THE

PROCEEDINGS

OF THE

LINNEAN SOCIETY

OF

NEW SOUTH WALES

FOR THE YEAR

1932

VOL. LVII.

WITH NINE PLATES
and 227 Text-figures.

SYDNEY:
PRINTED AND PUBLISHED FOR THE SOCIETY BY
AUSTRALASIAN MEDICAL PUBLISHING CO., LTD.,
Seamer Street, Glebe, Sydney,
and
SOLD BY THE SOCIETY.
1932.

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CONTENTS OF PROCEEDINGS, 1932.

PARTS I–II (Nos. 239–240).

(Issued 15th May, 1932.)

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(Issued 15th December, 1932.)

ANNUAL GENERAL MEETING.

WEDNESDAY, 30th MARCH, 1932.

The Fifty-seventh Annual General Meeting was held in the Society's Rooms at Science House, Gloucester Street, Sydney, on Wednesday, 30th March, 1932.

Professor T. G. B. Osborn, D.Sc., President, in the chair.

The minutes of the preceding Annual General Meeting (25th March, 1931) were read and confirmed.

PRESIDENTIAL ADDRESS.

Ladies and Gentlemen,

Another year has passed and it falls to my lot to deliver, as retiring President, the address on the occasion of our Fifty-seventh Annual Meeting. The year has been a comparatively uneventful one for our Society, except that, in common with all other organizations in the State and Commonwealth, we are feeling in our corporate life the same type of financial anxiety that faces the individual citizens. Application and work, we are told, will help to right the ills that beset us, and as a Society we may justly feel we have done our bit. The year has been one of successful work which we hope that the papers published in our PROCEEDINGS will show to be of value. There have been no sensational happenings, but we hope for steady consolidation of the advantages derived from our position in the new quarters in which we first met a year ago.

The official opening of Science House was performed by His Excellency the Governor on 7th May, 1931, and advantage was taken of the occasion by the owners and tenants to hold an exhibition of their work, the building being open for public inspection for a period of three days. Another successful exhibition has just been held in association with the opening of the Sydney Harbour Bridge with the object of drawing attention to the scientific and technical aspects of bridge-building.

The proposal brought forward at the beginning of last year by the Australian Chemical Institute for the provision of lounge room accommodation in Science House for members of the various scientific societies was abandoned for the time being. The Committee which was considering the whole matter came to the conclusion that, although it approved of the proposal, it would not be possible to finance it at the present time.

The Society's library is now in better condition than it has been for many years. The classification of the periodicals and books is complete and they are easily accessible. Having spent approximately £100 a year on bookbinding over the last eight or ten years, we are in the happy position of having most of the periodicals bound, though it may be some time before finances will allow us to resume expenditure in this direction.

Your Honorary Treasurer will tell you later that the past year has been one of the worst experienced by the Society from a financial point of view, and that the coming one promises to be worse. It is unfortunate that Science House has been unable to attract new tenants, although we may consider ourselves fortunate that all the present tenants were secured before the House was built. After remaining vacant for about eight months the Society's former premises at 16 College Street were let at what is only a nominal rental, it being considered better to have the premises occupied than to allow them to remain vacant any longer. It will be necessary to exercise the strictest supervision over expenditure during the year and various measures of economy have already been adopted. Chief amongst these is the projected issue of the PROCEEDINGS in three Parts instead of six, Parts 1 and 2 being issued under one cover, and similarly with Parts 3 and 4, and 5 and 6. In view of the cost of printing, authors are asked to condense their papers into the smallest possible space, and particularly to limit the number of illustrations for which they ask.

Evidence of an increasing public appreciation of the value of our native flora and fauna is seen in the support given during the year to the tree-planting ceremony at Ball's Head Reserve, the efforts to retain the Pymble Forest as a reserve, the movement which has resulted in the dedication of an area of some 34,600 acres, including Point Lookout and the headwaters of the Bellingen, Nambucca and Macleay Rivers as a recreation reserve, and the protests made to the Chief Secretary against the declaration of an open season for opossums, kangaroos and wallabies. The continued efforts made to have the proclamation protecting certain wild flowers extended from year to year were once more successful, and it is gratifying to note that the results of this protection amply repay these efforts.

During the year the Council discussed the question of the admission of Associates to permit of the entrance to the Society of persons under the age of twenty-five years at a reduced subscription. The members of the Society endorsed the principle put forward by the Council in the adoption of a new rule granting power to the Council to admit such Associates under certain conditions.

The second Fletcher Memorial Lecture was delivered during November by Professor W. E. Agar of the University of Melbourne. Professor Agar took as his subject "The Animal Mind and its Significance for Biology", and the lecture was thoroughly appreciated by a large audience.

The question of the imposition of Sales Tax and Primage Duty on books and periodicals entering Australia is one which has caused widespread concern amongst all interested in science. Protests in various States culminated in a strong deputation to the Prime Minister in February, but it is regretted that the deputation was unsuccessful. The Prime Minister did indicate, however, that something might be done towards allowing the admission of publications received as exchanges without these duties. This concession, though much less than might have been expected, would ensure the maintenance of those scientific libraries which are built up almost entirely by exchange of publications and which are invaluable to scientific workers in Australia.

The concluding part of Volume lvi of the Society's PROCEEDINGS was issued in February. The complete volume (534 plus lxxii pages, thirty-four plates, one coloured plate and 268 text-figures) contains thirty-two papers from twenty-two authors, five papers being from Linnean Macleay Fellows and three from the Macleay Bacteriologist.

The second coloured plate of Australian Wildflowers (*Telopea speciosissima*) was issued with Part i of the PROCEEDINGS for 1931. The sale of the postcards of this series has been very satisfactory and, if funds permit, it may be possible to issue the third of the series during the coming year.

Exchanges received from scientific societies and institutions total 1914 for the year, compared with 1821, 2084 and 1866 for previous years. The following institutions have been added to the exchange list: Bureau of Entomology of Chekiang Province, China; Botanical Institute, Sun Yatsen University; East Siberian Branch of the Geological and Prospecting Survey, Irkutsk; Hiroshima University, Japan; University of Western Australia; and the Faculty of Science, Hokkaido University, Sapporo, Japan. The Royal Australasian Ornithologists' Union has discontinued exchange relations, and our exchange list now stands at 228.

The vacancy on the Council caused by the resignation of Mr. G. M. Goldfinch was filled by the appointment of Mr. T. C. Roughley.

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

Augustus Albert Lawson died at his residence, Charlotte Street, Ashfield, on 2nd September, 1931, at the age of 80. He had been a member of the Society since 1923, and was a regular attendant at meetings except during the last few years, when his health would not permit him to attend during the winter months. In his business capacity he had been connected with the Society since about 1898, when he first made process blocks to be used in illustrating the PROCEEDINGS, and the firm of A. A. Lawson Ltd., still prepares such blocks for our illustrations. Mr. Lawson was keenly interested in new processes for the production of illustrations in colour; throughout his career he conducted much research into the improvement of methods of photo-engraving.

Arthur Mills Lea, who died at Adelaide on 29th February, 1932, at the age of 63, was born in Sydney and had been a member of the Society since 1892. In 1891 he was appointed Assistant Entomologist in the Department of Agriculture, New South Wales, the Government Entomologist at the time being the late A. S. Olliff. In 1895 he was appointed Government Entomologist of Western Australia, and in 1899 he accepted a similar position in Tasmania. In 1911 he became Entomologist to the South Australian Museum, a position which he held till the time of his death. During his twenty-one years at the South Australian Museum he succeeded in transforming the entomological collection from a comparatively small one to a collection comprising more than a million specimens, and one which will for long stand as a monument to his enthusiasm and untiring efforts. He made many collecting trips to other States, as well as to many parts of South Australia and in 1924 he visited Queensland, Java, Malaya, Borneo and Fiji, studying methods of control for the Coconut Moth. He devoted himself particularly to the study and collection of Australian Coleoptera and the greater part of his scientific writings is concerned with this group, in which he described approximately six thousand species as new. He contributed 44 papers to our PROCEEDINGS during the years 1893–1931 and not a year passed during that period without at least one paper from him being read before the Society. This represents only a portion of his published research, for many of his papers appeared in the publications of scientific societies throughout Australia. His interests were not wholly confined to his entomological work, for he took an active part in the work of the Royal Society of South Australia, of which he was for many years a member of Council and also for seven years Assistant Editor.

Alfred Eland Shaw was born at Carlow, Ireland, in 1861 and died at Sydney on 16th June, 1931. He graduated in medicine (M.R.C.S., L.R.C.P.) at St. Mary's Hospital, London, in 1892, having previously worked for some years at the British Museum. In 1910 he arrived in Australia and went into practice at Healesville, Victoria, later going to New Guinea and then to Wynnum, Queensland. Ill-health caused him to give up his practice, and he was for a time engaged in medical work at the Mental Hospital at Goodna, Queensland. Later he came to Sydney and obtained various posts as ship's surgeon, hoping that the sea voyages would result in improvement in his health. Amongst the vessels on which he served were the trans-Pacific liners "Aorangi" and "Niagara". In between times he was also engaged in relief work at the Sanitarium at Waterfall, and the Mental Hospitals at Callan Park and Rydalmere. He was an entomologist by hobby, his chief interest being the Orthoptera, and particularly the Blattidae. He published papers in the *Entomologists' Monthly Magazine*, before coming to Australia, and later in the *Victorian Naturalist*, the *Memoirs of the Queensland Museum*, and the *Queensland Naturalist*. In our own PROCEEDINGS he published two papers on Blattidae (1922, 1925). He had been a member of this Society since 1922, and a Fellow of the Entomological Society of London since 1883. His collection of Blattidae, he presented to the Queensland Museum, Brisbane.

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 definition and subdivision of the genus *Actinomyces*. A basis having been obtained for the study and classification of these organisms, attention was directed to their importance in the soil under various conditions; studies were commenced of various groups of microorganisms under different soil conditions of moisture and temperature, one of the objects being to solve the still obscure question of the decomposition of lignin. Observations have been made on about thirty strains of soil mycobacteria and corynebacteria, the latter group appearing to occur abundantly in the soils. Results of the Bacteriologist's work have appeared in the PROCEEDINGS for 1931 in three papers:—"Contributions to Our Knowledge of the Actinomycetales. i. A Case of Hereditary Variation in the Genus *Actinomyces*"; and "ii. The Definition and Subdivision of the Genus *Actinomyces*, with a Preliminary Account of Australian Soil Actinomycetes"; and "A Note on the Systematic Position of *Mycobacterium coeliacum*". He has also completed No. iii of the Actinomycetales series, giving further observations on the genus *Micromonospora*.

Miss Ida A. Brown, Linnean Macleay Fellow of the Society in Geology, continued her work on the Geology of the South Coast of New South Wales. She paid special attention to the Devonian formations of the far South Coast, and her paper on "The Stratigraphical and Structural Geology of the Devonian Rocks of the South Coast of New South Wales" which appeared in the PROCEEDINGS for 1931 is an important contribution towards our knowledge of Devonian stratigraphy in Australia. Her classification of these rocks into three stages may, as she has shown, well be extended to cover the other known Devonian occurrences of south-eastern Australia. In coming to her conclusions she has made extensive study of the field occurrences, as well as of the conditions of sedimentation and the tectonic history of the series. She also has investigated the evidence of important diastrophic movements between Middle and Upper Devonian in south-eastern Australia. Miss Brown has summarized the whole of her work in the form of a thesis which has been accepted by the University of Sydney for the degree of Doctor of Science. In this she dealt with the history of Devonian sedimentation as far as she has studied it and described the distribution and petrological characters of the igneous rocks. We congratulate her on the attainment of her doctorate, one of the aims of every Research Fellow. During the coming year she hopes to complete her investigations of the main problems of the geology of the South Coast, concerning the geological age, conditions of sedimentation, mutual relationships and subsequent tectonic history of the sedimentary rocks, and the relationships, petrogenesis and correlation of the associated igneous rocks.

Mr. F. A. Craft, Linnean Macleay Fellow of the Society in Geography, carried out field work in the Nerriga district, being particularly concerned with the fall of the streams from the coastal ranges to the tableland and thence into the gorges. This area gives the key to the stream system and pattern of the Shoalhaven Valley and an accurate record of erosion dating from before the late Tertiary basalts. Further field work covered the Upper Shoalhaven, and the series of papers dealing with the Shoalhaven is now complete. The final paper gives a review of the Shoalhaven and adjacent areas, together with comments on the development of peneplains under the conditions which have been disclosed in the areas examined. Four papers were published in the PROCEEDINGS for 1931, and two others are completed ready for publication. The published papers comprise Numbers i to iv of the Physiography of the Shoalhaven River Valley: i. Tallong-Bungonia; ii. Nerrimunga Creek; iii. Bulee Ridge; and iv. Nerriga. During the coming year Mr. Craft proposes to examine in general the coastal drainage of New South Wales, commencing with a critical review of the physiographic work that has been published, then considering the relationship of the various highland masses and their coastal slopes, and finally proceeding to a classification of all the coastal streams and the history of their development.

Eight applications for Linnean Macleay Fellowships, 1932–33, were received in response to the Council's invitation of 25th September, 1931. I have pleasure in reminding you that the Council reappointed Miss Ida A. Brown and Mr. F. A. Craft to Linnean Macleay Fellowships in Geology and Geography respectively, and appointed Miss Lilian Fraser, B.Sc., and Dr. H. Claire Weekes to Linnean Macleay Fellowships in Botany and Zoology respectively for one year from 1st March, 1932. We all wish them a successful year's research.

Miss Lilian Fraser graduated in Science at the University of Sydney in May, 1930, with First Class Honours in Botany. Since graduation she has paid special attention to Mycology and Plant Pathology. She held the post of Demonstrator in Botany for one year, but resigned this to accept a Science Research Scholarship in order that she might be able to devote the whole of her time to research. During her tenure of this Scholarship she completed two pieces of work which were published in the PROCEEDINGS for 1931, viz.: "The Reaction of *Viminaria denudata* to Increased Water Content of the Soil", and "An Investigation of *Lobelia gibbosa* and *Lobelia dentata*. i. Mycorrhiza, Latex System and General Biology". She has carried out some preliminary experiments on the growth of fungi which form the epiphytic flora of leaves attacked by scale insects, and she proposes to extend this work by examining the effects of environmental conditions on the growth and reproduction of these fungi. In addition, she proposes to extend the work she has done on *Lobelia dentata* by attempting to germinate seeds under controlled conditions in order to ascertain whether this plant is wholly dependent on fungal infection for satisfactory germination, and also to investigate the nature of the relationship between *L. dentata* and the fungus associated with its roots.

Dr. H. Claire Weekes is already well known to you. She held a Fellowship for about two and a half years, and then took advantage of an opportunity to proceed to England, where she has been working for two years under Professor Elliott Smith and Professor J. P. Hill. She now proposes to extend her investigations to the study of the reproductive cycle of reptiles along new lines that have been suggested during her work abroad. She will investigate, by experiments and analysis, the causes of such phases in reproduction as parturition and the retention of the embryos within the uterus. The approach to these subjects through the medium of the Reptilia, where all the transitional stages in the adaptation to viviparity occur, is one with many possibilities and we may look forward to some very interesting and important results.

My last duty before proceeding with the scientific portion of my address is a pleasant one. It is to thank my colleagues on the Council for their assistance in the past year. Particular thanks are due to the Secretary, Dr. A. B. Walkom, and the Hon. Treasurer, Dr. G. A. Waterhouse, for the care that they have given to the management of the affairs of the Society.

The Plant in relation to Water.

In addressing you to-night I propose to make a brief summary of our present knowledge of the xerophyte, and to apply that knowledge to the plants of the local flora in an attempt to decide whether we are justified in considering these xerophytic.

The vegetation of arid regions has for many years past been of considerable economic importance. As the more fertile regions of the earth become settled, man has been compelled more and more to seek those areas that lie beyond the assumed limits of cultivation, with the intention, if not to make "the desert blossom as the rose", at least to wrest a living from soils that were too inhospitable for his forbears.

The attempted settlement of such areas has led to an increasingly active study of the problems connected with the life of plants growing within them. The results of such studies have had their influence on pure Botany as well as on the problems that were their immediate object. In some of the broad generalizations of philosophic Botany we are apt to forget that the subject, even in its modern sense, grew up in Western Europe and Eastern United States of America, and that the pioneer workers in the modern field inevitably had their ideas coloured by their experiences of the vegetation around them. It was familiar to them to see the broad green leaf, the deciduous tree, and, because familiar, it was regarded as normal that vegetation should have these characteristics. The mesophyte represented to them the usual vegetation, anything differing from it in structure must in some way or other be abnormal.

Mr. Rodway, the veteran Tasmanian botanist, referred to this in the introduction to his article on the Tasmanian Flora in the Handbook written for the British Association visit of 1914. He pointed out that the Tasmanian climate is distinctly temperate. Between the moderate heat of summer and the winter frost there is a relatively lengthy spring and autumn. The rainfall is evenly distributed throughout the year. And yet, though the cryptogams and smaller flowering plants do not differ markedly from those of other temperate regions, the larger plants are decidedly xerophytic. "Yet with these xerophytes, not in their shade but boldly exposed to insolation, there are shrubs with broad leaves of thin succulent texture, as e.g., *Senecio velleyoides* and *Solanum aviculare*, which are as strongly mesophytic as the most ardent ecologist could desire." He points out, further, that for upwards of a century northern mesophytic species have thriven in cultivation and concludes that there appears up to the present no climatic reason why the predominant Tasmanian flora is xerophytic.

Rodway, of course, was using the terms xerophyte and xerophytic in their older sense. Used in the same sense, much of the native flora in the Sydney district shows xerophytic features. Yet the coast of New South Wales is not a "dry belt". What meaning, then, are we to attach to the terms xerophyte and xerophytic?

The term xerophyte appears to have been first used by Schouw in 1822, to describe plants, usually of characteristic appearance, which are inhabitants of dry places (Delf, 1915). At that time little was known of the climatology of arid and desert regions. It was generally agreed that they were hot and dry, but whether constantly so had not been ascertained.

In 1898 Schimper published his great work, "Plant Geography upon a Physiological Basis", made available in English through the Oxford University Press in 1903. First among the factors influencing vegetation, Schimper placed water. He notes that the structure of many plants favours the exit of the water which has been absorbed, that of some impedes it. These latter are "xerophytes", plants furnished with "devices for assisting absorption and limiting transpiration". But Schimper realized that the term xerophyte could not be limited to plants of dry localities alone. To him we owe the concept of physical and physiological dryness, a concept which has been of importance in modern work on xeromorphy (Yapp, 1912).

At that time relatively little was known of either the climate or the vegetation (as distinguished from the flora) of Australia. The great extent and diversity of the country was only appreciated by a few, except those who had direct dealings with the far-off island in the South Pacific, until quite recent times. Even today, the average city-dwelling Australian is far more impressed by the heat and the drought of the interior than he is by the cold and the floods.

When, following the classic work of de Bary, plant anatomy began to be a study, the structural peculiarities of Australian plants became known. The thick cuticle, the sunken stomata, the abundance of sclerenchyma tissue were all held to show in these plants from Australia, as from elsewhere, devices for restricting transpiration.

To Schimper, therefore, the flora of "dry temperate Australia" was xerophytic. On page 6 of his great work he figures, after Tschirch, two stomata of presumably typical plants from that region. In the light of modern work it is interesting to note the species, which we recognize as growing half a continent apart. One is *Franklandia fucifolia*, which Robert Brown (1866) described as occurring "on moist heaths near the shores of King George's Sound". The other is *Eucalyptus gigantea*, which, according to Patton, is a true subalpine species ranging from 3,000–4,500 ft., and living in Victoria wherever rainfall and elevation permit; Maiden (Critical Revision of the Genus Eucalyptus) states that it is a tree of cold localities, having only been found at high elevations in Tasmania, Victoria and Southern New South Wales. In the "Flora Australiensis" *E. gigantea* is united with *E. obliqua*, but even if Tschirch cut leaves of the latter, he was far from dealing with a species of even semi-arid distribution (Adamson and Osborn, 1924). Similarly with the other so-called Australian xerophytes figured in the textbooks of plant anatomy. *Kingia australis* and *Hakea suaveolens* range from King George's Sound to Swan River, i.e., in the wetter parts of Western Australia. Even Maximov (1927), in his book "Plants in Relation to Water", to which I shall make frequent reference, when he wants to show a leaf which really has stomates calculated to check water loss, selects Tschirch's figure of the stoma of *Xanthorrhoea hastilis*, a species of the Sydney district, with a rainfall of 48 inches, "the Coast and Dividing Range of New South Wales"! *Xanthorrhoea* may be a xerophyte, but it is not a plant of a "dry place". I make these remarks with the sincerest respect for the work of the great masters of Physiological Anatomy, but also as a warning of the danger in generalizing on the physiology or ecology of a plant from its structure alone. No one of these examples of so-called xerophytes, quoted above, grows in arid or even semi-arid Australia.

The modern intensive study of desert ecology may be said to date from the decision of the Carnegie Trustees in 1902 to found a desert botanical laboratory, which was opened in the following year at Tucson, Arizona. It is interesting to see how the concept of the xerophyte stood at about that time. This is well reflected in Warming's "Oecology of Plants", first written in Danish in 1895, but re-written in its English form in 1909. Schouw's original definition of the xerophyte was one based on habitat. Schimper introduced the idea of restriction of transpiration. Warming, as Miss Delf pointed out in 1915, attempts three definitions in his book, two expressed in terms of habitat and the third in terms of adaptive modification. Neither of the first two is at all satisfactory, nor is this to be wondered at in view of the then little knowledge of desert conditions. The third states that "those species that are adapted to meet the conditions of strongest transpiration and most precarious water supply are termed xerophytes" (Warming, p. 101). Warming followed Schimper in the recognition of certain structural features as characteristic of xerophytes, but it is significant that, after referring to thickened cuticles, varnished leaves, number and distribution of stomata, abundance of palisade tissue, ethereal oils, and so on, he states that "it must not be concluded that xerophytic leaf structure is inconsistent with vigorous transpiration" (p. 108). Dealing with the development of sclerenchyma he says that the reasons are "still somewhat obscure, but intense light and vigorous transpiration seem to be the causes" (p. 129). While referring to Volkens and others on the anatomy and morphology of desert plants, Warming notes that the physiology of desert plants had scarcely been touched upon. Since his time contributions from the American schools on desert ecology, from Yapp on the xeromorphy of marsh plants, and Maximov and his co-workers on the physiology of the xerophyte have added much to our knowledge. We are now in a position to envisage the problem, to clear away some misconceptions and to present hypotheses with a basis of experimental fact.

In our consideration of the problems of the xerophyte we ask ourselves—What are the climatic features of an arid region? What kinds of plants grow there? What light does their study throw on the so-called xerophytic structure? How far may the Sydney–Blue Mountain area be said to have a xerophytic climate? Is it legitimate to say that xerophytic plants occur in that area?

Some features of an arid climate.

A desert climate is popularly considered to be uniformly hot and dry. Yet some of the coldest nights I have ever spent when camping in Australia have been in the Lake Eyre Basin or the valley of the Finke River, Central Australia. In arid regions the diurnal fluctuations of temperature are great. In considering the aridity of a climate the whole complex of factors must be taken into account.

It is natural to consider the rainfall first among the climatic factors. Figures of mean annual precipitation are misleading. In addition to knowing the total, it is essential to take into consideration the monthly distribution and the rainfall reliability. Thus Marree (formerly Hergott Springs) on the edge of the Lake Eyre Basin has an average annual rainfall of 604 points, but during 30 years of published records (1885-1915) the falls have varied from 221 points in 1902 to 1006 points in 1904. The percentage departure from the mean annual fall for four stations in arid and desert Australia is given below. Taylor (1918), in his monograph on the Australian environment, dealt at some length with the question of rainfall reliability.

Percentage departure from mean annual rainfall at certain stations.

	Mean ann. rainfall.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.
Alice Springs	1071	−46	−27	−48	+49	+13	−10	+21	−8	+65	−24
Charlotte Waters ..	541	−30	−40	−56	+78	−30	−27	−43	0	+129	−58
Oodnadatta	468	−67	+5	−43	+17	+90	−25	−33	+38	+82	−38
Marree	604	−42	−55	−63	+22	+66	−15	+53	+1	+7	−16

Rainfall figures given in points, 100 points = 1 inch.

The monthly distribution of even so low a rainfall as that at Marree is of importance. In any month of the year no rain may fall; two or three rainless months in succession are not uncommon. On the other hand any month, except November, during the period under review, may show a fall of over 200 points, while in March, June, September and December falls of more than half the average annual total have been recorded. The number of days on which rain falls also must be considered, as well as the amount of any one fall. Cannon (1921) regarded falls of less than 15 points as ineffective for vegetation. As a result of our work at Koonamore we are disposed to put the figure higher, regarding falls of 25 points and over as alone useful to the roots of plants, if they occur during a dry season. During the 1929 drought at Koonamore we had 5 consecutive rainless months and 10 months in succession without any effective fall (Osborn, Wood and Paltridge, 1931).

Coupled with a low and unreliable rainfall there is a high evaporation rate. Evaporation data are not available for many stations. It is usual to record the wet and dry bulb readings, and so obtain the relative humidity of the air. Unfortunately this is only a relative figure, and as Livingstone and Shreve (1921) have said, "bears no qualitative relation to atmospheric evaporation, even with wind and barometric effects left out of consideration, for it is obvious that air with a given relative humidity must be more effective in promoting evaporation at a higher temperature than at a lower". But, given the relative humidity, it is possible to determine the "saturation deficit", which measures the difference in vapour pressure from saturated air in inches of mercury, and is independent of the temperature. From this, as Patton (1930) and Prescott (1931) have shown, the evaporation can be obtained by a simple formula. Given the values for the evaporation and the precipitation the ratio P/E, known as the Transeau ratio, can be ascertained. This Livingstone and Shreve (1921) consider "the nearest approach as yet possible toward an ideal index of the external moisture-relation of plants". Prescott (1931), in his recent bulletin on the Soils of Australia, uses the Meyer Ratio of P/s.d., and from the data has compiled an interesting map (*l.c.*, fig. 9) showing the isologs for the Meyer ratio of precipitation to saturation deficit. The south and central Australian stations listed above as having unreliable rainfall have a Meyer ratio of between 15 and 20. At Koonamore the value is about 25. In Adelaide the value lies between 75 and 100, while in Sydney it is between 200 and 250. These last values may be of interest in discussing the degree of xerophily in our local flora.

That the temperature of deserts is subject to great daily range has been known for a long time (*cf.* Warming, *l.c.*, p. 273). At Koonamore the mean annual range between the mean maximum and mean minimum temperatures is 30° F. Maximum temperatures of 100° F. and over are usually recorded in the arid and semiarid parts of Australia during the summer months. The minima are less usually noted, yet at Koonamore in July, 1929, during a time of drought the mean daily minimum was 30·1° F. on the screen and 26·5° F. on the ground (Osborn, Wood and Paltridge, 1931). These fluctuations in the temperature have their effect on the saturation deficit, which varies widely during a 24-hour period. During a portion of the day the air becomes almost saturated with moisture, even during the hot summer months and during a drought. This fact we believe accounts, in part, for the success of the saltbush in much of arid Australia.

No brief survey of the climatic factors in desert and arid areas would be complete without reference to wind. Unfortunately fully equipped meteorological stations are rare and for inland Australia anemometer records are wanting. The influence of the wind in promoting both evaporation and transpiration is too familiar to need comment. It must, however, be remembered that, as Knight (1917) has shown, evaporation from a free water surface is not the same thing as transpiration and that the maximum water loss from an atmometer does not coincide with that from the plant's transpiring surface, even though they occur at the same time of day. The plant is less sensitive to atmospheric currents than an atmometer. It is less as an agent in promoting evaporation and transpiration than as a mechanical agent, that I would here stress the action of wind. Arid erosion is often an aeolian erosion. The desert and arid soils are dry, and dust particles or sand grains are caught up and borne through the air both by strong blowing constant winds or by local whirlwinds that arise on a still hot day. The abrasive force of such particles has to be felt to be appreciated to the full. It has a very destructive effect on soft leaves.

To summarize, the arid climate is one with a low and unreliable rainfall, a high evaporation rate, but owing to the large daily fluctuation in temperature the saturation deficit may for a portion of each day only be very small. The climate is one of extremes and any plant growing in it must be able to accommodate itself to these extremes. What types of plants do so?

Arid plant types.

There is no doubt that the term desert plant has a special significance in the minds of most people, even those who have some botanical training. It calls to mind some hypothetical vegetable, whose characters are compounded of those from a number of the more familiar desert species seen in cultivation or described in books. Like the cacti, it is assumed to have considerable water reserves which it loses only slowly because of its low transpiration rate. It may be leafless, or, if leafy, the leaves are assumed to be hard, tough and fibrous like those of *Yucca* or *Dasylirion*, or succulent as in *Agave*, *Aloe* or *Cotyledon*. The cuticle is thought of as thick, the stomates sunken; thorns or spines are commonly assumed to be present. Now while some of these characteristics are possessed by some desert species, they are not by any means universally present.

It was in 1910 that MacDougal and Spalding published their monograph on the water balance of succulent plants, in which they showed clearly that the physiology of the succulent, with its great water reserves and low even rate of water loss, was peculiar. They separated the succulent from the hard-leaved desert plant as a specialized type.

In 1911 Kearney and Shantz divided plants of arid regions into four classes: drought-escaping; drought-evading; drought-enduring; and drought-resisting. Of these four classes, the first, the drought-escaping (i.e., the quick growing annuals) is very numerous in point of species and individuals. Raunkaier's work (Smith, 1913) showed how high was the percentage of therophytes in arid flora. Biological spectra published for Australian arid regions show how important an element is the small quick growing annual, *e.g.*, Adamson and Osborn (1922) at Ooldea where 35% of the flora are therophytes, Miss Murray (1931) in the Lake Torrens region where 32% of therophytes occur. Such plants have no special xerophytic features. Their seeds germinate, they grow up (often forming a plant body of considerable size), flower, and fruit during favourable wet periods. Except when they are dying off, passing rapidly from flower to fruit, it is doubtful if they are subject to water shortage for many hours together. Like any mesophyte, they may wilt during the day, for they have no "devices" for checking transpiration. At Koonamore, according to the unpublished results of Mr. Paltridge, the root system of some of these ephemerals is deep in proportion to the above-ground height. Thus one important class of arid plants, the drought-escaping or desert-ephemeral, is devoid of any positive characters which might fit it for its habitat, unless it be that of rapid growth.

Drought-resisting plants are the succulents, well known as a desert type through the cacti from certain American deserts. The succulent type is also of importance in the flora of the Karroo and other arid parts of South Africa. Maximov states, on the other hand, that succulents are very rare in the deserts of the Old World (*l.c.*, p. 251). This is also the case in Australian arid regions. *Sarcostemma australe* is the only true stem succulent that I have found, and it is a rare plant. *Euphorbia eremophila* passes into an aphyllous condition, but it is an annual. There are a few perennial succulent-leaved types, e.g., *Aizoon quadrifidum*, *Lycium australe*, and *Zygophyllum fructiculosum*. *Nitraria Schoberi* and *Arthrocnemum leiostachyum*, a stem-succulent of the well known *Salicornia* type, are usually plants of saline habitat, though Miss Murray (1931) records the latter in the shrub steppe west of Lake Torrens. There are a few succulent-leaved annual species, e.g., *Calandrinia*, but these give no character to the permanent flora of the Australian arid regions. Even the introduced succulent species of *Opuntia*, the prickly pears, are pests in a localized region of the arid area (Johnston, 1924). They do not extend into the region of lowest rainfall.

True succulents are a class of highly specialized desert plants. Their processes of photosynthesis and respiration (Spoehr, 1919) are peculiar, as is their water economy (MacDougal and Spalding, 1910). It is quite true that the rate of water loss from these plants is very low, both absolutely, when the mass of transpiring body is considered, or relatively compared with mesophytic plants. The root system of the cacti is wide spreading and superficial. It absorbs rapidly the water which penetrates the surface layers of the soil and transfers it to the body of the plant which is virtually a great reservoir. Unlike most desert perennials, the osmotic pressure of the cell sap in these plants is low (Harris, 1917). When their metabolism is considered as a whole, its peculiarities are seen to be inter-related.

The second and third groups of Kearney and Shantz, the drought-evading and drought-enduring species, contain the bulk of the perennials. The drought-evading type is characterized by its small size, restricted growth, its low water requirement and wide spacing in the field. In the drought-enduring forms we find the desert shrubs, concerning the behaviour of which we have now many records. Thus the American creosote bush, *Covillea glutinosa*, has small sticky leaves which pass the summer in a state of permanent wilting. Thoday (1921) states that twigs of another drought-enduring plant, *Myriothamnus flabellifolius*, were collected by him from the exposed rocky slopes of the Matoppo Hills in July, 1920, when air dry and dormant. The leaves were then plicately folded and tightly adpressed to each other at the tips of the twigs. In this state they contained but 7% of moisture. Yapp records recovery of twigs of this plant after having been kept in an air dry state for 13 months (footnote in Maximov, 1929, p. 243).

We have no determination of the water content of arid Australian plants during times of drought, but the probability is that certain of the Myoporineae, e.g., *Eremophila Sturtii* (turpentine) or *Eremophila glabra* (tarbush) which have lacquered leaves, behave much as the American creosote bush, *Covillea*.

Wood (1924) divided the plants of arid regions into three groups, the stem succulent, the indurated microphyll and the tomentose microphyll. In arid Australia the two latter forms are prominent. The indurated microphyll class includes *Acacia aneura* (mulga), *Acacia Victoriae*, *Eremophila glabra*, *Pholidia scoparia*, etc., the common plants of the scrub communities in arid Australia. "All these plants are woody and have reduced leaves, thickened cuticles, sunken stomates or similar xerophytic characteristics. Such modifications are not only characteristic of arid regions, but of any region where the evaporation is markedly in excess of the rainfall, as, for example, in the sclerophyll brush of the Mt. Lofty Ranges in Adelaide (Adamson and Osborn), where the rainfall varies from 20 to over 40 inches and yet similar modifications are seen" (Wood, 1924). The tomentose microphylls are the salt bushes (*Atriplex* spp.), blue bushes (*Kochia* spp.) and other Chenopodiaceous shrubs which form a characteristic shrub steppe vegetation in much of arid Australia. Wood (1925) has shown them to be peculiar in that, having a high content of sodium chloride in their leaves and a non-cuticularized epidermis covered with hairs or vesicles, they are able to absorb water through their leaves from light falls of rain, dew or even an atmosphere of high humidity. The general ecology of these plants, and in particular their reaction to grazing during a time of drought, has been a subject of special study at Koonamore by Messrs. Wood, Paltridge and myself. Wood also devoted some time to the general physiology of these plants and he kindly informs me that his results (as yet unpublished) show them to belong to a special class nearer to the stem succulents than to the indurated microphylls.

A survey of plant forms from arid Australia then shows that there is no one desert type. The plants of arid regions are a diverse assemblage and their reaction to the complex of the environmental factors which, in sum, we term drought, is diverse. The ephemerals, as Raunkaier has pointed out, are also numerically important in the flora of cultivated areas. Their abundance in the desert is due more to the accident of having much bare space to colonize than to any structural peculiarities fitting them for their habitat. Indeed, during the time at which the ephemeral flourishes, the habitat is not a peculiarly arid one.

The stem succulents form a very distinct class. They have peculiar structural and physiological features which are closely inter-related. The tomentose microphyll, an exceedingly important element in the flora of a great part of arid Australia, is also structurally peculiar and, it would seem, physiologically specialized too. Finally, the indurated microphyll is a perennial type of much wider distribution than the arid regions. Plants which have relatively small hard leaves—the sclerophyll type—occur abundantly over almost the whole of the Australian continent.

The Sydney climate.

Let us now consider briefly certain features of the Sydney climate before passing shortly to review the flora of the district.

The average annual rainfall is 48·20 inches, with a mean fall of 2·60 inches during the driest month. Sydney thus has no rainless season, though the influence of the monsoon is seen in the occurrence of a summer maximum. The average annual evaporation is 38·45 inches, and for eight months in the year the rainfall exceeds the evaporation. However, during October to January inclusive evaporation exceeds rainfall, in December and January by somewhat more than two inches a month. This is the dry season. The Transeau ratio for Sydney (P/E) is, then, greater than unity, approximately 1·3. Sydney is the only one of the Australian capitals in which this is so. As far as the Transeau ratio is of value in comparing climates the ratio for Sydney compares with that of Boston (Mass.) 1·26 and New Orleans 1·27, towns which lie within the area of "southern mesophytic forest", according to Livingstone and Shreve. Sydney has not a "xerophyte climate".

The Sydney flora.

Turning now to the vegetation of the Sydney district, we find that in this area we have a meeting ground of two very distinct types of flora, belonging to different plant geographical regions. One is the Austro-Malayan element which passes down the whole of the eastern coast of Australia, reaching its southern limit just over the Victorian border in Gippsland (Patton, 1930, p. 178). Though not so richly developed about Sydney as it is along the northern rivers of New South Wales, or in patches along the Queensland coast, it still is an impressive relic of what at one time, before European settlement, must have been the flora of considerable areas. This flora is the "Brush flora", so-called in New South Wales, a rain-forest type which, in its characteristic development, consists of laurel-leaved trees with lianas, epiphytes and an important element of ferns. The Eucalypt plays a subordinate part as a constituent in this vegetation and is absent in the climax stage. The ecology of the coastal brushes is yet to be worked out, but McLuckie, Brough and Petrie, in an important series of papers read before this Society, on the Mount Wilson Forests, have given a valuable account of the rain-forest there and its relation to the Eucalypt forests that occcur in the same area. It will be generally admitted that the brush forest is not xerophytic, yet the "xerophytes" of the Sydney district occur in the other communities which grow side by side with the brush under the same climatic conditions.

The plants of these other communities belong to the endemic Australian flora. They are the Eucalypts and other members of the Leptospermoideae section of the Myrtaceae, the phyllodineous Acacias and various shrubby Papilionatae, Proteaceous species in great numbers, Epacrids and Rutaceous plants, to mention only a few of the more important groups. This element around Sydney occurs in two distinct communities, scrub and forest, though both are in the same plant formation, the climax being *Eucalyptus* high forest. This plant formation is now much influenced by cultivation and grazing, and exists over much of the district as a savannah forest rather than as a closed forest type.

In any of the many stages in this great plant association xeromorphic plants are to be found. The evergreen or sclerophyll leaf type* is universal, and with it we have the commonly associated features of thick cuticle and sunken stomata. The leaves tend to be smooth rather than hairy, though hairs on young leaves in Myrtaceae and Proteaceae are not uncommon. Hairs are general in the adult foliage of the Sterculiaceae and Goodeniaceae. On the other hand, the leaf surface is often glaucous or has a covering of resin or caoutchouc when young.

Around Sydney almost any other leaf form than the broad leaf is usual; the broad mesophytic leaf is the curiosity to the student familiar with the Australian flora. Terete leaves (*Hakea*), sometimes much divided (*Petrophila* or *Isopogon*), small leaves to microphyllous (Epacridaceae and Papilionatae), or no leaves at all as in the phyllodineous Acacias, to true aphylly (*Ampiera*, *Bossiaea*)—these are the familiar foliage. The chief trees (Eucalypts and *Angophora*) have isobilateral leaves. Internal secretion of ethereal oils characterizes the important families, Myrtaceae and Rutaceae. From the point of view of texture, it is the sclerophyll leaf, with its close veining and its abundance of mechanical tissue, that we know. Are all these forms xerophytes? Clearly the older definition based on climate is quite inapplicable. Are they all plants "adapted to meet conditions of strongest transpiration and most precarious water supply"?

Before we examine this, the physiological aspect of xerophytism, it is interesting to consider what plants replace this endemic Australian vegetation when it is cleared for any reason, and the cleared ground thrown open to competition as it were to the world, or at least to such aliens as are available to colonize it. Lantana, blackberry, *Ricinus*, *Paspalum distichum*, *Erigeron crispus* (*linifolius*), *Hypochoeris radicata*, *Rumex* spp., *Amaranthus retroflexus*, *Modiola caroliniana*, *Sonchus*, all are common weeds often competing successfully with the indigenous vegetation once they are given the chance to establish themselves. The upper portion of Centennial Park, with its wide grassy slopes, through which there occasionally project the typical cliff exposures of Hawkesbury sandstone, is a good example of a complete change of vegetation type within the Sydney area

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* These terms are not synonymous. "Evergreen" is here used to signify non-deciduous. Our trees of the 'brush' or rain-forest are evergreen, e.g., *Ceratopetalum apetalum*, *Eugenia*, *Tristania*, but they are not sclerophyllous like the Eucalypts.

without additional water when the woody type of plant is prevented from re-establishing itself.

Some general physiological considerations.

The great advances that have been made in plant physiology since the time of Schimper and Warming have made possible the modern outlook on the problem of xerophily. In his book "The Plant in Relation to Water", published in 1929, Prof. Maximov has reviewed the position in a comprehensive and critical manner. Quite apart from the value of his original views on xerophytism, the book is remarkable for the wide perspective with which the problem is treated. The xerophyte has been considered too long from one angle, that of regulating water loss. Important though this aspect is, it is only one side of a complex figure which must be considered in its entirety if we are to get a true impression.

If the plant be viewed as a wick through which water is drawn up from the soil and passed out as vapour into the air, there are obviously stages of water absorption, and water transport to be considered, as well as the emission of water vapour. If there be any difficulties affecting entry of water, or transport or delivery to the transpiring tissues, these experience a water shortage whatever the climatic conditions. The water is absorbed from the soil; in the vast majority of cases this is the sole source of supply, though the saltbushes in parts of arid Australia provide an interesting and locally widespread exception. We have then to consider the state of the water in the soil, its availability to the plant, and the manner of its entry.

The old view was that the soil had a structure, as it were, composed of sand grains of various sizes over which water was spread in thin films. Of the forces tending to hold it in the soil, that of capillarity was most important. With the study of the properties of colloids, the colloidal soil constituents were recognized as playing an important part in retaining the soil water, possibly even of more importance than capillary forces. Russell (1927) summarized the physical forces acting on the soil water and against which the plant must compete as:

"(1) Gravity, which acts on all the water and which is equivalent to a pressure of about 1 atmosphere.

"(2) Surface forces under the heads.

"(*a*) Capillarity, which holds water on the surface of the particles or in pores and interstices of less than a certain size: (*b*) imbibition, the force with which the colloids hold water. These forces vary with the amount of water and with the conditions; they may range from one to several hundred atmospheres. But how far this division affects the relationships between the soil water and the growing plant is not yet known.

"(3) More intimate surface forces of high magnitude (i.e., several hundred to 1,000 ats.) affecting only a small portion of the water."

It is important to note that these forces overlap in their operation and the state of the soil water is continuous, except perhaps at the extreme condition of desiccation. The old divisions of "gravitational water", "capillary water", "imbibitional water" and "hygroscopic water" are abandoned, and the water is thought of as being held by forces which vary continuously and smoothly, very small when the water content is large and very large when the water content is small. The amount of water available to the plant varies with the size of the soil particles and quantity of colloidal material present. Obviously there is always a residue left which is unavailable to the plant. In experiments with crop plants, grown under conditions in which they are protected from extremes of external conditions (cf. wind, intense light) this residue tends to be constant for a particular soil, irrespective of the species of plant grown. It is the wilting coefficient of the soil.

When a soil has been wet by rain, the water held in its surface layers, and available to the roots of the plant, fairly quickly assumes a state of stability, the field carrying capacity of the soil. Of this water only a portion, roughly half, is available to the plant at all. The water at and below field carrying capacity does not move readily in the soil. As Shantz (1927) has said, "under ordinary conditions of growth, the roots move through the soil to the water, and the water does not move through any considerable distance to the plant".

Acting in opposition to the forces which tend to stabilize the water in the soil are the absorbing portions of the roots. These, of course, are but a fraction of the total root length, for the older portions of most roots have an impermeable surface layer of cork. This is an important point when the soil moisture is low. In the case of the desert perennial, there is actually a danger of loss of water from the root into the dry soil. The actual feeding root system of the saltbush is composed of deciduous rootlets; in droughts the widespread surface root system serves for anchorage and storage, it has no functional absorptive rootlets.

The forces that may move water from the soil into the root absorbing regions are those of imbibition (Shull, 1924), those due to osmotic phenomena, and possibly, in the case of absorption from moister soils, a purely passive absorption extending across the turgid root from the vascular system of the plant. Of these forces, those due to osmotic pressure of the cell sap are most readily appreciated. These vary much from species to species. The mesophytic group has osmotic pressures ranging from 10 to 25 atmospheres, in xerophytes the range is definitely higher, ranging upwards from 30 to 50 atmospheres or more.

At the other end of the plant, as it were, is the foliage, chief seat of water loss, but also chief seat of the essential process of photosynthesis. If the need for water conservation makes for compactness of structure, the needs of photosynthesis—surface exposure for light and gaseous exchange with the atmosphere—make for a diffuse foliar system. It is the balance, as it were, between these two opposing needs that has a dominating influence in plant structure.

To maintain its efficiency as a photosynthetic mechanism the leaf must be turgid. As turgidity is lost the efficiency of the leaf is reduced, partly owing to closure of the stomates, partly to less easily appreciated changes on the surfaces and inside the assimilating cells. Thoday (1910) has shown that turgid leaves of the sunflower were approximately ten times more efficient in starch manufacture than drooping ones.

Water is lost from the leaf in two ways. The bulk of it passes out as vapour through the stomata, but a portion is lost through the cuticle. Cuticular transpiration varies inversely as the thickness of the cuticle; therein may lie a physiological significance of the thick cuticles of xerophytic plants. Lee and Priestley (1924) have shown that a correlation exists between the formation of cutin and suberin and the humidity of the air. When the stomata are closed a thick cuticle may be of importance in restricting water loss. On the other hand, when the stomata are open transpiration is governed by the laws affecting transfusion of gases through a multiperforate septum. Clearly, then, the number and size of the stomata are of importance.

The number of stomata has been shown by Salisbury to increase with the height of the plant in British woodlands, also with degree of exposure. The following figures may be quoted (Salisbury, 1927):

Type of flora.	Mean height.	Mean Stomatal Frequency.
Herbs, shade	0·23 metres	92 per sq. mm.
Marginal plants	0·61 ,,	167 ,, ,, ,,
Shrub stratum	2·40 ,,	199 ,, ,, ,,
Tree stratum	13·0 ,,	224 ,, ,, ,,

The number of stomata per unit area of leaf surface varies, increasing with the height of insertion of the leaf along the shoot (see Maximov, 1929, pp. 327–332, on Zalenski's Law). Yapp (1912), in his valuable paper on *Spriea*, independently* arrived at the same conclusion. Evidence along the same line is to be obtained in the important work on the physiology of "sun" and "shade" leaves on the same tree (see the summary by Huber (1931), to which reference is made below).

The stomatal frequencies given by Wilson (1923) for Australian plants range from 70 per sq. mm. in *Hakea gibbosa* to 610 in *Eucalyptus botryoides*. These counts were all made on small potted plants, but they cannot be connected with the insertion along the stem of any particular leaf. McLuckie and Petrie (1927) give some stomatal numbers for the Mt. Wilson flora, but again we have no information as to the level at which the estimate was made. The plants are grouped by them into the three major associations, but unfortunately one cannot compare the stomatal numbers of the dominant species. The highest figure given is for *Acacia melanoxylon*, av. 241 per sq. mm. on the phyllode, the lowest for *Persoonia salicina*, which has stomates on both leaf surfaces, 24 per sq. mm. on the upper and 28 on the under.

This very low stomatal number has been confirmed by Mr. H. F. C. Davis working in the Botany School here in a series of counts made on different leaves along one shrub.

Position of leaf.	No. of stomates per sq. mm.
Basal	22 ± 4
15th node	23 ± 4
30th node	22 ± 2
38th, near apex, and immature	28 ± 7

Mr. J. G. Wood tells me that his unpublished results show that in Australian plants high or low stomatal frequencies may be linked with the families to which the plants belong. The Proteaceae certainly appear to have a low number of stomates.

Between the leaves as areas of water loss and the absorbing zones of the roots there stretches the whole length of the conducting system of the plant. Wilting of a leaf may be due to a local shortage of water in the leaf due to the failure of the roots to supply sufficient water at a given moment to the trans-

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* Zalenski's work, published 1902, was overlooked for some years.

piring area. There may be water available to the plant in the soil. The transport is at fault.

Thoday (1931) contributed to the recent symposium on Xeromorphy a paper of great interest to Australian students upon the "Significance of Reduction of Leaf Size", in which he shows that the total leaf area of microphyllous plants is really large, but that the small size of the leaf enables the assimilating tissue to be placed in close contiguity with the vascular elements. He states that the reduction of internal resistance to the flow of water to the transpiring cells is probably far more significant in the microphyll than the reduction of leaf surface, which is in fact often illusory. Yapp had shown that the portions of a leaf blade which showed first the effects of drought were those parts lying furthest from the main veins (1912, p. 841). Bearing such observations in mind, it is easy to appreciate the importance of the centric type of leaf as in *Hakea*, or the centric and divided form as in *Isopogon anaethifolius*. The chlorenchyma is in contact with the veins throughout the whole of the length of the lamina.

New light on the problem of xeromorphy has come from the work that has been done by Zalenski, Huber and others on the difference in the rates of transpiration from leaves taken at different heights on the stem. It is found that the transpiration rate increases as the height. This might be held to be merely the result of the greater exposure to which the leaves are subjected, but the interesting point arises that in structure the more exposed leaves are more xeromorphic, i.e., they are thicker, better cuticularized, the veins branch more freely, leaving smaller islands of parenchyma between them, the stomata are smaller, more numerous and distributed on both leaf surfaces. Huber states (1931) that the structures which characterize the foliage at the exposed crowns of trees as opposed to the deeper layers are of the same type as those which distinguish the xerophytic plants from those that are mesophytic. He considers that the xerophytic type of structure corresponds with the reaction to exposure shown by the leaves at the tops of trees. To him both are plants having a "sun-type" of leaf.

That many plants of arid regions (excluding the ephemeral and succulent types) are capable of high transpiration rates seems certain. As Maximov has put it in his most recent statement (1931): "It is not the rate of transpiration when an abundant water supply is present, but the capacity to restrict water loss to a minimum in time of drought, that characterizes the water utilization of the xerophyte."

The real test of the xerophyte appears then to be a capacity to resist drought, not to restrict transpiration when the water is available, but to maintain a functioning organism when water is scarce. This would appear to be the biological advantage of the sclerophyll structure. It does not explain its development, the causes of which are to be found in the conditions operating on the expanding leaves. Yapp and Mason (footnote in Maximov, 1927, p. 344) sought to ascertain at what stage or stages were the modifications induced by differences of turgor impressed upon the leaf. Using sunflower and bean plants, they found that it is probable that the water factor influences the leaf during actual expansion. It is when the leaf is leaving the bud that the turgor of the cells is lowest and subject to greatest fluctuations. But the case is not so simple as it might seem. Something must be allowed for the heredity of the plant. Inherent causes also play their part; at any rate we have not yet found in the sclerophyll flora a species sufficiently plastic to develop leaves of a mesophyte type when supplied with abundant water and kept at reduced illumination. But it is unnecessary to invoke inherent causes to explain the xerophytic features of the flora in all cases around the Sydney district.

The Sydney habitats.

In spite of its high rainfall and low evaporation rate, the plants of the Hawkesbury Sandstone do suffer from periodic drought. The soil is shallow, its water-retaining capacity low, while, being derived from siliceous rocks low in calcium carbonate, it tends to an acid reaction. Wherever local conditions of drainage permit, swamps form and there is developed a peat-like soil. It is not surprising that the local florulas in such places should show a xeromorphy of the type associated with similar edaphic conditions in other parts of the globe.

The shallow sandy soil in the better drained areas becomes very dry, especially during late spring and early summer. At that time the water deficit in the perennial flora must be considerable; the common occurrence of scrub fires shows how low is the water content. The condition is comparable to many of the sand heaths in western Europe. The drought from which the plants suffer is largely due to edaphic causes and, given the sufficient soil moisture coupled with protection from wind, the vegetation passes from the scrub to the high forest type. The work of McLuckie and Petrie (1927) has shown that at Mt. Wilson rain forest may occur on siliceous soils wherever better soil moisture relations permit. Under such conditions a humus reserve is built up and the vegetation advances to a type that cannot reasonably be termed xerophytic. In the Sydney district the rain-forest type is limited to a few patches or to fringing forests along the creeks, such as those in the National Park. Formerly it must have been much more extensive. Degenerate relics are to be found on Hawkesbury Sandstone soils at the head waters of the Lane Cove River. Occasional burnt logs of Coachwood (*Ceratopetalum apetalum*), one of the co-dominants in the rain forest, may be found in a forest that is now of the open Eucalypt type. These logs represent trees of considerable size and are remains of the rain forest that has now disappeared.

Transpiration in crop plants.

As I indicated in my opening remarks, the problems of xerophily have far more than an academic significance. They have a direct practical bearing upon the type of crop or forage plant suited to an arid area.

Influenced by the older concept of the xerophyte as a plant necessarily economical of water, extensive experiments have been conducted on the "efficiency of transpiration". The value of a crop or a fodder plant lies not in the amount of water stored in its tissues, but in the quantity of solid material, largely utilizable carbohydrate, which is produced. Has this production any relation to the amount of water transpired? Do plants exist which with a small expenditure of water yield a relatively large amount of valuable foodstuff?

Shantz and his co-workers have been investigating this problem for some twenty years (Kearney and Shantz, 1911) and the results of an extensive series of experiments at Akron, Colorado, appeared in 1927. Concurrently the problem has been investigated elsewhere, as, for instance, by Maximov at Tiflis, and Richardson (1923) in Victoria.

The amount of water transpired by a plant during the growing period per unit of dry weight is termed the "coefficient of transpiration" or the "water requirement" of the plant. Another expression is the "efficiency of transpiration", a term used by Maximov to express the amount of dry material accumulated per kilogram of water transpired. According to Shantz and Piemeisel (1927), the results for some common plants are as follows:

	Water requirement.	Efficiency of transpiration.
Sorghum, various varieties	274-312	3·21-3·64
Wheat, various varieties	455-550	1·82-2·20
Common pumpkin	820	1·25
Lucerne	626-920	1·09-1·60

If other things were equal, the plant making the greatest growth with a given supply of water would be most valuable economically. Yet sorghum has a water requirement of approximately 300, while lucerne may range up to 900, under the same conditions. In spite of that difference, both are valued in dry warm climates.

No satisfactory explanation has been given of the difference in water requirement of plants, says Shantz (1927). He then points out that, comparing lucerne and sorghum leaves growing side by side, there will be a considerable difference in temperature between the two on a hot day. Much of the energy falling on the lucerne leaf is used in evaporating water; this will cool the leaf below the temperature of the air. Sorghum may have a leaf temperature of several degrees higher than the air. The lucerne leaf absorbs heat energy from the surrounding air, the sorghum radiates it. Transpiration effects in a leaf cannot be thought of simply in terms of water loss. The whole energetics of photosynthesis must be thought of as well.

Conclusion.

And now I must conclude. I know I have ranged widely and, in an attempt to present to you that many-sided problem, the xerophytic plant, I have had to compress, to suggest views here, and indicate results there, when a whole address would have done scant justice to the work in question. That was inevitable. Emerging from the mass of detail is the fact that the plant in its relation to water refuses to fit any simple formula, that transpiration loss alone is no criterion of a xerophyte, unless indeed we follow Maximov and make a high transpiration rate a mark of the xerophyte. It is not a matter of how much (or how little) water a plant can use when moisture conditions are favourable which determines its xerophytic nature. What is important is, how does the plant behave when the water supply is restricted? What is the capacity of the plant to go on as a functioning organism when water supply is reduced below the minimum needs of the hypothetical "normal" plant? We learn that there is no one type of desert plant, and that in Australia the sclerophyll leaf-type common in arid areas characterizes much of the vegetation of the continent, even extending to the regions that on a climatic test are moist. It may be that, following Huber, the sclerophyll is a sun-leaf type.

It is unsafe at present to assume that all the plants which show xerophytic structure in the Sydney district do so in response to the same set of physical causes. We have swamp xerophytes of peaty soils, xerophytes of areas of the sand-heath type, as well as those of the Eucalypt forest. The possibility must be faced, however unsatisfactory it may be, that heredity and inherent nature play their part. The suggestion does not push the difficulties so far into the region of the unknowable as at first sight might appear. When we know more of the rates of flow of water through some plants which obstinately show xerophytic features, though growing under conditions in which water shortage appears impossible, we may have more light on the problem.

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Dr. G. A. Waterhouse, Honorary Treasurer, presented the balance sheets for the year 1931, duly signed by the Auditor, Mr. F. H. Rayment, F.C.P.A., Chartered Accountant (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. Anderson, M.A., D.Sc.

Members of Council: E. C. Andrews, B.A., E. Cheel, T. Storie Dixson, M.B., Ch.M., Prof. T. G. B. Osborn, D.Sc., T. C. Roughley, H. S. H. Wardlaw, D.Sc.

Auditor: F. H. Rayment, F.C.P.A.

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

Linnean Society of New South Wales

GENERAL ACCOUNT. Balance Sheet at 31st December, 1931.

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				11,860	12	0
Fletcher Memorial Fund at 31st December, 1931				23	17	0
Commercial Banking Co. of Sydney, Ltd.				1,176	6	4
				£33,060	15	4

ASSETS.

	£	s.	d.
Society's Freehold	11,000	0	0
Consols	3,080	0	0
Loans on Mortgage	3,600	0	0
Science House (one-third share)	13,813	6	8
Cash in hand	10	0	0
Income A/c at 31st December, 1931	1,557	8	8
	£33,060	15	4

INCOME ACCOUNT. Year Ended 31st December, 1931.

