, when the dip again becomes easterly and subject to plications as the serpentine is approached.

Near Paita the Mesozoic sedimentaries are steeply inclined, vertical in places, in others overfolded. Again, near Dumbéa, calcareous shales, limestones and coal-beds of Cretaceous age have been intensely crushed and are standing almost vertically in places. Yet, generally speaking, the sedimentary rocks occurring west of the serpentines are not metamorphosed. On the other hand, the sedimentary rocks occurring east of the serpentine belt in the north part of the island are not only steeply folded and plicated, but are intensely metamorphosed as well, sandstones being changed to quartzite and sandy schist, shales to aluminous schist and limestone to crystalline limestone. Yet in this schist series east of Koumac Cretaceous fossils have been obtained. Thus the highly schistose series developed east of the serpentine belt is, at least in part, coeval with the less altered sedimentaries.

The Metamorphics.

The metamorphic rocks east of Koumac just referred to are, as far as the Diahot River, schistose but not highly crystalline, though in a few places on the Divide they grade locally into mica-schist with glaucophane-schist. Judging by the composition of the schistose rocks east of the Diahot, the composition of the soils on them and by the vegetation, quite apart from the paucity of fossil evidence, I consider this series altered Mesozoics. The Diahot River divided this series from a block of high mountain country, with peaks more than 5,000 feet high, consisting of intensely crystalline, and coarsely crystalline metamorphic rocks which comprise ordinary mica-schist, micaceous phyllite, coarsely crystalline quartzite, garnetiferous quartzite, amphibolite and glaucophane schist, and a vast proportion of schists which contain variable proportions of muscovite, glaucophane, other amphiboles and garnet. These glaucophane schists are probably all derived from volcanic lavas and tuffs, and from semi-tuffy sedimentary rocks. Since the schistose series west of the Diahot valley passes in places into crystalline schists of the same type as those east of the Diahot, it is my opinion that the great crystalline schist series of north-eastern New Caledonia is derived from the same kind of Mesozoic sedimentaries with interstratified tuffs, breccias and melaphyres as extend in the unmetamorphosed form through the western part of the island.

Several of the French geologists have regarded the crystalline schists of the north-east as a very old formation comparable with the Ordovician of Victoria. I am, however, inclined to regard them as the same Mesozoic agglomeration of strata as in the west of the island, which has been completely fused up and recrystallized by having been lowered or foundered into the zone of fusion. It has been subsequently re-elevated by the thrusts accompanying and following the extrusion of the serpentines. In many places in the crystalline schist area east of the Diahot we get semi-serpentinized rocks and amphibolites, parts of which are but little altered and which bear the closest resemblance to the vesicular andesite and melaphyre in other parts of the island.



GEOLOGICAL MAP of NEW CALEDONIA

Earth Processes and the Serpentines.

To understand fully the processes which have taken place it is necessary to comprehend the distribution of the serpentines in New Caledonia. The entire southern end of the island is serpentine. On the west coast the Mesozoic sedimentaries commence to show half-way between the south end of the island and Noumea, attaining its maximum width in the vicinity of Bourrail, and the main serpentine axis hugs the east coast northwards as far as Houailou (Wailou). Here the serpentines leave the east coast and the axis passes to the centre of the island as far as Poya and then the serpentine belt swings over to the west coast. From Mouéo north the serpentines largely squeeze out the sedimentary series, of which pockets are left at Voh, Gomen and Koumac, but the serpentine has become the dominant west-coast formation. The serpentine belt is very continuous to Koumac, then is lost for a score of kilometres, apparently covered by Tertiary sedimentary formations, but resumes in the dome of Tiebaghi north of Koumac. As mentioned before, west of the serpentine belt the sedimentaries are folded and even contorted near the serpentine, but not metamorphosed, while east of the serpentine belt they are metamorphosed. West of the serpentine belt all the limestones are ordinary limestone, east of it they are crystalline limestone.

The more highly metamorphosed nature of the rocks east of the serpentine is easily explained on the supposition that the basic lavas now altered to serpentine (originally peridotite and dunite), were thrust up from the oceanic depths east of New Caledonia between that island and Tonga, and advanced as a sill under the Mesozoic sedimentaries for a considerable distance before breaking through. The roof rocks of the intrusion were therefore subjected to much more metamorphism and plication than the rocks underlying the intrusion, the heat of the intrusion causing expansion of strata, shearing movements, and schistosity.

This, while explaining the greater schistosity of the rocks east of the serpentine belt, does not explain the greater metamorphism of the titanic block east of the Diahot which is further from the serpentine belt. But if we imagine a portion of the roof rocks to have subsided into the zone of fusion, into a cauldron, so to speak, of molten peridotite magma, it is easy to understand its complete metamorphism. A further movement of the still plastic peridotite magma has subsequently pushed this intensely altered block up again so that it now over-rides the serpentines and the less altered metamorphics.

The crystalline schists form the highest country in New Caledonia. Mt. Ignambi, Mt. Colnett and Mt. Panie exceed 5,000 feet in height. There are dykes and masses of serpentine included in the crystalline complex.

In the country immediately near the Diahot several shear zones strike NNW. and NW., consisting largely of quartz and chlorite, and dipping steeply to the east. These quartz-chlorite zones have developed in the crush material of the movement planes of the last big thrusts. The intensely metamorphosed crystalline schist block rides on these great shear zones, and is portion of the super-serpentine roof rock which has been engulfed in the zone of fusion, pushed up again by further thrusts from the east. Great movement planes and master joints in the crystalline series dipping east indicate a dragging differential movement. Thrusts from the south also took place, developing another set of master joints with movement on them dipping south-east. In some places there have been pressure movements causing gliding planes in so many directions that we get schists weathering out into masses like logs of wood each 5 to 6 feet long and about 2 feet in diameter. That may be well seen on the Balade Road about half a mile from the Cailloux.

It is seldom possible to determine the original dip of the crystalline schist masses. The dips within them are cleavages parallel to movement and thrust planes and at right angles to cooling planes. They are in fact controlled by the major joint directions.

A belt extending from Pondalai to Fern Hill shows a general south-westerly dip at gentle to moderate angles west of the Cailloux–Pam road, but within the belt there are several reversals and contortions. This belt lies west of the great quartz-chlorite shear-zones. The rocks within it are not as highly crystalline as those east of it. There are many quartz reefs in it running mostly north and south. In the Tiari and Reussites range, east of the main quartz-chlorite shear, the dip changes to easterly and the same east to south-east dip at steep angles is maintained east of the road to Pam. But it is far from constant, for at the Balade Mine the dip is again south-westerly. On and along the east coast the dip is generally easterly, with numerous deviations, but in the whole of the mass between the Diahot River and the east coast there are thrust-planes and strong joints developed by crush and movement, the latter shown by alteration to chlorite and deposition of quartz, dipping south-east in the south-eastern part of the massif, easterly in the central part and north-east in the northern part. The effect of these thrust-planes is to produce long regular slopes on the east coast, where the thrust-planes and dip usually agree, and a rough serrated configuration in the western part of the massif.

The rocks of the massif comprise mica-schist, sericite-schist, talc-schist, quartzite, garnetiferous quartzite, garnet-rock, amphibolite, serpentine, glaucophanite, tremolite, and a variety of gneissic mixtures grading from one of these to the others.

The country west of the Diahot right to Koumac is metamorphic, but not so strongly. It is, however, folded to such an extent that for a distance of eight kilometres across the central range, at right angles to the strike, the beds stand vertical or nearly so. On the east side of the central point, the Crescent, there is a tendency to an easterly dip and on the west side to a westerly dip. The country, therefore, suggests a strongly compressed anticline, in each limb of which the same big body of crystalline limestone is represented. The other rocks are clay-schist, slate, sericite-schist, arenaceous schist, interbedded andesite, andesitic tuff and breccia, all traversed by quartz veins and reefs. There is minor folding between this anticline and the Tiari-Panie massif which probably sits on the geosyncline or partly on the geosyncline and partly on the eastern flank of a smaller anticline which occupies the line of the Diahot and Mauprat Rock, in which rock and adjacent hills the limestone belt is again repeated.

Age of the Serpentine.

The age of the serpentines is post-Mesozoic and earlier than Pliocene. The upper Tertiary (probably Pliocene) rocks west of Koumac overlie the serpentines, and conglomeratic beds in them contain pebbles of serpentine and jasper; the Miocene in the south of the island also overlie serpentine. Hence we may regard the serpentine (peridotite dunite) intrusions as Eocene and the grand upheaval of the Tiari–Panie crystalline complex as later, perhaps Miocene.

Comparison of Northern New Caledonia with North Queensland.

The high coastal range of Bellenden Ker and Bartle Frere south of Cairns, continued north of Cairns as the Dividing Range with Mt. Spurgeon and Mt. Windsor, attaining a general height of from 3,000 to over 5,000 feet, and also the high coastal and Dividing ranges north of Princess Charlotte Bay give a physiographic resemblance between these parts of the Queensland coast and the crystalline Panie mass of north-eastern New Caledonia. It has been suggested by Dr. H. C. Richards that possibly the 2,000-fathom Carpenter Deep has controlled the history of the Barrier Reef and possibly the thrusts which have caused movements along the North Queensland Coast (*Trans. Roy. Geog. Soc. Q.*, Vol. 1, n.s.). I have also suggested that the great movements of thrust in New Caledonia had their origin in the enormous deeps to the east of that island.

Here, however, the comparison ends. The great metamorphic-cum-igneous massifs of North Queensland consist of metamorphic rocks with granite intrusions, a 'continental' intrusive magma, while those of northern New Caledonia consist of metamorphics with ultrabasic, that is 'oceanic', intrusives.

The great shear zones and master-joint zones and the dip of the metamorphics in North Queensland are all steeply to the west, while the shears and master-joints and related dip-planes in the Panie massif are all to the east; in the former case the shears dip away from the deep ocean, in the latter towards it. In the North Queensland areas mentioned, the great igneous injections came up from the west and south-west; in the New Caledonian area they came up from the east and south-east.

Hence in the parts of North Queensland mentioned the shears, intrusions, folds, joints and dips were controlled by the wide and deep sedimentation of a subsiding continental mass to the west, whereupon granitic crustal magmas were driven away laterally from the parts most heavily sedimented into the rim of the sedimented area. A wide continental expanse existed east of the present coast which has since foundered. The basic and ultrabasic magmas played only a slight rôle in the process.

In the case of New Caledonia a continent lay to the west, most of which is now foundered. To the east were enormous oceanic deeps at the time of the igneous intrusions. An enormous line of weakness, the great volcanic zone of the Pacific, lay only a short distance to the east. Subsidence and engulfment of sedimentary strata in this zone and subsequent uplift connected with extrusions of magma from the deeps played a large part in the building of New Caledonia.

Comparison with the American Cordillera.

In the American Cordillera we have a coastal range, a central range and the Rocky Mountains. Both the Coastal Range on the west and the Rockies in the east are ge-anticlinal in structure and the formations involved range from Pre-Cambrian to Carboniferous and Mesozoic. The Central Range consists entirely of crystalline schists and granite and is geosynclinal in structure. The eminent French geologist Termier considered the crystalline schists produced by the fusion of folded Carboniferous and Mesozoic rocks in the geosyncline.

The glaucophane-schist series in the Dinaric Alps in Europe are also considered to be derivatives of Mesozoic rocks highly metamorphosed.

There is quite as much reason to consider the New Caledonian crystalline schists to be derived from the Mesozoic sediments by analogous extreme metamorphism.

Evidence of the Ore Deposits on Genetic Relationship between the Sedimentary and Metamorphic Rocks.

In the more volcanic portions of the folded and unmetamorphosed sedimentaries we have many shear zones developed in which the minerals of copper, silver, lead and zinc, often with a little gold, have been precipitated, in my opinion, by lateral secretion. The source of these minerals is metal contained in the hornblende of andesite and andesitic tuff, and hot springs have, at least in some cases, played a part in dissolving it out of the mother rock and precipitating it in shears, as shown by the frequent association of chalcedonic quartz with the lodes.

In the great crystalline schist block east of the Diahot we have the same metals contained in fissure lodes. A system of fissures in two directions at right angles striking 40° and 130° occurs and in them we get copper and silver-lead ore and more or less gold. Neither quartz nor any other mineral suggesting derivation from granitic or dioritic magma is present. The gangue is crush-rock, fault-breccia, kaolin and iron gossan. These lodes, too, owe, in my opinion, the ore content to lateral secretion. The copper of the Balade and Pam Mines, the silver-lead of the Meretrice, the gold of the Fernhill and Reussites, are probably all of this origin and derived from the highly metamorphosed volcanics now represented by glaucophane schist and amphibolite.

Acidic Rocks.

Granite occurs only in two places in New Caledonia, and there only over a small area, namely, at the source of the creeks of Saint Louis and Coulée where it is surrounded by serpentine, and a little more to the north-west in the cirque of Grosses–Gouttes. In both cases it is probable that the granite represents upthrusts of the broken edge of the old continental mass forced up by the serpentine along the great fracture zones which it followed.

Felsitic and trachytic rocks, however, occur as thin sheets and dykes in the mesozoic andesites, and it is interesting to record that similar rocks, but somewhat metamorphosed, are seen among the more basic members of the crystalline schists.

Description of the Coast and Coastal Movements of Recent Times.

The whole of the south end of New Caledonia is composed of serpentine, and the configuration of the coast in this part is indicative of rapid depression. Where subsidence is more rapid than silting up of harbours the deeper inlets are met. We get 30 to 40 metres of water in the strait of Woodin between the mainland and the island of Ouen which is a detached mountain of the mainland that has become separated by rapid subsidence. Further east in the Canal de la Havannah depths of 40 to 60 metres prevail. Along the whole east coast between the coral reef and the mainland as far north as Yenghène the depth of the water ranges from 40 to 70 metres. In the beautiful harbour of Canala, a sunken river valley, depths are 25 to 40 metres. Between the inner fringing reef and the outer barrier reef north of Houailou (or Wailou) and thence to Hienghen (Yenghène) we have depths of from 40 to 70 metres. The harbour of Koua, between Canala and Houailou, opening into a beautiful coastal lake (another sunken river valley), has depths of from 20 to 40 metres. Serpentine coastline with rugged mountains, bare or clad only with a growth of heaths, prevails from the extreme south to Moneo and Mu.

At Mu, about the middle of the east coast, schists commence to show, much harder and more metamorphosed than those on the west coast. The serpentines take a swing from the east coast to the middle of the island, opposite Poya, and thence swing over to the west coast at Mouéo, and then they occupy the west side of the island to Gomen forming high mountain ranges. A detached serpentine mass lies between Gomen and Koumac, in which there are several nickel mines; another, the Dome of Tiebaghi, lies north of Koumac, and in it occurs the famous chrome mine of Pagumene, a huge pipe of wonderful chrome-ore.

Returning to the east coast we observe, north of Moneo, hills and ranges clad with tea-tree (niouli) skirting the coastline, and in the higher ranges, about 5 miles back, escarpments of crystalline limestone can be seen. Common among the metamorphic rocks along the coast are the epidiorites and garnetiferous greywacke, weathering in huge black boulders, similar to those seen in the metamorphics east of the Diahot River. Coastal plain is negligible. The limestone belt approaches the coast closer and closer until it goes into the sea at Hienghen (Yenghène) and thence northwards it is under the sea.

The east coast north of Yenghène becomes more and more elevated as the Panie plateau of crystalline rocks develops, the mountains dropping sheer into the sea. The waters inside the Barrier Reef become shallower, namely from 20 to 30 metres, the silting up process towards the north keeping pace with depression. Th large river Ouaieme, south of the Panie massif, is not navigable and has only 6 to 8 metres of water at its mouth, as compared with 40 metres in the Canala entrance. The alluvial 'pointes' or peninsulas at Puebo and Balade, clad with mangroves, indicate, as does also the inter-reef channel, that as we go north silting up is overtaking subsidence. The large Harcourt Gulf, into which the Diahot enters, is only 10 to 12 metres deep in the channel, and the rest of it is largely sand-banks at low tide. The islands north of New Caledonia, like those to the south, are detached from the mainland by a great late Tertiary subsidence, which at its conclusion had made all the now alluviated Diahot Valley an arm or gulf of the sea, but, as subsidence slackened off, this arm was silted up again. That fact is evidenced by a number of bores which I supervised in the Diahot basin passing from river alluvial into coastal deposits, shell beds with *Arca*, *Potamides*, and an enormous variety of other shallow-water mudbank species.

The northern portion of the west coast was also subjected to rapid subsidence during the same part of the late Tertiary, but the movement has ended here, for the harbours of the west coast, the bays of Banare, Néhoue, Gomen, Koné, Uo, Voh, Bourail and St. Vincent, right to near Noumea, are all shallow, due to sedimentation from the decomposable serpentinous and Mesozoic strata behind exceeding any present depression. In places, I am informed, there are even small raised beaches, indicative of local elevation. South of Noumea, however, the west coast is rapidly subsiding.

Late Tertiary Elevation.

In spite of the general late Tertiary subsidence following upon the great post-serpentine uplifts, there are localities on the west coast where local Miocene and Pliocene elevations have taken place. Miocene rocks have been recorded from various places in southern New Caledonia, but these may have been contemporary with a local delayed spasm in the great early Tertiary uplift. However, west of Koumac, we get a fair area of uplifted Pliocene sediments which rise to form a group of small hills known as the Pointe de Koumac, or Pointe de Pandop. They consist of interlaminated mudstones, marls, sandstones, pebbly beds, peats and magnesian streaks, dipping west at an angle of 15° to 20°. They overlie serpentine.

A large serpentine massif, Mt. Kaala, lies south-east of the Pointe de Koumac and at its western base there is a remarkable oil seep coming out of a magnesian vein in the serpentine. An old man has been prospecting for oil here for a generation by sinking shafts and driving tunnels in the serpentine in a most patient manner. On some of his wells a scum of oil forms, which, by skimming, yields about a pint a day.

This oil can hardly be derived from the igneous serpentine, nor can it be derived from the metamorphic Cretaceous rocks which form the base and the eastern margin of the serpentine mass of Mt. Kaala. The metamorphic Cretaceous is schistose and the beds stand almost vertically. The most feasible explanation is that the oil is derived from the late Tertiary (Pliocene) beds to the west under the ocean and is being forced by water pressure into magnesian crevices in the serpentine whence it again escapes to the surface. The oil has the consistency of light machine oil and is of a brownish-green fluorescence. The oil-producing series probably extends a long way under the ocean to Chesterfield Island.

Summary of Movements.

The processes that went towards the building up of the present New Caledonia are therefore as follows:

(*a*). Oscillatory movements with heavy deposition of sandstone, shale, coal, marl, mudstone, limestone, tuff, breccia, agglomerate and conglomerate, and interbedded andesitic lavas on the eastern platform of the Melanesian continent during the Triassic, Jurassic and Cretaceous periods.

(*b*). Faulting with thrusts from the ocean deeps to the east, followed by an uprising of peridotite magmas in the late Cretaceous or Eocene, accompanied by, or followed by, further thrust movements from the east resulting in the upheaval of the New Caledonian platform and the folding of the Mesozoics. These movements may have extended in places into the Miocene.

(*c*). Deposition of Middle Tertiary beds on both sides of the platform. The overthrust of the crystalline schists in the north-east may have been as late as early Miocene. Local uplifts in the Koumac region, probably of earthquake nature, at the end of the Pliocene.

(*d*). Pleistocene subsidence on a grand scale leading to the separation of the Loyalty Islands and all the islands north and south of New Caledonia, this downward movement continuing to the present time in the south, and along the east coast from the south end to Hienghen, but arrested in Recent times in the north of the island and the northern half of the west coast.

(*e*). Cessation of depression and sedimentation by river deposition in the Diahot valley.

Literature on the Geology of New Caledonia.

The earliest geologists investigating this country, Jules Garnier and Heurteau, investigated principally the mineral resources of the island. M. Pelatan, in 1892 and the ensuing years, continued that good work. In 1901, M. Maurice Piroutet carried on stratigraphical and palaeontological investigations which added much to our knowledge. The researches of M. N. E. Glasser, in 1902 and 1903, carried the work of all these investigators still further, and his report (Annales des Mines, 2^{me} semestre, 1903; and 1^{er} semestre, 1904) contains an excellent summary of his own, as well as all previous work.

In my own investigations I have neither had the time nor the opportunity to investigate palaeontological problems, but I may remark that, in country which has been subjected to such catastrophic vicissitudes as New Caledonia, one must expect much inter-mixture of fossils of various ages and confusion. It is almost certain that small remnants with Miocene and Eocene fossils will from time to time, as work proceeds, be found among the Mesozoic beds, lodged in unexpected positions by early Tertiary overthrusts and uplifts.

The Serpentine.—The French geologists have done a vast amount of excellent work on the chemical composition of the serpentines, instigated by the importance of these rocks in regard to ore deposits of nickel, chrome, cobalt, and manganese. Those interested in ores of these metals should study the work of Garnier, Heurteau and Glasser. It appears certain that the serpentine is derived from peridotite which was intruded before the elevation of the New Caledonian platform above sea-level. Ingress of sea-water in the course of the upheavals has probably contributed largely to the alteration to serpentine.

Ocean Soundings and their Bearing on Past Continental Areas.

Ocean soundings show waters ranging principally between 1,500 and 2,000 fathoms between Australia, the New Hebrides and New Caledonia, the Loyalty Islands and New Zealand. A marked shallow belt or range extends from Sandy Cape north-east to Wreck Reef, then to Chesterfield Reef, then to the north of New Caledonia, where soundings show less than 1,000 fathoms and mostly less than 500 fathoms. This sunken range is probably genetically related to the nearly east-west fundamental structural direction in the older Palaeozoic formations of the Australasian continental mass. This was probably also the last chain joining Australia to New Caledonia. The Admiralty chart shows no strong evidence of folding within the large area embraced between the coasts of New Guinea, Australia and New Caledonia over the Coral Sea. It looks like a subsided peneplained continental mass with isolated hills and ranges, and plains of sedimentation well submerged.

But from Sandy Cape south along the Australian coast commences a deep zone, exceeding 2,000 fathoms, and for the most part approaching 3,000 fathoms, which divided the platform of Lord Howe Island from the continent. The Lord Howe platform with depths ranging from 400 fathoms to 1,000 fathoms extends north-east to within 100 miles of New Caledonia, where the ocean deepens though it does not exceed 2,000 fathoms. The ocean chart, therefore, shows a strong synclinal or downfaulted block east of south-eastern Australia running in the same direction as the Australian coast and a less depressed, extended, but older, continental area, round Lord Howe Island, which extends right to Northern New Zealand, but which is separated from New Caledonia by a depression to 2,000 fathoms, which is of recent and late Tertiary development. The Loyalty Islands are separated from New Caledonia by water 1,000 fathoms deep, in places dropping to 2,000 fathoms. The irregularity of the bottom in this basin is evidence of continental depression, and the coral islands of the Loyalties are obviously built on sunken portions of the New Caledonian platform which, as already shown, is still sinking in the direction of the Loyalties.

But east of the Loyalty Islands we meet with a startling depression between these islands and the New Hebrides, deeps of 3,000 and 4,000 fathoms indicating a deep synclinal trough which has a NNW.–SSE. trend, less marked in both directions, though traceable northerly past the south of the Solomons and along that group on the western side and through the strait between the Solomons and New Ireland. Towards the south-east it occurs between New Caledonia and Tonga in ocean depths of between 2,000 and 3,000 fathoms. East of the line joining Kermadecs, Tonga, and Samoa, enormous depths exceeding 3,000 fathoms prevail.

Thus from the soundings it would appear that in times as remote as the Trias there was a continent extending over the Coral Sea, and also over the vast area between the Australian coast and New Zealand and New Caledonia (the Lord Howe Island continent). The present volcanic chain through Samoa and Tonga, the Kermadecs and New Zealand represented its eastern fringe. The Triassic rocks of New Zealand, New Caledonia, and Eastern Australia were deposited over lacustrine areas and marine transgressions over the continental shelf.

More transgressions followed in Jurassic and Cretaceous times, but in the upper Mesozoic periods the foundering of the Lord Howe Island continent had already commenced and had split it into groups of islands while waves of thrust from the subsidence areas caused the Cretaceous and post-Cretaceous uplift of the east Australian Mesozoics. The last portion to disappear was the Coral Sea portion, and the thrusts in Northern Australia connected with the deeps and affecting the earth movements of the present day in north Queensland are Tertiary and Recent. The Coral Sea subsidence probably commenced in the late Cretaceous and is continuing even at present with attendant elevatory movement under the Gulf of Carpentaria. That subject I am dealing with in another paper.

The late Tertiary subsidence of New Caledonia separated from it the Loyalties and other islands of the group and developed the beautiful east coast harbours already referred to. The depression west of New Caledonia is the reaction caused by the early Tertiary upheaval and overthrusts from the east.

APPENDIX.

A Note on the Petrology of a Small Collection of Schists from New Caledonia.

By Germaine A. Joplin, B.Sc., Ph.D.

Thirty specimens have been sectioned and twenty-four of these contain glaucophane. These may be divided into a number of groups which are briefly described hereunder. They were collected from the Diahot Valley and the north-east coast.

1. *Glaucophane Schists.*

(i). *Glaucophane–lawsonite–augite Rocks.*—In the hand-specimen these rocks show a very slight schistosity; they are dark greyish-blue in colour and contain crystals of augite which show a bronzy lustre. Under the microscope two of the specimens show a relict ophitic fabric and two contain large (5 mm.) crystals of augite which suggests a coarse-grained intrusive rock. The augite is frequently threaded with needles and long prisms of glaucophane and the original felspar laths are pseudomorphed by small tabular crystals of lawsonite. One rock contains a good deal of calcite, and albite may be present. Iron-ores and sphene are accessory, and glaucophane shows alteration to chlorite.

(ii). *Glaucophane–epidote Schists.*—These may be subdivided into muscovite-bearing and muscovite-free types. Muscovite is usually accompanied by quartz. In the hand-specimen these rocks are markedly schistose and vary from pale bluish-grey to mottled-green and bluish-grey. The density is fairly high. Under the microscope the dark dense bluish type is found to be very rich in glaucophane and chlorite, and the greenish rocks richer in epidote. Epidote or clinozoisite occurs as granular aggregates between glaucophane crystals or long prisms 1 mm. in length. They are often parallel to the schistosity. Quartz is often abundant and usually occurs in granular aggregates. One rock of this type consists almost entirely of ink-blue glaucophane, and epidote is present only in minute interstitial granules. Sphene is usually abundant in these rocks and may be more plentiful than epidote. In the muscovite-bearing type the mica may often be detected in the hand-specimen.

These schists are often plicated. They show a good deal of variation with respect to the relative amounts of the minerals present. In some cases epidote or clinozoisite is abundant, with muscovite and quartz subordinate, and the rocks appear to grade into the muscovite-free group. On the other hand, epidote and sphene may be present only as a trace and the rocks grade into the glaucophane–muscovite–quartz assemblages described below.

(iii). *Glaucophane–garnet Schists.*—These may also be subdivided into muscovite-bearing and muscovite-free types, and the former grade into the glaucophane–quartz schists which contain very little glaucophane and garnet. The muscovite-free type is represented by a single example which contains clinozoisite as well as garnet and indicates a grade of metamorphism intermediate between that characterized by epidote and that by garnet. This schist also contains a good deal of calcite and chlorite and in the hand-specimen glaucophane-rich and chlorite-rich bands may be discerned.

The muscovite-bearing glaucophane-garnet schists are well represented in the collection examined. Some are extraordinarily rich in glaucophane and the hand-specimen is a dense bluish-grey rock studded with reddish-brown garnets. The types less rich in glaucophane are lighter in colour and more distinctly schistose. Muscovite is sometimes developed in large plates more than 1 cm. across. Under the microscope the garnets are idioblastic and are often in groups. Incipient alteration to chlorite is frequent. When mica is not abundant it often forms radiating masses between glaucophane crystals, but may occur also in large sheets. Clinozoisite is present in some of these rocks.

(iv). *Glaucophane–muscovite–sphene Schist.*—One example of this type is recorded. Except for the absence of garnet and the presence of sphene, it is identical with some of the glaucophane–garnet–muscovite schists. It would appear that the abundant titania inhibited the formation of garnet and that lime entered the sphene molecule, though it is difficult to say why the spessartite molecule should not be formed. Possibly the rock had a deficiency of iron and magnesia and neither of these oxides remained when soda had been satisfied after the formation of glaucophane.

(v). *Glaucophane–muscovite–quartz Schists.*—These rocks are characteristically rich in quartz and poor in glaucophane. Muscovite is fairly abundant and as a rule the glaucophane crystals are larger than in the other schists. In the hand-specimen they are light-coloured quartz-mica schists, often containing large prisms of blue glaucophane which measure 1·5 cm. Several of the rocks show strong plication, and small quantities of garnet and sphene indicate affinities to the above assemblages.

2. *Chlorite–albite–epidote–garnet Schist.*

This rock is somewhat banded with chlorite–epidote layers alternating with albite–epidote–garnet layers. The epidote occurs in long prisms and a slight schistosity is apparent. In the hand-specimen large crystals of pyrites and quartz indicate mineralization.

3. *Chlorite Schists.*

These are soft green schistose rocks consisting almost entirely of chlorite. A little sphene and epidote are sometimes present.

4. *Sheared Hornblende–gabbro.*

The rock is coarse-grained (6 mm.) and consisted originally of brown hornblende and basic plagioclase. Shearing has caused shattering of both minerals and partial saussuritization of the felspar. Chlorite is developed as a secondary mineral.

5. *Garnet Schist.*

This rock has not been sectioned, but in the hand-specimen it is seen to be thickly studded with red, idioblastic garnets which measure about 5 mm. These are set in a groundmass of pale green mica and a little quartz is present.

6. *Chloritoid Schist.*

In the hand-specimen the rock shows a marked schistosity, and black crystals of chloritoid measuring up to 1·25 cm. are embedded in muscovite which is slightly stained by iron-oxides.

Under the microscope the chloritoid shows the characteristic bluish-green colour and the rock is seen to consist almost entirely of chloritoid and muscovite with accessory iron-ores and zircon.

7. *Quartz Schist.*

These consist mostly of quartz and muscovite. Pyrites indicates mineralization.

8. *Actinolite Schist.*

This rock consists of a felted mass of pale green actinolite needles which measure up to 5 mm.

PETROGENESIS.

The writer has no knowledge of the field relations of these various types of schist, and any suggestion made regarding their origin is entirely speculative.

Dr. Jensen considers that the glaucophane-schists are the metamorphosed equivalents of the Mesozoic "andesite series". This series includes a number of types ranging from basalts and dolerites to rhyolites. Some of the earlier writers have designated some of the lavas by the rather indefinite terms melaphyre and ophite, but the present writer has not been able to examine any specimens from this series.

The ophitic fabric of the glaucophane–lawsonite rocks would suggest that at least some of the schists were derived from dolerites, but most of the rocks are too much altered to speculate upon their origin, and detailed field work is desirable.

According to Harker (1932) glaucophane schists are either formed by the metamorphism of alkaline rocks or by the metasomatism of sediments.

It is possible that spilitic lavas may occur in Dr. Jensen's "andesite series", but it is also conceivable that normal basic lavas may have been albitized as the result of deuteric alteration. The old name melaphyre is usually applied to rocks that have suffered late magmatic alteration, and the writer would suggest that under suitable conditions of metamorphism these may give rise to glaucophane schists.

Nevertheless, the lawsonite- and epidote-bearing types indicate that there was an abundance of lime prior to metamorphism, and this suggests a normal calcic rock rather than a deuterically altered or alkaline one. In the case of the lawsonite-bearing rocks with relict ophitic fabric the lawsonite pseudomorphs laths of plagioclase and it is evident that the felspar contained a large percentage of the anorthite molecule. The glaucophane schists rich in lawsonite, clinozoisite or garnet must surely have a composition similar to the albite–epidote rocks, and it has been shown that these latter are not alkaline rocks but that the formation of basic plagioclase has been inhibited by the low temperature conditions.

Washington (1901) has compiled a list of analyses of glaucophane-bearing rocks, and some of these do not indicate a soda percentage above that of normal calcic rocks. It, therefore, seems possible that the formation of glaucophane requires special conditions of metamorphism rather than of composition, though its genesis is possibly facilitated by an abundance of soda. Reference to the petrography will show that the glaucophane rocks occur in several metamorphic grades and for this reason a correlation between the formation of glaucophane and the conditions of metamorphism is very difficult.

It will also be seen that muscovite is a conspicuous mineral in some of the glaucophane rocks. Harker suggests that the glaucophane–muscovite rocks represent tuffs, and this is possible in the present instance, as Dr. Jensen finds tuffs in the "andesite series".

Finally, the quartz–muscovite rocks containing but little glaucophane must surely represent a metasomatized sediment. This is difficult to account for, unless it be assumed that there was adinolization by spilitic lavas or metasomatism of accidental xenoliths by magmatic fluids in calcic lavas.

Those rock types which do not contain glaucophane might be associated with any series of lavas, either alkaline or calcic, and need no further comment.

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NOTES ON THE OCCURRENCE OF THE TRICHOPELTACEAE AND ATICHIACEAE IN NEW SOUTH WALES, AND ON THEIR MODE OF NUTRITION, WITH A DESCRIPTION OF A NEW SPECIES OF *ATICHIA*.