	£	s.	d.	£	s.	d.
To Salaries and Wages				1,142	5	0
,, Printing Publications	761	11	0			
,, Illustrations	164	18	6			
				926	9	6
,, Rates and Insurance				236	16	1
,, Postage	57	11	0			
,, Cleaning	30	3	11			
,, Petty Cash	28	14	0			
				116	8	11
,, Audit	7	7	0			
,, Printing and Stationery	44	3	11			
,, Attendance	12	10	3			
,, Fletcher Memorial Lecture	31	0	0			
,, Legal Expenses	7	7	0			
,, Furniture, etc.	355	14	1			
,, Repairs	68	5	7			
,, Expenses	50	10	2			
				576	18	0
,, Interest on Overdraft, etc.				61	13	6
,, Rent—Science House				125	1	4
,, College Street—Repairs, etc.				287	6	9
,, Appropriation: Contingencies Reserve				24	3	0
,, Bank Expenses				3	0	5
				£3,500	2	6

	£	s.	d.	£	s.	d.
By Balance from 1930				18	7	3
,, Subscriptions: 1931	139	13	0			
Arrears	16	16	0			
In Advance	4	4	0			
				160	13	0
,, Life Subscriptions				15	15	0
,, Entrance Fees				8	8	0
,, Interest				445	8	8
,, Rents				115	4	2
,, Sales (including 60 copies of Proceedings purchased by Government of New South Wales)				140	18	7
,, Bank Exchange				3	17	6
,, Fellowships A/c (surplus income transferred)				1,034	1	8
,, Balance to 1932				1,557	8	8
				£3,500	2	6

Examined and found correct. Securities produced.
F. H. Rayment, F.C.A. (Aust.),
Auditor.
4th February, 1932.

G. A. Waterhouse,
Hon. Treasurer.
7th January, 1932.

LINNEAN MACLEAY FELLOWSHIPS ACCOUNT.

BALANCE SHEET at 31st December, 1931.

LIABILITIES.	£	s.	d.	ASSETS.	£	s.	d.
Amount bequeathed by Sir William Macleay	35,000	0	0	Consols	9,700	0	0
Surplus Income Capitalized	14,082	14	8	Loans on Mortgage	38,700	0	0
				Commercial Banking Co. of Sydney, Ltd.	682	14	8
	£49,082	14	8		£49,082	14	8

INCOME ACCOUNT. Year Ended 31st December, 1931.

	£	s.	d.		£	s.	d.
To Salaries of Linnean Macleay Fellows	883	6	8	By Interest	2,778	19	4
,, Fellows' Subsidies	61	11	0				
,, Capital A/c	800	0	0				
,, General A/c	1,034	1	8				
	£2,778	19	4		£2,778	19	4

Examined and found correct. Securities produced.
F. H. Rayment, F.C.A. (Aust.),
Auditor.
4th February, 1932.

G. A. Waterhouse,
Hon. Treasurer.
7th January, 1932.

A REVIEW OF THE TIPULIDAE OF AUSTRALIA (DIPTERA). I.

Introduction; Historical; Distribution.
Subfamily Tipulinae: Clytocosmus Skuse.

By Charles P. Alexander, Massachusetts State College, Amherst, Mass., U.S.A.

(Plate ii; four Text-figures.)

[Read 30th March, 1932.]

Introduction.

The crane-flies (family Tipulidae) are among the most generalized of all existing Dipterous insects. The family is particularly numerous in species in the Australian fauna, with approximately 550 valid described species (end of 1930), the great majority of which are from the mountainous sections of New South Wales, Victoria and Tasmania. This particular area must be considered as being fairly well known, although numerous additions to the list will be made as a result of further collecting at different seasons, at all possible stations, particularly in the mountains, and by investigation of hitherto neglected ecological habitats. Crane-flies are notable lovers of moisture and almost all are to be found in damp, shady places, as along woodland streams, among ferns in the gullies, around damp spots in low-lying pockets on mountain slopes, on the wet, vertical faces of cliffs, in and about the margins of sphagnum bogs, in helophytic associations having little or no shrubbery or tree growth, and, in fact, in a great variety of minor ecological societies where there is some amount of moisture. An excellent idea of the haunts of Victorian Tipulidae is given in the paper by Wilson (concerning crane-flies, *Vict. Nat.*, 46, 1929, 88–94). Some species of these flies are extremely local, occurring in certain restricted habitats while being entirely absent from other apparently suitable stations near by. Many of the smaller types are not in evidence during the hours of sunlight, lurking among the bases of close-growing sedges or rushes and becoming active only at sundown, then appearing in small dancing swarms during the hours of twilight or night. From the above statements it will become apparent that in any country, even in Europe and eastern North America, where the Tipulid fauna has been particularly well collected and studied, previously unknown species are still being discovered. Crane-flies occurring in the mountains are apt to be more limited in range than are coastal species, the more widely distributed of such mountain forms being found at low altitudes in Tasmania, at increasing heights in the Victorian and Australian Alps, while in the northern part of their range, as at Barrington Tops, they are found only at considerable altitudes (5,000 feet and higher).

The only monographic treatment of this group of flies for the Australian fauna is that by Skuse (1889–1890), a notable work that is rendered obsolete only by the great accession of new forms. A few groups of Diptera that were held to be Tipulidae by older workers and were so considered by Skuse have since been removed to separate families and since they have already been discussed by the present writer will not be included in this series of papers. These isolated groups are the Tanyderidae and Trichoceridae, together with the subfamily Bruchomyiinae, now generally placed with the Psychodidae. The following papers consider the Australian species in these groups:

ALEXANDER, C. P., 1926.—The Trichoceridae of Australia. PROC. LINN. SOC. N.S.W., 51, 299-304, 11 figs.

———, 1928A.—The Australian species of the genus *Nemopalpus*. *Ibid.*, 53, 291-294, 2 figs.

———, 1928B.—The Tanyderidae of Australia (Diptera). *Ibid.*, 53, 367-374, 4 figs.

———, 1930.—Observations on the Dipterous family Tanyderidae. *Ibid.*, 55, 221-230, 2 Pl., 1 fig.

The only major group formerly held to fall within the limits of the family Tipulidae that has not been taken within the Australasian Region is the family Ptychopteridae, represented by two genera (*Bittacomorpha* and *Bittacomorphella*) in the Northern Hemisphere, and *Ptychoptera* with representatives in the Nearctic, Palaearctic, Oriental and Ethiopian Regions. The possibility is remote that members of this family will be found to occur in Australia.

The family Tipulidae as now restricted has three subfamilies, the Tipulinae, Cylindrotominae and Limoniinae, all of which are represented in Australia, the second by a single genus with two closely allied species. The subfamily Limoniinae, which includes almost all of the small and medium-sized Tipulidae, has five tribes—Limoniini, Lechriini, Pediciini, Hexatomini and Eriopterini—all of which are represented in the Australian fauna, the second and third by a single genus each, the others by a host of species distributed in many genera and subgenera. After due planning I have decided to attempt the present review of the Australian Tipulidae along the following lines:

The initial part will discuss briefly the historical development of the subject, the chief points in the facies of the fauna, and a table of all known genera and subgenera in Australia, showing their extra-limital distribution. The keys to the subfamilies will be followed in subsequent parts by keys to the tribes, genera and species, as the various groups fall under consideration in their proper sequence. Suitable illustrations of species will be provided and full references to all other such published figures given. The treatment of the individual species must necessarily be brief lest the papers assume unnecessary proportions. As now planned, and worked out in this part of the review for the genus *Clytocosmus*, it is intended only to give a brief diagnosis of the individual species, with particular emphasis on the critical points needed for separation from allied forms, followed by the detailed distribution as known, and any further pertinent observations concerning the species. Following such a plan, it is hoped that a serviceable treatment may result. It should be emphasized at the start that much work remains to be done, that in very many cases only fragmentary and insufficient materials are available, that in the majority of cases the seasonal and geographical distribution of any given species is little known, and, lastly, that the writer would greatly appreciate further co-operation in the nature of specimens for determination, records of distribution, notes on habits of adults, and any other data. The almost total lack of information on the early stages of Australian Tipulidae has been referred to by the author elsewhere and need not be discussed here.

The story of progress in our knowledge of these flies has been one of unselfish aid and co-operation on the part of almost all Australian Dipterologists, as well as many other collectors and interested persons. The more important sources are here indicated, while others will be mentioned in the various subsequent parts.

Queensland: Collections made by T. L. Bancroft, L. Biró, the late W. H. Davidson, the Dodds, H. Hacker, G. H. Hardy, J. F. Illingworth, A. M. Lea, E. Mjöberg, F. A. Perkins, F. H. Roberts, F. H. Taylor and others.

New South Wales: By V. J. Robinson and W. Heron in Dorrigo and northward; and by the late E. W. Ferguson, W. W. Froggatt, G. Goldfinch, Ian Mackerras, A. J. Nicholson, R. J. Tillyard, A. L. Tonnoir and F. E. Wilson, in the Blue Mountains and Southern Alps.

Victoria: By C. Barrett, C. H. Borch, J. Clark, G. F. Hill, J. A. Kershaw, J. Searle, A. L. Tonnoir and F. E. Wilson, and by Miss Jean Galbraith and Mrs. Edith Coleman.

Tasmania: By H. J. Carter, G. H. Hardy, G. F. Hill, the late A. M. Lea, A. L. Tonnoir and G. Weindorfer.

South Australia: By the late A. M. Lea, F. E. Wilson and J. O. Wilson.

Western Australia: By J. Clark, the late E. W. Ferguson, W. H. Mathews and L. J. Newman.

The most extensive of these collections, including in each case in excess of one hundred specimens, are those of Dr. Illingworth and Mr. Taylor in Queensland; Mr. Heron, the late Mr. W. H. Davidson, the late Dr. E. W. Ferguson, Dr. Mackerras, Mr. Tonnoir and Mr. F. E. Wilson in New South Wales; the Tonnoir and Wilson collections in Victoria; and the Hardy and Tonnoir collections in Tasmania.

The outstanding collections of Australian Tipulidae in the Commonwealth are the following:

Queensland Museum, Brisbane.—A few types of species described by the writer (*Mem. Queensland Mus.*, 7, 1920, 52–63), as well as some further specimens taken by Hardy and Perkins.

Macleay Collection, University of Sydney.—Contains almost all of the Skuse collection, arranged in five large drawers, including all types of the 1889–1890 papers with twelve exceptions, indicated below. My information on the present state of this collection is based on enlarged photographs of the drawers taken by Mr. John Shewan through the kind interest of the Museum authorities. Drawer I includes all material in the tribe Limoniini, as now constituted, as well as *Leiponeura* (*Lipophleps*), now placed in the Eriopterini. Three species of Anisopodidae (as Rhyphidae) are also included. Drawer II includes the Eriopterini, beginning with *Amphineurus*, and the Hexatomini through the genus *Limnophila*. Drawer III includes the remainder of the Hexatomini, beginning with *Gynoplistia*; the Pediciini; and the beginning of the Tipulinae, including *Dolichopeza*, through *Ptilogyna*. Drawer IV continues the Tipulinae, from *Plusiomyia* to *Ischnotoma par*. Drawer V completes the collection, including the Tipulinae from *Ischnotoma rubriventris* through *Macromastix*. The collection is in a beautiful state of preservation. Through the kind interest of Dr. Ian Mackerras, the male hypopygia of *Molophilus* and *Tasiocera* were made into micromounts and were kindly sent to me for study, being then returned and placed on pins with the remainder of the insect. It is hoped that other species will be dealt with in the same way.

The Macleay Museum collection also includes (1) the types of the Tipulidae collected by the University Zoological Expedition to Barrington Tops in January, 1925, and described by the writer (These PROCEEDINGS, 53, 1928, 51–70); (2) the types of species of *Molophilus* described by the writer from the Ferguson Collection; and (3) the type of Skuse's *Plusiomyia olliffi.*

Australian Museum, Sydney.—Includes the Tipulidae collected by Helms on Mt. Kosciusko and by Olliff in Victoria described by Skuse (1889–1890). The following types are included: *Dicranomyia helmsi, Geranomyia lutulenta, Amphineurus maculosus, Molophilus helmsi, M. montivagus, Gynoplistia viridithorax, Clytocosmus helmsi, Platyphasia princeps, Acracantha inornata, Limnophila imitatrix, Macromastix obscurirostris,* and *M. helmsi.* The type of *Teucholabis meridiana* is represented only by a microslide of a leg and a wing; as far as known the types of *Gynoplistia chalybeia* and *Dapanoptera richmondiana* are nonexistent. In this collection are also the types of twenty-two species (other than those of *Molophilus* mentioned above) described by the writer from the Ferguson Collection.

School of Public Health and Tropical Medicine, University of Sydney.—Types of the Taylor Collection described by the writer.

Collection of the Division of Economic Entomology, Canberra.—One of the largest collections of Australian Tipulidae, based primarily on the material taken by A. L. Tonnoir in New South Wales, Victoria, and Tasmania, including more than 100 holotype specimens.

National Museum, Melbourne.—A large general collection, including several types of species described by the writer, received through the kindly interest of Messrs. Clark and Kershaw.

F. Erasmus Wilson, Melbourne.—The largest collection of Victorian Tipulidae, also including many other notable specimens, especially a large series from the Blue Mountains, New South Wales; totals in excess of 100 holotype specimens.

South Australian Museum, Adelaide.—Includes some fifty types of species described by the writer (*Rec. S. Aus. Mus.*, 2, 1922, 223–270), received through the kindly interest of the late Mr. Arthur M. Lea.

A number of collections outside the Commonwealth possess a certain number of type-specimens. The more important of these are:

Alexander Collection, Amherst, Mass., U.S.A.—More than 50 types, based chiefly on material collected by Barrett, Davidson, Dodd, Hardy, Heron, Hill, Illingworth, Mathews, Robinson and others.

Hawaiian Sugar Planters' Collection, Bishop Museum, Honolulu.—A few species, taken by the late R. Helms.

British Museum (Natural History), London.—The Walker types, with a few others.

Hope Museum, Oxford.—The Westwood types.

Museum of Natural History, Paris.—The Guérin and Macquart types.

Riksmuseets, Stockholm.—A few species described from Mjöberg's collections, named by Alexander and Riedel.

Deutsches Entomologisches Museum, Berlin-Dahlem.—The type of *Clytocosmus lichtwardti* Riedel.

Natural History Museum, Vienna.—Types of Schiner.

HISTORICAL.

A brief historical summary of the development of our knowledge of the Tipulidae of Australia may be given. Of the more than 600 names that have been applied to species in this fauna, more than 550 species appear to be valid. These names have been bestowed by seventeen workers on the group. In the accompanying summary I have listed the total names given by the individual authors, indicating which of these are valid species, synonyms and doubtful species. When further collecting is done and, especially, when certain doubtful type-specimens may be examined, these various figures will be slightly altered. Our subject may well be divided into three periods—1. The pre-Skusean; 2. The period of Skuse; and 3. The modern or post-Skusean phase of our knowledge of this subject.

1. *The pre-Skusean period.*

The first crane-fly to be described from Australia was the common and widely-distributed *Macromastix costalis*, named by Swederus in 1787. Two synonyms of this species represent the sole contributions of Erichson (1842) and Jaennicke (1867). Guérin (1830) erected the genus *Leptotarsus* for the single species, *L. macquarti* Guérin. Wiedemann (1828) described *Conosia irrorata*, a fly of extremely wide distribution in the tropical and subtropical regions of the Old World.

The rapid development of the country in the first half of the 19th century found considerable rivalry between three describers of Diptera, Macquart (1838-1855), Walker (1834-1861) and Westwood (1835-1876). Macquart proposed 13 names, of which 7 are valid, 3 synonyms and 3 of doubtful identity, the valid names including some of the largest and showiest species of *Ischnotoma*. The materials studied by Macquart were entirely or in great part collected by the Verreaux brothers, the majority of the species being indicated as coming from Tasmania. Hardy (PROC. LINN. SOC. N.S.W., 54, 1929, 61–64) has most ably presented the evidence to show that only a portion of the Verreaux Diptera were actually collected in Tasmania and that the majority of the species were presumably taken in the near vicinity of Sydney. This conception quite changes our ideas of many of the Macquart species and affects certain of the Tipulidae. As regards this family, I consider it as assured that some of the species (as some *Ischnotoma* and *Macromastix*, notably *M. macquartiana* Alexander) were actually taken in Tasmania but that in the majority of cases, the specimens were taken in coastal New South Wales, as shown by Hardy. The early rivalry between Walker and Westwood, where certain of the best-known species of Australian Tipulidae (*Ptilogyna ramicornis*, *Gynoplistia bella*) were evidently characterized under different names from the self-same specimens by the two authorities, is unfortunate. Walker proposed 19 names, of which 10 are valid, 7 are synonyms and 2 remain doubtful, the valid species including such familiar forms as *Ptilogyna ramicornis*, *Plusiomyia gracilis*, *Ischnotoma par* and *Gynoplistia bella*. Westwood proposed 12 names, 6 being valid, 5 synonyms, while 1 remains of doubtful identity, the valid species including some of the finest of Australian Tipulidae, notably the two species of *Semnotes* described in 1876.

The voyage of the "*Novara*", as reported for the Diptera by Schiner (1868) produced 4 Tipulidae, of which 2 are valid, 2 synonyms. The valid species are somewhat noteworthy, including *Gynoplistia melanopyga* and *Eriocera metallica*. In 1921, through the kind interest of Dr. Hans Zerny, I was enabled to examine the types of these two species and so ascertain the true systematic position of the second named, this being a true *Eriocera*. The Tipulidae of the voyage of the "*Eugénie*" as recorded by Thomson (1869) yielded two species, one of which (*Gymnastes fascipennis*) is valid but, at the same time, unfortunately preoccupied, the name thus requiring replacement by *cordialis* (1887), the sole contribution of Osten-Sacken to the nomenclature of the Australian Tipulidae. Loew (1851) in an unfortunate re-naming of a preoccupied species created a synonym of the already overburdened *Ptilogyna ramicornis.*

2. *The period of Skuse.*

The great pioneer worker on the crane-flies of Australia, Frederick A. A. Skuse, published three papers dealing with this subject, two of which (Proc. Linn. Soc. N.S.W., (2) 4, 1889, 757–892, Pl. 21–24 and (2) 5, 1890, 53–139, Pl. 4–6) are monographic treatments of the two chief subfamilies of the Tipulidae. Skuse proposed 107 names in the Australian Tipulidae, almost all of which are valid, and gave us our first true conception of this very remarkable fauna, as the abundance of the genera *Dolichopeza*, *Limnophila*, *Gynoplistia*, and *Molophilus*, and the definition of many beautiful new Tipuline types, as *Clytocosmus*, *Plusiomyia*, and *Platyphasia.*

For the data included in the following brief account of the life of Skuse, and especially for the opportunity of reproducing what appears to be the only known existing portrait of him, I am very deeply indebted to Mr. Walter W. Froggatt. I take the liberty of quoting parts of a letter from Mr. Froggatt (February 7, 1927), which gives a particularly clear idea of the conditions under which Parts vii and viii of the "Diptera of Australia" were prepared.

"I always considered F. A. A. Skuse one of our best entomologists, and it was a great pity that he got into bad company, personally went 'to the dogs' and died at the age of 33. He commenced life in England as a student in the British Museum of Natural History, and tried to get a position with C. Waterhouse. There being no opening, he got an introduction to Sir Daniel Cooper, the Agent-General in London for New South Wales, who advised him to try this country where he thought there would be openings for Zoologists. He came out to Sydney, arriving early in 1889 or late in 1888. His first record was giving a series of lectures at the Sydney School of Arts on popular Natural History. He was introduced to the Hon. William Macleay, afterwards Sir William Macleay, a wealthy landowner and founder of the Linnean Society of New South Wales. Macleay was a wonderful man and the leading amateur scientific worker in Australia. He helped everybody who wanted to work at Science and kept open house for all visiting scientists. He gave me my opportunity when I came back from an exploring expedition in New Guinea, and helped me in every way. The Macleay Museum was housed at Elizabeth Bay. I collected for it all over Queensland and north-western Australia and in off times was on the staff of the Macleay Museum. I had leave from Sir William on my return from West Australia in 1888, and had a trip to England. On my return early in 1889, I found Skuse installed in the Macleay Museum, working up the Diptera. This was a very fine collection, built up at Macleay's expense, who also sent Skuse on collecting trips round the country for fresh material.

"Skuse and I worked side by side in the old Museum, with Macleay in one corner describing beetles up till 12 o'clock every day. Skuse and I spent all Saturdays and holidays collecting and wandering through the wonderful Hawkesbury sandstone scrub. He was the son of a Church of England parson, he told me, but I don't remember his natal place (must have been born in 1863, from the date of death). A very well educated, handsome, charming young fellow. He was a great worker all the time he was with us in the Macleay Museum, where all his good work was done, and he had a free hand from Macleay to work as he liked. He was there three years.

"A. S. Olliff, another young English entomologist, was promoted from the Australian Museum to the newly-created Department of Agriculture. Skuse applied for the position of Entomologist to the Australian Museum, to which he was appointed in September, 1890. Here he got into bad company and did practically no work of any great value. He died on the 10th of June, 1896, aged 33, in Sydney, a perfect physical wreck. He had married about a year previously, and I believe there was a son born after his death, but Mrs. Skuse married again and I never met her. I have a very good photograph of him taken when he was at his best, about 1889."

One cannot but feel the deepest sorrow and keen regret for the various occurrences that led to the early demise of this highly capable student. From a critical line-by-line study of all of Skuse's publications on the Australian Tipulidae, I would consider him as being one of the most intelligent workers on this group of flies, the equal of Osten-Sacken and Bergroth and the inferior of no one. The photograph here reproduced (Plate ii) was taken when Skuse was about 26 years of age and at the exact period of the preparation of the monographs on the Tipulidae. The present writer has long felt the coincidence that the date of publication of the first part of Skuse's Australian Tipulidae—September 25, 1889—was the date of his own birth in the distant United States.

The different genera and subgenera of Tipulidae described by Skuse have had varied fates. Some (*Lechria*, *Thrypticomyia*) are now known to range widely to the west in the Oriental, or even to the Ethiopian Region. Still others, *Tasiocera*, *Leiponeura* (which equals *Lipophleps* Bergroth), and *Rhabdomastix*, have a much more extensive distribution, including the New World. Certain Tipuline genera (*Clytocosmus*, *Plusiomyia*, *Platyphasia*, *Ischnotoma*) seem to be confined to Australia, but others (*Acracantha*, *Habromastix*) are more widely distributed.

3. *The post-Skusean period.*

Following the passing of Skuse, nothing seems to have been done on the Australian Tipulidae until 1914 when Edwards described *Styringomyia bancrofti*. In 1919 the present writer began a study of the Tipulidae of Australia and Tasmania, resulting in the publication of some 45 titles to the end of 1930, these papers describing as new more than 400 species of Australian Tipulidae. The beautiful *Clytocosmus lichtwardti* was described by Riedel in 1920.

This recent study of the Australian Tipulidae and allied families has added some notable groups to the fauna, including the Tanyderidae and Trichoceridae, the Bruchomyiine Psychodidae, and in the Tipulidae, the subfamily Cylindrotominae, together with such notable genera and subgenera as *Phacelodocera*, *Megistocera*, *Rhipidia*, *Antocha*, *Tonnoiromyia*, *Tonnoirella*, *Horistomyia*, *Skuseomyia*, *Eriocera*, *Elephantomyia*, *Austrolimnobia*, *Cryptolabis* and *Toxorhina*.

DISTRIBUTION.

1. *General facies of the Australian fauna.*

Australia is very rich in autochthonous Tipuline genera, notably the group with branched antennae, as *Clytocosmus*, *Ctenogyna*, *Ptilogyna*, *Platyphasia* and *Plusiomyia*. The closely related *Phacelodocera* has one species in Tasmania, with one other in Brazil. Other noteworthy groups of Australian Tipuline crane-flies are *Semnotes* and *Leptotarsus*, with allies in Chile; *Acracantha*, in New Zealand and Chile; *Habromastix*, in South Africa and southern South America; *Macromastix*, in New Zealand, New Caledonia, Chile, and fossil in Baltic amber. Other autochthonous genera in this subfamily include *Phymatopsis* and *Ischnotoma*. Major Tipuline groups that have invaded the continent only in the extreme north are *Tipula*, *Nephrotoma* and *Ctenacroscelis*, represented here only by a mere fraction of their total vast numbers. The genus *Dolichopeza* is very rich in species, with allied forms in New Zealand but not in Chile. The origin of these Australian species of *Dolichopeza* is doubtful, since their nearest relatives in the Malayan region are members of other subgenera, as *Nesopeza* and *Mitopeza*. The occurrence of a single species of *Brachypremna* in north Queensland is a matter of note, as all other members of the genus are from the New World. *Megistocera* is represented by a single widespread Austro-Malayan species.

The Cylindrotominae have only the endemic genus *Stibadocerodes*, allied to the Oriental genera *Stibadocera* and *Stibadocerella*, and to the Chilean genus *Stibadocerina*. The great genus *Limonia* has several very characteristic subgenera, notably *Dicranomyia* and *Geranomyia*. *Limonia*, s.s., and *Rhipidia* are represented by comparatively few species, although with hosts of forms elsewhere in the world. *Discobola* is worthy of special mention, since the single species has its near allies in New Zealand, but not in Chile. Austro-Malayan elements in *Limonia* are found in the subgenera *Thrypticomyia*, *Pseudoglochina* and *Libnotes*. *Dapanoptera* is a southern representative of a highly characteristic Papuan group, while *Idioglochina* has two species on the Queensland coast, with numerous others on many of the Pacific islands, probably all of which are marine in habit. The genus *Helius* has two subgenera, one, the typical subgenus, having representatives in all the major regions of the globe, including New Zealand, the other, *Eurhamphidia*, being more essentially Austro-Malayan. *Antocha* has only the subgenus *Orimargula*. *Orimarga* is represented only by the typical subgenus. The isolated genus *Tonnoiromyia*, with two species in south-eastern Australia and one other in Chile, is of the greatest interest from the standpoint of distribution.

The genus *Lechria*, described from Australia, is now known to be a highly characteristic Austro-Malayan group. The Pediciini has only a single genus, *Tricyphona*, with two species in Australia, one being from the east, the other from the west. Three additional species occur in New Zealand, with a few others in southern Chile and Patagonia. The primitive Hexatomini, such as *Austrolimnophila*, are represented by several showy species, though not so well developed in species as either New Zealand or Chile. Autochthonous Hexatomine genera include several notable types, as *Tonnoirella*, *Horistomyia*, *Bergrothomyia*, *Skuseomyia* and *Diemenomyia*. *Limnophila* and *Epiphragma* have rather numerous Australian representatives. *Ischnothrix* is of great interest, having several species in Australia, New Zealand and South America. The most characteristic Antarctogaean genus of crane-flies is *Gynoplistia*, with five subgenera, four of which occur in Australia. Of these *Xenolimnophila* is endemic; *Cerozodia* is found only in Western Australia and in New Zealand; *Paralimnophila* reaches its greatest development in eastern Australia, where occur species with simple antennae, as well as others showing the greatest development of antennal flabellation so far found in the subgenus; elsewhere *Paralimnophila* has only representatives with simple antennae, there being a few in New Zealand, several in Chile, while one, *G.* (*P.*) *conspersa* (Enderlein), reaches southern Brazil, where it is associated with some other crane-fly groups that are otherwise known only from south-eastern Australia (as *Phacelodocera*). The typical subgenus, *Gynoplistia*, is tremendously developed throughout the Australasian region, with several forms in Australia, many more in New Zealand, and with fewer species in the Papuan subregion as far west as Celebes, and still others in Chile. The abundant and widespread genus *Eriocera* has four species only. *Elephantomyia* is represented by the typical subgenus in the south, with closely allied species in New Zealand and Chile, and by the subgenus *Elephantomyodes* in the north, this representing a characteristic Austro-Malayan element.

In the Eriopterini, *Conosia* has a single species with a wide range in the palaeotropics. *Austrolimnobia* is endemic, with two species in Victoria and Tasmania. *Gonomyia* has but two of the five recognized subgenera, these being the vast group *Lipophleps*, together with *Ptilostena* occurring only in the north-east. Other elements that have entered the continent from the north include *Teucholabis*, *Gymnastes*, *Trentepohlia*, *Styringomyia* and *Toxorhina*, the latter with the single subgenus *Ceratocheilus*. The most characteristic genus of small crane-flies in Australia is *Molophilus*, with some 150 species already described and many others awaiting discovery. This genus is almost equally well developed in New Zealand and in the Chilean region, indicating an Antarctic origin for the group. *Tasiocera*, with several species in Australia and almost equal numbers in New Zealand but only a few elsewhere in the world, deserves special mention as being one of the most characteristic genera of small crane-flies in the fauna. *Cryptolabis*, *Amphineurus* and *Rhabdomastix* have evidently been dispersed over the former Antarctic continent, since all have closely allied forms in southern Chile. *Erioptera* has two isolated species (*amabilis* and *delectabilis*) in south-eastern Australia, with other more normal species in the east, these latter elements having evidently been derived from the north. *Trimicra* is represented by one or possibly more species that have been generally identified with the wide-spread *pilipes* of Europe, but which may prove to be distinct when more carefully examined.

The details of distribution of the various components of the Australian crane-fly fauna is best shown by the accompanying tabular arrangement.

2. *Comparison of the Tipulid fauna of Australia and New Zealand.*

One of the greatest surprises in a study of the Diptera of Australasia is the almost total distinctness of the species occurring in Australia and in New Zealand, the chief exceptions being in those groups that are spread through the agency of man. As regards the Tipulidae, no single species is known from both these areas, the nearest approach being in groups such as *Trimicra*, where the specific limits are not well understood.

At the time of issue of Tillyard's "Insects of Australia and New Zealand", 1926, only 250 species of Tipulidae were known from Australia and Tasmania, as contrasted with 500 species described from New Zealand. Intensive collecting in the past five years has remedied this deficiency for the continental area, there now being nearly 600 species known from Australia, while the fauna of New Zealand has remained nearly at the former figure. It is certain that the Commonwealth will be found to have a Tipulid fauna greatly exceeding in numbers of genera and species that of New Zealand, although this preponderance will by no means be proportional to the relative size of the areas.

A brief contrast of the two regions is of much interest.

Australia is characterized by a great development of genera of Tipulinae having branched antennal segments (*Clytocosmus*, *Plusiomyia*, *Platyphasia* and others), these having no counterpart in the Maorian subregion. This latter area is also lacking in several important widespread to cosmopolitan genera that have

	Australasian.			Orien-tal.	Ethio-pian.	E. Palae-arctic.	W. Palae-arctic.	Nea-arctic.	Neotropical.	
Group.	Aus-tralia.	New Zea-land.	Pa-puan.						Extra-Chilean.	Chilean.
Tipulinae										
Clytocosmus ..	*									
Ctenogyna ..	*									
Ptilogyna	*									
Plusiomyia ..	*									
Phacelodocera ..	*								*	
Platyphasia ..	*									
Ischnotoma	*									
Acracantha ..	*	*								
Leptotarsus ..	*									*
Semnotes	*									
Phymatopsis ..	*									
Habromastix ..	*				*				*	
Macromastix ..	*	*	*	*						*
Ctenacroscelis ..	*		*	*	*	*				
Tipula	*		*	*	*	*	*	*	*	*
Nephrotoma ..	*		*	*	*	*	*	*	*	
Megistocera ..	*		*	*	*			*	*	
Brachypremna ..	*							*	*	
Dolichopeza, s.s. ..	*	*			*		*	*		
Cylindrotominae										
Stibadocerodes ..	*									
Limoniinae										
Limoniini										
Limonia										
Limonia ..	*	*	*	*	*	*	*	*	*	*
Discobola ..	*	*		*		*	*	*	*	
Dicranomyia ..	*	*	*	*	*	*	*	*	*	*
Rhipidia ..	*			*	*	*	*	*	*	
Geranomyia ..	*			*	*	*	*	*	*	*
Thrypticomyia ..	*		*	*	*	*				
Libnotes	*		*	*	*	*				
Dapanoptera ..	*		*							
Idioglochina ..	*	*	*	*		*				
Pseudoglochina ..	*			*						
Helius										
Helius	*	*		*	*	*	*	*	*	
Eurhamphidia ..	*			*	*					
Antocha										
Orimargula ..	*			*	*	*	*			
Orimarga										
Orimarga ..	*		*	*	*	*	*	*	*	
Tonnoiromyia ..	*									*
Lechriini										
Lechria	*			*						

	Australasian.			Oriental.	Ethiopian.	E. Palaearctic.	W. Palaearctic.	Nearctic.	Neotropical.	
Group.	Australia.	New Zealand.	Papuan.						Extra-Chilean.	Chilean.
Pediciini										
Tricyphona	*	*		*		*	*	*		*
Hexatomini										
Austrolimnophila	*	*								*
Epiphragma	*			*		*	*	*	*	
Tonnoirella	*									
Horistomyia	*									
Limnophila	*	*	*	*	*	*	*	*	*	*
Bergrothomyia	*									
Skuseomyia	*									
Diemenomyia	*									
Ischnothrix	*	*								*
Gynoplistia										
Gynoplistia	*	*	*							*
Cerozodia	*	*								
Xenolimnophila	*									
Paralimnophila	*	*								*
Eriocera	*			*	*	*		*	*	
Elephantomyia										
Elephantomyia	*	*		*	*	*	*	*	*	*
Elephantomyodes	*			*						
Eriopterini										
Conosia	*			*	*	*	*			
Austrolimnobia	*									
Gonomyia										
Lipophleps	*	*	*	*	*	*		*	*	
Ptilostena	*			*	*	*	*	*		
Teucholabis	*			*	*	*		*	*	
Gymnastes										
Paragymnastes	*									
Trentepohlia										
Mongoma	*			*	*	*				
Trentepohlia	*			*	*	*	*			
Rhabdomastix										
Rhabdomastix	*			*					*	*
Sacandaga	*	*				*	*	*	*	
Erioptera, s.s.	*			*	*	*	*	*	*	*
Molophilus	*	*		*	*	*	*	*	*	*
Cryptolabis, s.s.	*							*	*	*
Tasiocera	*	*		*	*					*
Amphineurus										
Amphineurus	*	*								*
Trimicra	*	*		*	*	*	*	*	*	*
Styringomyia	*			*	*	*			*	
Toxorhina										
Ceratocheilus	*	*	*	*	*				*	

invaded Australia only in the north (*Tipula, Nephrotoma, Megistocera*). Other important Tipuline genera of Australia that do not occur in New Zealand include *Semnotes, Leptotarsus, Ischnotoma* and *Habromastix*. Important Tipuline genera common to the two areas include *Dolichopeza, Acracantha* and *Macromastix*. The most important Tipulinae in New Zealand having no vicarious representatives in Australia are found in the genus *Zelandotipula* (which is evidently distinct from *Ctenacroscelis*, being more nearly allied to certain Chilean species of *Holorusia*) and in three noteworthy subgenera of *Macromastix*—*Chlorotipula*, including the familiar green crane-flies of New Zealand; *Aurotipula*, the equally conspicuous orange and black species; and the more isolated *Maoritipula*. The relationship of the New Zealand *Hudsonia* to the Australian *Phymatopsis* seems to be very close.

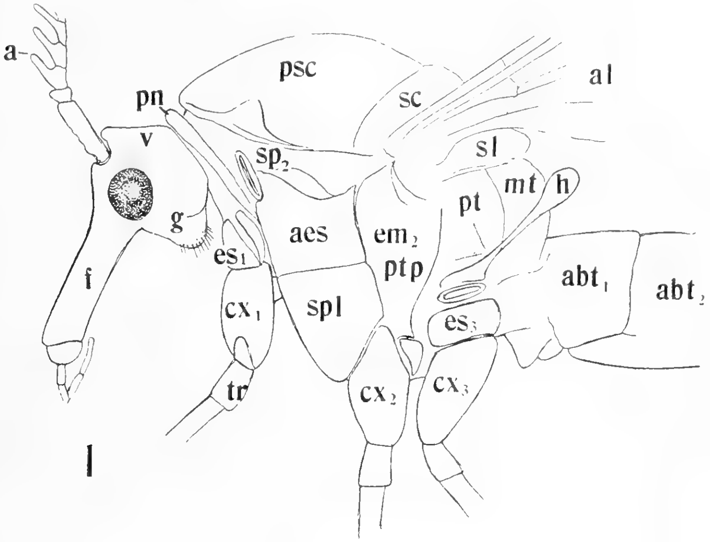
The Cylindrotominae (*Stibadocerodes*) and Lechriini (*Lechria*) of the Australian fauna have no representatives in New Zealand.

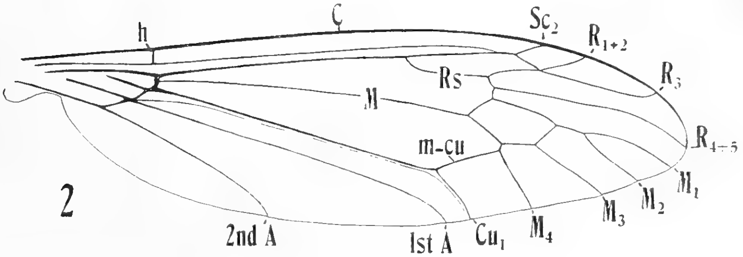
The remaining four tribes of Limoniinae are rather proportionately developed in the two regions. Australia has ten subgenera in the great genus *Limonia*, whereas New Zealand has but five, of which *Discobola, Dicranomyia* and *Zelandoglochina* are especially characteristic, the last having no representatives in Australia. Of the remaining four subtribes of Limoniini in the Commonwealth, only one, the Heliaria, with a single species of *Helius*, is found in New Zealand. The Pediciini are of great interest in that a few closely allied species of *Tricyphona* occur in the two regions, with still others in Chile. The Hexatomini have a number of characteristic genera common to the two regions, notably *Austrolimnophila, Limnophila, Ischnothrix, Gynoplistia* and *Elephantomyia*. Each of the regions possesses a number of isolated Hexatomine types, Australia having such genera as *Tonnoirella, Horistomyia, Bergrothomyia, Skuseomyia* and *Diemenomyia*, while New Zealand has *Rhamphophila, Tinemyia, Nothophila, Metalimnophila* and *Harrisomyia*. Australia has in *Eriocera* a few species of the subtribe Hexatomaria, the group being quite absent from New Zealand.

The Eriopterini of the two regions have several features in common, notably the vast development of the two groups *Molophilus* and *Tasiocera*. Other common features lie in the possession of such groups as *Gonomyia* (subgenus *Lipophleps*), *Rhabdomastix* (*Sacandaga*), *Toxorhina* (*Ceratocheilus*), and the typical subgenus of *Amphineurus*. Australia has gained several immigrant genera from the north that are quite lacking in New Zealand, such elements being found in *Conosia, Teucholabis, Gymnastes, Trentepohlia* and *Styringomyia*. The isolated genera *Astelobia* and *Aphrophila* are found in New Zealand and again in Chile, but not in Australia or Tasmania, being relicts of the penultimate Antarctic land-connection, as postulated by Tillyard. One species of *Erioptera* (*Empeda*) in New Zealand has no representative yet discovered in Australia. Other isolated Eriopterine groups in New Zealand are *Campbellomyia* and some peculiar subgenera of *Amphineurus*, as *Nesormosia* and *Nothormosia*. On the other hand, Australia has scarcely any endemic Eriopterine genera, the most notable being *Austrolimnobia*.

GENERAL MORPHOLOGY.

Following the plan of the present series of papers, it is not deemed necessary to enter into any detailed discussion of morphological terminology. A wealth of literature is now available to the interested student, a score of titles being provided that cover the various regions of the insect body. These papers are selected with special reference to their direct citations to the Tipuloidean flies. For all general purposes, the excellent discussion of Dipterous morphology given by Tillyard ("Insects of Australia and New Zealand", 1926, pp. 333–341, figs. W_1–W_{13}) will provide ample information. The general features of morphology of the head and thorax of *Clytocosmus*, together with the venation of the same, are shown in the accompanying text-figures.





Text-figs. 1, 2.

1.—Lateral aspect of body of *Clytocosmus helmsi* Skuse.—*a*, antenna; *abt*, abdominal tergite; *aes*, anepisternum (mesepisternum); *al*, wing; *cx*, coxa; *em*, epimeron; *es*, episternum; *f*, frons; *g*, gena; *h*, halter; *mt*, postnotal mediotergite; *pn*, pronotum; *psc*, praescutum; *pt*, postnotal pleurotergite; *ptp*, pteropleurite (mesepimeron); *sc*, scutum; *sl*, scutellum; *sp*, spiracle; *spl*, sternopleurite (mesepisternal katepisternum); *tr*, trochanter; *v*, vertex.

2.—Wing of *Clytocosmus helmsi* Skuse.—A, anal veins; C, costa; Cu, cubitus; h, humeral crossvein; M, media; m-cu, medial-cubital crossvein; R, radius; Rs, radial sector; Sc, subcosta.

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SYSTEMATIC REVIEW OF THE TIPULIDAE.

The remainder of the present paper, as well as the series to follow, will be devoted to a systematic treatment of the Australian species of crane-flies. The keys provided at this time include only those to the subfamilies, the genera of the subfamily Tipulinae, and the species of the genus *Clytocosmus*.

Key to the subfamilies of Tipulidae.

1. Last segment of maxillary palpus elongate, whiplash-like; nasus usually distinct; antennae with not more than 15, usually with 13, segments; wings with Sc_1 usually obliterated, Sc thus apparently ending in R; vein Cu_1 constricted at m-cu, the latter close to the fork of M_{3+4}, or more distad on M_4 .... Tipulinae

   Last segment of maxillary palpus short, subequal to the others; no nasus; antennae with fewer than 13 segments (*Eriocera*) or with from 14 to 39 segments; wings with Sc_1 preserved, Sc thus ending in C; m-cu in most cases at, before or only a short distance beyond the fork of M, only very rarely at the fork of M_{3+4} (*Skuseomyia*); Cu_1 not constricted at point of insertion of m-cu 2

2. Wings having r-m connecting with Rs at or before the fork; extreme tip of R_{1+2} atrophied, producing the appearance of a long apical fusion of vein R_{1+2+3} back from the margin .... Cylindrotominae
Wings having r-m connecting with R_{4+5} or R_5 beyond the fork of Rs (except in *Helius: Eurhamphidia*); no appearance of a long apical fusion of vein R_{1+2+3} back from the margin .... Limoniinae

Various exceptions to the above statements are to be found. *Phymatopsis brevipalpis* Alexander, has the terminal segment of the maxillary palpus short. Many genera of Tipuline crane-flies in the Australian fauna lack the nasus. *Semnotes* and *Leptotarsus* have only 8 to 10 antennal segments.

Several species of subapterous Tipulidae have been found in Australia. Their subfamily positions may be determined by the non-venational characters outlined above. The species with vestigial wings so far discovered in the Commonwealth fall in the following genera.—Tipulinae: *Plusiomyia* Skuse, *Phymatopsis* Skuse, *Macromastix* Osten-Sacken; Limoniinae: *Limnophila* Macquart, *Gynoplistia* (*Xenolimnophila* Alexander), *Molophilus* Curtis.

As a general rule, only the female sex is subapterous, the condition involving the males only in *Xenolimnophila* among the known species.

Key to the genera of Tipulinae.

1. Wings with cell 1st M_2 open by the atrophy of the basal section of M_3, giving a pectinate appearance to the medial field .... *Dolichopeza* Curtis
Wings with cell 1st M_2 closed 2
2. Wings with r-m before the fork of Rs; R_{2+3} almost perpendicular at origin and angularly bent at near midlength; vein M_4 at base directed proximad to point of union with m-cu .... *Megistocera* Wiedemann
Wings with none of the venational characters listed 3
3. Wings with Sc very long, Sc_1 preserved, separated on costa from the free tip of Sc_2 by a distance about equal to one-half the latter; R_3 nearly perpendicular; cell 2nd A reduced to a linear strip .... *Brachypremna* Osten-Sacken
Wings without the above combination of characters; Sc_1 usually atrophied and cell 2nd A wide 4
4. Wings with vein M_{3+4} lacking, vein M_4 leaving directly from the end of vein M at or before the level of the remaining elements of the cord; Rs short and nearly transverse, simulating a crossvein, in approximate transverse alignment with the other elements of the cord .... *Nephrotoma* Meigen
Wings with M_{3+4} present, M forking into the two elements M_{1+2} and M_{3+4}; Rs longer, not simulating a crossvein 5
5. Vein R_3 bent strongly caudad at near midlength, so cell R_3 is strongly narrowed at this point (least constricted in *C. aberrans* Alexander) .... *Ctenacroscelis* Enderlein
Vein R_3 nearly straight, gently sinuous, or gently curved throughout its entire length, not as above 6
6. Antennae with a certain number of definitely branched segments (male); in the female with the tendency more reduced to a subpectinate or subserrate condition 7
Antennae without definitely branched segments in the males, simple or nearly so in the females (compare some *Ischnotoma* species, couplet 14) 13
7. Antennae with a single branch on each of flagellar segments 2 to 8 .... *Platyphasia* Skuse
Antennae with two or three branches on individual basal flagellar segments 8
8. Wings with r-m obliterated by the fusion of vein R_{4+5} on M_{1+2} .. *Ptilogyna* Westwood
Wings with r-m present 9
9. Antennae with three pectinations on individual flagellar segments, two being basal, one more apical, being placed at or beyond midlength of the segment 10
Antennae with not more than two pectinations, both basal 11
10. Antennae flabellate, flagellar segments 2 to 9 with three very long branches, the single outer branch only a little shorter than the basal branches .... *Phacelodocera* Enderlein

Antennae long-pectinate to short-pectinate, scarcely flabellate; the single outer branch is usually a mere tubercle, in its greatest development (*P. clarki* Alexander) not exceeding two-thirds the basal branch .... *Plusiomyia* Skuse (in part)
11. Anterior vertex and front in direct alignment; frontal prolongation of head long and slender; nasus lacking 12
Frontal prolongation of head short, meeting the remainder of head at an acute angle; nasus present but short and stout .... *Ctenogyna* Macquart
12. Legs relatively short and stout; terminal simple segments of antennae with numerous very long verticils that much exceed the segments in length .... *Clytocosmus* Skuse (in part)
Legs long and slender; terminal simple segments of antennae with relatively inconspicuous verticils that are shorter than the segments .... *Plusiomyia* Skuse (in part)
13. A certain number of enlarged basal antennal flagellar segments, the terminal segments abruptly more slender, long-cylindrical 14
Terminal flagellar segments of antennae not differing in general form from the basal ones 16
14. Terminal segments of antennal flagellum with long conspicuous verticils that exceed the segments in length 15
Terminal segments of antennal flagellum without long verticils, these being shorter than the segments .... *Ischnotoma* Skuse (in part)
15. Frontal prolongation of head elongate, in alignment with the anterior vertex, without nasus; legs relatively stout .... *Clytocosmus* Skuse (in part)
Frontal prolongation of head short and stout, with a conspicuous nasus; legs long and slender .... *Acracantha* Skuse
16. Antennae with only 8 to 10 segments 17
Antennae with from 12 to 14 segments 19
17. Antennae with not more than 8 segments; first segment of scape elongate, about two-fifths the entire antenna; first flagellar segment enlarged; maxillary palpus with short terminal segment .... *Semnotes* Westwood
Antennae with 9 or 10 segments; first segment of scape shorter, not exceeding one-third the entire antenna; first flagellar segment not more conspicuously enlarged than the succeeding segments .... (*Leptotarsus* Guérin) 18
18. Cell M_1 of wings lacking; antennae 9-segmented .... Subgenus *Pseudoleptotarsus* Alexander
Cell M_1 of wings present; antennae 10-segmented .... Subgenus *Leptotarsus* Guérin
19. Nasus lacking 20
Nasus present 21
20. Antennae short in both sexes .... *Phymatopsis* Skuse
Antennae elongate in male, subequal to entire body, in female shorter, about equal to the thorax alone .... *Habromastix* Skuse
21. Male hypopygium of simple structure; female with fleshy valves to ovipositor (both cerci and hypovalvae) .... *Macromastix* Osten-Sacken
Male hypopygium incrassated; ovipositor of female with chitinized valves 22
22. Wings with vein R_3 straight, in alignment with R_{3+3}; cell 2nd A narrow; claws of male toothed .... (Australian species of subgenus *Acutipula* Alexander) *Tipula* Linnaeus
Wings with vein R_3 usually more or less arcuated; if more nearly straight, then cell 2nd A wide; claws simple in both sexes .... *Ischnotoma* Skuse (in part)

The subapterous Tipuline genera may be separated by the following supplementary key. As indicated before, only females show this condition.

1. Flagellar segments more or less branched .... *Plusiomyia* Skuse
Flagellar segments simple 2
2. Ovipositor with the valves (cerci and hypovalvae) long and chitinized .... *Phymatopsis* Skuse
Ovipositor with the valves (cerci and hypovalvae) blunt and fleshy .... *Macromastix* Osten-Sacken

The only species of *Plusiomyia* with reduced wings are two found in the mountains of Tasmania. All members of the typical group of larger species of *Phymatopsis* have almost wingless females. The subapterous species of

Macromastix include the nearly wingless females of such species as *M. fergusoni* Alexander, *M. luteicosta* Alexander, and others.

CLYTOCOSMUS Skuse.

Skuse, PROC. LINN. SOC. N.S.W., (2) 5, 1890, 72 (generic key), 74–76 (generic diagnosis).—Alexander, *Ibid.*, 45, 1920, 184–185 (species key).—Alexander, *Mem. Queensland Mus.*, 7, 1920, 53.—Riedel, *Arch. f. Naturg.*, 85 A, Heft 4, 1920, 85–88 (discussion of generic limits).—Alexander, *Ann. Mag. Nat. Hist.*, (9) 9, 1922, 159–160 (species key).—Pierre, *Genera Insectorum*, Fasc. 186, 1926, 7 (generic key), 49 (generic diagnosis).—Alexander, PROC. LINN. SOC. N.S.W., 52, 1927, 58, fig. 44 (venation of radial field).

Pierre (*l.c.*) has keyed and defined the genus to include only the male sex of the genotype, *helmsi*. By this work it would be impossible to identify other species of the genus.

Generic characters.—Body unusually stout. Head prolonged into a long trunk-like rostrum, without nasus; plane of the front and vertex meeting at about a right angle, the front and rostrum in direct alignment. Antennal fossae close together at summit of vertex. Eyes relatively small, protuberant, with fine ommatidia. Genal region tumid and provided with a group of long yellow setae. The antennae are 13-segmented in the male, 13, or usually, 14-segmented in the female, with a certain number of enlarged basal flagellar segments, the greatest number of these being nine (*helmsi*), the smallest three (*lichtwardti*). In *helmsi* (male) these segments bear two conspicuous, strongly divergent, terminal branches; in *helmsi* (female) and *tillyardi* (both sexes) the basal segments are weakly bilobed; in *edwardsi* (both sexes) and *lichtwardti* (both sexes) the segments are merely obtusely rounded beneath, without bilobing. Terminal flagellar segments elongate-cylindrical, much more slender than the basal segments, with long conspicuous verticils. Both sexes of all species have on the enlarged basal segments, numerous subhyaline punctures that are set with microscopic setae; these punctures are most abundant on the pectinations and lobes of the segments, becoming few in number on the outermost modified segment.

Legs relatively short and stout. Venation (Text-fig. 2): Sc_1 lacking; Sc_2 with its free tip longer than the fusion of Sc_2 and R_1; R_2 obliterated by a short fusion of R_1 with R_{2+3} before the fork of the latter; cell M_1 short-petiolate; basal section of M_{3+4} longer than the basal section of M_3, the fork of M_{3+4} thus being at or beyond midlength of cell 1st M_2. Veins C, Sc and R with small macrotrichia, the other veins with the trichia very reduced in size and number. Postnotal pleurotergite produced into a conspicuous compressed tubercle immediately before the halteres. Male hypopygium (Text-figure 4) of primitive structure. Tergite (*t*) a depressed plate, the caudal margin with a small U-shaped median notch, the broad lobes thus formed subtruncate or with the margins sinuous; apex of tergite densely set with abundant setae. Basistyles (*b*) relatively long and slender, the outer face provided with very abundant delicate setae. Outer dististyle a flattened ear-like lobe. Inner dististyle (*id*) at base produced into a flange that is set with numerous small squat black spines that are arranged more or less in a semicircle around the margin of the basal extension. Ovipositor with the cerci long and slender, straight; hypovalvae appearing as shorter, powerful, compressed blades.

Genotype, *Clytocosmus helmsi* Skuse (by monotypy).

The peculiar antennae, with a certain number of enlarged flagellar segments that are followed by cylindrical ones bearing unusually long, conspicuous verticils, are also found in *Acracantha* Skuse (Australia, New Zealand) and *Elnoretta* Alexander (Chile).

Geographical distribution.—Almost all of the known species are surprisingly local in range, all being known from but a single State of the Commonwealth. The most widely distributed, as known, is *C. edwardsi*, which has an extensive range in southern Victoria, from the Dandenong Ranges east to Gippsland. The other species are more restricted, *helmsi* being known only from Mt. Kosciusko in southern New South Wales; *tillyardi* from the Dorrigo Plateau in northern New South Wales, while *lichtwardti* has been taken only near Herberton, North Queensland. It will be very interesting to determine which species frequents the Blue Mountains, the Barrington Tops, the Macpherson Range and other intermediate stations in the known range of the genus.

Seasonal distribution.—The species are on the wing in late Summer and Autumn.

General observations.—The large heavy body of these superb crane-flies has impressed different observers in different manners. Tillyard, writing of *C. tillyardi*, was struck by a resemblance to a large robber-fly. Wilson wrote concerning *C. edwardsi* that "when flying, it resembles more one of the large yellow and black Pompilid wasps than a Cranefly". From Wilson's observations regarding this last species, as quoted later in this review, it seems certain that the immature stages are spent in and near the margins of mountain streams. It is to be hoped that the larvae and pupae of this fly will soon be made known. Dr. G. Chester Crampton has in preparation a complete morphological treatise on *Clytocosmus tillyardi* that may well serve as a basis for all future work on this subject for the Australian fauna. A comparable study of the early stages would thus become of especial value.

Key to the Species of Clytocosmus.

1\. Males 2

Females 5

2\. Stripes of mesonotal praescutum orange; antennae with the basal nine flagellar segments enlarged, each with two conspicuous branches .... *helmsi* Skuse

Stripes of mesonotal praescutum black; antennae with not more than seven enlarged flagellar segments, none with distinct branches 3

3\. Basal three flagellar segments subpyriform; abdomen black, tergites two and three orange .... *lichtwardti* Riedel

Antennal flagellum with from five to seven enlarged segments; abdomen with the orange pattern on basal tergites lacking or reduced to a ring on the second segment 4

4\. Abdominal tergites black and white, only the genital segments brightening to orange; antennae with five enlarged segments, these with the lower face merely rounded .... *edwardsi* Alexander

Abdominal tergites black and white, the base of the second segment narrowly ringed with orange; antennae with seven or eight enlarged segments, the basal five or six weakly bilobed .... *tillyardi* Alexander

5\. Stripes of mesonotal praescutum black; antennae with only three enlarged flagellar segments .... *lichtwardti* Riedel

Stripes of mesonotal praescutum orange; antennae with at least five enlarged flagellar segments 6

6\. Prothorax, mesonotal scutellum and postnotum black; thoracic pleura black, spotted with white; antennae with eight or nine enlarged flagellar segments, all but the ultimate ones of which are bilobed .... *helmsi* Skuse

Prothorax, mesonotal scutellum and postnotum orange; thoracic pleura orange, spotted with white; antennae with not more than eight enlarged flagellar segments, none of which is bilobed 7

7\. Abdominal tergite two with its basal ring orange; tergite seven orange; antennae with seven or eight enlarged flagellar segments, all but the ultimate cordiform, strongly produced beneath .... *tillyardi* Alexander

Abdominal tergites one to seven black, spotted with white, without orange markings; antennae with four or five enlarged flagellar segments, all but the ultimate merely rounded beneath .... *edwardsi* Alexander

The above key illustrates the striking colour dimorphism found in certain of the species. *Clytocosmus helmsi* and *C. lichtwardti* have the sexes generally similar in coloration, but *C. edwardsi* and *C. tillyardi* are entirely dissimilar, having nearly black males and chiefly orange females. This sexual dimorphism led me into the error of describing the black males of *C. tillyardi* as a supposed new species which was defined as *C. skusei.*

CLYTOCOSMUS HELMSI Skuse.

Skuse, PROC. LINN. SOC. N.S.W., (2) 5, 1890, 76–77, plate 4, fig. 5 (adult male); 5*a*, male antennae; 5*b*, apex of same; 5*c*, head, lateral aspect; 5*d–f*, female antennae, with details.—Alexander, *Ibid.*, 45, 1920, 184.—Alexander, *Ann. Mag. Nat. Hist.*, (9) 9, 1922, 160.—Pierre, Diptera, Tipulidae, Tipulinae, Genera Insectorum, Fasc. 186, 1926, 49, plate 5, fig. 9 (wing), fig. 10 (male antennae), fig. 11 (female antennae).

Sexes generally alike in colour; antennae of both sexes (Plate ii, figs. 1, 2) with nine (rarely eight in female) enlarged flagellar segments, those of male with two conspicuous apical branches, of the female merely bilobed; ground-colour of mesonotal praescutum and scutum orange, with four scarcely differentiated darker orange stripes; cephalic portion of praescutum more or less suffused with blackish; scutellum, postnotum and pleura black, variegated with silvery-white areas; abdomen black, variegated with conspicuous silvery-white areas, the genital segments of both sexes orange.

The antennae (male) show the greatest development of pectination of any of the discovered species. The first nine flagellar segments each bear two conspicuous branches, apical in position; basal segment stout-based, the succeeding segments more slender, their bases shorter than the branches except on the ninth segment, where the branches are shorter and tend to be unequal in length; tenth flagellar segment elongate-cylindrical, simple, with numerous conspicuous setae that are more than one-third the length of the segment; terminal segment short, subconical. In the female, the antennae have thirteen or fourteen segments, the basal eight or nine flagellar segments enlarged, with all but the last of these weakly and asymmetrically bilobed, the segments being conspicuously produced on the ventral face into a cylindrical lobe; on the first and again on the outer segments these lobes become smaller and more obtuse; last enlarged segment with a simple lobe; terminal three segments cylindrical, the last elongate-cylindrical, all with long conspicuous setae. It seems probable that there is a terminal button-like segment, not indicated in my material, in which case the organ in this sex would have as many as fifteen segments in certain individuals.

Distribution.—Skuse described this superb fly from three specimens, representing both sexes taken at Moonbar, Mt. Kosciusko, altitude 3,000–3,500 feet, in March, by Mr. R. Helms. The types are preserved in the collection of the Australian Museum, Sydney. The only subsequent records of occurrence of the species seem to be at various altitudes on Kosciusko. Nicholson took specimens at altitudes as high as 5,500 feet in February, as described in his account of the species later in the present paper. Other material has been taken at 5,000 feet (February 4, 1929, Tillyard) and 4,000 feet (L. Harrison).

Observations.—The following account of the occurrence and habits of this fly are contained in a letter from Dr. A. J. Nicholson, dated November 15, 1927.

"With regard to your inquiries about *Clytocosmus helmsi.* I found this insect on Mount Kosciusko at a height of about 5,500 feet, where it was extremely common. The country may be described as a mountain heath; it is practically treeless, slightly marshy in places and is covered with small low-growing bushes which appear to correspond ecologically with the heaths and heathers of the Holarctic Region. *C. helmsi* appears to be commonest amongst the bushes near small streams, but this may be due to the fact that most of the collecting was carried out in such situations. It was very noticeable that while this insect was very common at 5,500 feet, it was quite scarce at 5,000 feet in similar country. This I believe to be due to the modifying influence of altitude on the season, for earlier in the year Prof. Harrison found *C. helmsi* in large numbers at about 4,000 feet. It is very noticeable here that the period during which a particular species of insect appears at a given altitude is very short in the mountainous regions.

"As you may imagine, *C. helmsi* is very conspicuous when alive, whether flying or settled. Its flight is clumsy and slow; the body hangs vertically and the rapidly vibrating wings appear only with difficulty to be able to support the ungainly body and propel it with a slow drifting motion through the air. While flying, the long and conspicuous legs are spread out to their full extent and execute slow waving movements. When settled, the insect appears to be always found in the most conspicuous possible situation. Usually it settles near the top of a plant and fully exposed on the outside, and its conspicuous coloration attracts attention to it immediately. The wings are folded over the back, as is shown in the photograph I am inclosing. The photograph is a flashlight taken at night of the insect in its natural environment. It is quite typical of the exposed situation of the resting insect, whether by day or night." I am very greatly indebted to Dr. Nicholson for the privilege of reproducing this unusually fine photograph (Plate ii, fig. B).

CLYTOCOSMUS EDWARDSI Alexander.

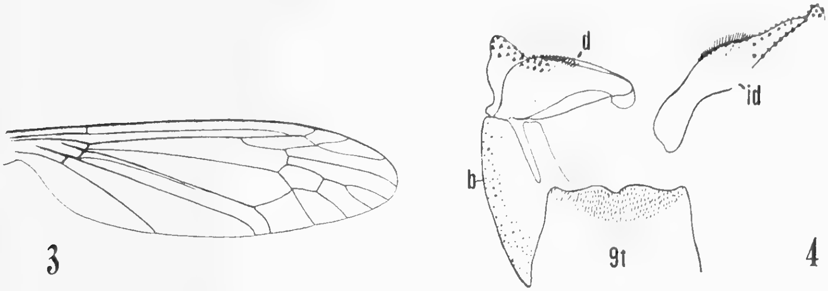
Alexander, *Ann. Mag. Nat. Hist.* (9), 9, 1922, 158–159.—Pierre, Diptera, Tipulidae, Tipulinae, Genera Insectorum, Fasc. 186, 1926, 49.—Wilson *Vict. Nat.*, 46, 1929, 91–92.

Sexes dissimilar in coloration, the males having the thoracic pattern (both dorsum and pleura) black and silvery-white, the females with the black colours replaced by orange; abdomen black, variegated with silvery-white spots, the genital segments of both sexes orange; antennae of both sexes (Plate ii, figs. 4, 5) identical or nearly so, there being five enlarged flagellar segments that are merely rounded on their lower face.

Antennae almost identical in structure in the two sexes; five enlarged flagellar segments that gradually decrease in size outwardly, the last being only a little thicker than the simple segment beyond; verticils of the enlarged segments decreasing slightly in length and becoming more numerous on the outer segments, on the simple outer segments being very long and numerous.

In some specimens of *edwardsi*, the first scapal segment of the male antenna is black, while in others it is orange, as is the case in the other species of the genus.

The wing (Text-fig. 3) and male hypopygium (Text-fig. 4) are figured.



Text-figs. 3,4.
3.—Wing of *Clytocosmus edwardsi* Alexander.
4.—Male hypopygium of the same; dorsal aspect.—b, basistyle; d, dististyles; id, inner dististyle; t, tergite.

Distribution.—*Clytocosmus edwardsi* is widely distributed in the mountains and fern-gullies of Victoria, appearing on the wing in late Summer and Autumn. The following records are available from various sources:

Dandenong Ranges (National Museum, Melbourne); Ferntree Gully, March 21, 1908 (National Museum, Melbourne); Monbulk (ex Brunetti collection, in the British Museum); mountains above Millgrove, on Mt. Donna Buang from altitudes of 450 feet to 3,800 feet, March, April (Wilson); Kinglake, May 12–13, 1914 (National Museum, Melbourne); Gippsland, April, 1906 (National Museum, Melbourne).

Observations.—Various observations by F. Erasmus Wilson constitute our sole information on the habits of this crane-fly.

"*Clytocosmus* were again met with, one male and one female being captured and a few others seen. They were at exactly the same spot where I secured the specimen last year (above Millgrove, on the Dee tributary of the Yarra river). When disturbed, the insect rises up to about 20 feet and then slowly flies about in large circles, frequently passing overhead again, at other times alighting thirty to forty yards away. They seem to show a preference for *Eucalyptus* leaves as a resting site."—F. E. Wilson, in litt., April, 1928.

"*Clytocosmus* were on the wing and very beautiful they looked as they sailed over our heads. I have never seen so many in my life before, as from this spot (altitude about 450 feet) to nearly the top of the mountain (Donna Buang, 3,800 feet) we were frequently observing them. Most of those seen were females, and incidentally I was able to learn a little of their domestic habits. I was standing on the edge of a little pool later in the day when I saw a big female plane down from the top of a *Leptospermum* bush, cross the pool, almost touching the water and finally alight at the water's edge. She then walked fairly fast about ten inches from the margin and inserted her ovipositor into a crevice in the mud. She then advanced about another twelve inches and crawled into a depression under a big stone where she feverishly began drilling operations. Often the implement would meet with some obstruction and another place had to be tried. I noticed that she made a slight twisting motion with her abdomen when inserting the ovipositor. I estimated that she laid about a dozen eggs in that little depression. I then caught and killed her and found that she had practically exhausted her egg-supply as only two were left. These are rod-like, with rounded ends (capsule-shaped), barely a millimeter in length and of a pale yellow colour. To me they appeared surprisingly small for so large an insect. Later I disturbed others from patches of damp earth near seepages and streams so I think we can safely say that we now know where these beauties breed."—F. E. Wilson, in litt., March 2, 1930.

CLYTOCOSMUS TILLYARDI Alexander.

Alexander, PROC. LINN. SOC. N.S.W., 45, 1920, 184–185.—*C. skusei* Alexander, *Rec. S. Aust. Mus.*, 2, 1922, 252–253.—*C. skusei* Alexander, *Ann. Mag. Nat. Hist.*, (9) 9, 1922, 159.—*C. tillyardi* Alexander, *ibid.*, (9) 9, 1922, 160.—*C. skusei* Pierre, Diptera, Tipulidae, Tipulinae, Genera Insectorum, Fasc., 186, 1926, 49.—*C. tillyardi* Pierre, *ibid.*, Fasc., 186, 1926, 49.—*C. skusei* Alexander, PROC. LINN. SOC. N.S.W., 52, 1927, 58, fig. 44 (venation).

Sexes dissimilar in colour, the males having the thoracic pattern (both dorsum and pleura) black and silvery-white, the females with the black colours replaced by orange; abdomen black, variegated with silvery-white spots, the second tergite at base ringed with orange; genital segments of both sexes orange; antennae of both sexes (Plate ii, figs. 6, 7) with seven or eight enlarged segments, in the male the basal ones slightly but distinctly bilobed, in the female more cordiform.

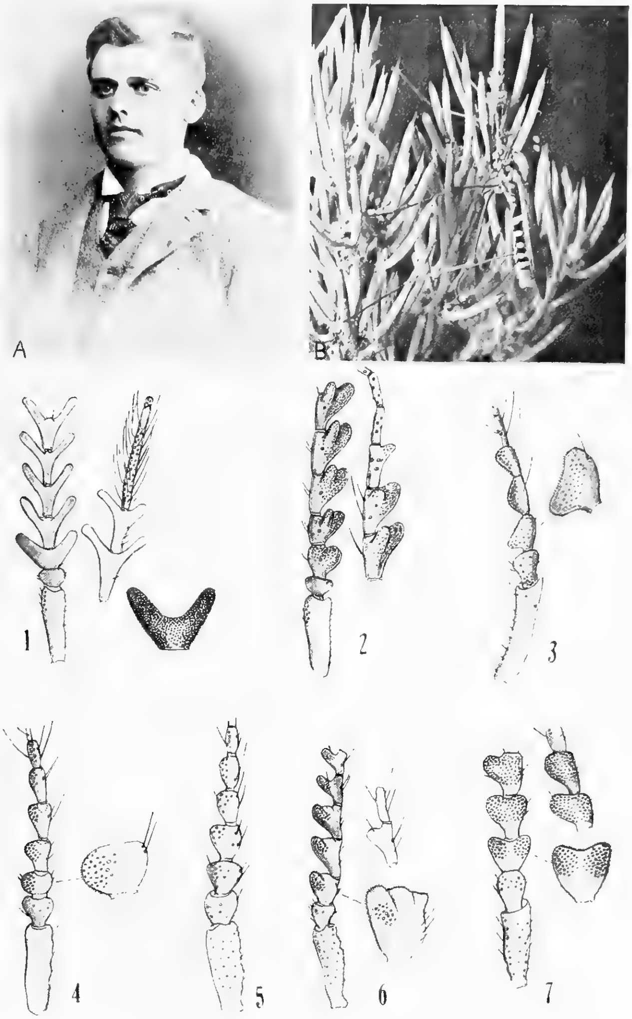
Antennae (male) with seven or eight enlarged flagellar segments, the basal five or six being shortly but distinctly bilobed, the two lobes somewhat unequal, set with transparent punctures; outer enlarged flagellar segments with a single conspicuous lobe, the eighth segment merely enlarged. In the female, flagellar segments one to seven are irregularly cordiform but scarcely bilobed, gradually decreasing in size outwardly and losing the cordiform appearance to a greater or less degree.

As stated before, the black males were earlier characterized by the writer as *Clytocosmus skusei*, the orange females as *C. tillyardi*.

Distribution.—This beautiful species is still known only from the Dorrigo Tableland in north-eastern New South Wales, where it has been taken from April to June, by Mr. William Heron and Dr. Tillyard.

Observations.—The following notes by Mr. Heron are of interest: "But two of the black and orange crane-flies came my way this year. I was always under the impression that they were to be found in April and May, making heavy flight, but on two sunny days I saw them very lively and flying high, one up to fifty feet. Most of them were found resting at considerable heights (about twenty feet) on *Eucalyptus* suckers and were obtainable only with long-handled nets."—W. Heron, in litt., July, 1922.

"First *Clytocosmus tillyardi* of year on April 24th. Met them on slopes of a north-south watercourse; climbed high trees with long pole attached to net but they were too suspicious and frisky. Finally caught several, flying in ones and pairs. They occurred basking high and low on shrubs, close to water."—W. Heron, in litt., April, 1927.



A.—F. A. A. Skuse. B, 1-7.—*Clytocosmus helmsi.*

CLYTOCOSMUS LICHTWARDTI Riedel.

Riedel, *Arch. f. Naturg.*, 85 A, Heft 4, 1920, 85–88, fig. 2 (head), 3 (antenna), 4 (fifth tarsal segment, with claw), 5 (wing).—Alexander, *Ann. Mag. Nat. Hist.*, (9) 9, 1922, 159.—Pierre, Diptera, Tipulidae, Tipulinae, Genera Insectorum, Fasc. 186, 1926, 49.

Sexes generally alike in colour and structure of antennae; size small (male, length 16 mm.; wing 13–14 mm.); antennae of both sexes (Plate ii, fig. 3) with only three enlarged flagellar segments, these with the ventral face merely rounded; ground-colour of mesonotal praescutum in both sexes yellowish-grey, with three black stripes; thoracic pleura black, variegated with silvery-grey areas; abdominal segments one and four to seven velvety-black; segments one, five and six with large silvery areas on either side; segments two and three fiery orange; segments eight and nine more reddish fulvous.

Antennae of both sexes with only three enlarged flagellar segments; first segment elongate; second subglobular beyond the constricted base; basal three flagellar segments enlarged, the first slightly more produced than the others, the outer face with a small seta, the latter becoming longer on the succeeding segments; on the eight simple terminal segments, the verticels are four in number on each segment, very elongate, the pair on the outer face separate, the pair on the inner face arising close together.

Distribution.—This smallest of the species of *Clytocosmus* is still known only from the Cairns district, North Queensland. The type-locality indicated by Riedel (Herberton, New Guinea) is erroneous, and should be Herberton, North Queensland, altitude 3,700 feet, collected in November, 1911, by Dodd. The type-series consisted of five males, and a single female, preserved in the Deutsches Entomologisches Museum, Berlin. Several additional specimens in the Brunetti material now preserved in the British Museum are from the type-locality, collected in January, 1911, by Dodd. It is possible that the November record is erroneous, perhaps due to a false reading of the locality labels, since all other members of the genus appear on the wing in late summer and autumn.

EXPLANATION OF PLATE II.

A. Frederick A. A. Skuse. (Courtesy of W. W. Froggatt.)

B. Male of *Clytocosmus helmsi* Skuse, showing normal resting position. (Courtesy of A. J. Nicholson.)

1.—Antenna of *Clytocosmus helmsi* Skuse; male; basal six and terminal four segments; enlarged view of flagellar segment one.

2.—Antenna of *C. helmsi* Skuse; female; basal seven and outer segments.

3.—Antenna of *C. lichtwardti* Riedel; male; basal six segments, with enlargement of first flagellar.

4.—Antenna of *C. edwardsi* Alexander; male; basal seven segments, with enlargement of first flagellar.

5.—Antenna of *C. edwardsi* Alexander; female; basal seven segments.

6.—Antenna of *C. tillyardi* Alexander; male; basal seven and outer segments, with enlargement of first flagellar.

7.—Antenna of *C. tillyardi* Alexander; female; basal five and outer segments, with enlargement of first flagellar.

THE OCCURRENCE OF *ATRAX VENENATUS* HICKMAN ON THE COMBOYNE PLATEAU.

By E. C. Chisholm, M.B., Ch.M.

(Two Text-figures.)

[Read 30th March, 1932.]

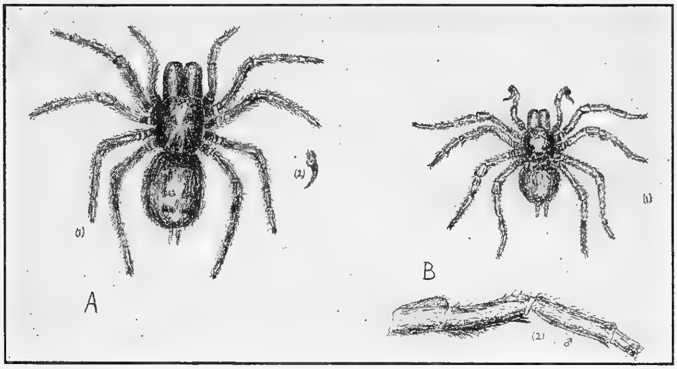
Atrax venenatus Hickman has, up till now (November, 1931), only been described from Tasmania, that being the only State so far in which this species has been found. It is rather surprising therefore to record it from the Comboyne Plateau so far north in New South Wales. My first acquaintance with this species here was on 1st March, 1931, when I found a dead male on a cattle track in an open cleared paddock sown with paspalum grass with a few logs lying here and there. Recognizing that it belonged to the genus *Atrax* and was a male, and noting that the hypophyses on the tibiae of the second pair of legs, present in the males of *A. robustus* and *A. formidabilis*, were wanting—a feature of the male of *A. venenatus*—I put it down tentatively as possibly *A. venenatus*, sending it to the Australian Museum in Sydney for identification and later to Dr. Pulleine in Adelaide. In neither case was the identity established. I then sent it on to Mr. V. V. Hickman in Launceston, Tasmania, who definitely identified it as *A. venenatus* and labelled the specimen as such. On 10th October, 1931, a female *Atrax* was sent to me, taken on the Comboyne, which, on comparing it with the male *A. venenatus*, I sent to Mr. V. V. Hickman in Tasmania as the female of *A. venenatus* for confirmation, and he identified and labelled it as such for me.

Notes taken at the time of finding the male are as follows.—"Funnel web spider *Atrax* sp.? ♂ found on ground dead on 1/3/31. General colour black. Total length 24·0 mm. Cephalothorax 13·4 mm. long by 8 mm. wide. Abdomen 10·6 mm. long by 9 mm. broad. A moveable spur on end of each pedipalpus (chitinous flagellum). Fangs 3·8 mm. long on the straight, and 4 mm. long allowing for convexity. Clump of bristles on tibia ii on under side thicker near the junction of patella with tibia and two stout bristles on under side of tibia near its junction with tarsus but no sign of an apophysis on tibia or tarsus. Two lung books ventrolaterally on each side. Two pairs of spinnerets, distal pair long. Two claws on the extremity of each leg. The chitinous spur on pedipalpus twisted towards extremity and 2·5 mm. long. No rastellum."

Notes on female *Atrax* quoted above.—"*Atrax venenatus* ♀ taken on the Comboyne and sent to me on October 10th, 1931. Total length including chelicerae 33 mm. Cephalothorax with chelicerae 17 mm. long by 9 mm. wide. Length of abdomen 16 mm. by 10 mm. at widest part. Anterior spinnerets small. Posterior pair 3·5 mm. long. Two pairs of lung books ventrolaterally. Length of fang 5·2 mm. Length of leg i with coxa 32 mm. Length of chelicerae 6·2 mm. No rastellum."

On 6th November, 1931, a splendid specimen of female *Atrax venenatus* was given to me alive, having been found on the Plateau amongst billets of split wood in a small stack of timber cut a few days before. Total length, including chelicerae but neither fangs nor spinnerets, 42·5 mm. Fang, straight measurement, 7·6 mm.; taking convexity of curve, 8 mm. Chelicerae 9 mm., remainder of cephalothorax 13·5 mm., and abdomen 20 mm. long without spinnerets. Width of cephalothorax 12 mm. and of abdomen 15 mm. Anterior edge of tergum in a straight line. Two pairs of spinnerets, posterior of which is 3-segmented and 6·2 mm. long. Anterior pair 2 mm. long. Two claws terminate each walking leg and one on each pedipalpus. Weight 80 grains.

Legs.	Coxa.	Trochanter and femur.	Patella and tibia.	Tarso-metatarsus.	Total.
1	7·0	13·0	12·5	10·5	43 mm.
2	6·4	11·5	11·3	10·5	39·7 mm.
3	5·5	10·5	9·5	9·5	35·0 mm.
4	5·5	12·5	12·2	11·5	41·7 mm.
Pedipalpi	6·0	10·0	7·0	5·5 (Tarsus)	28·5 mm.



Atrax venenatus Hickman.
A.—(1) Female, × ½; (2) Poison fang. B.—(1) male, × ½;
(2) Tibio-tarsus of leg ii.

The general colour of cephalothorax and legs is black. Tergum shiny black and devoid of hairs. Dorsal surface of chelicerae covered with silky hairs. Legs and pedipalpi hairy. Abdomen hairy and dark brown in colour on dorsal surface, slightly lighter on ventral surface. Tergum bounded all round by a broad reddish line. The joints on both sides of trochanters show a white ring each on all legs and pedipalpi. Under surface of cephalothorax very hairy; endite of pedipalp having red hairs. Lung books slightly hairy and light brown in colour; opening of duct of poison fang 0·4 mm. from point and situated on convex surface of fang. When one considers that the largest fangs of the deadly snakes of New South Wales are possessed by the Death Adder, the longest of a series recorded being 8·3 mm., and the average 6·2 mm., and the fang of the larger female *Atrax* measures 8·0 mm., on the convexity, one begins to realize that this species of *Atrax* is probably very deadly. Especially is this likely to be so in this and other species of large ground spiders which bite perpendicularly, i.e., the members of the suborder Mygalomorphae, because the fangs are canalized and are thus comparable with those of the vipers, all the poison being injected under the skin, clothing being no protection as it is to a certain extent in the case of our Colubride snakes on account of the more or less open groove in the fang. Moreover, the Mygalomorph spiders bite downwards and the fangs penetrate much more deeply than is the case with the members of the suborder Arachnomorphae, of which the red-backed spider, *Latrodectus*, is an example, which bite horizontally and penetrate to no great depth. In *Atrax* there is always the risk from the depth of the bite that a vein may be punctured with quickly fatal results, especially as the opening of the duct is only a short distance from the tip of the fang. Up to the present time no bites have been recorded from the species under review.

THE GASTEROMYCETES OF AUSTRALASIA. XIV.

THE FAMILY TULOSTOMATACEAE.

By G. H. CUNNINGHAM, M.Sc., Ph.D., F.N.Z.Inst.,
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(Plate i; seven Text-figures.)

[Read 30th March, 1932.]

Under this family I have placed those genera in which the gleba, consisting of spores and a definite capillitium, is carried within a 2-layered peridium supported at the apex of a definite elongated stem (which traverses the gleba in *Podaxon*). Thus defined, the family contains the genera *Podaxon*, *Phellorina*, *Chlamydopus*, *Tulostoma*, *Queletia* and *Battarraea*, which I have arranged under the following subfamilies and tribes. This grouping is not in accordance with that of other workers, differing in several respects, as will appear.

Family TULOSTOMATACEAE.

Plants at first subterranean, completing their development below ground, becoming elevated upon a rapidly elongating stem as they approach maturity. With a well developed peridium (of two layers, endoperidium and exoperidium) containing the gleba, carried at the apex of a simple but conspicuous stem (which traverses the gleba in *Podaxon*). Gleba consisting of spores and a well developed capillitium, of simple or branched, hyaline or coloured hyphae. Spores continuous, coloured, smooth or verrucose. Basidia bearing apically (or laterally in *Tulostoma*) sessilely or on sterigmata, 1–4 spores.

- Basidia arranged in fasciculate clusters; persistent at maturity . . Subfamily Podaxonoideae.
  - Peridium traversed by an axile columella . . . . . . Tribe I. Podaxoneae.
    - Containing one genus . . . . . . 1. *Podaxon* Fr.
  - Peridium carried at the apex of the stem, a columella being absent . . . . . . Tribe II. Phellorineae.
    - Peridium continuous with the stem, appearing as a cupulate extension of the stem apex . . . . . . 2. *Phellorina* Berk.
    - Peridium not continuous with the stem, but seated upon its truncate expanded apex . . . . . . 3. *Chlamydopus* Speg.
- Basidia not fasciculate; disappearing at maturity.
  - Elaters not present in the gleba . . . . . . Subfamily Tulostomoideae.
    - Peridium with a definite apical stoma . . . . . . 4. *Tulostoma* Pers.
    - Peridium opening irregularly . . . . . . *5. *Queletia* Fr.
  - Elaters present in the gleba . . . . . . Subfamily Battarraeoideae.
    - Containing one genus . . . . . . 6. *Battarraea* Pers.

General Morphology.

The family is characterized by the fact that the peridium is carried upon a well developed stem, the wall consists of two membranes, the exoperidium and

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* Not present in Australasia.

the endoperidium, and the gleba contains a well developed capillitium of sparsely septate, simple or sparingly branched hyphae.

The exoperidium is in *Podaxon* composed of fine or coarse fugacious scales, which frequently disappear as plants attain maturity; in *Chlamydopus*, *Tulostoma*, *Queletia* and *Battarraea* it is a well-defined membrane, although brittle and soon disappearing in mature specimens. In *Phellorina* it is persistent, and covers both stem and peridium as a continuous membrane. The endoperidium is similar in all genera, being membranous and tough. It is persistent in all save *Battarraea* (excluding *B. Digueti*). Dehiscence of the peridium is effected by a definite apical pore or stoma in *Chlamydopus* and *Tulostoma*, by irregular apical rupture in *Phellorina* and *Queletia*; in *Battarraea* it occurs as a result of circumscissile rupture of the endoperidium where this membrane junctions with the periphery of the discoid expansion of the stem apex; and in *Podaxon* by the peridium separating at its base from the stem, and becoming longitudinally lacerate.

The stem is woody and strongly developed, and carries at its modified apex the peridium, save in *Podaxon*, where it traverses the gleba as an axile columella. In *Chlamydopus* and *Battarraea* the apex of the stem is abruptly expanded to form a discoid seat for the gleba; in *Tulostoma* and *Queletia* it is inserted into a definite socket at the base of the peridium. In *Phellorina* the stem merges imperceptibly with the urceolate (at maturity) peridium. The exterior of the stem may be glabrous or covered with scales. In *Chlamydopus* and certain species of *Tulostoma* it is almost or completely smooth and often longitudinally grooved; in *Podaxon* it is covered with appressed imbricate scales, and in *Battarraea* these become noticeable as a dense fibrous covering.

The stem at its base is attached to or inserted in the so-called volva, a structure which in its most highly developed state can hardly be considered as homologous with the volva of the Phallales. It is represented merely by a bulbous expansion of the base of the stem in *Podaxon*, *Phellorina*, *Tulostoma* and *Queletia*, and consists of hyphae mixed with sand particles, though in a few specimens an appearance of an enclosing membrane is given to it by the persistence as a ring at its apex of rudiments of the exoperidium. In *Chlamydopus* this structure consists of two layers of coarsely chambered tissue, which in developing plants is filled with a mucilaginous matrix. In *Battarraea* the volva reaches its highest development, a 2-layered structure into which the stem is inserted in a conic socket. In *B. phalloides* the cavities of this tissue are in the young plant filled with a gelatinous matrix, as in *Chlamydopus*. Thus the volva would appear to be residuary tissue formed during subterranean development, and varying according to the type of peridium produced. Its ontogenetic significance is therefore slight.

In all genera the gleba consists of the spores and a well developed persistent capillitium. The latter consists of numerous simple or sparingly branched, sparsely septate hyphae, hyaline or coloured, and frequently flattened. In *Podaxon* the threads are attached to the axile columella, but are free from the peridium, so that even when the latter has quite weathered away the capillitium remains as an investing sheath enclosing the columella. In *Phellorina*, *Tulostoma*, *Queletia* and *Chlamydopus* the threads are attached to the inner wall of the endoperidium; in *Battarraea* they arise from the discoid base of the peridium, to which they are firmly attached. In this last genus they are arranged in a palisade manner, with their axes predominantly vertical.

Associated with the capillitium of *Battarraea* are numerous closed cells internally strengthened by spiral or annular thickenings, which have been termed elaters because of their close morphological resemblance to these structures in *Hepatica*. These structures are unusual in that this is the only known genus in the fungi in which they occur. Their function, manner of development and ontogenetic significance are unknown.

The basidia in all genera carry from 1 to 4 spores on short sterigmata. The spores are borne apically, save in the genus *Tulostoma*, where they are produced laterally. In the genera *Podaxon*, *Chlamydopus* and *Phellorina* the basidia occur in persistent fasciculate clusters; whereas in *Tulostoma*, *Queletia* and *Battarraea* they are produced singly and disappear at maturation of the gleba. The nature of the hymenium is unknown in genera with fasciculate basidia, so that we have no means of determining the manner in which this condition arises. In *Tulostoma* the hymenium is scarcely differentiated, basidia being produced in an irregular manner on hyphae lining barely defined glebal chambers; whereas in *Battarraea* Maublanc and Malencon (1930) have shown that a definite hymenium is produced, lining well-marked glebal chambers.

The spores present no peculiar features in *Tulostoma*, *Chlamydopus*, *Phellorina* and *Queletia*, being globose or subglobose, small in size, thin walled and regularly verruculose. In *Podaxon*, however, they are quite distinctive, and alone would serve to distinguish members of this genus, for a thick 2-layered wall is present, the spore is apically truncate, pierced by a conspicuous germ pore, and externally smooth. In *Battarraea* the spores are even more remarkable, for the wall consists of 3 distinct layers, the outer one being hyaline, somewhat subgelatinous and perforate by a large number of minute pores.

Details of development have not been worked out for any member of the family, consequently particulars of this phase cannot be given. They are especially required to determine the manner in which the fasciculate basidia of *Podaxon* and its allies arise, and to ascertain the origin of the elaters of *Battarraea*.

Acknowledgements.—Thanks are again due to Dr. J. B. Cleland, the University, Adelaide, for the generous manner in which he has placed at my disposal the whole of his collections of this interesting family; and to Mr. H. Drake, of this Station, for all photographs reproduced herein.

Subfamily PODAXONOIDEAE.

Basidia arranged in fasciculate clusters; peridium traversed by an axile columella.

1. PODAXON (Desvaux).

Fries, *Syst. Myc.*, iii, 1829, 62.—*Scleroderma* Pers., *Syn. Meth. Fung.*, 1801, 150, *pro parte*.—*Podaxis* Desv., *Jour. de Bot.*, ii, 1809, 81.—*Schweinitzia* Grev., *Ed. Phil. Jour.*, viii, 1823, 257.—*Mitremyces* Spreng., *Syst. Veg.*, iv, 1827, 518, *pro parte*.—*Cionium* Spreng., *l.c.*, 529.—*Chainoderma* Mass., *Grev.*, xix, 1890, 46.

Plant at maturity consisting of a peridium borne on a strongly developed stem, which traverses the gleba as an axile columella and is firmly attached to the apex of the peridium. Peridium of two layers, a fugacious scaly exoperidium, and a persistent membranous endoperidium; dehiscing by longitudinal fissure and by becoming free from the stem at the base. Gleba of spores and a copious capillitium, to the threads of which are attached the fascicles of basidia; capillitium threads simple, sparingly branched, scantily septate, flattened, coloured or hyaline. Spores coloured, smooth, continuous, with a 2-layered wall apically perforate by a distinct germ pore; borne on short sterigmata on the clavate or subglobose basidia.

Habitat.—Growing solitary in sandy soil.

Type Species.—*Podaxon carcinomalis* (L.) Fr.

Distribution.—India; Africa; North and South America; Australia.

The genus was partly included under *Scleroderma* by Persoon, then placed under *Podaxis* by Desvaux. As *Scleroderma* is used in a valid sense for a different genus, the latter name has priority; but as Fries (*l.c.*) has shown, the derivation of the term is such that it should be written *Podaxon*. Fries' ruling has been accepted by most workers, save Massee (1890), who endeavoured to revive the original *Podaxis*, but his combinations have been ignored by recent systematists.

Chainoderma was erected by Massee to contain an Australian plant supposed to differ in the method of dehiscence. As all other characters are identical, as the "genus" has never been met with subsequently, and as apparently no type exists, it is evident Massee erected it upon a specimen of *Podaxon*.

The peculiar fascicles of basidia are limited to *Podaxon*, *Chlamydopus* and *Phellorina*, indicating a close relationship of these three genera. Each basidium may bear from 1 to 4 spores, seated on short sterigmata. Massee (1890) claimed that the basidia were asci, and that each contained a single ascospore; but as this remarkable belief has not been supported by other workers, it is evident it was based on faulty observation. It is significant that Massee discovered basidia in his "genus" *Chainoderma*, which is a synonym of *Podaxon*. An interesting feature of the genus is the peculiar thick double wall of the spores, perforated by an apical germ pore, characters which are unusual in the Gasteromycetes.

About 30 species have been described, but owing to the great variability of most of the characters regarded as specific, it is not possible to recognize the majority of these. For the size of the plant and shape of the peridium vary in any one collection to such an extent as to render these characters valueless in specific diagnosis. Likewise the degree of roughness of the peridium would appear to have little value, since this feature depends principally upon the age of the plant at the time of collection, young plants usually appearing scaly, old and weathered specimens almost smooth. Age of the plant also affects the colour of the gleba, since, when plants are approaching maturity, the gleba is olivaceous, and as they age this colour changes through reddish-brown to black. Similarly the colour of the spores is alone of little specific value, as this feature too is affected by the age of the specimen when collected. Shape and size of the spores also in this variable genus possess little value, as variation is considerable in any one plant. After an examination of some 31 specimens in the collections of Dr. Cleland, I believe the Australian collections can be grouped under two species on the following grounds:

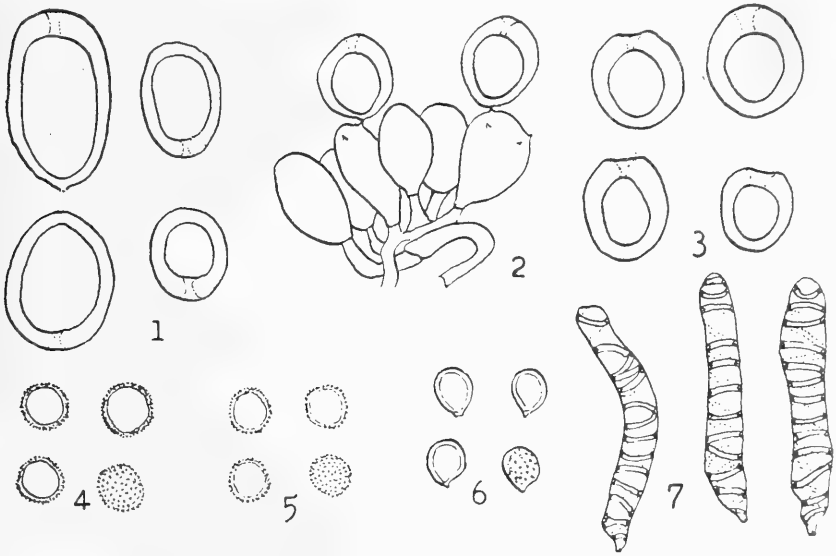
1. Capillitium copious, tough; threads deeply coloured. Spores chestnut or reddish-brown, often fuscous and opaque (*P. pistillaris*).
2. Capillitium scanty, tenuous and fragile, threads hyaline or tinted only. Spores olivaceous or pallid chestnut, not reddish (*P. loandensis*).

But even when such characters are used, many intermediate forms are encountered which can be grouped only with difficulty, and then arbitrarily upon some feature only weakly expressed.

1. Podaxon pistillaris (L.). Plate i, figs. 1, 2; Text-figs. 1, 2.

Fries, *Syst. Myc.*, iii, 1829, 63.—*Scleroderma pistillare* (L.) Pers., *Syn. Meth. Fung.*, 1801, 150.—*Mitremyces indicus* Spreng., *Syst. Veg.*, iv, 1827, 518.—*Podaxon aegyptiacus* Mont., *Syll. gen. spec. crypt.*, No. 1044, 1856.—*P. arabicus* Pat., *Bull. Soc. Myc. Fr.*, iii, 1887, 122.—*Podaxis indica* (Spreng.) Mass., *Jour. of Bot.*, xxviii, 1890, 74.

Plant to 15 cm. tall. Peridium ovate-oblong, 3–7 cm. tall, 1–3 cm. diam.; exoperidium in the form of a few closely appressed scales, which usually fall away at maturity; endoperidium membranous, externally white or bay-brown, sometimes ferruginous, at first smooth, shining or silky fibrillose, becoming wrinkled and in old specimens longitudinally lacerate; apex bluntly acuminate or rounded. Stem to 4–8 cm. tall, 2–10 mm. diameter, covered with white, crustose, brittle fibrils, arranged irregularly (as imbricately or spirally), disappearing readily when the stem appears brown and longitudinally sulcate, smooth, often twisted, tapering from base to apex, and produced below into a bulbous attachment, consisting of hyphae and sand particles, sometimes appearing volvate due to persistence



Text-figs. 1-7.

1.—*Podaxon pistillaris.* Spores. The top right spore is from the form *macrosporum*; the others are taken from the same field of the typical form.

2.—*Podaxon pistillaris.* One of the fasciculate clusters of basidia shown in part with spores attached to the rudimentary sterigmata.

3.—*Podaxon loandensis.* Spores. Note the truncate apex perforated by the prominent germ pore.

4.—*Phellorina inquinans.* Spores showing the finely verruculose epispore.

5.—*Chlamydopus Meyenianus.* Spores showing the finely verruculose epispore. Note the close resemblance of these spores to the preceding.

6.—*Battarraea Stevenii.* Spores showing the apiculus and fine punctate markings of the epispore.

7.—*Battarraea Stevenii.* The peculiar elaters showing spiral and annular thickenings. These are small specimens, others in the same field attaining a much greater length. Note the basal point of attachment.

Drawings original and × 1000.

of part of the peridium. Gleba dense, ranging in colour from olivaceous through reddish-brown to black; capillitium threads deeply coloured, olivaceous or reddish-brown, sparingly septate, scantily branched, often flattened. Spores obovate or shortly elliptical, reddish-brown, 10–16 × 9–12μ; truncate apically, and thickened to 4μ, frequently with a rudimentary pedicel basally, smooth, apically perforate.

Type Locality.—India. *Distribution.*—India; Africa; Madagascar; Australia.—Queensland: Arrabury Station, near Cordillo, 5/24*.—South Australia: Ooldea, 8/22*; Wilgena, 5/26, Dr. Campbell*; Stewart's Range, 8/23, Dr. Campbell*; near Wirrealpa, Flinders Range, 12/30*.—Central Australia: Alice Springs to Jay River, 8/29*; MacDonald Downs, 8/30*.

Forma *macrosporum*: spores 12–20 × 12–15μ. Near Wirrealpa, 12/30*.

The characters of the species are the copious, tough, coloured capillitium threads and frequent reddish colour of the basidia and spores. The spores are variable in size, for in the majority of collections recorded above they are 10–16 × 9–12μ (commonly 10–12 × 9–10μ), whereas in the form *macrosporum* they are considerably larger; but as few authors are agreed as to the size of the spores of this or any other species, and as I have found they vary considerably in different collections, it is evident spore size alone has little if any specific value in the genus. Cooke (1892, p. 223) recorded the species from Australia under the name of *Podaxis indica*, the record being based (according to Lloyd, 1905, p. 5) on a specimen at Kew from Sutton River. Lloyd also recorded it from Bourke, but under the name of *Podaxon aegyptiacus*, which appears to be a small form, not uncommon in the collections at hand. The type was described by Linnaeus (as *Lycoperdon pistillare*) from a specimen from India, which is, according to Lloyd (*l.c.*), still in his herbarium.

Judging from the published descriptions, it is probable that *Podaxon ghattasensis* P. Henn., *P. Perraldieri* Pat., *P. Chevalieri* Pat. et Har. and *P. algericum* Pat. are additional synonyms of this species.

2. PODAXON LOANDENSIS Welwitsch and Currey. Text-fig. 3.

Trans. Linn. Soc., xxvi, 1868, 288.—? *Podaxon calyptratus* Fr., *Syst. Myc*, iii, 1829, 63.—? *Cionium sengalense* Spreng., *Syst. Veg.*, iv, 1827, 519.—*Podaxis axata* (Bosc) Mass., *Jour. Bot.*, xxviii, 1890, 14.—*Chainoderma Drummondii* Mass., *Grev.*, xix, 1890, 46.—*Podaxon Muelleri* P. Henn., *Hedw.*, xliii, 1904, 187.

Plants similar to the preceding, but differing in typical plants in the characters of the gleba and spores. Gleba either well developed or scanty, olivaceous or black, not reddish, arachnoid, fragile; capillitium threads hyaline or tinted only, sparingly septate and scantily branched. Spores obovate or shortly elliptical, olivaceous or chestnut-brown, 11–15 × 9–11μ, perforate apically, basally shortly pedicellate (or as frequently without this feature), thick-walled, smooth.

Type Locality.—West Africa. *Distribution.*—Africa; Australia.—South Australia: Near Wirrealpa, Flinders Range, 12/30*.

Typical plants are characterized by the fragile hyaline hyphae of the capillitium and olivaceous colour of the gleba and spores. But variation in these characters is so considerable that in many specimens it is difficult to decide as to the species

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* An asterisk indicates that the specimens are in the herbarium of Dr. J. B. Cleland, the University, Adelaide; and where no collector is given, signifies that the collection has been made by Dr. Cleland himself.

to which they belong. For the capillitium, although fairly well developed (though fragile) in typical plants, may be scanty or almost obsolete in others. The hyphae of which it is composed are usually hyaline, but forms with tinted threads are not uncommon. In such cases the olivaceous colour of the spores is the only feature which can be used in segregation, and here too difficulty arises in that young plants of the preceding species often possess olivaceous spores, the reddish colour not developing until maturity is reached.

This plant is certainly *Podaxon Muelleri*, and has been identified as such by Lloyd (1905, p. 5), who examined the type at Berlin. It agrees equally with *P. loandensis*, the type of which is in the British Museum. It has also been listed as *P. calyptratus* by Massee (under the synonym *Podaxis axata*) and Cooke (1892, p. 223), since specimens from Australia are so labelled at Kew. Lloyd examined these and stated they were specimens of *P. Muelleri*; and Massee, after examination of the type of *P. loandensis*, considered this to be a synonym of *P. calyptratus* (his *Podaxis axata*). It is evident therefore that *P. Muelleri* and *P. loandensis* were based on collections of the plant regarded by Massee and Cooke as *P. calyptratus*. But whether this is *P. calyptratus* of Fries cannot be solved, for Fries based his species (1829) upon Bosc's illustration of *Lycoperdon axatum* (1792), and Desvaux named the same drawing *Podaxis sengalensis*, a name which has priority. As no type is extant, it becomes evident that it is mere speculation as to whether our species is that named by Fries as *P. calyptratus*; and as this name is invalid, since it was based on an illustration which cannot be identified specifically, I believe that our species should be called *P. loandensis*, with which it agrees, and of which the type is in existence.

Chainoderma Drummondii was evidently based on a specimen of this species in which the base of the peridium was more firmly attached than usual to the stem, and so becomes a synonym, the colour of the spores showing it to belong to this species, and not to the preceding. It is probable too that *P. squarrosus* Pat. and *P. Gollani* P. Henn. are synonyms, since the descriptions appear to agree in most particulars.

Excluded Species.

Podaxon carcinomalis (L.) Fr.—This was recorded by Cooke (1892, p. 223) from Australia, but I have seen no specimens which can be so referred. It differs in the more robust size of the stem and peridium, smaller size and dark reddish colour of the spores, and especially in habitat, since it has the peculiarity of growing upon termite nests.

Podaxon anomalum Lloyd, *Myc. Notes*, 1920, 992.—This appears to be a specimen of *Secotium*, for the description shows it cannot be a *Podaxon*. As the species was based "on a single old half specimen in bad condition", it should not have been named.

2. PHELLORINA Berkeley.

Hook. *Lond. Journ. Bot.* ii, 1843, 417.—*Xylopodium* Mont., in Dur. *Fl. d. Alg.*, i, 1849, 390.—*Cypellomyces* Speg., *An. Mus. Nac. Buenos Aires*, xvi, 1906, 25.—*Whetstonia* Lloyd, *Myc. Notes*, 1906, 270.

Plant consisting of a 2-layered peridium supported upon a definite stem. Exoperidium roughened, continuous with the exterior of the stem; endoperidium a fine parchment-like membrane seated on the expanded apex of the stem, dehiscing by the irregular breaking away of the apical portion, the whole ultimately becoming cupulate. Stem thick, woody, stout. Gleba of capillitium, spores and persistent fascicles of basidia; capillitium threads long, simple, flattened, rarely branched and sparingly septate. Spores globose, tinted yellow, verruculose. Basidia bearing apically 1–4 spores on short sterigmata.

Habitat.—Growing solitary in sandy soil.

Type Species, Phellorina inquinans Berk.

Distribution.—Africa; North and South America; India; Australia.

The genus is closely related to *Chlamydopus*, having exactly the same spores, capillitium and persistent fasciculate basidia, but is separated by the different exoperidium and method of dehiscence. The exoperidium encloses the stem and passes as an unbroken tissue to form the outer wall of the peridium. The so-called volva is but a bulbous development of hyphae and sand particles attached to the base of the stem, mixed with fragments of the walls of the peridium.

Cypellomyces was based on a plant with a somewhat greater development of the volva, a feature which, as R. E. Fries (*Arkiv f. Bot.*, viii, 1909, 25) has shown, has no generic value. *Whetstonia* was based on the persistent cells of the gleba, Lloyd apparently being unaware at the time of its erection that the basidia occurred in persistent fascicles. It is probable too that *Dictyocephalos* is co-generic with *Phellorina.*

About 4 species are known, of which *P. macrospora* Lloyd is confined to North America; *P. argentensis* (Speg.) R. E. Fr. to South America; *P. inquinans* Berk. to Africa, North America and Australia; *P. strobilina* to Australia.

1. PHELLORINA INQUINANS Berkeley. Plate i, fig. 3; Text-fig. 4.

Hook. *Lond. Journ. Bot.* ii, 1843, 417.—*Xylopodium Delastrei* Mont., in Dur. *Fl. d. Alg.*, i, 1849, 390.—*X. australe* Berk., *Jour. Linn. Soc.*, xiii, 1872, 171.—*X. Aitchisonii* Cke. et Mass., *Grev.*, xvi, 1888, 69.—*Phellorina californica* Peck, *Forty-third Rept. N.Y. State Mus.*, 1890, 35.—*P. saharae* Pat. et Trab., *Bull. Soc. Myc. Fr.*, xii, 1896, 151.—*P. Delastrei* (Mont.) Fisch., *Nat. Pflanzenfam.*, i, 1900, 334.—*? Whetstonia strobiliformis* Lloyd, *Myc. Notes*, 1906, 270.

Plant to 9 cm. tall. Peridium pyriform, 3–5 cm. tall, 2–4 cm. diameter; exoperidium ochraceous, continuous with the stem, covered with coarse overlapping scales, which are longitudinally grooved and irregularly arranged; endoperidium membranous, shining, smooth, cream-coloured or white, continuous with the stem, rupturing by irregular breaking away of the upper surface and becoming urceolate. Stem 3–4 cm. long, 6–12 mm. diameter, solid, of two layers, an outer fibrillose scaly layer, and an inner ochraceous tough and woody layer, bulbous at the base. Gleba reddish-brown, pulverulent; capillitium threads simple, flattened, sparsely septate, tinted, almost hyaline. Spores globose, tinted yellow, 6–8·5μ, covered with flat-topped coarse warts, appearing areolate.

Type Locality.—South Africa. *Distribution.*—Africa; North America, Australia.—South Australia: Herb. Kew (Lloyd, 1905, p. 10); Kinchina, Monarto South, 11/22*; Minnie Downs, L. Reese, 7/26*.—Victoria: Warracknabeal, F. M. Reader (Lloyd, 1905, p. 11).

According to Lloyd (*Myc. Notes*, 1923, 1199), *Xylopodium Delastrei*, *X. australe*, *Phellorina californica* and *X. Aitchisonii* are synonyms; and judging from published descriptions it is probable too that *X. Bonaciniæ* Speg., *P. leptoderma* Pat. and *P. squamosa* Pat. are synonyms. *Whetstonia strobiliformis* likewise appears to be a synonym, but the description is too poor to permit of its being placed with certainty. The following species is also closely related, differing only in the much larger size of the plant and large scales of the exoperidium.

2. PHELLORINA STROBILINA (Kalchbrenner).

Kalchbrenner and Cooke, *Grev.*, ix, 1880, 4.—*Scleroderma strobilinum* Kalch., *Grev.*, iv, 1875, 74.—*Xylopodium ochroleucum* Cke. et Mass., *Grev.*, xv, 1887, 95.—*Areolaria strobilina* (Kalch.) De Toni, in Sacc. *Syll. Fung.*, vii, 1888, 144.

Differing from the preceding in the nature of the exoperidium, which is covered with large, thick, pyramidal, persistent, zoned scales which are larger and more prominently developed apically. Gleba and spores as in *P. inquinans*.

Type Locality.—Rockhampton, Queensland. *Distribution.*—Australia.—Queensland: Rockhampton (Kalch., *l.c.*, as *Scleroderma strobilina*); Darling River (Cke. et Mass., as *Xylopodium ochroleucum*).—South Australia: Monarto South (Cleland and Cheel, 1923, p. 75).

Lloyd (*Myc. Notes*, 1921, 1072, and *Myc. Notes*, 1923, 1174) recorded 2 collections from Dr. Cleland, and in the latter case illustrated the plant with a photograph taken *in situ*, which appears to be of a specimen of *P. inquinans*. I have seen no specimens I would refer to this species.

3. CHLAMYDOPUS Spegazzini.

Anal. Mus. nac. Buenos Aires, vi, 1899, 189.

Plant consisting of a long stem bearing upon its dilated apex the 2-layered peridium. Exoperidium fragile, breaking away in pieces; endoperidium membranous, tough, persistent, dehiscing by an apical pore which enlarges as the plant ages. Stem enlarged apically, solid, supported basally in a fibrillose, cupulate volva. Gleba of spores and capillitium, threads simple or sparingly branched, immixed with numerous clusters of persistent, fasciculate basidia. Spores coloured, verrucose, globose, continuous. Basidia bearing apically, 1–4 spores on short sterigmata.

Habitat.—Growing solitary on sandy soil.

Type Species, Tulostoma Meyenianum Klotzsch.

Distribution.—North and South America; Australia.

Although *Chlamydopus* is often confused with *Tulostoma*, it has little other than a superficial resemblance to that genus. It differs in that the basidia are of the persistent fasciculate type common to *Phellorina* and *Podaxon*, whereas in *Tulostoma* they occur scattered singly, arranged in a primitive palisade lining the scarcely differentiated glebal cavities, and disappear at maturity. Spores are borne apically on the basidia of *Chlamydopus*, whereas in *Tulostoma* they are arranged laterally. These striking differences show that the genus differs considerably from *Tulostoma*, and closely approaches *Phellorina*, and these facts have been made use of in the rearrangement of the family given in preceding pages.

1. CHLAMYDOPUS MEYENIANUS (Klotzsch). Plate i, fig. 4; Text-fig. 5.

Lloyd, *Myc. Notes*, 1903, 134.—*Tulostoma Meyenianum* Klotzsch, *Nov. Act. Caes. Leop. Carol. Nat. Cur.*, xix, 1843, 243.—*Tylostoma maximum* Cke. et Mass., *Grev.*, xv, 1887, 94.—*Chlamydopus clavatus* Speg., *Anal. Mus. nac. Buenos Aires*, vi, 1899, 189.—*C. Amblaiensis* Speg., *l.c.*

Peridium to 2 cm. tall, 2–3·5 cm. diameter, depressed globose or pulvinate; exoperidium fugitive, soon breaking up and falling away, of sand or other debris mixed with hyphae; endoperidium tough and membranous, ochraceous, bleaching to a pallid cream colour, smooth or finely asperate, firmly attached to the peripheral apex of the stem, dehiscing by a plane apical mouth which later becomes torn irregularly. Stem to 13 cm. tall, and 12 mm. diameter, woody, solid, grooved longitudinally, silky fibrillose or with a few coarse peeling scales, sometimes arranged as an annulus in old specimens, ochraceous, attenuate below and seated in a fragile volva of two layers, gradually thickened above and expanded into a flattened, discoid, truncate apex. Gleba ochraceous or yellowish-brown; capillitium densely developed, of long hyaline or tinted threads attached both to apex and inner wall of the endoperidium. Spores globose, tinted yellow, 6–9·5μ, mostly 7–8μ, covered with coarse, flat-topped warts, appearing areolate.

Type Locality.—Peru, South America. *Distribution.*—North and South America; Australia.—South Australia: Miller's Creek, 8/21, Dr. Campbell*; Minnie Downs, 7/26*; no loc., Mr. Zietz*.—West. Australia: Kurrawang, 7/18, Mrs. A. F. Cleland*; Gascoyne River (Cke. et Mass., *l.c.*, as *Tylostoma maximum*); Kalgoorlie, 6/17*.

The volva is quite a distinct feature in this genus, and is of a coarsely chambered tissue, the cavities of which are in young plants filled with a gelatinous matrix. The stem is cellular and tissue-like, and is also partially filled with matrix when young.

Hollos (*Gast. Ungarns*, 1904, p. 45) examined the type of *Tylostoma Meyenianum* at Berlin and found it to be identical with the illustration and description of *Chlamydopus clavatus*; and Lloyd examined the type of *Tylostoma maximum* at Kew and found it to be a specimen of the same species.

Subfamily TULOSTOMOIDEAE.

4. TULOSTOMA Pers.

This genus has been dealt with in a former paper (PROC. LINN. SOC. N.S.W., l, 1925, 245–258); but to make it comparable with other genera treated in this paper an artificial key to the species is given below.

Key to the species of Tulostoma.

Mouth definite.
  Mouth tubular, margin entire.
    Spores finely verruculose, often almost smooth.
      Peridium smooth or practically so .... *T. albicans* White.
      Peridium finely pubescent .... *T. pubescens* G. H. Cunn.
    Spores distinctly echinulate, aculeate or warted.
      Peridium uncoloured (dingy white or pallid tan).
        Peridium smooth.
          Spores 5-8μ .... *T. McAlpinianum* Lloyd.
          Spores 9-13μ .... *T. macrosporum* G. H. Cunn.
        Peridium rough with the adhering persistent exoperidium .... *T. adhaerens* Lloyd.

Peridium deeply coloured.
Peridium chestnut brown, mouth more deeply coloured than the peridium .... *T. brumale* Pers.(1)
Peridium chocolate brown .... *T. Purpusii* P. Henn.
Mouth fibrillose-fimbriate.
Spores perfectly smooth .... *T. obesum* Cke. et Ell.(2)
Spores finely but minutely verruculose .... *T. minutum* White.
Spores distinctly echinulate, aculeate or warted.
Spores closely echinulate-verrucose .... *T. subfuscum* White.
Spores with echinulae arranged in striae .... *T. striatum* G. H. Cunn.
Mouth indefinite.
Mouth merely an indefinite torn aperture.
Spores smooth .... *T. pulchellum* Sacc.(3)
Spores minutely verruculose .... *T. australianum* Lloyd.(4)

Subfamily BATTARRAEOIDEAE

5. BATTARRAEA Persoon.

Syn. Meth. Fung., 1801, 129.—*Dendromyces* Liboschitz, *Beschr. neu entd. Pilzes*, 1814, f. 1.—*Sphaericeps* Welw. et Curr., *Trans. Linn. Soc.*, xxvi, 1870, 290.

Plant with a small applanate peridium borne upon a long and strongly developed stem seated in a basal volva. Peridium of 2 layers; exoperidium of sand particles mixed with hyphae, soon disappearing, endoperidium tough and membranous, dehiscing by circumscissile cleavage of the upper hemisphere from the periphery of the discoid apex of the stem. Gleba of spores and capillitium; capillitium of two types, long sparsely branched threads, and elaters. Spores globose, punctate, of 3 layers, the outer being somewhat gelatinous. Basidia bearing 1–4 spores apically on long sterigmata.

Habitat.—Growing solitary, partially buried in sand.

Type Species, *Battarraea phalloides* (Dicks.) Pers.

Distribution.—Europe; Asia; North and South America; Africa; Australia.

The genus may be recognized by the manner in which the small pulvinate peridium, usually naked at maturity, is borne on the greatly expanded discoid apex of a stout, greatly elongated stem, and by the manner of dehiscence. The capillitium is copious and consists of hyphae mixed with numerous elaters, arranged in a dense palisade. The elaters are short closed cells which internally contain spiral or annular thickenings. The spores, too, are characteristic, for the wall consists of 3 layers, the outer one being perforated with numerous punctate openings.

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(1) Some doubt exists as to whether the spores of this species are finely verruculose or whether they are distinctly warted. I have examined specimens from Europe (ex herb. Bresadola) and from England (ex herb. Kew) and find that they are distinctly sparsely warted, the warts not being so pronounced as other species included in the section. Our plants agree with these European plants exactly, so that there is little doubt but that the species occurs in this region.

(2) On page 254 of the paper cited above, I recorded this species as *T. poculatum* White. Coker and Couch (*Gasteromycetes,* 1928, p. 155) have shown this to be a synonym of the earlier named *T. obesum*. *T. gracile* White and *T. kansense* Peck appear to be additional synonyms.

(3) As Lloyd (*Myc. Notes*, 1923, p. 1233) examined the type of this species, and found it to be a plant with indefinite mouth and smooth spores, it is placed under this section.

(4) Re-examination of specimens of this species shows the spores to be minutely verruculose (hence the reference to their being smooth in the original diagnosis); so that the species is included under this section. *T. Readeri* Lloyd and *T. egranulosum* Lloyd appear to be synonyms, since they possess almost identical features, having the same indefinite mouths, finely verruculose spores and roughened exoperidia.

Although the genus may be recognized readily, the species are confusing, for of the 15 which have been named, but 3 can be recognized with certainty. Of these, *B. phalloides* (Dicks.) Pers. is characterized by the gelatinous volva and interior of the stem in young specimens; it is known with certainty to occur only in Britain and Europe. *B. Digueti* Pat. et Har. is characterized by the persistent endoperidium, and is limited to North America. *B. Stevenii* (Lib.) Fr. is separated from the first by the non-gelatinous volva, and from the second by the dehiscent endoperidium. It has apparently a wide range through Europe, North and South America, Africa and Australia. Most records of *B. phalloides* appear to be based on this plant, which is the sole representative of the genus in this region.

The name of the genus was derived from Antonio Battara, and was spelled *Batarrea* by Persoon; in 1804 it was changed to *Battarea* by Beauvais, and in 1825 to *Battarrea* by Fries, though in his later work of 1829 this author again used the older spelling of Persoon. Finally Maublanc and Malencon in 1930 used *Battarraea*, which, being the correct derivation of the name, is used in this paper.