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(Plates xiii–xiv; ten Text-figures.)

[Read 25th November, 1936.]

The Trichopeltaceae and Atichiaceae are two families of epiphyllous ascomycetes considered by the writer to form part of the sooty-mould complex. They are usually associated with other sooty-mould fungi, the most important of which are the species of the Capnodiaceae (Fraser, 1935*a*, 1935*b*). Both the Trichopeltaceae and the Atichiaceae are specialized for their environment but in very different ways. They do not appear to be closely related systematically.

The method of nutrition of the species of these families has not previously been established, most of the work which has been done on them being purely systematic.

The Trichopeltaceae.

a. Historical.

The species belonging to this family have a peculiar mycelium which is quite distinct from that of any other fungus. The hyphae, instead of being separate from each other, remain in contact to form a flat thallus, one cell thick and many cells wide. It resembles in structure the thallus produced by the algae of the family Trentipohliaceae, especially the epiphyllous genera *Phycopeltis* and *Cephaleuros*. The thallus may be circular, in which case growth takes place round the whole circumference, or strap-shaped and branching, the growth being principally localized at one end.

Perithecia are produced beneath the thallus as local circular thickenings. They dehisce by means of a pore torn in the thallus above the centre.

The first species described was *Asteroma Labecula* Montagne (1840), from material collected in South America. Later (Montagne, 1856) it was transferred to the genus *Asterina*. In 1868 a fungus collected in Cuba was described by Berkeley and Curtis as *Asterina reptans*. Spegazzini (1889), from an examination of the material used by Berkeley and Curtis, recognized a fungus of distinctive character, which he took to be that described by the earlier authors. Because of its outstanding differences from the genus *Asterina* he placed it in a new genus *Trichopeltis*, using the specific name *reptans* of Berkeley and Curtis. It seems clear from the descriptions given, however, as Stevens (1925) has pointed out, that the type of *Asterina reptans* B. & C. is not the same fungus as that described as *Trichopeltis reptans* (B. & C.) Speg. by Spegazzini. Consequently it is doubtful whether all the fungi recorded from various parts of the world as *Asterina reptans* belong to the genus *Trichopeltis*.

Spegazzini also (1888) described the genus *Brefeldiella* which has a flat circular thallus, one cell thick. The genus *Trichopeltella*, very similar to *Trichopeltis*, was described by von Hoehnel in 1910.

Theissen (1913) proposed the family Trichopeltaceae to include these genera and described several new genera based on characters of spore septation and colour. He placed *Asterina Labecula* in the genus *Trichopeltis*, and gave a very detailed account of the structure and growth of the thallus in this family.

Stevens (1925) gave a review of the family and species described. He clarified the position with regard to the nomenclature of *Trichopeltis* and *Asterina reptans*, and gave conclusive reasons for the acceptance of *T. reptans* Speg. as the type of the family. He rejected *Asterina reptans* B. & C. as a fungus too imperfectly described to be recognizable.

At present the family Trichopeltaceae is regarded as being closely allied to the Microthyriaceae.

b. Species occurring in New South Wales.

Cooke (1892, p. 315) recorded the fungus *Asterina reptans* B. & C. as occurring on leaves in Queensland. The description he gave is as follows: "Mycelium thin, rather reticulated, perithecia minute, constructed from the radiating cells, asci clavate, sporidia oblong, somewhat fusiform, uniseptate." From this, which is a direct translation of the type Latin description given by Berkeley and Curtis, it is impossible to tell without an examination of the original material whether an *Asterina* or a *Trichopeltis* is indicated.

Theissen (1913), in the course of his investigation of the family Trichopeltaceae, examined specimens from the Kew collection labelled *Asterina reptans*. He made no mention of any specimen from the mainland of Australia; therefore, it seems probable that the fungus recorded by Cooke is a species of *Asterina*, not *Trichopeltis*. Theissen recorded *Trichopeltis reptans* Speg. on the leaves of *Tasmania* (probably a typographical error for *Drimys*) *aromatica*, Tasmania, from collections at Kew.

No other record has been made of the occurrence of this fungus in Australia.

During the present investigation three species belonging to the Trichopeltaceae have been collected.

1. *Trichopeltis reptans* Speg.—This species has been identified in 45 collections. It is most common on the leaves of rain-forest trees in shaded localities, either alone or associated with sooty-mould fungi, chiefly members of the Chaetothyrieae (Plate xiii, fig. 1). The thallus is strap-shaped, branching at intervals, closely adherent to the host leaf (Plate xiii, fig. 2). The cells in the centre of the thallus form a longitudinal strand. In old thalli the cells along the margin may grow outwards at right angles to the long axis, thus giving rise to a certain amount of lateral growth (A in fig. 2, Plate xiii). *Trichopeltis reptans* appears to be a widespread species. It is common in South America and the West Indies, and has also been recorded in the East Indies and in Hawaii.

2. *Brefeldiella brasiliensis* Speg.—This species has been identified in 20 collections. Like *Trichopeltis reptans*, it is found chiefly on the leaves of rain-forest trees associated with *Atichia* and the Chaetothyrieae (Plate xiii, fig. 3). The thallus is roughly circular or slightly lobed (Plate xiii, fig. 4). The margin is more or less even. The fungus grows smoothly round obstacles in its path, such as a colony of *Phycopeltis* or a young *Brefeldiella*, joining up again on the other side. Consequently an old thallus may have a patchy appearance. *Brefeldiella brasiliensis* has been recorded in South America.

3. *Trichothallus hawaiiensis* Stevens.—This species has been identified in three collections. It therefore appears to be much less common than the two preceding species. It occurs on the leaves of rain-forest trees in especially humid situations, associated with *Trichopeltis* and members of the Chaetothyrieae (Plate xiii, fig. 5).

It was first described by Stevens (1925) from Hawaii, and has not been recorded since. As originally described, the fungus showed neither pycnidia nor perithecia, and none were observed in the material collected in New South Wales. From the structure of the thallus it is obvious that the fungus belongs to the Trichopeltaceae. The margin of the thallus is, as a rule, rather uneven. Not uncommonly a single hypha, or several hyphae together, may grow out as a narrow strand. The forward growing edge also sometimes shows this feature, single hyphae, or narrow bands of hyphae growing out, often later coalescing, thus giving the thallus a reticulate appearance (Plate xiii, fig. 6). The most peculiar feature of the thallus is the presence of hairs. These are single hyphae composed of cells growing upwards from the thallus at frequent intervals. They measure 75–120 × 9–10μ, often tapering towards the base and apex. They break off fairly readily and undoubtedly function as organs of propagation.

Because of its more loosely aggregated thallus and the presence of hairs, this species appears to be a more primitive type than either *Trichopeltis* or *Brefeldiella*.

Trichothallus hawaiiensis has been collected on the leaves of *Backhousia myrtifolia* and *Eugenia Smithii* in the Upper Williams River District, N.S.W., May 1933, January 1934, and May 1936.

The Atichiaceae.

A review of the changes in nomenclature and classification of the members of this family has been given in an earlier paper (Fraser, 1932).

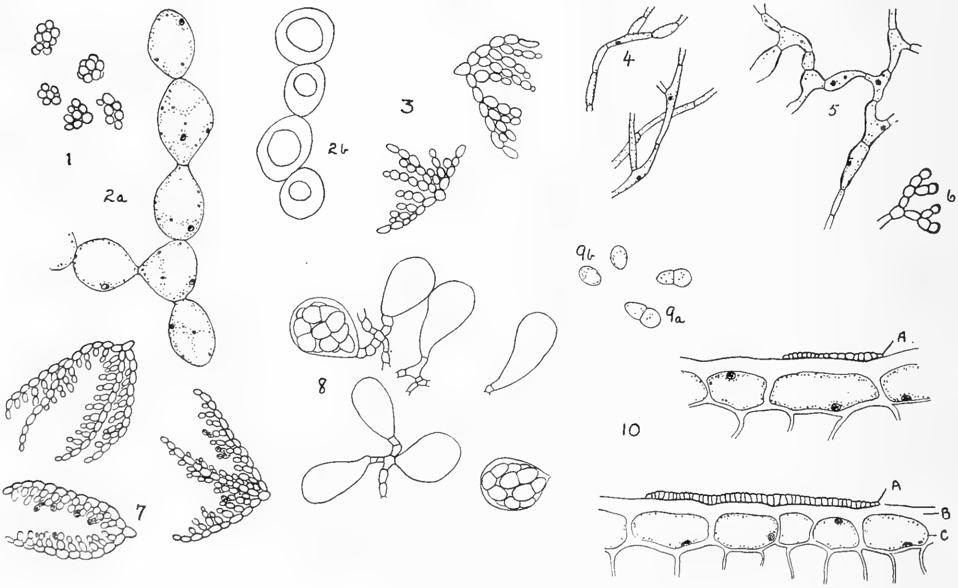
Only two references have been made to the occurrence of *Atichia* in Australia. McAlpine (1896), in describing the sooty-mould-forming fungus *Capnodium citricolum* attributed to it structures which he called "glomerulae", and which he considered to be a type of imperfect fructification. These were globular gelatinous colonies of yeast-like cells, 0·5 mm. or more in diameter. Through the kindness of the Government Biologist of the Department of Agriculture, Victoria, the writer was able to make an examination of McAlpine's type specimens. Small colonies of *Atichia glomerulosa* were recognizable in one of his collections, and there can be no doubt that these are the "glomerulae" to which he referred. Fisher (1932) recorded a species of *Phycopsis* on *Myoporum* and *Bursaria* in Victoria, but was unable to assign it to any species owing to the lack of perfect material.

Four species of fungi belonging to the Atichiaceae have been found in collections made during the present investigation.

1. *Atichia glomerulosa* (Ach.) Flot.—This species has been identified in 17 collections. It is usually associated with sooty mould fungi, and occurs both in sunny and shaded positions. The colonies are globular and gelatinous, composed of yeast-like cells, usually 300–600μ in diameter, mostly closely aggregated, or solitary, sometimes obscurely lobed. Somewhat stellate colonies up to 2 mm. in diameter consisting of a number of large lobes have been seen. The propagulae, which are borne in a concavity at the apex of the thallus, are globular or obscurely 3-branched, and 12–20μ in diameter (Text-fig. 1). The asci, which are borne just below the surface at the apex of the thallus, are globular or pear-shaped, and

8-spored. The ascospores are 1-septate, hyaline, 12–16 × 8μ. This agrees very well with the descriptions given by Vuillemin (1905) and von Hoehnel (1910), and with the figures of Arnaud (1910). This species appears to be very widespread; it is common in Europe and has been recorded in many countries, including Java.

2. *Atichia Millardeti* Pat.—This species has been identified in 58 collections, and appears to be by far the most common *Atichia* in New South Wales. It occurs exclusively in shaded positions, chiefly on the leaves of rain-forest trees, either alone or associated with members of the Trichopeltaceae and Chaetothyriaceae (A in fig. 7, Plate xiv). The colonies have always 3 or more prominent lobes (Plate xiv, figs. 8, 9) and may attain a diameter of 5–6 mm. They are composed of yeast-like cells (Text-figs. 2*a*, 2*b*). The propagulae are produced in elongated or circular cavities in the upper surface of the lobes of the thallus (A in Plate xiv, fig. 9). They are triquetrous branch systems, 40–50μ in length



Text-figures 1-10.

1.—Propagulae of *Atichia glomerulosa*. × 285.

2.—Cells of the thallus of *Atichia Millardeti*, 2*a* showing cytoplasm and nuclei after removal of oil, 2*b* showing oil drops. × 1,000.

3.—Propagulae of *Atichia Millardeti*. × 285.

4-9.—*Atichia botriosa.*

4.—Hyphae from the centre of the lobes of the thallus showing filamentous nature. × 285.

5.—Hyphae from nearer the margins of the lobes of the thallus than those shown in Text-figure 4, showing slight inflation and irregular darkening of the walls. × 285.

6.—Hyphae from the margins of the lobes of the thallus showing thickening of the walls, branching and bead-like appearance. × 285.

7.—Propagulae showing branching. × 285.

8.—Asci. × 285.

9*a*.—Ascospores; 9*b*.—Cells of the ascospore after separation. × 285.

10.—Part of two transverse sections of the epidermis of a leaf showing the thallus of *Trichopeltis reptans* (A). B, cuticle; C, epidermal cells. × 285.

(Text-fig. 3). The asci are produced in raised cushion-like swellings near the base of the lobes of the thallus (A in Plate xiv, fig. 10). They are very numerous, globose or pear-shaped and 8-spored. The ascospores are 11–14 × 6–7μ, 1-septate, hyaline, slightly constricted at the septum.

The branches of the propagulae of the type specimens of *A. Millardeti* are described as being terminated by narrow hair-like cells. Such hairs are not a feature of the New South Wales form, but thin cells approximating to them have been seen several times. However, the New South Wales form resembles *A. Millardeti* so closely in all other respects that it is regarded as a climatic variation only of the type. *A. Millardeti* has previously been recorded only from Tahiti.

3. ATICHIA BOTRIOSA, n. sp.—Thallo gelatinoso, ramosissimo, ad 5 mm. lato et ad 4 mm. crasso, nigro arido, fusco humido, ramis brevibus et latis. Thalli hyphis in muco immersis, ramorum mediis partibus angustis et hyalinis, margine moniliformibus, fuscis, stipitatis. Propagulis fuscis, in lacunis ramorum apicibus latis, 1–5-, plerumque 3-ramis, 55–75 × 10–14μ. Ascis globosis aut piriformis, fere sub superficiem ramorum apicibus latis, 30–42 × 18–25μ, 8-sporis. Sporis hyalinis, 1-septatis, septo constrictis, 16–19 × 7–8μ, altera cellula paulam longiore et angustiore et acutiore altera. Cellulis aliquando etiam in asco separantibus.

The colonies are epiphyllous, gelatinous, up to 5 mm. in diameter and 4 mm. in thickness. They are black when dry, dark sooty-brown when moist, adhering firmly by means of a large gelatinous disc. The thallus is closely branched in three dimensions in a somewhat dichotomous fashion, forming a botryoidal colony (Plate xiv, fig. 11). The branches or lobes are as broad as long, and are rounded at the apex (Plate xiv, fig. 12). The thallus is composed of hyphal threads embedded in mucilage. The hyphae at the centre of the lobes are filamentous, narrow, thin walled and light coloured, the cells measuring 40–50 × 2–6μ, not, or scarcely, inflated (Text-fig. 4). Towards the periphery the hyphae branch and anastomose fairly frequently; the cells are shorter, broader and somewhat constricted at the septa, 15–30 × 6–10μ, light coloured but with parts of the wall thicker and darker (Text-fig. 5). The cells forming the outer layer of the thallus are bead-like, globular or nearly so, constricted at the septa but not yeast-like, 4–6μ in diameter, the walls moderately thick and dark, especially the outermost wall of the apical cell of each filament (Text-fig. 6). The central hyphae are arranged longitudinally in the thallus; towards the outside they branch in all directions, and at the margin are arranged in close, dichotomously branching, parallel rows at right angles to the surface of the thallus. The propagulae are dark brown, produced in very great numbers in cavities at the apices of the lobes (A in Plate xiv, fig. 13); when full grown they are 1–5-, usually 3-branched, the branches comparatively long and narrow, 55–75 × 10–14μ (Text-fig. 7). Each cell of the branch bears on its inner side 1 or 2 rows of 2–3 small cells. Asci are produced in considerable numbers at the ends of the lobes, just below the surface. They are globular to pear-shaped, 8-spored, 30–42 × 18–25μ (Text-fig. 8). Asci and propagulae are not produced simultaneously. The ascospores are hyaline, 2-celled, constricted at the septum, one cell relatively longer, narrower and more pointed than the other, 16–19 × 7–8μ (Text-fig. 9*a*). The cells often separate while still in the ascus, becoming ovoid and vacuolate (Text-fig. 9*b*).

Atichia botriosa is distinguished from all other species of this genus by the number, size and shape of the branches of the propagulae, and by the shape and method of branching of the thallus, and by the filamentous nature of the cells composing it.

Atichia botriosa has been collected at Barrington Tops, on *Callistemon pallidus* D.C., January, 1934 (asexual stage), October, 1934 (asexual stage), and March, 1934 (sexual stage).

4. *Phycopsis vanillae* (Pat.) Mang. & Pat.—This species has been identified in 9 collections. It is usually associated with sooty-mould fungi and occurs only in shaded positions (A in Plate xiii, fig. 3). The colonies are globular, 200–400μ in diameter, never lobed, and composed of yeast-like cells. The propagulae, which are large and globular, are produced singly all over the upper part of the thallus, just below the surface. The asci are borne in the thallus just below the surface as in *Atichia glomerulosa*. They are globular or pear-shaped, and 8-spored. The ascospores are 1-septate, hyaline, 15–18 × 7–9μ. *Phycopsis vanillae* has been recorded in Java, Tahiti and the Gambier Islands.

Mode of Nutrition.

It has been recognized from the first that the species of the Atichiaceae are saprophytes, but their dependence on scale-insect excretions has not previously been established. Any reference to the source of food has usually been omitted in descriptions of species. Cotton (1914) noticed the occasional association of *Atichia dominicana* with scale insects, but came to the conclusion that it was without significance. However, as he dealt only with dried material, his conclusions were not based on a first-hand knowledge of the conditions under which the fungus lived. In the writer's experience, *Atichia* mostly occurs where scale insects are present, and is usually associated with members of the Capnodiaceae. Colonies of *Atichia* have sometimes been found in positions where they would receive a little "honey dew", but are not directly associated with scale insects. For instance, the scale insects might be on a neighbouring tree. The most numerous and luxuriant colonies have always been found nearest to parts affected by scale insects. They have never been found in any position where scale insects are entirely absent.

In the case of the Trichopeltaceae the position is not so clear. Neither Spegazzini (1889) nor Theissen (1913) has expressed any opinion on the mode of nutrition of the members of this family. In discussing *Trichopeltis reptans* Stevens (1925) used the word "host" when speaking of the tree on whose leaves this fungus grew. This seems to indicate that he considered the species to be parasitic. From observations in the field the writer came to the conclusion that the members of the Trichopeltaceae formed part of the sooty-mould association. A careful examination of the relation of the thallus of the various species of the Trichopeltaceae to the leaves on which they occurred was therefore necessary. The following points were observed: The thallus was found to lie in very close contact with the epidermis of the leaf on which it grew, following its contours exactly. Microtome sections 4μ thick were cut of parts of leaves bearing *Trichopeltis* and *Brefeldiella*. No trace of haustoria could be found (Text-fig. 10). The thallus of the fungus appears to be strictly external to the cuticle. No case has been observed of damage by the species of the Trichopeltaceae to the leaf on which they were growing. This in itself does not mean that they are not parasitic, since species of *Meliola*, though parasitic, sometimes appear to do no visible harm to their host leaves. An additional proof of their saprophytic nature is afforded by the fact that dry thalli of *Trichopeltis*, *Brefeldiella* and *Trichothallus* can be flaked off the leaves on which they grow. This is well shown by *Brefeldiella*, in which the central parts of large colonies often break off, leaving the margins to continue their growth (C in Plate xiii, fig. 3). It was found that both *Brefeldiella* and *Trichopeltis* grow readily in culture on potato-dextrose-agar. These facts seem to afford sufficient proof that the members of this family are not parasitic.

In the field, the three species of the Trichopeltaceae are frequently associated with sooty moulds. The best development takes place near scale insects. Often, however, their thalli appear to be unassociated with scale insects or other fungi (Plate xiii, fig. 1). In these cases scale insects are always to be found on neighbouring trees, so that a little "honey dew" is probably available to the fungi. Moreover, small scale-insects of a brown or greenish colour, closely adhering to stems or the under-surfaces of leaves, are easily overlooked.

On the above grounds it appears reasonable to assume that the members of the Atichiaceae and Trichopeltaceae are true saprophytes living on "honey dew" like the members of the Capnodiaceae, and that they therefore should be included in the sooty-mould group.

Systematic Position of the Atichiaceae.

The family Atichiaceae has been considered by various writers to show affinities with the Saccharomycetes, Capnodiaceae, Bulgariaceae, etc. The general opinion seems to be that it is most closely related to the Saccharomycetes because of the yeast-like appearance of the cells composing the thallus.

In this connection it may be of interest to consider the species *Atichia botriosa.* This is a typical member of the Atichiaceae in all respects, except in the nature of the mycelium. Instead of being composed of yeast-like cells easily separating from each other, the hyphae, especially those at the centre of the thallus, are filamentous, not inflated. Each cell contains one small inconspicuous nucleus (Text-figs. 4, 5), quite unlike the large characteristic nucleus of the yeasts. This feature is also shown by *A. Millardeti* (Text-fig. 2*a*).

Asci in all members of the Atichiaceae occur embedded separately in specialized areas in the thallus as in the Myriangiales and appear to be produced by a ramifying system of ascogenous hyphae (Text-fig. 8).

It therefore seems probable that the relationships of the Atichiaceae with the Saccharomycetes are apparent rather than real, and that its closest relationships are with the Myriangiales.

Summary.

A brief review is given of the changes in nomenclature and classification of the members of the Trichopeltaceae.

Trichopeltis reptans Speg., *Brefeldiella brasiliensis* Speg. and *Trichothallus hawaiiensis* Stevens are recorded for the first time in New South Wales. *Atichia glomerulosa* (Ach.) Flot., *A. Millardeti* Pat. and *Phycopsis vanillae* (Pat.) Mang. and Pat. are recorded for the first time in New South Wales. A new species, *Atichia botriosa*, is described.

It is shown that both the Atichiaceae and Trichopeltaceae are epiphytes dependent on scale-insect excretions, and that they therefore form part of the sooty-mould flora.

Because of the position of the asci and the nature of the mycelium, especially in *Atichia botriosa*, the Atichiaceae are considered to show affinities with the Myriangiales.

In conclusion, the writer wishes to thank Assistant Professor J. McLuckie, of the Department of Botany, University of Sydney, for helpful criticism during the course of this work.

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EXPLANATION OF PLATES XIII-XIV.

Plate xiii.

1.—Leaves of *Eugenia Smithii* showing thalli of *Trichopeltis reptans* Speg. × ⅓.

2.—Part of the thallus of *Trichopeltis reptans* showing lobes, marginal growth along edges of lobes (A), and position of the young perithecia (B). × 40.

3.—Leaves of *Citrus* sp. showing colonies of *Phycopsis vanillae* (A) and *Brefeldiella brasiliensis* (B). C, colonies of *Brefeldiella* from which the central parts have flaked off. × ½.

4.—Thallus of *Brefeldiella brasiliensis* showing position of perithecia (A). × 20.

5.—Leaves of *Backhousia myrtifolia* showing thalli of *Trichothallus hawaiiensis* Stevens. × ½.

6.—Part of the thallus of *Trichothallus hawaiiensis* showing setae (S) and method of branching. × 20.

Plate xiv.

7.—Leaf of *Daphnandra micrantha* showing epiphyllous colonies of *Atichia Millardeti.* × ½.

8.—A large colony of *Atichia Millardeti* showing lobing. × 20.

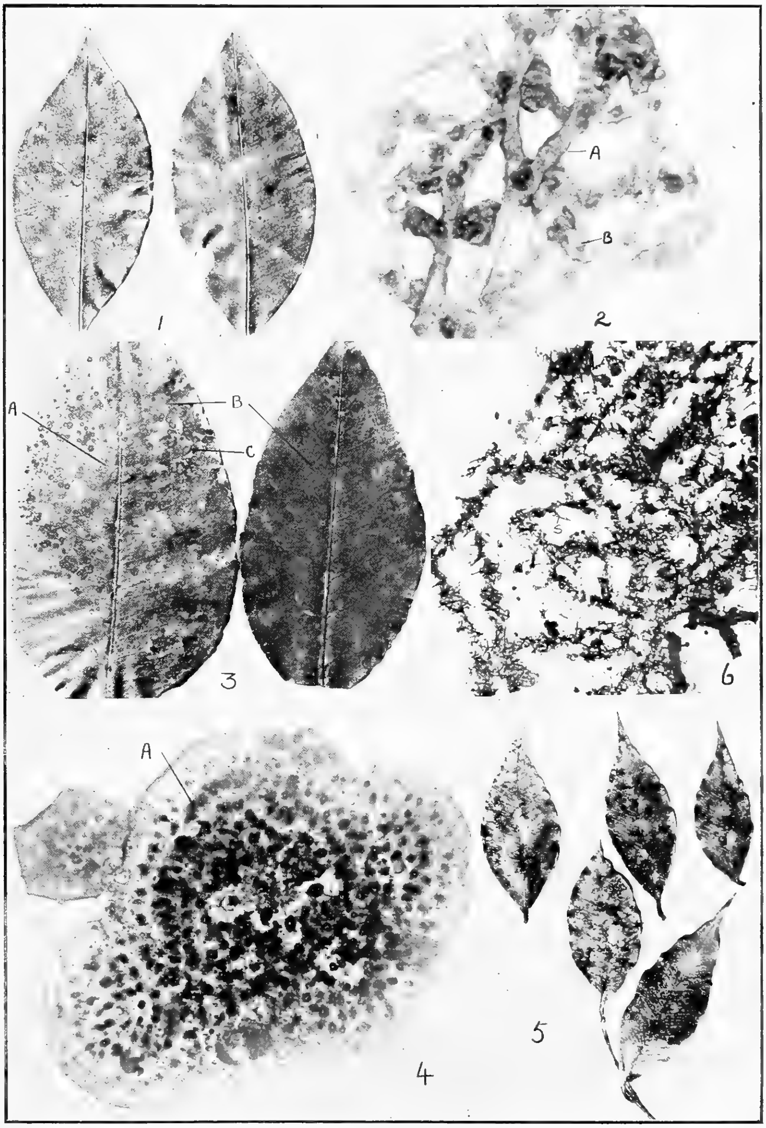
9.—Colonies of *Atichia Millardeti* showing lobing, propagula cavities (A) and disc of attachment (B). × 20.

10.—A colony of *Atichia Millardeti* showing ascal cushions at the base of the lobes. × 20.

11.—Colonies of *Atichia botriosa* on a twig of *Callistemon pallidus.* Nat. size.

12.—Part of a large colony of *Atichia botriosa* showing lobing. × 20.

13.—Part of a colony of *Atichia botriosa* showing lobing and position of the propagula cavities (A) at the apices of the lobes. × 20.



Species of Trichopeltaceae from New South Wales.

Species of Atichiaceae from New South Wales.

PLANT ECOLOGY OF THE BULLI DISTRICT.

PART I: STRATIGRAPHY, PHYSIOGRAPHY AND CLIMATE; GENERAL DISTRIBUTION OF PLANT COMMUNITIES AND INTERPRETATION.

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(Plate xv.)

[Read 25th November, 1936.]

Introduction.

The area studied extends from Darke's Forest on the north to Towradgi Creek on the south, and from the coast up to seven miles inland (Plate xv). In this area, a wide range of rock types occurs, with consequent variation in soils; moreover, the unusual physiography leads to important results ecologically.

In this paper a general survey is made of the stratigraphy, the physiography and the climate of the area. The main plant communities are briefly mentioned, and interpretation of these as seres, subclimax, climax and postclimax vegetation is attempted. In subsequent papers each community will be dealt with in greater detail; the chief features of the soil types listed; and the comparison of leaf-size, and life-form spectra, undertaken.

The author acknowledges great indebtedness to Professor J. McLuckie, under whose guidance ecological observations of this area were commenced; and to Professor T. G. B. Osborn, for stimulating criticism.

Systematic names, except those to which the respective authors' names are appended, are those used in Moore and Betche (1893), or, for Pteridophytes, those used in the recent Check-List (Melvaine, 1936).

Stratigraphy and Physiography. (Plate xv.)

Except for small and unimportant dykes and sills, there are no igneous rocks in the district. Besides the recent soil (alluvial, or wind-blown sand), increasing in importance as the coastal plain widens, and the talus slopes below the scarp, which are considered as part of the rocks from which they are derived, the following is the sequence of sedimentary rocks:

Triassic:
- Wianamatta Shale.
- Hawkesbury Sandstone.
- Chocolate Shale.
- Narrabeen Sandstone.

Permian: Upper Coal Measures.

The bedding of these strata appears at first sight to be almost horizontal, but actually there is a marked dip towards the north and west. It is to this dip that the unusual physiography can be attributed, the main features being the coastal plain, widening towards the south; the terraced slopes running back from the plain to the Hawkesbury Sandstone scarp; and above the scarp the flat plateau gently sloping north and west, dissected to some extent, especially towards the southern extremity of the area studied.

The widening of the coastal plain is caused by the greater amount of soft rock exposed below the Hawkesbury Sandstone as the strata rise to the south; this softer rock weathers, and the sandstone, left projecting, breaks off from time to time, the perpendicular face of the scarp being thus maintained. One such fall of rock occurred recently above the town of Thirroul, and cleared a wide swathe through the underlying brush vegetation of the slopes (Pl. xv, A).

The following figures are quoted from Griffith Taylor (1923):

Distance from Sydney.	Locality.	Height of Upper Coal Measures.	Width of Plain.
33 miles	Otford	near sea level	nil
44 miles	Bulli Pass	300 feet	2 miles
55 miles	Mt. Kembla	800 feet	7 miles
66 miles	Shellharbour	1,000 feet	12 miles

Although these figures are at variance with Harper (1912) as to the position of junction of the Upper Coal Measures and the Narrabeen Series, they convey the reason of the occurrence and conformation of the coastal plain.

With the widening of the coastal plain, the conditions for vegetation immediately adjacent to the sea change. Whereas in the northern part of the district studied there are short beaches lacking sand-dune formations, interspersed with steep sea-cliffs carrying a typical vegetation, to the south the beaches are longer and the ground lying behind flatter, so that sand-dunes are frequent. In addition, the widening plain gives additional catchment for the easterly-flowing creeks, and alluvial soils become more important. These creeks, in the southern parts of the area, expand near the sea to subsaline lagoons, due apparently to the difficulty of access to the sea, a possible result of uplift. The vegetation bordering these lagoons is also typical.

Turning from the plain itself to the slopes running back to the vertical scarp, we find a considerable amount of terracing, the result of alternate bedding of hard and soft strata. This terracing is important from the aspect of brush development. The slopes are also dissected with gullies by creeks running down to the plain.

Coming to the plateau itself, we find the greater part of it consists of an undulating surface, for the most part with a deep, mature soil, and little exposed rock. The surface slopes north towards the Sydney geosyncline, and west towards the Nepean River, so that the streams of the plateau do not reach the coast directly. The whole of this sandstone plateau running north and west has been termed the "Nepean Ramp".

At Darke's Forest, on the north of the area studied, a small isolated cap of Wianamatta Shale occurs. To the south of the area, the westerly-flowing creeks running into Cataract River have, following pronounced post-Tertiary uplift, eaten through the Hawkesbury Sandstone, exposing the underlying Chocolate Shale and Narrabeen Sandstone. The dissected areas of the Hawkesbury Sandstone carry vegetation differing from that of the level parts of the plateau.

Climate.

The following figures are given for Wollongong, on the coast immediately to the south of the area studied:

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Daily Temperature—												
(°F.) Maximum*	79·2	78·7	76·8	72·6	67·1	62·7	61·8	64·4	68·6	72·4	75·1	77·6
Minimum* ..	62·3	62·6	60·4	56·3	51·3	47·8	46·0	47·0	50·4	53·7	57·1	60·4
Relative humidity	75	76	76	76	75	76	75	71	68	69	69	73
Rainfall (inches)	4·41	4·61	4·65	5·32	4·59	4·22	3·96	2·29	2·61	2·71	2·68	3·60

Average Maximum Daily Temperature, 71·4° F.—Average Minimum Daily Temperature, 54·6° F.—Average Relative Humidity, 73%.—Total Yearly Rainfall (average), 45·65 inches.

The Meyer Ratio (P./s.d.) calculated from the above figures is just under 300, and mature soils throughout the district studied were typically podsolized.

The following figures for average total annual rainfall are given for other stations in or adjacent to the area: Sherbrooke, 58·63; Madden's Plains, 58·94; Appin, 36·04 inches.

(The first two stations are within the area studied, on the plateau at an elevation of about 1,200 feet, and within two miles of the scarp; the third is immediately to the north-west of the area studied, some twelve miles from the coast.)

It is apparent that the coastal climate is very similar to that of the Sydney district, but that, behind the coastal plain, the upper slopes and the plateau have a higher rainfall, due to the forcing upwards of moisture-laden air from the sea. Proceeding inland from the eastern edge of the plateau, however, the rainfall decreases rapidly.

The higher rainfall of the eastern edge of the plateau, coupled with the frequent occurrence of mists, produces climatic conditions sufficiently differing from those of the Sydney district to explain partly the greater prevalence of swamp or moor communities on the plateau, as at Madden's Plains.

The effect of winds on the vegetation of the area is important, especially from the two following aspects: (1) the physiographic shelter available from the winds from the general direction of the west (amongst which the south-westerly winds are especially important) is the primary factor conditioning the development of brush (or sub-tropical rain forest); (2) the sea-winds have an important effect on the vegetation near the coast. The effect of winds on dune-formation on the New South Wales coast has been dealt with by Andrews (1912), and need receive no further attention here. The sea-winds also have important effects on the sea-cliff vegetation from Austinmer northwards. Although not dry, they aid in inhibiting tree development, and in stunting many of the shrubs of the cliffs, while the spray carried by them tends to cause the development of halophytic types on the lower parts of the cliffs.