1. BATTARRAEA STEVENII (Liboschitz). Plate i, fig. 5; Text-figs. 6, 7.

Fries, *Syst. Myc.*, iii, 1829, 7.—*Dendromyces Stevenii* Lib., *Beschr. neu entd. Pilzes*, 1814, f. 1, 2.—*Batarrea Gaudichaudii* Mont., *Ann. Sci. Nat.*, ser. 2, ii, 1834, 76.—*Sphaericeps lignipes* Welw. et Curr., *Trans. Linn. Soc.*, xxvi, 1870, 290.—*Battarrea Guicciardiniana* Ces., *Atti d. R. Accad. sci. fis. e mat.*, vii, 1875.—*B. Muelleri* Kalch., *Grev.*, ix, 1880, 3.—*B. Tepperiana* Ludw., *Bot. Centralbl.*, xxxvii, 1889, 337.—*B. laciniata* Undw., ex White, *Bull. Torr. Bot. Club*, xxviii, 1901, 439.

Peridium pulvinate or depressed globose, seated on the expanded discoid apex of the stem, to 6 cm. diameter, and 2–3 cm. tall, base white or ochraceous and appearing roughened when the gleba is removed, smooth and white beneath; apically at first consisting of two membranes, the outer falling away in flakes, the inner dehiscing circumscissilely and falling away in one piece as a distinct calyptra. Stem 10–35 cm. tall, 5–15 mm. diameter, tapering below and attached to the substratum by a definite 2-layered volva (which is not gelatinous at any time of its development), covered externally with numerous, coarse, overlapping scales, which are more numerous and coarse apically, ochraceous or bay-brown, weathering away ultimately and exposing the cream-coloured, fluted exterior, hollow or stuffed with silky fibres. Gleba pulverulent, with a capillitium of two types, single hyaline threads predominantly vertically arranged, and elaters which are fusiform or cylindrical bodies with annular or spiral thickenings on the inner wall. Spores globose or subglobose, often apiculate, 5–7μ, commonly 5–5·5μ, finely and sparsely punctate.

Type Locality.—Russia. *Distribution.*—Europe; Asia; North and South America; Australia.—New South Wales: Baan Baa, 1/17*; Barellan, 7/18, Miss D. Balfour*.—South Australia: Tapley's Hill Road, J. A. Kelley*; Monarto South*; Murray Bridge, 7/21, Mr. Ashby*; Nankeri, 5/21, Prof. Osborn*; Normansville, 1924, Dr. Morgan*; Grange, near Adelaide, 1926*; Adelaide Hospital, 5/28*.—West. Australia: Kurrawang, 1918, 1921, Mrs. A. F. Cleland*.

This species is the most widely distributed of the three known species, and has in consequence been listed under numerous names, as the synonymy shows. It is probable that *B. levispora* Mass. from India, *B. franciscana* Copeld. from California, *B. Guachiparum* Speg. and *B. patagonica* Speg. from Argentine are also

Gasteromycetes of Australasia.—Tulostomataceae.

synonyms. The species is separated from *B. phalloides* by the non-gelatinous volva, but otherwise differs only in the (usually) larger size and coarser scales of the stem. In an interesting paper, Maublanc and Malencon (1930, p. 63) have commented at length on the name to be applied to this plant. While admitting that *B. Guicciardiniana* and *B. Stevenii* are the same species, and that the latter has priority, they considered it advisable to use the former name since this was applied to a plant complete with volva (absent from the existing specimen of *B. Stevenii*) and of which the type collection is well represented by complete plants. This volva, which is so characteristic a feature of the Australian collections, consists of two distinct layers; an outer crust of hyphae and vegetable debris (and sand) immixed, and an inner, more fibrous layer (Cleland and Cheel, 1923, p. 75). No trace of the gelatinous matrix present in young specimens of *B. phalloides* has been noted at any time. It is this feature alone which separates these two closely related species.

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EXPLANATION OF PLATE I.

1.—*Podaxon pistillaris* (L.) Fr. × $^4/_9$.—Mature plant immediately after it has appeared above the ground. Note the twisted stem of this specimen.

2.—*Podaxon pistillaris.* × $^4/_9$.—Mature plant showing the peridium partly weathered away, exposing the gleba. The exoperidium has disappeared and exposed the glabrous but rugulose endoperidium. Note the strong development of the bulbous base.

3.—*Phellorina inquinans* Berk. × $^2/_3$.—This shows the almost white endoperidium, the thick exoperidium and manner in which the latter membrane extends as an outer covering to the stem. Remnants of the volva are apparent at the base.

4.—*Chlamydopus Meyenianus* (Kl.) Lloyd. × $^2/_3$ approx.—The plant on the right shows a well developed volva and the apical mouth; in the centre is a specimen with a scurfy stem; and on the left a specimen with collapsed endoperidium and strongly sulcate stem.

5.—*Battarraea Stevenii* (Lib.) Fr. × $^2/_9$.—The plant on the right shows the volva in section and the discoid expansion of the apex of the stem to which is attached the peridium (note pitted surface which indicates points of attachment of the capillitium and elaters); the one on the left shows the gleba in position, but exposed as the peridium has disappeared.

Photographs by H. Drake.

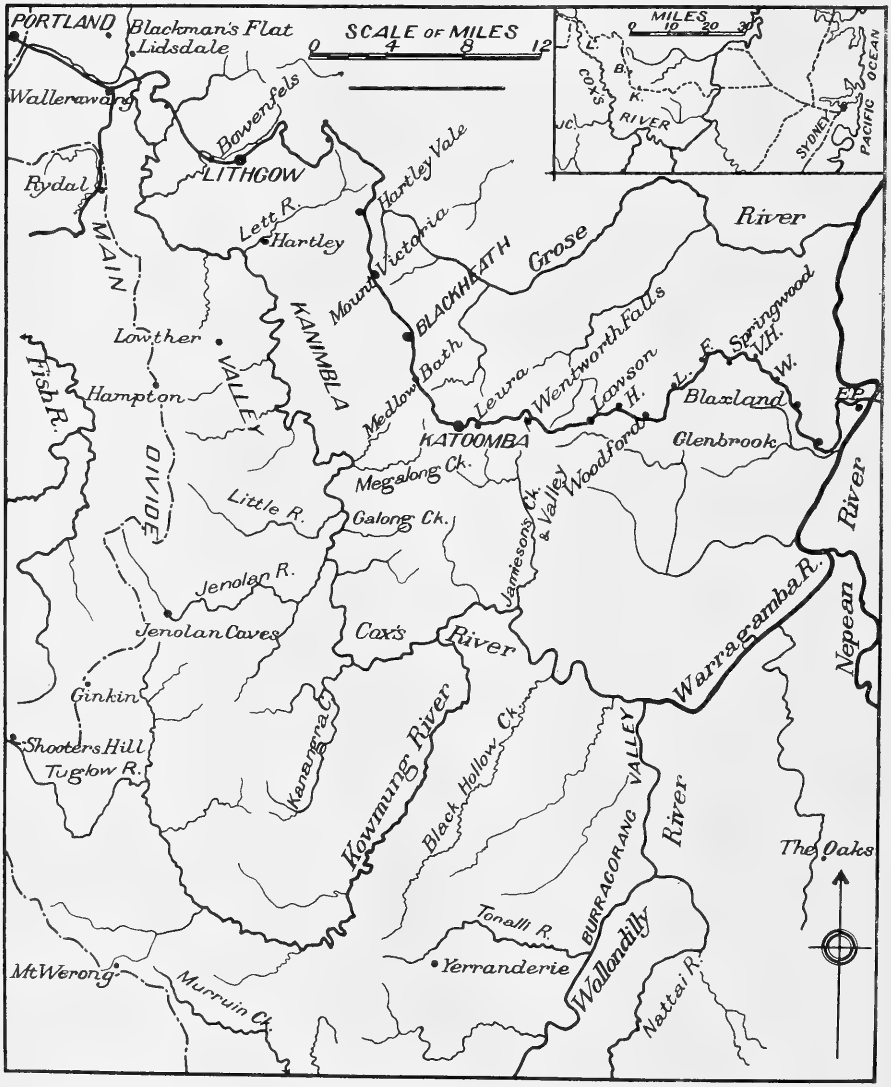
GEOGRAPHICAL STUDIES IN THE BLUE MOUNTAIN TABLELAND.

By FRANK A. CRAFT, B.Sc., Linnean Macleay Fellow of the Society in Geography, and formerly Caird Scholar in Geography, University of Sydney.

(Plate iii, and five Text-figures.)

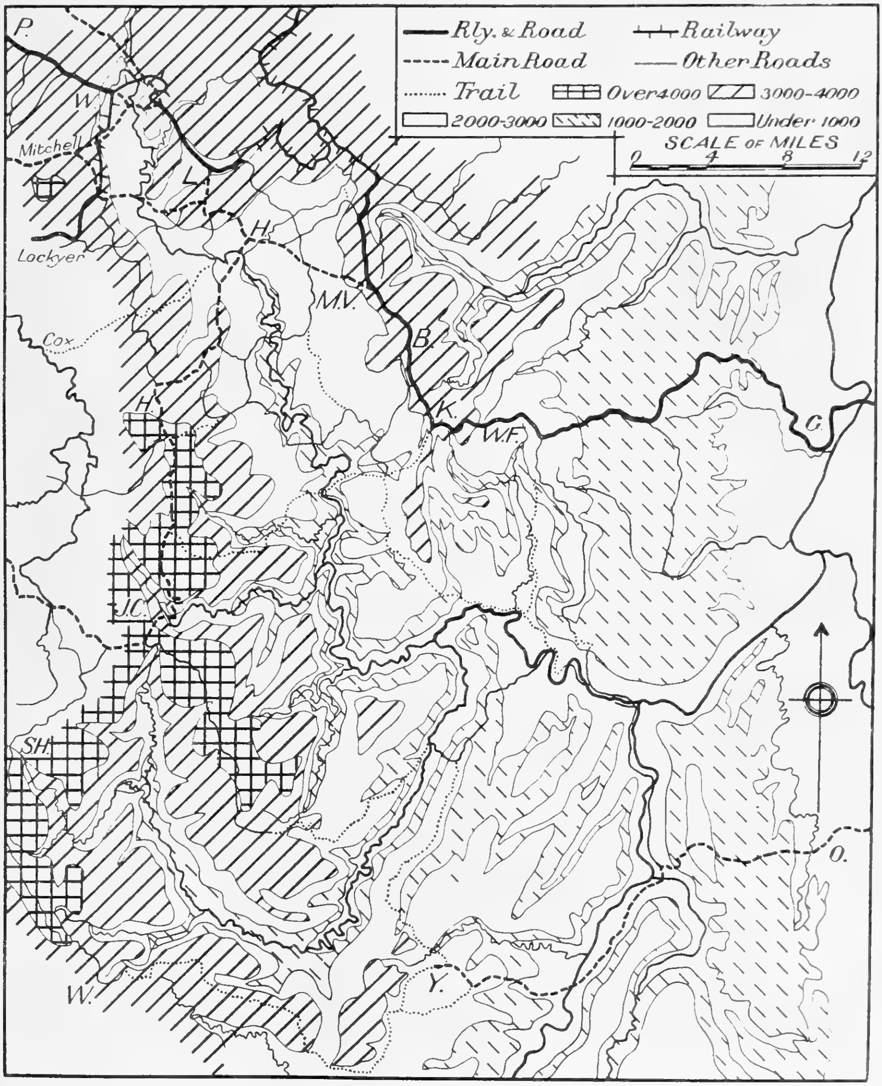
[Read 27th April, 1932.]

The Great Western Railway of New South Wales crosses the Blue "Mountain" Tableland, and along that part of its course is a series of towns and villages surrounded by wild and unoccupied country. Outposts of settlement are found in the



Text-fig. 1.—Locality Map of the Area. On the inset, broken lines indicate the principal railways.

less sterile parts of the highlands and in the valleys, but their people are isolated both in life and thought from those of the towns. In the succeeding pages I wish to examine the development and outlook of the various groups, and to make a series of studies in the geographical factors by which they have been most affected, beginning by considering the physical environment and the historical development of the settlements, and then going on to consider the life of the people in the less accessible parts.



Text-fig. 2.—Orographic Map of the Area. This shows also the means of communication and emphasizes the dependence of the various types upon topography.

Physical Conditions—Topography, Soil and Climate. Text-fig. 2.

The tableland rises gently westward from the Nepean River to an elevation of 3,500 to 4,400 feet, and there are extensive plains and slopes broken by deep valleys and gorges. In the north and east the plateau sandstone has been cut off sharply to form precipitous escarpments above the valleys, and the passage of these by roads and railways is a difficult and costly matter. Toward the south and west we find granite and folded rocks, but the absence of great lines of precipices is offset by the presence of narrow canyons, which the streams of an involved river system have eroded right to their heads. This compels land routes to keep close to the divides, although even there much difficult topography is encountered.

So far as climate is concerned, the area is essentially part of a unit in which the main differences are determined by altitude and distance from the sea. Increasing altitude gives an increasing rainfall from the foot of the eastward slope to its crest at Katoomba, but further inland the normal decrease again becomes apparent. The greatest precipitation is in summer, and there is a distinct minimum in spring, when the prevailing wind is from the west under conditions of rising temperature. The country above 2,800 feet is liable to experience snow in winter, but falls are few and light, and their effects disappear in two or three days. Frosts are experienced between May and October, so the cold climate fruits only can be grown successfully on the highlands, and destructive winds and hail in mid-summer may inflict severe damage on the ripening crop.

On the whole, the climatic differences from place to place are not sufficiently great to exert much influence on settlement or the utilization of the land, but they give local differences in crop types. Variations of soil, however, are of great importance, partly because of their control of plant growth, and partly on account of the water-holding capacities of different types of soil and topography. The plateau sandstones give a soil deficient in plant food, but of a high retentive value, and capable of holding much moisture. The granite soils of Kanimbla Valley are richer, but their porous nature and sharply undulating surfaces render them dry and generally unsuitable for cultivation. The clay soils of the high tableland about Jenolan Caves are more valuable, but here again much of the country is highly siliceous, or is steep and broken.

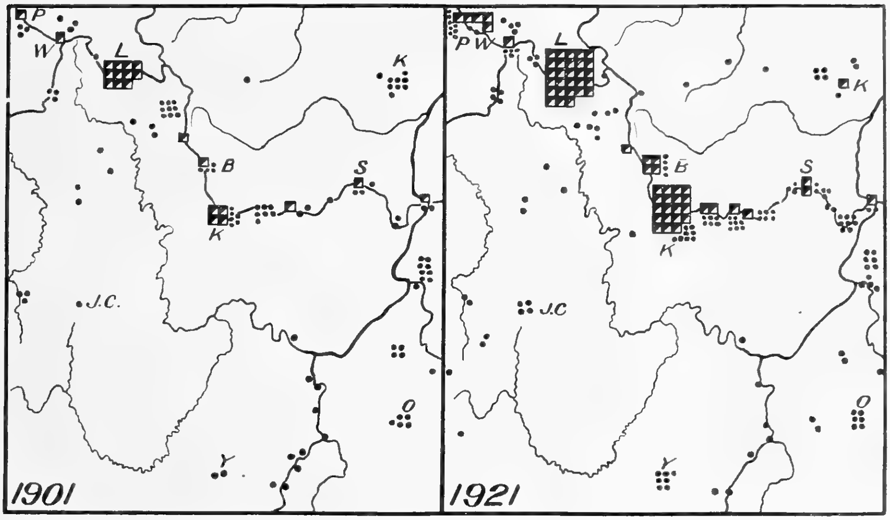
Taking the area as a whole, it gives little encouragement to settlers. It was originally covered with light eucalypt forest or scrub, part of which has now been cleared: it is greatly broken by precipices and gorges whose appearance is unfriendly and forbidding, and the more accessible streams cease to flow during very droughty summers. Apart from the railway towns, it has come to be a back-water between the more populous and productive districts about Sydney and Bathurst.

Occupation of the Land.

After the construction of Cox's road in 1815 from Sydney to the site of Bathurst, some 27 miles to the west of Rydal, a regular stream of traffic began to flow between the coast and the new inland settlements. The slow-moving bullock or horse teams required closely spaced halting places where water and grass were available, so inns and tiny hamlets came into being at such convenient places as Emu (Plains), Blaxland (originally "Wascoe's"), Springwood, Woodford

(Twenty-mile Hollow), Wentworth Falls (Weatherboard, later Brasfort), Mt. Victoria (One Tree Hill) and Hartley. This latter soon became an administrative post and a considerable centre, where laden teams from the west halted before commencing the arduous climb to "One Tree Hill". The pleasant slopes in this part of the Cox Valley were cleared and made productive, and settlement spread to Bowenfels, where there are still some stone houses built for the early colonial gentry.

In those early days of the colony, all building material had to be obtained locally, so the first constructions were of wooden slabs, "wattle and daub", or stone. This latter was used for government buildings or the homes of wealthier people, which were roofed with shingles or, later, with flat iron, whilst the houses of the poorer people were covered with the bark of the Stringybark (*Eucalyptus eugenioides* and *E. capitellata*), or, in some cases, with thatch. The settlers had to live on the country and use its resources for their homes and their living, the only alternative being to provide for the needs of travellers. Extensive settlement on the barren tableland between Glenbrook and Mount Victoria was impossible under such conditions, so the western edge of the shales of the Sydney Basin between Kurrajong, Emu Plains and The Oaks continued to mark the western limit of the first wave of settlement, whilst the second began about Hartley and had almost its whole development to the west of the Main Divide. The population maps still reflect these conditions.



Text-fig. 3.—Distribution of Population. Each *square* represents 500 people, and each *dot* 50. "K" in the N.E. corner is Kurrajong.

The Building of the Railway. Text-figs. 3, 4.

The building of the Great Western Railway between 1867 and 1870 (to Bathurst in 1876) marked the beginning of considerable development in this area. As the small army associated with its construction passed on, individuals and groups were left in its wake for operating and repairing the track, and their isolated houses frequently marked the beginnings of later villages. But the greatest effect was felt in Lithgow Valley, where the line passed across the outcrop of coal measures, whose importance as a possible source of fuel for the railway and more westerly towns was quickly realized. Commercial mining began in 1868 (see Carne, 1906), and about the same time the exploitation of lenses of "kerosene shale" occurring in the coal seams was begun at Hartley Vale. Exploration and testing were carried out along the whole outcrop, but with the exception of small coal and oil shale mines at Katoomba, nothing further was done to the south of Hartley Vale, partly on account of cliff barriers and costly haulage, but chiefly because of the marked deterioration of the coal seams. It is a fortunate coincidence that the railway should cross the best part of the outcrop in the shallow Lithgow Valley!

The inception of Lithgow and Katoomba, in particular, can be traced to the building of the railway. Most of the land along its course over the sandstone tableland was taken up by private speculators, and has gradually been subdivided into town and village sites as the occasion has demanded. This has given rise to a new type of settlement—one in which the people depend on wealth gained elsewhere, which enables them to live in retirement, or which is paid for service by those attracted to the tourist resorts that have been established to exploit climate and scenery. When the only means of transit was by road, the "Blue Mountains" were a toilsome interlude in the journey between Sydney and Bathurst; but when the railway brought them within easy reach of Sydney on the one hand, and the monotonous interior on the other, people began to visit them on account of their beauty of form and colour, and to seek relief in summer from the humid coast or the hot and dusty interior plains.

The two most obvious sites for settlements of such a nature are Katoomba and Blackheath, for in each case level country is available overlooking scenes of great beauty. By 1891 these had the respective populations of 1,590 and 770, whilst Mt. Victoria, with a considerable number of railway employees and miners, was rather smaller. During the next ten years (which included the depression of 1893), progress was slow. Blackheath and Mt. Victoria actually declined, but other settlements had sprung up—notably Lawson and Springwood—which rivalled all except Katoomba in size.

Here we have a second stage in the development of the tourist towns. More enclosed sites were now being occupied on the slopes, and commercial people from Sydney began to establish their homes or country houses in these resorts, dividing their favour equally between the nearer lower slopes and the more distant and picturesque settlements on the higher tableland. At the same time, these centres developed as holiday resorts, leading to the establishment of boarding-houses and hotels, the building of houses for seasonal occupation, and the growth of a population of artisans, tradesmen and others depending for a livelihood upon wealth gained by production or business elsewhere, but spent here. This is the distinguishing feature of a tourist resort, and its essential character as a non-producer of wealth is shown by its inability to maintain the natural increase of population when the tourist traffic no longer increases.

In the decade following 1901 the process of development accelerated, the most spectacular event being the rise of Leura (1,360 people—included with Katoomba on the maps), while Katoomba, Blackheath and Wentworth Falls showed respective increases of 1,680, 580 and 410. Mt. Victoria, however, fell below 500. We may generalize and say that the places with the greatest scenic attractions drew and held the greatest number of people—a condition which holds to the present day, although the next decade saw a notable growth in the city-facing villages of Glenbrook, Springwood, Hazelbrook and Lawson. Since then there has been relatively little change, and a general condition of equilibrium seems to have been reached. It will be interesting to see how this condition has come about.

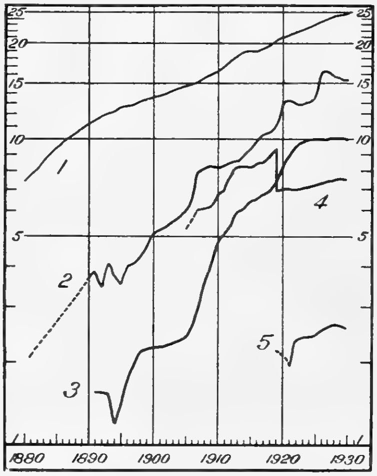
The Tourist Resorts.

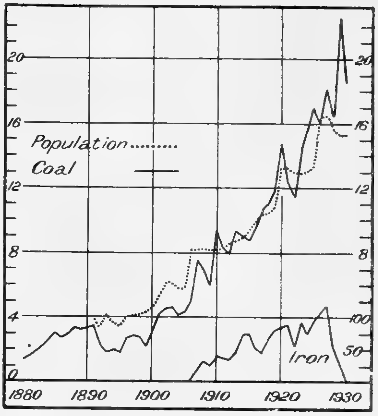
Katoomba was originally named "The Crushers", because rock breaking machinery was located there during the construction of the railway. From 1880 onwards small coal and oil-shale mines were worked beneath the cliffs immediately to the south, but exhaustion of the oil-shale lenses and a period of general depression caused the village to suffer a temporary setback, which was soon offset by new growth due to the increasing tourist traffic.

As we have already observed, the combined town of Katoomba and Leura has great natural advantages in site and aspect, and its central position gives it a superiority to rivals on either side, thus favouring a maximum of development. Seven years of relative inactivity ended in 1905, and were followed by five years of phenomenal growth. Although figures are not available, it is probable that the Blue Mountain Shire enjoyed a similar expansion of population three years ahead of the town, but their progress was similar from 1910 to 1913. By this latter year the wave of progress had spent its greatest force, and the uncertain years of the Great War are reflected in the population curves, although it is significant that Katoomba's advance continued, and accelerated during the post-war boom period—a movement which was not fully shared by the shire. After the ending of the boom about 1921, the rate of progress declined in both, and did not recover in the years of national prosperity between 1924 and 1928, although some such movement is found in the newly-formed municipality of Blackheath, and may have been present in individual villages of the shire.

What is the full explanation of these curves (Text-fig. 4), which differ materially from State conditions? The years 1902 to 1907 were marked by a great expansion in the State's trade, with the value of exports greatly exceeding that of imports. Mining and manufacturing were developing steadily, but the population of Katoomba showed no movement in sympathy with these factors. It would appear that, towards the end of this period, a people who had grown prosperous, but who were packed into a congested metropolis, began to realize the scenic and climatic advantages of the Blue Mountain Tableland, and a demand arose for those things. This had been largely satisfied before the war broke out, but it revived in 1917 and, after the close of the war, when a people released from that strain began to seek new diversions in places where they could be had with comparatively little restraint, they chose Katoomba rather than the smaller and more intimate towns of the shire. This was reflected in the increased popularity of dance halls and other places of amusement. The end of the post-war boom period had a marked effect upon the tourist traffic and the places living by it, but there was a more subtle change.

Had the simple economic factor prevailed, the succeeding years of prosperity would have caused marked rises in population, but, as it is, a decline was shown relative to the population of the State: the demand for these places has decreased, and they cannot support their natural increase of population. For this the motor car is largely responsible. Many of the city and inland people with money to spend—the class catered for by these towns—have become car owners, and they are no longer compelled to spend their holidays in or near the railway towns. They are dispersed far and wide and the tourist resorts, deprived of many of their former supporters, have much difficulty in holding their own populations. There is, however, some compensation, as many people are taking advantage of the freedom of movement which the automobile gives, and are establishing their homes in the healthier tablelands away from the crowded metropolis. For climatic reasons also, small boarding-schools have come into existence in the larger centres, and sanatoria for the treatment of tuberculosis are found rather away from the most severe climate, the principal being at Wentworth Falls.





Text-fig. 4.—Population Graphs. 1 = New South Wales (unit 100,000); 2 = Lithgow; 3 = Katoomba Municipality; 4 = Blue Mountain Shire; 5 = Blackheath Municipality, separated from B.M. Shire in 1919. Units for curves 2-5 are thousands. The vertical scale is logarithmic, and changes in equal proportion are parallel, irrespective of the actual numbers involved.

Text-fig. 5.—The Growth of Lithgow. Units refer to population in thousands, to coal in hundred-thousands of tons, and, in the bottom right corner, to the production of pig iron in thousands of tons. The coal production is for the whole of the Western field, for which see the text.

Summing up, we find that the tourist resorts exploit two great assets—climate and scenery—and they depend for their existence on the introduction of wealth created elsewhere. For some years the demand for their services has not increased, and their population shows a slight decline, which will probably continue.

Lithgow. Text-figs. 3–5.

While this process of development has been going on, Lithgow has had a different and an even more eventful history. Industry first came to the valley from the south, in the form of a small flour mill, established on Farmer's Creek (Cooerwull Brook) in 1848, a water wheel being used to supply the necessary power. After ten years, the spinning and weaving of wool were substituted for the milling of wheat, but the water wheel, assisted by a steam engine, continued to supply power until 1896, when it was finally abandoned. Coal had been won in connection with this mill, but it was not until 1868 that regular mining was attempted on a commercial scale, and for several years the growth of the industry was slow, for although the coal produced here has always been cheaper than that from the northern and Illawarra fields, it is of rather inferior quality, and its principal use lies in raising steam.

But this coalfield has important advantages of position, since ores produced to the west must pass through it on their way to the coast, and it has proved more profitable to refine them here than carry them right to Sydney. The reverse is true with respect to wool and wheat, which go direct to the manufacturing and exporting centre, where there is a considerable local market for the finished articles. Copper refining began in 1874, although the greatest developments were in 1895, when the treatment of Cobar ores was begun and in 1900, when electrolytic refining was introduced. The growth of settlement and industry created a demand for bricks and pottery, which were made from clays derived from the coal measures from 1877 onwards; the working of iron began about 1875, but eleven years elapsed before the industry was placed on a sound footing and worked continuously. These movements of progress were assisted by industrial troubles in the northern (Newcastle) coalfield causing an increased demand for Lithgow coal, so that by 1890, although the town was still small, its mining and industrial activities were firmly established, and it might look forward to a period of growth and prosperity.

But this was not yet to be, for the coal production of the north again increased while depression, irregular trade and industrial unrest gave a severe setback to the Lithgow mines. The expansion of other industries was sufficient to hold the population, but no considerable growth took place until regular trade and industrial peace again prevailed.

The next forward step was the building of a new blast furnace, and the smelting of iron combined with increased coal production to establish a new high level of population which remained fairly constant until the beginning of the war, when the interruption of trade brought a greater demand for coal, metals, and later the small arms that were made in the town. The post-war boom saw further expansion, which was checked until more prosperous years returned, when a new maximum was attained in 1927. The management of the steelworks has since transferred its ore-smelting activities to Port Kembla and proposes to close the Lithgow works, but this movement has been partly offset by the further development of mining, especially during the stoppage on the northern field in 1929. The Railway Commissioners have extended the State coal mine, which is now responsible for a fourth of the production of the western field, and have established a central power house to supply electricity to the townships on the Blue Mountain Tableland (except Katoomba), and westward to Orange.

If we look at the population curve again, we are struck by its fluctuations in sympathy with coal production. It is true that part of the mining is carried on away from Lithgow and probably supports 1,000 or 1,500 people, but much of that development has taken place since 1925, and it explains part of the disparity between the graphs about that time. Lithgow is the workshop and industrial supplier of these outlying mines, some of their men live in the town, and many who have moved out from the main centre still retain their associations with it. As a generalization, we may state that one person is supported in Lithgow for each hundred tons of coal produced annually on the western field. Coal is the index of Lithgow's growth, and factors of national prosperity which affect it have a proportionate effect on the subsidiary industries, or the striking relationship of the curves would not be shown. Such arbitrary factors as the closing of the steelworks would have the effect of lowering population per unit of coal produced, but if the total production increased, the population would tend to remain stationary.

During the past forty years coal mining has become relatively more important in the lives of the people: the graphs show production to rise above the population curve, and the taking away of an important industry will accentuate this relative increase. We may say, however, that the progress of manufactures has not kept pace with that of mining, for which costly haulage and the absence of a large market in the immediate vicinity are probably largely responsible. Lithgow is a coal mining centre with subsidiary industries, and the present unfavourable position of mining holds no promise of any immediate progress for the town.

Nature of the Towns.

We shall see presently that the pioneer settlers continue to use the natural resources of the land so far as possible, as in the construction of their homes, but the centres of population have been developed according to the original character and environment of their inhabitants. Lithgow is a typical urban area; isolated settlements have been established in branches of the valley about the principal coal mines, and have grown outward to meet one another on the main valley floor. Although there is a great expanse of level country nearby (Plate iii, fig. 1), the town is cramped into a small part of the valley, and is as thoroughly urbanized as the most densely populated parts of Sydney. This is the result of the gathering of what might be termed "town-minded people", although a few individuals whose employment lies in the town prefer to occupy larger holdings or small farms outside its boundaries (the "commuters" of American geographers). Portland and Wallerawang have shown the urban tendency in a slightly lesser degree, but the small outlying mining centres are conspicuous examples of it, where any number of people up to 200 may live on a few acres of land in the immediate vicinity of a large colliery in the midst of vacant fields.

The Blue Mountain towns have been modelled on suburban lines without any particular respect for site or contour. Most of them (like Lithgow) have grown without plan as the result of private subdivisions of land, and the effect of enclosed streets is to cut off all sight of the surrounding country until the cliff edges are reached. Katoomba is a conspicuous example of this, but throughout there is a tendency to line the main streets with ugly double-storied shops, and others with conventional suburban cottages. The nucleus of each settlement is (in the case of Glenbrook, was) the railway station: shops and hotels have been constructed in its vicinity, generally along the main road, which runs close to the railway. Streets have been built at right angles to the line, leading eventually to some beauty spot such as a ravine or waterfall, and have formed the main lines of settlement and, in the cases of Katoomba and Leura, of shops and business generally. Thus the essential plan of each township is in the form of a cross, of which one or other of the limbs may be askew or imperfectly developed, and on which a series of rectangles is constructed as land near the centre of development or along the main existing lines of expansion becomes alienated and built on. As the original land holdings were surveyed along meridional and transverse lines, there is a tendency for roads and settlement generally to parallel them. In most cases this is a positive advantage, as the valleys trend in these directions in sympathy with underlying rock structure, thus making a "cross" plan inevitable. So far as the towns and villages themselves are concerned, the people have modified their surroundings to suit their own tastes and former environment, although an awakening of civic pride has caused the development of parks and gardens in the principal tourist resorts.

The Upper Valleys.

We have traced the development of settlements that have arisen apart from their surrounding countryside in response to special impulses. Turning now to the valley of Cox's River, we find that it falls naturally into three sections, which differ in altitude and are separated by areas of rough, unsettled country. These valleys may be distinguished by the titles "upper", "middle" (Kanimbla) and "lower", in which order we will treat them.

The upper valley and its branches penetrate the barren sandstone tableland, but their slopes rise southward to the Main Divide in the vicinity of Rydal. Alluvials of indifferent quality are found along the two main streams meeting at Wallerawang, while the country about that town and part of the land along Solitary Creek (flowing through Rydal) are clayey. Settlement has avoided the sterile higher tableland and has followed the valleys, which have been used as pasture land or, in small areas, for the growing of apples, oats, turnips and potatoes. Rural settlement is not continuous: the country north of Lidsdale has been abandoned, while the number of farmhouses about Wallerawang, Lidsdale, Blackman's Flat and Piper's Flat has not increased, although on the other hand there are a few more farms on the ridges southward, and on the level ground by Solitary Creek. Land which was cleared and used many years ago, and which was allowed to revert to its natural state, has been re-enclosed, cleared in parts, and cultivated in small patches. This process of re-occupation can be observed throughout the less desirable part of the Central Tableland, in country which was originally taken up during the intensification of settlement that preceded the opening of the great wheat producing areas of the inland slopes.

In the present case, the bleak and wind-swept country of the highlands has a poorish soil, and there is excessive moisture in the valleys during winter. The crops can only be disposed of with difficulty in the neighbouring towns, and they are generally forwarded to the central market in Sydney. At the same time, similar produce is brought from the metropolis and other distant centres to these very places! The few orchards in the tourist resorts have a like experience, which demonstrates the futility of present marketing arrangements, and condemns those who countenance such a system, for it is not only wasteful, but it helps to make the present absolute cleavage between the life and interests of the towns and those of the small rural communities near them.

Apart from the scattered population which we have just described, there are larger groups in the valleys. Wallerawang is the meeting-place of important roads and railways, and the centre for the outlying Newnes oil-shale field some 21 miles northward. Its population includes many railway employees and some miners, while nearby collieries at Lidsdale, Blackman's Flat and Angus Place have small miners' villages attached to them. Portland exists by reason of great cement works which exploit local limestone, clay and coal. These larger groupings occupy little space, and are artificial growths upon the countryside.

The Middle Valleys (Kanimbla).

A different picture is presented by the middle valleys of the Cox. They are flanked on the west by the high ridge of the Main Divide, whose western slope leads to the cleared granite hills of Fish River Valley, whose crest is partly occupied by occasional small farms, and whose forested eastern ridges lead down to the pasture lands of Kanimbla. That name is applied to the whole broad and partly dissected valley between the Main Divide and the sandstone tableland, whose precipices crown the sharp eastern rise.

Kanimbla Valley extends from Hartley in the north to Megalong (Creek) in the south, and is enclosed by higher land. Cox's River debouches from a gorge above Hartley and becomes entrenched in the valley floor, which it leaves by means of a deep canyon. The valley is thus cut in two by the river, and is only crossed readily in the vicinity of Hartley. Small settlements towards the west and south depend upon the roads along the Main Divide for means of communication, whilst those to the east and north have access to the tableland by roads surmounting breaks in the precipices at Hartley Vale, Mt. Victoria and Blackheath.

There is a deterioration of environment as one passes down the river; routes become more difficult and round-about as deep gorges make their appearance, and granites and undulating topography give place to the siliceous sediments and square outlines of a sterile region. In sympathy with this progressive alteration there is a regular change in the amount and type of settlement. Along the Main Divide between Rydal and Hampton, and again between that place and Hartley, a number of small farms have been established by the roadside at the heads of gentle valleys. These grow oats, potatoes, turnips and vegetables and rear a few sheep and cattle, but agriculture is the main resource, and the area of an individual farm rarely exceeds 40 acres. Passing from the forested eastern slope of the Divide into the valleys of the Cox and its western tributaries, cleared granite hills are observed which are almost entirely given up to sheep. They extend to the northern divide of Little River. Individual holdings are large and the homesteads are scattered, but there is some tendency towards grouping, and community centres may be established at convenient points. Thus Hampton has a store, churches, and a school, whilst the position of Lowther is marked by a church and a hall near the road, although there are only a couple of houses in the immediate vicinity. Most of the homesteads are situated in the level valleys, where a richer and moister soil enables small fodder crops to be grown to help feed the animals engaged in the working of the farms.

On the opposite side of the river the old town of Hartley has practically disappeared, since the reasons for its existence have gone. Likewise Hartley Vale has declined with the exhaustion of its kerosene-shale deposits and the abandonment of its oil refinery, although there has been a slight increase of population between it and Hartley as more land has been utilized for the growing of apples and peaches. Catering for tourists and holiday-makers provides another occupation of some importance.

Passing southward, a great stretch of country is comprised in one holding, the granite slopes being cleared, while most of the other land is too infertile to justify any attempt at use. Coming to Megalong Creek more farms are observed, devoted mainly to cattle and sheep, although a few have market gardens and apiaries, and those towards Blackheath cater for tourists. In passing, it is interesting to note the popularity of sheep in this valley, as Katoomba, only a few miles away, has an annual rainfall of 56 inches—about twice the optimum for sheep. It is probable that the rainfall of the sheltered valleys is considerably lower than this, and the porous soil of the undulating valley floor is dry and healthy.

The settlement ends to the north of Galong Creek, although there is one house by that stream on the edge of the granites, which give the locality a small area of good pasture land. The history of that farm set in the midst of forest supplies a commentary on the boundaries of settlement in the wilder tablelands. The house is of wattle and daub roofed with iron, and the holding occupies a strategic position between the tableland on one side and the gorges of Galong Creek and Cox's River on the other. The trail to the lower Cox passes through it, so the holder commands the right of way, and is able to lease the inferior country to the south and depasture his stock on it without interruption from others, or risk of his ("annual") leases passing to competitors. The only stock on this country are cattle. A previous owner of the property tried sheep, but wild dogs destroyed many of them and the experiment failed. Apart from this, cattle are more suited to the timbered and dissected country, as they are more fitted to move between the scattered bits of pasture in the wilderness and to overcome the obstacles offered by tangled scrub. On the opposite side of the Cox in the valleys of Little, Jenolan and Kanangra Rivers there is no settlement: a couple of pioneer farms started on the inadequate areas available have been long abandoned, and the country is only penetrated by occasional prospectors or walking parties.

The occupation of the southern end of Kanimbla Valley has been marked by a few outstanding incidents. Although much of the country was taken up before the beginning of this century, clearing and settlement were first confined to the vicinity of Hartley or of the Jenolan road. The country about Megalong Creek was ringbarked by aborigines in 1905, and there was a prolific first growth of grass. In the following summer the valley was swept by a great fire, which was followed immediately by an invasion of rabbits—a succession of events which ruined much good pasture land. The destruction of surface vegetation combined with the burrowing of rabbits and with overstocking to make the light soil very susceptible to erosion, and much of it was swept into the river, leaving poor clays or rock slopes on the steeper hillsides. As a consequence the river gradually silted up, and year by year the lower course has been encroached on by sand, until at the present time only the last five miles above its junction with the Wollondilly River retain their original depth and appearance.

For many years these generally adverse conditions prevailed, and a number of the "frontier farms" on the edge of settlement were abandoned (Plate iii, fig. 2). Some efforts were made to cope with the rabbit plague by trapping and poisoning and by the destruction of warrens, but in most cases these were ineffective owing to the amount of rocky country, fallen timber and bracken available for cover, and to fresh incursions from neglected paddocks. However, there was some benefit in post-war years, when an increasing demand for rabbit skins caused an influx of trappers during the winter months, and the landholders themselves were not slow to benefit by this new source of revenue. Some of them, indeed, came to be known as "rabbit farmers", for while they complied with laws relating to the systematic destruction of the pest, they did not interfere with its breeding. But the majority of holders were sincere in their efforts, and by the end of the winter of 1926, aided by a considerable number of men attracted by the high prices offering for furred skins, they had got the plague under control, although rabbits have been eliminated only from those holdings which are enclosed by vermin-proof fences. These places have recovered rapidly, and their uniform turf contrasts with neighbouring holdings which are still rabbit infested and overstocked, and on which there is only an irregular growth of poorer grasses, with many bare places on the hillsides.

Settlement of the middle valley, then, has been restricted by physical difficulties and areas of poor soil. Extensive destruction of the land has followed in the wake of settlement, although this can be remedied even now. The permanency of the main streams has not been greatly affected, as much of their water comes from swamps on the higher tableland.

The Lower Valleys.

Continuing down the Main Divide south of Hampton, the tourist resort of Jenolan Caves is passed, and small settlements are found of a type similar to Hampton. The one exception is Mt. Werong, where a few men find employment in prospecting for gold and minerals; this is typical of the old alluvial workings from which all of the easily obtained wealth had been extracted before the end of last century, but which are still occupied by a few old men who have no other means of livelihood, or by others who would rather eke out a precarious existence in such a place and hope for sudden wealth than engage in regular and monotonous work in towns or on farms. There is no settlement in the nearby Kowmung valley, and of the half score of farms originally found in the valley of Jamieson's Creek and on the neighbouring portion of Cox's River, only half are now occupied. The infertility of the greater part of these valleys combines with rough topography to give this result. In addition, the enclosed valleys are very hot in summer, and in the Kowmung district the water supply is poor, with the exception of the river itself flowing in a deep gorge. The slopes to Cox's River from the Kowmung divide and part of the floor of Jamieson's Valley are used for grazing cattle, with a few sheep and goats near one or two of the homesteads. Occupation was originally effected from more attractive country to the east in the deep lower valleys.

These easterly valleys (Plate iii, fig. 3) are relatively narrow trenches in the sandstone tableland, and their sides are surmounted with cliffs. Those occupied by the Cox and Wollondilly have flood plains or bottoms of fine brown silt, which is easily worked and is very fertile. The material has been brought down from granite and clay lands, but minor streams flowing in the horizontal rocks have only limited sandy flats, which are not inhabited in parts of their courses. Farms are dotted along the productive river flats, and while terraces above the flood limit are cultivated, the slopes to the river banks and the better parts of the hill bases are lightly grassed, and are used directly as pasture. The greater part of the settlement is found by the Wollondilly above its junction with Nattai River, for here the valley opens out and the good land becomes more extensive. As a rule, the single road line which serves the farmers is clear of the richer ground, and keeps to the bases of the slopes or to sandy parts of the lower river terraces.

The only ready means of access is by road from Camden, which enters the valley by way of a pass cut in the sides of the cliffs. It replaces the original steep zig-zag road which served the earlier settlers, or the still older road to Nattai River; but even now transportation is costly, and maize grown on the bottom lands is fed to pigs or cattle, which are taken to market in Camden by motor trucks. There are also a few apiaries, dairies, market gardens and orchards, while the slopes to the south of Tonalli River support sheep. In the wilder Kowmung district these animals are liable to attack by wild dogs and would be difficult to locate on the broken, scrubby hillsides, so their place is taken by cattle.

The aspect of the valley settlement has changed greatly since its inception, and an early maximum of population has been followed by conditions of stagnation or decline, the figures for 1891 and successive decennial census years being 531, 492, 491, and 396 in 1921. (These figures include 80 people for Cox's River in 1911 and 67 in 1921. That settlement had previously been omitted altogether.) At first, the settlers were practically isolated from the rest of the world and lived a life of their own, producing their food and a sufficient surplus to exchange for tools and manufactured goods necessary for life. Many of the holdings were small: some are not occupied at the present day, and others have been amalgamated. The first houses were built of slabs and were roofed with bark or iron, and the whole tendency of the settlement was to produce a backward type of people, who are found in parts of the valleys to the present day.

With the opening of the silver mines at Yerranderie about the beginning of this century, intercourse with the outside world became freer, although the settlement along Cox's River remained especially isolated. A new market was provided for portion of the valley's produce, and some of its people went to work in the mines. About this time, brick and sawn-board houses began to replace the original structures, but there was no increase of population. The reason for this is best sought, perhaps, in social conditions, for with maize as the staple crop the full potentialities of the valley have never been exploited, and there is no apparent deterioration of the country. While the farmer was satisfied to make a bare living from his holding and to live to himself, he remained on his farm; but when the idea of high wages, short hours of labour and the possession of money to spend as they pleased attracted his children, they moved into the towns, and became artisans or labourers for the most part. Some of the people found their way to the Blue Mountain towns, and others to the Camden district or to the city.

But there were others who were unwilling to follow this course, and they struck out into new country. The hillsides between Yerranderie and the Wollondilly River were further selected and cleared, while the strip of country between Black Hollow Creek and Kowmung River was selected and surveyed during the first five years of this century. A quantity of cedar (*Cedrela toona*) was won from the wild slopes to the west of that river, parts of the gentler slopes were cleared, and a few small homesteads were established on the ridge between the streams. These were unsuccessful; the frontier of permanent occupation retreated to the vicinity of Cox's River and Yerranderie, and the few people who had settled in the deep valleys between Black Hollow Creek and the Wollondilly River were also unable to hold their ground. At present, this country is held by people living in the valley settlements, and it supports a few cattle which roam along the small grassy flats in the deep Kowmung gorge, or on the hills and slopes of the other alienated country. A similar state of affairs exists on the high tableland south of Jenolan and in the rougher part of the Tuglow drainage, where land selected in the early years of this century has almost been abandoned. In all cases the wilder territory has never been effectively occupied.

With the decrease of population in the valley settlements, the size of individual holdings tended to increase, although some were given up. The coming of motor transport finally did away with the old isolation, although its influence is still seen in the Cox's River settlement, where communication is hindered by deep fords. An influx of tourists has caused many of the farmers to depend less on their holdings and more on catering for visitors, thus giving the lower part of the valley the appearance of a regular tourist resort with motor camps and small dwellings for occasional occupation. But, apart from this, the community has changed from one which provided most of its own necessities to one which depends upon the outside world even for such things as meat and bread, and whose activities are directed to the production of a few crops for outside markets.

We have mentioned Yerranderie in passing. Mining first began about 1892, and the respective populations for 1901, 1911 and 1921 were 100, 840 and 350, and there has probably been little change in subsequent years. The value of silver produced has been considerable, but the village has suffered the vicissitudes of its type, generally due to industrial troubles, but on occasions to a lowering of the price of silver making mining unprofitable. Although there is daily motor communication with Sydney, Yerranderie is virtually isolated, and the miners, shut in by their barren hills, live to themselves. The partly-refined ores pass to Sydney, which supplies most of the necessities of life. Prevailing industrial conditions have caused the closing of the mines, and the future existence of the village is a matter of doubt.

These conditions and movements, while remarkable in themselves, are still more noteworthy when it is remembered that they have developed within 60 miles of a great capital—the second largest city in the southern hemisphere!

Communications. Text-fig. 2.

We have seen that the mass of settlement has come into being with the railway, and has clung to the original route across the tableland. Apart from this, the more productive soils have been used for pasturage or agriculture, and occasional waves of settlement have penetrated the more broken country, only to retreat and leave a few wandering stock as evidence that the land is owned by people in more favourable parts.

The lines of communication were determined in the first place by physical features, which are such a barrier to free intercourse between the coast and the interior that the main road and railway through the Blue Mountain towns are the only important through routes between the Hunter valley in the north and Goulburn in the south—a distance of 140 miles. There is, indeed, only one other route of any note, namely, the mountain road across the Wollondilly River and past Wombeyan Caves, immediately to the south of this area. Meridional gorges to the north and south are separated by the gentle ridges forming the watersheds of Grose River, which can be likened to bridges across otherwise impassable country.

The first main road (Cox's) was built in 1815, and followed a steep course to the south-west from Hartley to cross the Main Divide, whence it passed in a more northerly direction to Bathurst. Lockyer's road crossed the Cox some miles higher up, and followed the valley of Fish River to Bathurst, but it was replaced by Sir Thomas Mitchell's line, which used a gentler route from the tableland at Mt. Victoria, and took the shortest way across the highlands to the north of Rydal and Fish River. This remains the highway to the present day, although recently (1929) a more level road was built to head the gorge of the Cox and to pass by

Wallerawang to Mitchell's road near Rydal. The eastern end of the road had also been improved by the selection of a gentler route at Glenbrook, and in the case of the railway line, the original zig-zags at Glenbrook and Lithgow have been replaced by contour railways and tunnels. There has been a continual endeavour to improve these arteries of commerce, and to mitigate the difficulties offered by the tableland.

In other parts of the area, however, there is a steady degeneration in the means of communication. About the head of Cox's River, roads follow the gentle valleys or water partings between tributary streams, and continue by the ridges into more broken country. In places, important roads cross deep valleys: that through Jenolan Caves owes its existence to the attractions of the caves, while the road between Camden and Yerranderie serves the valley farmers and miners: but on account of the difficult terrain which they traverse, and the fact that they do not belong to the network of ways between large centres of population, these cannot be regarded as other than specially developed local roads. The natural route to the lower Cox and Wollondilly via Warragamba River has not been utilized—partly on account of the rough nature of the gorge, but more especially because the existing road links the great majority of its users to the nearest railhead.

Coming towards Kowmung River from any direction, roads to serve outlying settlers become rougher and more difficult, and finally end in trails which can only be traversed on foot or on horseback. Although these serve some purpose in the movement of stock, they emphasize the natural difficulty and unproductiveness of the country through which they pass, and contrast with the highly-developed roads and railway which serve the towns immediately to the north. This quick change from advanced conditions to those of a primitive nature corresponds with the changing types of life and occupation of the people, and the various sections of the community may be enumerated in distinct classes as: the people of the tourist towns; those of the mining and manufacturing centres; the farmers of the upper and lower valleys; those of the middle valley; and, finally, the people who do not live permanently in the locality. This latter type includes graziers who spend part of their time with stock in the wilder country; rabbit-trappers, whose occupation is limited to winter, and prospectors, who move from place to place in the rough highlands in search of gold and minerals.

Future Development.

Taken as a whole, the area is as highly developed as it will be for many years to come. The growth of the towns is not being maintained, and the rural population has adjusted itself to the country so that, without an entirely different type of settlement, there is no probability of a considerable increase of population in the more sparsely-settled districts.

There are two assets of great potential value—coal and water. Coal outcrops continuously between Lithgow and the eastern hills of the Wollondilly, and although the quality is inferior in parts of this line, the value of the asset as a whole must increase as the more accessible coal is won from Lithgow district. The easterly outcrops are more favourably situated with respect to Sydney than is Lithgow, as the distance from the lower end of Burragorang Valley to the metropolis (via Warragamba River and Penrith) is 63 miles as against 97 miles from Lithgow, and in addition the former route is level, while the existing railway has to surmount the tableland. So the coal measures of the lower valleys may be looked on as a valuable reserve, although a small mine now beginning to operate above the junction of the Wollondilly and Nattai Rivers is premature.

As regards water, it has been proposed to utilize this by throwing a dam across the Warragamba River immediately above its junction with the Nepean. The water impounded would stretch back to Jamieson's Creek and Nattai River, flooding the river terraces in that section. The great objection to the proposal lies in the presence of large towns within the catchment—Goulburn, Moss Vale and Bowral to the south, and Lithgow, Katoomba, and others of the Blue Mountain towns to the north. Water from the larger towns would need special purification before being stored, but this is considered to be practicable. If the growth of the metropolis continues, such a scheme may be warranted, but in any case nothing is to be gained by further deforestation in the catchment area, to which practice some settlers appear to be inclined.

In conclusion, it may be remarked that the Blue Mountain Tableland has many features in common with the remainder of the State's highlands. The existence of great undiscovered possibilities is unlikely, and the future of the country lies in the systematic exploitation of known wealth. When it is economically possible, this involves the development of low-grade mineral deposits, more intense cultivation in agricultural areas, and a greater growth of fodder crops in pastoral regions (one form of the latter is the cultivation of natural pastures). So far as this area is concerned, the backward conditions that we have noticed in its less accessible parts may continue almost indefinitely, despite their nearness to the great complexity of modern towns and cities.

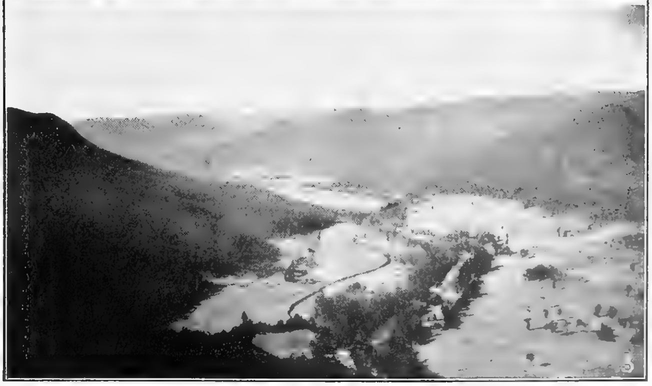
[*Postscript.*—The information embodied in the foregoing was collected mainly during 1926, when the writer was an Honours student under Professor Griffith Taylor, and Caird Scholar in Geography at the University of Sydney. The text, maps and diagrams are new.]

EXPLANATION OF PLATE III.

1.—Lithgow Valley. The industrial town is spread along the narrow valley in the background, and is expanding into the grazing lands. Note the barren tableland.

2.—An abandoned outpost of settlement, Little River. Note the pioneer hut, the garden clearing, and the hill-slopes used for pasture.

3.—Lower valley of Cox's River, to show the cultivated bottom lands, grazing country at the foot of the slopes, and the difficulty of communication in the broken highland.



1.—Lithgow Valley. 2.—Abandoned settlement, Little River.
3.—Lower valley of Cox's River.

NOTES ON NEW SOUTH WALES ORCHIDS. II.

By the Rev. H. M. R. Rupp, B.A.

(Eleven Text-figures.)

[Read 30th March, 1932.]

Discovery of a Remarkable New Genus and Species at Bullahdelah.

In the last week of November, 1931, Mr. E. Slater, of Bullahdelah, was scraping away fallen leaves and debris from about the roots of a few plants of the orchid *Dipodium punctatum*, which he had been asked to procure for Mr. and Mrs. F. Fieldsend, of East Maitland. These plants were on the western slope of the Alum Mountain, only a short distance above Bullahdelah township. As he was about to dig, his attention was caught by a curious little object on the surface of the soil he had just exposed. Investigating, he found this to be the top of a peculiar form of plant quite strange to him; and suspecting in spite of its withered flowers that it might be of orchidaceous character, he sent it with the *Dipodium* plants. Mr. and Mrs. Fieldsend, after inspecting it, sent it on to me for my opinion. Notwithstanding the fact that the flowers had evidently been withered for some considerable time, a few minutes' investigation sufficed to convince me that Mr. Slater had made what, from the point of view of orchidology, may fairly be termed a sensational discovery. It will be remembered that in 1928 no little stir was created in botanical circles by the accidental discovery at Corrigin, in Western Australia, of an orchid which apparently germinates, grows, and comes into flower beneath the surface of the soil. This plant was described by Dr. R. S. Rogers (*Journ. Roy. Soc. W. Aust.*, xv, 1928) under the name *Rhizanthella Gardneri*. Of the orchidaceous character of Mr. Slater's Bullahdelah plant I had no doubt directly I had examined a withered flower, and its habit and general character were immediately suggestive of *Rhizanthella*. At once I communicated with Mr. Fieldsend, asking that Mr. Slater be urged to make a further search, and at the same time I wrote to Dr. H. L. Kesteven, of Bullahdelah, requesting him to co-operate. Within a week these gentlemen sent me four more specimens. Three had fully matured ovaries with remnants of long-withered flowers; the fourth, a smaller one, was in a far less advanced condition and the flowers, though withered, could be dissected sufficiently after softening to show all the parts clearly. No further specimens have been found. On 26th December I was able to pay a very brief visit to Bullahdelah, and Dr. Kesteven kindly took me to the spot where the discovery was made. It is only a few feet away from the trolley-line of the old Alum Company's works, close to some of their dumps. The ground is barren and stony. Underneath a stringybark eucalypt was an accumulation of dead leaves, amongst which several stems of *Dipodium* were still standing. I had not time to make a search for the new plant, but the ground for yards around had been thoroughly investigated by Dr. Kesteven and Mr. Slater.

I had sent the most recently withered specimen to Dr. R. S. Rogers, after extracting two flowers from the capitulum. From Dr. Rogers's comments, added to the results of my own examination of all the material available, I am able to supply the following description, which will doubtless require to be supplemented when, as we hope may be the case next season, flowers are discovered in a less advanced stage.

Subtribe RHIZANTHELLINAE Rogers.

CRYPTANTHEMIS, n. gen.

Herbae terrestres aut subterraneae, *Rhizanthellae** consuetudinem factitantes. Sepala petalaque separata, membranea. Sepalum dorsale concavum, incurvum, fere acuminatum. Sepala lateralia concava, basi lata, apice tenuissima. Petala parviuscula, acuta. Labellum indivisum, latum, carnosum, supra concavum, ad columnae pedem ungue affixum. Columna cum appendicibus duobus, non ad sepalum dorsale adnata. Stigma in altum editum. Anther in speciminibus marcidis obscurus.

Species singula adhuc nota, Novae Cambriae orientalis incola.

Herbaceous plants, terrestrial or subterranean, following on the lines of *Rhizanthella* in habit. Sepals and petals not all equal in dimensions, quite free. Dorsal sepal concave and incurved. Lateral sepals concave, very slender in front. Petals relatively small, acute. Labellum fleshy, entire, broad, concave above, attached to the foot of the column by a claw. Column with two appendages; quite free. Stigma placed high. Anther in my specimens obscure. Ovary large.

CRYPTANTHEMIS SLATERI, n. sp.

Herba parviuscula, saprophytica, plane partimve subterranea. Rhizoma crassum, 6–10 cm. longum, plus minusve bracteis latis sucosis imbricatis tectum, ubi nudum cum pilis paucissimis et tuberculis minutis pluribus. Unum specimen cum ramo parvo tenuique. Flores, parvi, numerosi, sessiles, in capitulo terminale conferti, ad centrum versi, sub arborum scobe summum solum attingentes? Flores externi majores. Sepala petalaque dense reticulata, in medio cum vena conspicua. Sepalum dorsale 5–8 mm. longum. Sepala lateralia majora, ad bases latissima, fere ad medium subito contracta. Petala breviora, certe interdum denticulata. Labellum in floribus externis, quantum 3 mm. longum, late ovatum, subacutum, cum marginibus serratis, ad apicem pedis columnae ungue tenui affixum. Labellum in floribus intimis minutum, prope lanceolatum cum ungue longo. Columna in speciminibus marcidis aliquantum obscura, certe separata, ad apicem appendicibus tenuibus curvatisque duobus praedita. Anther verisimiliter biloculatus, pollinia non adhuc observata. Ovarium post floris mortem magnopere tumescens, sucosissimum, obscure quadrilaterale. Semina matura ficoidea, in longitudinem costata.