Under the heading of climate, the local low saturation-deficit that has been observed in certain situations may be briefly mentioned. In conditions of shelter, a microclimate of higher relative humidity occurs, which may be regarded partly

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* Average for month.

as a result of physiographic shelter, and as such as a cause of the corresponding vegetation; but, especially at lower levels in the brush, it must be regarded as an effect of the vegetation in decreasing evaporation. In the extensive swamps of the plateau, in conditions of extreme exposure, the low but dense vegetation, by reducing wind effects, materially acts to retain a low saturation-deficit, near ground-level, and to maintain the swamps in their present state by reducing evaporation. This must be regarded as entirely a result of the vegetation, whereas in the microclimate of the brush, cause and effect are so intimately mingled as to be indistinguishable.

General Distribution of Communities.

Vegetation of the Plateau.

(1). *Hawkesbury Sandstone.*

This is subdivided as follows: (*a*) The *Eucalyptus Sieberiana* association, and variations; (*b*) Developments subject to physiographic shelter; (*c*) Lithoseres; (*d*) Extensive swamp or moor communities; (*e*) Vegetation of the Scarp.

(*a*). Eucalyptus Sieberiana *Association.*

This is the most extensive vegetation on mature soils of the Hawkesbury Sandstone. The association forms a low forest with a very marked shrub stratum. The association is similar to that found in the Sydney district, somewhat poorer floristically, and with few additional species. The main floristic features are given below.

Tree stratum.—Besides the dominant *Eucalyptus Sieberiana*, *E. corymbosa* occurs occasionally, especially in the drier situations, whilst *E. micrantha* Benth. is of occasional occurrence, especially approaching swamp conditions. The low-tree stratum is not pronounced, *Banksia serrata* being common but somewhat local.

Shrub stratum.—The great variety of sclerophyll shrubs is the most striking feature of the association. The following are especially abundant: *Banksia ericifolia*, *Acacia juniperina*, *A. suaveolens*, *Bossiaea heterophylla*, *B. scolopendria*, *Dampiera stricta*, *Dillwynia floribunda*, *Epacris microphylla*, *E. obtusifolia*, *Grevillea oleoides*, *Hakea pugioniformis*, *Isopogon anemonifolius*, *Lambertia formosa*, *Leptospermum scoparium*, *Leptomeria acida*, *Leucopogon juniperinus*, *Olax stricta*, *Persoonia lanceolata*, *P. salicina*, *Petrophila pulchella*, *Pimelea linifolia*, *Ricinocarpus pinifolius*, and *Sprengelia incarnata*.

Herbs.—*Xanthorrhoea hastilis*, *Gahnia psittacorum* and *Xerotes longifolia* are the most abundant large herbs; of the smaller herbs the following are especially important: *Haemodorum planifolium*, *Leptocarpus tenax*, *Lepyrodia scariosa*, *Patersonia glauca*, *Stackhousia viminea*, and *Xerotes flexifolia*. The most important climbing plant is *Cassytha pubescens*.

Variations.—The following variants within the association deserve notice:

(i). On the short gradual slope running down towards the scarp (as at B, Pl. xv), where excellent drainage renders the soil drier, but where protection from the west is greater than on most of the plateau, certain more mesophytic shrubs and herbs are mixed with the sclerophyll element. In particular, *Pultenaea daphnoides*, *Olearia elliptica*, *Gleichenia flabellata*, *Lycopodium densum* and *Persoonia mollis* may be noted. Due to the drier soil conditions, the relative importance of *Eucalyptus corymbosa* increases slightly.

(ii). On the drier slopes running in a more or less westerly direction, especially approaching the western limit of the area, where the rainfall is less, the proportion of *E. corymbosa* to *E. Sieberiana* also rises, but with no marked change in the composition of the lower strata.

(*b*). *Developments subject to Physiographic Shelter.*

In regions of greater dissection, higher associations develop, the spatial sequence being *E. piperita* association, *E. pilularis* association, and brush. The effects are due primarily to the topography, and do not in any way represent an autogenic succession. The immediate causes are partly shelter from wind, but, more important, the higher humus content and water-retaining capacity of the soil, and a high moisture content not associated with poor drainage. The smaller prevalence of fires in these associations is a major cause in determining the high humus-content, as also is the higher water-content.

E. piperita is found on the upper slopes of the sides of gullies, especially near Loddon Falls (Pl. xv, C), and in situations between the two arms of Cataract Reservoir. *E. pilularis* is found on the lower slopes of gullies in the latter area (as at D, Pl. xv). Associated with both are the low trees *Exocarpus cupressiformis, Acacia longifolia* and *Persoonia linearis,* and the shrubs *Trachymene Billardieri, Leucopogon lanceolatus, Cassinia denticulata* and *Hakea saligna,* together with shrubs and herbs of the drier areas.

Brush only develops in situations of extreme shelter, as below the Loddon Falls. It is dealt with in a later section.

In other districts, *Angophora lanceolata* is found associated with *E. piperita* in situations such as the above. It has not been observed in this district, but immediately to the north, at Helensburgh, it occurs at the heads of Hawkesbury Sandstone gullies.

(*c*). *Lithoseres.*

Xeric lithoseres proceed on the few exposed rock surfaces of the plateau where a high water-table does not occur, the initiating stages being chiefly lichens, with a few mosses. Prominent among the first low shrubs are *Darwinia taxifolia* and *D. virgata,* and the numerous sclerophyll shrubs of the *E. Sieberiana* association follow. The fairly abundant areas interspersed amongst the *E. Sieberiana* association, where the soil is shallow and the highest development is a shrub community, are regarded as a stage in this succession.

More often, the colonization of bare rock proceeds through the intermediate local swamp sere, due to a high water-table, often caused by cupping of the underlying rock. Mosses constitute the first stage, followed by herbs, especially species of *Drosera, Utricularia lateriflora* and *Lepyrodia scariosa,* and similar types. This stage proceeds imperceptibly to a local swamp community, in which the following species are most abundant: *Banksia latifolia* var. *minor, Epacris microphylla, Hakea pugioniformis, Olax stricta,* and *Symphyoneme paludosa*; *Bauera rubioides, Chorizandra sphaerocephala, Gahnia psittacorum, Gleichenia dicarpa, Goodenia bellidifolia, Gymnoschoenus sphaerocephalus, Hypolaena lateriflora, Lepidosperma laterale, Leptocarpus tenax, Lepyrodia scariosa, Mitrasacme polymorpha, Restio complanatus, Selaginella uliginosa, Sprengelia incarnata, Xanthorrhoea hastilis,* and *X. minor.*

This community proceeds, by emphasis of the shrubs and decline of the sedges, until the *E. Sieberiana* association is reached, *E. micrantha* Benth. being prominent at the ecotone. This succession is characterized by a gradual lowering of the water-table.

(*d*). *Extensive Swamp or Moor Communities.*

Large areas of the sandstone are covered with a mixed sedge-swamp, in some cases with the addition of shrubs tolerant of swamp conditions. The factor preventing development of a higher type of vegetation is the high average water-table. The low pH and high humus-content of the soil are secondary.

The topography where these communities occur is moderately flat, but with sufficient slope, at first sight, to cause wonder at the swamp conditions. Briefly, the apparent causes of the high water-table are: (1) Slowness of evaporation at ground-level, already mentioned. (2) An extremely clayey horizon at a depth of about 4 feet. (3) The tussocky nature of the plants, retarding water flow. (4) The presence of peculiar furrows, at intervals of one to two yards, at right angles to the normal slope and drainage. These, although not universal, are surprisingly frequent and regular; they may partly be due to the burrowing activities of the crayfish which are present in large numbers throughout these swamps.

In the large swamps near Sublime Point (as at Pl. xv, E) the following species are most important (in order of decreasing abundance):

Larger Herbs: *Gymnoschoenus sphaerocephalus, Lepidosperma Forsythii* Hamilton, *Lepyrodia scariosa, Chorizandra sphaerocephala, Restio complanatus* and *Xanthorrhoea minor.*

Smaller Herbs: *Selaginella uliginosa, Hypolaena lateriflora, Lycopodium laterale, Leptocarpus tenax, Goodenia bellidifolia, Xyris gracilis, Mitrasacme polymorpha* and *Epacris obtusifolia* (dwarfed).

Shrubs are very rare, being represented by scattered individuals of *Persoonia salicina, Hakea pugioniformis* and *Leptospermum juniperinum* Sm. In the somewhat drier community at Madden's Plains (as at Pl. xv, F), shrubs, especially the above species, together with *Banksia paludosa* and *Melaleuca squarrosa,* become more prominent, as also does *Xanthorrhoea minor.*

The ecotone between these communities and the *E. Sieberiana* association is similar to that bordering the local swamps mentioned in the preceding section. In several isolated instances, young specimens of *E. micrantha* Benth. extend beyond the tree limit, indicating a forward succession. In most cases, however, the limits are static, and swamp conditions cannot be superseded by a uniform increase in level due to plant remains. The soil is in most cases already very deep—in some cases more than sixteen feet, with plant remains occurring at a considerable depth. The water-table can only be lowered by allogenic causes, e.g., the working back of the Loddon Falls gorge by erosion, leading to better drainage conditions. The sequence of events which originally caused these swamps is obscure, but they have apparently been in their present state for a very long period.

(*e*). *Vegetation of the Scarp.*

Conditions on the face of the scarp and on the ledges and local small ravines which occur on it vary from very dry and exposed to moist and sheltered. Corresponding plants occur in these varying situations, and succession proceeds up to a certain stage, but trees are never formed on account of the transient nature of the surface and the frequent falls of rock.

Next to lichens, the mats of *Cyclophorus serpens, Polypodium Billardieri* and *Dendrobium linguiforme* are most important in colonizing dry rock faces. When sufficient soil is formed, the following types occur: *Actinotus Helianthi, Dracophyllum secundum, Epacris coriacea, E. longiflora, Xanthorrhoea arborea* and *Xanthosia pilosa.*

In moister situations, mosses and liverworts initiate the sere, which develops up to a stage where *Blechnum Patersoni, B. capense, Gleichenia circinata* and *Hypolaena lateriflora* and bushes of *Callicoma serratifolia, Cassinia denticulata, Doryphora sassafras, Pultenaea daphnoides* and *Tristania laurina* are prominent.

(2). *Wianamatta Shale.*

As one passes from Hawkesbury Sandstone to Wianamatta Shale at Darke's Forest, there is a pronounced change from *Eucalyptus Sieberiana* low forest to a high forest dominated by *E. piperita* and *Angophora lanceolata.* The low-tree stratum is much more pronounced than on the sandstone, *Acacia binervata, A. longifolia, A. rubida* and *Exocarpus cupressiformis* being the important species. In the shrub layer, the more mesophytic element is represented by *Hakea saligna, Leucopogon lanceolatus, Olearia ramulosa,* and *Persoonia ferruginea,* and, more rarely, *Cassinia aurea, Lomatia ilicifolia,* and *Olearia viscidula.* In addition there is an admixture of typical sandstone forms, *Acacia myrtifolia, Banksia ericifolia, B. spinulosa,* and *Persoonia salicina* being most important.

The most important herbs are *Blechnum cartilagineum, Haloragis teucrioides, Pteridium aquilinum* and *Viola hederacea,* with such typical sandstone species as *Doryanthes excelsa* and *Xerotes longifolia.*

The change of vegetation as one passes from sandstone to shale must be attributed to the greater water-retaining capacity of the soil derived from the latter. The absence of certain trees (notably *Syncarpia laurifolia*) characteristic on Wianamatta Shale elsewhere is surprising, and appears to be due to isolation rather than unsuitability of habitat.

(3). *Narrabeen Series.*

The vegetation of the Chocolate Shale and Narrabeen Sandstone exposed by the dissection of the plateau is discussed in this section; that on these rocks on the coastal slopes is discussed later.

Except in shelter, the vegetation on soils derived from both the above rock types is high Eucalyptus forest, dominated in the former case by *E. saligna,* and in the latter by *E. piperita.* Important constituents of the low-tree stratum in both communities are *Acacia longifolia, A. mollissima,* and *Exocarpus cupressiformis,* and of the shrub stratum *Indigofera australis, Persoonia ferruginea, P. lanceolata, P. salicina, Pimelea ligustrina, Pomaderris elliptica* and *Prostanthera Sieberi* Benth. The most abundant herbs are *Blechnum cartilagineum, Imperata arundinacea, Pteridium aquilinum* and *Viola hederacea.*

In conditions of partial shelter on the Chocolate Shale and efficient shelter on the Narrabeen Sandstone, brush develops. The constitution of the brush is discussed later. On Narrabeen Sandstone, in partial shelter, the *E. saligna* association forms. Brush elements, especially *Livistona australis* and *Alsophila australis,* are frequently scattered amongst the *E. piperita* and *E. saligna* associations in conditions where there is insufficient shelter for true brush to occur.

Surrounding the Cataract Reservoir, an interesting zonation occurs due to constant raising of the water-level (as at Pl. xv, G). Following the aquatic stages, there is an area of mud, frequently exposed, and inhabited only by introduced annuals; above this, a narrow zone of several species of *Juncus,* leading back through grasses (chiefly *Poa annua* (introd.) and *Imperata arundinacea*) to a shrub zone dominated by *Leptospermum flavescens* and *Melaleuca squamea,* and thence to the Eucalyptus forest.

VEGETATION OF THE SLOPES AND COASTAL PLAIN.

This section is subdivided as follows: (1) *E. pilularis* association and variant; (2) Brush; (3) Sand-dune succession; (4) Subsaline lagoon succession; (5) Sea-cliff vegetation. The vegetation altered by clearing and grazing has been omitted in the present study.

(1). E. pilularis *Association and Variant.*

Except where there is sufficient shelter and soil moisture for the development of brush, the coastal slopes and plain support a high forest dominated by *Eucalyptus pilularis*, with *E. paniculata* and *Syncarpia laurifolia* fairly commonly represented. The soil is derived chiefly from Narrabeen Sandstone and from the varied strata of the Upper Coal Measures (ranging from shale to coarse sandstone), but is also influenced by the rock lying above. Other smaller trees prominent in this association are *Casuarina torulosa*, *Notolea longifolia* and *Persoonia linearis*, and, especially in the moister situations, *Acacia binervata*. Other important elements are *Acacia myrtifolia*, *A. suaveolens*, *Helichrysum bracteatum*, *H. diosmifolium*, *Hibbertia dentata*, *Indigofera australis*, *Leucopogon lanceolatus*, *Oxylobium trilobatum*, *Persoonia salicina*, *Pimelea ligustrina*, *Prostanthera Sieberi* Benth., *Senecio dryadens* and *Zieria Smithii*, and the herbs *Hypochaeris glabra* (introd.), *Pteridium aquilinum*, and more rarely *Imperata arundinacea*, *Doodia aspera* and *Xerotes longifolia*. The introduced *Rubus fruticosus* is also abundant.

In soils derived from a tuffaceous mudstone in the Towradgi area, a mixed Eucalyptus forest occurs, of which the most important species are *E. botryoides*, *E. eugenioides*, *E. longifolia*, *E. paniculata* and *E. punctata*. The lower strata are similar to those of the climax of the subsaline lagoon succession discussed later.

(2). *Brush.*

East of the scarp, brush occurs on the uppermost slopes (except at the most prominent ridges) (e.g., Pl. xv, H), and on the inner side of terraces and in gullies at a lower level. These situations are sheltered from dry winds, and provided with copious water-supply, and conditions are favourable for the development of soil humus. The scarp, besides offering shelter from dry winds, decreases insolation by cutting off direct sunlight shortly after noon.

Brush also develops in partial shelter from the west on soils derived from the Chocolate Shale (e.g., Pl. xv, J), and under more extreme conditions of shelter on soils derived from Narrabeen and Hawkesbury Sandstone. In all cases, the ecotone between the brush and the adjacent Eucalyptus forest is indistinct, numerous brush types extending beyond the limit of the true highly-integrated brush formation.

Except for occasional high trees of *Eucalyptus saligna* and *Ficus rubiginosa*, the coastal brush is composed of a great number of species of trees of moderate height, mostly of the laurel-leaved type. The following are of particular importance:

Cargillia australis R.Br., *Ceratopetalum apetalum*, *Doryphora sassafras*, *Ficus stephanocarpa* Warb., *Eugenia Smithii*, *Hedycarya Cunninghamii*, *Laportea gigas*, *Livistona australis*, *Omolanthus populifolius*, *Panax sambucifolius*, *Pittosporum undulatum* and *Sloanea australis*. Of these, *Livistona australis* is singled out as the most abundant and characteristic species.

In the brush, low trees are rare, the tree-fern *Alsophila australis* being the sole exception; but on the ecotone between brush and Eucalypt forest, *Breynia oblongifolia*, *Eupomatia laurina*, *Lantana camara* (introd.), *Rhodamnia trinervia* and *Synoum glandulosum* are abundant.

Of the ground layer, the ferns *Adiantum aethiopicum*, *A. formosum*, *Asplenium flabellifolium*, *Histiopteris incisa*, *Pellaea falcata* and *Pteris umbrosa*, and the herbs *Gymnostachys anceps* and *Pollia cyanococca*, are the most important members.

In addition, climbers and epiphytes form a distinctive portion of the brush, the most abundant being *Eustrephus Brownii*, *Lyonsia straminea*, *Palmeria scandens*, *Sarcopetalum Harveyanum*, *Senecio mikanioides* Otto (introd.), *Smilax australis* and *Stephania hernandifolia*; *Pleopeltis diversifolia*, *Davallia pyxidata* and *Asplenium nidus*.

It is certain that the brush was far more extensive in this region in former times, but the effect of settlement, and the ravages of fire, have had disastrous effects on an association only able to regenerate itself slowly after fire or partial clearing.

Inland, brush developed on soils derived from the Narrabeen Series is comparable to the coastal brush, but poorer floristically and less highly integrated. The brush occurring in extreme shelter on Hawkesbury Sandstone is very poor floristically, the only common trees being *Callicoma serratifolia*, *Ceratopetalum apetalum*, *Doryphora sassafras*, and *Tristania laurina*.

(3). *Sand-dune Succession.*

Succession from wind-blown dunes is proved to be acting in a forward direction in parts of the area, as at Towradgi, by examination of the soil underlying the seral communities behind the dunes. It does not, however, reach the climax, for in all cases the highest development on what has been sand-dune—*Eucalyptus botryoides–Banksia integrifolia* associes—meets the opposing succession from the subsaline lagoon (the *E. robusta* associes) (as at Pl. xv, K). Areas where a climax may have been reached in the past have been cleared completely.

The sere is normal, being represented thus: (1) *Festuca litoralis–Spinifex hirsutus–Carex pumila* associes. (2) Shrub-dune dominated by *Leptospermum laevigatum*, *Leucopogon Richei* and *Acacia Sophorae*. (3) *Eucalyptus botryoides–Banksia integrifolia* associes, with a shrub layer mainly composed of relics of the earlier stage.

(4). *Subsaline Lagoon Succession.*

The sere leading from the subsaline lagoons can be listed as follows: (1) *Phragmites communis* associes (a narrow belt in shallow water). (2) *Juncus maritimus* associes (a broad belt at the edge of the lagoon, subject to constant flooding). (3) Where the lagoon border is very flat, a small zone, the *Cladium junceum* associes. (4) *Casuarina glauca* associes, forming a low forest, the ground layers mainly composed of *Juncus maritimus*. (5) *Eucalyptus robusta* associes, with ground layers composed of members of the preceding seres, and *Gahnia psittacorum*. (6) Climax mixed forest in which *Eucalyptus botryoides*, *E. eugenioides* and *E. paniculata* are predominant. The lower strata contain elements of the former stages of this succession and of the hind-dune vegetation (e.g., *Cladium junceum*, *Gahnia psittacorum*, *Leucopogon Richei*, *Leptospermum laevigatum*), with a definite brush element (e.g., *Breynia oblongifolia*, *Clerodendron tomentosum* and *Stephania hernandifolia*).

(5). *Sea-cliff Vegetation.*

Vegetation on the steep sea-cliffs, as at Austinmer (Pl. xv, L), is subjected to great exposure to sea-winds, and, on the lower portions, a high concentration of salt. These factors, coupled with frequent landslips, prevent the development of anything higher than a shrub community. An interesting zonation occurs, but does not constitute a true case of succession:

(1) A zone of halophytic herbs, the most prominent being *Lobelia anceps* and *Samolus repens*, and less commonly *Apium prostratum*, *Plantago varia* and *Scaevola hispida*. This merges into:

(2) A shrub zone, dominated by *Banksia integrifolia*, *Leptospermum laevigatum*, *Westringia rosmariniformis*, and small shrubs of *Casuarina glauca*.

Behind this zone the vegetation passes with an indefinite ecotone to the *Eucalyptus pilularis* association, with trees of *Banksia integrifolia*, decreasing in number with distance from the sea.

Interpretation.

Omitting communities which are either seres or are held in a condition obviously below the climax and are unable to proceed by a forward autogenic succession to the climax, we may summarize the distribution of the main communities as in the following table:

Conditions of Shelter.	Parent Rock of Soil (coarsest soil to the left).				
	Hawkesbury Sandstone.	Narrabeen Sandstone.	Wianamatta Shale.	Upper Coal Measures.	Chocolate Shale.
Flat or undulating conditions	*E. Sieberiana* association.	*E. piperita* association.	*E. piperita–Angophora lanceolata* association.	*E. pilularis* association; mixed Eucalyptus forest (tuffaceous mudstone.)	*E. saligna* association.
Moderate shelter	*E. piperita* association.	*E. saligna* association (inland); *E. pilularis* association (coastal slopes).	Conditions do not occur.	Brush (low grade).	Brush.
Good shelter ..	*E. pilularis* association.	Brush (low grade).	Conditions do not occur.	Brush.	Brush.
Extreme shelter	Brush (low grade).	Brush.	Conditions do not occur.	Brush.	Brush.

From this table it will at once be seen that a prominent part is played, in the distribution of communities in this area, by the influence of parent rock on vegetation by the medium of the derived soil. The influence of topographic shelter can likewise be gauged.

Although no definite objective test can be made as to what constitutes the climax association, and such interpretations must necessarily be guided by personal opinions, the following classification is submitted:

The climax formation for the district is *Eucalyptus* forest (sclerophyll forest). Brush in all cases constitutes a physiographic postclimax. Weaver and Clements (1929) give the following details concerning the postclimax (p. 78): "Local communities may develop or persist where especially favourable conditions of soil, humidity, etc., exist, which represent a more highly developed stage than the present climatic climax of the region." Subsequent statements by Clements (1936, p. 269) do not appear to alter this interpretation, although the relict nature of the postclimax is emphasized.

It seems logical to extend the concept of the postclimax, within the major limits of the formation, to the smaller units of associations. Thus the climax is taken as the highest association that develops in homologous positions, on mature soils with undulating to flat topographical conditions, on the soils derived from the varying rock types; the climax association thus varying with the parent rock, and an association which is the climax on one soil corresponding to a postclimax development on a soil of coarser texture. Thus the following climaxes are recognized:

Hawkesbury Sandstone: *Eucalyptus Sieberiana* association.
Narrabeen Sandstone: *E. piperita* association.
Wianamatta Shale: *E. piperita–Angophora lanceolata* association.*
Upper Coal Measures (mostly): *E. pilularis* association.
Upper Coal Measures (tuffaceous mudstone): Mixed *Eucalyptus* forest.
Climax of sere from Subsaline lagoon: Mixed *Eucalyptus* forest.
Chocolate Shale: *E. saligna* association.

Comparing the communities listed in the table for Hawkesbury Sandstone, Narrabeen Sandstone, and Upper Coal Measures, we see that if similar associations in the respective columns be joined, the lines represent diagonals. On mature soils on the coastal plain derived from shales of the Upper Coal Measures, the *E. pilularis* association forms the climax; on soils from this parent rock, brush forms as a postclimax, in varying degrees of integration depending on varying degrees of shelter. If we take a homologous situation on soil derived from Narrabeen Sandstone to that on which the *E. pilularis* association develops on the coastal plain, the vegetation is found to be the *E. piperita* association. In conditions of greater shelter, the *E. pilularis* association (or, inland, the corresponding *E. saligna* association) develops; in any greater shelter, brush develops. These are regarded as primary and secondary postclimaxes. On mature soil derived from Hawkesbury Sandstone, with undulating topography, the highest community found in this district is the *E. Sieberiana* association; primary, secondary and tertiary postclimaxes on soil from this rock are represented by the *E. piperita* association, the *E. pilularis* association and low-grade brush; the first in partial, the second in good, the last only in extreme shelter.

Turning now to communities below the climax, we can dismiss the following as being legitimate cases of autogenic succession leading to the climax of the region:

(1) Xeric lithoseres as on Hawkesbury Sandstone leading eventually to the *E. Sieberiana* association or corresponding climax.

(2) Lithoseres subject to moister conditions, as detailed under the Hawkesbury Sandstone vegetation, where local swamps form an intermediate stage.

(3) The sand-dune sere (not observed to reach a climax in this district, but this negative observation is probably due to clearing).

(4) The seres bordering the subsaline lagoons (*Phragmites communis* associes–*Juncus maritimus* associes–*Casuarina glauca* associes–*Eucalyptus robusta* associes), leading to climax mixed Eucalyptus forest.

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* As stated earlier, it is probable that a climax richer floristically would develop if it were not for isolation.

Both (3) and (4) are subject to retrogression also in certain places, as by "blow-outs" caused by southerly winds in (3), and scouring in (4). Moreover, where a narrow belt of land occurs between dune and lagoon, (3) proceeds to *Eucalyptus botryoides–Banksia integrifolia* associes, (4) proceeds to *E. robusta* associes, and the seres meet at this point, the climax not forming (Pl. xv, K).

The remaining communities below the climax are regarded as subclimax vegetation in the restricted sense of Godwin (1929). The extensive swamps or moors of the sandstone plateau appear unable to proceed (except in the very few instances noted, insignificant from the point of view of total area), beyond the present state, except by allogenic causes, for reasons of high water-table. The varying vegetation of the sandstone scarp, proceeding by autogenic succession from the bare rock faces left by rock falls up to a certain stage, can never attain climax status under the present system of erosion, but can proceed to varying stages in the lithosere succession before the next fall brings the conditions back to the bare rock face stage again. The vegetation surrounding Cataract Dam represents a true subclimax due to periodic artificial raising of the water-table.

The sea-cliff vegetation, although it shows a clear zonation from the base of the cliff to climax forest on the cliff-top, does not represent a forward succession in time. Erosion causes inhibition of development, as on the sandstone scarp, and the actual result to the vegetation, due to this allogenic cause, is retrograde. Under the present conditions, corresponding portions of the cliff will always regenerate, following landslips, to their former vegetation, but no higher; and as a result of the erosion the cliff-face as a whole works backwards, to cause the destruction of the adjacent parts of the higher communities.

It will be gathered from the above that subclimax vegetation is a very important feature of the area. Indeed, cases of forward autogenic plant succession to the climax are believed to be far rarer in this country than is sometimes supposed, and a mere spatial zonation must always be examined very critically before it can be pronounced to represent a true succession.

The above interpretations may be regarded as unconventional, but it is submitted that, since the explanation of the basic causes of the distribution of communities has been suggested, the nomenclature of these communities is a secondary consideration. The terminology used in interpreting plant communities has become so involved that there appears to be a tendency to consider it an end in itself, and not a utilitarian method of classifying facts due to direct natural causes, the understanding of which is, in the end, the main object. The following remarks of Benjamin Moore epitomize well the necessary attitude in controversies of nomenclature: "Care is needed that in entering into disputations . . . terminology is not becoming confused so that the dispute is only over terms, instead of over things."

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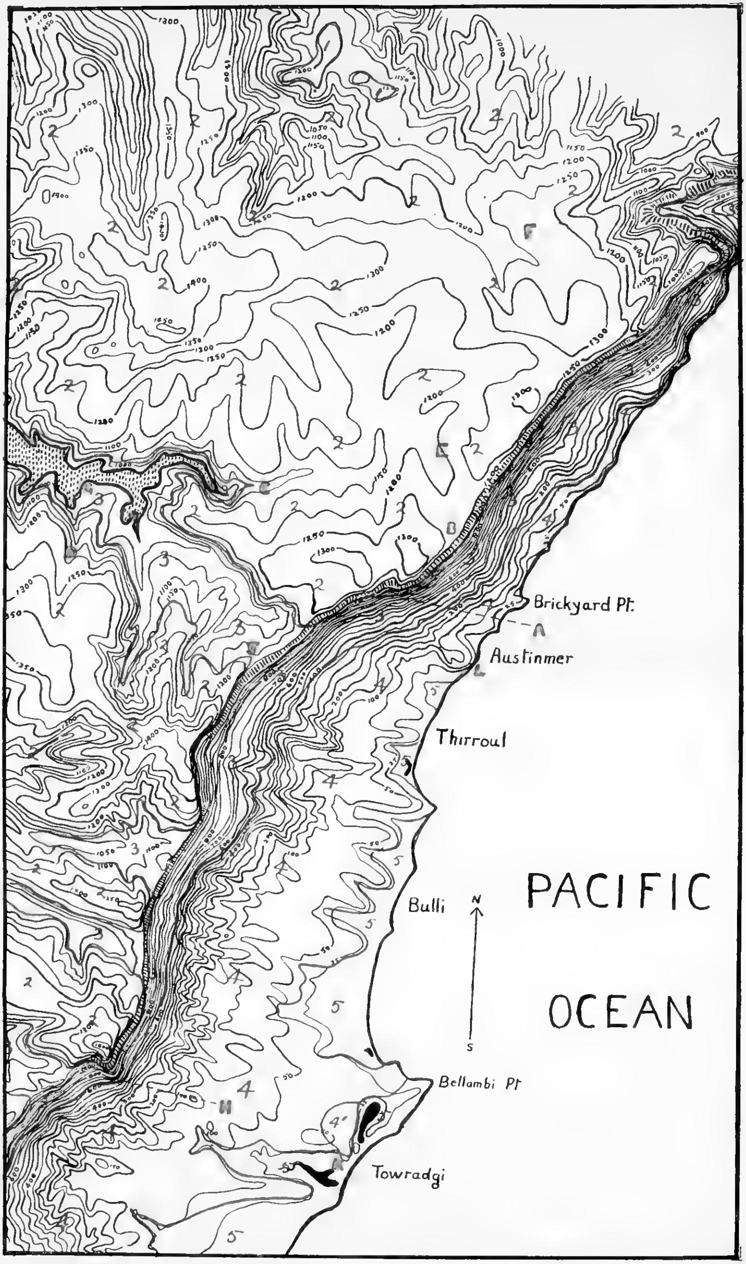

Geological and Contour Map of the Bulli District (1 inch = 1 mile, contour interval, 50 feet).

EXPLANATION OF PLATE XV.

Geological and Contour Map of the Bulli District (1 inch = 1 mile).

Explanation.

Geological Formations (outlines and numbering in colour): 1, Wianamatta Shale; 2, Hawkesbury Sandstone; 3, Narrabeen Series (top 50 feet (approximately), Chocolate Shale; remainder, Narrabeen Sandstone); 4, Upper Coal Measures; 4′, Upper Coal Measures (Tuffaceous Mudstone); 5, Recent (Alluvial, and Wind-blown Sand).

■ Subsaline lagoon. ▥ Cataract Reservoir.

Points referred to in Text (A-L, coloured lettering): A. Position of landslip from scarp; B. Short easterly slope of plateau; C. Position of partial shelter on Hawkesbury Sandstone, Loddon Falls, with *Eucalyptus piperita* association; D. Position of efficient shelter on Hawkesbury Sandstone, with *E. pilularis* association; E. Large swamp near Sublime Point; F. Large swamp or moor at Madden's Plains; G. Edge of Cataract Reservoir, with zonation of plant communities; H. Ridge on slopes immediately below scarp, with no brush development; J. Brush in conditions of slight shelter on Chocolate Shale soil; K. Junction of sand-dune and subsaline lagoon seres on neck of land between lagoon and sea; L. Sea-cliff at Austinmer.

(Except A, H, and K, and to a less extent C, D, and J, letters represent merely one point in an extensive community.)

REVISION OF AUSTRALIAN LEPIDOPTERA. OECOPHORIDAE. V.

By A. Jefferis Turner, M.D., F.R.E.S.

[Read 28th October, 1936.]

We have now to deal with a difficult group consisting of the genus *Eulechria* and its closest allies. Since the publication of my key in Part iii (May, 1935) I have modified my views. I find that the length of the palpi in *Eulechria* varies much in allied species, and occasionally to some extent in the same species (for instance in *E. tropica*). I have, therefore, abandoned the proposed genus *Phanerozancla*, which remains a *nomen nudum*. The name *Brachyzancla* is retained, but in a different sense from that formerly given. *Sphyrelata* is omitted, and will be dealt with later. (*Epithymema*, which concludes Part iv, should have been numbered 54, not 53.) The last part of my Key is amended as follows:

Key to Genera.