A small herbaceous saprophyte, wholly subterranean, with the possible exception of the flowers, which in the specimens so far discovered just reach the surface of the soil (in a withered state) hidden beneath dead leaves and other debris. Rhizome stout, up to 10 cm. long, in one case with a short and rather slender branch: more or less covered with broad, fleshy, imbricate bracts

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* Vide *Journ. Roy. Soc. W. Aust.*, xv, 1928.

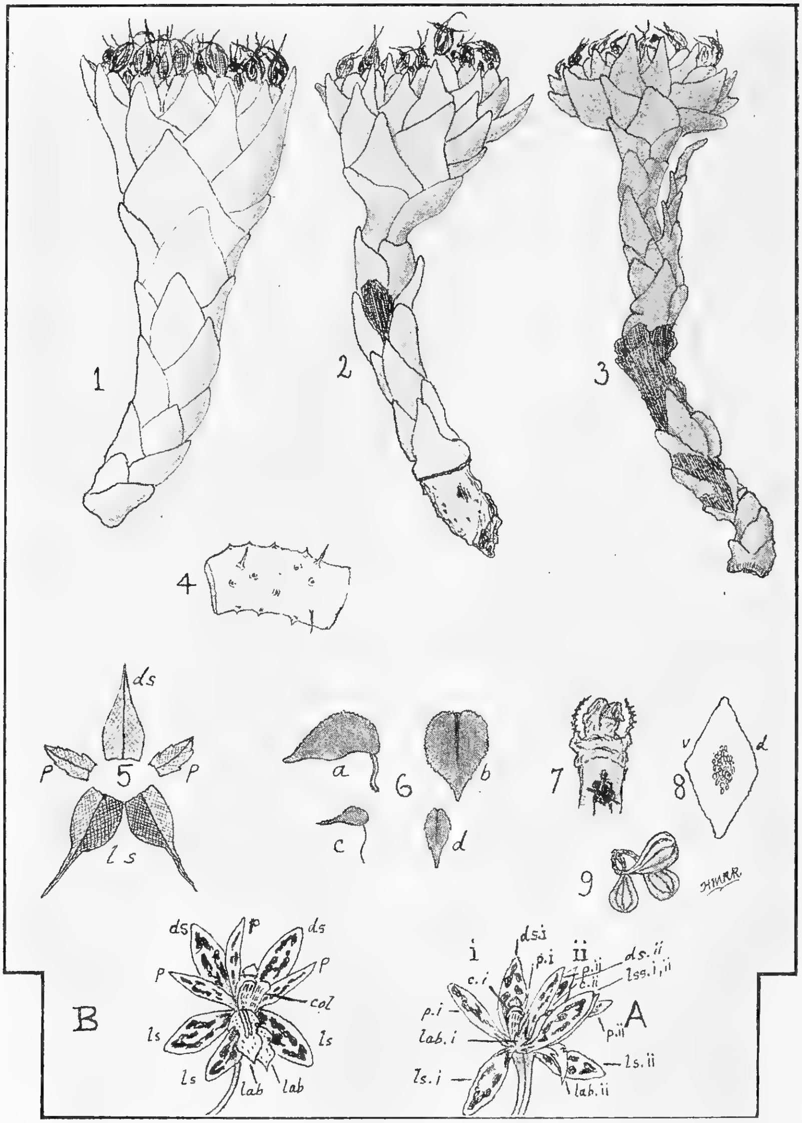
from white to dingy brown in colour. Uppermost bracts elongated, scarcely spreading, subtending the outer flowers. Bractless portions of rhizome with a very few short, scattered white hairs and far more numerous minute tubercles. Rhizome expanding at its upper end into a broad capitulum containing 15–30 crowded flowers, sessile on irregularly quadrilateral ovaries. Flowers facing inwards, the outer ones larger than the inner. (Colours uncertain owing to withered condition.) Sepals and petals quite free, all with a prominent mid-vein and densely reticulate. Dorsal sepal 5–8 mm. long, broad below, but usually tapering to an acuminate point, concave and curving to form a hood over the column. Lateral sepals larger, very broad and concave to about the middle, then suddenly contracting and becoming almost filiform: longitudinally the half on the inner side of the mid-vein darker than that on the outer side. Petals about half as long as the lateral sepals, acute, margins usually denticulate. Labellum in the outer flowers up to 3 mm. long, broadly ovate-mucronate, concave above, fleshy and apparently glandular-rough, margins serrate or minutely denticulate; attached at its base to a projection from the column-base by a ribbony claw one-third to one-half its own length. Labellum in the small inner flowers minute, almost lanceolate, with a claw as long as itself. Column in the withered flowers somewhat obscure in detail, quite free, a little shorter than the petals: two very slender, dark appendages near the summit apparently curving round the anther. Stigma high up. Anther obscure, but in one flower apparently 2-celled, pollinia not seen. Ovary white, but becoming dingy and greatly swollen as it matures, very succulent. Ripe seeds fig-shaped, brown, ribbed longitudinally.

Dr. Rogers was unable to detect, in the flower he dissected from the single specimen sent to him, the denticulate margins of the petals, and the sepals appeared to be merely acute. In the five flowers which I dissected from two specimens, the details in these respects were as I have described above.

Alum Mountain, Bullahdelah, late November, 1931, E. Slater, and a week later, E. Slater and Dr. H. L. Kesteven.

The affinities of this remarkable orchid with *Rhizanthella Gardneri* Rogers are sufficiently obvious to warrant its inclusion in the subtribe Rhizanthellinae if, as Dr. Rogers himself suggests, the description of this subtribe be modified to admit genera having flowers with free segments. The following comparison, however, will serve to indicate that the new plant cannot be placed within the genus *Rhizanthella.*

Rhizanthella.	*Cryptanthemis.*
Flowers succulent and directly continuous with their ovaries so that the point of union is externally obscure.	Sepals and petals membranous, flower continuous with the immature ovary but the point of union quite obvious.
Sepals and petals more or less connate into a tube or bell.	Sepals and petals quite free.
Labellum relatively large, on a very short claw.	Labellum rather small, in the central flowers minute: claw varying in length, in central flowers as long as the labellum.
Column at least partly adnate to the dorsal sepal, and without appendages.	Column quite free, with two apical appendages.



Text-figs. 1-9.—*Cryptanthemis Slateri*, n.g. et sp.

1, 2, 3.—Specimens of the plant, showing capitula of withered flowers. No. 1 was in better condition than 2 and 3. No. 3, in which the flowers were scarcely recognizable, was found lying partly exposed. It was the only specimen seen with a branch to the rhizome. The bracts of the rhizome appear to darken with age and exposure.—4. Portion of rhizome without bracts, showing hairs and tubercles.—5. Sepals and petals.—6. Labellum: *a, b,* side and front views of labellum in an outer flower; *c, d,* the same in an inner flower.—7. Upper part of column, showing appendages, shrivelled anther, and particles of earth, etc., adhering to stigma.—8. Cross-section of ovary; *d,* dorsal; *v,* ventral surface.—9. Ripe seeds.

1-3 approx. nat. size; 4-9 variously enlarged.

The white hairs on the bractless portions of the rhizome of *Rhizanthella*, which in the plates accompanying Dr. Rogers's description are shown to be very numerous, are represented in *Cryptanthemis* by only a very few scattered units, but there are numerous minute tubercles which in some cases are elongated upwards. Both hairs and tubercles may be the remnants of a root-system. From my examination of the specimens, and after inspecting the site of the dicovery, I am inclined to believe, as Dr. Rogers suggests of *Rhizanthella*, that the flowers of *Cryptanthemis* actually develop and open beneath the surface, the capitulum of ripening ovaries subsequently pushing up, but still remaining hidden under debris. If this is the case, we may hope that the association with *Dipodium* will prove to be more than accidental, for otherwise the discovery of fresh flowers will be a very difficult problem.

I desire to express thanks to Messrs. Slater and Fieldsend and Dr. Kesteven for their ready help, without which this description could not have been given, and to Dr. Rogers for his valuable comments and suggestions. I may point out, in concluding, that the only rhizome branch yet seen in *Cryptanthemis* is nearly parallel with the rhizome itself, and not approximately horizontal, as the branches are described in Rhizanthellinae. The *Cryptanthemis* branch, however, is very small and possibly immature, and the points of agreement in habit and character between the Corrigin and Bullahdelah plants seem to me to justify their inclusion in the same subtribe at least until both are more thoroughly known.

I have given the plant the generic name of *Cryptanthemis* in allusion to its habit, for even if it should be found that the flowers open on the surface of the soil, they still remain hidden beneath bush debris. I think it only right that Mr. Slater's keen faculty of observation in the circumstances of this striking discovery should be recognized, and I have therefore named the species after him.

DIURIS CUNEATA Fitzg.

In January, 1932, Dr. F. A. Rodway sent a fine specimen of *Diuris* from Bowen Island, Jervis Bay. I think there can be no doubt that this is Fitzgerald's *D. cuneata*. In my specimen these are 9 flowers, but only 2 were living when it reached me; these lasted for several days. The labellum and column agreed almost perfectly with Fitzgerald's figures. The lateral sepals were relatively longer—9 cm. in one flower; the petals were hardly spotted as in Fitzgerald's plate, but irregularly tinged with deeper colour. After watching one flower gradually open and mature, I am of opinion that the basal portion of the

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Text-figs. A, B.—Two abnormal specimens of *Cymbidium canaliculatum* R.Br. on a plant grown by Mr. F. Fieldsend of East Maitland. × ⅗ approx.

A consists of two flowers, i and ii, with their ovaries and stalklets completely united, a narrow channel marking the union. In i, the labellum is almost abortive (A, *lab. i*), and is erect; the petal nearest ii is also very small (*p. i*, middle of specimen). The other petal (*p. i*, on left), dorsal sepal (*ds. i*) and left lateral sepal (*ls. i*) are normal, as is the column (*c. i*). The right lateral sepal is united along its dorsal surface with the left lateral sepal of ii (*ls. i, ii*). All other parts of ii are normal.

B consists of two flowers united into a "compound" flower on a single ovary and stalklet. There are two dorsal sepals (*ds.*), neither of them directly behind the column: three petals (*p.*), the middle one occupying the place of a normal dorsal sepal: three lateral sepals (*ls.*), the middle one under the labella but twisted slightly to the left: two labella, one above and slightly to the left of the other: and two columns completely united, the right-hand one without any anther.

petal is really an unusually broad claw or stalklet. The petals in my two flowers were reflexed at maturity from the base of the broadest part or lamina, but not from the base of the whole petal. In Fitzgerald's plate (Vol. ii, part 4) the topmost flower seems to have petals broadly clawed. The Bowen Island plant is more robust than that figured by Fitzgerald, which came from Cootamundra.

PTEROSTYLIS BAPTISTII Fitzg.

In October, 1931, Dr. Rodway found this fine Greenhood orchid near Huskisson, Jervis Bay. So far as I am aware, this constitutes a new southern record for the species.

DENDROBIUM TERETIFOLIUM R.Br. var. FAIRFAXII.

In These PROCEEDINGS, lvi, Part 5, 1931, I described a peculiar form of this orchid found by the Rev. E. Norman McKie in the Guyra district. Mr. McKie has reminded me that I was mistaken in recording it as growing on a tree. It was on a mossy and lichen-covered granite rock, at an elevation of 4,500 ft. In view of its characteristics, this circumstance seems to strengthen the hypothesis that it may be a natural hybrid with *D. striolatum* F.v.M.

PRASOPHYLLUM ACUMINATUM Rogers.

This species, which was named by Dr. Rogers a few years ago from specimens sent by me from Bullahdelah and Paterson, extends at least 100 miles further north than the former locality. In January, 1932, I found it in great abundance near Port Macquarie, with many remarkably fine specimens.

This may be a convenient place to call attention to an important revision of certain of the "pigmy" species of *Prasophyllum* by Mr. W. H. Nicholls (*Vict. Nat.*, Oct., 1931), since it affects the identification of more than one New South Wales form. The late Messrs. Maiden and Betche (These PROCEEDINGS, xxxiv, 1909) described a small *Prasophyllum* found by Mr. J. L. Boorman near Braidwood as a variety of Brown's *P. fimbriatum*. Mr. Nicholls has examined this plant and found it identical with what has for many years passed in Victoria as *P. Archeri* Hook. But he demonstrates with convincing evidence that the real *P. Archeri* is the plant named by C. Stuart *P. intricatum*, and (in a variety) by Ewart and Rees *P. ciliatum*. The wrongly-named *P. Archeri*, which is certainly not identical with *P. fimbriatum*, Mr. Nicholls has now named *P. Morrisii*. From our New South Wales Prasophylls, therefore, the name *P. intricatum* must be deleted, and replaced by *P. Archeri* Hook.; while the Braidwood plant becomes *P. Morrisii* Nicholls. A full description of the latter is given by Mr. Nicholls in the paper referred to.

CYMBIDIUM CANALICULATUM R.Br.

In the late spring of 1931 I received two very interesting teratological specimens of this orchid from Mr. F. Fieldsend, of East Maitland. The description given with the accompanying text-figures A, B, will, I think, be found sufficient to explain the abnormal formation of these flowers without any further comment. Both were on a plant grown by Mr. Fieldsend in his fernery. This handsome *Cymbidium*, which is often found in immense clumps requiring several men for handling, appears to have a peculiar range of habitat in New South Wales.

I have not heard of it south of Newcastle, but in the Hunter and Paterson valleys it is quite common, and unfortunately too conspicuous for its own welfare. On the western slopes of New England it is extraordinarily abundant, and I have myself seen it well out on the great western plains. In my own experience it is the only "tree orchid" found west of the Dividing Range. It ascends the New England heights for at least 3,000 ft., but I have not heard of its occurrence on the tableland, and I am doubtful if there are authentic records of it anywhere along the North Coast. I discovered a solitary plant on the eastern base of the Alum Mountain at Bullahdelah, and that is my only record of its existence in the neighbourhood of the coastal rain-forests.

NOTES ON AUSTRALIAN DIPTERA. XXX.

By J. R. MALLOCH.

(*Communicated by Dr. G. A. Waterhouse.*)

(One Text-figure.)

[Read 27th April, 1932.]

Family CALLIPHORIDAE.

Genus CALLIPHORA Robineau-Desvoidy.

When I wrote my paper on this genus in 1927 (These PROCEEDINGS, 52, p. 299) I intended merely to make available to Australian students of these flies such data as were necessary to prompt some resident entomologist to tackle the elucidation of the closely allied species the limits of which were not at all clear to me. One of the species which I considered required elucidation was *hilli* Patton, as I pointed out there was a possibility that one or more of the species names which Major Patton had listed as synonyms of *stygia* (Fabricius) would prove to be valid species and that it might be that *hilli* would prove to be a synonym of one of them. My own material was quite limited and from only the localities listed, there being no specimens from the western portions of Australia and none from the south or Tasmania. It was therefore of interest to me to note the appearance of a paper by G. H. Hardy (*Bull. Ent. Res.*, 21, pt. 4, 1930, 441) in which there was an attempt made to divide the complex further. As I have, since the appearance of my first paper, received many specimens of the genus and quite a few that fall within the scope of what very probably has been accepted as *stygia* by most systematists, I considered it worth while to check up the available material with the published findings of Hardy. I present below the data obtained from my survey.

CALLIPHORA HILLI Patton.

I had the males of but one species before me when I wrote my paper, and this has the fore coxae fuscous in front and much darker than the bases of the femora. It runs down to the first section of Caption 6 in Hardy's key and there he places *hilli* and *rufipes* Macquart, both with an added question mark. Evidently we agree in this respect, though it is difficult to understand how he arrives at the conclusion that I had probably two other species which he describes as new confused under *hilli*. I now have *fulvicoxa* as noted below.

CALLIPHORA FULVICOXA Hardy.

This species is readily distinguished from *hilli* as accepted by me by the fulvous yellow fore coxae, and the almost invariable presence of three pairs of presutural acrostichal bristles. It may be noted that Hardy mentions in his paper that Bezzi and Malloch "have used the bristles of the scutellum and thorax for discriminating the species with more or less success", and that "with certain alterations their characters may be used advantageously". It is very rarely the case that the presutural acrostichals vary, and when they do it is usually the anterior pair or pairs that lack either one or other of the bristles; when there are three pairs present the posterior pair is close to the suture and generally well developed. In the case of two females with three pairs of presutural acrostichals which I noted in my previous paper, it appears that these, though not the male from the same locality, Eungella, Queensland, are *fulvicoxa*.

I have now specimens of this species from Barrington Tops, Feb., 1925, Allyn Range, on *Leptospermum* (S.U. Zool. Exped.).

CALLIPHORA AURIVENTRIS Malloch.

This species was known to me only from one female, but apparently Hardy has seen the male. It has entirely black legs and is readily distinguished from the others in this group.

CALLIPHORA TIBIALIS Macquart.

This species has the femora black, tibiae reddish-yellow or brownish, and the tarsi black. The almost invariable presence of a strong lower anterior sternopleural bristle is a good distinguishing character.

I have seen some additional material since my paper appeared, some very large examples from Barrington Tops taken under the same circumstances as the specimens of *fulvicoxa* recorded above.

CALLIPHORA STYGIA (Fabricius).

Similar in coloration to *hilli* as accepted herein, the fore coxae being dark in front, but the enlarged eye-facets of the male readily distinguish it.

CALLIPHORA STERNALIS, n. sp.

♂, ♀. Very similar to *tibialis* Macquart, but in both sexes there are many fulvous yellow hairs on the pleura and venter of abdomen and on the extreme base of the first visible abdominal tergite there are some brownish-yellow hairs; the apices of the femora are usually brownish or yellowish, more noticeably so in the female, and on the mid and hind legs; the tibiae are fulvous yellow; hairs on disc of lower calypter fulvous; bases of wings yellowish.

Structurally distinguishable from *tibialis* by the wider frons in the male, the widest part being distinctly greater than the width across the posterior ocelli and noticeably greater than the width of the third antennal segment. The presutural acrostichals are in two pairs, and the posterior sublateral bristle is present. The most striking structural character for separating the male from that of *tibialis* is the form of the fifth abdominal sternite, this being radically different from that of any other species known to me, as shown in Figure 1*a*, the other species having the same sternite consisting of two long broadly rounded lobes separated by a deep cleft (Fig. 1*b*). Length, 8–10 mm.

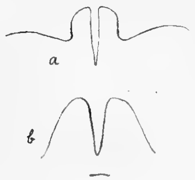


Fig. 1.—Outline of apex of fifth sternite of (*a*) *Calliphora sternalis* and (*b*) *C. tibialis*.

Type, male, allotype, one male and two female paratypes, Barrington Tops. February, 1925, Allyn Range, on *Leptospermum* (S.U. Zool. Exped.); female paratypes, Wondandian Cr., 26.12.1927 (Mackerras); Milson Is., 19.12.1909.

This may be the species, referred to by Hardy as being in the possession of Dr. Mackerras, that seems to run to couplet 5 in his key, but is quite distinctive in its genitalia and is represented by a unique male. My material was sent to me about two years ago by Dr. Mackerras, but has been laid aside waiting on an opportunity for a report until now. I am returning all material except one male and one female to Dr. Mackerras for disposal in some Australian museum.

CALLIPHORA RUFIPES Macquart.

This species was originally described from Java, and though it was subsequently recorded from Tasmania by its describer (*Dipt. Exot.*, Suppl. 2, p. 99), he there mentions that the specimens in hand differed from the original in certain colour characters, which leads me to believe that the second record does not belong to the same species. The description of the thorax as black-blue and the abdomen as blue does not indicate that the species was one of the same group as *tibialis*, which is fairly accurately described as to the pollinose dorsum of the abdomen with the distinct checkering.

Patton has placed *rufipes* as a synonym of *stygia*, but whether he saw the real type or not I do not know. In any case, I do not believe it is Australian, and it is certainly not one of the present group.

It may be of interest to note that Patton places *Calliphora rufipes* Macquart as a probable synonym of the American species (*Hemilucilia*) *segmentaria* (Fabricius) on a subsequent page of the paper above referred to (*Phil. Journ. Sci.*, 27, No. 3, 1925, p. 401). The reason for this statement is not given, and Aldrich, in writing up the group to which this species belongs, did not include *rufipes* as a synonym of *segmentaria*.

CALLIPHORA AUSTRALIS Boisduval.

Patton has placed this species as a synonym of *stygia* in the paper above referred to, but whether he is correct in doing so, or Hardy is correct in accepting it provisionally as a species occurring in Western Australia, there may be no means of determining unless the type is extant.

In my opinion, it is best to drop the species *rufipes* Macquart from the Australian list. This will leave *hilli* as accepted by me, and apparently also by Hardy, as a definite name for a well established species, but in the case of *australis* it would appear best to relegate the species to the list of those that are unrecognizable, unless one accepts Patton's decision that it is a synonym of *stygia*. In either case the action would leave the way clear for the description of the two western species now before me and possibly the same two referred to by Hardy in his paper. Whether there may be more than these two species in that region remains to be determined by more extensive collecting.

CALLIPHORA VARIFRONS, n. sp.

♂, ♀. Very similar in most respects to *hilli*, differing in the much more conspicuous white dusting on the frontal orbits and upper parafacials in the male, and the more distinctly checkered appearance of same. It is noteworthy that the postocular orbits are also densely silvery-white dusted, whereas in *hilli* they are yellowish-grey dusted. These colour differences hold also for the females.

Structurally similar to *hilli*, with two pairs of presutural acrostichal bristles, and the posterior sublateral bristle generally present. The frons of the male is wider than in *hilli*, being about twice as wide as the distance across the posterior ocelli, and the parafacials are wider in profile. Length, 7–9 mm.

Type, male, and allotype, Mundaring, W.A., 23.8.1926 (E. W. Ferguson); paratypes, one female, Perth, W.A., 15.11.1924 (Nicholson); one female, Wyalkatchem, W.A., 1.9.1926 (E. W. Ferguson). One female will be retained by the author and the others returned to Dr. Mackerras.

CALLIPHORA ALBIFRONTALIS, n. sp.

♂. Similar to the preceding species, but owing to the much narrower frons and slightly narrower parafacials the white dust is less conspicuous and not noticeably checkered; the postocular orbits are white-dusted, but not as markedly checkered as in the preceding species. Both specimens before me have a dark-brown stripe on the posterior surface of the fore femur which is widest and most distinct basally, in addition to the brownish stripe usually present in this group on the apical half of the anterior surface of this femur.

Structurally the species differs from the preceding one in having the narrowest part of the frons not as wide as the distance across the posterior ocelli, the parafacials narrower, the presutural acrostichals in three pairs, and a quite evident but not very strong lower anterior sternopleural bristle. This last feature is lacking in most of the species with the yellow femora, but well developed in those in which the femora are black or largely so. Length, 7–9 mm.

Type and one paratype, Mundaring, W.A., 23.8.1926 (E. W. Ferguson). Type will be returned to Dr. Mackerras, the paratype retained meanwhile by the author, but probably sent later to Australia.

Female unknown.

Although I realize that there are more species of this group yet to be obtained, especially in the west, I present a key to those listed above in the hope that it may be useful in connection with that already published by the author and the one by Hardy.

Key to males of species related to stygia *Fabricius.*

1. Facets on the upper half of eyes strikingly larger than those of the lower half; presutural acrostichals in three pairs; fore coxae darkened in front; femora and tibiae yellow .... *stygia* (Fabricius)
   Facets of upper half of eyes not much larger than those of the lower half 2
2. Fore coxae entirely yellow; presutural acrostichals in three pairs; frontal orbits yellow-dusted .... *fulvicoxa* Hardy
   Fore coxae distinctly blackened in front at least 3
3. Femora of all legs largely or entirely blackened 4
   Femora of at least the mid and hind legs fulvous yellow and not darker than the tibiae 7
4. Tibiae always distinctly paler than at least the basal halves of the femora; sternopleurals 2 + 1 5
   Tibiae not noticeably paler than the femora, the legs entirely black 6
5. Femora partly yellowish apically; fifth abdominal sternite with a pair of closely approximated processes in centre of apex (Fig. 1); posterior sublateral bristle of mesonotum present; narrowest part of frons fully as wide as third antennal segment .... *sternalis*, n. sp.
   Femora entirely black; fifth abdominal sternite normal, with a deep central cleft; posterior sublateral bristle almost invariably lacking; narrowest part of frons not as wide as third antennal segment .... *tibialis* Macquart
6. Abdomen with some yellow hairs; narrowest part of frons about as wide as distance across posterior ocelli; frontal orbits silvery-white dusted .. *canimicans* Hardy
   Abdomen without any yellow hairs; narrowest part of frons about as wide as anterior ocellus; frontal orbits yellow-dusted .... *auriventris* Malloch

7. Presutural acrostichals in three pairs; narrowest part of frons not wider than the distance across posterior ocelli; frontal orbits and upper portion of parafacials, and the postocular orbits, densely white-dusted .... *albifrontalis*, n. sp.
   Presutural acrostichals in two pairs 8
8. Narrowest part of frons about twice as wide as width across posterior ocelli, the frontal orbits, upper half or more of parafacials, and the postocular orbits densely silvery-white dusted and quite noticeably checkered .. *varifrons*, n. sp.
   Narrowest part of frons not noticeably wider than distance across posterior ocelli, the frontal orbits, parafacials, and postocular orbits yellowish, greyish, or white-dusted 9
9. Narrowest part of frons about as wide as distance across posterior ocelli; frontal orbits white-dusted .... *hilli* Patton
   Narrowest part of frons not as wide as distance across posterior ocelli; frontal orbits yellow-dusted .... *fallax* Hardy

N.B.—It will be necessary to check up identifications made by the use of the key with the descriptions in the various papers on the group. There are some minute distinctions in the form of the inner processes of the male hypopygia shown by Hardy in his figures, but these require careful checking, and there may be slight variations in the different species, which only comparative work on large series will establish.

Subgenus PROEKON Surcouf.

I have not cared to use the subgenera suggested by Hardy in my papers because they do not appear to be well established, and the character of colour has never appealed to me as a good one for subgeneric segregations. However, I do not propose to raise the question of the validity of these group names here, but merely point out that there may be some question of the validity of the species name *lateralis* Macquart as the species was described as *Ochromyia lateralis* and there is another *lateralis* Macquart (*Dipt. Exot.*, 2, pt. 3, 1843, 277) on a previous page in the same volume, which, though described as a *Bengalia*, is an *Ochromyia*, these generic names being applicable to the same concept.

It is thus evident that even if this second *lateralis* Macquart is not, as stated by Patton, a synonym of *augur*, it has no standing in our classification.

Genus ONESIA Robineau-Desvoidy.

Bezzi used in his paper on the Calliphoridae of the Pacific Islands and Australia the following characters for distinguishing *Calliphora* as a subgenus from *Onesia*:

"Parafacials narrow, bare or only slightly pilose above; squamae blackish .... *Calliphora*
Parafacials broad and pilose above, chiefly in the female; squamae broadly whitish; peristomalia black, with black hair; scutellum with two laterals; arista with rather long bare terminal portion .... *Onesia*"

These characters will not distinguish two groups; if they are made use of for that purpose we will then have several additional groups containing one or more species in different parts of the world which will require recognition also. As a matter of fact, *Onesia* cannot be clearly distinguished from *Calliphora* except in so far as the genotypes are concerned, and there are so many intergrading forms that the recognition of them as separate genera or subgenera is impossible.

A PRELIMINARY ACCOUNT OF THE PROTURA OF AUSTRALIA.

By H. WOMERSLEY, A.L.S., F.E.S., Division of Economic Entomology, C.S.I.R.

(*Communicated by Dr. R. J. Tillyard.*)

(Twenty Text-figures.)

[Read 27th April, 1932.]

Dr. R. J. Tillyard (Insects of Australia and New Zealand, 1926) stated that this order had not so far been found in either Australia or New Zealand. Prof. W. J. Dakin, in a letter to *Nature* (19th June, 1926), said of the pabulum in which specimens of Peripatus were sent to England: "A few termites were present in the soil and there were a number of Protura". Inquiries in Australia have elicited the information that the soil was collected by Miss M. G. C. Fordham in the Nannup district. As Prof. Dakin's communication was the first suggestion that Protura occurred in Australia, I immediately wrote to him requesting the opportunity of examining the soil in question. Publication of his letter had been delayed for some two months, and in the meantime the material had been thrown away. This possible first record of Protura from Australia consequently cannot be substantiated by description of specimens or species.

Since my arrival in Western Australia in September, 1930, I have paid special attention to these insects and have been able to examine and study all the specimens so far taken by myself and other entomologists, and the result is embodied in this paper.

In all, six species have been determined, four belonging to the genus *Acerentulus* Berlese, and two to *Eosentomon* Berlese. From Western Australia are now known the two species of *Eosentomon* and three of *Acerentulus*, the fourth species of the latter genus having beeen found in Federal Territory by Dr. R. J. Tillyard, and in Victoria by Mr. F. H. Drummond. The bulk of both species and actual specimens from Western Australia were found by Mr. D. C. Swan of the Biological Department of the University of Western Australia.

His first specimen was taken from leaves lying at the foot of Eucalypts in the University grounds at Crawley, W.A., 30/10/30. Other specimens were taken later in the same locality and also, by Mr. Swan and myself, from similar habitat in King's Park, Perth. I have since (28/8/31) taken *Eosentomon westraliensis*, n. sp., at Greenbushes, 159 miles south of Perth, while still more recently (30/9/31) Mr. Swan has found five specimens of *Acerentulus occidentalis*, n. sp., in the Darling Ranges near Pinjarra, about 50 miles south of Perth. Both the species on these occasions were found under deeply embedded stones, while the original captures were from decaying leaves, etc., and the specimens obtained by means of the Berlese funnel. Apart from these records, all specimens were from Crawley and King's Park. More intensive collecting in other parts of Australia will doubtless bring to light more species and a very wide distribution.

To Mr. D. C. Swan of the University of Western Australia I would like to express my deep appreciation of his intensive search for these interesting insects in which he has been so extremely successful. He has also very kindly checked up the chaetotaxy of the various species.

This order of insects was first discovered by Prof. Silvestri (1907) in Italy when he described *Acerentomon doderoi.* Prof. Berlese (1909) in a monograph on the order described many species. He differed, however, from his fellow countryman in regarding them as closely related to the myriapods and not to the insects. In his work he calls them *Myrientomata.*

Whether they should be regarded as myriapods rather than insects depends on the importance to be attached to the feature of "anamorphosis" possessed by these creatures. This anamorphosis consists of the interpolation of additional abdominal segments one at a time, between the last and last but one, as the creature grows from the nine- to the twelve-segmented stage. This is, of itself, a myriapod character and does not occur in any other insects except in a secondary manner in the antennae and cerci of some Apterygota. The absence of antennae in all known species, with one possible exception, has also been used to support the argument against their being insects. On the other hand, the mouth parts, distinct division of body into head, thorax and abdomen, and position of the genital opening show without much doubt that they are really insects, and most authorities to-day agree with Prof. Silvestri in regarding them as such. They may perhaps be considered as an early branch of the primitive insect stock running parallel with the myriapod stem. It would consequently be earlier than any of the known forms of the true insects (including the Collembola).

The Protura differ from all other insects in possessing in the adult twelve abdominal segments, the last three of which in life are telescoped within the others. With the possible exception of *Protapteron indicum* (Schtf., 1909) which I have discussed elsewhere, all known species lack antennae. The head is usually egg-shaped and the mouth-parts are contained within the head capsule. In one genus the labrum is produced in a snout-like manner. Eyes are entirely absent, but on each side of the head is a small oval or circular sensory organ termed a pseudocellus.

The thoracic segments are well developed, generally strongly chitinized and carry the usual three pairs of legs. The insects are remarkable in that, in life, the front legs, which are comparatively long and possess special sensory hairs on the tarsi, are not used for walking but rather as tactile organs in place of the antennae. Each tarsus carries a single claw with a bristle-like empodium. The claws are generally evenly curved on all feet, but in the family Eosentomidae those on the front feet are S-shaped. In the family just mentioned the meso- and metathoracic segments have a pair of stigmata. These are not known in any other family, with the possible exception of the Protapteridae.

The abdomen is generally tapering and well chitinized, especially towards the apex. Towards the front edge of each tergite is a more strongly chitinized band known as an apodeme. Although these apodemes vary a little in curvature in the different genera, they cannot be used for specific differentiation as has been done by some workers. In this respect I have previously shown (1927) that they also vary very greatly during the immature stages. The first three abdominal segments also carry a pair of appendages. In the Eosentomidae all three pairs are two-jointed, while in the Acerentomidae the first or first and second pairs only are two-jointed. In some genera, on the posterior lateral corners of the tergites, there is a small pectine or comb which varies somewhat between species.

Of the life history of these minute creatures little is known. The largest species known does not exceed 2 mm. in length.

They occur in more or less damp situations, under stones well buried in clayey marl, in moss, in peat, and under bark. Although they can be picked out under a lens in the field when they occur under bark or under stones they can best be got from moss, etc., by bringing it home and putting it through the Berlese funnel.

The earliest known instar is that with nine segments. The eggs have not been seen except *in situ* in the ovaries. Here they are comparatively large, occupying about one-third of the abdomen.

Distribution.

Including the new species described in this paper there are now 49 species of Protura known. From the different regions of the world they are as follows: Europe, 26; America, 15; India, 2; South Africa, 1; Java, 1; Australia, 6. The number of American species probably needs revision for, as I have previously indicated, the character used, namely, the forking or otherwise of the apodemes, is not a good character on which to separate species. This character varies within the larval stages.

Classification.

I. Antennae present, many jointed. Thoracic stigmata present on front of segments 2 and 3 .... Fam. Protapteridae Börner.—*Protapteron indicum* Schptf.
II. No antennae. Stigmata, when present, on sides of segments.
  1. Stigmata absent. First or first and second pairs of abdominal appendages two-jointed. Pectines usually present on segments v and viii .... Fam. Acerentomidae Berlese.
    a. First pair only of abdominal appendages two-jointed .... Subfam. Acerentominae Womersley.
    aa. Labrum produced, snout-like .... Gen. *Acerentomon* Silv.
    bb. Labrum not produced .... Gen. *Acerentulus* Berlese.
    b. First two pairs of abdominal appendages two-jointed .... Subfam. Merentominae Womersley.
    cc. Abdominal tergal apodemes absent, all segments dorsally with a single row of setae. Pectines absent .... Gen. *Merentomon* Womersley (= *Protentomon* Ewing, preoccupied).
    dd. Abdominal tergal apodemes present. Tergites i-vi and viii with an anterior row of two setae. Segment viii with modified pectines .... Gen. *Parentomon* Womersley.
  2. Meso- and metathorax with lateral stigmata. All three pairs of abdominal appendages two-jointed .... Fam. Eosentomidae Berlese.—Gen. *Eosentomon* Berlese.

Description of Australian Species of Protura.

ACERENTULUS Berlese.

ACERENTULUS WESTRALIENSIS, n. sp. Text-figs. 9, 10.

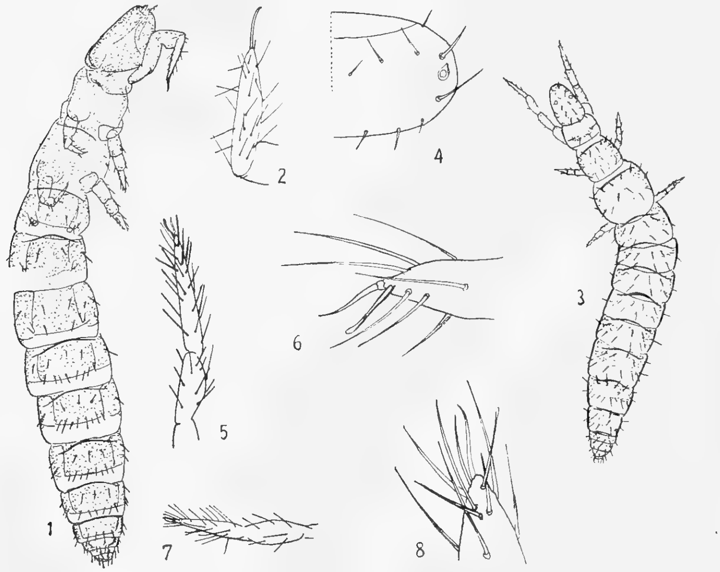
Length (extended with acetic acid), 875 μ. Head 75 μ long, 65 μ wide, almost round; pseudocelli 8 μ diam.; head well chitinized; front cephalic setae 12 μ long, basal setae 12 μ. Thorax well chitinized, with slight apodemes on meso- and metathorax. Front legs 210 μ long, tarsus 54·6 μ, claw evenly curved, 15·4 μ, ratio of length of tarsus to claw =TR ≐ 3·5, subapical setae 22 μ long. Middle legs 98 μ, tarsus 22·4 μ, claw 11·2 μ. Hind legs 106 μ, tarsus 25·4 μ, claw 14 μ. Abdominal segments strongly chitinized, especially apically, apodemes present on segments i-viii, simple and curved on i-vii, nearly straight on viii. Pectines present on tergite viii, but indistinct. Abdominal appendages on segments i-iii normal, i 20 μ long, ii and iii 14 μ. Chaetotaxy as in figures and table of species.

This appears to be one of the most abundant forms so far found in Australia. It has been taken by Mr. Swan as follows: University Grounds, Crawley, W.A., 2/11/30 (2 specimens), 21/4/31 (1 specimen), 8/5/31 (1), 11/6/31 (1), 9/7/31 (1).

ACERENTULUS AUSTRALIENSIS, n. sp. Text-figs. 3, 11, 12.

Length (extended), 750 μ. Head 84 μ × 61·6 μ, moderately chitinized, pseudocelli round, 8 μ diam., front cephalic setae 12 μ, basal setae 5 μ. Thoracic segments well chitinized, apodemes on ii and iii. Front legs 176 μ, tarsus 21·6 μ, claw evenly curved, 11·75 μ, TR= 4·75, subapical setae 16·8 μ. Middle legs 92 μ, tarsus 21·6 μ, claw 8·4 μ. Hind legs 100·8 μ, tarsus 28 μ, claw 10 μ. Abdomen well chitinized, tapering posteriorly, apodemes present and strongly chitinized on tergites i-viii, curved on i-vii, straight on viii. Pectines present but indistinct on segment viii. First pair of abdominal appendages 28 μ long, second and third pairs 14 μ. Chaetotaxy as in figures and table of species.

This form, which is very distinct in the chaetotaxy of the eighth sternite, as well as the value of the tarsal claw ratio (TR), has so far been found on only one occasion. It was found by Mr. Swan in leaf mould in the University Grounds, Crawley, W.A., on 30/10/30.



Text-figs. 1-8.

1, 2.—*Acerentulus tillyardi*, n. sp. 1. Drawing of Dr. Tillyard's specimen, ventral view. 2. Front tarsus and claw.

3.—*Acerentulus australiensis*, n. sp. Dorsal view.

4-6.—*Eosentomon westraliensis*, n. sp. 4. Right half of mesothorax showing stigma. 5. Terminal joints of front leg. 6. Tip of tarsus of front leg showing claw.

7-8.—*Eosentomon swani*, n. sp. 7. Terminal joints of front leg. 8. Tip of front tarsus and claw.

Acerentulus tillyardi, n. sp. Text-figs. 1, 2, 13, 14.

Length (unextended) 750 μ, (extended) 875 μ. Head 89·6 μ × 61·6 μ, well chitinized, pseudocelli small, 5·6 μ diam., front cephalic setae 14 μ, basal setae 8·5 μ. Thoracic segments only moderately chitinized, apodemes barely visible on meso- and metathorax. Front legs 193 μ, tarsus 59 μ, claw evenly curved, 19·6 μ, TR= 3·0, setae 20 μ. Middle legs 101 μ, tarsus 33·6 μ, claw 8·4 μ. Hind legs 112 μ, tarsus 37·8 μ, claw 9·8 μ. Abdomen more chitinized, tapering posteriorly, apodemes curved on segments i-vii, nearly straight on viii, slightly forked anteriorly on vii, pectines on segments v and viii scarcely visible. Chaetotaxy as in figures and table of species.

This is the only species so far found in the eastern States. It was first found by Dr. R. J. Tillyard in soil from the base of a tree-fern at Blundells', F.C.T., 18/2/31. On this occasion only one specimen was obtained. Several other specimens of the same species were found by Mr. F. H. Drummond, of Melbourne University, at Belgrave, Victoria, on 19/4/31.

This species is very similar to *A. westraliensis* in the arrangement of setae, but differs distinctly in the value of TR.

Acerentulus occidentalis, n. sp. Text-figs. 15, 16.

Length (extended) 1350 μ. Head 124 μ × 81·5 μ, well chitinized, pseudocelli 9·8 μ diam., front cephalic setae 20 μ, basal setae 10 μ. Thorax well chitinized, segments ii and iii with distinct apodemes. Front legs 270 μ, tarsus 88 μ, claw 22 μ, TR= 4·0, setae 32 μ. Middle legs 160 μ, tarsus 39 μ, claw 15 μ. Hind legs 176 μ, tarsus 42 μ, claw 16·3 μ. Abdomen tapering, strongly chitinized, apodemes on i-vii thin, strongly curved and simple, on viii practically straight, distinct pectines on viii with teeth of equal length. First abdominal appendages 33 μ long, second and third 22 μ. Chaetotaxy as in figures and table of species.

This species is the largest so far known from Australia, and was taken by Mr. Swan as follows: University Grounds, Crawley, W.A., 21/4/31, 29/6/31; Fairbridge Farm, Pinjarra, W.A., 30/9/31 (5 specimens under stones).

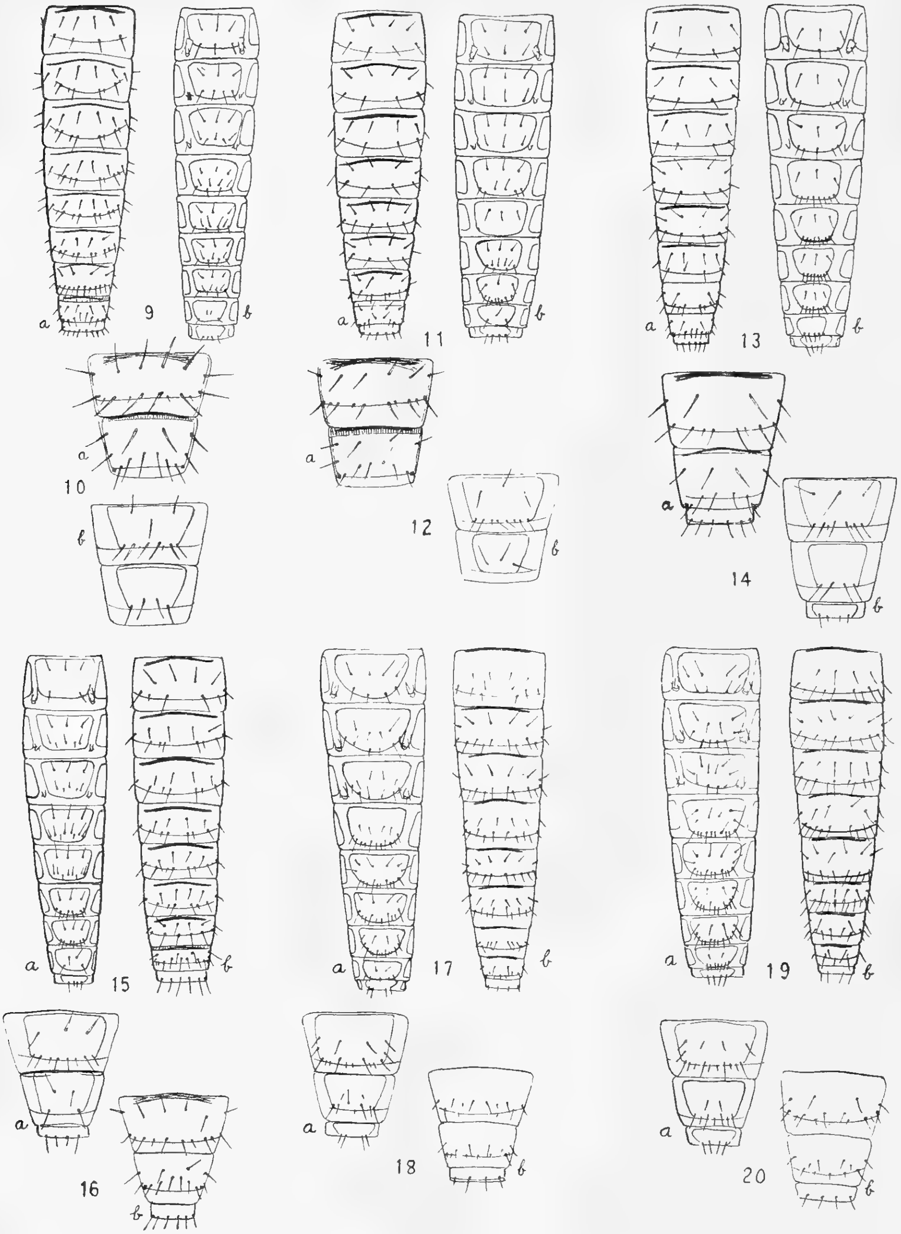
Table for Australian species of the genus Acerentulus.

1. Sternite viii with only three macrosetae in a single subposterior row. TR = 4·75. Length 750 μ .... *australiensis*, n. sp.
   Sternite viii with four macrosetae 2
2. Macrosetae on sternite viii in two rows, an anterior submedial pair and a posterior sublateral pair. TR = 4·0. Length 1,350 μ .... *occidentalis*, n. sp.
   Macrosetae on sternite viii in a single subposterior row 3
3. TR = 3·5. Length 875 μ .... *westraliensis*, n. sp.
   TR = 3·0. Length 875 μ .... *tillyardi*, n. sp.

Genus Eosentomon Berlese.

Eosentomon westraliensis, n. sp. Text-figs. 4–6, 17, 18.

Length (extended) 1,250 μ. Head well chitinized 124 μ × 91 μ, labrum not produced, pseudocelli large, long, diam. 15 μ; front cephalic setae 10 μ, basal setae 10 μ. Thorax much chitinized, slight apodemes on segments ii and iii, spiracles laterally on segments ii and iii, diameter 6 μ. Front legs 326 μ, tarsus 98 μ, claw S-shaped, 16·3 μ, TR = 6·0, setae 30 μ. Empodium bristle-like almost reaching tip of claw, apical clavate hair present. Middle legs 179 μ, tarsus 49 μ, claw evenly curved, 13 μ. Hind legs 212 μ, tarsus 49 μ, claw evenly curved, 15 μ. Abdomen well chitinized, tapering posteriorly, apodemes thin and almost straight on i-viii, pectines absent. All three pairs of abdominal appendages 39 μ × 19 μ. Chaetotaxy as in figures.



Text-figs. 9-20.—Diagrammatic figures showing arrangement of setae.

9-10.—*Acerentulus westraliensis*, n. sp. 9*a*. Tergites i-ix. 9*b*. Sternites i-ix. 10*a*. Tergites vii and viii enlarged. 10*b*. Sternites vii and viii enlarged.

11-12.—*Acerentulus australiensis*, n. sp. 11*a*. Tergites i-ix. 11*b*. Sternites i-ix. 12*a*. Tergites vii and viii enlarged. 12*b*. Sternites vii and viii enlarged.

13-14.—*Acerentulus tillyardi*, n. sp. 13*a*. Tergites i-ix. 13*b*. Sternites i-ix.

King's Park, Perth, W.A., 19/4/31, 21/4/31 (H.W.); Crawley, W.A., 19/5/31, 7/7/31 (D. C. Swan); Greenbushes, W.A., 28/8/31 (H.W.), (3 specimens under deeply embedded stones in clay soil).

EOSENTOMON SWANI, n. sp. Text-figs. 7, 8, 19, 20.

Length (extended) 1,175 μ. Head 98 μ × 85 μ, almost round, labrum not produced, pseudocelli 9–10 μ, front cephalic setae 10 μ, basal setae 6·5 μ. Thoracic segments well chitinized, ii and iii with slight apodemes and spiracles, the latter 8 μ diam. Front legs 260 μ, tarsus 78 μ, claw sinuate 17·3 μ, TR = 4·5, setae 30 μ, apical clavate hair present, empodium almost reaching tip of claw. Middle legs 140 μ, tarsus 28 μ, claw 9 μ. Hind legs 173 μ, tarsus 42 μ, claw 12 μ. Abdomen well chitinized with thin almost straight apodemes on tergites i-viii. All three pairs of abdominal appendages 39 μ × 19 μ. Chaetotaxy as in figures.

Crawley, W.A., 2/11/30, 18/5/31, 19/5/31, 6/6/31, 11/6/31, 14/6/31, 29/6/31, 27/7/31 (D. C. Swan).

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17-18.—*Eosentomon westraliensis*, n. sp. 17*a*. Sternites i-ix. 17*b*. Tergites i-ix. 18*a*. Sternites vii-ix enlarged. 18*b*. Tergites vii-ix enlarged.

19-20.—*Eosentomon swani*, n. sp. 19*a*. Sternites i-ix. 19*b*. Tergites i-ix. 20*a*. Sternites vii-ix enlarged. 20*b*. Tergites vii-ix enlarged.

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THE LARVAE OF THE AUSTRALIAN SHEEP BLOWFLIES.

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(Twenty-two Text-figures.)

[Read 27th April, 1932.]

Introduction.

In order to identify with certainty maggots taken from sheep, it has been found necessary in the past to breed them through to the adult stage. This method of identifying the sheep fly requires a good deal of careful work and considerable delay before results are obtained, and, moreover, is open to grave error. Inadequate breeding technique may result in the loss of much of the material, or one species may overgrow and destroy others, but the greatest danger lies in the lack in most parts of Australia of proper insectary equipment, which makes it almost impossible to avoid contamination by outside flies. Moreover, the survey of species in relation to strike in sheep is greatly simplified by the recognition of the fly in the maggot stage.

The desirability of identifying the larvae of blowflies was recognized by J. L. Froggatt in 1918. He described and figured the spiracles of *Anastellorhina augur* (*Calliphora augur*), *Pollenia stygia* (*Calliphora stygia*), *Pycnosoma rufifacies* (*Chrysomyia rufifacies*), *Pycnosoma varipes* (*Microcalliphora varipes*), *Lucilia sericata* and *Ophyra nigra* (*Peronia rostrata*). The list of species from sheep has since been added to and unfortunately his account is not sufficiently detailed for the recognition of closely related species.

The purpose of this paper is to provide a quick and satisfactory method of identifying the sheep fly larvae.

The following species have been recorded from live sheep. They are arranged in order of succession, which is just as marked on the sheep as it is in carrion (Mackerras, 1931).

Primary.—*Lucilia cuprina* Wied., *L. sericata* Mg., *Calliphora stygia* Fabr.,* *C. augur* Fabr., *C. fallax* Hardy (one record only).

Secondary.—*Chrysomyia rufifacies* Macq., *C. micropogon* Bigot, *Microcalliphora varipes* Macq., *Sarcophaga* (3 spp.).

Tertiary.—*Peronia rostrata* A.D., *Musca hilli* J. & B., ? *Ophyra nigra* Macq.

All the measurements and descriptions are taken from full-grown third instar larvae. By the time strike is noticeable on a sheep in the field, the maggots are mostly in the third stage. They reach this by the end of the second and on the third day on the living animal, or even sooner with some species in warm

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* This species appears to be replaced in Western Australia by *C. australis* Boisd.

weather. The third instar maggot may be recognized by the presence of three slits in the posterior spiracles, regardless of the size of the body.

A detailed description of the larva of *C. stygia* is given, and the others are compared with it. This account should serve to explain the terms used in the other descriptions.

The descriptions and drawings of mouth parts and spiracles are from mounted specimens, but it is possible with the aid of the key and the descriptions to identify any maggot without mounting any of the parts.

The writer wishes to thank Dr. I. M. Mackerras for material and notes and for his interest and assistance in the preparation of the manuscript.

Key to Larvae.

1. Peritreme closed; button or external scar of spiracles situated in peritreme (Calliphorinae) 2
   Peritreme open; button indistinct, in gap of peritreme (Chrysomyiinae and Sarcophaginae) 6
   Peritreme closed; button on spiracular plate internal to peritreme (Muscidae) 9
2. Spiracles very large (more than 0·4 mm. across), separated from one another by less than the spiracular length; peritreme scalloped and wide .... *C. stygia.*
   Spiracles much smaller (less than 0·3 mm. across) 3
3. Spiracles separated by more than the spiracular length; peritreme not scalloped, narrow .... *C. fallax.*
   Spiracles separated by not more than the spiracular length 4
4. Peritreme scalloped and fairly wide, with portion round button projecting prominently; slits far apart, angle of bottom slit with horizontal 13° to 15° .... *C. augur.*
   Peritreme not scalloped, narrow; spiracular plates separated by less than the spiracular length; angle of bottom slit with horizontal 32° to 35° 5
5. Spiracles pear-shaped (longer than broad); peritreme thin and narrow; slits long and thin .... *L. sericata.*
   Spiracles rounded, smaller; peritreme thicker and wider; slits shorter and wider .... *L. cuprina.*
6. Spiracular plates hidden in deep fossa; peritreme with wide opening; slits thin, sloping outwards and downwards (inner and middle) and outer slits vertical; angle between spiracles re-entrant (Sarcophaginae) .... *Sarcophaga* spp.
   Spiracular plates visible; peritreme opening narrower; slits wide and thick; angle between spiracles acute or obtuse (Chrysomyiinae) 7
7. Larvae hairy (tuberculate) 8
   Larvae smooth .... *Ch. micropogon.*
8. Large larvae (up to 16 mm.), very hairy, greyish in colour; peritreme forked at the opening, which is narrow .... *Ch. rufifacies.*
   Small maggots (up to 11 mm.), much less hairy, brownish; peritreme opening wide .... *M. varipes.*
9. Slits very sinuous; peritreme wide .... *M. hilli.*
   Slits slightly sinuous; spiracular plate heavily chitinized, and perispiracular gland openings conspicuous; peritreme narrower .... *P. rostrata.*
   Slits straight and arranged like Calliphorid; peritreme narrow but heavily chitinized .... *O. nigra.*

CALLIPHORA STYGIA Fabr.

The average length of the full-grown, third-stage larva is 19 mm. It is whitish in colour, robust, thick in the middle, pointed anteriorly and broadly truncated posteriorly. The segmentation is well marked, the anterior borders of all the segments bearing bands of small brown spines.

The head is divided into two lobes, each bearing near the apex a small lightly chitinized papilla representing the antenna. This consists of two segments, a larger basal one and a small, dome-shaped, apical one. Close to this, but below the apex, is a small tubercle surrounded by a yellow chitinous ring enclosing a group of minute colourless papillae. This represents the maxillary palp. Ventrally the lobes bear well developed oral grooves converging towards the mouth. Just above this the oral hooks project ventrally from between the lobes.

The three thoracic segments increase in width from the head backwards. Each is bordered anteriorly by a band of several rows of spines. The band on the first segment is wider and very spiny, especially ventrally. Near its posterior border this segment bears the anterior spiracles, consisting of a pair of chitinous fan-like structures, one on each side.

The first four abdominal segments have the anterior bands of spines well developed all round, but in the rest they are scanty dorsally. Ventrally on each abdominal segment the anterior edge is swollen and raised and the bands of spines widened at this point, making a spiny pad on the ventral surface of each segment. Near the centre of these pads is a clear smooth patch. The first to the seventh abdominal segments are all similar, but the eighth is very short and has a deep postero-dorsal hollow in which the spiracles lie. On the dorsal rim of this hollow are three pairs of large fleshy papillae, and there are three more pairs on the ventral rim, the innermost lower pair being much smaller than the others. The ninth segment is very small and consists of a dorsal swollen part covered with spines and two large lateral projections below this. The tenth segment consists of two small smooth flaps lying between the processes of the ninth and with the anus between them.

Buccopharyngeal armature (Text-fig. 1).—This consists of three parts on each side. The posterior part is the pharyngeal sclerite (PH). It has a deep incision at the posterior end forming the dorsal (DV) and ventral cornua (VC). In this species the pharyngeal sclerite is comparatively long and narrow, the dorsal cornu being very long. The ventral surface is ribbed, showing that the species is characteristically saprophagous in habit. There is a pair of slender hooked rods (R) projecting from the anterior end of this sclerite above the middle or hypopharyngeal sclerite (HP). The chitin is thinner along the dorsal edges of the dorsal cornua, and in the centres of the ventral cornua and also along the ventral edges of the sclerite. Anteriorly at the narrow part below the slender rods it articulates with the hypopharyngeal sclerite. This is small and heavily chitinized, with a projecting ventral portion. In front of this and articulated with its anterior end are the oral hooks. These are wide and somewhat triangular at the base, strongly chitinized, not very sharply curved and rather blunted at the extreme end. Projecting forwards between them is a thick chitinous bar (B). The dental sclerite (D) is a small, thick, somewhat crescent-shaped part at the base of the oral hooks on the ventral side.

Anterior spiracles.—There is a wide felt chamber at the end of the tracheal trunks, and this terminates in 11 or 12 finger-like processes which spread fan-wise and are well separated. Each has a small opening in the end surrounded by a thick chitinous rim.