31.	Palpi with second joint extremely long, more than 5 times length of face	54. *Epithymema*
	Palpi not so	32
32.	Hindwings lanceolate	33
	Hindwings elongate-ovate	37
33.	Palpi with second joint thickened and usually roughened anteriorly, terminal joint stout, at least at base	34
	Palpi with second joint smooth and slender, terminal joint slender	35
34.	Hindwings with 4 and 5 stalked	55. *Phloeocetis*
	Hindwings with 4 and 5 separate	56. *Ischnophanes*
35.	Hindwings with 4 and 5 stalked or rarely connate	57. *Elaphromorpha*
	Hindwings with 4 and 5 separate	36
36.	Hindwings with 5 approximated to 6 at origin	58. *Asthenica*
	Hindwings with 5 approximated to 4	59. *Macronemata*
37.	Palpi usually not reaching vertex, terminal joint less than half second	38
	Palpi exceeding vertex, terminal joint more than half second	39
38.	Palpi with second joint short and slender	60. *Brachyzancla*
	Palpi with second joint thickened and moderately long or elongate	61. *Idiozancla*
39.	Palpi with terminal joint stout	62. *Trachyntis*
	Palpi with terminal joint slender	40
40.	Hindwings with 5 strongly approximated to 6	63. *Eccrita*
	Hindwings with 5 not approximated to 6	41
41.	Palpi with long rough hairs on posterior surface of second joint	64. *Anomozancla*
	Palpi not so	65. *Eulechria*

55. Gen. Phloeocetis, n.g.

φλοιοκοιτις, lurking in bark.

Tongue present. Palpi recurved, ascending; second joint just reaching base of antennae, thickened with appressed scales, slightly rough anteriorly; terminal joint shorter than second, stout, acute. Antennae with basal pecten; ciliations in male long. Forewings narrow; 7 to apex. Hindwings lanceolate; 4 and 5 stalked, their common stalk connate or stalked with 3.

A derivative of *Ischnophanes* with specialized neuration of hindwings.

435. PHLOEOCETIS VIRGEA, n. sp.

virgeus, streaked.

♂, ♀. 14–15 mm. Head white, some irroration and a pair of spots on crown blackish. Palpi with terminal joint three-fifths; blackish, second joint with postmedian and apical, terminal joint with antemedian and apical white rings. Antennae grey; ciliations in male 2½. Thorax white; a pair of longitudinal bars, spots on tegulae, and one on posterior end, blackish. Abdomen grey. Legs white with blackish rings. Forewings lanceolate, costa straight, apex obtusely pointed, termen extremely oblique; white finely sprinkled with fuscous so as to appear grey; markings blackish; a fine costal streak from base to two-fifths, leaving costal edge white; a median streak from base to one-fifth; a discal streak from beneath two-fifths costa to apex, containing a discal dot at one-fourth from base; a short streak below middle; another less defined on apical part of dorsum, tornus, and lower half of termen; cilia white with some dark fuscous points. Hindwings broadly lanceolate; whitish; thinly scaled and translucent towards base; suffused with grey towards apex; cilia 1; grey.

Queensland: Toowoomba in October and November; four specimens received from Mr. W. B. Barnard, who has the type.

56. Gen. ISCHNOPHANES, n.g.

ισχνοφανης, narrow.

Tongue present. Palpi with second joint not or just reaching base of antennae, thickened and usually roughened anteriorly; terminal joint rather stout, at least towards base. Antennae with basal pecten; ciliations in male short, moderate, or long. Forewings narrow, 7 to apex. Hindwings lanceolate; 3 and 4 connate, 5 approximated to 4.

Type, *I. thrypticopa* Meyr. Differs from *Macronemata* in the palpi, and from *Eulechria* in the palpi and hindwings. It appears to be a natural genus.

Sixteen species: 436. *macromita*, n. sp. (Adavale, Q.).—437. *semidalota*, n. sp. (Toowoomba, Macpherson Range).—438. *leucospila* Meyr., *Exot. Micro.*, ii, p. 370 (Brisbane, Toowoomba, Stanthorpe).—439. *symmicta*, n. sp. (Sydney, Mittagong).—440. *idiotropa*, n. sp. (Brisbane).—441. †*cimmeriella* Meyr., P.L.S.N.S.W., 1882, p. 543 (Bowenfels, Cooma).—442. *elaphropa*, n. sp. (Stradbroke I.).—443. *capnopleura*, n. sp. (Talwood, Q.).—444. *thrypticopa* Meyr., *Tr.R.S.S.Aust.*, 1902, p. 153 (Melbourne, Gisborne).—445. *euthemon*, n. sp. (Gosford).—446. *plagiospila* Low., *Tr.R.S.S.Aust.*, 1920, p. 59 (Sydney).—447. *nefanda* Meyr., *Exot. Micro.*, i, p. 171 (Brisbane to Gisborne) = *mesochra* Turn., P.L.S.N.S.W., 1916, p. 364.—448. *suffusa*, n. sp. (Mt. Tambourine).—449. *atelesta*, n. sp. (Brisbane).—450. *hermaea* Meyr., *Exot. Micro.*, i, p. 172 (Emerald, Q., Macpherson Range, Bathurst, Beaconsfield).—451. *potheta*, n. sp. (Tweed Hds.).

436. ISCHNOPHANES MACROMITA, n. sp.

μακρομιτος, with long threads.

♂, ♀. 15–20 mm. Head and thorax dark grey. Palpi with terminal joint one-half; fuscous, terminal joint white with two fuscous rings. Antennae grey; ciliations in male 1. Abdomen and legs grey. Forewings lanceolate; grey; a grey-whitish streak on costa from base to one-third; a fine blackish streak from base of costa through disc above middle to near below apex, some grey-whitish suffusion on its upper edge; a similar streak on fold from base nearly to tornus; cilia grey. Hindwings and cilia pale grey.

Queensland: Adavale in April and May; three specimens.

437. ISCHNOPHANES SEMIDALOTA, n. sp.

σεμιδαλοτος, floury.

♂. 15 mm. Head whitish with some fuscous scales. Palpi with second joint not reaching base of antennae, terminal joint three-fifths; fuscous, second joint with postmedian and apical, terminal joint with antemedian and apical white rings. Antennae grey, becoming whitish towards base; ciliations in male 2½. Thorax dark fuscous; anterior and posterior spots and tegulae white. Abdomen ochreous, apices of segments and tuft grey-whitish. Legs whitish; anterior and middle tarsi with fuscous rings. Forewings narrow-oblong, costa straight, apex rounded, termen extremely oblique; white with dark fuscous irroration and markings; a much interrupted subcostal line from base to beyond middle; a very short streak on midcosta; first discal at one-third, plical beneath it, second discal at two-thirds; a short median streak before termen, another parallel before and beneath it; three costal bars before apex, and a terminal series of dots; cilia white with a few fuscous points. Hindwings broadly lanceolate; grey-whitish; cilia 1; grey-whitish.

Allied to the preceding; forewings somewhat broader, whiter, and less streaked.

Queensland: Toowoomba in October; Macpherson Range (Springbrook) in October; two specimens.

439. ISCHNOPHANES SYMMICTA, n. sp.

συμμικτος, commingled.

♂, ♀. 18 mm. Head and thorax whitish-ochreous, pinkish-tinged. Palpi with second joint reaching base of antennae, terminal joint four-fifths; dark fuscous, second joint with postmedian and apical, terminal joint with sub-basal and subapical white rings. Antennae dark fuscous with white annulations; ciliations in male 1½. Abdomen fuscous; tuft grey. Legs dark fuscous with white rings; posterior pair mostly white. Forewings narrow, costa slightly arched, apex rounded, termen very oblique; whitish-ochreous, pinkish-tinged, densely sprinkled with dark fuscous scales, the absence of which gives rise to pale spots; a basal spot; a dot on costa near base, and costal spots on middle and three-fourths; a subdorsal spot at one-third; several more or less confluent spots in posterior half, and a suffused terminal band; stigmata blackish, first at one-fourth, plical beyond it, second discal about middle; cilia whitish-ochreous, bases sprinkled with dark fuscous. Hindwings and cilia grey.

New South Wales: Mittagong in November; Sydney (National Park) in February; two specimens received from Mr. G. M. Goldfinch, who has the type.

440. ISCHNOPHANES IDIOTROPA, n. sp.

ἰδιοτροπος, peculiar.

♂. 14 mm. Head and thorax white. Palpi with second joint not reaching base of antennae, terminal joint three-fifths; white, base of second joint and a median ring on terminal joint dark fuscous. Antennae pale grey; ciliations in male one-half. Abdomen whitish. Legs fuscous with whitish rings; posterior pair whitish. Forewings very narrow, costa nearly straight, apex rounded, termen very oblique; white; markings blackish; a dot on base of dorsum; a dot on one-fourth costa; a suffused mark on midcosta; first discal at one-fourth, plical well before it, second discal enlarged into an irregular angular spot; a fine curved interrupted line from three-fourths costa to tornus, preceded by some suffusion; cilia white. Hindwings lanceolate; whitish; cilia 1, whitish.

Queensland: Burpengary, near Brisbane, in August; one specimen.

442. Ischnophanes elaphropa, n. sp.

ἐλαφρωπος, light.

♂. 11–12 mm. Head and thorax pale grey. Palpi with terminal joint one-half; pale grey, apex of terminal joint fuscous. Antennae pale grey; ciliations in male 1. Abdomen grey. Legs pale grey; posterior pair whitish. Forewings narrow, lanceolate; pale grey with blackish dots; first discal at one-third, plical beyond it, second discal just before two-thirds; a dot on midcosta; a series of dots close to margin of termen and apical third of costa; cilia pale grey. Hindwings lanceolate; pale grey; cilia 1, pale grey.

Queensland: Stradbroke I. in September; two specimens.

443. Ischnophanes capnopleura, n. sp.

καπνοπλευρος, with dark costa.

♂. 13 mm. Head white. Palpi with terminal joint one-half; blackish, subapical and apical rings on second joint, median ring on terminal joint, white. Antennae fuscous; ciliations in male 1. Thorax white; anterior edge blackish. Abdomen pale grey. Legs fuscous with whitish rings; posterior pair mostly whitish. Forewings very narrow, costa slightly arched, apex rounded, termen obliquely rounded; white; whole of costal area except near apex blackish; a broad transverse median fascia and a subapical blotch blackish; some blackish irroration in terminal area; cilia white with some blackish points. Hindwings and cilia grey.

Queensland: Talwood in December; one specimen received from Mr. W. B. Barnard.

445. Ischnophanes euthemon, n. sp.

εὐθημων, neat.

♂, ♀. 13–14 mm. Head grey. Palpi with second joint not reaching base of antennae, terminal joint three-fifths; fuscous, second joint with postmedian and apical, terminal joint with median and subapical, whitish rings. Antennae grey with blackish annulations; ciliations in male 1. Thorax grey-whitish. Abdomen grey. Legs dark fuscous with whitish rings; posterior pair mostly whitish. Forewings narrow, lanceolate; grey-whitish with markings and scanty irroration dark fuscous; a sub-basal costal dot, and a short basal dorsal streak; costal spots at one-fourth and middle; first discal at one-third forming apex of first costal spot, plical beyond it, connected by irroration with dorsum, second discal at two-thirds, an additional spot between last and tornus more or less developed; a subapical costal spot, usually part of an apical suffusion; cilia grey-whitish sprinkled with dark fuscous, on tornus grey. Hindwings lanceolate; grey; cilia 1, grey.

Probably *I. plagiospila* Low. is nearly allied, but the only example of this I have seen had no palpi.

New South Wales: Gosford in November; three specimens.

448. Ischnophanes suffusa, n. sp.

suffusus, suffused.

♂. 15 mm. Head pale brown. Palpi with second joint reaching base of antennae, terminal joint one-half; fuscous-brown, second joint with median, postmedian, and apical fuscous bars on outer surface, inner surface mostly whitish. Antennae grey; ciliations in male 1¼. Thorax fuscous-brown. Abdomen grey. Legs fuscous with whitish rings; posterior pair whitish. Forewings narrow, costa straight except towards extremities, apex rounded, termen very obliquely rounded; brownish-fuscous; a rather broad transverse whitish fascia at one fourth, not quite reaching costa, its edges not sharply defined; stigmata obscurely darker, first discal at one-third near edge of fascia, plical slightly beyond it, second dorsal before two-thirds; some whitish suffusion beyond second discal; cilia grey-whitish. Hindwings and cilia grey-whitish.

Queensland: Mt. Tambourine in November; one specimen.

449. Ischnophanes atelesta, n. sp.

ἀτελεστος, unfinished.

♂. 17 mm. Head whitish. Palpi with second joint not reaching base of antennae, terminal joint three-fifths; whitish sprinkled with dark fuscous. Antennae whitish; cilia in male 6. Thorax whitish sprinkled with dark fuscous. Abdomen grey, partly brownish-tinged; apices of segments and tuft whitish. Legs whitish; anterior pair fuscous. Forewings narrow, oblong, costa slightly bisinuate, apex rounded, termen very obliquely rounded; white with sparse patchy fuscous irroration; a moderate ill-defined darker basal patch; an elongate dorsal patch from middle to tornus; a large oval subapical patch from four-fifths costa to tornus; stigmata two, blackish, first discal at one-third, second at two-thirds; cilia whitish-grey. Hindwings and cilia pale grey.

Queensland: Brisbane in October; one specimen.

451. Ischnophanes potheta, n. sp.

ποθητος, desired.

♂. 14–16 mm. Head whitish. Palpi with second joint reaching base of antennae, terminal joint one-half; fuscous, second joint with subapical and apical, terminal joint with broad median white rings. Antennae grey; ciliations in male 5. Thorax whitish (damaged). Abdomen pale grey. Legs fuscous; posterior pair ochreous-whitish. Forewings narrow, costa gently arched, apex round-pointed, termen strongly oblique; white with some fuscous scales; markings blackish; basal dots on costa and dorsum; a conspicuous spot on costa at three-fifths; a smaller spot between this and base, and another subapical; a terminal series of dots; cilia whitish. Hindwings and cilia pale grey.

Queensland: Caloundra in August; New South Wales: Tweed Heads in November; two specimens.

57. Gen. Elaphromorpha, n.g.

ἐλαφρομορφος, lightly built.

Tongue present. Palpi smooth, slender, recurved; second joint not reaching base of antennae; terminal joint shorter than second, slender, acute. Antennae with basal pecten present but not strongly developed; ciliations in male moderately long. Forewings with 7 to apex. Hindwings lanceolate; 4 and 5 stalked (in one example of *E. glycymilicha* these veins are coincident).

Type, *E. glycymilicha.* Differs from *Phloeocetis* by the slender smooth palpi, and from *Macronemata* by the origin of 5 of hindwings.

Two species: 452. *glycymilicha*, n. sp. (Mt. Tambourine, Macpherson Range).—453. *dryoterma* Meyr., *Exot. Micro.*, ii, p. 372 (Brisbane, Toowoomba, Warwick, Gosford).

452. Elaphromorpha glycymilicha, n. sp.

γλυκυμειλιχος, charming.

10–13 mm. Head fuscous; face white. Palpi with terminal joint three-fifths; white, apex of terminal joint fuscous. Antennae grey; ciliations in male 1½. Thorax fuscous; apices of tegulae white. Abdomen grey. Legs white; anterior tibiae fuscous; anterior and middle tarsi with fuscous rings. Forewings narrow, oval, costa moderately arched, apex rounded, termen extremely oblique; white; markings brownish-fuscous; a large spot on base of dorsum, rounded, extending two-thirds across disc; a moderate oblique fascia from two-fifths costa to mid-dorsum; a similar direct fascia from two-thirds costa to tornus; a large apical spot; cilia whitish with some basal fuscous scales. Hindwings pale grey, towards base whitish; cilia 1, pale grey.

Queensland: Mt. Tambourine in November; Macpherson Range (3,500 feet) in December; three specimens.

58. Gen. Asthenica, n.g.

ἀσθενικος, feeble.

Tongue present. Palpi with second joint not reaching base of antennae, slender, smooth; terminal joint one-half, slender, acute. Antennae with basal pecten; ciliations in male moderately long. Forewings lanceolate; 7 to apex. Hindwings lanceolate; 3 and 4 widely separate, 5 strongly approximated to 6 at origin, 6 and 7 parallel.

Characterized by the peculiar neuration of the hindwings.

454. Asthenica stenopolia, n. sp.

στενοπολιος, narrow, grey.

♂. 15 mm. Head and thorax grey. Palpi grey. Antennae grey; ciliations in male 2. (Abdomen missing.) Legs fuscous; posterior pair whitish. Forewings narrow, costa slightly arched; apex pointed, termen extremely oblique; grey; discal dots and some scanty irroration fuscous; a large but ill-defined darker basal patch; first discal at one-third, sometimes lost in basal patch, plical beneath it, second discal at three-fourths, a dot in disc above and before middle; some fuscous scales on termen; cilia grey. Hindwings broadly lanceolate; pale grey; cilia 1, pale grey.

Queensland: Macpherson Range in March; one specimen.

59. Gen. Macronemata Meyr.

Proc. Linn. Soc. N.S.W., 1883, p. 345.

Tongue present. Palpi with second joint not or just reaching, or rarely slightly exceeding, base of antennae; terminal joint shorter, or rarely as long as second, slender, acute. Antennae with basal pecten; ciliations in male ranging from very short to long. Forewings narrow; 7 to apex. Hindwings lanceolate; 3 and 4 connate or rarely stalked.

Type, *M. elaphia* Meyr. Differs from *Eulechria* in the narrower forewings, lanceolate hindwings, and usually shorter palpi. Their separation is not always easy, but appears necessary.

Fifty-three species: 455. *cycnoptera* Meyr., P.L.S.N.S.W., 1887, p. 966 (Brisbane to Kiama, Adavale).—456. *consimilis*, n. sp. (Townsville, Yeppoon).—457. *argochroa*, n. sp. (Brisbane).—458. *elaphia* Meyr., P.L.S.N.S.W., 1883, p. 346 (Glen Innes, Ebor, Mt. Kosciusko, Tasmania) = *exigua* Turn., ibid., 1916, p. 259.—459. *pauromorpha*, n. sp. (Caloundra, Q.).—460. *aphaurophanes*, n. sp. (Mt. Wellington).—461. *optalea* Meyr., *Tr.R.S.S.Aust.*, 1902, p. 151 (Brisbane, Gisborne).—462. *semidalis*, n. sp. (Cairns).—463. *leptogramma*, n. sp. (Brisbane).—464. *stoechodes*, n. sp. (Cardwell, N.Q.).—465. †*paurogramma* Meyr.[*] (Mt. Wellington, Deloraine).—466. *fragilis* Meyr., *Exot. Micro.*, i, p. 271 (Adaminaby, Gisborne).—467. *nepheloma* Low., P.L.S.N.S.W., 1899, p. 105 (Broken Hill).—468. *proscedes*, n. sp. (Talwood,

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[*] P.L.S.N.S.W., 1882, p. 542.

Q.).—469. *zalias* Low., P.L.S.N.S.W., 1899, p. 107 (Broken Hill, Birchip, Beaconsfield, V.).—470. *suppletella* Wlk., xxix, p. 645; Meyr., P.L.S.N.S.W., 1888, p. 1585 (Gisborne, Beaconsfield, Deloraine, Mt. Gambier).—471. *anarcha* Meyr., P.L.S.N.S.W., 1888, p. 1584 (Bulli).—472. *stenodes*, n. sp. (Albany, W.A.).—473. *rhadinodes*, n. sp. (Toowoomba).—474. *araeoptera*, n. sp. (Stanthorpe, Sydney).—475. *pleurocapna*, n. sp. (Mt. Tambourine).—476. *pleurosticha*, n. sp. (Broken Hill).—477. *amaloptera*, n. sp. (Perth, W.A.).—478. *pusilla*, n. sp. (Macpherson Range).—479. *filifera*. n. sp. (Brisbane).—480. *omospila*, n. sp. (Mt. Wellington, Lake St. Clair, Gordon R.).—481. *basisticha*, n. sp. (Brisbane).—482. *textilis* Meyr., *Tr.R.S.S.Aust.*, 1906, p. 36 (Glen Innes to Sydney, Campbelltown, Tas.).—483. †*perdita* Meyr., P.L.S.N.S.W., 1882, p. 547 (Sydney).—484. *perangusta*, n. sp. (Broken Hill).—485. *eriopa* Low., P.L.S.N.S.W., 1900, p. 41 (Broken Hill).—486. *quaerenda* Meyr., *Exot. Micro.*, ii, p. 309 (Nambour, Brisbane).—487. *abrithes*, n. sp. (Macpherson Range).—488. *delotypa*, n. sp. (Cairns).—489. *asthenospila*, n. sp. (Yeppoon).—490. *didymospila*, n. sp. (Gosford).—491. *glaberrima*, n. sp. (Brunswick Heads).—492. *zemiodes* Meyr., *Tr.R.S.S.Aust.*, 1902, p. 149 (Bendigo).—493. *cyrtoloma*, n. sp. (Talwood).—494. *stramenticia*, n. sp. (Bunya Mts.).—495. *pentasticta*, n. sp. (Atherton).—496. *mesoscia*, n. sp. (Brisbane).—497. *lopelictes* Meyr., P.L.S.N.S.W., 1883, p. 346 (Toowoomba, Macpherson Range).—498. *tacita* Turn., *P.R.S.Tas.*, 1926, p. 146 (Zeehan, Strahan).—499. *epiconia*, n. sp. (Jervis Bay).—500. *dyspines*, n. sp. (Macpherson Range).—501. *litopis*, n. sp. (Atherton, Eungella, Brisbane, Bunya Mts.).—502. *commoda*, n. sp. (Cape York).—503. *phaeogramma*, n. sp. (Cape York).—504. *phaeostephes* Meyr., P.L.S.N.S.W., 1887, p. 956 (Cape York, Duaringa, Emerald, Chinchilla, Charleville).—505. *megalospora*, n. sp. (Bowen, Talwood, Adavale).—506. *modica* Turn., P.L.S.N.S.W., 1916, p. 352 (Brisbane, Warwick, Killarney).—507. *achlyopa*, n. sp. (Mareeba, Atherton).

455. MACRONEMATA CYCNOPTERA Meyr.

Palpi with second joint just reaching base of antennae; terminal joint one-half. Antennal ciliations in male one-half.

456. MACRONEMATA CONSIMILIS, n. sp.

consimilis, extremely similar.

♂, ♀. 12–14 mm. Head and thorax white. Palpi with second joint slightly exceeding base of antennae, terminal joint three-fourths; white, external surface of second joint except apex pale fuscous. Antennae whitish; ciliations in male one-half. Abdomen whitish-grey. Legs pale fuscous; posterior pair whitish. Forewings narrow, costa gently arched, apex pointed, termen very oblique; white, costal edge near base often dark fuscous; cilia white. Hindwings and cilia whitish-grey.

Distinguishable from the preceding by its longer palpi.

North Queensland: Townsville in September and October. Queensland: Yeppoon in October; six specimens.

457. MACRONEMATA ARGOCHROA, n. sp.

ἀργοχροος, shining white.

♂. 13 mm. Head and thorax white. Palpi with second joint slightly exceeding base of antennae, terminal joint three-fifths; whitish, external surface of second joint pale fuscous. Antennae whitish; ciliations in male one-third. Abdomen whitish. Legs whitish; anterior pair pale fuscous. Forewings with costa gently arched, apex rounded, termen very oblique; clear white; stigmata and a few scattered scales pale fuscous; dots minute, first discal at one-third, plical beyond it, second discal at two-thirds, a dot midway between and above discals, a dot beneath and slightly beyond second discal; cilia white. Hindwings lanceolate; grey-whitish; cilia grey-whitish.

Queensland: Brisbane in December; one specimen.

459. Macronemata pauromorpha, n. sp.

παυρομορφος, little.

♀. 12 mm. Head and thorax white. Palpi with second joint just reaching base of antennae, terminal joint one-half; whitish, apex of terminal joint fuscous. Antennae whitish. Abdomen pale brownish-grey. Legs whitish; anterior tibiae and tarsi fuscous with whitish rings. Forewings narrow, costa slightly arched, apex acute, termen slightly rounded, strongly oblique; white; stigmata minute, fuscous, first discal at one-third, plical slightly beyond it, second discal at two-thirds; slight subdorsal fuscous irroration; some minute submarginal fuscous dots on apical part of costa and upper part of termen; cilia white. Hindwings lanceolate; pale grey; cilia 1, pale grey.

Queensland: Caloundra in October; one specimen.

460. Macronemata aphaurophanes, n. sp.

ἀφαυροφανης, weak-looking.

♂. 13 mm. Head and thorax grey. Palpi with second joint not reaching base of antennae, terminal joint three-fifths; ochreous-whitish, terminal joint except apex fuscous. Antennae grey-whitish with blackish annulations; cilia in male 3. Abdomen grey-whitish. Legs fuscous; posterior pair whitish. Forewings very narrow, costa scarcely arched, apex acute, termen extremely oblique; ochreous-whitish; markings and some scattered scales fuscous; first discal at one-fourth, palpi well beyond it, second discal at two-thirds; irroration more pronounced towards apex and termen; cilia ochreous-whitish, some fuscous points on bases. Hindwings whitish; cilia 1½, whitish.

Tasmania: Mt. Wellington (2,500 feet) in January; one specimen.

462. Macronemata semidalis, n. sp.

σεμιδαλις, floury.

♂. 13 mm. Head and thorax pale grey. Palpi with second joint not reaching base of antennae, terminal joint two-thirds; grey-whitish. Antennae grey; ciliations in male 1. Abdomen grey. Legs pale ochreous-grey; anterior pair fuscous. Forewings suboval, costa gently arched, apex rounded, termen obliquely rounded; ochreous-grey-whitish; stigmata fuscous, minute or obsolete, first discal at one-third, plical beyond it, second discal before two-thirds; some fuscous irroration towards termen; some obscure fuscous terminal dots; cilia greyish-ochreous with faintly darker postmedian and terminal lines. Hindwings lanceolate, pale grey; in male a strong tuft of grey hairs on costa; cilia 1, pale grey.

North Queensland: Kuranda in June; one specimen.

463. Macronemata leptogramma, n. sp.

λεπτογραμμος, lightly marked.

♂. 15 mm. Head and thorax white. Palpi with terminal joint three-fourths; white, outer surface of second joint except apex fuscous. Antennae white; ciliations in male one-third. Abdomen whitish. Legs fuscous; posterior pair whitish. Forewings suboval, costa moderately arched, apex rounded, termen obliquely rounded; white, lightly sprinkled, especially in terminal area, with pale ochreous; a suffused pale ochreous tornal spot; and another less developed on costa before apex; cilia whitish sprinkled with fuscous, on tornus grey. Hindwings ovate-lanceolate; pale grey; cilia pale grey.

Queensland: Brisbane in February; one specimen.

464. Macronemata stoechodes, n. sp.

στοιχωδης, arranged in rows.

♂, ♀. 14–16 mm. Head and thorax white. Palpi with second joint reaching base of antennae, terminal joint in male three-fifths, in female four-fifths; whitish, lower two-thirds of external surface of second joint pale fuscous, apex of terminal joint fuscous. Antennae whitish; ciliations in male 1½. Abdomen grey. Legs whitish; anterior pair pale fuscous. Forewings elongate-oval, costa moderately arched, apex round-pointed, termen very oblique; white with fuscous dots; first discal at one-third, plical beneath it, second discal before two-thirds; a series of submarginal dots from three-fourths costa around termen to tornus; cilia white. Hindwings ovate-lanceolate; grey-whitish; cilia whitish.

North Queensland: Cardwell in August; two specimens.

468. Macronemata proscedes, n. sp.

προσκηδης, allied.

♂, ♀. 16–18 mm. Head and thorax ochreous-whitish. Palpi with second joint reaching base of antennae, terminal joint three-fifths; ochreous-whitish, outer surface of terminal joint fuscous towards apex. Antennae grey-whitish; ciliations in male 1½. Abdomen ochreous-grey. Legs ochreous-whitish; anterior pair fuscous. Forewings narrow, costa slightly arched, apex pointed, termen extremely oblique; ochreous-whitish, sometimes with a few fuscous scales; stigmata obsolete except a minute second discal at two-thirds; cilia ochreous-whitish. Hindwings and cilia grey.

Queensland: Talwood in April; five specimens received from Mr. W. B. Barnard, who has the type.

472. Macronemata stenodes, n. sp.

στενωδης, narrow.

♂. 12 mm. Head and thorax white. Palpi with second joint not reaching base of antennae, terminal joint 1; white, basal half of second joint fuscous. Antennae dark fuscous; ciliations in male two-thirds. Abdomen pale grey. Legs fuscous; posterior pair whitish. Forewings narrow, costa strongly arched, apex pointed, termen oblique; white; markings dark fuscous; an oblique fascia from beneath one-third costa to above base of dorsum; another from two-thirds costa to mid-dorsum; a third from two-thirds costa to tornus; an apical blotch; cilia fuscous. Hindwings and cilia pale grey.

Western Australia: Albany in February; one specimen received from Mr. W. B. Barnard.

473. Macronemata rhadinodes, n. sp.

ῥαδινωδης, slender.

♂, ♀. 12–14 mm. Head and thorax brownish. Palpi with second joint not reaching base of antennae, terminal joint two-thirds; whitish sprinkled with fuscous, base of second joint fuscous. Antennae fuscous; in male minutely ciliated (one-fourth). Abdomen grey; tuft whitish. Legs fuscous with whitish rings. Forewings narrow, costa gently arched, apex round-pointed, termen very oblique; brownish; markings and some irroration fuscous; a narrow interrupted sub-basal fascia; two or three dots placed transversely at one-third; a short mark on costa at two-thirds; a longitudinal median streak from two-thirds joining a subapical spot and connected with a dorsal mark before tornus; cilia pale grey. Hindwings and cilia pale grey.

Queensland: Toowoomba in October; two specimens received from Mr. W. B. Barnard, who has the type.

474. Macronemata araeoptera, n. sp.

ἀραιοπτερος, narrow-winged.

♀. 18 mm. Head and thorax brownish-fuscous. Palpi with second joint reaching base of antennae, terminal joint 1; ochreous-whitish sprinkled with fuscous, terminal joint except extreme apex fuscous. Antennae fuscous. Abdomen pale brown; apices of segments and tuft ochreous-whitish. Legs fuscous with ochreous-whitish rings; posterior pair ochreous-whitish. Forewings very narrow, costa almost straight, apex pointed, termen very oblique; ochreous-whitish with general fuscous irroration more pronounced posteriorly; stigmata dark fuscous, first discal at one-third, plical slightly beyond it, second discal at two-thirds, a dot between and in a line with discals, separated from them by pale spots; cilia ochreous-whitish sprinkled with fuscous. Hindwings and cilia pale grey.

Queensland: Stanthorpe in October. New South Wales: Heathcote, near Sydney, in August. Two specimens.

475. Macronemata pleurocapna, n. sp.

πλευροκαπνος, with dark costa.

♀. 13 mm. Head and thorax ochreous-whitish. Palpi with second joint just reaching base of antennae, terminal joint two-thirds; ochreous-whitish. Antennae ochreous-whitish annulated with fuscous. (Abdomen missing.) Legs grey with whitish rings; posterior pair whitish. Forewings narrow, costa moderately arched, apex pointed, termen very obliquely rounded; ochreous-whitish; markings and a slight irroration fuscous; a dot on one-fourth costa; a rather large triangular spot on costa beyond middle; a suffused inwardly oblique streak from costa near apex; stigmata dark fuscous, first discal at two-fifths, plical before it, suffusedly connected with dorsum, second discal at two-thirds, a dot in line with discals shortly before second; cilia whitish with a median fuscous line. Hindwings and cilia pale grey.

Queensland: Mt. Tambourine in October; one specimen.

476. Macronemata pleurosticha, n. sp.

πλευροστιχος, with costal streak.

♂. 14–15 mm. Head white. Palpi with terminal joint 1; fuscous. Antennae grey; ciliations in male 1½. Abdomen grey. Legs grey; posterior pair whitish. Forewings narrow, costa gently arched, apex pointed, termen very oblique; whitish with fine sparse fuscous irroration and markings; a suffused costal streak from base to apex; stigmata minute, first discal at one-third, plical beneath it, second discal at two-thirds, a dot above first discal, another above and before second discal; cilia whitish. Hindwings and cilia grey-whitish.

New South Wales: Broken Hill; two specimens.

477. Macronemata amaloptera, n. sp.

ἀμαλοπτερος, weak-winged.

♂. 15 mm. Head whitish-brown. (Palpi missing.) Antennae fuscous; ciliations in male 1. Thorax fuscous. Abdomen grey. Legs fuscous. Forewings narrow, costa gently arched, apex pointed, termen oblique; pale brownish-grey; markings and some irroration fuscous; stigmata small, first discal at about one-third, plical before it, second discal before two-thirds, larger; a fuscous suffusion connects second discal with tornus, and another occupies apical area; cilia grey with fuscous points. Hindwings and cilia pale grey.

Western Australia: Mundaring, near Perth, in June; one specimen received from Mr. J. Clark.

478. MACRONEMATA PUSILLA, n. sp.

pusillus, tiny.

♀. 12–14 mm. Head whitish-ochreous. Palpi with second joint not reaching base of antennae, terminal joint three-fifths; whitish-ochreous, basal half and a subterminal ring on second joint and basal and terminal rings on terminal joint fuscous. Thorax whitish-ochreous sprinkled with fuscous. Abdomen fuscous. Legs fuscous with whitish-ochreous rings. Forewings very narrow, costa gently arched, apex rounded, termen very obliquely rounded; whitish-ochreous sprinkled with fuscous; markings fuscous, rather obscure; first discal at one-third, plical well before it, second discal before two-thirds, suffusedly connected with dorsum; elongate costal spots at one-fourth, middle, and three-fourths; from the last proceeds a line with a strong acute inward tooth in middle, and an equally developed outward tooth beneath this, thence to tornus; cilia whitish-ochreous sprinkled with fuscous, on tornus grey. Hindwings and cilia grey.

Queensland: Macpherson Range (3,500 feet) in January and March; two specimens.

479. MACRONEMATA FILIFERA, n. sp.

filiferus, thread-marked.

♂, ♀. 12–15 mm. Head and thorax grey sprinkled with fuscous. Palpi with second joint not reaching base of antennae, terminal joint four-fifths; fuscous, second joint with postmedian and apical and terminal joint with antemedian white rings. Antennae grey; ciliations in male 1. Abdomen grey. Legs fuscous with whitish rings; posterior pair mostly whitish. Forewings very narrow, costa straight, apex pointed, termen extremely oblique; grey with dark fuscous irroration and markings; sometimes a fine subcostal streak from base to middle; stigmata elongate, forming short streaks, first discal at one-third, plical beyond it, second discal at two-thirds; a short streak between discals, and another above and parallel; an interrupted streak from beneath two-thirds costa to tornus evenly curved close to costa and termen; cilia whitish with median and terminal fuscous points. Hindwings pale grey; cilia 1, pale grey.

Queensland: Brisbane in September, October, November, December and April; seven specimens.

480. MACRONEMATA OMOSPILA, n. sp.

ὠμοσπιλος, shoulder-spotted.

♂. 12–13 mm. Head, thorax, and abdomen grey. Palpi with second joint just reaching base of antennae, terminal joint one-half; fuscous, inner surface and terminal joint whitish. Antennae fuscous; ciliations in male 4. Legs fuscous; posterior tibiae fuscous-whitish. Forewings narrow, costa gently arched, apex pointed, termen extremely oblique; pale grey, sometimes ochreous-tinged; markings and some scattered scales fuscous; first discal and plical obsolete, second discal at two-thirds; irroration more pronounced towards termen; cilia pale grey. Hindwings and cilia pale grey.

Tasmania: Mt. Wellington (2,500 feet) in January and February; Lake St. Clair and Gordon R. in January; five specimens.

481. Macronemata basisticha, n. sp.

βασιστιχος, with basal streak.

♀. 14 mm. Head whitish. Palpi with second joint exceeding base of antennae, terminal joint 1; whitish sprinkled with fuscous, second joint with base and a subapical ring fuscous. Antennae fuscous. Thorax fuscous; tegulae white. Abdomen dark grey. Legs whitish sprinkled with fuscous. Forewings narrow, costa almost straight, apex pointed, termen extremely oblique; fuscous sprinkled with white; a white streak from base of costa along fold to one-fourth; a suffused interrupted white fascia from midcosta to tornus; cilia fuscous. Hindwings with 3 and 4 stalked, grey; cilia grey.

Queensland: Brisbane in September; one specimen.

484. Macronemata perangusta, n. sp.

perangustus, very narrow.

♂. 17–18 mm. Head white. Palpi with second joint not reaching base of antennae, terminal joint one-half; fuscous, terminal joint white. Antennae grey; ciliations in male one-fourth. Thorax grey. Abdomen pale grey. Legs grey; posterior tibiae whitish. Forewings elongate, narrow, costa slightly arched, apex pointed, termen very oblique; white sprinkled with grey, more densely at base and beneath costa to four-fifths; stigmata fuscous, sometimes not fully developed, first discal at one-fourth, plical beyond and sometimes connected with it, second discal at two-thirds, a dot above and between discals, another between and below them, and a dot beneath second discal; cilia white with grey points. Hindwings and cilia grey-whitish.

Readily distinguished from the following by the much shorter antennal ciliations of the male.

New South Wales: Broken Hill in September; two specimens.

485. Macronemata eriopa Low.

♂. 11–15 mm. Head and thorax white. Palpi with second joint not reaching base of antennae, terminal joint one-half; fuscous, terminal joint white. Antennae grey; ciliations in male 1½. Abdomen whitish, towards base grey. Legs fuscous; posterior tibiae whitish. Forewings narrow, costa slightly arched, apex pointed, termen very oblique; white sprinkled with grey, more densely beneath costa from base to apex; stigmata fuscous, minute or obsolete, first discal at one-third or obsolete, plical beyond it, second discal at two-thirds, a dot beneath it; a suffused grey line on termen; cilia white with a few grey points. Hindwings grey-whitish, sometimes grey at apex; cilia grey-whitish.

Probably Lower confused this with the preceding species, but his description, particularly the white thorax, applies better to this one.

487. Macronemata abrithes, n. sp.

ἀβριθης, light.

♀. 13 mm. Head grey-whitish. Palpi with second joint not reaching base of antennae, terminal joint three-fifths; fuscous. Antennae fuscous obscurely annulated with grey-whitish. Thorax grey-whitish sprinkled with whitish. Abdomen pale grey with brownish bars on dorsum of basal segments. Legs fuscous with ochreous-whitish rings; posterior pair mostly ochreous-whitish. Forewings narrow, suboval, costa moderately arched, apex pointed, termen extremely oblique; grey-whitish with markings and some irroration dark fuscous;

first discal at one-third, plical beyond it, second discal at two-thirds; a short suffused inwardly oblique streak from costa beyond middle, apical area densely irrorated; cilia pale grey with some dark fuscous points. Hindwings grey; cilia pale grey.

Queensland: Macpherson Range (3,000 feet) in October; one specimen received from Mr. W. B. Barnard.

488. MACRONEMATA DELOTYPA, n. sp.

δηλοτυπος, clearly marked.

♂. 12 mm. Head and thorax white. Palpi with second joint not reaching base of antennae, terminal joint three-fourths; grey, terminal and apex of second joint white. Antennae grey; ciliations in male 1. (Abdomen missing.) Legs grey; tarsi whitish; posterior pair whitish. Forewings narrow, costa strongly arched, apex pointed, termen obliquely rounded; white; a narrow basal fascia, a broad costal streak from one-fourth to middle, and a short inwardly oblique streak from costa before apex fuscous; stigmata blackish, first discal at one-fourth touching costal streak, plical beyond it, second discal at two-thirds, a dot above and between discals, another beneath second; some streak-like dots on termen; cilia whitish. Hindwings and cilia pale grey.

Queensland: Kuranda in October; one specimen.

489. MACRONEMATA ASTHENOSPILA, n. sp.

ἀσθηνοσπιλος, weakly spotted.

♂. 14 mm. Head and thorax whitish-grey. Palpi with second joint just reaching base of antennae, terminal joint three-fifths; fuscous, terminal and apex of second joint white. Antennae pale grey; ciliations in male one-third. Abdomen pale grey. Legs fuscous; posterior pair whitish. Forewings very narrowly oval, costa strongly arched, apex pointed, termen very oblique; whitish-grey; stigmata grey, small and inconspicuous, first discal at one-third, plical beyond it, second discal at two-thirds, a dot above and between discals; cilia grey-whitish. Hindwings grey; cilia pale grey.

Queensland: Yeppoon in October; one specimen.

490. MACRONEMATA DIDYMOSPILA, n. sp.

διδυμοσπιλος, twin-spotted.

♂. 16 mm. Head and thorax whitish-grey. Palpi with second joint not reaching base of antennae, terminal joint one-half; grey, terminal and apex of second joint white. Antennae pale grey annulated with dark fuscous; ciliations in male two-thirds. Abdomen grey; tuft grey-whitish. Legs whitish; anterior tibiae fuscous; tarsi fuscous with whitish rings. Forewings elongate-oval, costa moderately arched, apex pointed, termen very oblique; whitish-grey; markings and a few scattered scales dark fuscous; first discal at one-fourth, plical beyond it, both conspicuous, second discal before two-thirds, minute; a much curved line of dots from four-fifths costa to tornus; a terminal series of dots; cilia pale grey. Hindwings and cilia pale grey.

New South Wales: Gosford in November; one specimen.

491. MACRONEMATA GLABERRIMA, n. sp.

glaberrimus, very smooth.

♂, ♀. 14–16 mm. Head and thorax fuscous. Palpi with second joint just reaching base of antennae, terminal joint three-fifths; fuscous. Antennae fuscous; ciliations in male two-thirds. Abdomen fuscous; tuft grey. Legs fuscous;

posterior pair grey. Forewings suboval, costa moderately arched, apex round-pointed, termen obliquely rounded; glossy fuscous; stigmata dark fuscous, minute, first discal at one-third, plical beneath it, second discal at two-thirds, a dot above and between discals; cilia fuscous. Hindwings and cilia fuscous.

New South Wales: Brunswick Heads in January; two specimens received from Mr. W. B. Barnard.

493. Macronemata cyrtoloma, n. sp.

κυρτολωμος, with curved edge.

♂. 15 mm. Head and thorax whitish finely sprinkled with fuscous. Palpi with second joint just reaching base of antennae; terminal joint three-fifths; fuscous, base, apex and inner surface of terminal joint whitish. Antennae grey; ciliations in male one-fourth. Abdomen pale grey; tuft ochreous-whitish. Legs fuscous; posterior pair whitish. Forewings narrow, costa strongly arched, apex rounded, termen extremely oblique; whitish finely sprinkled with fuscous; stigmata fuscous, minute, first discal at one-fourth, plical beyond it, second discal before two-thirds, a dot between and above discals; cilia whitish with many fuscous points. Hindwings and cilia grey.

Queensland: Talwood in November; one specimen received from Mr. W. B. Barnard.

494. Macronemata stramenticia, n. sp.

stramenticius, straw-coloured.

♂. 17 mm. Head pale brownish-ochreous. Palpi with second joint not reaching base of antennae, terminal joint four-fifths; pale brownish-ochreous, outer surface of second joint sprinkled with fuscous and with a fuscous subapical ring, terminal joint except extreme apex fuscous. Antennae whitish-ochreous annulated with fuscous; ciliations in male one-half. Thorax pale brownish-ochreous anteriorly suffused with fuscous. Abdomen pale brown; apices of segments and tuft brown-whitish. Forewings rather narrow, elongate-oval, costa gently arched, apex rounded, termen very obliquely rounded; pale brownish-ochreous with general sparse fuscous irroration; stigmata fuscous, first discal at one-third, plical elongate and beneath it, second discal at three-fifths; cilia whitish-ochreous with some fuscous points. Hindwings and cilia grey-whitish.

Queensland: Bunya Mts. in December; one specimen.

495. Macronemata pentasticta, n. sp.

πενταστικτος, five-spotted.

♀. 14–16 mm. Head and thorax fuscous-brown. Palpi with second joint reaching base of antennae, terminal joint three-fifths; fuscous, apex of second and base of terminal joint whitish. Antennae fuscous annulated with ochreous-whitish. Abdomen grey. Legs fuscous; posterior pair mostly ochreous-whitish. Forewings narrow, costa gently arched, apex round-pointed, termen obliquely rounded; pale brownish densely sprinkled with fuscous; markings fuscous; first discal at one-third, plical slightly before it, second discal before two-thirds, a dot close to and slightly above and beyond first discal, another close beneath second; a marginal series of dots from midcosta around apex and termen; cilia with pale basal median and apical lines, a fuscous sub-basal, and a grey subapical line. Hindwings and cilia pale grey.

North Queensland: Millaa Millaa, Atherton Tableland, in September; three specimens.

496. MACRONEMATA MESOSCIA, n. sp.

μεσοσκιος, with median shade.

♂. 15 mm. Palpi with second joint not reaching base of antennae, terminal joint three-fourths; grey, inner surface whitish. Antennae grey; ciliations in male 1. Abdomen grey. Legs fuscous; posterior pair whitish. Forewings narrow, costa rather strongly arched, apex pointed, termen very oblique; grey with fuscous markings; a moderate ill-defined basal fascia; a median fascia, anterior edge sharply defined from one-third costa outwardly curved to one-third dorsum, posterior edge much suffused, second discal at two-thirds; cilia grey. Hindwings grey-whitish; apex grey; cilia grey-whitish.

Queensland: Brisbane in February; one specimen.

499. MACRONEMATA EPICONIA, n. sp.

ἐπικονιος, sprinkled with ashes.

♂, ♀. 12 mm. Head, thorax, and abdomen fuscous. Palpi with second joint just reaching base of antennae, terminal joint three-fourths; fuscous. Antennae fuscous; ciliations in male 1½. Legs fuscous; posterior pair grey-whitish. Forewings with costa moderately arched, apex pointed, termen oblique; grey, apices of scales whitish, causing a very fine mottling; costal edge whitish; cilia pale grey. Hindwings with 3 and 4 stalked; fuscous; cilia grey.

New South Wales: Jervis Bay in October: four specimens beaten from *Leptospermum*.

500. MACRONEMATA DYSPINES, n. sp.

δυσπινης, squalid.

♂. 15 mm. Head grey-whitish. Palpi with second joint slightly exceeding base of antennae, terminal joint three-fifths; ochreous-whitish sprinkled with fuscous, basal half of second joint fuscous. Antennae pale grey; ciliations in male one-fourth. Thorax grey with two fuscous dots. (Abdomen missing.) Legs fuscous with whitish-ochreous rings; posterior pair mostly whitish-ochreous. Forewings elongate, suboval, costa slightly arched, apex rounded, termen very obliquely rounded; whitish-grey with slight dark fuscous irroration; stigmata blackish, first discal at one-third, plical slightly before it, second discal well before two-thirds; some blackish irroration towards base and apex; cilia pale grey with some fuscous points. Hindwings and cilia pale grey.

Queensland: Macpherson Range (3,000 feet) in November; one specimen received from Mr. W. B. Barnard.

501. MACRONEMATA LITOPIS, n. sp.

λιτωπις, smooth.

♂, ♀. 12–14 mm. Head and thorax pale brown. Palpi with second joint just reaching base of antennae, terminal joint three-fifths; brown-whitish, second joint partly fuscous towards base. Antennae pale brown; ciliations in male 6. Abdomen brown. Legs fuscous; posterior pair brown-whitish. Forewings oval, costa strongly arched, apex pointed, termen very oblique; pale brown; markings fuscous; usually a spot on base of costa; first discal at one-third, plical beneath or slightly beyond, second discal before two-thirds; some fuscous irroration in apical area, sometimes forming an ill-defined subterminal line; cilia brown-whitish. Hindwings and cilia pale grey.

North Queensland: Atherton in August; Eungella in October. Queensland: Brisbane in September; Bunya Mts. in January. Eleven specimens.

502. Macronemata commoda, n. sp.

commodus, pleasing.

♂. 12 mm. Head and thorax white. Palpi with second joint reaching base of antennae, terminal joint three-fourths; whitish. Antennae grey, towards base whitish; ciliations in male two-thirds. Abdomen whitish-grey. Legs fuscous; posterior pair whitish. Forewings with costa rather strongly arched, apex round-pointed, termen obliquely rounded; white markings pale ochreous-fuscous, well defined; a broad sub-basal fascia and another similar at one-third, neither reaching costa, both united on dorsum; a small round subcostal spot in middle; a posterior fascia from costa shortly before apex obliquely inwards, connected by a short process with subcostal spot and with a suffused costal spot just beyond it, then broadening so as to extend on dorsum from second fascia to tornus; cilia grey. Hindwings and cilia grey.

North Queensland: Cape York in April; one specimen received from Mr. W. B. Barnard.

503. Macronemata phaeogramma, n. sp.

φαιογραμμος, with dusky markings.

♀. 13–14 mm. Head white. Palpi with second joint just reaching base of antennae, terminal joint three-fourths; whitish, second joint except apex fuscous. Antennae whitish-grey with fuscous annulations. Thorax fuscous; tegulae and posterior margin white. Abdomen grey; apices of segments and tuft white. Legs fuscous; posterior pair whitish. Forewings suboval, costa moderately arched, apex rounded, termen obliquely rounded; white sparsely sprinkled with fuscous, more so in terminal area; markings fuscous; first discal at one-third, plical slightly beyond it, second discal at two-thirds, a fourth dot between and above discals, a fifth below second discal; a suffused spot on two-fifths costa; another at four-fifths connected by a sinuate line with a spot on tornus; a terminal series of dots; cilia white sprinkled with fuscous. Hindwings and cilia pale grey.

North Queensland: Cape York in April; three specimens received from Mr. W. B. Barnard, who has the type.

505. Macronemata megalospora, n. sp.

μεγαλοσπορος, large-spotted.

♂. 12–15 mm.; ♀. 15–16 mm. Head white. Palpi with second joint just reaching base of antennae, terminal joint two-thirds; whitish, second joint except apex fuscous. Antennae grey; ciliations in male one-fourth. Thorax whitish; bases of tegulae fuscous. Abdomen grey; tuft ochreous-whitish. Legs whitish; anterior pair fuscous. Forewings narrow, costa moderately arched, apex rounded, termen very oblique; white sparsely sprinkled with fuscous; markings fuscous; a large transversely oval spot in disc at one-third; a similar spot on tornus, inwardly oblique; a small suffused inwardly oblique streak from costa before apex ending in second spot; cilia whitish with fuscous points. Hindwings and cilia pale grey.

North Queensland: Bowen in June. Queensland: Talwood in November and December; Adavale in May. Six specimens; type in Coll. Barnard.

507. Macronemata achlyopa, n. sp.

ἀχλυωπος, gloomy.

♂, ♀. 16–18 mm. Head and thorax grey sprinkled with whitish. Palpi with second joint just reaching base of antennae, terminal joint three-fifths; fuscous, terminal joint and apex of second whitish. Antennae grey; ciliations in male one-third. Abdomen grey; tuft ochreous-whitish. Legs grey; posterior pair ochreous-whitish. Forewings elongate, narrow, costa slightly arched, apex round-pointed, termen obliquely rounded; whitish densely sprinkled with fuscous appearing grey; markings fuscous, obscure; first discal at one-fourth, plical well beyond, second discal before two-thirds, suffusedly connected with tornus, a median dot between and above discals; cilia whitish with fuscous points. Hindwings and cilia grey.

North Queensland: Mareeba and Herberton in July; two specimens.

60. Gen. BRACHYZANCLA, n.g.

βραχυζαγκλος, with short sickles.

Tongue absent or weakly developed. Palpi short, not reaching vertex; second joint short, slender; terminal joint one-fourth to two-fifths, acute. Antennae with basal pecten; ciliations in male short or rather long. Forewings with 7 to apex. Hindwings elongate-ovate; neuration normal.

Type, *B. lissodes*. Resembles *Limothnes* in the obsolescence of the tongue, but differs from it in the palpi.

Five species: 508. *pallidula*, n. sp. (Inglewood, Q.).—509. *cretosa*, n. sp. (Cape York).—510. *lissodes*, n. sp. (Atherton).—511. *strongyla*, n. sp. (Darwin).—512. *celaenopa*, n. sp. (Scone).

508. BRACHYZANCLA PALLIDULA, n. sp.

pallidulus, somewhat pale.

♂. 15 mm. Head and thorax whitish-grey. Tongue present but very weakly developed. Palpi with second joint reaching middle of face, terminal joint two-fifths; fuscous, terminal joint whitish. Antennae whitish-grey; ciliations in male one-half. Abdomen pale grey. Legs grey; posterior pair whitish. Forewings narrow, costa moderately arched, apex rounded, termen very obliquely rounded; pale grey suffused with white except beneath costa and with a few fuscous scales towards termen and dorsum; stigmata fuscous, minute, first discal at two-fifths, plical beneath it, second discal at two-thirds, a dot above and between discals and another beneath second; cilia whitish with grey points. Hindwings and cilia pale grey.

Queensland: Inglewood in October; one specimen.

509. BRACHYZANCLA CRETOSA, n. sp.

cretosus, chalky.

♂. 14–16 mm.; ♀. 19 mm. Head and thorax white. Palpi with second joint not reaching middle of face, terminal joint one-third; grey, inner surface of terminal joint white. Antennae whitish; ciliations in male 1. Abdomen grey; terminal segments and tuft whitish. Legs whitish; anterior pair fuscous. Forewings narrow, costa moderately arched, apex pointed, more obtuse in female, termen very obliquely rounded, white sprinkled with grey, but less in female; stigmata fuscous, minute, first discal at one-third, absent in female, plical beyond it or absent, second discal at two-thirds; cilia white, in male with a faint grey median line. Hindwings and cilia pale grey.

North Queensland: Cape York in October; four specimens received from Mr. W. B. Barnard, who has the type.

510. BRACHYZANCLA LISSODES, n. sp.

λισσωδης, smooth.

♂. 20 mm. Head and thorax grey-whitish. Palpi with second joint reaching middle of face, terminal joint one-fifth; pale grey. Antennae white; ciliations in male 2. Abdomen whitish. Legs grey; posterior pair whitish. Forewings elongate-oval, costa moderately arched, apex rounded, termen oblique; white with very pale grey irroration, which in terminal half is mostly between veins; cilia white. Hindwings pale grey; cilia whitish.

North Queensland: Herberton in September; one specimen.

511. BRACHYZANCLA STRONGYLA, n. sp.

στρογγυλος, rounded.

♀. 34 mm. Head and thorax fuscous. Palpi with second joint reaching middle of face, terminal joint one-sixth; fuscous. Antennae grey. Abdomen grey. Forewings elongate, strongly dilated, costa slightly arched to two-thirds, thence strongly arched, apex rounded, termen obliquely rounded; grey finely sprinkled with fuscous throughout; markings fuscous, indistinct; first discal at one-third, plical beneath it, second discal before two-thirds, two dots above and between discals, another beneath second; a suffused line from second discal outwards, then strongly curved, ending on fold near tornus; cilia grey. Hindwings and cilia pale grey.

North Australia: Darwin; one specimen received from Mr. G. F. Hill.

512. BRACHYZANCLA CELAENOPA, n. sp.

κελαινωπος, dark.

♂. 19–22 mm.; ♀. 26–30 mm. Head and thorax fuscous, in male with fine whitish irroration. Palpi just reaching vertex, terminal joint one-fourth; fuscous sprinkled with whitish. Antennae fuscous; ciliations in male 1½. Abdomen in male reddish-brown; tuft whitish-grey; in female brownish-fuscous. Legs fuscous sprinkled with whitish; posterior pair mostly whitish. Forewings narrow, elongate-oval, costa moderately arched, apex round-pointed, termen very obliquely rounded; fuscous with more or less whitish irroration; markings blackish, sometimes partly obsolete, always so in female; first discal at one-third, plical slightly beyond it, more so in female, second discal at two-thirds; in male sometimes a dot above and between discals and another beneath second discal, or confluent with it to form a crescentic mark; in male sometimes a line from five-sixths costa, angled outwards and thence subterminal to tornus; cilia grey. Hindwings and cilia grey.

New South Wales: Scone in March; eight specimens, of which all but one were received from Mr. H. Nicholas.

61. Gen. IDIOZANCLA, n.g.

ιδιοζαγκλος, with peculiar sickles.

Tongue developed. Palpi not reaching or slightly exceeding vertex; second joint moderate or long, thickened with appressed scales; terminal joint very short, smooth, acute. Antennae with basal pecten; ciliations in male short or rather long. Forewings with 7 to apex. Hindwings elongate-ovate; neuration normal.

Type, *I. pycnosticha*. Differs from the preceding genus in the second joint of palpi being much stouter and moderately long or elongate, but the terminal joint very short (one-sixth to one-third). The tongue is better developed.

Three species: 513. *pycnosticha*, n. sp. (Duaringa).—514. *spumifera*, n. sp. (Cape York).—515. *colacma*, n. sp. (Cape York).

513. IDIOZANCLA PYCNOSTICHA, n. sp.

πυκνοστιχος, thick-lined.

♂. 18 mm. Head white; posterior half of crown blackish. Palpi with second joint reaching middle of face, somewhat thickened anteriorly towards apex, terminal joint one-fourth; blackish, terminal and apex of second joint whitish. Antennae fuscous; ciliations in male 2½. Thorax white; base and apex of tegulae and two posterior spots blackish. Abdomen pale ochreous-grey; apices of segments and tuft ochreous-whitish. Legs fuscous; posterior pair ochreous-whitish. Forewings rather narrow, costa slightly arched, apex rounded, termen obliquely rounded; white with blackish markings; a narrow transverse basal fascia; a moderate straight fascia from one-third costa to two-fifths dorsum; a similar fascia from two-thirds costa to tornus, but slightly sinuate and giving off a strong process from posterior edge, whose rounded extremity nearly reaches apex; a slender terminal line; cilia whitish with a very fine fuscous median line. Hindwings with 5 from middle of cell; pale grey; cilia pale grey.

Queensland: Duaringa in February; one specimen received from Mr. W. B. Barnard.

514. IDIOZANCLA SPUMIFERA, n. sp.

spumiferus, frothy.

♂. 20 mm. Head and thorax white. Palpi with second joint long, terminal joint one-sixth; whitish. Antennae white; ciliations in male one-fourth. Abdomen and legs ochreous-whitish. Forewings narrow, suboval, dilated anteriorly, costa moderately arched, base of dorsum strongly curved, apex pointed, termen extremely oblique; white; markings pale ochreous, suffused; an interrupted fascia from two-fifths costa to two-fifths dorsum; a tornal spot; a small apical blotch; cilia whitish-ochreous. Hindwings and cilia grey-whitish.

North Queensland: Cape York in October; one specimen received from Mr. W. B. Barnard.

515. IDIOZANCLA COLACMA, n. sp.

κολακμος, shortened at the apex.

♀. 19 mm. Head ochreous-grey-whitish. Palpi with second joint reaching base of antennae, thickened and rough anteriorly, terminal joint one-third, rather stout; grey. Antennae pale grey. Thorax grey. Abdomen whitish-grey. Legs grey; posterior tibiae mostly whitish. Forewings oval, costa moderately arched, apex pointed, termen very oblique; grey; stigmata dark fuscous with pale halos, first discal at one-third, plical beyond it, second discal at two-thirds; a fuscous line from costa shortly before apex to tornus, indented opposite apex; cilia grey. Hindwings and cilia pale grey.

North Queensland: Cape York in May; one specimen received from Mr. W. B. Barnard.

62. Gen. TRACHYNTIS Meyr.

PROC. LINN. SOC. N.S.W., 1888, p. 1586.

Tongue present. Palpi long, ascending, recurved; second joint reaching or exceeding base of antennae, more or less thickened with appressed scales, sometimes rough beneath; terminal joint shorter than second, stout, sometimes slightly rough anteriorly, acute. Antennae with basal pecten; ciliations in male moderate. Forewings with 7 to apex. Hindwings elongate-ovate; neuration normal. Type, *T. delophanes* Meyr.

Unfortunately I have not seen the type or any of the Western Australian species described by Meyrick, and am consequently not quite certain as to the definition of this genus.

Nine species: 516. †*xenopis* Meyr., P.L.S.N.S.W., 1888, p. 1679 (W.A.: Albany).—517. †*delophanes* Meyr., ibid., 1888, p. 1587 (W.A.: Geraldton).—518. †*metrospila* Meyr., ibid., 1888, p. 1587 (W.A.: Albany).—519. †*coenodes* Meyr., ibid., 1888, p. 1588 (W.A.: Carnarvon).—520. †*epiphaula* Meyr., ibid., 1888, p. 1588 (W.A.: York).—

521. †*epipona* Meyr., *Tr.R.S.S.Aust.*, 1902, p. 154 (Sydney).—522. *holarga*, n. sp. (Stradbroke I.).—523. *diaphanes* Turn., ibid.. 1898, p. 208 (Nambour, Mt. Tambourine, Macpherson Range, Killarney).—524. *inferna* Low., P.L.S.N.S.W., 1899, p. 106 (Cunnamulla, Broken Hill).

522. TRACHYNTIS HOLARGA, n. sp.

ὁλαργος, wholly white.

♂. 15 mm. Head and thorax white. Palpi with second joint just reaching base of antennae, terminal joint four-fifths; white. Antennae white; ciliations in male 2½. Abdomen and legs white. Forewings moderately broad, not dilated, costa moderately arched, apex round-pointed, termen obliquely rounded; white; cilia white. Hindwings with 5 from below middle; white; cilia white.

The palpi are not typical, being smooth-scaled, the second joint rather slender, but the terminal joint as stout as second.

Queensland: Stradbroke I. in October; one specimen.

63. Gen. ECCRITA, n.g.

εκκριτος, picked out.

Tongue present. Palpi long, ascending, recurved; second joint exceeding base of antennae, moderately thickened with appressed scales; terminal joint shorter than second, slender, acute. Antennae with basal pecten. Forewings with 7 to apex. Hindwings elongate-ovate; 3 and 4 connate, 5 nearly approximated to 6 at origin.

525. ECCRITA PHAEOXYSTA, n. sp.

φαιοξυστος, darkly polished.

♀. 17 mm. Head and thorax dark fuscous. Palpi with second joint much exceeding base of antennae, terminal joint three-fourths; fuscous. Antennae fuscous. Legs fuscous; posterior tibiae grey-whitish. Forewings rather narrow, costa slightly arched, apex round-pointed, termen very obliquely rounded; glossy fuscous; stigmata blackish, discals approximated, first at one-third, second beyond middle, plical absent; cilia fuscous. Hindwings and cilia dark grey.

Tasmania: Strahan in February; one specimen.

64. Gen. ANOMOZANCLA, n.g.

ἀνομοζαγκλος, with unusual sickles.

Tongue present. Palpi very long, ascending, recurved; second joint three times length of face, expanded with long rough hairs towards apex, especially posteriorly; terminal joint very slender, acute. Antennae with basal pecten; ciliations in male short. Forewings with 7 to apex. Hindwings elongate-ovate; neuration normal.

Characterized by the peculiar palpi.

526. *scopariella* Wlk., *Cat. Brit. Mus.*, xxix, p. 765; Meyr., P.L.S.N.S.W., 1882, p. 546 (Brisbane, Stanthorpe, Sydney, Gisborne).

THE COLOUR-CHANGES OF BATOID FISHES.

By MERVYN GRIFFITHS.
(From the Department of Zoology, University of Sydney.)

(Plate xvi.)

[Read 25th November, 1936.]

Introduction.

Apart from the work of Schaefer (1921), Lundstrom and Bard (1932), Parker (1933, 1936), and that of Parker and Porter (1934), no research has been done on the colour-changes of Elasmobranch fishes. Schaefer recorded absence of colour-change for the Batoids, *Raja clavata* and *R. batis*, whilst the other authors studied the colour-change process in the Selachian, *Mustelus canis*. It has been established that if this fish be placed in a dark-walled tank, the pigment of the dermal melanophores is dispersed, and the animal becomes dark in colour so as to resemble the background. The process of darkening takes about one hour. If the eyes of *M. canis* be removed, the fish becomes much darker than under any other circumstances, and does so much more quickly (Parker and Porter, 1934). In addition, Lundstrom and Bard have shown that the dispersion of pigment in the dermal melanophores is due to the action of a hormone secreted by the pars intermedia of the pituitary gland. When placed in a white-walled tank, *Mustelus* becomes light in colour, the condition of maximum lightness being attained in about two days. The light phase is caused by contraction of the melanophores, and Parker and Porter have shown that this contraction can be caused by nervous action.

Schaefer (1921) records that, when either *Raja batis* or *Raja clavata* is placed in dark-walled or light-walled tanks for a long period ("längerem Aufenthalt") no colour-change occurs. Unfortunately he did not mention the exact duration of the experiment. However, Parker (1933) has carried out the above procedure with *Raja erinacea* and has gained definite colour-changes after periods of nine to twelve hours.

The Batoids, *Urolophus testaceus* and *Trygonorrhina fasciata*, were the types used by the writer. The work on *T. fasciata* was carried out at the Sydney University Marine Biological Station at South Head, Port Jackson. The writer wishes to express his gratitude to Miss Burns, of the Zoology Department, for the photographic work which illustrates the results of these experiments.

Observations on Urolophus testaceus.

The rays were caught by spearing through the pectoral fin. The mutilation involved would not affect the specific problem in hand, since even extensive injury to the brain in *Mustelus canis* did not affect the colour-change process (Lundstrom and Bard, 1932). All the specimens of *Urolophus testaceus* seen by the writer have been of a uniform sandy colour on the dorsal surface when taken from the water. In this condition the dermal melanophores are in a moderately contracted state (Plate xvi, fig. 1). Two rays of the colour described were placed in a black-walled tank, illuminated from above, whilst a third ray was blinded by removal of the eyes, and placed in another tank. After four hours, no change in colour could be seen in any of the rays, not even in the blinded ray which would be receiving the maximum possible stimulus to turn black. Unfortunately it was impossible to keep the rays alive beyond this period. However, with a second batch of rays it was found that on injection of 0·4 c.c. of Burroughs Wellcome's infundin (pituitary posterior lobe extract, containing a melanophore-expanding hormone), a not particularly marked darkening of the skin on the dorsal surface was obtained one and a half to two hours after injection. That this darkening was due to expansion of the dermal melanophores is seen in Plate xvi, fig. 2. Comparison with Plate xvi, fig. 1 shows that the expansion is not great.