Posterior spiracles (Text-fig. 2).—The distance between the spiracular plates averages 0·335 mm. The length of the plate is 0·397 mm. and the breadth is 0·420 mm. The plates are almost round in outline with a slight bulge at the button. The peritreme (P) is wide and strong and it is distinctly scalloped on the inner surface, that is, it has inward projections between the slits, that between the inner and middle slits being bifid. The button or external scar (B) is a clear opening completely enclosed in the peritreme. The three slits are straight, long and narrow, running the entire length of the plate. They are close together near the button and then are directed outwards and upwards, the lower slit being least and the upper slit most inclined upwards. Each slit is rounded at the ends and is surrounded by a thick scalloped chitinous border, the actual slit itself being narrow and crossed by a network of chitinous bars. The distance between the outer and middle slits is less than that between the inner and middle slits, Froggatt's "intermediate structure" (IS) coming between the last two. There are four openings of perispiracular glands (PSG) in the form of clear spaces in the ground membrane of the plate. These occur, one at the top of the intermediate structure, one on the upper margin of the inner slit and the lower margin of the outer slit about their middles respectively, and the fourth on the outer margin of the middle slit towards its top end. From the openings of the perispiracular glands a series of chitinous hairs radiate out to the peritreme. Many of these bifurcate at the ends. Except round the slits and in the intermediate structure the ground membrane of the plates is very thin and transparent.

The maggots of *Calliphora stygia* have been obtained from sheep from Canberra, Albury, Jerilderie and Inverell. The writer is indebted to Dr. Holdaway and Mr. Mulhearn for material from the last three localities.

CALLIPHORA FALLAX Hardy.

The average length of the full grown maggot is 18 mm. It is white in colour and not quite so robust as *C. stygia*, although very similar to it. In general structure these two species are almost identical. They can only be separated on the structure of the mouth parts and the posterior spiracles.

Buccopharyngeal armature (Text-fig. 3).—The pharyngeal sclerite is shorter than in *C. stygia*, both cornua, particularly the dorsal one, being much shorter. The hypopharyngeal sclerite is practically the same. The oral hooks are more sharply curved and more pointed, and are wider in the base than those of *C. stygia*. There is a slight constriction in the middle of the hooks in *C. stygia*, but this is absent in *C. fallax*. The oral bar between the hooks and the dental sclerite is essentially the same.

Posterior spiracles (Text-fig. 4).—The distance between the plates is 0·285 mm. The length is 0·275 and the breadth 0·280 mm. Thus the plates are separated by more than the spiracular length, whereas in *C. stygia* they are separated by less. The plates are also noticeably smaller and more delicate. The peritreme is narrower and either entirely without scallops or inward projections, or, if these are present, they are poorly developed and indistinct. The slits are straight and equal distances apart. The middle one does not come as close to the button at its lower end as the other two. The button is enclosed in the peritreme, but the peritreme bulges outwards at this point and does not show an inward curve round the button as well as in *C. stygia*. The prominence of the button gives a point to the plate, which shows a tendency to become pear-shaped.

The maggots of *Calliphora fallax* were obtained from an experimental sheep in Canberra by Dr. M. J. Mackerras, and are believed to be the first of this species recorded from the live animal, although it is likely that they have been bred before, but the species not recognized as distinct from *C. stygia*. This species has only recently been described (Hardy, 1930) and the maggot has not been recorded previously.

CALLIPHORA AUGUR Fabr.

The average length of the maggot when full grown is 18 mm. It is white in colour, robust and very similar in appearance to the other two Calliphoras described above. The segmentation, the details of spines and papillae, the papillae round the dorsal spiracular hollow, and the characters of the 9th and 10th abdominal segments are practically the same. The anterior border of the first thoracic segment is, however, very spiny and there is a ventral fold just behind the spiny band. This segment also has a slight constriction just before the middle. The head lobes seem to be more pointed than in the other species, and the antennae particularly small.

In the anterior spiracles there are 9 to 11 processes, spread out and well apart as in the other two maggots.

Buccopharyngeal armature (Text-fig. 5).—The pharyngeal sclerite is not quite as long as it is in *C. stygia*, but is longer than in *C. fallax*. It is comparatively broad, being much wider than in *C. fallax*. The general shape of this sclerite is the same as in the other two Calliphoras, the dorsal cornua and the inner edge of the ventral cornua being, however, slightly curved. The ribbed pharynx and the anterior projecting rods are the same as the others. The hypopharyngeal sclerite is the same shape as the others, but is much shorter than in *C. stygia*. The oral hooks are slightly different in shape, being shorter and rather flattened along the dorsal surface, curving sharply downwards into a point at the extremity. The bar between the hooks, the dental sclerite and other features are the same as in the other species.

Posterior spiracles (Text-fig. 6).—The plates are 0·230 mm. apart on the average, but in some examples are much closer. They are closer together than in the other two Calliphoras, being separated by much less than the spiracular length which averages 0·275 mm. The breadth is 0·305 mm., so the plates are noticeably broader than long. The peritreme is wide and strongly chitinized, scalloped with strong inward projections between the slits. The button is particularly prominent, causing a sudden bulge in the outline of the plate, which is a good diagnostic character. The slits are straight and, as the plate is broader than long, they appear short and well separated. Of the three Calliphoras, *C. augur* has the slits farthest apart from each other. The structure of the slits, the perispiracular gland openings and chitinous radiations are similar to the other species described.

The maggots of *C. augur* have been taken from sheep in Canberra, and from Albury, Jerilderie and Inverell.

LUCILIA SERICATA Mg.

The average length of the full-grown maggot is 14 mm. The colour is deep cream with pinkish tinges. The maggot is comparatively slender and cylindrical, all the abdominal segments being about the same circumference. The thoracic segments have the anterior bands of spines well developed and wide. The spines are very small. The first thoracic segment is constricted behind the head and has a ventral fold. The ventral spiny pads on the abdominal segments are similar to those of the *Calliphora* larvae, but the spines are smaller. The spiracular hollow on the 8th segment has an almost perpendicular face with a dorsal shelf bent sharply almost at right angles to it. The spiracles are situated on the upright posteriorly directed face. There are the usual six pairs of papillae on the rim of this hollow and the 9th and 10th segments are as in *Calliphora* maggots.

The head is like the other maggots described, and the antennae and oral grooves are conspicuous.

Buccopharyngeal armature (Text-fig. 7).—The whole structure is smaller and more delicate than in the Calliphoras. The pharyngeal sclerite is very similar in shape, with curved rods projecting from the anterior end and a ribbed ventral surface as in the others. Only the anterior and middle of the sclerite and the inner edges of the cornua are heavily chitinized, the rest being thin. The hypopharyngeal sclerite is short and the same shape as in the other larvae with the ventral projection narrower. The oral hooks are rather short and thick with a heavy base and are not very long or curved; they are relatively blunt at the end. The dental sclerite is present and somewhat crescent-shaped. There is no bar between the hooks. This is the chief difference from *Calliphora* maggots.

Posterior spiracles (Text-fig. 8).—The plates are on an average 0·199 mm. apart and 0·270 mm. long, being thus separated by much less than the spiracular length. The breadth of the plate is 0·249 mm. The plates, being longer than broad and coming to a gradual point at the button, are pear-shaped. The peritreme is narrow and not very heavily chitinized. It has no inward projections. The button is enclosed in the peritreme. The three slits are long and straight, equal distances apart, and more inclined upwards than in the Calliphoras. The details of the slits, perispiracular gland openings and chitinous radiations are the same as in the others described.

In the anterior spiracles there are ten finger-like processes, slender and well spread out.

Very few larvae of this species have been obtained from the fleece of live sheep. There is only one case recorded here from a mixed infection on a sheep in the field at Canberra, but it has produced experimental strike in the insectary.

LUCILIA CUPRINA Wied.

The average length of the maggot is 12 mm. Its colour and form are the same as in *L. sericata*, but it is slightly more robust. The head is similar, but the antennae are much less obvious. The papillae around the posterior spiracles are slightly shorter and less prominent. The 10th segment is more prominent, showing a papilla on each side of the anus. In every other feature, except for difference in the spiracles and mouth parts, it resembles *L. sericata*.

Buccopharyngeal armature (Text-fig. 9).—The mouth parts are smaller and more slender than in *L. sericata*. The cornua of the pharyngeal sclerite are chitinized along their inner edges only, the rest being yellow and transparent. The ribbed pharynx and anterior rods are the same as in the other species. The hypopharyngeal sclerite is slightly longer. The hooks are the feature by which the mouth parts of the two species may be distinguished. The base is much smaller and narrower. The actual hook is longer, more slender and curved and very sharply pointed. The dental sclerite is the same and there is no oral bar present.

Posterior spiracles (Text-fig. 10).—The distance between the plates is 0·175 mm. The length is 0·220 mm. and the breadth 0·215 mm. The plates are rounded in outline. The peritreme is wider and darker than in *L. sericata* and, like it, has no inward projections. The button is enclosed in the peritreme, but makes no bulge in the outline of the plate. The slits are short and stumpy, and inclined upwards at about the same angle as in *L. sericata.* Apart from any other feature, both Lucilias may be distinguished from the Calliphoras by noticing that the lower or outer slit is practically horizontal in *Calliphora* and inclined at about 45 degrees in *Lucilia.*

There are seven or eight processes in the anterior spiracles and they are rather wider and shorter than in *L. sericata.*

Of the two species of *Lucilia*, *L. cuprina* is the common one on live sheep, and although the two are very closely related, it is possible to distinguish between the larvae. Maggots have been obtained and flies bred from such widely separated localities as Canberra, Albury, Jerilderie and Inverell in New South Wales, and Springsure and Winton in Queensland.

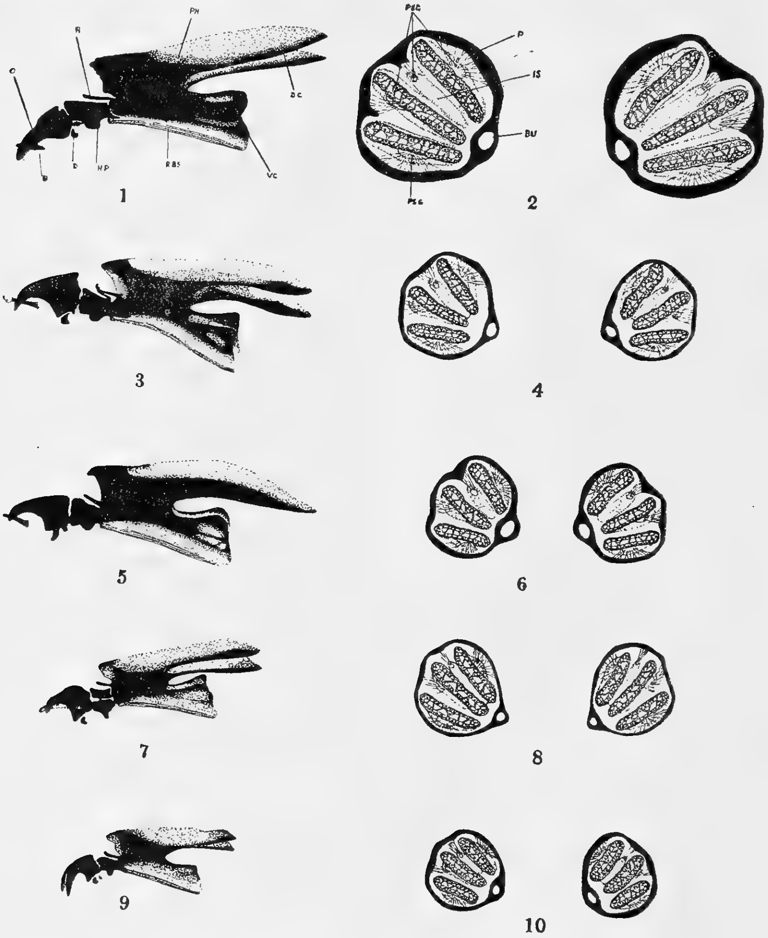
CHRYSOMYIA MICROPOGON Bigot.

The average length of the maggot is 16 mm. It is robust and whitish in colour. The third thoracic segment and the first six abdominal segments have their anterior margins very swollen, making annulations round the body. Ventrally on each of the abdominal segments, including the seventh and eighth, the ring widens to form the usual ventral pad. Each of the segments has a secondary fold in the middle, but these folds have no spines. The swollen anterior margins of the segments are covered with spines. The spines are scattered and have no regular arrangement on the bands. They are short, colourless, with dark tips. Laterally there is a small swelling between each of the abdominal segments. This is covered with spines like the annulations. The head is very small and the oral grooves are highly developed. The antennae and maxillary palps are of the usual types.

The eighth segment consists of a spiny pad ventrally and a deep postero-dorsal hollow, the spiracles being situated at the anterior end of the hollow. The rim is divided into six pairs of well developed papillae. The ninth segment is spiny on the posterior and ventral surfaces and has two prominent lateral papillae. The tenth segment consists of two smooth lips enclosing the anus. The spiracular hollow is deeper than in *Calliphora.*

Buccopharyngeal armature (Text-fig. 11).—The mouth parts are large. The pharyngeal sclerite is the usual shape. The ventral cornua have a hump on the inner edge and slope back to a point on the outer extremity. This makes them longer than those of any of the previous species, so that here the dorsal and ventral cornua are more equal in length. The ribbed pharynx and the anterior rods are as in others described. The hypopharyngeal sclerite is of the usual shape, but rather narrow for the size of the other parts. The hooks are large and massive, the base being broad, with a backward projection on the lower edge. The hook part is long, curved and sharply pointed. The dental sclerite is large. There is no oral bar between the hooks, but a small sclerite below and away from the hooks.

Posterior spiracles (Text-fig. 12).—The plates are very large, being slightly bigger than those of *C. stygia.* The distance apart is about 0·225 mm. The length is 0·397 and the breadth 0·435 mm. The peritreme is wide and dark and dips inwards slightly between the slits. It is interrupted at the button, where it becomes very thin and transparent, making an apparent gap. The button is in this gap and is almost invisible. The slits are straight and very wide, with thick chitinous borders. They are close together, occupying practically all the plate. The intermediate structure between the inner and middle slits is narrow. The perispiracular gland openings are large and conspicuous and the radiations from them very numerous and fine, many being forked at the ends.



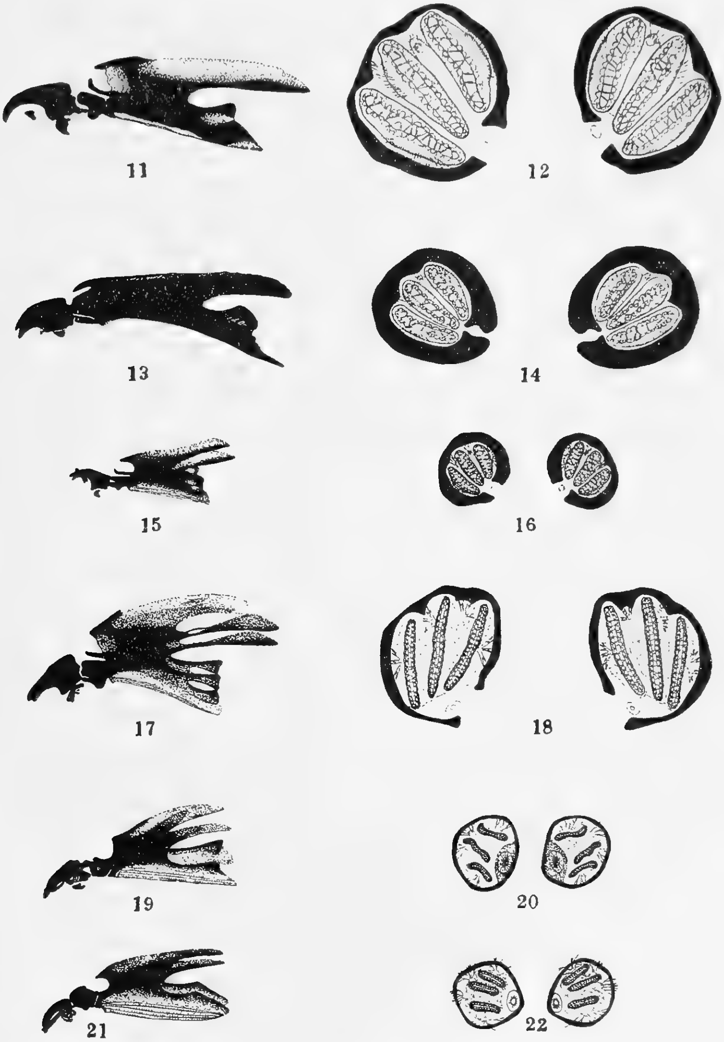
Text-figs. 1-10.—Buccopharyngeal armature (× 22) and posterior spiracles (× 53) respectively of 1-2, *C. stygia*; 3-4, *C. fallax*; 5-6, *C. augur*; 7-8, *L. sericata*; 9-10, *L. cuprina*. B, bar; BU, button; D, dental sclerite; DC, dorsal cornua; HP, hypopharyngeal sclerite; IS, "intermediate structure"; O, oral hooks; P, peritreme; PH, pharyngeal sclerite; PSG, perispiracular gland openings; R, rods; VC, ventral cornua.

Chrysomyia micropogon larvae were collected on sheep at Springsure by Dr. I. M. Mackerras, and have also been obtained from Winton.

CHRYSOMYIA RUFIFACIES Macq.

The full-grown maggot averages 14 mm. in length. It is robust, thick and broad. The skin is a dirty-yellowish colour with grey tinges on the dorsal surface.

It is thickly covered with small, dark, blunt papillae. There are the usual swollen pads on the ventral surface at the anterior edge of each segment, but they are divided into a narrow ridge bearing one row of dark spines and a wider swollen part with several rows, the two being separated by a smooth level area. From the 5th to 8th segments the spines are not well developed on the posterior part of the ventral swelling. Ventrally also and behind the raised part, bringing it near to the posterior edge of the segment, is a ridge bearing a row of six long fleshy protuberances. This is not present on the eighth segment. Running from the sides across the back, just in front of the middle line of each segment, is



Text-figs. 11-22.—Buccopharyngeal armature (× 22) and posterior spiracles (× 53) respectively of 11-12, *Ch. micropogon*; 13-14, *Ch. rufifacies*; 15-16, *M. varipes*; 17-18, *Sarcophaga* sp.; 19-20, *P. rostrata*; 21-22, *O. nigra*.

a row of long fleshy papillae directed backwards. These increase in size up to the middle of the dorsal surface; each is covered near the base with little dark knobs, and the tip is crowned with a cluster of tiny spines. There are eight papillae in each row, four on the back and two at each side. They are present on every segment of the abdomen up to the seventh and also on the thoracic segments, but are there smaller and shorter.

The head is of the usual form, but very small and pointed, and the thoracic segments are narrow. The anterior border of the first thoracic segment is very densely covered with strong black spines and is slightly constricted just behind this area. The anterior border of the other two thoracic segments is also marked by a band of spines all round. The eighth segment has the usual truncated postero-dorsal surface, the spiracles being conspicuous and situated towards the anterior end. It is surrounded by six pairs of very long fleshy papillae which are clearly annulated and crowned by a ring of tiny black spines. The ninth segment is long and protrudes well behind the eighth and is covered, especially round the posterior edge, with strong dark spines. It bears two small white papillae laterally. The 10th segment is smooth and white, consisting of two flaps with a small papilla on each.

Buccopharyngeal armature (Text-fig. 13).—The mouth parts are distinct from any of those described above. The pharyngeal sclerite is remarkably elongated and narrow and heavily chitinized. It is divided at the posterior end into the two cornua as usual, but, unlike all the others, these are of the same length. The lower edge of the ventral cornu is produced into a long point and the inner edge shows a conspicuous hump. Ventral pharyngeal ribbings are absent, which Keilin considers to be evidence of a predaceous habit. The narrow anterior rods are absent, but the dorsal front edge of the sclerite is narrowed and pointed. The hypopharyngeal sclerite is massive and appears to be fused with the pharyngeal sclerite. It has a narrow part divided off ventrally. The hooks are strong, thick, wide, sharply pointed and curved. The dental sclerite is large and there is no oral bar between the hooks.

Posterior spiracles (Text-fig. 14).—The plates are on an average 0·217 mm. apart. They are 0·337 mm. long and 0·315 mm. broad. The peritreme is very wide and dark and the plates are rounded in outline. The peritreme is scalloped on the inner edge, having projections between the slits. There is a gap at the button and the peritreme is slightly forked at this point, the gap being much narrower than in *Ch. micropogon.* The button is inconspicuous and pale. The slits are straight and very wide, with strong borders, almost filling the plate so that the intermediate structure is compressed and narrow. The perispiracular gland openings and the chitinous radiations are of the usual form.

There are nine or ten processes in the anterior spiracles which are like all the others in structure and shape.

This species has been collected from sheep at Canberra and at Springsure, Queensland.

MICROCALLIPHORA VARIPES Macq.

The average length of the maggot is 10 mm. It is dirty-yellowish in colour with brown tinges on the back. The three thoracic segments are narrowed and elongated. The whole skin is finely rugose. The first abdominal segment is also narrowed and the rest much wider, so that the maggot has a neck-like anterior end. The band of spines at the anterior borders of the thoracic segments is wide, and the spines are brown with very sharp points. The head is of the usual structure. The first to the seventh abdominal segments bear on the dorsal surface a row of four fleshy protuberances along the middle. The top of each is crowned by a cluster of tiny sharp black spines, with the exception of those on the first segment. Laterally each segment comes to a blunt point, giving the maggot a scalloped appearance down the sides. This part is covered with minute, fine, delicate spines. Ventrally the anterior swelling of the segments is almost imperceptible and can only be distinguished by the double row of dark spines present in this region. The truncated surface of the eighth segment is not hollowed, the spiracles being displayed conspicuously. The usual six pairs of papillae are borne around the edge of this part, but they are short and not as outstanding as the segmental protuberances. The ninth segment is spiny, projects beyond the eighth and bears two very small white papillae at the sides. The tenth segment is white and consists of two ventral papillae with the anus between.

The details of the head including the palps and the oral grooves are similar to the others described. The anterior spiracles are large and wide for the size of the maggot. There are 9 or 10 processes which are strong, wide and well spread out.

Buccopharyngeal armature (Text-fig. 15).—The mouth parts are smaller than any described above. The pharyngeal sclerite is of the usual shape. The incision is not very deep and the ventral cornua are rather wider than usual. The pharynx is ribbed and there are a pair of narrow rods anteriorly. These are longer than usual, running the length of the hypopharyngeal sclerite. The hypopharyngeal sclerite is long and narrow and divided anteriorly. The oral hooks are strong and heavy and readily detached from the hypopharyngeal sclerite. They are strongly curved and sharply pointed and have a chitinous bar between them. The dental sclerite is small and crescent-shaped.

Posterior spiracles (Text-fig. 16).—The plates are close together, being separated by only 0·142 mm. They are 0·172 mm. long and 0·202 mm. broad. The peritreme is very wide and dark, slightly scalloped on the inside, and with a gap at the button. The general appearance of the plate is rather like *Ch. rufifacies* on a smaller scale, but in *Microcalliphora* the plate is broader than long. The slits are short and wide, almost filling the plate as in *Chrysomyia.* The other features are the same. The button is pale and inconspicuous and is situated in the gap of the peritreme.

The larvae of *M. varipes* have not as yet been obtained by us from live sheep. Froggatt in 1915 bred it from sheep at Brewarrina.

SARCOPHAGA SP.

The maggot is 14 mm. long when full grown. It is very stout and robust, with a tough creamy-yellowish skin. The skin is covered all over with small, blunt, colourless tubercles. There are extra folds and prominences obscuring the ordinary segmentation. Dorsally it is possible to see the normal segmentation, but ventrally it is very difficult. In the middle of each abdominal segment underneath is a row of large protuberances as well as the usual spiny swelling of the anterior border. These spines are colourless. Laterally on the abdominal segments there are also fleshy protuberances. The thoracic segments are smoother and without extra folds. The eighth segment has a very deep spiracular hollow in the form of a narrow-mouthed fossa, so that the spiracles are not visible externally. This distinguishes a *Sarcophaga* from any other maggot. The edges of this fossa bear the usual six pairs of papillae in the same relative positions as in the other maggots described. The skin of the three thoracic segments is not tuberculate all over, but undulating and marked with crack-like lines. Their anterior borders are spiny. The head is bilobed and of the usual form, with antennae, palps and oral grooves like the others. The whole maggot has a dull, rough appearance as compared with the shining smoothness of the *Calliphora* and *Lucilia* maggots. The anterior spiracles have 15 to 18 processes, which are short and crowded together. The end of the spiracles and felt chamber is wide.

Buccopharyngeal armature (Text-fig. 17).—The pharyngeal sclerite is short and wide, and the incision at the posterior end between the cornua is deep and wide. The outer edges of the cornua are only lightly chitinized. The ventral cornua are much shorter than the dorsal, and the dorsal cornua are more curved than in Calliphorine larvae. The ventral cornua are straighter on the inner edge and rather narrower than any previously described. The pharynx is ribbed and there is a pair of projecting rods at the anterior end of the sclerite. The hypopharyngeal sclerite is wide and strong, with the typical Calliphorid ventral hump. The oral hooks are rather short, thick, blunt at the ends and not very curved. There is no bar between them. The dental sclerite is irregularly shaped and narrower than in the Calliphorines.

Posterior spiracles (Text-fig. 18).—These are the most characteristic feature of the *Sarcophaga* maggot. The plates are D-shaped, sloping slightly towards each other, and there is a wide gap in the peritreme at the inner edge ventrally. The button is very difficult to distinguish and is situated just inside this gap. The peritreme is narrow and scalloped on the inside by the projections between the slits. The slits are long, narrow and delicate, with a similar structure to those of other maggots, but their disposition in the plate is curious and characteristic of the genus. Instead of running from the button outwards, they are almost perpendicular, with the inner two inclined in the opposite direction to those of other maggots; that is, they slope in a dorso-medial direction from the button. The perispiracular gland openings are in the same relative positions as in other genera. The chitinous processes radiating from them are not in the usual form of thin rays, but are wide, branched structures forking at their distal end.

Sarcophaga froggatti has been recorded from sheep by Taylor, and Froggatt records *Sarcophaga aurifrons*. Whilst at Springsure, Dr. Mackerras bred two other species. One of these has been used for the description in this paper. All Sarcophagas are extremely similar in all stages and are very characteristic, so that any could be recognized from the one described. No attempt has been made to separate the species in the larval stage.

PERONIA ROSTRATA R.D.

The length of the full-grown larva is 15 mm. It is a deep yellowish-cream in colour, and unlike a Calliphorine maggot in being slender, shining and waxy in appearance. The segmentation is not well-marked, especially dorsally, as the segments are not banded with spines or swollen at their anterior borders. However, each of the second to the eighth abdominal segments has a raised area ventrally at the anterior edge bearing two rows of rather large colourless spines directed backwards. There is a smooth patch between the rows of spines. There are also a few rows of smaller spines on the anterior borders of the thoracic segments.

The eighth segment is smooth and shining, and has no spiracular hollow, the pair of very chitinous spiracular plates being raised and borne on the posterodorsal face of the eighth segment. The usual twelve papillae are present around this truncated part, but they are very flattened and inconspicuous. The ninth segment is below the eighth and entirely ventral in position, a character which distinguishes Muscid larvae from those of Calliphorines. It consists of a prominent spiny area bearing six large smooth papillae running in a row, three each side of the middle line. The tenth segment is represented by two small yellowish flaps surrounding the anus.

The head is the same as in other maggots, but the antennal palp is more noticeable, as the basal segment is elongated. The oral grooves are present, but are colourless and not very conspicuous. The anterior spiracles have 7 or 8 elongated, slender and delicate processes which are well separated from each other.

Buccopharyngeal armature (Text-fig. 19).—The pharyngeal sclerite is short and wide. The incision in the anterior end is remarkably wide, and the dorsal and ventral cornua are of the same length. The dorsal cornua are arched and curved. The pharynx is more strongly ribbed on the floor than in blowflies. There are no anterior rods projecting above the hypopharyngeal sclerite, which is small and of the same general shape as in a blowfly, but bears a small projection on the dorsal surface. The oral hooks are the most distinctive feature. They are entirely different from any yet described. The two hooks are not of equal size, one being much smaller and shorter than the other. They are narrow, differently shaped from those of Calliphorine larvae and have a much narrower base. They are not very strongly curved and are blunt at the ends. There is a large keel-shaped sclerite close to and just below the hooks. The dental sclerite is comparatively large and irregularly shaped.

Posterior spiracles (Text-fig. 20).—The plates are small, close together and roughly D-shaped. The peritreme is narrow and completely encloses the plate without a break. The slits are small, narrow and slightly sinuous, converging at the top end and spreading apart toward the button. They are well separated and have the usual structure. The ground membrane of the plate is more strongly chitinized than in a Calliphorine, the only clear parts being the perispiracular gland openings, which are in the same relative positions, but have a different appearance from those in blowfly spiracles. The chitinous hairs radiating from them are fine, forked and elongated, some appearing outside the peritreme. The button or external scar is near the inner edge of the plate internal to the peritreme. It is large, conspicuous and dark, being quite different from the clear space seen in blowflies.

W. W. Froggatt recorded *Ophyra nigra* from live sheep at Brewarrina and New England in 1916, and J. L. Froggatt, in his paper on the spiracles of Muscoid larvae in 1918, gave a description of the spiracles of the same species. There is little doubt that both these authors referred to *Peronia rostrata*, J. L. Froggatt's description fitting the spiracles of *Peronia* and not *Ophyra*. The two flies have been long confused, so that it is difficult to say which species attacks living sheep, or whether they both have this habit. The larvae of both are therefore described in this paper.

OPHYRA NIGRA Macq.

The maggot reaches only 13 mm. in length when full grown. It is distinguished from all other species by its slender form and bright yellow colour. It somewhat resembles *P. rostrata*, but is not so waxy and shining. It is perfectly smooth, but the segmentation is well marked by the anterior border of each segment bearing rows of very minute brown spines. These spines are arranged in broken lines and are not developed on the dorsal surface of the last four abdominal segments. They are most conspicuous on the thoracic segments. The usual ventral swellings on the abdominal segments have a peculiar structure. They bear rows of scale-like spines very regularly arranged in a palisade fashion. They are much longer than the other spines, and are pale with brown tips. The head is very small and of the usual shape and structure. The antenna has a long basal segment as in *P. rostrata.* The anterior spiracles are comparatively large, spreading fanwise, with six long slender processes at the end. The eighth segment is peculiar and unlike any other maggot described. It is abruptly truncated, but there is no dorsal face, the free surface being entirely posterior. The edge of this posterior face is raised and has eight large undulations with broad rounded tops. These are the ends of ridges which run the whole length of the eighth segment, giving it a fluted appearance. The posterior face is slightly hollowed and bears the posterior spiracles, each plate of which is raised on a boss of finely striated colourless chitin. The spiracles are inclined sharply inwards towards each other. The ninth segment is very reduced and appears to come from between the seventh and eighth as a small ventral outgrowth. It is more heavily chitinized than the rest, and hence a deep-orange colour. It consists of two projecting areas covered with spines, and between these is the tenth segment which has two spiny papillae, one each side of the anus.

Buccopharyngeal armature (Text-fig. 21).—The pharyngeal sclerite is a little longer, but not as wide as that of *P. rostrata.* It is of a similar shape with a wide incision, and the dorsal and ventral cornua are the same length. The dorsal cornua are arched, and they are narrower than those of a blowfly, whilst the ventral cornua are wider. The floor of the pharynx is strongly and conspicuously ribbed. There are no anterior rods. The hypopharyngeal sclerite is short and thick. The oral hooks are of unequal length, slender, with narrow bases and shaped like those of *P. rostrata.* The dental sclerite is large and complex and there is a small sclerite ventral to the hooks as in *Peronia.*

Posterior spiracles (Text-fig. 22).—The plates are small and close together. They are a short pyriform shape, with the points facing each other. The peritreme is narrow and completely surrounds the plate. The slits are straight, small and well separated, lying almost horizontal and parallel. They have the usual structure. The ground membrane of the plate, as distinct from that of *Peronia,* is thin and clear. The colourless chitinous hairs which project from the peri-spiracular gland openings are thin and branched. They are very long and project well outside the plate. The button is just inside the peritreme on the inner edge at the point. It is large, but pale and not outstanding.

MUSCA HILLI J. & B.

This species has also been bred from sheep, but no larval material is available for study. The fly was bred at Springsure in Queensland by Dr. Mackerras from two old extensive infections in ewes. A description of the larva with figures has been published by Johnston and Bancroft in the *Memoirs of the Queensland Museum,* 1920. The larva is distinguished by the very sinuous spiracular slits.

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ON THE PRODUCTION IN AUSTRALIA OF TWO NEW PHYSIOLOGIC FORMS OF LEAF RUST OF WHEAT, *PUCCINIA TRITICINA* ERIKSS.

By W. L. Waterhouse, University of Sydney.

[Read 27th April, 1932.]

Introduction.

The phenomenon of specialization in the rust fungi has long been known (Eriksson, 1894). Its importance has been realized in more recent times, but only lately has the mode of origin of physiologic forms been investigated.

Craigie (1927) demonstrated that certain rusts are heterothallic, and thus paved the way for experiments on the origin of physiologic forms as a result of rust hybridization. Waterhouse (1929) reported two physiologic forms of *Puccinia graminis tritici* which owed their origin to mixing of the spermatial juices on the barberry. Miss Newton *et al.* (1930) and Stakman *et al.* (1930) have also shown that physiologic forms of *P. graminis tritici* arise as a result of hybridization on the barberry, as well as by mutation. So far no such occurrence has been recorded for *P. triticina.*

Materials and Methods.

In November, 1930, dry leaves of wheat heavily infected with the teleutospore stage of the leaf rust were collected at Hawkesbury Agricultural College from a plot where it was known that there were present the two forms previously described (Waterhouse, 1929), and shown in Table I. These leaves were kept in the laboratory throughout the summer. In the autumn they were sent to Bathurst, N.S.W., where Mr. R. E. Dwyer was responsible for exposing the material to the winter weather. In the spring (September, 1931) examinations revealed abundant teleutospore germinations. This was the first occasion in attempts extending over 10 years on which germinations were seen. The success was due to following the suggestion made by Dr. C. O. Johnston of Kansas, U.S.A., to protect the teleutospores from the high summer temperatures which prevail in the field.

Thanks to the courtesy of Dr. G. P. Darnell Smith, Director of the Sydney Botanic Gardens, vigorous plants of *Thalictrum flavum* were obtained for inoculation tests. Young seedling plants of *T. dipterocarpon* were also used for a similar series of tests.

Fragments of the wheat leaves carrying teleutosori were soaked in water for an hour and then placed on moistened young growths of the *Thalictrum* plants. Only such "mass inoculations" were made. Incubation lasted for 24 hours. Abundant infections resulted on both species, and from these, aecidiospores were taken to inoculate seedlings of "Federation" wheat under controlled conditions. Normal uredosori were produced and yielded the uredospores which were used in the specialization studies.

Determination of the Physiologic Forms.

Using for comparative purposes stock cultures of the two forms of leaf rust known in Australia and designated "Australian 1" and "Australian 2", numerous cultures derived from the aecidiospores were tested on the differential set of wheat varieties used by Mains and Jackson (1926), and kindly supplied in 1927 by Dr. Mains.

The result has been the derivation of four different physiologic forms, which by repeated subculturings have been sorted out and proved to be constant. One is identical with that designated "Australian 1", which was known to be present in the uredospore stage in the material used to provide the aecidial stage. The form "Australian 2", which was also present in this material, has also been recovered but with a lesser frequency. The remaining two forms have not previously been met in Australia. Their identity has been established by repeated tests made side by side with the stock cultures of "Australian 1" and "Australian 2". Using the well-known notation (Stakman and Levine, 1922), the typical reactions shown are set out in the following table:

TABLE I.
Comparison of typical reactions shown by 4 physiologic forms of *Puccinia triticina* on the differential wheat varieties.

Wheat Variety.	C.I. Number.	Form Australian 1.	Form Australian 2.	Form New A.	Form New B.
Malakoff	4898-4	0	0	1	1
Norka	4377-2	0	0	4	1
Unnamed	3756-4	4	4	4	4
Do.	3778	4	4	4	4
Webster	3780-8	0	0	4	4
Unnamed	3747-5	0	0	4	4
Do.	3779-5	4	4	4	4
Mediterranean	3332-3	0	0	1	1
Hussar	4843-2	4	4	1	1
Democrat	3384-1	0	0	0	0
Kawvale	5274-1	1	1	1	1
Thew		0	4	4	0

It has been pointed out previously (Waterhouse, 1929) that the American set of differentials is ineffective in separating "Australian 1" from "Australian 2", but that the Farrer variety "Thew" and certain other wheats clearly differentiate the two forms. "Australian 1" gives a sharply resistant reaction, while "Australian 2" exhibits a fully susceptible reaction. It is interesting to find that "Thew" (and the other wheats like it) also serves to separate the two new forms, as shown in Table I. "Norka" is the other variety in the set of differentials which separates the new forms.

As already stated, "mass inoculations" only were made in this work. It cannot therefore be yet said with certainty that the new forms arose from hybridization of the forms "Australian 1" and "Australian 2". Until further tests are carried out there must remain the possibility that selfing may have led to segregation of the new forms.

Grateful acknowledgment is made of financial assistance given by the Trustees of the Endowment Fund of the Council for Scientific and Industrial Research.

Summary.

Experimental evidence shows that as a result of inoculating *Thalictrum* plants with a mixture of germinating teleutospores of the forms of *Puccinia triticina* designated "Australian 1" and "Australian 2", aecidia were produced. From these, cultures on wheat showed that there were four physiologic forms present, of which two have not previously been found. These new forms arose on the alternate host plant, most probably as a result of hybridization of the forms "Australian 1" and "Australian 2".

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RAINFALL RELIABILITY IN AUSTRALIA.

By J. ANDREWS, B.A., Demonstrator in Geography, Sydney University.

(Three Text-figures.)

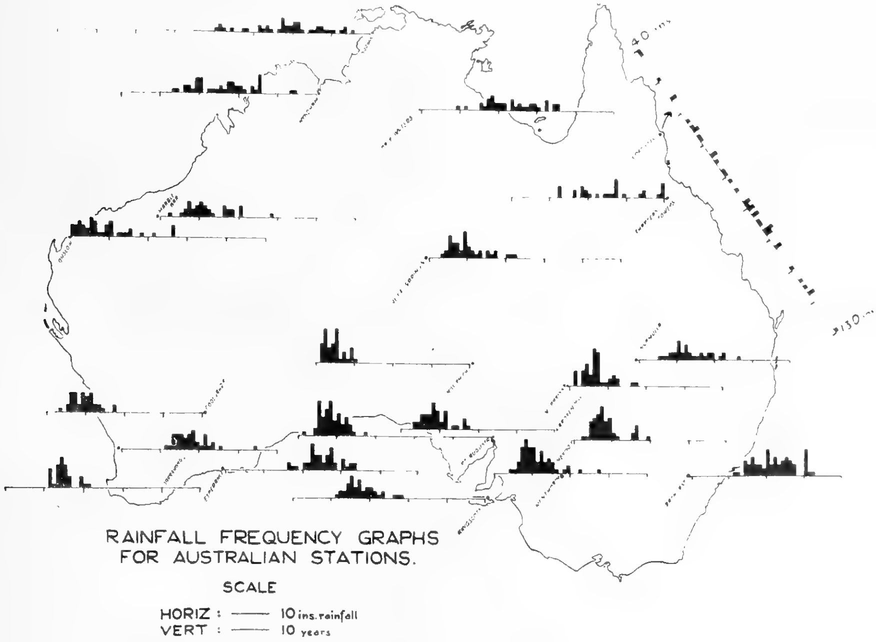
[Read 27th April, 1932.]

Introduction.

From the point of view of the agriculturalist and pastoralist the most important aspect of rainfall generalization is the question of reliability. Rainfall reliability is principally concerned with (1) the amount of rain which might be expected during any season, and (2) the degree of probability of obtaining it. These two aspects are discussed here on the basis of annual figures and for the continent of Australia as a whole. It is hoped that later discussion of these aspects for regional areas and for seasonal periods will be presented.

Map of Most Frequent Rainfall.

Two values suggest themselves as expressions of rainfall expectation. It has been usual among geographers (and others) to use the arithmetical mean of



Map 1.—Frequency graphs of rainfall for the years of record at representative Australian stations. The number of years recorded varies from State to State, so that the general shape of the polygons is comparable, but the amplitude is not.

the observations and speak of the average annual rainfall. It is now, however, being realized that this average figure, calculated as it is over 35 years or more, may mean little in reality. It is expected that a glance at Map 1 will show how the average figure may give a quite wrong impression of the facts. Sometimes the average is a value that is never experienced; it is almost invariably higher than the value that occurs most frequently, and so to that extent it is misleading as a description of actual conditions. One further objection might be made to the exclusive use of this figure. From the point of view of the farmer, when once the rainfall for the period in question has dropped below the amount necessary for the growth of his crops, it is relatively unimportant whether the final total is 5 or 15 inches below the required amount. Similarly, an excess of rain over the required amount may produce harmful results (flooding, rust, etc.); yet these variations from his expectations affect the average value to a considerable degree, and may lead to false estimations of the possibilities of the region concerned.

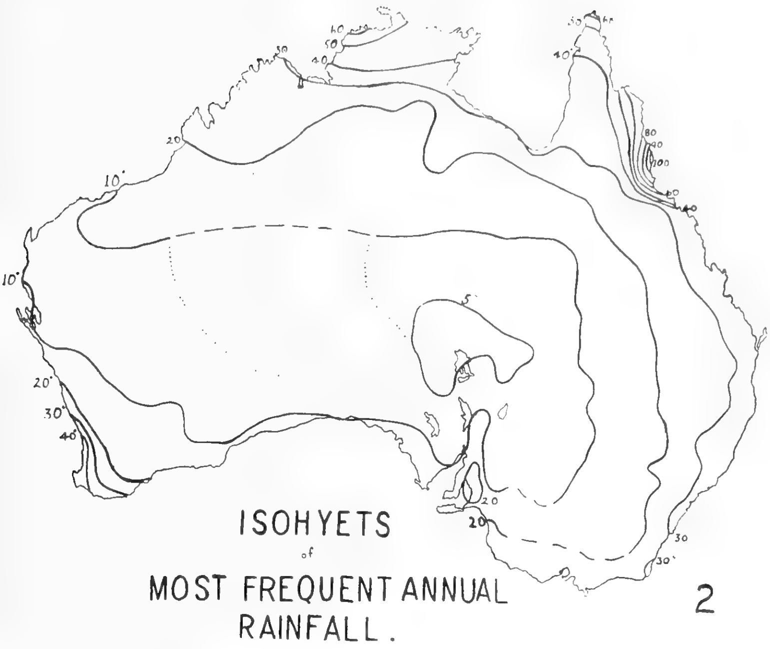
The mode (or value which occurs most frequently) offers another basis of determination. The modal frequency of the annual rainfall was determined for a large number of stations in each of the States, and Map 2 was constructed from these values. These figures have been obtained from observations spread over a long period, but, except in the case of New South Wales, the observations, while dating back to the commencement of observations, have not been taken up to the most recent years, but only so far as given in the Bulletins of Rainfall Observations for the various States. It is maintained, however, that the length of the periods dealt with is sufficient to give accurate cross-sections of the conditions prevailing at each station. In practically every case the period of observation is more than 20 years, and in very many cases more than 35 years. It is not likely that an additional few years' records would change the distribution of the frequencies to any notable extent.

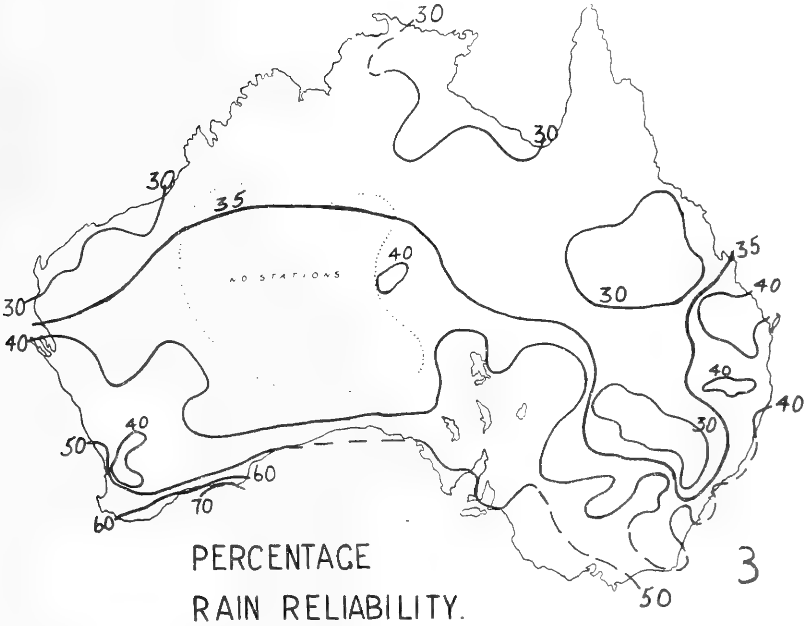
Map 2, then, shows the isohyets of the most frequent annual rainfall calculated on the basis described. The points most deserving of attention in this map are: (i) The isohyets are concentric with the continental outline; (ii) there is a decrease in rainfall with increasing distance from the coast; (iii) in comparison with the average annual rainfall map (H. A. Hunt), the area receiving 20 in. or more is considerably reduced; (iv) the eastern half of Australia is favourably placed as compared with the western half, probably a result of the combination of the factor of elevation and the paths of the rain-bearing storms.

Rain Reliability.

The second step in our argument is to determine the method by which to obtain an index of the reliability of this most frequent rainfall value (referred to hereafter for the sake of convenience as the M.F.).

In this connection Griffith Taylor's (1920) map of "rainfall reliability" is important, for it is the map (and the method) most in use among geographers. It is held, however, that: (i) The values from which the map is constructed are obtained by expressing the mean departure from the average annual rainfall as a percentage of the average annual rainfall, a method that seems to the writer too loose and generalized for detailed use. Neither of the primary figures (mean departure and average annual) may be at all real in the sense that they ever occur at the station concerned. (See Holmes, 1931, where many of the stations show that the annual average rainfall was never experienced during the years





Map 2.—The isohyets of most frequent annual rainfall of Australia.
Map 3.—The reliability of rainfall in Australia. The higher the index number, the greater is the reliability. Note the complexity of conditions in the south-eastern and south-western areas.

under observation.) (ii) A few large variations above the average may hide the fact (most important to the farmer) that the usual variation is a small amount below the average or vice versa. (iii) Once again, as in the case of the average annual rainfall map itself, the abnormal value has too great an influence on the final figure. Thus in the case of Onslow, as quoted by Griffith Taylor (1920, p. 157), the average variation is 50% on an average of 8 in. (*cf.*, however, *op. cit.*, p. 120, where the position of Onslow is shown outside the 10 in. isohyet). This, on Taylor's interpretation (1930) means that the most likely rains are from 4 in. to 12 in. Actually, however, from the records of the Rainfall Observations for W.A. (1928), only 9 years out of 43 had a rainfall of from 8 to 12 inches inclusive, while more than half of the years (24 out of 43) had a total rainfall below 8 inches. (iv) Obviously, then, the method of working with averages gives only a fictitious value when applied to all the stations. One effect is to give the station that has a small rainfall, but occasional years in which the fall is up to ten times the average, an appearance of unreliability; while stations of high rainfall might have departures as great which would be smaller in relation to the average value. Yet, as has been emphasized, both variations (20 in. on an average of 2 in. and 20 in. on an average of 60 in.) might be equally embarrassing to the farmer.

The method employed in making Map 3 is as follows: The number of years in which is received the M.F. rainfall is expressed as a percentage of the total numbers of years on record. That is: $R = \frac{100f}{y}$,

where R = degree of reliability, f = frequency of modal value, y = number of years on record.

The following points are to be considered:

(i) *Limiting percentages.*—From the point of view of the farmer there are certain fairly well defined limits of precipitation within which he can grow his crop, and outside of which he will not be able to farm on the same crop basis. These limits vary considerably for every crop and also for various farms under the same crop; but on the knowledge one has of the crop conditions in Australia, 10% has been selected as the limiting percentage. Therefore, in the formula the "f" value signifies the frequency of the modal value ± 10%. The value of the particular limiting percentage will not affect the value of the method; further work is being done on the determination of more precise figures for certain definite areas.

(ii) The final figure gives an index of the probability of occurrence of the M.F. rainfall. Thus a value of 50% for a station with an M.F. of 20 inches means that in five years out of ten that station will receive 20 in. ± 10%; or, in other words, the chances every year of receiving this amount are even. It is not, of course, regular alternation, but when such a high value is obtained, and since neither the good nor the bad years are found in groups, the years in which the value occurs cannot be very unevenly spaced.

(iii) In certain of the polygons (Map 1) there is apparent a well marked group of frequencies about the mode, but the modal frequency with the limiting percentage may not give the greatest possible number of observations. In such cases, therefore, the figure used has been the greatest possible number of years within the prescribed limits. The central figure of this range has usually been very close to the mode.

(iv) In one or two cases there were "double maxima", or two modes. Where later figures were not available to turn the balance between these, the modal frequency relating to the lower rainfall has been used.

Conclusions.

1. There is considerable uniformity in reliability over the continent, the greater part of which shows values between 30 and 50 per cent.

2. The concentric grouping of the isolines about the interior as shown in Map 2 has given place to a south-north increasing unreliability, with certain modifying factors operating along the eastern coasts and highlands.

3. The most reliable region is some distance east of Cape Leeuwin with very high figures.

4. The points of greatest resemblance between this map and Taylor's are this south-western region, and that of the north-western coast from Onslow to Broome, which is one of the regions of least reliable rainfall in Australia. In the interior and in the east the differences between the two maps are striking.

5. One of the most interesting features is the great Flinders-Torrens loop. Here a region of high reliability stretches from Milparinka (47) and Broken Hill (39) west to the centre of South Australia. This great loop is almost certainly due to the great bays in the coast and to the Torrens rift valley, in so far as they affect the paths of rain-bearing winds. East into New South Wales the reliability declines, and the central plain of the State has low reliability (Bourke, 21). This belt extends to the highlands (Bathurst, 29); thence there is an increase in reliability to the coast (Sydney, 37).

6. Along the eastern highlands there are some interesting and rather puzzling features. The broken areas and the relative positions of the isolines indicate that in some cases the influences at work over the plain (Central New South Wales and Central Queensland) sometimes extend to the highlands, while other parts of the highlands area are higher or are so placed with reference to the storm tracks that they benefit uniformly. Detailed work remains to be done on these regions. It is interesting to note, however, that as regards New South Wales the areas of greatest reliability are the Far West, a strip of the Southern Slopes, and the Coastal strip.

7. As Taylor notes, there is an unreliable region about the Gulf of Carpentaria, although it is defined differently in the two maps. It is noteworthy that on the North Queensland coast there are one or two stations with values below 30. A fair proportion of the rain of the two regions comes from hurricanes, and as these move along fairly well frequented tracks, the regions may not be as uniform as indicated.

8. The interior has quite a considerable degree of reliability; it is notably greater than that of the eastern plains mentioned above. The region of Alice Springs, probably on account of the presence of mountain ranges, has an even greater reliability than most of the interior. It should be noted, of course, that there is a large area in Western Australia with no recorded observations.

These results are in conflict with the generally held opinions regarding the rains of the interior, and it is worth while to examine some of the factors that have given rise to these opinions: (i) In the first place, the farmer or the pastoralist usually judges his rainfall characters by the response of the vegetation, although this is by no means a complete reflection of rainfall. There is, for instance, a definite lag in response in areas that have suffered several bad years in succession, even when conditions are not complicated by stocking. (ii) In the case of the farmer on the dry side of the wheat belt, there is small margin on the low side of rainfall, so that each variation below his expectation impresses itself on his notice, while in wetter regions the same percentage variation may not have any untoward effect. In other words, the farmer of the outer belt is depending on the higher values, while the more fortunate farmer inland relies on the low values. Hence arises the conception that the rainfall of one area is less reliable than that of another, though actually there is little to choose between them. (iii) The same argument applies to grasses in the arid belts. (iv) It must not be forgotten that we are dealing here with annual summations, and that the most important factors for plant growth are the amount of individual fall and the time period between falls. In this particular map these factors are necessarily ignored. (v) It seems to be indicated that the problem of settling much of the interior is the problem of finding crops (fodder or otherwise) that will grow with from four to eight inches per year.

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NEW GUINEA AND AUSTRALIAN COLEOPTERA.

NOTES AND NEW SPECIES. NO. 2.

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

(Two Text-figures.)

[Read 25th May, 1932.]

Family GEORYSSIDAE.

GEORYSSUS OCCIDENTALIS, n. sp.

Black, subnitid; head almost wholly withdrawn within prothorax, the visible part seen closely adpressed to prosternum. Prothorax sub-bilobate, anterior half narrower than posterior half and on a lower plane than it, widely rounded at apex and at base, widest near base, margins rather widely foliate on basal half, extreme edge crenulated by pustules; basal half of disc with two large pustules, forming with a wide longitudinal ridge a "fleur de lys" design, smaller pustules irregularly placed elsewhere on disc, this widely sulcate on anterior two-thirds. Elytra transversely convex, each with three distinct costae, the suture also costate, the former three entire, but surmounted by granules, the second more strongly granulose than the first, the third than second, intervals finely pustulose. Underside covered with round pustules, tibiae crenulated by granules on exterior edge, front tibiae widened and arched, front femora very wide, sulcate beneath, front coxae contiguous, mid and hind coxae wide apart. *Dimensions*: 1·5 mm. long.

Habitat.—Western Australia: Preston River near Bunbury (Mr. F. Lawson Whitlock).

Two examples sent by Mr. Whitlock, taken from submerged wood, form the third species recorded from Australia. It is difficult to see the head or antennae even from beneath, but the wide pear-shaped apex of the antennae can be made out. In form, size and general sculpture it is not unlike *G. australis* King and *G. kingi* Macl., with the types of which I have closely compared it under a Zeiss binocular. In *australis* the pustules on anterior area of thorax are much coarser, the posterior lobe is narrower, the three medial humps form a transverse ridge, with two smaller humps behind these, and a line of small pustules at base. The elytral costae—only two are visible—consist of lines of pustules on a ridge, the intervals are punctate-foveate. In *kingi*, the prothorax is also more coarsely pustulose, the three large postmedial knobs form a triangle; the elytral costae more strongly raised and less marked by granules than in *occidentalis*, the intervals have cancellate ridges, forming large rugose foveae. Thus *occidentalis* is distinguished chiefly by the finer sculpture of pronotum and elytra. Holotype and paratype in Coll. Carter.

Family BUPRESTIDAE.

CHRYSOBOTHRIS SUBSIMILIS Thoms. ♂ (= *C. arcana* Macl. ♀).—Following the suggestion of my friend, Mr. F. E. Wilson, I have examined a series of examples taken by Mr. J. Armstrong on the Bogan River, N.S.W., and now consider that *C. subsimilis* is the male of *C. arcana* Macl. The structural difference of the apical segment of the abdomen is remarkable. In the ♂ this segment is concave without medial carina, the apex with wide triangular excision, of which the extreme angles are bifid ("Apex 4-spinose" in my Table, see These PROCEEDINGS, 1925, p. 229). In the ♀ this segment has a well raised carina extending throughout its length and slightly produced behind, giving the "3-spinose apex" of my Table. The triangular apical excision is narrower than in the ♂. Mr. Armstrong has given me eleven examples (3 ♂, 8 ♀), all taken on the River Wilga (*Acacia stenophylla*). I can discover no character in colour, size or form of the upper surface to distinguish the sexes. I have other examples from N.W. Australia and from Bowen and Camooweal, Queensland.

MELOBASIS MYALLAE, n. sp.

Elongate-navicular; head and pronotum steel-blue bronze, elytra violaceous bronze, basal area and shoulders coppery, apex blue; underside cyaneous with coppery gleams; antennae and tarsi blue, the former with basal segments coppery. Head densely, finely punctate, rather densely clad with golden hair. Prothorax: Apex and base bisinuate, sides obliquely narrowed from base to apex; covered with a dense system of punctures larger than on head, with a general transverse tendency; without defined foveae or medial line. Scutellum small, round, with a single central puncture. Elytra slightly wider than prothorax at base; subparallel to half-way, thence obliquely narrowed to apex, apices separately rounded, margins strongly serrated on apical half. Disc with light subsutural depression on basal half, and some ill-defined striae, the whole rather densely punctate. Prosternum finely and closely punctate, abdomen very finely strigose-punctate and moderately pilose; apical segment arcuately excised between triangular spines. *Dimensions*: 12 × 3·5 mm.

Habitat.—New South Wales: Bogan River (Mr. J. Armstrong).

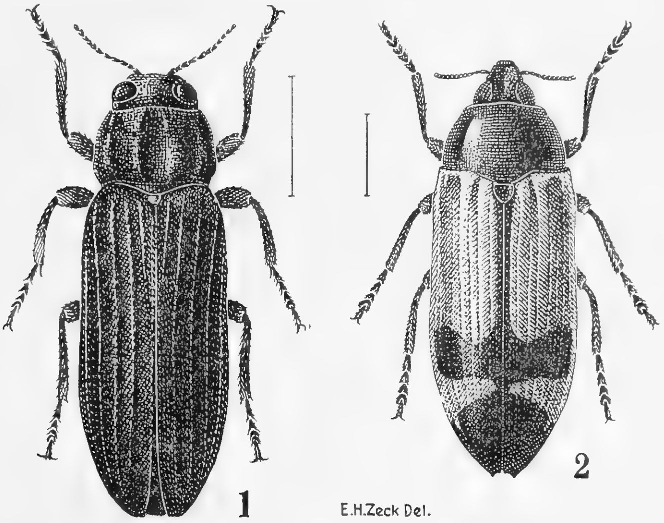
Two examples, both I think ♀, have been sent by this keen young entomologist as taken on the Myall bushes (*Acacia pendula*). The species is quite distinct, with a nearly straight-sided prothorax as in *costata* Macl., or *picticollis* Cart. (as in fig. 14, Pl. ii, *Trans. Ent. Soc. Lond.*, 1923), with nearly flat elytra like that of *apicalis* Macl., which it most nearly resembles. Holotype and paratype in Coll. Carter.

NEOBUPRESTIS TRISULCATA, n. sp. Text-fig. 1.