As the melanophores were expansible it seemed desirable to test the possibility of the pituitary gland elaborating an expanding hormone.

To check up on this point, the following procedure was carried out:

(1) Extracts were made from the pituitaries of rays by crushing up two pituitaries in 1·0 c.c. of Ringer's solution.

(2) Three dry, well illuminated jars were taken and into each was placed a pair of frogs (*Hyla aurea*). After four hours in these jars all six frogs were bright green and golden in colour.

(3) In two jars one frog of each pair was injected with 0·5 c.c. of the ray pituitary extract, whilst one frog from the third jar was injected with 0·4 c.c. of infundin. At the end of an hour and a half each of the injected frogs was black in colour, whilst the uninjected controls were still green and golden.

The darkening of the frogs' skin was found to be due to expansion of the dermal melanophores. In Plate xvi, figure 3, is shown the unexpanded melanophores of a control, whilst figure 4 shows the expanded melanophores of one of the frogs injected with ray pituitary extract two hours after injection.

This shows conclusively that a melanophore-expanding hormone is elaborated by the pituitary of *Urolophus testaceus.*

Observations on Trygonorrhina fasciata.

Two specimens, both of a browny-buff colour with grey markings, were placed one in a white-walled tank and the other in a black-walled tank. Both tanks were illuminated from above. At the beginning of the experiment a small piece of skin was removed from the dorsal surface of each ray, and fixed. On examination it was found that the dermal melanophores in this fixed material from each animal were expanded. In Plate xvi, figure 5, is seen the condition of the melanophores of the ray which was immediately afterwards placed in the white tank. After seventeen hours the ray in the white tank was very slightly paler than that in the black tank. Again homologous pieces of skin were taken from each ray, fixed, and examined. The state of expansion of the melanophores of the ray from the dark tank was found to be the same as at the beginning of the experiment, but the melanophores of the ray from the white tank were found to have contracted a little (Plate xvi, fig. 6). Thus *T. fasciata* can respond to change in tint of the background, only by a very slight change in colour. The darker ray was then killed, its pituitary was removed and an extract made from it by crushing up in 1·5 c.c. of Ringer's solution. One cubic centimetre of this extract was then injected into the light ray which had been replaced in the white tank. After two hours the ray had become slightly darker in tint. A preparation of a homologous piece of skin fixed at this stage showed that the melanophores were fully expanded (Plate xvi, fig. 7). Clearly the dark phase of the fish is caused by the expansion of the melanophores, whose expanded condition in turn is due to the action of a pituitary hormone, whilst the light phase is caused by the contraction of the melanophores.

Discussion.

The experiments on *Urolophus testaceus* show:

(1) That its melanophores are expansible.

(2) That a melanophore-expanding principle is elaborated in the pituitary gland. Probably *U. testaceus*, therefore, is capable of a slow colour-change in response to change in environmental colour, as is *Raja erinacea* and *Trygonorrhina fasciata.* It is clear that in *Urolophus* and *Trygonorrhina* the dark phase is due to the action of a pituitary hormone. Parker and Porter, and Lundstrom and Bard are also agreed that this is so in *Mustelus.* But Parker and Porter consider that the light phase is caused by "the action of contracting nerve fibres on the melanophores, an action which when excessive may overcome that of the expanding mechanism". However, when *Mustelus* is hypophysectomized, the animal rapidly becomes pale, and remains so, unless pituitary extract is injected. This suggests that the action of the melanophore nerves is tonic, tending always to contract the melanophores, whilst the presence of a sufficient quantity of expanding principle in the tissue fluid bathing the melanophores overcomes this contracting influence, and expansion results. Thus the true picture of the colour-changes in Elasmobranchs appears to be a reflex stimulation of the pituitary, due to the visual stimulus of a dark background, causing a heightened production of expanding hormone, and so melanophore expansion. The visual stimulus occasioned by a white background results in a decrease in production of expanding principle, the concentration in the blood falls, unmasking the contracting action of the melanophore nerves, and so the light phase is attained.

Summary.

(1) Probably *Urolophus testaceus* can alter its colour, as its dermal melanophores are expansible, and a melanophore-expanding hormone is produced by its pituitary gland.

(2) *Trygonorrhina fasciata* is capable of changing its colour to a very slight degree in response to change in tint of the environment.

(3) The dark phase of *T. fasciata* is due to expansion of the dermal melanophores, which expansion is caused by a pituitary hormone. The light phase is due to the contraction of the melanophores.

(4) It is considered that probably the light phase in Elasmobranch fishes is caused by tonic nervous action tending continually to contract the melanophores, which contracting action is revealed when the concentration of expanding hormone in the blood falls, due to diminution of the rate of secretion by the pituitary gland.

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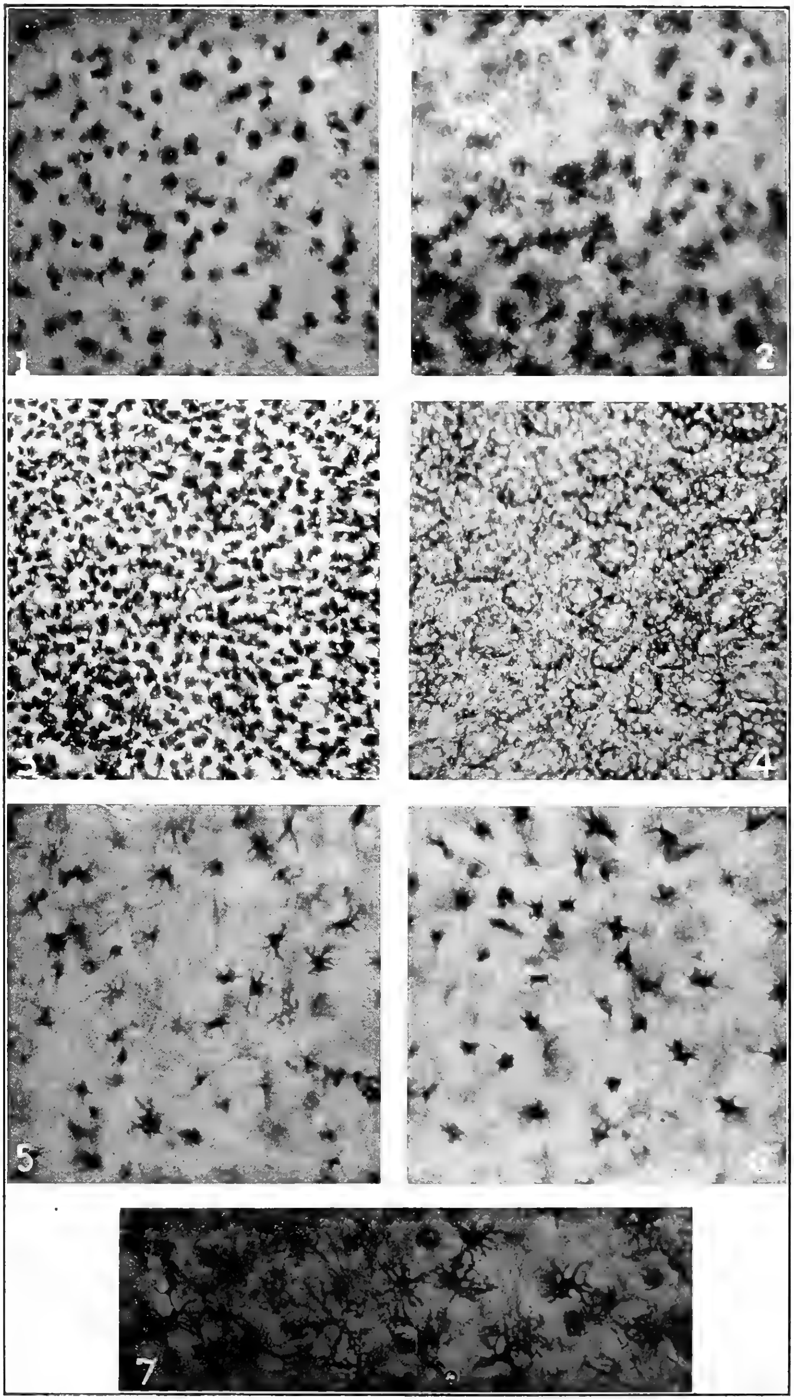

Melanophores in skins of *Urolophus testaceus* (figs. 1, 2), *Hyla aurea* (figs. 3, 4) and *Trygonorrhina fasciata* (figs. 5, 6, 7).

EXPLANATION OF PLATE XVI.

Fig. 1.—Skin of *Urolophus testaceus,* before injection. Dermal melanophores partially contracted.

Fig. 2.—Skin of *Urolophus testaceus,* after injection of 0·4 c.c. infundin. Melanophores expanded.

Fig. 3.—*Hyla aurea,* skin of control. Melanophores partially contracted.

Fig. 4.—*Hyla aurea,* skin of specimen 2 hours after injection of extract of pituitary of *Urolophus testaceus.* Melanophores expanded to form a network.

Fig. 5.—Control piece of skin of *Trygonorrhina fasciata.* Melanophores expanded.

Fig. 6.—Portion of skin from same specimen, after seventeen hours in a white-walled tank. Melanophores slightly contracted.

Fig. 7.—Portion of skin from same animal, 2 hours after injection of 1·0 c.c. of pituitary extract. Melanophores fully expanded.

THE DIPTERA OF THE TERRITORY OF NEW GUINEA. V.

FAMILY TIPULIDAE. PART III.*

By CHARLES P. ALEXANDER.
(*Communicated by F. H. Taylor, F.R.E.S., F.Z.S.*)

(Twenty-seven Text-figures.)

[Read 25th November, 1936.]

HEXATOMINI.

AUSTROLIMNOPHILA FLUXA, n. sp. Fig. 22.

Mesonotal praescutum dark brown on cephalic half, the posterior portion and remainder of mesonotum grey pruinose; fore and middle femora darkened, the tips narrowly yellow; posterior femora and all tibiae yellow; wings tinged with yellow; a restricted brown pattern, including seams to the cord and outer end of cell 1st M_2, as well as marginal spots at ends of all longitudinal veins excepting R_5 and M_1; Rs square at origin; r-m connecting with Rs at the fork or nearly so; inner end of cell 1st M_2 arcuated; m-cu beyond midlength of cell 1st M_2; abdominal tergites dark brown; sternites yellow, the incisures narrowly infuscated.

♀.—Length about 10 mm.; wing, 9 mm.

Rostrum obscure yellow, darker basally; palpi dark. Antennae with scape dark above, paler beneath; pedicel yellow; flagellum broken. Head dark grey; anterior vertex reduced to a narrow strip.

Pronotum obscure yellow. Mesonotal praescutum dark brown on cephalic half, the colour continued obliquely backward to the suture, leaving the posterior portion of the praescutum grey; posterior sclerites of notum grey pruinose. Pleura dark brown, sparsely pruinose. Halteres elongate, yellow, the knobs infuscated. Legs with the coxae yellow, darker basally; trochanters yellow; fore and middle femora infuscated, the tips narrowly yellow; posterior femora more uniformly yellow; tibiae golden-yellow; tarsi passing into yellowish-brown. Wings (Fig. 22) tinged with yellow, the costal region scarcely more saturated; a restricted brown pattern, distributed as follows: Small brown spots at arculus; origin of Rs; cord, the latter extended to the costa at fork of Sc; outer end of cell 1st M_2; fork of M_{1+2}; marginal areas at ends of all longitudinal veins excepting R_5 and M_1; veins yellow, darker in the clouded areas. Venation: Sc_2 at tip of Sc_1; Rs square at origin but not angulated; r-m connecting with Rs at the exact fork or immediately beyond on R_5, the basal deflection of the latter thus obliterated; inner end of cell 1st M_2 arcuated, r-m being at near midlength of the cell; m-cu beyond midlength of cell 1st M_2.

Abdominal tergites dark brown, the sternites yellow, the incisures narrowly infuscated; ovipositor with the valves horn-coloured.

Holotype, ♀, Wau, New Guinea, altitude 3,400 feet, 21 December, 1933 (F. H. Taylor).

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* Continued from these PROCEEDINGS, lxi, 1936, p. 183.

The most closely allied species is *Austrolimnophila interventa* (Skuse) of eastern Australia, which, while having a somewhat similar wing-pattern, has the venation entirely different, especially in the central radial and medial fields.

AUSTROLIMNOPHILA INTERJECTA, n. sp. Fig. 23.

General coloration of mesonotal praescutum dark brown on anterior third, this colour continued laterad and caudad across the posterior thoracic pleura; posterior portion of praescutum and scutum light ashy-grey; antennae yellow, elongate; fore femora darkened; wings cream-yellow, with a heavy, pale brown pattern, including a broad crossband at cord, and conspicuous marginal spots at ends of all longitudinal veins; Rs very strongly angulated at origin.

♀.—Length about 11 mm.; wing, 11 mm.

Rostrum brownish-yellow; palpi yellow. Antennae elongate, yellow; flagellar segments long-cylindrical, with verticils that are much shorter than the segments; outer segments gradually decreasing in length. Head light grey.

Pronotum and propleura light yellow. Mesonotal praescutum with anterior third dark brown, this colour continued laterad and caudad across the humeral and lateral portions of the sclerite, thence passing on to the pleura and including the dorsal pteropleurite and postnotum; posterior portion of praescutum and scutum light ashy-grey, contrasting abruptly with the brown anterior portions of the former; scutellum and mediotergite darker grey, the pleurotergite more brownish-grey. Pleura light yellow. Halteres elongate, darkened basally, the outer ends of stem and the knob more yellow. Legs with the coxae yellow, the surface very sparsely pruinose; trochanters yellow; fore femora brown, the middle pair more brownish-yellow, somewhat brighter on distal half; posterior femora yellow; tibiae and tarsi yellow, the terminal segments of the latter darkened. Wings (Fig. 23) light cream-yellow, with a heavy and conspicuous pale-brown pattern, including a broad, complete crossband at the cord, entirely darkening cell 1st M_2 and involving the ends of all cells on both sides of the cord; a large area at origin of Rs; smaller spots at arculus, fork of M_{1+2} and as marginal spots, including all longitudinal veins excepting R_5 and M_1; veins yellow, darker in the clouded areas. Venation: Rs bent at more than a right angle at origin; elements of anterior cord in oblique alignment, the inner end of cell 1st M_2 more basad; m arcuated, longer than basal section of M_3; m-cu at midlength of cell 1st M_2; anterior arculus lacking.

Abdomen brown, the lateral portions and bases of sternites restrictedly more blackish. Ovipositor with cerci long and slender, very gently upcurved.

Holotype, ♀, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor).

The closest allies of the present species are *Austrolimnophila antiqua* (Skuse) and *A. interventa* (Skuse), of eastern Australia, both of which are readily distinguished by the wing-pattern and venation.

EPIPHRAGMA (EPIPHRAGMA) FUSCODISCALIS, n. sp. Fig. 24.

General coloration of mesonotum dark brown; praescutum obscure yellow, with brown stripes; antennae short; legs yellow, the femora with three narrow brown rings, the last subterminal in position; tibiae yellow, with three very narrow, scarcely indicated darker annuli; wings light yellow, with a heavy dark-brown pattern, including a large discal area over anterior cord and cell 1st M, and a series of marginal spots at ends of all longitudinal veins; male terminalia with a slender erect spine before apex of interbase.

♂.—Length about 8·5 mm.; wing, 8·5 mm.

Rostrum brown; palpi black. Antennae short, if bent backward not extending beyond pronotum; scape and pedicel dark brown; basal segment of flagellum yellow; succeeding segments dark brown; basal flagellar segments oval, soon passing into elongate, the verticils long and conspicuous, exceeding the segments. Head dark brown.

Pronotum obscure yellow, variegated by dark brown medially and on sides. Mesonotal praescutum obscure yellow, with a complete median brown stripe and indications of incomplete lateral areas on cephalic portion; scutal lobes dark brown, the median area narrowly pollinose; scutellum and postnotum dark brown. Pleura dark brown, vaguely and restrictedly marked with obscure yellow. Halteres yellow, the knobs weakly darkened. Legs with the fore coxae yellow, the middle and posterior coxae dark brown; trochanters yellow; femora yellow, each with three narrow dark-brown rings that are a little narrower than the yellow interspaces, the last dark ring subterminal and a trifle more extensive than the pale apex; tibiae yellow, with three very narrow and scarcely evident dark rings, the most distinct a very narrow subbasal annulus, the outermost a nearly terminal darkening; tarsi yellow, the outer segments weakly infuscated. Wings with the ground-colour light yellow, with a heavy solid, brown pattern, including a large discal area that completely covers cell 1st M_2 and adjoining cells, reaching the costal border as a seam on the anterior cord; large and conspicuous brown spots at ends of all longitudinal veins, larger in the anal field, where additional marginal clouds occur at mid-distance between the veins in both cells 1st A and 2nd A; additional dark brown areas at arculus, origin of Rs, cells M and Cu, and as a large circular area at fork of M_{1+2}; interpolated pale-brown clouds of lunate form encircle the supernumerary crossvein in cell C and the marginal area at R_{1+2}; veins yellow, darker in the clouded areas. Costal fringe moderately long. Venation: m longer than basal section of M_3, arcuated; m-cu about its length beyond fork of M.

Abdominal tergites chiefly infuscated, scarcely variegated by brighter areas; terminalia yellow. Male terminalia (Fig. 24) with the lobes of the tergite, *9t*, narrow. Interbase, *i*, bearing a pale erect spine on mesal face a little more than its own length back from tip of rod.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor).

The only Australasian species with a somewhat similar, solidly darkened wing-pattern are *Epiphragma* (*Epiphragma*) *hebridensis* Alexander (New Hebrides) and *E.* (*E.*) *meridionalis* Alexander (south-eastern Australia), both of which differ conspicuously in the details of pattern of the wings and legs.

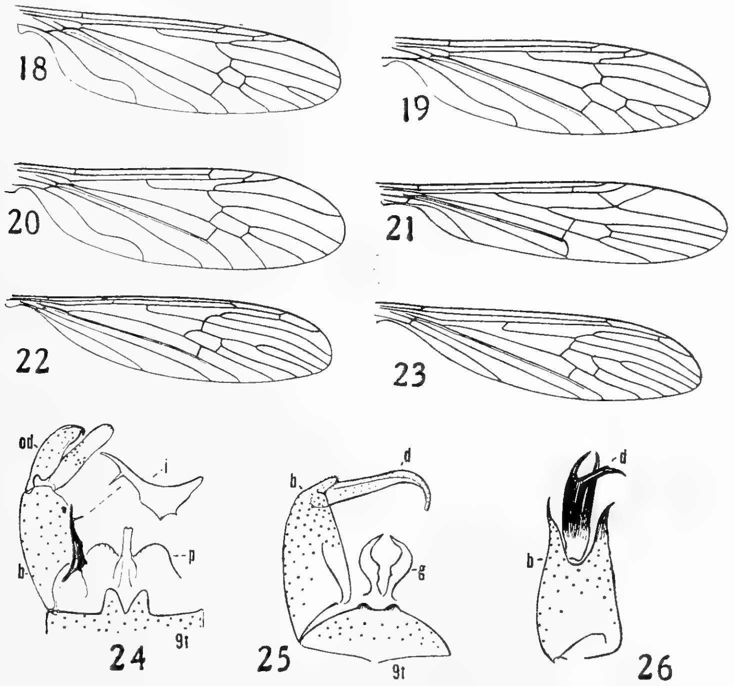
EPIPHRAGMA (EPIPHRAGMA) GLORIOLA, n. sp.

General coloration reddish-brown, the praescutum with darker brown stripes; antennae bicoloured; femora and tibiae yellow, each with two black rings; wings pale yellow, with a heavy dark-brown pattern, the areas solid and chiefly costal in distribution; a series of yellow spots near distal ends of outer medial, cubital and anal cells; m-cu at near two-thirds the length of cell 1st M_2.

♀.—Length about 12 mm.; wing, 11 mm.

Rostrum brown; palpi black. Antennae relatively elongate; scape and pedicel light brown; basal segment of flagellum yellow, weakly darkened at base; succeeding flagellar segments bicoloured, the basal portion black, the outer end yellow, the latter colour involving about one-half the sclerite on the basal segments but becoming more restricted on outer segments; terminal segments uniformly darkened; verticils shorter than the segments. Head brown.

Pronotum brown. Mesonotal praescutum reddish-brown, variegated with darker brown, including three stripes that are confluent behind to involve most of disk; humeral region with a brownish area; lateral border of sclerite before the suture brownish-black; scutal lobes brownish-black, the median area abruptly yellow; scutellum yellow, parascutella dark; mediotergite almost uniformly brownish-black. Pleura brownish-black, variegated by somewhat paler areas that include the dorsopleural region and a broad diffuse ventral stripe extending from behind the fore coxae to the pleurotergite. Halteres elongate, pale, the apex of knob obscure yellow. Legs with the coxae and trochanters brownish-black; femora yellow, with two black annuli, placed at near midlength and before apex, these dark rings subequal in area to the alternate yellow bands; indications of a third, more basal darkening appear on the upper surface of sclerite only; tibiae yellow,



Text-figs. 18-26.

18.—*Gynoplistia* (*Gynoplistia*) *scimitar*, n. sp., venation.
19.—*Gynoplistia* (*Gynoplistia*) *attrita*, n. sp., venation.
20.—*Gynoplistia* (*Gynoplistia*) *luteoannulata*, n. sp., venation.
21.—*Trentepohlia* (*Mongoma*) *nigrescens*, n. sp., venation.
22.—*Austrolimnophila fluxa*, n. sp., venation.
23.—*Austrolimnophila interjecta*, n. sp., venation.
24.—*Epiphragma* (*Epiphragma*) *fuscodiscalis*, n. sp., male terminalia.
25.—*Gynoplistia* (*Gynoplistia*) *scimitar*, n. sp., male terminalia.
26.—*Gynoplistia* (*Gynoplistia*) *luteoannulata*, n. sp., male terminalia details.

a, aedeagus; *b*, basistyle; *d*, dististyle; *i*, interbase; *id*, inner dististyle; *od*, outer dististyle; *p*, phallosome; *t*, tergite.

with two dark rings, a narrower subbasal one and a broad ring at and beyond midlength of the segment; tarsi brown, passing into brownish-black. Wings pale yellow, more saturated in prearcular and costal regions; a very heavy dark-brown pattern, the areas solid and chiefly costal in distribution, placed at arculus; origin of Rs; at supernumerary crossvein in cell C; a major band from costa along anterior cord to fork of M; tips of radial veins; other dark areas at outer end of cell 1st M_2, fork of M_{1+2} and m-cu; distal ends of all outer medial, cubital and anal cells paler brown, before their margins enclosing a small, pale-yellow spot, these larger and more extensive in the anal field; in cell 2nd A this latter appears as a streak for almost the length of the cell; paler brown washes in costal field, one before and one beyond the area at origin of Rs; cell R_4 darkened except at outer end; veins brown, luteous in the yellow areas. Venation: Supernumerary cross-vein in cell C opposite the fork of Rs; m-cu at near two-thirds the length of the narrow cell 1st M_2; m and basal section of M_3 subequal; cell M_1 exceeding twice its petiole.

Abdomen dark brown, scarcely variegated by brighter; cerci blackened at bases, the slender valves horn-coloured.

Holotype, ♀, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor).

Epiphragma (*Epiphragma*) *gloriola* is so different from all other regional species that it is unprofitable to compare it with any species described to this date.

GYNOPLISTIA (GYNOPLISTIA) SCIMITAR, n. sp. Figs. 18, 25.

Thorax dull brownish-black, the propleura pale, the pteropleurite heavily light-grey pruinose; antennae 17-segmented, with 13 long-branched segments; knobs of halteres blackened; femora obscure yellow, the fore pair undarkened, the remaining femora with tips blackened; wings with basal fourth clear light-yellow, the outer portions more suffused, the cells beyond cord uniformly blackened; still darker seams at origin of Rs and on anterior cord; cell M_1 present; cell 1st M_2 small; abdomen with basal four segments orange-yellow, unmarked, the remaining segments velvety-black; male terminalia with a single, elongate, blade-like dististyle.

♂.—Length about 9 mm.; wing, 8·2 mm.

Rostrum brown; palpi infuscated. Antennae 17-segmented; formula 2+2+11+2; scape, pedicel and axis of basal three or four flagellar segments yellow, the outer segments and all branches black; longest branches (at midlength of flagellum) nearly one-third the length of the entire organ; basal two branches long and slender; branch of twelfth flagellar segment about one-half longer than the segment; branch of thirteenth flagellar segment a mere lobe. Head liver-brown, a little brightened behind.

Prothorax and mesothorax almost uniform dull brownish-black, the praescutum a little brightened on humeral portion; propleura, surrounding the anterior spiracle, extensively obscure yellow; pteropleurite heavily pruinose with light grey, the mesepisternum thus appearing as a darkened girdle between the pale propleura and the pteropleurite. Halteres with the base of stem yellow, becoming more obscure outwardly, the knob blackened. Legs with the coxae brownish-black, the surface light-grey pruinose, more conspicuously so on fore and hind coxae; fore trochanters brown, the middle and hind pair black; femora obscure yellow, the fore pair undarkened, the middle and hind femora with conspicuously blackened tips; tibiae and tarsi black. Wings (Fig. 18) with basal fourth clear light-yellow, beyond this point suffused with blackish, more brightened before stigma; cells beyond cord uniformly darkened; cell Sc, an area at origin of Rs and a broad seam at anterior cord darker brown; veins black, clear yellow in the flavous basal areas. A series of macrotrichia on vein R_5, but vein R_4 without such setae; medial field and all veins posterior to it, glabrous. Venation: Cell 1st M_2 relatively small, with m-cu just beyond one-third its length; cell M_1 subequal in length to its petiole; vein 2nd A rather strongly sinuous.

Abdomen with basal four segments orange-yellow, immaculate; succeeding segments and terminalia velvety-black. Male terminalia (Fig. 25) with the caudal margin of tergite, *9t*, bearing two low rounded tubercles. Basistyle, *b*, slender, terminating in a fleshy, finger-like lobe that is delicately setuliferous. A single long, blade-like dististyle, *d*, that is only a little shorter than the basistyle, gradually narrowed to the decurved point. Gonapophyses, *g*, simple, each appearing as a narrow blade, the apex acute and spinous.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor).

Gynoplistia (*Gynoplistia*) *biróana* Alexander, likewise from north-eastern New Guinea, appears to be the closest ally of the present fly, which differs especially in the pattern of the body, legs and wings, and in the structure of the male terminalia.

GYNOPLISTIA (GYNOPLISTIA) ATTRITA, n. sp. Fig. 19.

Thorax dark liver-brown to brownish-black; antennae (♀) 16-segmented, with seven branched segments; head brownish-black; knobs of halteres orange-yellow; femora yellow, the tips rather broadly and conspicuously blackened; middle and posterior femora with a more diffuse brown ring at near midlength; wings pale yellow, the prearcular and costal regions deeper yellow; a conspicuous brown pattern, chiefly costal in distribution, the apical band relatively narrow; abdomen with basal segment black, the succeeding four tergites yellow, darkened laterally; a black subterminal ring.

♀.—Length about 10 mm.; wing, 9 mm.

Rostrum brownish-black; palpi black. Antennae (♀) 16-segmented; formula 2+2+5+7; scape, pedicel and bases and apices of the axes of proximal two or three flagellar segments brownish-yellow; remainder of organ, including branches, black; longest branch (about flagellar segments four or five) approximately three times the length of the segment itself. Head brownish-black, polished.

Prothorax and mesothorax uniformly dark liver-brown to brownish-black, unvariegated except for a weak pruinosity on the pleurotergite. Halteres with the stem dusky, the knob light orange-yellow. Legs with the coxae brownish-black; trochanters obscure yellow; fore femora yellow, the tips rather broadly and conspicuously black; middle and hind femora with tips similarly and subequally blackened, and at near midlength with indications of a broader but more diffuse infuscated ring, more evident on the posterior legs; fore and middle tibiae black, the posterior pair somewhat more brownish-black on basal portion; tarsi black. Wings (Fig. 19) pale yellow, the prearcular and costal fields deeper and more saturated yellow; a conspicuous brown pattern, as follows: Arculus and humeral cross-vein; origin of Rs; a band from stigma across cord, narrowed posteriorly and becoming a mere seam on m-cu; wing-tip abruptly darkened, its proximal edge about on a level with the fork of M_{1+2}; a brown wash along vein Cu and in proximal half of cell Cu, culminating in a darkened spot at near two-thirds the length of vein 1st A; a darkened cloud at bend of vein 2nd A;

most of longitudinal veins in the interspaces very narrowly and insensibly seamed with brown; veins dark, yellow in the luteous areas. Numerous macrotrichia on veins R_4 and R_5; in medial field restricted to outer portion of vein M_1. Venation: Vein R_4 long, cell R_3 at margin very extensive; cell 1st M_2 relatively large, with m-cu about its own length beyond the fork of M; cell M_1 longer than its petiole; m-cu moderately sinuous.

Abdomen with basal segment black; tergites two to five, inclusive, yellow, darkened laterally; sternites two to five more obscure yellowish-brown; subterminal segments black; genital shield of ovipositor obscure orange. Ovipositor with cerci yellow, slender, gently upcurved.

Holotype, ♀, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor).

Somewhat similar in general appearance to *Gynoplistia* (*Gynoplistia*) *fulviceps* Walker, of north-western New Guinea, but differing widely in all details of coloration of body, legs and wings. The brightened knobs of the halteres separate the species from almost all other regional members of the genus.

GYNOPLISTIA (GYNOPLISTIA) LUTEOANNULATA, n. sp. Figs. 20, 26.

General coloration coal-black; head deep blue; antennae 16-segmented, with ten branched segments; legs black, the femora with a broad conspicuous yellow ring before tips; wings with the ground-colour of the basal cells greyish-white, the cells beyond cord uniformly darkened; a restricted darker pattern at arculus; a narrow cross-band at origin of Rs and on anterior cord; cell M_1 lacking; vein 2nd A very strongly sinuous; male terminalia with the basistyle bispinous at apex; dististyle single, terminating in three long spines.

♂.—Length about 6 mm.; wing, 6 mm.

Rostrum and palpi black. Antennae 16-segmented, black throughout; formula 2+2+8+4; longest branches (at near midlength of organ) about one-third the length of the entire antenna; branch of tenth flagellar segment short, about as long as the segment; terminal segment a trifle longer than the penultimate. Head deep blue.

Mesonotum black, the surface subnitidous; postnotum weakly pruinose. Pleura pruinose. Halteres with stem black, the knobs broken. Legs with coxae black, pruinose; trochanters black; femora black, with a broad conspicuous yellow ring before tips; on the posterior legs this annulus includes more than one-fourth the total length of the segment; tibiae and tarsi black. Wings (Fig. 20) with the ground-colour of cells basad of cord greyish-white, beyond the cord and in costal field uniformly suffused with blackish; darker areas at arculus and as cross-bands at origin of Rs and along anterior cord, the former nearly complete but narrow, the latter much wider; veins brownish-black. Anterior branch of Rs with a single trichium close to R_2; veins R_4 and R_5 with almost complete series of trichia; medial veins glabrous. Venation: R_{2+3+4} very short; cell M_1 lacking; vein 2nd A very strongly sinuous.

Abdomen short, black, including the terminalia. Male terminalia (Fig. 26) with the caudal margin of tergite convex, produced medially into a small subacute point. Basistyle, *b*, at apex produced into a lateral and a mesial spinous point, both slender and blackened. Dististyle, *d*, terminating in three blackened spines. Gonapophyses, *g*, appearing as straight spatulate blades, the tips broadly obtuse. Aedeagus slender, shorter than the apophyses.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor).

The closest ally of the present fly is *Gynoplistia* (*Gynoplistia*) *perjucunda* Riedel (New Guinea), which differs conspicuously in the coloration of the body, legs and wings, and in the number of antennal segments.

ERIOPTERINI.

CONOSIA IRRORATA (Wiedemann).

Limnobia irrorata Wiedemann, *Aussereur. zweifl. Ins.*, 1, 1828, 574.

1 ♀, Wau, New Guinea, altitude 3,400 feet, 21 December, 1933 (F. H. Taylor).

TRENTEPOHLIA (MONGOMA) NIGRESCENS, n. sp. Fig. 21.

General coloration almost uniformly dark brown; antennae black throughout; halteres blackened; legs long and slender, posterior tarsi about equal in length to the femora; legs brownish-black, only the terminal tarsal segments paler; wings with a faint blackish tinge; Rs shorter than R_{2+3+4}.

♂.—Length about 7 mm.; wing, 8 mm.

Rostrum brown; palpi obscure yellow. Antennae black throughout; flagellar segments long-oval, with numerous verticils, the longest subequal in length to the segments. Head brownish-black.

Mesonotum almost uniformly dark brown, the scutellum a trifle paler. Pleura dark brown, the sternopleural region a little paler. Halteres blackened. Legs brownish-black, only the terminal tarsal segments paling to brownish-white or dirty-white; legs long and slender, the posterior tibiae a trifle longer than the femora, the latter subequal in length to the tarsi; legs without specially modified armature. Wings (Fig. 21) with a nearly uniform, faintly blackish tinge; stigma ill-delimited, a trifle darker; veins dark brown. Costal fringe (♂) short. Venation: Rs shorter than R_{2+3+4}; R_2 just before fork of R_{3+4}; vein R_3 moderately oblique, cell R_2 at margin about one-fourth cell R_3; cell 1st M_2 moderately long; inner ends of cells R_5 and M_3 about in transverse alignment; m-cu close to fork of M; apical fusion of veins Cu_1 and 1st A slight.

Abdominal tergites and terminalia brownish-black; basal sternite obscure yellow, the succeeding sternites passing through brown to brownish-black.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor).

By means of keys to the regional species of *Trentepohlia*, the present fly runs to *Trentepohlia* (*Mongoma*) *brevipes* Alexander, a very different fly having short tarsi and with the venational details quite distinct.

GONOMYIA (LIPOPHLEPS) NIGRIDORSATA, n. sp. Figs. 27, 33.

Belongs to the *sulphurella* group; mesonotal praescutum and scutum polished black; pleura black, with a longitudinal grey stripe; halteres dusky; legs black; wings almost uniformly tinged with dusky; vein R_3 present, erect; male hypopygium with the armature of the tergite spinous; dististyle bearing a long slender spine.

♂.—Length about 4 mm.; wing, 4·5 mm. ♀.—Length about 4·5 mm.; wing, 5 mm.

Rostrum reddish; palpi black. Antennae black throughout; flagellar segments long-oval, in male with the usual very elongate verticils. Head black, dark-grey pruinose.

Pronotum and lateral pretergites yellowish-white. Mesonotal praescutum, together with the scutal lobes, entirely polished black, median region of the scutum grey pruinose; scutellum yellow, the parascutella black; mediotergite black, the cephalic portion grey pruinose. Pleura black, with a longitudinal grey stripe extending from behind the fore coxae to the base of abdomen; dorso-pleural membrane dull black. Halteres dusky. Legs with the fore coxae black, the remaining coxae brownish testaceous; trochanters dark brown; remainder of legs black. Wings (Fig. 27) almost uniformly tinged with dusky, the stigma not or scarcely differentiated; veins brownish-black. Venation: Sc_1 ending about opposite one-fourth the length of the long Rs, the latter subequal to R_{2+3+4}; vein R_3 present, erect, without trichia.

Abdominal tergites brownish-black; sternites yellow. Male terminalia (Fig. 33) with the tergal armature consisting of strong spines or spinous setae. Lobe of basistyle, *b*, flattened, with abundant setae on mesial face, including a longer brush at apex. Dististyle, *d*, single, symmetrical on the two sides, bearing a long curved spine; rostral portion of style slender, terminating in a powerful fasciculate seta, with other strong setae on disk of style. Phallosome, *p*, consisting of two pale flattened rods, the distal third of each narrowed, the tips gently divergent.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor). Allotopotype, ♀.

Gonomyia (*Lipophleps*) *nigridorsata* is very different from the other regional members of the *sulphurella* group, as *G.* (*L.*) *nubeculosa* (de Meijere), *G.* (*L.*) *pallidosignata* Alexander and *G.* (*L.*) *perreducta* Alexander, in the conspicuous coloration of the body, and in the structure of the male terminalia.

GONOMYIA (LIPOPHLEPS) NIGRIDORSATA PLEUROSTRIATA, n. subsp.

Characters entirely as in the typical form, differing only in the very different coloration of the thoracic pleura. Pleura, including dorso-pleural region and pleurotergite, yellow, with a relatively narrow, dark-brown, longitudinal line extending from the fore coxae to above the posterior coxae.

Holotype, ♀, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor).

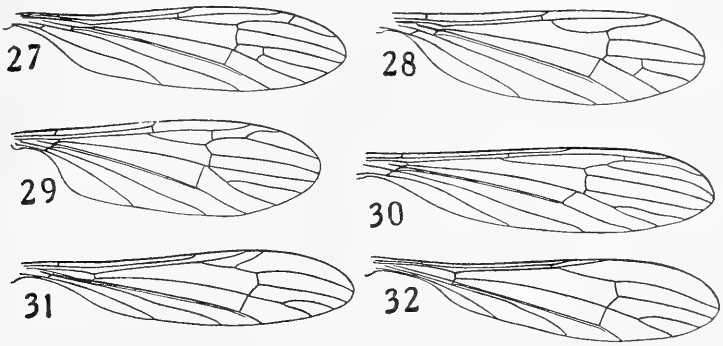
GONOMYIA (LIPOPHLEPS) ACUS, n. sp. Figs. 28, 34.

General coloration of mesonotum dark brown; scutellum and postnotum brightened; thoracic pleura striped longitudinally with brownish-black and yellow; legs black; wings almost uniformly suffused with greyish, the stigmal area very faintly darker; Sc_1 ending opposite origin of Rs; basal deflection of R_5 long; abdominal tergites brownish-black, the caudal borders very narrowly yellow; male terminalia with the outer dististyle a long aciculate spine from an expanded base; phallosome a densely hairy column, terminating in two slender black spines that are microscopically spinulose at base.

♂.—Length about 3·6 mm.; wing, 4·2 mm.

Rostrum and palpi black. Antennae black, the scape a little brightened above; flagellar verticils very long and conspicuous. Head chiefly infuscated.

Pronotum and anterior lateral pretergites white. Mesonotal praescutum and scutum uniform brown; scutellum obscure yellow; mediotergite black, obscurely brightened beyond the base, the apical portion broadly dark. Pleura striped longitudinally with yellow and brownish-black; dorsal pleurites, including the pleurotergite, obscure yellow; a broad pale-yellow stripe from behind the fore coxae to beneath the halteres, bordered both above and beneath by blackish. Halteres yellow, the knobs weakly darkened. Legs with the coxae blackened, the posterior pair restrictedly paler at apices; trochanters yellow; remainder of legs black. Wings (Fig. 28) almost uniformly suffused with greyish, the stigmal area very faintly and diffusely darker; veins pale brown, the anterior cord darker; prearcular veins and Cu more yellow. Venation: Sc$_1$ ending opposite origin of Rs, Sc$_2$ near its tip; basal deflection of R$_5$ long, subequal to m; cell 1st M$_2$ closed; m-cu shortly before fork of M.



Text-figs. 27-32.

27.—*Gonomyia* (*Lipophleps*) *nigridorsata*, n. sp., venation.
28.—*Gonomyia* (*Lipophleps*) *acus*, n. sp., venation.
29.—*Erioptera* (*Empeda*) *albidibasis*, n. sp., venation.
30.—*Erioptera* (*Meterioptera*) *sziladyi* Alexander, venation.
31.—*Toxorhina* (*Ceratocheilus*) *fumipennis*, n. sp., venation.
32.—*Toxorhina* (*Toxorhina*) *suttoni*, n. sp., venation.

Abdomen brownish-black, the surface sparsely pruinose; caudal borders of the tergites very narrowly obscure yellow; on sternites, the borders are much less distinctly brightened; terminalia light brown. Male terminalia (Fig. 34) with the dististyles apical in position, the outer one, *od*, expanded beyond the narrow base, thence produced into a long, very slender, needle-like point; inner style short and broad, with numerous setae, including two fasciculate bristles at outer apical angle. Phallosome, *p*, consisting of a pale, densely hairy column that terminates in a pair of slender black spines, each of the latter with microscopic spinulae on upper margin near bases, the tips acute, long and slender.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor).

Gonomyia (*Lipophleps*) *acus* is allied to *G.* (*L.*) *kertésziana* Alexander (northeastern New Guinea), differing most evidently in the venation and in the structure of the male terminalia.

ERIOPTERA (EMPEDA) ALBIDIBASIS, n. sp. Figs. 29, 35.

General coloration grey, the mesonotum unmarked; antennae black, the first flagellar segment yellow; halteres white throughout; femora obscure yellow to yellowish-brown, provided with setae and flattened scales; wings tinged with greyish, the prearcular field abruptly whitened; Sc short, R$_3$ long; abdominal tergites brownish-black, the terminalia of male small; dististyles entirely pale, the outer one unequally bifid, its inner arm shorter and more slender than the outer.

♂.—Length about 2·5–2·6 mm.; wing, 3·2–3·4 mm. ♀.—Length about 3·8–4 mm.; wing, 4–4·2 mm.

Rostrum and palpi black. Antennae short in both sexes; scape and pedicel black; basal flagellar segment somewhat enlarged, yellow to obscure yellow; remainder of flagellum black; longest verticils much exceeding the segments and unilaterally distributed. Head dark grey.

Pronotum and pretergites white. Mesonotum almost uniformly dark-grey, the margin of praescutum before the pseudosuture restrictedly yellow; tuberculate pits and pseudosutural foveae black. Pleura dark brownish-grey; dorso-pleural membrane paler. Halteres white throughout. Legs with the fore coxae and trochanters darkened, the remaining coxae and trochanters yellow; femora uniformly obscure yellow to yellowish-brown, the darker colour produced by setae and flattened scales; tibiae and tarsi brownish-black to black. Wings (Fig. 29) tinged with greyish, the prearcular field abruptly and conspicuously whitened; stigmal region scarcely darkened; veins pale brown, whitish in the basal area, the arcular elements a trifle infuscated. Venation: Sc relatively short, Sc_1 ending just beyond origin of Rs, Sc_2 but faintly indicated, near tip of Sc_1; R_2 about equal to R_{2+3+4}; R_3 unusually long and not as oblique as in most species of the subgenus; m-cu shortly before fork of M.

Abdominal tergites brownish-black, sternites brownish-yellow; terminalia small, obscure yellow. Male terminalia (Fig. 35) with both dististyles pale, the outer one, *od*, entirely glabrous, simply but deeply bifid, the outer arm relatively wide, the inner arm shorter and unusually slender, its tip obliquely truncated. Inner dististyle, of about the same conformation and size as the outer arm of the outer style, provided with a few microscopic setulae at apex.

Holotype, ♂, Aramaiti, Papua, altitude about 6,000 feet, July, 1935 (K. J. Clinton). Allotype, ♀, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor). Paratopotype, 1 ♂, with holotype; paratype, 1 ♀, Maini, New Guinea, altitude 6,300 feet, July, 1935 (K. J. Clinton).

Erioptera (*Empeda*) *albidibasis* belongs to the group of the subgenus that includes species having a short Sc and an unusually long vein R_3; femora uniformly coloured, without suddenly blackened tips, and provided not only with setae but also with flattened scales; male terminalia small, the dististyles entirely pale, the outer style bifid. In this group, the closest described ally is *E.* (*E.*) *lunensis* Alexander (Mindanao), which differs most evidently in the distinct male terminalia.

ERIOPTERA (ERIOPTERA) LUNICOLA Alexander.

Philippine Journ. Sci., xlviii, 1932, 630–631.

Known from Luzon and Mindanao. A small series of what certainly appears to be the same species from Maini, Papua, altitude about 6,300 feet, July, 1935 (K. J. Clinton), and Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor).

The male terminalia are very similar to the condition found in the Philippine types, except that the spine on the inner dististyle is a little shorter and slightly less curved. The basal segments of the flagellum are paler than in the types.

ERIOPTERA (METERIOPTERA) SZILADYI Alexander. Fig. 30.

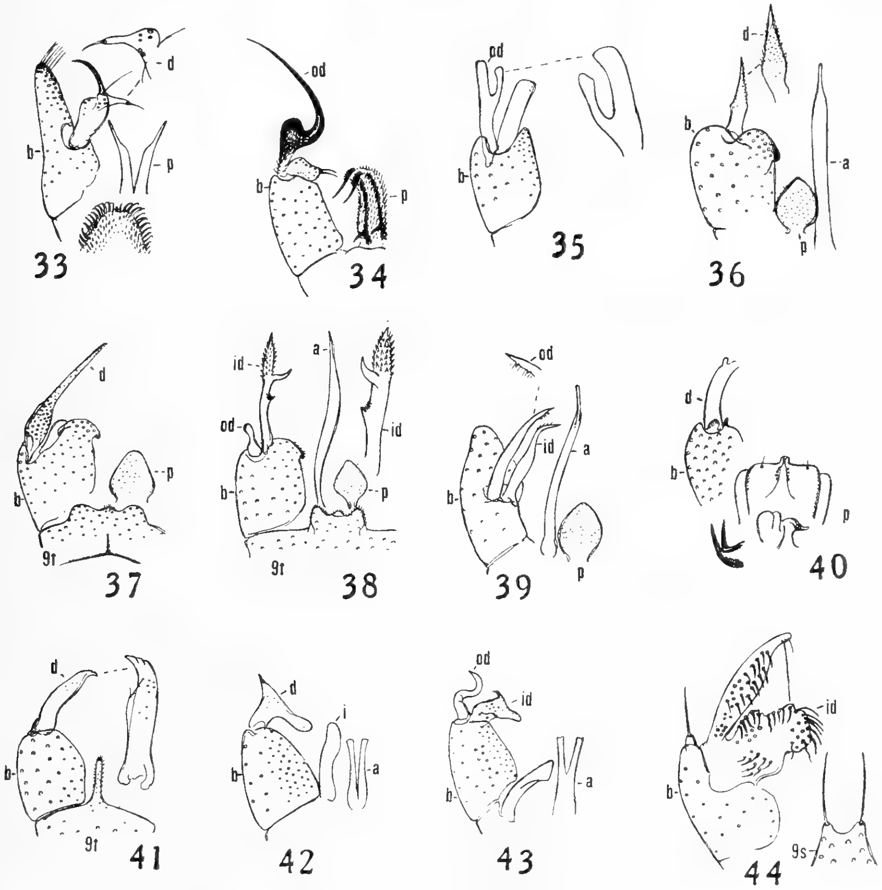
Philippine Journ. Sci., liv, 1934, 468–469.

The type, a male, was from Sattelberg, Huon Peninsula, north-eastern New Guinea, collected in late September, 1898, by the late Ludwig Biró.

A second specimen is from Wau, New Guinea, altitude 3,400 feet, 18 December, 1933 (F. H. Taylor). This individual is somewhat larger than the type (length about 5 mm.; wing, 5·5 mm.), but otherwise very similar. The wing-venation is shown (Fig. 30).

MOLOPHILUS UNISTYLUS, n. sp. Fig. 36.

Belongs to the *gracilis* group, *ruficollis* subgroup; general coloration dark grey, the pronotum and pretergites china-white; antennae short, the first flagellar



Text-figs. 33-44.

33.—*Gonomyia* (*Lipophleps*) *nigridorsata*, n. sp., male terminalia.
34.—*Gonomyia* (*Lipophleps*) *acus*, n. sp., male terminalia.
35.—*Erioptera* (*Empeda*) *albidibasis*, n. sp., male terminalia.
36.—*Molophilus unistylus*, n. sp., male terminalia.
37.—*Molophilus taylorinus*, n. sp., male terminalia.
38.—*Molophilus concussus*, n. sp., male terminalia.
39.—*Molophilus aterrimus*, n. sp., male terminalia.
40.—*Tasiocera papuana*, n. sp., male terminalia.
41.—*Tasiocera tarsalba*, n. sp., male terminalia.
42.—*Toxorhina* (*Ceratocheilus*) *fumipennis*, n. sp., male terminalia.
43.—*Toxorhina* (*Toxorhina*) *suttoni*, n. sp., male terminalia.
44.—*Styringomyia spinicaudata*, n. sp., male terminalia.

a, aedeagus; *b*, basistyle; *d*, dististyle; *i*, interbase; *id*, inner dististyle; *od*, outer dististyle; *p*, phallosome; *s*, sternite; *t*, tergite.

segment yellow; halteres and legs brownish-black; wings with a strong blackish tinge; male terminalia with a single dististyle, lying in the notch of the low apical lobes of basistyle; phallosomic plate with abundant setae.

♂.—Length about 3·8–4·2 mm.; wing, 4·5–5 mm. ♀.—Length about 4·2–4·5 mm.; wing, 4·5–5 mm.

Rostrum and palpi black. Antennae short, if bent backward not or scarcely attaining the wing-root; scape and pedicel brown; basal segment of flagellum yellow, the remaining segments dark brown to black; flagellar segments oval, with long conspicuous verticils. Head grey.

Pronotum and lateral pretergites conspicuously china-white. Mesonotum dark grey, the scutellum unbrightened. Pleura blackened, sparsely pruinose. Halteres brownish-black throughout. Legs with the coxae and trochanters brown; femora brownish-black, the bases brown; tibiae and tarsi black. Wings with a strong blackish tinge; veins and macrotrichia brownish-black; costal fringe relatively conspicuous, black. Venation: R_2 lying proximad of r-m; m-cu about one-third the petiole of cell M_3; vein 2nd A ending about opposite the proximal end of m-cu.

Abdomen, including terminalia, black. Male terminalia (Fig. 36) with the apical lobes of basistyle, *b*, short and blunt, the mesial lobe with more numerous setae and further produced into a low blackened lobule. A single dististyle, *d*, lying in the shallow notch at apex of basistyle, appearing as a simple spine that is produced into an acute glabrous point, the surface basad of this point with abundant setae and setulae. Aedeagus, *a*, long and conspicuous, pale, at apex suddenly narrowed into a slender point. Phallosome, *p*, a broad suboval plate, its outer end slightly pointed, the surface with abundant setae.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor). Allotopotype, ♀, carded with type. Paratopotypes, 5 ♂ ♀, with the type.

The structure of the male terminalia will at once separate this fly from the numerous Australian species of the genus so far described. I am referring the insect to the *ruficollis* subgroup with considerable doubt, since all other species hitherto placed therein have two dististyles. The presence of a single dististyle in the species discussed above and in *Molophilus taylorinus*, n. sp., is much as in the genus *Tasiocera* and in the otherwise very different *Molophilus monostylus* Alexander, of Chile.

MOLOPHILUS TAYLORINUS, n. sp. Fig. 37.

Belongs to the *gracilis* group, *ruficollis* subgroup; general coloration black, including the antennae and halteres; wings strongly tinged with blackish; male terminalia with the caudal margin of the tergite trilobed; a single dististyle, appearing as an elongate simple rod, the base dilated and provided with abundant long erect setae.

♂.—Length about 2·8–3 mm.; wing, 3·5–4 mm.

Rostrum and palpi black. Antennae black throughout, short, if bent backward not attaining the wing-root; flagellar segments oval, with conspicuous verticils. Head black, sparsely grey pruinose.

Thorax entirely black, very sparsely pruinose. Halteres black throughout. Legs with the coxae black; trochanters dark brown; remainder of legs brownish-black. Wings with a strong blackish tinge, the veins even darker coloured; macrotrichia black. Venation: R_2 in transverse alignment with r-m, or even slightly proximad of this point; petiole of cell M_3 relatively short, only about one-half longer than m-cu; vein 2nd A ending about opposite the posterior end of m-cu.

Abdomen, including terminalia, black. Male terminalia (Fig. 37) with the caudal margin of tergite, *9t*, conspicuously trilobed, the median lobule smaller and with shorter, more dense setae than the laterals. Basistyle, *b*, with the only developed lobe (ventral) terminating in a small obtuse darkened lobule, the remainder of lobe with long coarse setae. A single well-developed dististyle, *d*, appearing as a simple elongate rod from a dilated base, the distal two-thirds gradually narrowed to a subacute point; basal enlargement provided with very abundant, long, erect setae that are longer than the diameter of style at point of insertion; apex of rod with a group of elongate setae. Phallosomic plate, *p*, with numerous setulae.

Holotype, ♂, Wau, New Guinea, altitude 3,400 feet, 18 December, 1933 (F. H. Taylor). Paratopotypes, 2 ♂, one of which is carded with the type.

This very distinct species of *Molophilus* is named in honour of the collector, Mr. Frank H. Taylor, who has done so much to make known the Dipterous fauna of eastern New Guinea. The species is readily distinguished from other generally similar black species by the peculiar structure of the male terminalia, notably of the dististyle.

MOLOPHILUS CONCUSSUS, n. sp. Fig. 38.

Belongs to the *gracilis* group, *ruficollis* subgroup; general coloration dark brown; antennae short, the basal segment of flagellum pale; halteres and legs black; wings strongly tinged with blackish; male terminalia with the tergite trilobed; two dististyles, the outer one very small; inner dististyle elongate, its distal fourth with scabrous points, at near two-thirds the length bearing a powerful glabrous spine.

♂.—Length, 3·5 mm.; wing, 4 mm. ♀.—Length, 4 mm.; wing, 4·5 mm.

In its general appearance, very similar to *Molophilus unistylus*, differing especially in the structure of the male hypopygium.

Antennae black, the basal segment of flagellum paler; verticils long and conspicuous. Coloration of mesonotum and pleura more brownish, without distinct grey pruinosity. Halteres dark throughout. Wings with a strong blackish tinge; veins darker; trichia black. Venation: R_2 lying shortly beyond the level of r-m; petiole of cell M_3 long, approximately three times m-cu; vein 2nd A ending just before level of posterior end of m-cu.

Abdomen, including terminalia, black. Male terminalia (Fig. 38) with the tergite, *9t*, trilobed medially, the central lobe a little lower. Two terminal dististyles, the outer, *od*, very small, scarcely one-fourth the length of the inner style, *id*; the latter elongate, its distal fourth with scabrous points; at near two-thirds the length bearing a powerful glabrous spine; at near one-third the length with a small conical point that bears several spinulae in its axil. Aedeagus, *a*, long and conspicuous. Phallosomic plate, *p*, more or less heart-shaped or suboval, the surface with microscopic setulae.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor). Allotopotype, ♀, carded with type.

Molophilus concussus, while very similar in its general appearance to *M. unistylus*, n. sp., is entirely different in the structure of the male terminalia. The possibility exists that the female carded with the type of *M. concussus* and referred to above as allotype of this species in reality pertains to *M. unistylus*.

MOLOPHILUS ATERRIMUS, n. sp. Fig. 39.

Belongs to the *gracilis* group, *ruficollis* subgroup; general coloration deep velvety-black, the pronotum and lateral pretergites china-white; knobs of halteres white; wings blackish, the prearcular field abruptly white; male terminalia with two simple dististyles of approximately equal shape and size.

♂.—Length about 3·2–3·5 mm.; wing, 4–4·5 mm. ♀.—Length about 4 mm.; wing, 5 mm.

Rostrum and palpi black. Antennae black throughout, of moderate length, if bent backward extending to a short distance beyond the wing-root; flagellar segments oval. Head black.

Pronotum and lateral pretergites pure china-white. Mesonotum entirely and uniformly deep velvety-black, the humeral region of praescutum more polished. Pleura, including propleura and pleurotergite, deep velvety-black. Halteres with basal half of stem blackened, the outer half pale, the knobs white. Legs entirely black. Wings with a strong blackish tinge, the prearcular field abruptly white; veins brown, very pale in the prearcular field; macrotrichia black. Costal fringe relatively long and conspicuous. Venation: R_2 lying opposite or just before level of r-m; petiole of cell M_3 about two and one-half times m-cu; vein 2nd A relatively short, ending distinctly before level of m-cu.

Abdomen, including terminalia, black. Male terminalia (Fig. 39) with apical lobe of basistyle, *b*, unarmed. Two dististyles of approximately similar length and shape, both slender and simple, the tips acute; outer style, *od*, before tip with two or three small tubercles or spines and several long erect setae; inner style, *id*, more curved on distal fourth, with long setae on outer margin before apex. Aedeagus, *a*, elongate. Phallosomic plate, *p*, oval, the surface with abundant setulae.

In the female, the amount of white on the pronotum and pretergites is more restricted, the knobs of halteres more yellowish-white, and the prearcular cells only insensibly brightened. Valves of ovipositor yellowish horn-colour.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor). Allotopotype, ♀. Paratopotype, ♂, carded with type; 1 separate ♂.

The deep black colour, white knobs of halteres, china-white pronotum and pretergites, pale wing-bases, and structure of the male terminalia, readily separate the present fly from the very numerous species of the genus now known from the Australasian region.

TASIOCERA PAPUANA, n. sp. Fig. 40.

General coloration pale brown; antennae pale, especially the apical pedicels; legs black; male terminalia with the dististyle apical in position, relatively stout and straight; phallosome complex, appearing as a depressed pale plate that terminates in a small median point; a pair of strong black spines near base of phallosome.

♂.—Length about 3 mm.; wing, 4 mm.

Rostrum and palpi brown. Antennae (♂) elongate, as normal for the sex in this genus, fully one-half longer than body; flagellar segments chiefly pale, especially the apical pedicels. Head pale brown.

Thorax, including pleura, almost uniformly pale-brown. Halteres dusky, the knobs blackened. Legs with the coxae and trochanters brownish testaceous; remainder of legs black, including all tarsi. Wings subhyaline, the veins only a trifle darker than the ground-colour; trichia brown; costal fringe long and conspicuous; anal fringe very long.

Abdomen pale brown. Male terminalia (Fig. 40) with the dististyle, *d*, terminal in position, relatively stout and straight, the extreme tip broken in type; before the apical point a small obtuse knob. Phallosome, *p*, very complex, as usual in the genus, appearing about as figured, consisting of a depressed pale plate, the apex of which is further produced into a small obtuse median point, around and cephalad of which are some powerful setae. A pair of powerful black spines, as illustrated, are distinctive of this species in comparison with the numerous Australian and New Zealand species now described.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor).

Among the rather numerous species of *Tasiocera* in eastern Australia, including Tasmania, that have the dististyle of the male terminalia apical in position (including *axillaris* Alexander, *bipennata* Alexander, *bucephala* Alexander, *caudifera* Alexander, *dicksoniae* Alexander, *dorrigensis* Alexander, *gracillicornis* Skuse, *nodulifera* Alexander, *otwayensis* Alexander and *taylori* Alexander), the present fly differs conspicuously in the structure of the terminalia, especially of the dististyle and phallosome.

TASIOCERA TARSALBA, n. sp. Fig. 41.

General coloration dark brown; wings with vein 2nd A apparently lacking, at most represented by a thickening of the axillary border far basad of the level of the arculus; male terminalia with a slender, finger-like lobe on caudal border of the apparent tergite; dististyle apical in position, relatively slender.

♂.—Length about 2·6 mm.; wing, 3·3 mm.

Rostrum and palpi brown. Antennae brownish-black throughout; in male, longer than body, as in the genus. Head brown.

Mesonotum dark brown, the pleura a little paler. Halteres black throughout. Legs with the coxae and trochanters testaceous-brown; femora and tibiae brownish-black, the tarsi snowy-white, only the bases a trifle infumed; ground-colour of tibiae chiefly pale but with dark vestiture. Wings with a uniform dusky tinge; veins dark brown; trichia black. Venation: R_{2+3+4} present as a short element; inner end of cell R_5 lying more basad than cell R_4; inner end of cell 1st M_2 strongly arcuated, with m-cu at the fork of M; vein 2nd A apparently lacking, evident only as a thickening of the axillary border that ends far before the level of the arculus.

Abdomen, including terminalia, black. Male terminalia (Fig. 41) with the caudal margin of the apparent tergite, *9t*, produced into a slender, finger-like median lobe that is covered with delicate setulae. Dististyle, *d*, apical, relatively slender, at apex more narrowed and gently decurved to the subacute tip.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor).

Tasiocera tarsalba is readily distinguished from all other described members of the genus by the snowy-white tarsi. The tail-like extension of the caudal border of the apparent tergite of the male terminalia is somewhat as in *T. caudifera* Alexander (New South Wales) yet quite different in its conformation and vestiture.

TOXORHINA (CERATOCHEILUS) FUMIPENNIS, n. sp. Figs. 31, 42.

Mesonotal praescutum brownish-yellow, darker medially; head light grey, with a conspicuous rectangular blackened area on vertex; legs black; wings with a strong brownish tinge; anterior branch of Rs moderately oblique, gently sinuous;

cell M_2 open; abdominal tergites brownish-black, the terminal sternites paler brown; male terminalia with a single dististyle that is produced into an acute spinous point on its outer margin before midlength.

♂.—Length, excluding rostrum, 3·5–4 mm.; wing, 5–5·6 mm.; rostrum, 3·3–3·7 mm.

Rostrum black. Antennae black throughout. Head light grey, with a very conspicuous, rectangular black mark extending from the occiput to the anterior vertex, touching the inner margins of eyes at the latter point.

Cervical region brownish-black. Mesonotal praescutum rich brownish-yellow to fulvous, more infuscated medially and behind but without distinct or evident stripes; scutal lobes dark brown, the median area paler; posterior sclerites of mesonotum brown. Dorsal pleurites and membrane infuscated, the ventral sclerites brownish-yellow. Halteres obscure yellow, the knobs darkened. Legs with the fore coxae darkened, remaining coxae and all trochanters yellow; remainder of legs black. Wings (Fig. 31) with a strong and almost uniform brown tinge; veins brownish-black. Costal fringe moderately long and dense; numerous macrotrichia on veins Rs, R_5, M_{1+2} and M_3; no trichia on anterior branch of Rs. Venation: Anterior branch of Rs moderately oblique, gently sinuous; cell M_2 open; m-cu at fork of M.

Abdominal tergites brownish-black, the sternites and terminalia somewhat paler brown. Male terminalia (Fig. 42) with a single dististyle, *d*, that is apical in position, the rostral portion produced into a spatulate blade, the heel portion produced into an acute blackened spine. Branches of the aedeagus, *a*, about equal in length to the interbasal plates, *i*.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor). Paratopotype, ♂.

The only close regional ally of the present fly is *Toxorhina* (*Ceratocheilus*) *biròi* Alexander (north-eastern New Guinea), which differs conspicuously in the coloration of the body and wings; the venation, especially the erect anterior branch of Rs; and the entirely distinct male terminalia.

TOXORHINA (TOXORHINA) TRILINEATA, n. sp.

General coloration grey, the praescutum with three conspicuous, dark brown stripes; scutellum dark brown, its posterior border more reddish-brown; legs brownish-black; wings greyish, the prearcular field light yellow; Sc short, Sc_1 ending some distance before origin of Rs; cell M_2 open; abdominal tergites uniformly dark brown, sternites obscure brownish-yellow.

♀.—Length, excluding rostrum, about 6 mm.; wing, 6 mm.; rostrum about 4·7 mm.

Rostrum unusually long, black. Antennae black throughout. Head dark grey, clearer grey on anterior vertex and posterior orbits.

Cervical sclerites and pronotum dark brown. Mesonotal praescutum grey, with three conspicuous dark-brown stripes that are entirely separate from one another; posterior interspaces slightly more infumed; scutal lobes dark brown, the median area paler; scutellum dark brown, its posterior border more reddish-brown; mediotergite clear grey. Pleura grey, the posterior sclerites somewhat more infumed. Halteres pale, the knobs weakly darkened. Legs with the fore coxae dark grey, the remaining coxae obscure yellow; trochanters brownish-yellow, darkened at tips; remainder of legs brownish-black. Wings almost uniformly tinged with greyish, the prearcular field light yellow; veins dark brown.

Venation: Sc short, Sc_1 ending some distance before origin of Rs, the distance on costa nearly equal to r-m; cell M_2 open; m-cu just beyond fork of M.

Abdominal tergites uniformly dark brown, the sternites obscure brownish-yellow, the subterminal segments more darkened. Ovipositor with genital shield darkened, the long slender cerci horn-coloured.

Holotype, ♀, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor).

Toxorhina (*Toxorhina*) *trilineata* is entirely different from the only other regional species, *T.* (*T.*) *suttoni*, n. sp.

TOXORHINA (TOXORHINA) SUTTONI, n. sp. Figs. 32, 43.

Mesonotum black, the humeral region of praescutum yellow, the lateral borders more velvety-black; pleura yellow; knobs of halteres infuscated; legs black; wings with a dusky tinge; Sc_1 ending a short distance beyond origin of Rs; abdominal tergites dark brown, sternites yellow, in the male with the subterminal two segments dark brown; male terminalia yellow, with two dististyles, the outer a slender, strongly sigmoid blade.

♂.—Length, excluding rostrum, about 4·2–4·5 mm.; wing, 5–5·6 mm.; rostrum, 3·3–3·5 mm. ♀.—Length, excluding rostrum, about 6 mm.; wing, 6 mm.; rostrum about 3·8 mm.

Rostrum black. Antennae black throughout. Head grey, more blackish or blackish-grey on the posterior vertex, the front and orbits light grey.

Cervical region and pronotum yellow. Mesonotum black, the humeral region of the praescutum yellow; lateral borders of praescutum and scutum more velvety-black; median region of scutum and the scutellum more brownish. Pleura entirely yellow. Halteres pale, the knobs infuscated. Legs with the coxae yellow, the fore coxae weakly infuscated on outer faces; trochanters yellow; remainder of legs black. Wings (Fig. 32) with a rather strong dusky tinge; veins black. Venation: Sc_1 ending a short distance beyond origin of Rs; cell M_2 open; m-cu at or shortly before fork of M.

Abdominal tergites dark brown; sternites yellow, the subterminal two segments in male dark brown; terminalia yellow. Male terminalia (Fig. 43) with two dististyles, the outer, *od*, a slender, strongly sigmoid, flattened blade, the tip acute. Inner dististyle, *id*, broader, at near midlength on outer margin with a small curved spine. Interbases appearing as pale blades, the apices obliquely truncated. Arms of aedeagus, *a*, relatively short.