♀. Elongate-ovate; head and pronotum black, subnitid, elytra and underside black with purplish lustre, legs dark blue, general surface glabrous. Head: Labrum short, lightly depressed on vertex, a smooth wide and short carina between eyes, surface rugose-punctate, antennae short, apical five segments serrate, 2, 3, 4 subequal; eyes separated by a space of the transverse diameter of one eye and converging behind. Prothorax (3·6 × 4·8 mm.) subdepressed, apex very lightly, base rather strongly bisinuate, widest behind middle, thence arcuately converging to the depressed, acute, anterior angles; disc very uneven, with three wide sulci, the medial oval with a suggestion of a smooth carina along its centre, the others at the middle of each lobe respectively, obliquely extending from base to near front angles, the raised areas on each side of sulci coarsely reticulate-punctate, the depressed areas more finely and densely punctate. Scutellum very small, almost hidden below surface of elytra. Elytra three and one-third times as long as, and wider than prothorax, rather flat, widest behind middle, sides entire, conjointly rounded at apex, each with five lightly-raised costae—including the sutural—besides a short, scutellary costa, the costae here and there irregular through the presence of vaguely defined impressions; intervals otherwise reticulate-rugose. Prosternum lightly depressed in middle, mesosternum divided, metasternum sulcate, whole region closely reticulate-punctate; abdomen and legs also strongly punctate and glabrous, the basal segment widely sulcate. Tarsi short. *Dimensions*: 18 × 6 mm.

Habitat.—New South Wales: Bogan River (Mr. J. Armstrong).

I am indebted to this keen young naturalist for the opportunity to describe this interesting species. Though differing from its congeners in the remarkable sculpture of its pronotum it is, I think, an ally of *N. albosparsa* mihi. The single specimen available is female. Holotype in Coll. Carter.



Text-figs. 1-2.
1.—*Neobuprestis trisulcata*, n. sp. 2.—*Stigmodera* (*Castiarina*) *suttoni*, n. sp.

Curis atrocyanea, n. sp.

Oblong, nitid blue-black above, pronotum—especially at sides—more evidently blue than elsewhere; beneath similarly coloured, but with patches of white flocculence at sides of prosternum, behind all coxae, and of sides of each abdominal segment, appendages blue-black. Head with wide, deep excavation; finely rugose-punctate. Prothorax: Apex and base bisinuate, the latter more strongly so; widest at middle, sides well rounded, subsinuate in front and behind, all angles a little acute; disc with an oval, shallow depression extending over basal half at middle, a fine medial sulcus just traceable on front half; surface covered with fine punctures, increasing in size and density laterally. Scutellum very small and round, punctate. Elytra slightly wider than prothorax at base, feebly compressed behind shoulders, not completely covering apex of abdomen, apices separately rounded, their margins strongly serrulate to apical third, with short scutellary and four other costae, these rather wide and moderately raised, the costae bounded by irregular series of punctures (more regular on basal half); intervals irregularly punctate near the middle, the lateral intervals—external to the second costa on each side—rather vaguely reticulate-rugose. Prosternum finely punctate, the rest of underside striolate only; apical segment excised between two spines. In ♂ the eighth ventral sternite clearly forcipulate. *Dimensions*: ♂, 12 × 4 mm.; ♀, 14 × 4·5 mm.

Habitat.—New South Wales: Bogan River (Mr. J. Armstrong).

A pair of this distinct species has been received from its captor. In form it is intermediate between *splendens* Macl., and *caloptera* Boisd. The elytral costae are well marked, but the interstitial punctures are less well defined than in either of these species. The flowery flocculence of the underside is readily removed with a pin, and may be variably present in older examples. Holotype ♂ in Coll. Carter. Allotype ♀ returned to Mr. Armstrong.

Anilara olivia Cart.—I have already shown (*Entomolog. Blatt.*, 1929, p. 184) the clear distinction of this species from *A. viridula* Kerr., but apparently my note was not in time to prevent a repetition of this mistaken synonymy in the Junk Catalogue edited by Dr. Obenberger.

Diceropygus macleayi Kerr. = *Melobasis suturalis* Macl. (1886).—When writing the Revision of this group I was unaware of Kerreman's "Catalogue synonymique" in which this new name was supplied for that preoccupied by *M. suturalis* Thoms. (1879)—a synonym of *M. apicalis* Macl. One of the references given by Obenberger in the Junk Catalogue (Buprestidae, p. 437) under this name, however, applies to *Hypocisseis suturalis* Saund. (Cisseis)—a widely different species.

Stigmodera (*Themognatha*) *yarrelli* L. & G.—I have received from Mr. H. W. Brown two beautiful blue varieties of this species—mentioned also in my Revision of 1916 (*Trans. Roy. Soc. S. Aust.*, 1916, p. 81)—that is found specially in the Moore River district. I suggest the name *coerulescens* for this very distinct variety.

STIGMODERA (CASTIARINA) SUTTONI, n. sp. Text-fig. 2.

Oblong; head and pronotum golden (sometimes greenish at sides), underside, legs and appendages dark-green; elytra yellow with base (narrowly), suture, post medial fascia (in 4 out of 5 examples not extending to sides) and wide apical mark, dark-green. Head finely, closely punctate, frontal sulcus wide and deep. Prothorax moderately convex, widest at base, sides lightly and arcuately narrowed to apex, this lightly and acutely produced, base moderately bisinuate, its angles subrectangular, disc finely punctate, more closely so towards apex, sparsely at base; deep mediobasal fovea placed in larger longitudinal depression, smooth medial line faintly indicated on basal half, a large rounded lateral fovea near each hind angle. Elytra, sides nearly straight, lightly compressed in front of, and lightly enlarged behind, middle; apices finely bispinose, with small semicircular lunation, sutural spine minute. Striate-punctate, all intervals convex on apical half, third and fifth also on basal half; seriate punctures distinct, intervals impunctate; underside very finely pubescent and punctate. *Dimensions*: 11–13 × 4–4·1 mm.

Habitat.—South Queensland: Fletcher (Mr. E. Sutton).

Five examples sent by this keen-eyed collector, to whom it is dedicated, show a species of the *andersoni* group nearest to *campestris* Blkb., and *skusei* Blkb., but distinct from both by the golden prothorax. In *S. campestris* the apices are widely bidentate, and the general shape different. In *S. skusei* the dark colour on suture is never continued beyond the fascia, the underside is blue amongst other differences. Holotype and allotype in Coll. Carter. Three paratypes returned to Mr. Sutton.

Family TENEBRIONIDAE.

Gonocephalum arenarium F.—Mr. G. F. Blair has identified examples from Albany, Western Australia, taken by Mr. H. Giles, as this species. Its wide distribution is shown by its locality—Bengal and the Moluccas (Junk Catalogue) and Cape of Good Hope (ex. sent me by Mr. Blair). Mr. F. L. Whitlock has lately sent it from Bunbury, W.A.

Saragus.—I am indebted to Mr. K. G. Blair for sending me accurate information on types examined by him. The following corrections should therefore be made in my Check List:

S. australis Boisd. = *tarsalis* Hope (*S. asperipes* Pasc., is not a synonym of *tarsalis* Hope as in my List).
S. inaequalis Blkb. = *lindi* Blkb.
S. levicostatus Macl. = *mediocris* Blkb. (? also = *interruptus* Boisd.).
S. confirmatus Pasc. = *opacipennis* Macl.

MYCHESTES PAPUANUS, n. sp.

Widely oval, brown. Head roughly shagreened, antennal ridge strongly raised (ear-like), antennae comparatively long and slender, third segment longer and more slender than first, 4–8 oblong, each lightly enlarged in front, 10–11 oval, forming a moderately wide club, 11 longer than 10. Prothorax widely oval and transverse, apex emarginate, front angles acute and prominent, sides well rounded, widest rather behind middle, margins roughly crenulate, posterior angle rounded off, base bisinuate, with a produced medial lobe, disc with six prominent protuberances, two conical, rather close together, just behind apex very prominent and sloping forward, two subspherical at basal third, themselves bearing small nitid tubercles, and a transverse one, less prominent than the preceding, near middle of and within each lateral margin, a longitudinal row of about five small double tubercles equally placed between the medial area and the concave margins, other small tubercles scattered along base or irregularly elsewhere on disc. Scutellum small, oval. Elytra widely oval and convex, at widest as wide as prothorax, posterior declivity very steep, subvertical; two prominent, costate lines of tubercles from base to hind declivity, a prominent rounded tubercle near middle exterior to costae on each side and a second similar to this, near declivity, and exterior to it, intervals bearing small nitid tubercles. Legs with short bristly hair, tibiae with small tubercles on exterior margins, not enlarged, at apex. *Dimensions*: 9 × 5·2 mm.

Habitat.—N.W. Papua: Mt. Lamington, 1300–1500 ft. alt. (C. T. McNamara).

A single example, forwarded by the late Mr. Lea, is gummed on a card. While generally similar to, it is strongly differentiated from, its Australian congeners, though nearest to *M. pascoei* Macl., in proportions, but wider and more convex than it. Holotype in South Australian Museum.

MARTIANUS AUSTRALIS, n. sp.

Elongate-ovate, subdepressed, subnitid; head, prothorax and underside reddish, elytra piceous-black with shoulder mark and apical margins red; antennae, palpi and legs red. Head unarmed, epistoma straight in front, rounded at sides, palpi narrowly semi-elliptic, strongly and closely punctate; antennae extending well beyond half the length of prothorax; segments beyond the fifth transverse and successively wider to apex; apical segment subcircular. Prothorax: Apex nearly straight (feebly advanced at angles and middle), base bisinuate, sides evenly rounded, all angles obtuse, the anterior slightly rounded off; surface strongly and closely, not confluently, punctate, the usual basal foveae marked by large shallow depressions. Scutellum transversely oval, punctured like pronotum. Elytra slightly wider than, and more than three times as long as, prothorax, lightly ovate; striate-punctate, the strial and interstitial punctures close and confused; intervals moderately convex, in places transversely wrinkled. Prosternum lightly pustulose, rest of underside and femora strongly punctate, metasternum the most sparsely so. *Dimensions*: 4·5–5 × 2 (+) mm.

Habitat.—N. Queensland: Cooktown. In palm tree (Mr. L. Wassell).

Four examples, kindly sent by their captor recently, are quite distinct from the Fiji species, *M. dermestoides* Chev. The sculpture gives it a subopaque appearance. An example sent to Mr. Blair for determination was returned as *Martianus* sp.—a genus not so far recorded from Australia, and distinguished from *Platydema* by (1) upper lip not connected by membranous hinge with epistoma, (2) body long, parallel, and (3) apical segment of maxillary palpi cylindric (Gebien, *Philippine Journ. Sci.*, 1925). In the above, (1) can only be certified by dissection, (2) is not the case, (3) the palpi are certainly much narrower than in *Platydema*, but are not cylindric, the external margin being slightly arcuate, widest in middle. Holotype in Coll. Carter. A paratype sent to British Museum.

SARAGUS BARRETTI, n. sp.

Oval, very convex; nitid black, foliate margins of prothorax, legs and underside reddish-brown, oral organs, antennae and tarsi red. Head coarsely punctate and slightly rugose, epistoma widely arcuate, its edges reflexed; antennae slender, 2–6 lineate, 7–8 subconic, 9–10 round, 11 oval. Prothorax strongly transverse, disc convex, finely but distinctly punctate, foliate margins wide behind, narrowing and concave towards front, all angles rounded off. Elytra convex, with steep apical declivity, apex rather acute, with fine, rather indistinct striae, containing rows of very small punctures; the flat intervals bearing a few, just perceptible, punctures; lateral margins very narrow, except near base, but continuous to apex. Prosternum finely punctate; abdomen glabrous, impunctate. *Dimensions*: 12·5 × 9 mm.

Habitat.—Western Australia: Nullarbor Plains (C. Barrett, Esq.).

A unique specimen was sent to Mr. F. E. Wilson amongst examples of *S. pascoei* Macl., by the well-known naturalist to whom I dedicate it. The following comparison will distinguish it from this its nearest ally:

S. pascoei.	*S. barretti.*
Head very finely punctate	more coarsely so
Antennae stouter, 3rd = 2 × 4th	more slender, 3rd less than 2 × 4th
Prothorax impunctate, margins black	clearly punctate, margins red
Elytra: seriate punctures, larger and irregular, margins much wider.	seriate punctures very fine, narrow
Form widely ovate, apices bluntly rounded, widest behind shoulders	tapering to a rather sharp apex, widest at base of prothorax
Hind tibiae flat between carinate edges	rounded, without carinae
Dimensions 16-19 × 12·5-15 mm. (from examples before me)	12·5 × 9 mm.

Holotype in Coll. Wilson.

Lepispilus Westw.—In conversation with me in 1922 Mr. K. G. Blair suggested the synonymy of the genus *Tyndarisus* Pasc., with *Lepispilus*, the former being the male form of the latter. I had long noted the similarity of structure, clothing and sculpture in these genera, and included *T. longitarsis* under *Lepispilus* in my Check List as a separate species. Field notes failed to provide indisputable evidence of sexual relation, i.e., no mated pair was taken of these comparatively common insects. Of late years I have carefully collected material and now entirely endorse Mr. Blair's opinion, as expressed by letter of 17/3/31: "Many thanks for the nice box of *Lepispilus* which I think clears matters up nicely—To me the identity is so obvious that you cannot escape it—You have four species, of three of which I return you a pair each." The males in each case differ from the females in their more slender form, longer legs, especially tarsi; so that Pascoe placed *Tyndarisus* in the Subfamily Strongyliinae. The more lightly built males are often taken on the wing, but I have never thus taken the heavier females. This, together with the erroneous determination by the late Mr. Masters of *T. longitarsis* for the common Blue Mountain species (*L. rotundicollis* Blkb. ♂) made me hesitate in accepting Mr. Blair's suggestion until recently.

T. longitarsis Pasc. (♂) = *L. stygianus* Pasc. (♀), the latter having page priority, the former name must therefore be sunk.

I have examined 213 examples from the chief Australian collections, and note the following distribution:

sulcicollis Boisd. 103 examples. New South Wales, Victoria and Tasmania.

rotundicollis Blkb. 60 examples. New South Wales, Victoria and South Australia (mostly from highlands, Blue Mountains, etc.).

stygianus Pasc. 35 examples. Alpine New South Wales and Victoria (Kosciusko–Mt. Buffalo, etc.).

ocularis, n. sp. 15 examples. New South Wales: Dorrigo and Williams River. Queensland: National Park and Tambourine Mountain.

The sexual distinctions are strongly marked by (*a*) form, as stated above, (*b*) (except in *sulcicollis*), eyes larger and closer in ♂, (*c*) sex organs. As regards (*c*), the ♂ organ has a longitudinal groove, but is undivided, with an acute apex; the ♀ often displays a prominent ovipositor which is more or less longitudinally divided, bifid at apex with two linear transverse appendages. These sex organs, if not obvious, can readily be dissected or squeezed out after soaking in warm water. The four species may be tabulated as follows.

1. ♂ with eyes closer, also form more elongate than ♀ 2
   Eyes similar in both sexes, sexual form less marked .... *sulcicollis* Boisd.
2. Sides of prothorax variously sinuate, never angulate, size larger 3
   Sides of prothorax subangulate, size smaller .... *ocularis*, n. sp.
3. Upper surface black (sometimes reddish) without pubescent patches except on scutellum .... *stygianus* Pasc.
   Upper surface uneven, elytra with large pale, pubescent patches, with raised subreticulate intervals .... *rotundicollis* Blkb.

N.B.—As in many other genera of the Tenebrionidae the females of the different species are sometimes difficult to separate.

LEPISPILUS OCULARIS, n. sp.

♂. Narrowly elongate and parallel; bronzy brown, clothed with more or less pale pubescence, this chiefly on depressed areas, e.g. lateral groove of pronotum, irregular patches of elytra. Head: Eyes large and close, their interspace less than the transverse diameter of one eye (less than 1 mm.); antennae slightly longer (especially apical segment) than in *sulcicollis*. Prothorax: Apex arcuate-emarginate, base lightly bisinuate, sides with outline of anterior half convex, posterior half concave, subangulate at middle, anterior angles subrectangular (wider than in *sulcicollis*), posterior acute, with narrow raised border, widely grooved within this; disc rather sparsely and finely punctate, with wide medial sulcus enlarged at base, and a basal depression on each side. Scutellum triangular, pubescent. Elytra wider than prothorax at base, parallel for the greater part, sides feebly constricted at middle, with roundish pubescent areas arranged chiefly in longitudinal series, the intervals raised and reticulate; two larger series of pubescence, the first originating at the constriction of sides and interruptedly continued half-way to suture, the second forming a vague fascia on apical third; underside pubescent, especially epipleurae. Hind tarsi with segments 1 and 4 longer than in *sulcicollis*. *Dimensions*: ♂, 15 × 6 mm.; ♀, 15–17 × 7–9 mm.

Habitat.—New South Wales: Dorrigo (W. Heron) and Williams River (A. Lea and F. E. Wilson); Queensland: National Park and Tambourine Mountain (H. Hacker).

♀. Differs in having the eyes more widely separated (1½ mm. apart), the prothorax relatively wider, elytra more or less obovate, tarsi stouter, front tarsi shorter.

Fifteen examples examined, 6 ♂, 9 ♀. The species is nearest *sulcicollis*, but clearly separated by the characters stated in the tabulation. Holotype ♂ in South Australian Museum, allotype ♀ in Coll. Carter.

N.B.—The pubescence is easily abraded, so that four of the ♂ examples only show clearly the lateral pubescence of prothorax and elytra. In such cases it can be readily distinguished from *stygianus* by the smaller size, coarser sculpture, besides the angulate pronotum; though the ♂ of *stygianus* has very similarly placed eyes.

L. rotundicollis Blkb. var.—Several examples from the Queensland National Park and Dorrigo, New South Wales, differ from typical examples in the larger size of yellow pubescent areas, making this the predominant colour. The male examples appear less elongate than the corresponding males of *rotundicollis* from the Blue Mountains. The type, said to be from Central Australia, has been lent me for examination. It appears to be a small ♀.

Zophophilus.—My friend Herr Gebien writes that the following synonymy should be recorded:

(*a*) *Zophophilus* Fairm. = *Sphenothorax* Geb. = *Teremenes* Cart.
(*b*) *Z. curticornis* Fairm. = *Meneristes dentipes* Cart. = *Z. raptor* Geb.

TITAENA WILSONI, n. sp.

Elongate, cylindric, sparsely pilose. Head and pronotum nitid, dark-green (almost black), elytra purple, underside black with purplish gleams, legs piceous, antennae and tarsi reddish. Head and pronotum sparsely punctate (compared with *columbina* Er.), the latter widest at apex, gibbous anteriorly, with large, shallow, laterobasal impressions. Elytra somewhat irregularly punctate, with a suggestion of linear arrangement; the punctures nowhere contiguous, more distant and with less tendency to rugulose intervals than in *columbina*. *Dimensions*: 12–13 × 3 mm.

Habitat.—Victoria: Bogong High Plains. 5,000–6,000 ft. alt. (F. E. Wilson).

Two examples taken are clearly separable from *T. columbina* Er., by the bicolorous and feebly pilose upper surface, the nitid and less densely punctate pronotum, and the elytral punctures also clearly more distant. No structural distinctions can be seen. Holotype in Coll. Wilson.

Strongylium wagneri Cart. (These PROCEEDINGS, 1930, p. 546).—Herr Gebien has courteously written to me that this name is preoccupied by *S. wagneri* Pic. (1918) for an Argentine species. I, therefore, propose the name LEAI as a substitute for the New Guinea species.

Corrigendum.—In the same paper (p. 547) the author of *Amarygmus mutabilis* was printed Geb. instead of Guér.

Obriomaia ruficornis Champ. (*Menephilus*).—Herr Gebien writes that this species, having no margin to the anal segment, cannot be referred to *Menephilus*, but is a member of the Cnodaloninae—genus *Obriomaia* Geb. He considers that *O. azuripennis* Cart., which I recorded as a variety of Champion's species, is a good species—an opinion with which I concur after a re-examination. Besides colour distinction, the sculpture of the pronotum is finer, and the sides of prothorax are almost straight, not sinuate behind as in *O. ruficornis*.

It is extremely probable that *O. aeneus* Cart. (*Menephilus*) is another species, distinguished by the fifth elytral interval carinate, besides colour distinction.

ANDROSUS WASSELLI, n. sp.

Oblong; head and prothorax subnitid black, elytra metallic dark-green, underside nitid black, above and below glabrous; antennae and tarsi castaneous, legs piceous above, red beneath. Head densely and strongly punctate, epistoma subcircular, its margin slightly reflexed, antennal segments successively wider and transverse from fifth outwards, eleventh subspherical. Prothorax: Apex somewhat squarely emarginate, anterior angles acute, and produced in front of eyes, base bisinuate, posterior angles subrectangular, sides straight on posterior half, thence arcuately converging to the front; lateral margins slightly foliate, extreme border raised, base without border; disc strongly punctate, less closely than on head, the punctures larger and more distant near base and sides. Elytra of same width as prothorax at base and about two and two-thirds as long; slightly enlarging at shoulder, thence parallel to near the bluntly rounded apex; striate-punctate, the striae well impressed, the strial punctures small near suture, increasing in size and distance apart in external striae; intervals flat, scarcely visibly punctate. Prosternum declivous, its process bisulcate, pointed at apex; prosternal episterna roughly punctate, abdomen very finely so. *Dimensions*: 4–5·5 × 2–2·2 mm.

Habitat.—Queensland: Clayfield, a suburb of Brisbane (Mr. L. Wassell).

Twenty-two examples of this little species were lately sent by my friend to whom it is dedicated. It is curious that so apparently common a species should have escaped notice. Holotype in Coll. Carter.

Note.—*Androsus* Geb., is separated from *Chariotheca* by rather slight characters, of which the bisulcate prosternal process seems the most definite; but it forms at least a convenient group division of a genus that has become inconveniently numerous in the Austro-Papuan fauna. Herr Gebien rightly diagnoses my *C. brevis* as an *Androsus*; *C. varipennis* Cart., is another member of this genus.

CARDIOTHORAX MONARENSIS, n. sp.

Oblong-ovate; moderately nitid black, antennae and tarsi brown. Head: Epistoma rather sharply rounded in front, the stirrup-shaped frontal impression bearing a few punctures, antennae stout. Prothorax: Apex arcuate-emarginate, base nearly straight; anterior angles rounded, sides widest near middle, sinuate near the obtuse, but fairly prominent hind angles (more prominent in ♀ than in ♂), sides well rounded, raised border moderately thick, foliate margins wide, separated from disc by shallow sulcus; without evident setae; disc with medial sulcus throughout, in general with transverse depression on each side within basal border. Elytra sulcate, with six wide and deep sulci on disc, three narrower sulci at sides, intervals convex and subequal, underside impunctate; posterior tibiae of ♂ widened and concave on the inside, with short hairy clothing. *Dimensions*: 17–18 × 6–6·5 mm.

Habitat.—New South Wales: Monaro District, Jindabyne, Thredbo River (the author), Cooma (T. G. Sloane), Yaouk (F. H. Taylor).

Ten specimens under examination belong to the *walckenaeri* Hope–*laticollis* Cart. Section, having sexually widened hind tibiae. This is the species wrongly determined by me hitherto as *brevicollis* Redt. There is an example of *brevicollis* in the British Museum, which Mr. Blair has compared with the actual type, sent from Vienna for that purpose. It has not yet been determined in Australian collections, nor is its habitat known, since both examples examined by Mr. Blair have only "Australia" on label. Yet the Gemminger and Harold Catalogue gives "Sidney" and Masters' Catalogue "New South Wales" as its habitat—the latter, I think, founded on a misdetermination of specimens in the Macleay Museum. Mr. Blair has courteously sent me the following comparison:

brevicollis Redt. ♀.	*monarensis*, n. sp.
Colour black (faint bronzy reflection)	black
Anterior angles of thorax sub-obtuse	fully rounded
Posterior angles obtuse; sides scarcely sinuate before them	prominent
Base of thorax angularly emarginate	nearly straight
Elytra more elongate	more ovate
Striae paired; 3rd, 5th, 7th intervals wider, especially towards apex, and flat	not paired, deeper and more sulciform, all intervals on declivity equal and convex.

Holotype in Coll. Carter.

ADELIUM PULCHELLUM, n. sp.

Oval, convex; brilliant golden-bronze above and below, antennae and tarsi opaque red. Head coarsely punctate, antennae rather short, submoniliform, third segment shorter than 4–5 combined, apical segment pyriform. Prothorax transverse, apex arcuate-emarginate, front angles widely rounded, base nearly straight, hind angles obsolete, sides subsemicircular; disc punctate—not at all rugose—the punctures sparse and fine near middle, larger and a little closer near sides and base, without distinct foliation, some laevigate areas here and there; extreme border finely raised. Scutellum triangular. Elytra ovate, slightly wider than prothorax, and about twice as long; widely rounded at shoulder, striate-punctate, with regular rows of very small punctures placed in fine, shallow striae; intervals flat and almost impunctate. Underside very nitid and impunctate save for a few small punctures on the epipleurae. Tarsi very short. *Dimensions*: 7–8 × 3–3·5 mm.

Habitat.—New South Wales: Dorrigo (Mr. Alfred Stephen and the author).

Two examples before me are amongst the smallest in the genus, distinguished by the brilliantly metallic gloss of its whole surface, the widely and evenly rounded sides of prothorax and the very fine sculpture of the elytral series. But for the transverse eyes it is not unlike certain Brycopiae. I took one example in July, 1910, the second was found by Mr. Stephen in December, 1920. Holotype in Coll. Carter.

AMARYGMUS AMPLIPES, n. sp.

Elongate-ovate; head, pronotum, underside and antennae black, legs dark, tarsi reddish, rufo-pilose. Elytra dark purple, blue-green at base, sides and apex—the colours merging and varying with aspect. Head: Eyes widely separated, interspace about length of third antennal segment, antennae with basal segments slender, successively thickened from the fourth onwards. Prothorax: Apex subtruncate, base lightly sinuate, widest at base, thence slightly and almost straightly, converging in front till near apex; here more strongly narrowed, all angles obtuse; disc evenly, densely punctate. Elytra slightly wider than prothorax at base, subcylindric in form, striate-punctate, the striae more clearly marked towards sides and apex, the strial punctures small, uniform in size and distance; intervals quite flat, except at sides, thickly covered with punctures much smaller than the seriate. Underside finely strigose, front tibiae lightly bent in middle vertically, then arcuate, and enlarged to apex; hind tarsi with basal segment longer than the rest combined. *Dimensions*: 9–10 mm. long.

Habitat.—Queensland (in Hamburg Museum).

Four examples sent by my friend Herr Gebien as "*suavis* Blkb. or sp. nov." are clearly separated from the Sydney species *suavis* by larger size, more sombre colour and uniform seriate punctures of the elytra, and especially the protibial characters. It is perhaps nearer *cupido* Pasc., which is a smaller, more oval species of a brighter colour. Holotype in Hamburg Museum. Paratypes in Coll. Carter.

Family CISTELIDAE.

CHROMOMOEA NIVALIS, n. sp.

Narrowly ovate; upper surface densely clad with recumbent, snowy pubescence, underside less densely but similarly clad. Legs red, knees, tarsi and antennae black. Head and prothorax blackish, where visible through the clothing, oral organs reddish; eyes moderately prominent; antennae not extending far beyond base of prothorax; segment 3 linear, longer than 4; 4–7 successively shorter and widened at apex, 8–10 subtriangular, 11 elongate-ovate. Prothorax subquadrate (slightly longer than wide), sides rounded in front, truncate behind, medial line shown at base. Elytra considerably wider than prothorax at base, shoulders rounded, sides tapering to a fine, common apex; finely striate-punctate, the seriate punctures clearly visible, striae well marked. *Dimensions*: 10–11·5 × 4 mm.

Habitat.—New South Wales: Mullaley (the author). On *Leptospermum* flowers in November.

Three examples taken—others eluded me by very active flight—show a species structurally near *C. fusca* Cart., and *ochracea* Cart., with equally dense clothing; but the size is larger, the prothorax more narrowly elongate, and the elytra relatively wider than in either of these. The striae give a somewhat striped appearance to the elytra. The largest of the three examples is clearly ♂. (Both *fusca* and *ochracea* were taken at the same place.) Holotype in Coll. Carter.

Note.—*Dimorphochilus* (*Allecula*) *gouldi* Hope = *D. diversicollis* Borch.—Examples of this common Western Australian species were compared with Hope's type in 1922. Immature examples are often red or brown.

HYBRENIA ARMIPES, n. sp.

Ovate; nitid bronzy-black, with close, fine, whitish pubescence, basal segments of antennae, tarsi, base of femora and tibiae reddish. Head finely and closely punctate, eyes rather close, interval about the length of 2nd antennal segment, antennae slenderly lineate, 3rd and 4th segments equal, 5–11 shorter than 4, subequal, 11 lanceolate. Prothorax: Apex slightly advanced in middle, base nearly straight, sides subparallel on hind half, rounded towards front, hind angles subrectangular; surface with fine dense punctures, slightly larger near base and sides; subobsolete medial impression indicated near base, two indistinct basal foveae. Scutellum triangular, finely punctate. Elytra wider than prothorax at base, sides scarcely widening behind middle; striate-punctate—the strial punctures scarcely distinct from the interstitial and generally hidden in rather deep striae; intervals convex, strongly, not coarsely, punctate, the short pubescence strongly shown at sides and apex; the forcipital anal appendage sharply incurved (hooked); fore tibiae with wide triangular enlargement at middle on inside; mid tibiae with an internal tooth near apex; hind tarsi with basal segment longer than rest combined. *Dimensions*: 14 × 5 mm.

Habitat.—Cape York: C. Weymouth District (Mr. Leathom Wassell).

A single ♂ example sent by Mr. Wassell is quite distinct in the genus by the combination of bronzy colour, pubescent surface, fine pronotal sculpture and convex elytral intervals. In my Table (These PROCEEDINGS, 1929, p. 77) it is nearest *pilosa* and *torrida*, but is separated by the longer clothing and coarser pronotal sculpture of the former and by the very different elytral sculpture of the latter. From both it is distinguished by its tibial armature. Holotype in Coll. Carter.

HYBRENIA CAUDATA, n. sp.

Oblong; glabrous, prothorax opaque, elytra nitid black, legs dark, labrum, tarsi and apical segments of antennae reddish. Head finely, not closely punctate, eyes separated by a space equal to half the transverse diameter of an eye; antennae slender, 3rd one and a half times longer than 4th, 4–11 very slightly successively shorter, but not wider than preceding. Prothorax: Apex feebly sinuate, base truncate, nearly as long as wide, parallel on basal half, sides converging and rounded in front, hind angles sharply rectangular; clearly but narrowly margined throughout; disc very finely punctate, the punctures crowded in middle area, sparse at sides and base; four large foveate depressions; two larger and deeper at base near hind angles, two, shallower, near centre; medial line scarcely indicated. Scutellum transverse and punctate. Elytra much wider than prothorax at base and three times as long, slightly widest behind middle, apices a little divergent at suture, each with a blunt tooth, emphasized by small external sinuation, the suture itself widened and bent outwards and again incurved near apex. Striate-punctate, the seriate punctures rather large and elongate, the sutural row following a depression from just behind scutellum to apex; intervals otherwise quite flat, each with a single row of irregular, small but defined, punctures. Sternal region finely and sparsely punctate, abdomen striate with a few lateral punctures. *Dimensions*: 20 × 7 mm.

Habitat.—S. Queensland: Milmerran (Mr. J. Macqueen).

A fine species, distinct by its sculpture from its allies. In my tabulation (These PROCEEDINGS, 1929, p. 77) it would follow *sublaevis* Macl. (a smaller species with approximate eyes). It is nearer *H. clermontia* mihi (These PROCEEDINGS, 1930, p. 188), but the pronotum is much more finely punctate, and the elytra more nitid—without pustules. The curiously formed apex may prove to be an individual aberration. Type in Coll. Carter.

Hybrenia concolor Cart.—In my Revision of the Australian Cistelidae (*Proc. Roy. Soc. Vict.*, 1915, p. 87) I recorded this name for an all-black variety of *H. vittata* Pasc. I now see that it is a distinct species strikingly similar in sculpture, but separated by its different antennae in which the segments are longer and more slenderly lineate than in *vittata*.

Family CERAMBYCIDAE.

ATHEMISTUS ABERRANS, n. sp.

Reddish-brown; pubescent, elytra with an oblique fascia of pale pubescence on apical third, extending backwards towards suture, but not reaching suture nor sides; apical region similarly but sparsely pubescent; tibiae with two rings of pale pubescence. Head with sparse, round punctures, antennae widely set, as long as body, third segment more than twice as long as fourth, 5–11 shorter than 4, subequal. Prothorax rather shortly and widely oval, without constriction, a small lateral spine near middle, surface coarsely and rather closely punctate, basal area obscured by pale pubescence, without defined discal tubercles. Scutellum very small. Elytra of same width as prothorax at base, ovate, apices separately rounded, each elytron with three distinct subparallel rows of elongate, black tubercles, extending from base to apical declivity; also some traces of a fourth row exterior to the former; intervals between rows coarsely punctate and pubescent, the interval between first row and suture forming a series of large punctures. *Dimensions*: 5 × 2 mm.

Habitat.—North Queensland: Cairns (the late Dr. E. W. Ferguson).

A single example (? ♂) was given me some years ago by my old friend. The rather regular series of larger tubercles distinguish its sculpture from the other members of the genus, but its general facies is similar, and I am unwilling to establish a separate genus for its reception. Holotype in Coll. Carter.

PARMENOMORPHA WASSELLI, n. sp.

♂. Black; antennae, tibiae and tarsi reddish-brown, elytra with loose, post-medial fascia of silvery pubescence, this more or less continuous along sutural region to apex; a slight trace of the same on shoulders and sides of prothorax; antennae and tibiae with indistinct rings of similar pubescence—at the base of segments in the former, at apical third of the latter; a few sparse upright hairs on forehead and sides of elytra, otherwise glabrous. Head with coarse, close punctures, antennae stout, extending slightly beyond the body, third segment longer than fourth, the latter twice as long as any of the succeeding, 5–9 subequal, 10–11 wanting. Prothorax oval, sub-bulbous, constricted towards apex and base, a small lateral conical spine at middle; surface densely and strongly punctate (the punctures larger and closer than in *P. irregularis* Blkb.). Scutellum small, triangular, pubescent. Elytra ovate, of same width as prothorax at base, widest at middle, tapering and declivous to apex, extreme apices separately rather widely rounded (subtruncate); basal half of elytra somewhat irregularly, not closely, punctate; punctures becoming obsolete on basal half. *Dimensions*: 8 × 3 mm.

Habitat.—Cape York: C. Weymouth District (Mr. Leathom Wassell).

A single example sent by its captor is an interesting addition to the Dorcadionini group of longicorns. Compared with *irregularis* Blkb., of which I have an example, besides the difference of colour, it is larger, more coarsely punctured and less pilose. Holotype in Coll. Carter.

MICROTRAGUS BROWNI, n. sp.

Black, antennae and legs ashen-grey, elytra clothed with pubescence, brown on disc, ashen at apex. Head velvety pubescent and sparsely pilose, with a few large punctures, front finely sulcate, antennae approximate, extending to the apical third of elytra. Prothorax rather closely covered with rounded tubercles, showing foveate intervals near apex, the tubercles smaller on apical half, larger and shining at sides, one large lateral triangular tubercle conspicuous near basal third. Elytra each with a compound humeral tubercle, formed by a larger tubercle surmounting three or more rounded tubercles; the whole surface, except a narrow sutural region, more or less bearing tubercles. Of these, two well defined series of large rounded and flattened tubercles with a coarsely crenulated outline (seen from sides) on each; between the suture and the first of these are smaller tubercles irregularly placed; between the exterior of these and the sides are larger, more conical tubercles; the whole sparsely clothed with upright hair, and irregularly pitted with foveate punctures. Beneath clad with velvety down. Mid tibiae with rounded enlargement externally near apex. *Dimensions*: 20 × 7 mm.

Habitat.—Lake Grace, 275 miles south-east of Perth, W. Aust.

Mr. H. W. Brown has kindly sent me a single example, which, having terminal segment of palpi widely oval, I take to be ♂ of this very distinct species. It is easily distinguished from *M. luctuosus* Shuck., by its denser pubescence and hair; besides its multituberculous surface. Holotype in Coll. Carter.

HESTHESIS RUFODORSALIS, n. sp.

♂. Head strongly albopilose; antennae wholly black, its segments—especially the third—longer and more slender than in *H. cingulata* Kirby. Dorsal surface of abdomen having the two penultimate segments red. Legs black. Otherwise similar to *H. cingulata.*

♀. Antennae as in *H. cingulata.*

Dimensions: ♂, 17–20 × 5 mm.; ♀, 27–28 × 7 mm.

Habitat.—New South Wales: Mullaley (on *Leptospermum* flowers—the author).

I took six examples (4 ♂, 2 ♀, one pair *in cop.*) in November, 1930, near Garrawilla Homestead. At first considered as a colour subspecies of *cingulata,* which it closely resembles, the distinct differences of the antennae in the ♂ point to specific divergence. The red dorsal surface of abdomen is its notable character. Holotype ♂ and allotype ♀ in Coll. Carter.

N.B.—In *cingulata* the red legs seem to be confined to the ♂.

H. moerens Pasc.—I am now of opinion that this is but a male form of *H. cingulata* Kirby: the elytral hind margins are here very much as in *rufodorsalis*, i.e., with a slight sexual divergence, less oblique in the ♂. I noted in my Revision of this genus (These PROCEEDINGS, 1928, p. 546) the variability in the ventral bands in *H. cingulata.*

CERESIUM AUSTRALE, n. sp.

Head, prothorax, underside and appendages castaneous, elytra castaneous with testaceous markings as follows: a wide, oblique fascia extending from shoulders to near suture in front of middle, a smaller irregular macula (sometimes connected with former) behind middle and a preapical fascia not reaching suture, upper surface pubescent. Head subtriangular, sulcate between eyes, antennae extending to apical third of elytra in ♂, shorter in ♀, first segment extending beyond the head, third longer than fourth, 4–11 subequal. Prothorax narrower than head, elongate-ovate, longer than wide, widest near middle, constricted in front and behind, surface rather strongly punctate-setose. Scutellum subcircular, pilose. Elytra wider than prothorax at base, subcylindric, shoulders rather squarely rounded, apices separately rounded, surface rather closely punctate, punctures subobsolete towards apex. *Dimensions*: 9–11 × 2–2·2 mm.

Habitat.—New South Wales: Sydney, Mittagong. Queensland: Townsville. Victoria (in South Australian Museum).

Six examples are before me of this widely distributed species that I cannot find described. It is erroneously labelled *Acyrusa ciliata* in the Macleay Museum, but the antennae are not spinose in either sex. The elytral pattern varies much by the extension of the pale yellow markings. Holotype and allotype in Coll. Carter.

SOME NOTES ON THE BIOLOGY AND MORPHOLOGY OF THE IMMATURE STAGES OF *HARPOBITTACUS TILLYARDI* (ORDER MECOPTERA).

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(*Communicated by Dr. R. J. Tillyard.*)

(Plate iv; thirteen Text-figures.)

[Read 25th May, 1932.]

Introduction.

The adult scorpion-fly *Harpobittacus tillyardi* E.P. is a fairly common insect in many Australian localities, but so far nothing has been known concerning any immature stage with the exception of the egg.

A female captured in hill country near Canberra laid 35 eggs on 7th January, 1930, these being placed in jars to await hatching. About the middle of February—no sign of hatching having been shown—some of the eggs were soaked in water and placed on moist sphagnum moss, some were kept in petri dishes in a moist atmosphere, and some were kept dry.

Early in April many of the eggs which had been kept moist were found to have hatched out during the writer's absence from the laboratory, and the larvae had died. One more larva hatched on 20th April, and this was fed through to the 3rd instar. The eggs which had been kept dry did not hatch.

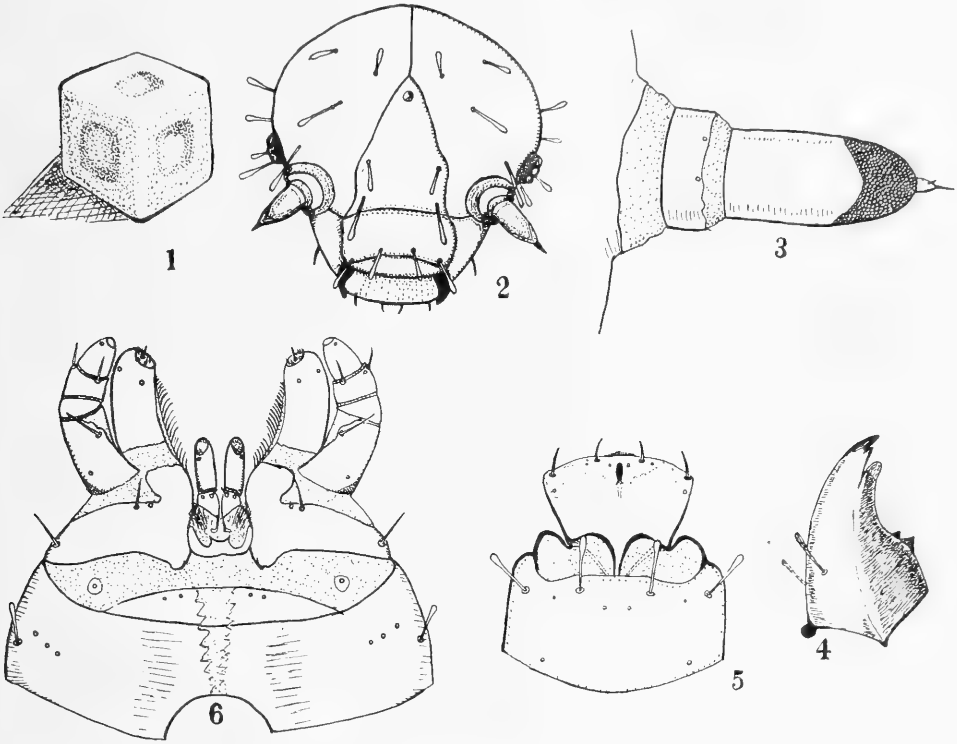
Profiting from the former experience, eggs laid by a female on 23rd January, 1931, were kept in a moist atmosphere on damp filter paper, and hatching commenced on 7th March. The larvae thus secured were reared through to the adult stage, and the material for this paper is mainly the result of observations of their behaviour and characteristics.

Description of Stages.

The Egg.—The egg (Fig. 1) is cuboid, grey-black in colour and measures about 0·55 mm. along its edges. The outer surface is formed of closely packed pigmented granules, which give it a rough appearance. The faces are somewhat concave when the egg is newly laid, and while dry, but as development of the embryo progresses in the presence of moisture, the egg becomes inflated to form a sphere which measures from 1·1 mm. to 1·2 mm. in diameter.

The Larva.—There are four larval instars, each stage differing from the former in point of total size and in the relative size of various parts, but differing little in structure. A general description of the larva, covering in essentials the four instars, will therefore be given.

The head is dark brown, small in comparison with the body and of general outline as illustrated in Fig. 2. The eyes consist of seven ocelli grouped together on a prominence, three larger ocelli on the dorsal side and four slightly smaller on the ventral side. This close grouping of the seven ocelli to form a compact unit is in sharp contrast with the widely separated ocelli in caterpillars. There is a median ocellus placed on the frons just below the junction of the occipital stem and the lateral sutures. The antennae are short and stout, pointed and with three joints. They are remarkable for the great development of pits on the second segment (Fig. 3). The mandibles (Fig. 4) are strongly chitinized and powerful, adapted to tearing the food.



Text-figs. 1-6.
1.—Egg of *Harpobittacus tillyardi* E.P., × 20. 2.—Head of 4th instar larva, × 13. 3.—Antenna, × 1,000. 4.—Mandible, × 50. 5.—Labrum, × 47. 6.—Labium, × 56.

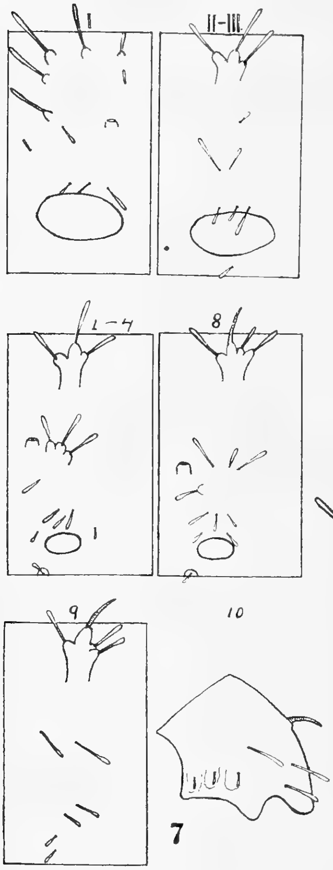
The following table shows the length of the body and width of the head capsule (before moulting) of the four larval instars:

	Width of Head Capsule.	*Length of Body.*
1st instar	0·6 mm.	3.4 mm.
2nd instar	0·9 mm.	10·0 mm.
3rd instar	1·2 mm.	15·0 mm.
4th instar	1·8 mm.	21·0 mm.

The details of the labrum and labium are shown in Figs. 5 and 6 respectively.

The setae on the head and body are mostly clubbed, both stems and swollen ends being hollow. In most cases these setae rise from fleshy protuberances, and the rows of these along each side of the mid-dorsal line, and the middle of the sides, give the larva a somewhat hexagonal appearance. Walking legs of simple pointed form are present on the three thoracic segments, and larvapods of similar structure, but somewhat smaller size, are present on abdominal segments 1–8 inclusive. There are no crochets on these larvapods. The last abdominal segment carries a trilobed, fleshy, protrusible sucker, which anchors the posterior part of the body, and aids in locomotion.

The setal maps (Fig. 7) are given so that homologies with the distribution of setae on other larvae can be worked out if desired. No suggestions are being put forward now although many similarities to setal distribution in lepidopterous larvae will be seen. Segments eight and nine both bear a pair of annulated setae quite different from the others, and a single, unpaired annulated seta is present in the middle of the dorsum of segment ten (Fig. 8). In *Chorista* the annulated type of seta is the rule, and it may be that it is the more primitive type, which in *Harpobittacus* is being slowly replaced from the head backwards by the hollow, clubbed type of seta.



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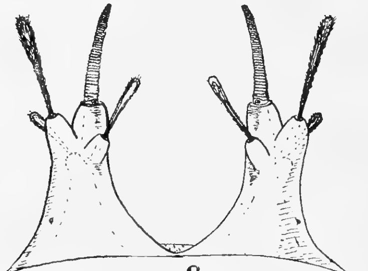

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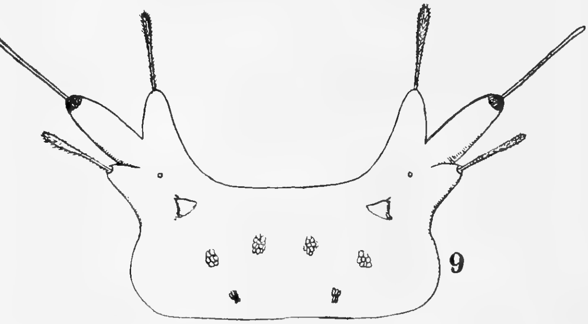

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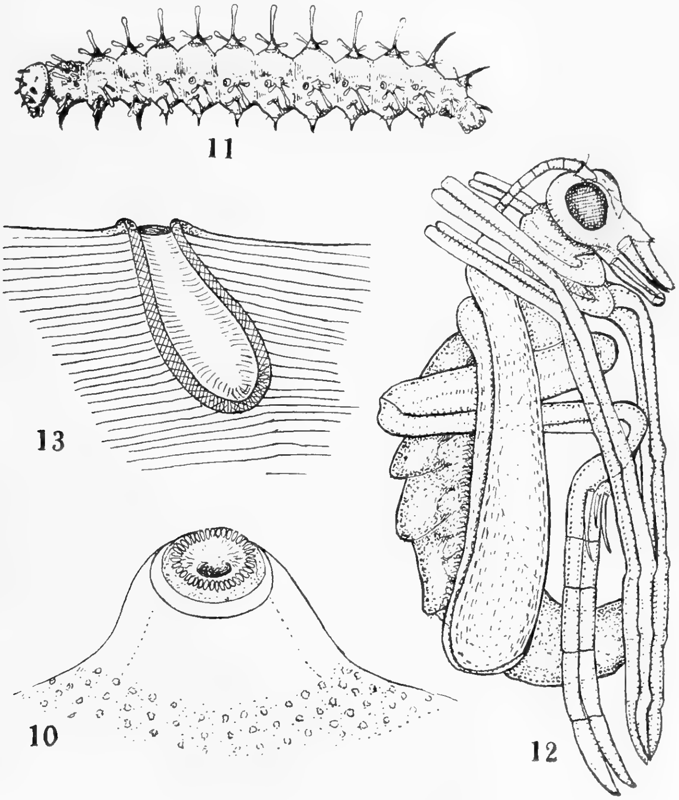
Text-figs. 7-9.
7.—Setal maps of 4th instar larva. I-III, segments of thorax; 1-10, segments of abdomen. 8.—Setae on dorsum of 8th abdominal segment, × 30. 9.—Tergum of 3rd abdominal segment, × 21.

Some details of the skin, and of the peculiar compound pore-like structures on the basal plates of the setae can be seen in the accompanying figures (Figs. 8 and 9), but as yet no attempt has been made to discover the significance of these structures.

Spiracles are present in the first thoracic segment and in segments 1 to 8 of the abdomen. They are conspicuous structures raised on a prominence. The details of their structure can be seen in Figure 10 while their distribution is shown in Figure 11.

The general shape of the larva can be seen in Figure 11 and in Plate iv which also clearly illustrates the fleshy tubercles, the rough skin covered with sand, and the two types of setae.



Text-figs. 10-13.
10.—Thoracic spiracle, × 1,500. 11.—4th instar larva, × 3. 12.—Pupa, × 6.
13.—Earthen cell in ground, × 1·5.

The Pupa.—The pupa (Fig. 12) is of the exarate type, of a greyish-white colour with brown patches on the sides of the abdomen. The illustration gives an idea of the relations of the various parts.

The Adult.—As the adult insect is fairly well known and illustrated there is no need to include a description here. The accompanying photographs show the adult in characteristic poses (Plate iv, figs. 5, 6).

Life History.

The adults appear from October to February, in the Federal Capital Territory, and seem to be somewhat local in their distribution, being associated most often with moist situations if not actually running streams. They feed on many types of insects, including beetles, bees, flies, bugs, and caterpillars, but they seem to favour most, soft-bodied insects such as tipulids of the genus *Macromastix.* They often catch their prey while crawling over blossoms and have been seen picking larvae of *Paropsis* from leaves in order to feed on them. *Harpobittacus* always eats its prey while hanging from a twig: it holds the insect to its mouth, sucks the juices and soft tissues, then drops the empty chitinous shell. The adults have been seen to suck nectar from flowers, as the accompanying photograph shows (Plate iv, fig. 6).*

Although not powerful on the wing the adults fly freely, and on warm days they may be found flying in shady places, in search of mates or prey. Mating takes place while the insects hang suspended, with ventral surfaces apposed.

The eggs, which may be laid at any time during the summer months, appear to be scattered promiscuously over the ground in moist places. If the eggs become desiccated, hatching may be delayed, though how long they can resist desiccation has not been ascertained. The eggs are at first somewhat cubical, with slightly concave surfaces, becoming inflated a few days before hatching by the absorption of water. The amount of water absorbed may be judged by the difference in weight, as follows:

Weight of 8 eggs uninflated	0·0019 gr.
,, ,, ,, inflated with water	0·0054 gr.

Eggs laid on 23rd January and kept moist began to hatch on 7th March, and the last egg hatched on 4th April—the period ranging from 43 to 71 days.

Eggs laid on 7th January (1930) and kept dry for a period hatched in 79 to 103 days.

The larva, in hatching, emerges from the egg-shell through an irregular opening, and proceeds to feed on a portion of the shell as its first meal. Young larvae were given soil, liverwort, mosses, and dead insects, and were found to feed on the juices of the dead insects, taking an occasional bite of liverwort. Their movements are sluggish, and when disturbed they have a habit of rearing the body in a perpendicular position.

The duration of the first instar, in the laboratory, was from 4 to 7 days, with an average of 5 days. Some time before moulting the larvae were seen to swallow soil, and the significance of this appeared later.

Having ceased to feed, a larva about to moult sought a high spot, such as a liverwort leaf or a small mound of soil, and there it lay quiescent for several hours. The clubbed setae of the next larval instar could be clearly seen through the transparent skin. A forward surging of the body juices, coming spasmodically in waves, swelled out the thoracic segments. This surging ebbed and flowed a number of times before culminating in a great wave which split the prothorax along the mid-dorsal line, and allowed the emergence of the humped-up thorax of the next stage. Further tumultuous surgings split open the old head capsule, the delicate new head emerged, and the larva crawled forward out of the old skin which it devoured later.

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* Observation made by Dr. A. J. Nicholson.

After resting for about ten minutes, the larva was seen to lift up its anal extremity and to carry it forward over the dorsum until the anus rested on the top of the head capsule. A stream of sand particles in a glutinous fluid was then poured from the anus, while the anal extremity was passed backwards with a brushing motion, bespattering the whole length of the dorsum with sand. After an interval of about twenty minutes this process was repeated, and after the back had been thoroughly covered with sand, from end to end, the sides were similarly treated: the whole process lasted for about two hours. When dry the sand stuck firmly to the skin, appearing to be fixed with some cement, and could not be removed without great difficulty (Pl. iv, fig. 2). This covering of the back and sides was repeated after each moult, with the result that the larva, covered with the soil in which it lived, became very inconspicuous, and so protectively disguised. The gut having been thus emptied after a moult, this process was not repeated until after the next moult.

In order to discover if the soil-swallowing habit had any relation to digestion, several larvae were fed on insects only, with no access to soil. These larvae grew just as rapidly, and moulted as easily as the larvae which had access to soil, and the contents of the gut (containing small pieces of chitin, etc.) were voided on the dorsum as in the case of the others.

As a control experiment in connection with the soil-eating habit, some larvae were given soil stained with methylene-blue, others soil mixed with carmine powder, still others clean white sand, and dark sand. Larvae blue, red, white and black were thus obtained, and it was easy to see through the transparent skin when a soil meal had been taken, and to trace its fate.

The main diet of the larvae consisted of dead blowflies, which were easily obtainable. They would not attack a live insect, but started away from any moving object. In feeding, they sucked and scooped all the softer parts out of the chitinous shell, which was left behind.

The larvae could not live long in a dry atmosphere, so had to be reared in glass vessels with moist filter paper covering the bottom, or on moist soil. Sometimes the hollow setae were seen to have drops of moisture at their tips: this may be due to some hygroscopic quality or may be a device for getting rid of surplus moisture from the body. If kept in a dry atmosphere the normally moist skin becomes dry, and the larva then has the peculiar faculty of flushing the skin with moisture. This moisture appears first just behind the head, and passes rapidly backwards over the thoracic and abdominal segments. After a time the larva becomes unable thus to flush the whole skin surface with moisture, and the moistened area becomes restricted to the thoracic segments, and finally to a small area on the prothorax. When kept for about a day in a warm, dry atmosphere, the larva usually succumbs.

The duration of the four larval instars in the laboratory was as follows:

1st instar	4 to 8 days	average 5
2nd instar	5 to 7 days	„ 6
3rd instar	6 to 11 days	„ 8½
4th instar (to entering soil)	12 to 17 days	„ 14
Resting larva in earthen cell	about 160 days	
Pupa to adult	14 to 50 days	

The fourth instar larva, on becoming full-fed, begins to dig a hole in the soil, pressing the earth into the sides and cementing it in position with saliva. An earthen cell is thus formed (Fig. 13) and a lid is made by the larva which then lies head upwards in the cell, and shrinks in size. The winter is passed as a prepupal larva, until, as the weather warms up in spring, the insect pupates and emerges later as an adult. In some cases, in the laboratory, the third instar larvae began to dig as the weather got cool in late March and April. The earthen cocoons were formed, the larvae passed the winter therein, and emerged in spring to recommence feeding. Only a few larvae behaved in this manner, and none of these succeeded in reaching the fourth instar. One larva in its earthen cell was kept for four months at a temperature of 80° F., but its pupation was hastened only by about three weeks.