Holotype, ♂, Edie Creek, New Guinea, altitude 6,550 feet, February, 1935 (F. H. Taylor). Allotopotype, ♀, carded with type. Paratopotype, ♂.

I take very great pleasure in naming this distinct species of *Toxorhina* in honour of Professor Harvey Sutton, to whom I express my indebtedness for many favours in the past. The species is very different from *T.* (*T.*) *trilineata*, n. sp., in all diagnostic features listed above.

STYRINGOMYIA SPINICAUDATA, n. sp. Fig. 44.

General coloration pale testaceous-brown, the mesonotum without distinct markings; flagellum pale yellow throughout; femora yellow, the fore and middle pair with two scarcely indicated dark rings, the posterior pair quite immaculate; wings with a strong uniformly yellow tinge, immaculate; male terminalia with the outer dististyle expanded, the surface with numerous long black spines.

♂.—Length about 5·5 mm.; wing, 4 mm.

Rostrum pale brown, palpi a little darker. Antennae with scape and pedicel dark brown; flagellum pale yellow throughout. Head pale testaceous-brown, setae unmodified.

Pronotum whitish. Mesonotum almost uniform pale testaceous-brown to yellowish-brown, without evident markings and with normal setae. Pleura testaceous yellow. Halteres pale, the knobs weakly dusky. Legs with the coxae and trochanters yellow; femora yellow, the fore and middle pair with very faint indications of darker rings, the posterior femora entirely immaculate; tibiae yellow, the tips and a narrow ring before midlength pale brown; tibiae yellow, the tips of the individual segments very insensibly darkened. Wings with a strong, uniformly yellow tinge, immaculate; veins slightly deeper yellow than the ground but pale and ill-delimited. Costal fringe very long and conspicuous. Venation: Anterior branch of Rs oblique; cell 2nd M_2 short-petiolate; m-cu more than its own length beyond fork of M; vein 2nd A simple.

Abdomen yellow; caudal borders of segments narrowly darkened; terminalia yellow. Male terminalia (Fig. 44) with apex of tenth tergite broadly obtuse, with abundant golden setae. Ninth sternite, *9s*, broad at apex, rather deeply emarginate, the outer lateral setae not especially modified. Basistyle, *b*, terminating in a single, relatively short spine from a swollen base. Dististyle complex, the outer arm expanded, its surface with more than thirty long black spines that extend distad almost to outer end of arm; more of these long slender spines grouped at extreme base of arm; inner arm, *id*, a broadly flattened plate, having an irregular outline, the surface, and especially the margin, with unusually long black spines, the outer peripheral ones very long, several of them strongly curved and bent.

Holotype, ♂, Wau, New Guinea, altitude 3,400 feet, 18 December, 1934 (F. H. Taylor).

Styringomyia spinicaudata belongs to the group of species with entirely immaculate wings, such species centring about *S. flava* Brunetti. From all these species, none of which had been reported previously from the Australasian Region, the present fly is distinguished by the immaculate posterior femora, and, especially, the structure of the male terminalia, notably of the dististyle.


T. W. Edgeworth David

TANNATT WILLIAM EDGEWORTH DAVID.
1858–1934.

(*Memorial Series, No. 6.*)

(With Portrait.)

An accomplished scholar, inspiring teacher, intrepid explorer, enthusiastic geologist, devoted patriot, generous in purse and person for a good cause, few men have displayed such versatile gifts in many-sided achievements as Tannatt William Edgeworth David; known to his own people as Edgeworth, to his wife as Twed, and to an applauding public as 'Professor'. Race, parentage, birth-place, teachers, all contributed to that notable combination of mental, moral and physical attributes that went to the making of him who was so widely known and acclaimed as the Knight Errant of Science.

His father was the Rev. William David, M.A., Fellow of Jesus College, Oxford, and Rector of St. Fagan's, near Cardiff, Glamorganshire. Sprung from a long line of David-ap-Davids, whose genealogies and traditions were subjects of his literary researches, he, with unusual parental devotion, used his scholarship in the early teaching of his three sons, of whom Edgeworth was the first-born. The influence of this fine start was shown in the lad's love of good poetry, as also in his success in the classics that accompanied his school and college career.

His mother was Margaret Harriet Thomson, daughter of a distinguished military officer in Quebec, whose ancestry included two notable branches—Ussher and Edgeworth. The former was famous for that Archbishop of Armagh, whose quaint 'Chronologia Sacra', published in 1686, was the accepted authority on Cosmic history in orthodox circles until recent times. The latter branch, of which David was, very naturally, proud, contained the distinguished names of Maria Edgeworth and the saintly Abbé Edgeworth, memorable for that last service and salute to his unfortunate King, Louis XVI.

The combination of Scotch, Irish and Welsh in his ancestry deserves notice.*

Tannatt Houston Thomson (Scotch) m. Margaret Ussher (Irish)
|
Margaret Harriet Thomson m. William David (Welsh)
|
Tannatt William Edgeworth David

St. Fagan's itself was interesting scenically and historically: scenically, for nowhere in Wales are the mountains far distant; historically, as the scene of a battle in Cromwellian days, amongst many other local traditions, in which the Celtic imagination of the youthful Edgeworth revelled. The neighbouring Brecon Hills were also the scene of his earliest field work in geology.

From his father's tuition he passed on to Magdalen College School, Oxford, of which he rose to be head boy, as well as captain of a successful football team

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* This is amongst the records that Lady David has generously allowed me to borrow from her own "Life of Sir Edgeworth David", now in the press.

and of the boats. From earliest days David was a natural student, with a mind avid of knowledge, ever open to the best and singularly closed to the grosser things of life, then, as throughout his career. The teaching here, as in most English schools of that day, was chiefly founded on Latin and Greek. Mathematics was tolerated, modern languages and science were trivial playgrounds to the majority, in which schoolboy ingenuity of evasion was given free scope. That Science came later as a coping stone to this literary structure was, in fact, no handicap to David, as also in the case of Darwin. For both men, the literary training resulted in the more effective interpretation of Science to the lay world, since the influence of such men lay greatly in the popular interest aroused, as well as in the matters technically discussed by scientific colleagues. To the teacher David, this special culture was of immeasurable advantage. The boy seems to have completely won the respect and affection of his school, as also, later, of his college, teachers. Here, for example, is a sentence from a letter from the Headmaster of Magdalen College School to his father: "There could scarcely have been a better specimen of English boyhood; this in character, manners and scholarship." He opened his Oxford career by winning the Senior Scholarship in Classics at New College, and was described to me by a fellow undergraduate as "an exceptionally fresh-complexioned, good-looking chap, known in the College as 'David the Psalmist' ". Whatever he did, he did with his whole soul. Thus, while working hard—too hard as it proved—he had taken con amore to the boats, showing his physical stamina, so often displayed in later days, by rowing 'bow' of his college eight, and also of a successful four, in which the well-known Sydney citizen Mr. Consett Stephen was 'cox'. The oar, then wielded so effectively, still adorns his Waitara home. He obtained a first class in Honour Mods., the essential test of classical scholarship at Oxford. But he had overrun his strength, and a rude interruption came to his University work when his doctor ordered complete rest. A short trip to America gave little respite and, with his father's help and advice, he took the long voyage, by sailing ship, to Melbourne. After his return he was only allowed to read for the ordinary degree, which he took in 1880. This later phase of University life, however, contained the significant factor—a course in Geology under Professor Sir Joseph Prestwich. Probably this course was suggested by what appears to have been the first spark lit in his geological enthusiasm by a relative, William Ussher, a geologist whose field work in the neighbourhood of St. Fagan's found an ardent coadjutor in his young cousin. Returning home from Oxford, and quick to take advantage of this new light, he set about the study of glacial action in South Wales. The result of this was the publication of his first scientific paper, "Evidences of Glacial Action in the Neighbourhood of Cardiff", by the Cardiff Naturalists' Society in 1881. For this and other scientific contributions, the Freedom of the City of Cardiff was conferred on him—a memorable honour to so young a man.

By this time David appears to have definitely decided on his profession, resisting considerable parental pressure to enter the church, not without incurring grave suspicions of spiritual or doctrinal deficiencies. A further temporary flirting with the idea of Medicine ended with the continuation of the study of Geology at the Royal School of Mines under Professor Judd and Professor Boyd-Dawkins of Owens College, Manchester. In 1882 he was selected by Sir Henry Parkes, then in England, for an appointment on the staff of the late C. S. Wilkinson, of the Geological Survey of New South Wales, and booked his passage by the Orient S.S. '*Potosi*'. By one of those freaks of destiny this voyage was momentous, since the lady who was to share, and greatly influence, a long life with him was a fellow passenger. Sir Henry Parkes had also selected Miss Caroline Mallett as head of the Hurlstone Training College for State teachers. Each of these unusual migrants had been advised of the other, but for some time failed to recognize the proverbial man of science and the stern preceptress in the guise of attractive youth. The romance, thus begun, developed into a very real and lasting happiness. Not only did Mrs. David—they were married in July, 1885—greatly help her husband by her firm, unvarying belief in his ability, but, as he became more and more absorbed in his work, regardless of his own material interests and comfort, it was she who protected hearth and home. One remembers her, too, as the social centre of science congresses, as at Hobart in 1892 and Dunedin in 1904, and then, as today, a leader of important movements. She also accompanied him on his early survey camps, encouraging his prentice hand and voice in lectures on his work—overcoming an extreme shyness and diffidence characteristic of his early days. Indeed, her influence was largely responsible for his finding the courage to accept the new Chair of Geology at the University of Sydney to which he was appointed in 1891. During the nine years of his Government work, David investigated the fossiliferous Silurian beds of Yass, and surveyed the rich tin-bearing leads of New England, on which he wrote an exhaustive memoir in 1887. But most important of all were his researches in the Hunter River coal-fields and his tracing of the famous Maitland–Cessnock coal-seams, which have added almost incalculable wealth to the State. He himself probably found far greater interest in the fauna and flora of the Permo-Carboniferous strata, while his first love of glacial phenomena found ample scope for investigation. Later, as Professor, he took a party of students during vacation to Maitland to test his theory of the approach of the Greta coal-seam to the surface. Arriving at the selected spot they were met by an obstinate farmer who objected to holes being made in his land. Only by diplomacy and a promise to restore the status quo was the experiment permitted. At 30 feet the Professor had foretold the evidence—and there it was. So various and voluminous were his activities in these coal-fields that long after he had ceased his connection with the Department his services were requisitioned. Here is an example that came directly under the present writer's notice. In 1904 David was President of the Dunedin meeting of the Australasian Association for the Advancement of Science. After a frantic rush of condensed work during the active week of this congress, his wife and friends had hoped that he could enjoy some rest in the social and scenic side of things that went with the second week of the meeting. Alas, a wire from E. F. Pittman came to remind him of certain unfinished reports on the coal-fields, and, with Spartan self-denial, he promptly left these premeditated joys to take the first boat back to Sydney to pass his vacation in monotonous work. His presidential address for this meeting—begun on the boat from Sydney—was only completed by an all-night sitting, preceding its delivery in our joint lodgings.

At the University David soon showed himself to be a galvanic force of inspiration to an important and growing school of geologists. Amongst his many gifts was great talent as a draughtsman and artist. This, combined with his glowing enthusiasm, first-hand knowledge and natural sympathy with youth, made him an extraordinarily forceful teacher, and the lucid and copious lessons of the lecture room were supplemented by courses of field work, conducted by himself and Mrs. David. Many an active student was worn with fatigue while the indefatigable professor set the pace, apparently little hampered by a weighty bag of specimens and geological hammer. This enthusiasm was passed on—it is the hall-mark of a great teacher—to a long procession of able geologists, who have filled important posts in Australia. Andrews, Benson, Browne, Cotton, Jensen, Mawson, Simpson, Sussmilch, Walkom, Ward, Woolnough provide an index of the standard of the school initiated by David.

In 1897 he led the second expedition to Funafuti, in the Ellice Islands, to test the Darwinian hypothesis of the structure of coral reefs. Raising private subscriptions—himself largely contributing—and obtaining from the Government the loan of a complete drilling plant, together with a staff of competent workmen, David, accompanied by his wife, a few volunteer students—including W. G. Woolnough—sailed for Funafuti, where the reef was bored to a depth of 643 feet. A further extension to 1,114 feet was carried out by A. E. Finckh. The core from this bore was investigated by a special committee in England and a vast tome records its report. This achievement was warmly acclaimed in the world of science and the F.R.S. was awarded to the leader of the expedition, besides the Bigsby Medal of the Geological Society of London. A delightful description of the island and its people is contained in another volume, 'Funafuti', by Mrs. David.

From 1897 to 1907 David was attracted to the evidence of glacial action on the Kosciusko plateau, largely through the observations of Richard Helms in 1889 and 1893, who exhibited an ice-scratched block to this Society. Two papers were published on this subject. The first, in March, 1901, in conjunction with R. Helms and E. F. Pittman, is entitled "Geological Notes on Kosciusko", the second, by himself, "Geological Notes on Kosciusko, with special reference to Evidences of Glacial Action". The latter was the outcome of a summer holiday camp, in which Judge Docker—a first-rate photographer—took part. Roused by the yarns of the guides of that period, as to the bottomless depth of the Blue Lake, David showed his ingenuity and revived some traditions of boyhood by devising a coracle for the taking of soundings. This coracle was made with wreaths of gum twigs, wire netting, and an outer skin of American cloth. The sounding line was a ball of string, measured off with coloured wool in foot lengths and weighted with a pound of shot. The actual depths across the lake were thus accurately taken. Many excellent stereoscopic photographs of this expedition were taken by Judge Docker.

In 1906 he was asked by the Chief Secretary of the State of New South Wales to represent the University of Sydney at the International Geological Congress to be held in Mexico. Leaving Sydney in May, David took the opportunity of visiting India to collect evidence of glacial action there, for a proposed paper to be read at the Congress. As usual, he was laden with geological specimens, which were given, or exchanged for others with various museums. Always the claims of Science were uppermost in his mind. One touch of humour from Mexico delighted us. President Diaz, wishing to do special honour to his distinguished visitors, sent a force of Rurales (mounted troopers) with mettled steeds, for a 12-mile excursion from Carrizal. Alas, few of the savants were capable horsemen. David himself, though laden with umbrella, camera, geological hammer and other impedimenta, survived this ordeal, but the landscape was strewn with unhorsed geologists. Some 500 miles of Mexico were traversed before this picturesque meeting was opened in state by the President himself, surrounded by ambassadors and consuls.

In 1908 the Shackleton Expedition to Antarctica sounded the trumpet of service. Chiefly through David's personal advocacy, the Commonwealth Government granted £5,000 to the Expedition, while he himself offered to make a long vacation voyage on the '*Nimrod*' for a brief glance at the South Land. Shackleton, however, recognizing the great value of his presence, induced him to stay on as a whole-time member. Here, at the mature age of 51, he accomplished two amazing feats: (1) planning, and himself leading, the first climb of the 13,000 feet of Mt. Erebus; standing, where never man had stood, on the edge of that vast crater, after five days of strenuous and dangerous effort by six men, all of whom were without special alpine experience; (2) with two younger companions, Mawson and Mackay, achieving the discovery of the South Magnetic Pole—a journey of 1,260 miles—man-hauling two sledges of, at first, half a ton weight each. Seven hundred and forty miles of this colossal tramp was relay work, since the three men could only drag one sledge. Much of this arduous feat was over the heavily crevassed Drygalski Glacier and hummocky ice, and included the climb from the coast line to a plateau of 7,350 feet altitude. All three men were variously recovered from crevasses, saved by their sledge harness from fatal injuries. Only by amazing good fortune, and the thoughtful devotion of Captain Evans of the '*Nimrod*', were the exhausted three found on their return to the coast in February, 1909. A party of his friends, assembled to welcome him on his return, at the house of J. H. Maiden in the Botanic Gardens, noted an astonishing sea change in his appearance. The hardship and starvation, followed immediately by plenty and rest, had converted our ascetic looking professor into a full-faced man with some rotundity of person—a passing phase of brief existence.

Much of his time during the next few years was devoted to the study of the Antarctic geological material, and in lecturing throughout the Commonwealth to raise funds for the publication of the scientific work of the expedition. Later came stalwart support of further Antarctic exploration, especially of Scott's last expedition, 1910–11, and of that Australasian expedition under Mawson—now Sir Douglas—1911–12, and of the second Shackleton expedition of 1914–15.

The visit of the British Association for the Advancement of Science to Australia in 1914 again called for strenuous exertions—a visit so tragically curtailed and shadowed by the clouds of war. The geological members of this were naturally his special interest. One of them, Councillor Penck, famous amongst German geographers, was his particular guest, and David actually incurred some unpleasant suspicions through his protective advocacy of this colleague. Later, one learned that a phrase from a speech by David at this time, "All men of Science are brothers", was used as the motto of the Deutsche Entomologische Institut, Berlin. But the war found no more ardent patriot than David. He took an active part in a volunteer rifle club. He was unanimously chosen as President of the Universal Service League of N.S.W., formed early in 1915, an office only resigned for active service at the age of 58. For in 1916 he became Major of the Australian Tunnellers, a battalion raised largely through his efforts from miners and mining engineers. The eminent work of these men culminated in the colossal upheaval of the Messines Ridge. But David had now been appointed Geologist of the Line, to advise on suitable sites for underground work. In order to procure accurate geological maps for his work he applied to his O.C. for a permit to visit a Paris colleague, to receive the official reproach, "No joy-rides allowed", a reply which greatly touched his sense of humour. Later he won the same high esteem in the Army that his services won everywhere. Besides the military honour of D.S.O. with the rank of Lieut.-Colonel conferred on him, here is an extract from a farewell letter to him from an officer at the Australian

Headquarters, France, on returning to Australia: "You have been a pattern to us in courage, courtesy and tact, and, may I add, in unremitting hard work." In search of geologic truth, David used to descend the numerous wells of the war area; and this nearly ended his life. A faulty windlass, or careless handling, led to a fall of 80 feet into shallow water, a fall broken, to some extent, by the metal bucket on which he was seated. To the astonishment of the young officer who descended to the rescue, he was found alive, though badly injured—except in his undaunted spirit; for he is said to have bidden the winders to "wind slowly, since his passage down had been too rapid for accurate observation". Returning in 1919, he set himself the stupendous task of writing a work on the Geology of a Continent. In order to concentrate on this, in 1924 he resigned his Chair and was made Professor Emeritus by the Senate of the University. Henceforth, when not actually working on the MSS., he spent himself and his resources in exhausting journeys; now a trans-continental car journey to Marble Bar, or repeated trips to South Australia, refusing to travel by air, as unfavourable for geological inspection. The latter were induced by the discovery of Pre-Cambrian fossils, that set the dawn of life far back beyond the realms of recorded knowledge. This discovery David himself declared to friends to be the most important geologic event of his life, though their organic origin has been received with doubt in some quarters.

In 1926 he again visited England, to consult authorities, interview publishers and, incidentally, to attend the meeting of the British Association at Oxford in August.

In 1933 he published his monumental Geologic Map of Australia, accompanied by a volume of 178 pages of explanatory matter, as a preliminary section of his greater uncompleted work. But the fires were burning low. Friends vainly expostulated with this energetic cripple who, with painfully injured hip, the sequel of the French well, hobbled or limped on his daily visit to the University. A fall from a tram on the last of these journeys brought on an attack of pneumonia and heart weakness to which his much-tried physique succumbed. He died in the Prince Alfred Hospital, 28th August, 1934. The enormous assemblage that attended the State funeral service at the Cathedral and the long procession to the Northern Suburbs Crematorium afford some indication of the place that David held in the hearts of our people.

Known to the world as a great geologist, he was even better known as a leader of scientific thought and movement and as a popular interpreter of Science to the layman. His versatile gifts made his requisition as a lecturer or speaker so valuable that he was in constant request, and it was always difficult for him to refuse. In 1902 he was selected by the State Government as one of the two Commissioners to travel in Europe and America to report on all branches of education; but when some discussion arose as to a third Commissioner, David withdrew in favour of G. H. (later Sir George) Knibbs, whom, with his usual modesty, he considered better fitted for the work. His achievements were recognized by the honours showered upon him. He was made C.M.G. in 1910 and K.B.E. in 1920. In 1908 he was awarded the Mueller Medal of the A.A.A.S.; in 1915 the Wollaston Medal of the Geological Society of London, the Conrad Malte-Brun Prize of the Geographical Society of France, and in 1919 the Clarke Memorial Medal of the Royal Society of N.S.W. The honorary degree of Doctor of Science was conferred on him by the Universities of Oxford, Wales, Manchester, Cambridge and Sydney. The University of St. Andrews made him Honorary Doctor of Laws.

Twice President of the Geological Section of the Australasian Association for the Advancement of Science (Hobart 1892, and Brisbane 1895), he was also twice President of this Association (Dunedin 1904, and Melbourne 1913). He was President of the Royal Society of New South Wales in 1896 and 1909, and a member of its Council for many years; President of our own Society 1893–1895, and a member of its Council until his death; and President of the Australian National Research Council 1921–22.

To his many friends, his achievements were but the flashes that illumined the background of a rare personality, in which courage, courtesy, unselfishness, modesty and humour were dominant. Of his courtesy there is the oft-told story of his delayed request to Mawson for help, when fallen into a crevasse—delayed since he was unwilling to disturb Mawson who was busy at photography.

His selflessness was phenomenal. Simple in his habits, he was the despair of his family in matters of food and dress: often going without food all day when any special work was on, and declining to waste time in visits to a tailor. His habit of seeing the other fellow's point of view came out in a story related only a few days ago by his old fellow colleger, Mr. Consett Stephen. Before accepting the Chair of Geology in 1891 he had some twinges of conscience as to the possible breach of faith with the Government, and asked his legal friend to examine the contract made between the Department and himself. After providing ample legal sanction and freedom of tie in his report, David came to him with an anxious face: "I think", he said, "you haven't been quite fair to the other side", and went on to argue their case, much to the amusement of the lawyer at this novel form of client.

He was always ready to give full credit to others, as, for example, in the Kosciusko observations of Richard Helms and in many speeches on work in which another had the smallest share.

Here are extracts from the letters of two of his University students: (1) "He was always so full of cheer and so full of charity, I always describe him as the most Christian man I have ever come in contact with. Often I look at his picture when I need courage to go forward, and then I think of his indomitable courage and find I can go on willingly."—(2) "Every right thought, every incentive for good has come to me from my loved professor. . . . Everything good or decent and honourable in myself has been brought out by his perfect example." These—and one could quote many of the like—are the records of a great teacher, whose principles became ingrained in his moral fibres in those early days when he learned from his prototype, "I will lift up mine eyes unto the hills whence cometh my help".

Amongst his mental endowments was a fine talent for drawing. Not only was this a great instrument for demonstration in blackboard work in lectures, but he could produce artistic sketches of scenes in real life, as he did in his home letters from the war. Curiously, this was not accompanied as usual—especially in the Welsh—by any musical sense, for he declared that he could only recognize two tunes, "God Save the King" and "March of the Men of Harlech". He loved poetry and good literature with all the love of a Celtic bard, and his memory was marvellous. Often would he quote not only phrases, but long passages from his old favourites, Tennyson and Browning. One evening he recited, from memory, the whole of 'Oenone', and I think the passage—

"Self reverence, self knowledge, self control,
These three alone lead life to sovereign power.
. . . . . .
Acting the law we live by without fear;
And, because right is right, to follow right
Were wisdom in the scorn of consequence"

was the very warp and woof of his life.

In late years his greatest relaxation was to lie on the floor and read Dickens to his grandchildren. A re-reading of Nicholas Nickleby was unfinished at his death.

We mourn his loss, but his life was joyous because so largely devoted to things in which he was intensely interested. In this Society we knew him as a genuine disciple of the great Linnaeus, in that Nature was to him the devised plan of the Great Architect, in whose cosmic cathedrals he loved to worship in the sense that those monks used the phrase "laborare est orare", and who did actually see "sermons in stones; books in the running brooks". After his Antarctic experiences he would quote Newman's "Lead, Kindly Light" as the refrain that had helped to bring him through. He was a practical idealist, carrying out the great things he planned, whether it was as a skilled craftsman repairing the boring plant at Funafuti or in thinking out workable schemes for the conquest of Erebus.

He was often wearied, dropping asleep when toiling on in the small hours, but he was never bored; and he died as he had lived, in harness, carrying on in the spirit of Ulysses—

"How dull it is to pause, to make an end,
To rust unburnish'd, not to shine in use!
As tho' to breathe were life. Life piled on life
Were all too little, and of one to me
Little remains: but every hour is saved
From that Eternal Silence, something more,
A bringer of new things; and vile it were
For some three suns to store and hoard myself,
And this gray spirit yearning in desire
To follow knowledge, like a sinking star,
Beyond the utmost bound of human thought."

H.J.C.

As a teacher David had few equals. In the early days of his occupancy of the Chair of Geology it fell to his lot to lecture on many branches of the science, and even till his retirement he insisted on giving the lectures to the first year class. No doubt there was much wisdom in this practice, since it is often in his first year that a student's orientation to his studies is definitely determined. And David's method of presentation of his subject was calculated to arrest the attention and arouse the interest of the least enthusiastic. He was a firm believer in the appeal to the eye as well as to the ear, and the spoken word was reinforced by specimens, by lantern slides and, above all, by those inimitable and artistic geological sections which used to grow as if by magic beneath his hand on the capacious blackboards, to the accompaniment of a running comment of explanation. A carefully-prepared synopsis of the lecture was invariably given out, but not infrequently it was in large measure ignored.

Apart from the actual gain in knowledge, students at these lectures inevitably got the impression of geology as a living and a growing science of absorbing interest, in which great things were doing and to be done, and in whose advancement each one of them might hope one day to play a part.

Further, no trouble was too great to be taken for a student who diffidently sought help in difficulty. From the least to the greatest all were sure of the same patient hearing, the same gracious courtesy, and the same careful elucidation of the knotty point.

Privileged indeed were those who accompanied him on a field-excursion, for on such occasions he was at his best. Many an old student cherishes pleasant memories of the exploits and adventures incidental to a geology camp at Gerringong, or Pokolbin, or Kosciusko, or some other place, where good geology was seasoned with the good fellowship that emanated from the leader of the party.

Little wonder that under the spell of David's personality many of his students took up geology as a life-work and have made their mark in Australia or abroad.

In the field of geological research David's interests were manifold, and he belonged to a scientific type which in these days of specialization is almost extinct. Indeed, it has been suggested that the spreading of his activities set limits to the greatness of his scientific achievements, but there can be little doubt that the wide range of his knowledge contributed materially to the breadth of his vision and to his grasp of the essentials of geological problems.

As an economic geologist his chief claim to distinction rests upon his tracing of the Greta coal-measures and the consequent economic development of the very important South Maitland coalfield; but his record also includes the investigation of the Vegetable Creek tinfield and—chiefly in conjunction with the late Mr. E. F. Pittman—a study of the problems of the Great Australian Artesian Basin.

He was early attracted to problems of structural and tectonic geology, and in many of his publications, with the aid of maps and sections, he has demonstrated graphically and in striking fashion the outstanding structural features of the State and the continent. An able summary of the chief tectonic lines of Australia is contained in his Presidential Address to the Royal Society of New South Wales, delivered in 1911.

In stratigraphical geology his greatest—as it was almost his earliest—interest was in the Permo-Carboniferous System, which had been the subject of his chief investigation when he was a member of the Geological Survey. Later, after the discovery of glacial beds at Seaham, he became a keen and active student of the problems of Carboniferous stratigraphy. Nor were his stratigraphical interests confined to this State. It was at his suggestion that the great sequence of strata overlying the pre-Cambrian schists in South Australia was detached from the Cambrian System and established as a separate Proterozoic Series. Indeed, there are few of the geological systems as developed in Australia to the knowledge of which he did not make important contributions.

The interest in glaciation which he first displayed in his native Wales remained with him throughout his life. The list of his papers on subjects connected with Australian glaciology is a long one; many of his contributions appear in the Reports of the Glacial Committee of Section C of the Australasian Association for the Advancement of Science. Of this committee he was Secretary from its inception in 1892 till the time of his death, and no inconsiderable portion of its reports really represents the results of work carried out by himself alone or in conjunction with his friend and colleague, Professor W. Howchin. His investigations included the South Australian Proterozoic tillites as well as the Permian tillites, etc., of South and Western Australia and New South Wales, and the Pleistocene deposits of Tasmania and Kosciusko.

A very fruitful line of research was opened up as a result of his discovery in 1914, while leading a British Association excursion, of glacial tillite at Seaham, near Maitland. Researches originating from this discovery have proved the existence of a great ice-age in Carboniferous time in Australia, the traces of which in New South Wales are now known to extend from the Hunter Valley for at least 120 miles northwards.

Outside Australia he made important contributions to our knowledge of the glacial geology of Antarctica, as well as of its physiography and general geology.

His services on the Western Front in the Great War are too well known to need recapitulation. A great variety of problems had to be solved, such as the finding of material for roads and concrete-making, the provision of water supplies, and, above all, the selecting of sites for trenches, dugouts and mine-tunnels. These last called for very close and detailed study of the dry and water-bearing strata, and of the seasonal fluctuations of the water-table, as well as of structural features such as folds and faults. The success of his labours, in the face of many difficulties, is a tribute no less to his tireless energy and indomitable will-power than to his geological ability.

In his geological research, as in all the other activities of his busy life, David combined with a passion for meticulous detail a broad and philosophic outlook. These characteristics, which would have gone far to bring him to eminence in any walk of life, were no doubt inherent in the man, but they had been nourished and strengthened by his early training, and it is no exaggeration to say that he was all the greater geologist because he was a classical scholar and had steeped himself in the literature and imbibed the thought-habits of the best thinkers and the best writers of ancient and modern times.

In spite of the immense amount of actual geological investigation he accomplished it is probable that his best contribution to Australian geology came through the exercise of his faculty for taking the long view, and for correlating and linking up geological formations far apart geographically. This faculty is particularly necessary in Australia, where most of the geological work has been carried on, more or less inevitably, within the water-tight compartments of State boundaries. Not once nor twice has the remark been made that comparison of State geological maps shows the curious feature of geological strata abruptly truncated by inter-State border-lines. It was David's happy privilege to do much to break down these unnatural barriers to geological progress, and his New Geological Map of the Commonwealth, published in 1932, embodies the first attempt on a large scale to represent the geological formations of the whole of Australia by a uniform set of symbols.

Here is the testimony of Sir Thomas Holland, given before the Geological Society of London in February, 1934: "Australia, alone among the Dominions, has no Commonwealth Geological Survey. Providence has, however, lent it temporarily the services of Sir Edgeworth David, who is possibly the only man living who could have correlated the scattered State Records to produce a Geological Map of the whole Commonwealth like that which he published two years ago."

The bringing of the details of Australian geological history into correlation with those of other parts of the world also engaged much of his attention, and it was largely this outstanding characteristic of his work that commended it to the attention of overseas geologists. It is true that on occasion his enthusiasm—one might almost say his passion—for correlation led him into mistakes, an almost inevitable happening, but no one was ever more ready than he to acknowledge and forsake error.

A word must be said about an investigation which in later years called forth all his characteristic unwearying and persistent enthusiasm. For many years he had envisaged the possibility that the rocks of the pre-Cambrian Adelaide Series of South Australia might yield fossil evidences of contemporary life, but it was not till 1928 that his quest was rewarded by the discovery of what he regarded with confidence as casts of animal fossils. A preliminary paper on some of these appeared in the *Transactions of the Royal Society of South Australia* for 1928; with the aid of grants from the Royal Society of London, much excavation was done and many more specimens were obtained. A monograph on some of these forms was written by David in conjunction with Dr. R. J. Tillyard, and has recently appeared in print.

The task that absorbed most of the energy of his later years, however, was that of writing a book on the Geology of the Commonwealth. Originally projected as far back as 1914, and even earlier, the work was interrupted by the Great War and was resumed as circumstances permitted after David's return to Australia. Eventually the plan for a one-volume book, which was well on towards completion, was abandoned in favour of a more detailed work of three volumes. Many years were devoted to the patient accumulation and examination of material for what would unquestionably have been a monumental work, but unfortunately it was never finished. It is pleasing to know, however, that, through the action of the New South Wales Government in acquiring the manuscript and making arrangements for its completion and publication, the fruits of a long life's labours are not to be lost.

Of David it might be said, as it was of Goldsmith, *Nihil tetigit quod non ornavit.* For certainly there is no branch of geological science to which he turned his attention that is not the richer for his researches. In no small degree will our knowledge of Australian geology be built on the foundations he has so well and faithfully laid, and his work and his example will long remain to kindle the enthusiasm and inspire the efforts of future workers.

W.R.B.

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GENERA AND SUBGENERA DESCRIBED AS NEW IN THIS VOLUME (1936).

LIST OF PLATES.

PROCEEDINGS, 1936.

INDEX.

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(a) GENERAL INDEX.

(b) BIOLOGICAL INDEX.

New names are printed in SMALL CAPITALS.

(Issued 15th May, 1936.)

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PROCEEDINGS, 1936, PARTS 1-2.

CONTENTS.

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Vol. LXI.
Parts 3-4.

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Parts 5-6.

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