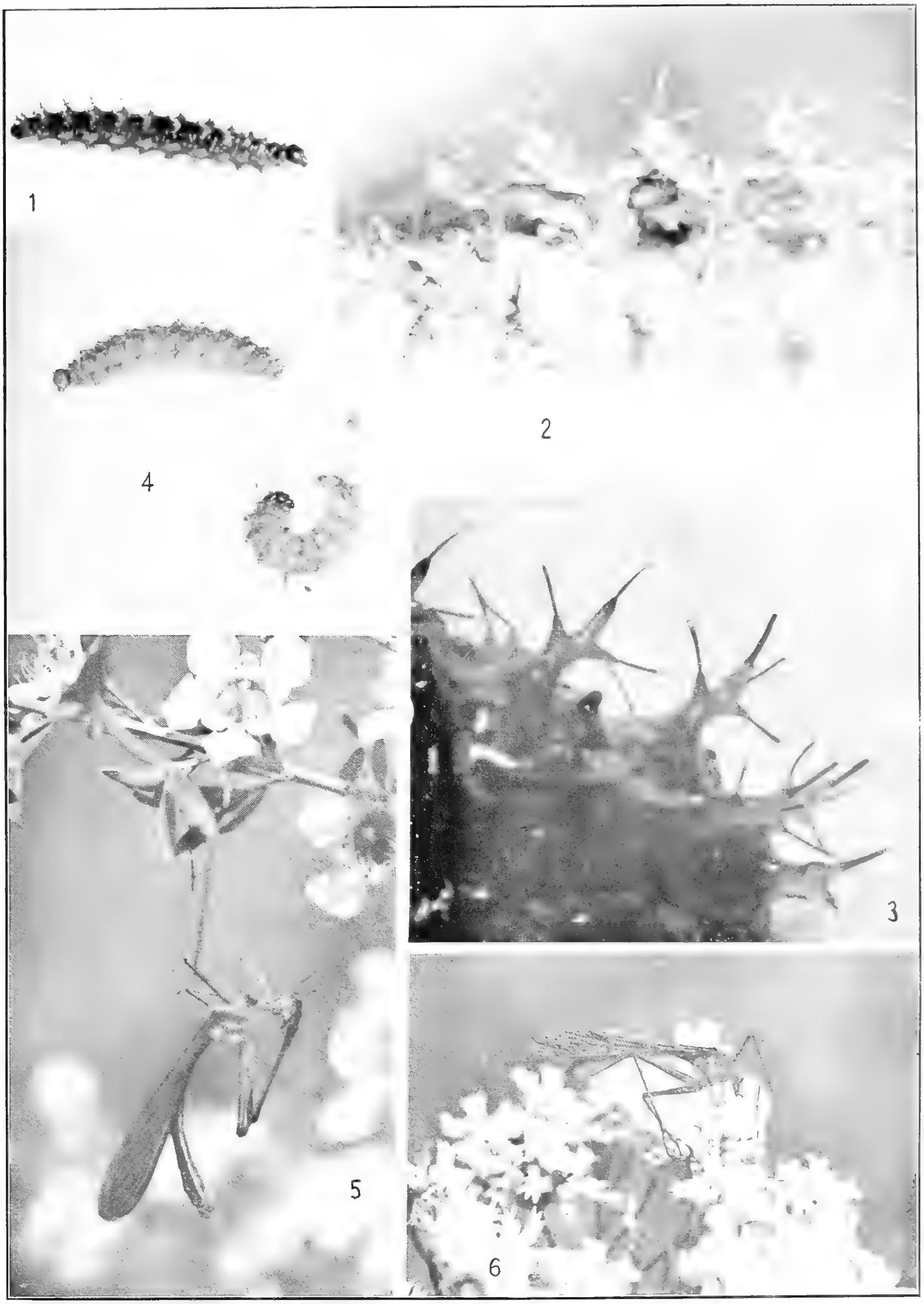
It is hoped that if time and opportunity offer, further work will be done on the biology of this most interesting and primitive insect, and that meanwhile these notes will be of value in adding to our knowledge of the Australian Mecoptera.

Acknowledgments.

Thanks are due to Dr. R. J. Tillyard who drew the author's attention in the first place to the meagreness of our knowledge concerning the immature stages of the scorpion-flies, and whose unflagging interest was always stimulating; to Dr. A. J. Nicholson who loaned the photographs of adult insects on Plate iv, and to Mr. J. W. Evans for helpful suggestions in the preparation of the manuscript.

EXPLANATION OF PLATE IV.

Fig. 1.—Side view of 4th instar larva. Fig. 2.—Back of larva showing skin covered with sand. Much enlarged. Fig. 3.—Portion of back of larva showing two types of setae. Fig. 4.—Back and side view of larvae. Fig. 5.—Adult feeding on fly. Fig. 6.—Adult searching flowers for nectar.



Harpobittacus tillyardi.

FOSSIL PLANTS FROM MOUNT PIDDINGTON AND CLARENCE SIDING.

By A. B. Walkom, D.Sc.

(Plate v; one Text-figure.)

[Read 29th June, 1932.]

The specimens described in this communication include a small collection from Mount Piddington, and a single specimen from Clarence Siding. The former were submitted to me by Mr. W. S. Dun, Palaeontologist to the Geological Survey of New South Wales, and the latter was originally brought under my notice by Mr. George W. Card, when he was Curator of the Mining Museum, Sydney. I wish to express my thanks to both these gentlemen for the opportunity of examining the specimens, all of which belong to the collections of the Geological Survey of New South Wales.

Both localities are in the vicinity of Mount Victoria and are near the western edge of the outcrop of the Hawkesbury Sandstone Series. In the Sydney district, in the central part of the basin occupied by the Hawkesbury Sandstone, that Series is approximately 1,000 feet thick, but it becomes thinner towards its western edge, where it is only about 300 feet thick. It is, therefore, a matter of considerable difficulty to compare the horizons on which these fossils occur at Mount Piddington and Clarence Siding with those on which plant fossils are known to occur in other parts of the basin, e.g., at Brookvale, near the coast about three miles north of Port Jackson. The specimens from Mount Piddington are not very well preserved, but it seems worth while recording them in view of our limited knowledge of the fossil flora of the Hawkesbury Sandstone. The specimen from Clarence Siding is different from any that have previously been found in Australian Mesozoic rocks, and it is considered to represent a new genus.

Specimens from Mount Piddington.

CLADOPHLEBIS AUSTRALIS (Morris).

Specimen of part of a fertile frond with broad rachis (4 mm. wide) and portions of three pinnae. The pinnules are about 8 mm. long by 2·5 mm. broad, with a strong midrib and apparently with a row of sori or groups of sporangia on either side of the midrib, the sporangia covering almost the whole of the lamina. The preservation is not good and no details of the sporangia can be made out, but the whole appearance of the specimen suggests that it is identical with those figured as *Cladophlebis australis* from the Ipswich Series at Denmark Hill, Ipswich, Queensland (see Walkom, 1917, Pl. 7, fig. 1, and Pl. 8, fig. 1). The registered number of the specimen in the Geological Survey Collection is F 3022.

THINNFELDIA FEISTMANTELI Johnston.

Specimen F 3105 is a typical example of portion of a frond of *Thinnfeldia Feistmanteli*, a species of common occurrence in Australian Triassic rocks.

Specimen 12485 is a fragment of a *Thinnfeldia*, probably portion of a pinna of *T. Feistmanteli*. It is poorly preserved and shows practically no trace of the venation, but a series of small regularly arranged depressions apparently indicate the positions of sori on the short, broad, bluntly rounded pinnules. This seems to be portion of a specimen similar to that previously figured (Walkom, 1917, p. 18, fig. 5*a*) from the Ipswich Series of Queensland.

? WILLIAMSONIA sp. (Plate v, figs. 4, 5.)

Specimens have been described from the Narrabeen Series near Sydney (Walkom, 1925, p. 220, Pl. xxix, figs. 7–9) as possible flowers of a species of *Williamsonia*. They showed a series of petaloid bracts borne on a stout peduncle. Some similar examples have been obtained at Mount Piddington. Specimen 12486*a* (Plate v, fig. 4) resembles figure 9, and specimen 12486*b* (Plate v, fig. 5) resembles the type illustrated in figure 8 mentioned above. No additional detail of structure is exhibited by these specimens.

PLANTAE INCERTAE SEDIS.

Specimen F 3107 (Plate v, fig. 3) shows some resemblance to Feistmantel's figure (1880, Pl. xiv*a bis*, figs. 1, 1*a*, 2) of *Phyllotheca robusta* from the Gondwana Series of India. Somewhat similar specimens have been described from the Jurassic flora of the Altai Coalfields by Schmalhausen (1879) as *Phyllotheca Stschurowskii*, but I have not been able to see figures of the latter. It is not, however, certain that our specimen belongs to *Phyllotheca* or even to an allied genus. It may even be that the specimen represents another modification of some of the floral parts of *Williamsonia*. It is figured in order to draw attention to its occurrence in the Hawkesbury Series.

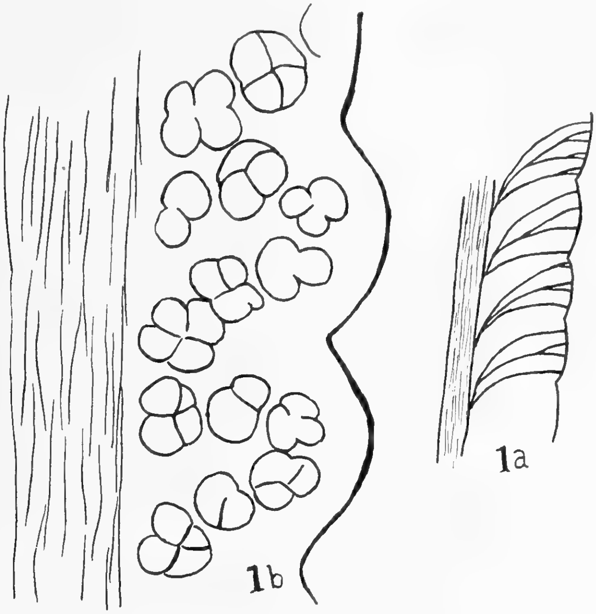
Specimen from Clarence Siding.

RIENITSIA SPATHULATA, n. gen. et sp. (Plate v, figs. 1, 2; Text-fig. 1).

A specimen from Clarence Siding, N.S.W. (No. 12487 in the collection of the Geological Survey of New South Wales), shows portions of three long, narrow, fertile pinnae of a plant which differs from any fossil genus known to me. The longest pinna is 14·5 cm. and is incomplete; the greater part of it (10·8 cm. long) is fertile, the apical portion being sterile (Pl. v, fig. 2). It varies in width, the fertile part being narrower (8–8·5 mm.) than the sterile portion (9–10 mm.). The midrib is prominent, 2 mm. wide, and finely striated. The margin is slightly lobed; the secondary veins (Text-fig. 1*a*) in the sterile portion leave the midrib at an acute angle and curve outwards to the margin; they divide usually three times, but to each segment of the lamina there appears to be a single secondary vein which branches twice very close to the midrib, thus giving three main veins to each segment and producing a characteristic venation. In the fertile portion the sori are distributed in groups of 5 or 6 (Text-fig. 1*b*), each group corresponding to a segment of the lamina; each sorus consists of 3–5, usually 4, sporangia. Occasionally small portions of the sporangial walls are preserved and are seen to be composed of thin-walled elongated cells, but there is not sufficient information available to show whether an annulus was present.

The general shape of the leaf may be compared with several described species, e.g., *Osmunda delawarensis* Berry from the Upper Cretaceous of Delaware (Berry, 1916, Pl. L, figs. 2–4), *Laccopteris* sp., from the Rhaetic of Nurnberg (Gothan, 1914, Pl. 18, fig. 3*a*), and leaves of *Thaumatopteris Schenki* (Gothan, 1914, Pl. 19, fig. 3), also from Nurnberg; the characteristic venation agrees with that of the two first mentioned of the above species, whereas the general appearance of the sporangia and their distribution recall some species of *Gleichenites.*

Among Australian Mesozoic plants, perhaps the only ones which may be compared with the present one are those specimens doubtfully referred to *Taeniopteris Carruthersi* from Cockabutta Mountain (Walkom, 1921, Pl. 3, fig. 3). The beds from which the specimens were obtained at Cockabutta Mountain are believed to belong to the Hawkesbury Sandstone Series.



Text-fig. 1.—*Rienitsia spathulata,* n.g. et sp. 1*a*. Portion of lamina showing characteristic venation. × 3. 1*b*. Portion of fertile lamina showing arrangement of sporangia. × 9.

A very similar type of venation is that exhibited in the short pinnules of *Pecopteris* (*Asterotheca*) *abbreviata* Brong., figured by Zeiller (1886, Pl. xxiv, fig. 1B) from the coal basin of Valenciennes.

It would seem justifiable to refer this specimen to a new genus, but it is not possible at present to suggest to which family it actually belongs. The generic name is in honour of Mr. H. G. Rienits, for many years principal of The School, Mt. Victoria, N.S.W., who collected extensively from the Mount Piddington beds.

Generic characters.

Rienitsia, n. gen.—Frond pinnate (?). Pinnae long, narrow, with prominent midrib. Secondary veins leaving midrib at acute angle, curved outward, dividing twice or thrice before reaching the margin. Sporangia grouped in sori, each sorus consisting of 3–5 sporangia; sporangial walls of elongate thin-walled cells, presence of annulus yet indeterminate.

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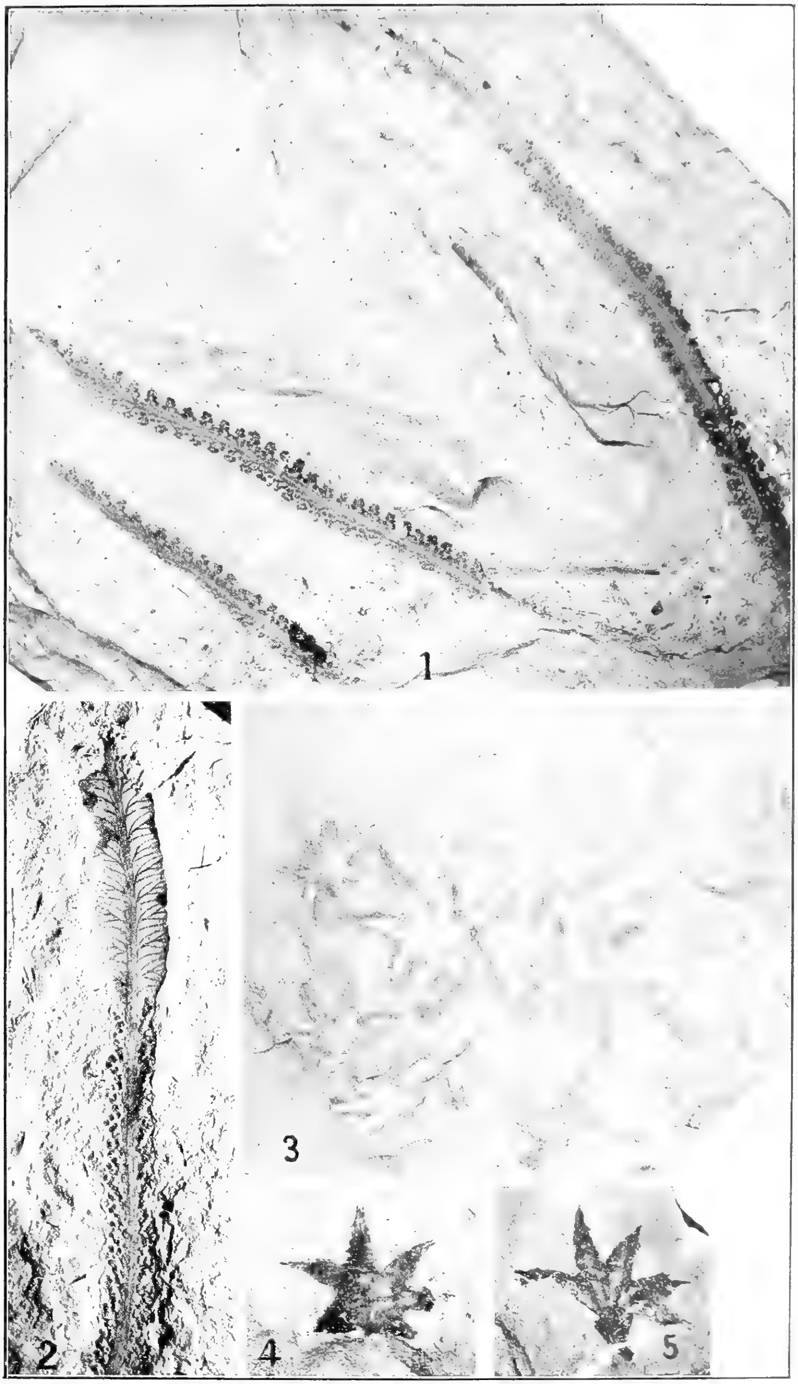
EXPLANATION OF PLATE V.

1, 2.—***Rienitsia spathulata,*** n.g. et sp. 1.—Specimen No. 12487, Coll. Geological Survey of N.S.W. × ⅔. 2.—Portion of pinna showing sterile apical portion and lower fertile portion. Nat. size.

3.—? ***Phyllotheca*** cf. ***robusta.*** Nat. size.

4, 5.—? *Williamsonia* sp. flowers. Nat. size.



1, 2.—*Rienitsia spathulata*, n.g. et sp. 3.—? *Phyllotheca* cf. *robusta*.
4, 5.—? *Williamsonia* sp., flowers.

NOTES ON AUSTRALIAN DIPTERA. XXXI.

By J. R. Malloch.
(*Communicated by Dr. G. A. Waterhouse.*)

[Read 29th June, 1932.]

Family Tachinidae.

Subfamily Dexiinae.

Genus Prosena St. Fargeau and Serveille.

In a recent paper in this series I dealt with the species of this genus known to me from Australia, basing my identifications of previously described species upon the descriptions as no type material of species recently described by Curran was available to me. Recently I applied to Dr. Walther Horn for a loan of species represented by types in the collection in Berlin, and have received from him types or paratypes of four species of the genus. Between the date of completion of my paper and its appearance in print a second paper by Curran appeared dealing with some additional species of *Prosena*, and this further complicates the identification of members of the genus, as practically no structural characters are cited, either in the keys or descriptions, that can be used as reliable guides to definite identifications. The acquisition of the type material above referred to, however, does give me a basis for certain changes in published identifications, and these are dealt with below.

It now appears entirely probable to me that this genus is more abundantly represented in Australia than I had suspected.

I present below an amended key to the species before me, but as the Curran species are represented by but one sex in all cases, I am not able to give keys to both sexes.

Key to the Species.

1. Femora black or almost entirely so 2
   Femora either entirely fulvous yellow or darkened only apically 8
2. Males 3
   Females 7
3. Hind tibiae very noticeably attenuated on basal fourth or more, longer than usual, and slightly sinuous, the length about equal to that of slender portion of proboscis 4
   Hind tibiae normal in form, not noticeably attenuated except at immediate base, and straight, the length much less than that of the slender portion of the proboscis 6
4. Mid tibia without a submedian anterodorsal bristle, fore tibia without a bristle beyond middle on that surface; fourth wing vein not undulated beyond the preapical angle, slightly and regularly arcuate .... *arcuata*, n. sp.
   Mid and fore tibiae each with an anterodorsal bristle beyond middle; fourth wing vein distinctly undulated beyond the preapical angle 5
5. Presutural dorsocentral bristles three; slender portion of the proboscis with very many fine erect and extremely short black hairs .... *varia* Curran, var. ?
   Presutural dorsocentral bristles two; slender portion of the proboscis bare or almost so .... *varia* Curran ?

6\. Mesopleura almost entirely yellow-haired; first visible abdominal tergite without apical central bristles .... *nigripes* Curran.

Mesopleura entirely black-haired; first visible abdominal tergite with a pair of quite long apical central bristles .... *bisetosa*, n. sp.

7\. Mesopleura largely pale-haired; interfrontal stripe reddish-yellow .. *nigripes* Curran.

Mesopleura black-haired; interfrontal stripe black .... *bisetosa*, n. sp.

8\. Males 9

Females 16

9\. Hind tibiae not noticeably attenuated except at extreme base, normal in form, almost entirely straight; mid tibia with a short anteroventral bristle near middle 10

Hind tibiae markedly attenuated on basal third or more and slightly sinuate; mid tibia without an anteroventral bristle near middle 13

10\. One or both of the bristles on the costa at apex of auxiliary (subcostal) vein much longer than usual, about as long as inner cross-vein; disc of scutellum with a pair of well developed bristles, the hairs shorter and less dense than usual; small species, 5-7 mm. in length .... *parva* Malloch.

Neither of the bristles at apex of auxiliary vein nearly as long as the inner cross-vein 11

11\. Bases of the superior hypopygial forceps quite abruptly differentiated from the apical slender portion, and with longer and more abundant brown hairs than in the other species, appearing tufted when seen in profile; humeri with quite dense black hairs on more than the upper three-fourths, pale-haired only on lower margin .... *tenuis* Malloch.

Bases of the superior hypopygial forceps tapered gradually into the slender apical portion, and not appearing at all tufted in profile 12

12\. Inferior hypopygial forceps deeply cleft, furcate .... *sibirita* Fabricius.

Inferior hypopygial forceps not cleft, more or less shoe-shaped .. *confusa* Malloch.

13\. Frontal orbits densely silvery-white dusted, touching for some distance in front of anterior ocellus and thus obliterating the interfrontal stripe; mesonotum densely silvery-white dusted, when seen from behind with the disc dark grey or fuscous both before and behind the suture, on the former area with traces of vittae, the posterior dark patch not extending to posterior margin; bases of superior hypopygial forceps with quite long, dense, slightly curled brown hairs .... *albifrons*, n. sp.

Frontal orbits not as conspicuously white, and separated on entire length; mesonotum not coloured as above 14

14\. Scutellum entirely velvety-black, with changeable brownish dust when seen from varied angles; apical half of wing distinctly darker than basal half; mesonotum with a black fascia immediately behind suture which extends entirely across surface and down over the pleura, and a less evident fascia on anterior margin .... *argentata* Curran.

Scutellum not entirely black, largely or entirely grey or yellowish dusted and appearing pale on all or most of the disc; mesonotum not marked as above .. 15

15\. Mesonotum with a dark brown or fuscous fascia behind suture which extends more than midway to posterior margin but does not reach the sides; scutellum dark brown or blackish at base, pale brown or yellowish at apex .. *bella* Curran.

Mesonotum with the dark postsutural markings consisting of four partial blackish vittae; scutellum blackish only on sides at base, the disc with yellowish or brownish grey dusting which is slightly darker at bases of the hairs .... *indecisa* Malloch.

16\. Scutellum entirely velvety-black, with brownish dusting on disc which varies in accordance with the various angles from which it is viewed; mesonotum with a broad black fascia behind suture which extends entirely across disc and down over pleura but not to posterior margin of mesonotum, and a less conspicuous anterior marginal fascia of same colour; wings conspicuously browned on apical halves; tibiae largely dark brown .... *argentata* Curran.

Scutellum pale brown or grey on at least a large portion of its extent; mesonotum and pleura not marked as above, and the wings less noticeably browned, not distinctly so on apical halves 17

17\. At least one of the bristles at apex of the auxiliary vein as long as inner cross-vein .... *parva* Malloch.

Neither of the two bristles at apex of auxiliary vein as long as inner cross-vein 18

18. Fore tibia with a series of very short, moderately strong bristles on almost the entire extent of the anterodorsal surface which terminates in a noticeably longer and stronger bristle near apex 19
Fore tibia with a much less extensive series of less regular short bristles which ceases at or near middle of anterodorsal surface beyond which there are usually two much longer and stronger bristles, the apical one about one-third of the length of tibia from apex 20
19. Thorax and abdomen with whitish-grey dusting, and third and fourth abdominal tergites with conspicuous black lateral apical marks; fore femur with the bristles on the posteroventral surface longest apically .... sp. ?
Thorax and abdomen with yellowish-grey dusting, the third and fourth abdominal tergites with brown or inconspicuous dark lateral apical marks; fore femur with the posteroventral bristles complete, generally longest near middle of the surface .... *sibirita* Fabricius.
20. Scutellum when viewed from behind with the basal half or more blackish-brown, tapering off apically into yellowish-brown; postsutural dark vittae fused into a broad blackish-brown fascia which does not extend to sides or the posterior margin; all tibiae quite distinctly infuscated apically .... *bella* Curran.
Scutellum darkened on the sides basally, not in centre of base; postsutural dark vittae not fused; at most the hind tibiae slightly darkened at apices 21
21. Basal visible tergite without strong apical central bristles; second tergite when viewed from behind with a rather broad central vitta and a narrow anterior marginal fascia of dense yellowish-grey dust; interfrontal stripe immediately in front of the grey-dusted ocellar triangle very slightly wider than either orbit .... *indecisa* Malloch.
Basal visible abdominal tergite with a pair of strong apical central bristles; second abdominal tergite with a broad entire basal fascia of dense yellowish-grey dust when seen from behind, the central vitta not developed; interfrontal stripe immediately in front of the grey-dusted ocellar triangle very distinctly wider than either orbit at same point .... sp. ?

PROSENA ARCUATA, n. sp.

♂.—This species belongs to the black-legged group in which the hind tibia is quite markedly attenuated on the basal third or more and slightly undulated.

Similar in general coloration to typical forms of *sibirita*, the thorax and abdomen with dense grey dusting, the former with four narrow dark-grey or fuscous vittae which do not extend to posterior margin of mesonotum and are most evident when seen from behind; scutellum entirely black, with dense grey dust which has a blackish dot at base of each hair when seen from behind. Abdomen yellowish testaceous on sides of basal three tergites, when seen from behind with dense yellowish-grey dust over the entire area of each tergite except on the narrow dark apex of third and less noticeably of second. Apices of femora reddish-brown. Wings hyaline, with very faint indication of yellowish tinge in marginal cell. Calyptrae white. Halteres yellow.

Frons at vertex about one-fifth as wide as either eye, the narrow yellowish-grey-dusted orbits separated on entire extent by the brown interfrontalia, the latter reduced to a mere line in front of ocelli; slender portion of proboscis entirely black and with minute but not dense erect black hairs. Presutural dorsocentrals three, the acrostichals on same area well developed, two; humeri and mesopleura entirely black-haired, the lower fine hairs on pteropleura also black. Abdomen subcylindrical, tapered apically, first visible tergite with a pair of strong apical central bristles, the fifth also with a strong pair projecting from below apex of fourth; superior hypopygial forceps similar to those of *sibirita*, not conspicuously haired; fifth sternite feebly haired. Legs moderately long; fore tibia with two posteroventral bristles and no bristles on anterodorsal surface; mid femur attenuated on apical half; mid tibia without anterodorsal or anteroventral bristles, and with three or four posterior bristles; hind femur slightly attenuated on apical third or more and with the usual series of four or five uneven bristles on basal halves of anteroventral and posteroventral surfaces; hind tibia with about four anterodorsal bristles, one anteroventral bristle, and a setula on or near middle of posteroventral surface. Fourth wing-vein quite evenly arcuate beyond preapical angle; outer cross-vein curved outward in front and inward behind. Length, 10·5 mm. Type, "Allowrie", Killara, N.S.W., Feb. 5, 1921.

PROSENA VARIA Curran ?

Ann. Ent. Soc. Amer., Vol. 22, 1929, p. 509.

Very similar to the preceding species, but differing in the characters listed in the foregoing key. The tibiae are also more or less distinctly reddish-brown at least centrally, and in most specimens the veins of the wings are slightly clouded with pale brown. I have not seen the type material of this species and have some doubts as to the correctness of my identification.

Localities, "Allowrie", Killara, and Austinmer. Described from New South Wales without more definite locality.

PROSENA NIGRIPES Curran.

I have now before me the type male of this species and have discovered that I was in error in my previous identification, as it belongs to the group in which the hind tibiae are normal in structure. I have no other examples before me that appear to be referable to the species, so that my previous records of localities must be disregarded. For further data on the characters see under the next species.

Locality, Palmerston, N. Aust. [The township of Palmerston is now non-existent.—ED.]

PROSENA BISETOSA, n. sp.

♂, ♀.—A darker species than *nigripes*, the dark dorsal vitta on the abdomen broader, though diffuse on sides, and the pleural hairs practically all black in both sexes. The female has the abdomen broader than the male, with the apices of the tergites dark brown merging into deep black on some parts, a less evident dark central vitta, and the grey dust more checkered. The wings are hyaline in *nigripes*, but in *bisetosa* they are slightly browned, more distinctly on costa beyond apex of auxiliary vein.

Structurally the presence of a pair of strong apical central bristles on the first visible abdominal tergite readily distinguishes the male from that of *nigripes*, but these bristles are lacking in the female which I place here. The fore tibia has a rather irregular series of very short setulae on the entire extent of the anterodorsal surface terminating in a slightly longer one near the apex as in other species in which the hind tibiae are not attenuated basally and distinctly undulated. Both sexes have an anterodorsal and a ventral submedian bristle on the mid tibia, and also three or four posterodorsal bristles on the basal half or more of the hind tibia. The type specimen of *nigripes* lacks the middle legs, so that I cannot say whether in the armature of these it differs from *bisetosa*. The latter has the outer cross-vein of the wing curved outward at anterior and inward at posterior extremity, while in *nigripes* it is merely slightly curved outward centrally. Length, 8–9 mm.

Type, male, and allotype, Cairns, Queensland (Dodd). One headless female from Sydney, N.S.W., 14.1.1923 (Health Dept.), appears to be referable here or to a closely allied species. Material will be returned to Australia.

PROSENA ARGENTATA Curran.

Access to the female paratype of this species received from Dr. Horn proves that I was in error in my identification of this species also. It strikingly resembles in colour markings certain species of *Anthomyia* Meigen, and related genera in which the mesonotum has two deep black fasciae, one on the anterior margin and the other just behind the suture, with accompanying velvety-black scutellar markings. The abdomen also has deep black markings across the apices of the tergites. The very noticeably browned apical halves of the wings are also characteristic. Unfortunately, I have not seen the male, so draw my characters from but one sex. The specimen lacks the fore legs, so that the armature of the fore tibia cannot be stated, but the hind tibia is of the same form and has the same armature as *bisetosa*, which leads me to conclude that it is one of the typical group, with straight hind tibia and the fore tibia armed with a series of short setulae on the entire extent of the anterodorsal surface.

Localities, Cairns and Kuranda, Qld.

PROSENA BELLA Curran.

Here again I must mark up an error in my identification of the species, as my female specimen recorded as this is the one listed in the last caption of the foregoing key without a specific name. It appears hardly possible that it belongs to *bella* as the characters by means of which it is separated from the latter in the key are very rarely of a variable nature. It will thus be seen that my attempts to identify Curran's species from his descriptions and key were all failures. I do not expect that the data put forward by me will prove infallible guides to specific identifications, but I do hope that they result in a greater percentage of correct names for species than I attained by other means.

This species belongs to the segregate in which the hind tibia is attenuated on the basal half and distinctly undulated. The females do not have this character as pronounced as do the males, but taken in conjunction with the armature of the fore tibia with its incomplete series of anterodorsal bristles, the less evident attenuation of the hind tibia may be distinguished the more readily. I have given sufficient data in the key to enable one to distinguish this species from the others now in hand.

Locality, Cairns, N. Qld.

PROSENA PARVA Malloch; PROSENA INDECISA Malloch.

I have nothing new to add to my records of these species, but I note that I did not include the male of *parva* in my key to this sex when I described the species. I have now done so and hope that the present key will suffice for its identification.

PROSENA DODDI Curran.

This species was described by Curran as listed in my catalogue of the Australian Tachinidae, but in his recent paper, referred to under *varia* Curran, he does not include it in his key to the Australian species. I nave before me the allotype of *doddi* and am not able to distinguish it from *sibirita* Fabricius. I thus place it as a synonym of that species.

PROSENA FACIALIS Curran.

This species name I find in Curran's paper in 1929 referred to under *varia*, but I cannot find a place in which the name has been proposed. In his 1927 key that author distinguished *malayana* Townsend from *doddi* by the character of the haired parafacials of the former and the bare parafacials of the latter. Dr. Aldrich published a statement that *malayana* Townsend does not have haired parafacials, and some time afterwards Mr. Curran told me that he had inadvertently transposed the two species in his key. He marked them in my copy of his paper as requiring transposition in the key.

In view of this fact it was of interest to me to examine the specimen of *doddi*. I find that this has a few microscopic yellow hairs on the upper portion of the parafacials which are very difficult to make out except under a high power lens and by turning the head to various angles. These hairs, however, are visible in *sibirita* and some other species related closely to it, or at least in some examples of these species, and I attach no importance to them as a specific criterion. Without fuller information as to the status of the name, I accept *facialis* tentatively as a synonym of *sibirita*.

PROSENA ALBIFRONS, n. sp.

♂.—This is the species which I identified as *argentata* Curran in my paper on the genus in 1930 (These PROCEEDINGS, lv, 114). There is nothing necessary to add to the characters in the two keys which I have presented, and the notes on the species under the name *argentata*. These, coupled with the figure of the male hypopygium, should serve to identify the species.

Type and four paratypes, Eidsvold, Qld., January 23 and December, 1922 (Mackerras); one paratype, Glenreagh, N.S.W., 1.2.1923 (Health Dept.); one, Yeppoon, Qld., 4–7 Nov., 1924 (Goldfinch).

Type and three paratypes will be returned to Australia.

PROSENA VARIEGATA Curran.

This species is unknown to me. It evidently belongs to the same group as *albifrons*, but has black femora and reddish tibiae if the key is correct, but in the description the legs are given as "reddish, tarsi black". Which is correct cannot be decided without consulting the type.

Locality, Gravesend, Qld. (Mann).

Presumably the type would be returned to the collector.

INHERITANCE OF RESISTANCE TO BUNT, *TILLETIA TRITICI* (BJERK.) WINTER, AND OTHER CHARACTERS IN CERTAIN CROSSES OF "FLORENCE" WHEAT.

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(Four Text-figures.)

[Read 25th May, 1932.]

Introduction.

Severe losses are occasioned by Bunt or Stinking Smut in wheat crops throughout the world. The losses are due to reduction in yield and to depreciation in the quality and market value of the grain.

In certain of the United States of America heavy losses occur annually, particularly in the winter wheats. The heavy infection is largely due to the wind-blown spores which lead to "soil infection" of the crop. The position in Australia is different. Here "Spring" habit wheats, sown in April-May, grow during the comparatively mild winter weather and are harvested in November-December. Soil infection seldom occurs under these conditions.

In England, largely owing to the moist seed-bed conditions at sowing time, steeping the grain in formalin is found to prevent bunt. In Australia the dry copper carbonate treatment is most effective. It was pointed out in a previous paper (Churchward, 1931) that this method is costly and acts as a preventive and not as a cure. Even so, considerable areas are sown every year with untreated grain. In the 1931 season, when crops were considered to be particularly clean, bunted samples from many districts of all the States of Australia were received.* The solution of the problem seems to lie in making use of the inherent qualities of resistance to bunt, possessed by some varieties, in developing types of commercial value that will resist attacks of the causal fungus.

It is unnecessary to stress the importance of knowing the manner in which the resistance of certain varieties is inherited. There are no commercial Australian wheats that are immune to bunt. "Florence", one of the Farrer varieties, is one of our most resistant wheats, and this quality marks it as a valuable parent for breeding work. A knowledge of its genetical behaviour is therefore desirable.

Review of Literature.

Farrer (1901) was the first worker to breed wheats specifically for bunt resistance. He produced two varieties, "Florence" and "Genoa", which gave low percentages of bunt (Pye, 1909). This "Florence" is the resistant parent used in the work herein described.

In 1905 Biffen showed that resistance to yellow rust (*Puccinia glumarum* Erikss.) behaves as a simple Mendelian recessive character. Since that time

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* A further paper will deal with the distribution of the species of *Tilletia* in Australia.

ability to resist many other diseases has been found to be inherited in a Mendelian fashion.

Gaines (1920) was the first worker to record the mode of inheritance of resistance to bunt of wheat. He considered that resistance, if inherited on Mendelian lines, was due to multiple factors. Varieties possessed different kinds of resistance, and the factors varied in their potency. For example, the factor carried by "Turkey" was supposed to be four times as powerful as that carried by "Marquis" (Gaines and Singleton, 1926). He claimed (1925) that some varieties have no heritable factors for resistance; others have two or three cumulative factors, each reducing the amount of bunt by 10–15 per cent. The factors may be concentrated by crossing (Gaines, 1923). "Florence" was supposed to possess several factors which reduce the amount of bunt by 70–75 per cent. when compared with susceptible varieties. In crosses between immune and susceptible varieties, resistance was found to be dominant. When a resistant variety like "Florence" was crossed with a susceptible variety, dominance of susceptibility resulted.

Briggs (1926) showed that there was a single factor difference for resistance between "Martin" and "Hard Federation". His results indicated that susceptible varieties possessed no factors for resistance. He demonstrated (Briggs, 1926) that "Hussar" differs from susceptible varieties such as "Baart" by two factors, one being identical with that possessed by "Martin", the other allowing the development of bunt in 50 per cent. of the heterozygous families. Further investigations (Briggs, 1929; 1931) showed that "White Odessa" and "Banner Berkeley" wheats differed from "White Federation" by one factor for resistance. This factor was identical with the one carried by "Martin". Briggs (1929) further found that modifying factors may influence the resistance of a variety to bunt. In a cross between "Hussar" (resistant) and "Hard Federation" (susceptible), strains were isolated which bred true for a small percentage of bunt infection.

In Australia, the writer (Churchward, 1931) showed that there was a single factor difference between "Florence" and "Hard Federation".

Material and Methods.

The various crosses were made in 1927 at the University of Sydney. The F_1 generations were grown in 1928, each F_1 plant being harvested separately. This generation was not inoculated. Portion of the harvest was kept; the other part was sown, uninoculated, and harvested as F_2 plants in 1929. In this way F_2 and F_3 grain of a single cross was available for sowing at one time—both generations being subjected to the same environmental conditions.*

In late June, 1931, the F_2 and F_3 generations were sown at Hawkesbury Agricultural College, Richmond, N.S.W., in a light red loam, of good depth, well aerated and drained, with an acid reaction. The sowing of the block of "Florence" crosses was completed within five days in order to minimize any effects from changing conditions within the soil.

The grain was inoculated with fresh spores of *Tilletia tritici* just before planting. The seed was shaken with an excess of inoculum in a test-tube until thoroughly blackened. The excess of bunt was tipped into the packet with the seeds.

The inoculum was originally obtained from Dr. W. L. Waterhouse in 1927. Since then it has been grown annually on "Federation" or "Hard Federation". All crosses were treated with this same inoculum.

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* Material was kindly supplied by Dr. W. L. Waterhouse of the Sydney University.

The grains were sown by hand half a link apart in 15-link rows. The rows were two links apart.

During the period of growth of the crop the occurrence of dwarfs or grass clumps was noted. The habit and dates of maturity in F_2 and F_3 generations of several crosses were studied.

Each plant was harvested separately and placed in one of three groups: (1) Bunt free, (2) plants showing "late tiller" infection, (3) Bunted. "Florence" showed approximately 18% "late tiller" infection. This type of infection was regarded as resistance.

Gaines (1923) made a quantitative estimate of the bunt present in each row. Briggs (1926) pointed out that, although this method gives a satisfactory quantitative measure of infection, the nature of the segregation is not indicated, as each plant ceases to be regarded as a genetical identity.

Parent Stock.

The varieties discussed in this paper are all common wheats (*Triticum vulgare*, Host.) having commercial importance. Their main characteristics are as follows:

"Florence" is an early-maturing variety, with a light-chaffed ear which is tip-awned. It shatters badly when being harvested, much grain being lost. It is notably resistant to bunt.

The remaining five varieties are susceptible to bunt: "Yandilla King" is the standard late-maturing variety in New South Wales. It is one of the heaviest yielders and is the most popular of the late varieties, being the third leading variety in the State. The young growth is prostrate in habit. "Marshall's No. 3" ranks second in popularity amongst the late wheats. It is a heavy yielder and the eighth leading variety in New South Wales. It has a purple pigment in the straw. "Firbank" is a very early maturing wheat. "Gullen" is an early variety with brown tapering ears. The grain is included in the strong flour type. It holds the grain well. "Hard Federation" is an early mid-season wheat. The brown ear is bald.

EXPERIMENTAL RESULTS.

Segregation in F_2 Generation.

The percentage of infection obtained in the F_2 generations and parent controls is recorded in Table 1.

TABLE 1.—Bunt infection obtained in varieties and F_2 generations.

Parents or Cross.	No. of Plants.		Percentage of Susceptible Plants.
	Totals.	Susceptible.	
Florence	940	65	6·5
Firbank	913	706	77·3
Gullen	337	267	79·2
Yandilla King	278	212	76·3
Marshall's No. 3	293	257	88
Florence × Firbank	546	369	67·6
Gullen × Florence	444	309	69·6
Florence × Yandilla King	310	169	54·5
Marshall's No. 3 × Florence	54	24	45

It will be seen that susceptibility is dominant.

The percentage of infection shown by the susceptible parents indicates that some plants in susceptible varieties escape infection. It is assumed that enough F_2 susceptible plants escaped infection to bring the percentage of infection up to 75 per cent. This assumption is confirmed by the F_3 results. On this basis "Florence" would seem to differ from each of the four susceptible parents by a single recessive factor for resistance to bunt.

The comparatively low percentage of bunt infection in the "Marshall's No. 3" × "Florence" cross cannot be regarded as significant. A poor germination in the F_2 gave a small number of plants. The F_3 showed normal segregation on monohybrid lines.

Segregation in F_3 Generation.

A number of F_3 families of each of the crosses were taken at random and the inoculated grain was sown. The grain was derived from the untreated portion of the F_2 generation sown in 1929. Thus susceptible families were grown which would have been lost in the F_2 generation, as totally smutted plants become automatically eliminated.

Further, while some susceptible plants in the F_2 generation may escape infection, it is not probable that an entire F_3 row will escape. The F_3 generation results are clearly more reliable than are the F_2.

"Florence" × "Firbank".

The reciprocal of this cross was used. As there was no difference in the type of reaction, the results of both crosses were combined. In this series there were 270 families represented, with check rows of each parent every tenth row. F_3 data are recorded in Table 2.

TABLE 2.—Distribution of parent and F_3 rows of the cross, "Florence" × "Firbank", into 5 per cent. classes for bunt infection.

Parents and Cross.	Distribution of Rows by Percentage Classes for Bunt Infection.																					No. of Rows
	0	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80	81–85	86–90	91–95	96–100	
Florence ..	23	—	8	3	1																	35
Firbank ..											1	—	2	—	6	5	5	7	5	3	1	35
Florence × Firbank ..	20	3	13	23	12	15	17	20	21	26	19	12	9	12	16	11	8	5	3	2	3	270

The average infection of the "Florence" controls was 3·4 per cent., the spread being over 4 classes. There were 75 per cent. of the "Firbank" controls bunted, ranging from the 46–100 per cent. class. The nature of the distribution is seen in Figure 1.

The broken line joining the plotted points makes an irregular graph. This is due to the comparatively small numbers of families in the various F_3 generations, and further to the small number of plants in each family (average = 20 plants). In other words, in a single family, the addition or subtraction of one plant would be equivalent to a change of 5 per cent. on the average, for susceptibility or resistance. As the range of the classes for bunt infection is 5 per cent., the probability of a family being incorrectly classed is fairly great. The continuous line is a smooth curve through these points and is probably a truer graphic interpretation of the figures given in Table 2.

The formation of a trimodal curve indicates a 1:2:1 ratio. The first minimum lies at 17·5 per cent. infection, and the second at 57·5 per cent. These do not strictly divide the homozygous and heterozygous genotypes. A certain amount of overlapping of the individuals is to be expected. At the lower minimum the balance lies slightly in favour of the heterozygous class, while at the higher minimum it favours the homozygous class. The numbers at these minima, however, are so small that they do not materially interfere with the counts. Sixty-five homozygous resistant families were obtained where 67·5 were expected, 136 heterozygous families where 135 were expected, and 69 homozygous susceptibles where 67·5 were expected. This closely approximates a 1:2:1 ratio, thus confirming the F_2 results.

A single factor difference for resistance to bunt, with dominance of susceptibility, is indicated in the cross between "Florence" and "Firbank".

"Gullen" × "Florence".

In this series there were 106 families with check rows of both parents distributed every tenth row. F_3 data are recorded in Table 3.

TABLE 3.—Distribution of parent and F_3 rows of the cross, "Gullen" × "Florence", into 5 per cent. classes for bunt infection.

Parents and Cross.	Distribution of Rows by Percentage Classes for Bunt Infection.																					No. of Rows.
	0	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80	81–85	86–90	91–95	96–100	
Florence ..	3	2	—	3	1	2																11
Gullen ..													1	—	4	—	3	—	6	1	—	15
Gullen × Florence ..	12	—	2	3	6	6	2	7	9	10	13	5	6	1	6	8	5	2	2	—	1	106

The average infection of the "Florence" controls was 13 per cent., and that of "Gullen" 79·2 per cent. The nature of the distribution is seen in Fig. 2. In this case the two minima lie at 27·5 per cent. and 62·5 per cent. respectively. The number of plants lying between the minima is shown in Table 4.

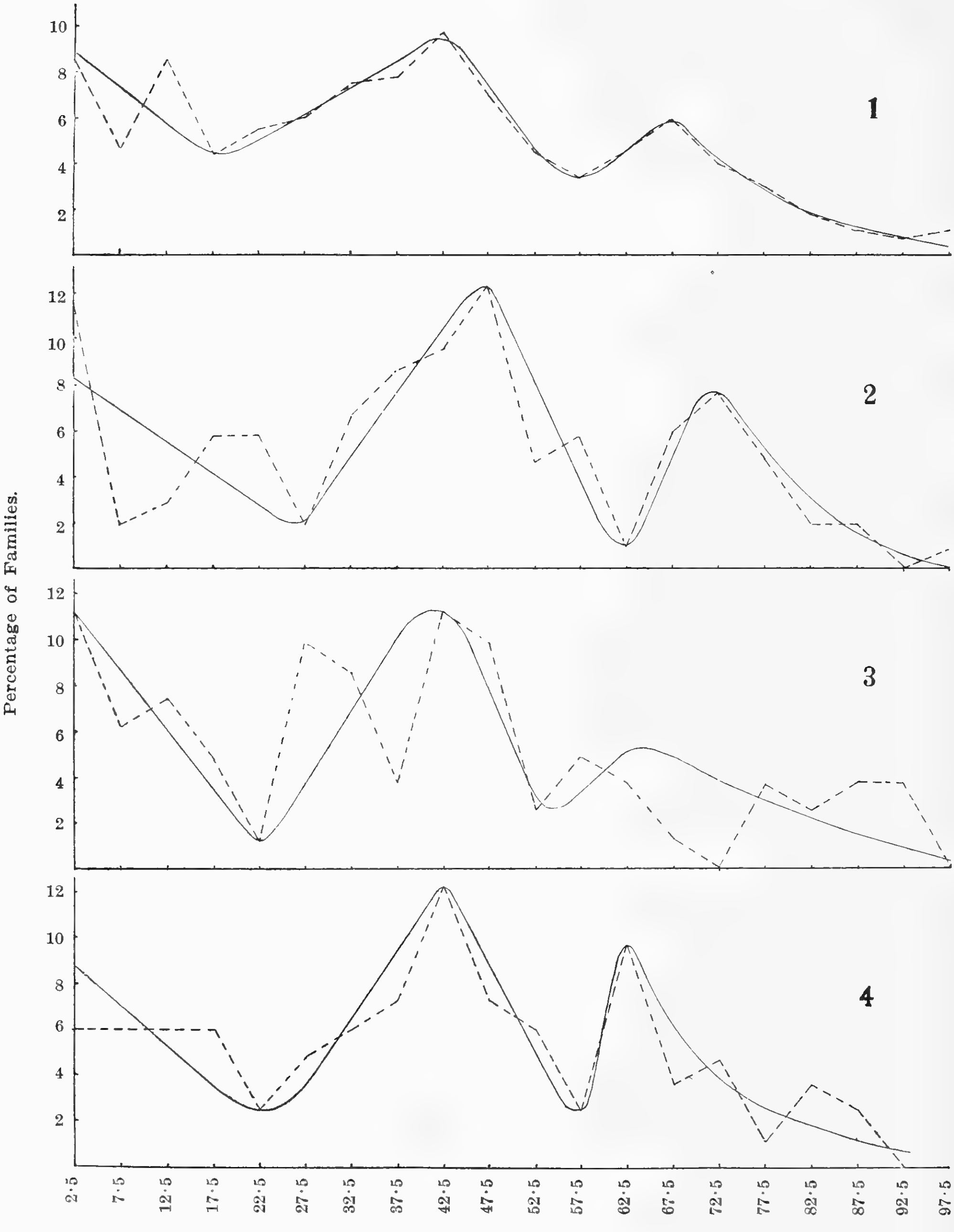

Fig. 1.—Distribution of F_3 families of the cross, "Florence" × "Firbank", in 5 per cent. classes for bunt infection.

Fig. 2.—Distribution of F_3 families of the cross, "Gullen" × "Florence", in 5 per cent. classes for bunt infection.

Fig. 3.—Distribution of F_3 families of the cross, "Florence" × "Yandilla King", in 5 per cent. classes for bunt infection.

Fig. 4.—Distribution of F_3 families of the cross, "Marshall's No. 3" × "Florence", in 5 per cent. classes for bunt infection.

TABLE 4.—Classification of families in the F_3 generation of a cross, "Gullen" × "Florence".

Kind of Family.	No. of Families.	
	Observed.	Expected.
Homozygous Resistant	30	26·5
Heterozygous	51	53
Homozygous Susceptible	25	26·5
Totals	106	106

There is, therefore, a close approximation to a 1:2:1 ratio. There are 76 susceptible families compared with 30 resistant to bunt. The P.E. for a 3:1 ratio in a population of 106 is 3·01, and $\frac{\text{D.}}{\text{P.E.}} = 1{\cdot}2$. There is a single factor difference between "Gullen" and "Florence" for bunt resistance, with dominance of susceptibility.

"Florence" × "Yandilla King".

The number of families grown in the F_3 of this cross was small. Eighty-one rows were sown with parent checks planted every 10 rows. Results are tabulated as follows:

TABLE 5.—Distribution of the parent and F_3 rows of a cross, "Florence" × "Yandilla King", into 5 per cent. classes for bunt infection.

Parents and Cross.	Distribution of Rows by Percentage Classes for Bunt Infection.																					No. of Rows
	0	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80	81–85	86–90	91–95	96–100	
Florence ..	3	1	1	2	1																	8
Yandilla King														1	1	4	—	6	—	—	—	12
Florence × Yandilla King	6	3	5	6	4	1	8	7	3	9	8	2	4	3	1	—	3	2	3	3	—	81

The average infection of the "Florence" controls was 8·7 per cent., and the "Yandilla King" controls 76·3 per cent. The nature of the distribution is seen in Fig. 3. The two minima lie at 22·5 per cent. and 52·5 per cent. The number of plants lying between the minima is shown in Table 6.

TABLE 6.—Classification of families in the F_3 generation of a cross, "Florence" × "Yandilla King".

Kind of Family.	No. of Families.	
	Observed.	Expected.
Homozygous Resistant	24	20·25
Heterozygous	38	40·5
Homozygous Susceptible	19	20·25
Totals	81	81

This approximates a 1:2:1 ratio. There are 57 susceptible families compared with 24 resistant to bunt. The P.E. on a 3:1 expectancy in this population is 2·63, and $\frac{\text{D.}}{\text{P.E.}} = 1{\cdot}5$. The results indicate a single factor difference between "Florence" and "Yandilla King" for bunt resistance, with dominance of susceptibility.

"Marshall's No. 3" × "Florence".

Again the number of the F_3 families grown was small, but sufficient to indicate the mode of inheritance. Eighty-three rows were sown, with parental controls every tenth row. Results are recorded in Table 7.

TABLE 7.—Distribution of parent and F_3 rows of a cross, "Marshall's No. 3" × "Florence", into 5 per cent. classes for bunt infection.

Parents and Cross.	Distribution of Rows by Percentage Classes for Bunt Infection.																					No. of Rows.
	0	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80	81–85	86–90	91–95	96–100	
Florence ..	4	2	3	1	1																	11
Marshall's No. 3 ..																1	—	2	5	3	1	12
Marshall's No. 3 × Florence ..	5	—	5	5	5	2	4	5	6	11	6	5	2	8	3	4	1	3	2	—	—	83

The "Florence" controls showed 6 per cent. infection and the "Marshall's No. 3" controls 87 per cent. The nature of the distribution is seen in Fig. 4. The minima lie at 22·5 per cent. and 57·5 per cent. These separate the F_3 families into three types as shown in Table 8.

TABLE 8.—Classification of families in the F_3 generation of a cross, "Marshall's No. 3" × "Florence".

Kind of Family.	No. of Families.	
	Observed.	Expected.
Homozygous Resistant	21	20·75
Heterozygous	40	41·5
Homozygous Susceptible	22	20·75
Totals	83	83

This is a close approximation to a 1:2:1 ratio. There is no significant deviation from the expected results. This indicates a single factor difference between "Marshall's No. 3" and "Florence" for bunt resistance, with dominance of susceptibility.

Grass Clumps.

Many workers have noted the occurrence of dwarf plants or grass clumps in segregating generations of wheat crosses. They occur also in barley, oat, and rye crosses. Waterhouse (1930) records the results of a number of crosses, the majority of which, in F_2, gave a ratio of 13 normals : 3 grass clumps, indicating the action of inhibiting factors. A few gave 15 normal plants : 1 grass clump.

Five of the crosses under consideration showed segregation for grass clumps in the F_2 generation. Four of them segregated as follows:

TABLE 9.—Occurrence of grass clumps in the F_2 generation of certain wheat crosses on a 13 : 3 expectancy.

Parents of Cross.	Observed.			Expected.		$\frac{D.}{P.E.}$
	Totals.	Normals.	Grass Clumps.	Normals.	Grass Clumps.	
Gullen × Florence	232	187	45	189	43	$\frac{2}{4\cdot01}=0\cdot49$
Florence × Gullen	326	264	62	265	61	$\frac{1}{4\cdot75}=0\cdot21$
Marshall's No. 3 × Florence..	72	58	14	58·5	13·5	$\frac{0\cdot5}{2\cdot23}=0\cdot22$
Roseworthy × Florence ..	249	201	48	202	47	$\frac{1}{4\cdot15}=0\cdot24$

The nature of the segregation in the F_2 generation of these crosses indicates the presence of an inhibiting factor. The F_3 families of all crosses except "Florence" × "Gullen" were grown in 1931. An analysis of these families gives the following results:

TABLE 10.—Number of F_3 families segregating for grass clumps compared with families producing only normals on a 6 : 7 expectancy.

Parents of Cross.	Phenotype.	No. of Families.		$\frac{D.}{P.E.}$
		Observed.	Expected.	
Gullen × Florence	Normal Segregating	53 52	56 49	$\frac{3}{3 \cdot 44}=0 \cdot 87$
Marshall's No. 3 × Florence	Normal Segregating	42 41	44 39	$\frac{2}{3 \cdot 06}=0 \cdot 65$
Roseworthy × Florence	Normal Segregating	41 29	37 33	$\frac{4}{2 \cdot 81}=1 \cdot 42$

The Probable Error for various populations for the ratio 6:7 was calculated from the formula $E.P._{n} = \pm\ 0 \cdot 6745 \sqrt{pqn}$ (Hayes and Garber, 1927).

The results confirm the F_2 assumption of the presence of an inhibiting factor for dwarfness.

Different results were obtained in the cross "Florence" × "Yandilla King".

In the F_2, the count for grass clumps showed 313 normal plants : 44 dwarfs. This approximates to a 55:9 ratio and indicates the presence of a dominant inhibiting factor and two dominant factors for dwarfness. Waldron (1924) obtained an approximation to this ratio in a "Kota" × "Marquis" cross.

TABLE 11.—Number of normal plants compared with number of grass clumps in F_2 generation of a cross, "Florence" × "Yandilla King", on a 55 : 9 expectancy.

Kind of Plant.	No. of Plants.		$\frac{D.}{P.E.}$
	Observed.	Expected.	
Normals	313	308	$\frac{5}{4 \cdot 43}=1 \cdot 1$
Grass Clumps	44	49	
Totals	357	357	

The Probable Errors of the Mendelian ratios 55:9 and 37:18 were calculated from the formula $E.P._{n} = \pm\ 0 \cdot 6745 \sqrt{pqn}$.

This result closely approximates to the expectancy.

Counts were made in the F_3 generation for families producing only normal plants, and families segregating for the grass clump habit. They were as follows:

TABLE 12.—Number of F_2 families segregating for grass clumps compared with number of families producing only normals in a cross, "Florence" × "Yandilla King", on 18 : 37 expectancy.

Phenotype of F_3 Family.	No. of Families.		$\frac{D.}{P.E.}$
	Observed.	Expected.	
Segregating..	52	54	$\frac{2}{2\cdot 85}=0\cdot 7$
Non-Segregating	29	27	
Totals	81	81	

This is a close approximation to the expected results and confirms the F_2 assumption.

Chaff Colour.

The inheritance of chaff colour has been studied by many workers. Biffen (1905), Kezer and Boyack (1918) and others obtained F_1 plants of intermediate colour and 3:1 segregation for coloured : colourless chaff in the F_2 generations.

In Australia Waterhouse (1930) obtained ratios approximating to 3 coloured: 1 white chaff plant in the segregating generations of certain crosses.

"Gullen" × "Florence".

Segregation for chaff colour in the F_2 and F_3 generations of the cross between "Gullen" (brown chaff) and "Florence" (light chaff) was studied. The F_1 was intermediate in colour. Results of F_2 are shown in Table 13.

TABLE 13.—Classification of F_2 plants for chaff colour and resistance to bunt in a cross, "Gullen" × "Florence", on 9 : 3 : 3 : 1 expectancy.

Number of Plants.	Brown-Chaffed.		White-Chaffed.	
	Susceptible.	Resistant.	Susceptible.	Resistant.
Observed	227	101	82	34
Adjusted	244	84	88	28
Expected	249·75	83·25	83·25	27·75
$\frac{\text{Deviation}}{\text{Probable Error}}$	$\frac{5\cdot 75}{7\cdot 05}=0\cdot 8$	$\frac{0\cdot 75}{5\cdot 55}=0\cdot 1$	$\frac{4\cdot 75}{5\cdot 55}=0\cdot 8$	$\frac{0\cdot 25}{3\cdot 42}=0\cdot 1$

There were 328 brown-chaffed plants and 116 white-chaffed. The P.E. for this population on a 3:1 expectancy is 6·15. $\frac{\text{D.}}{\text{P.E.}}$ = 0·81. Approximately 7·2 per cent. of the susceptible F_2 plants in this cross escaped infection. Assuming that all susceptible plants had become infected, the numbers of plants in each class were calculated. The adjusted figures give a close approximation to a 9:3:3:1 ratio.

There does not appear to be any correlation between inheritance of chaff colour and resistance to bunt.

Results of the F_3 of the cross grown in the same year are shown in Table 14.

TABLE 14.—Classification of families for chaff colour in the F_3 of a cross, "Gullen" × "Florence", on a 1 : 2 : 1 expectancy.

Chaff Colour.	No. of Families.	
	Observed.	Expected.
Homozygous brown	23	26·5
Heterozygous brown	56	53
Homozygous white	27	26·5
Totals	106	106

There were 89 families with brown chaff and 27 with white chaff. The P.E. for this population on a 3:1 expectancy is 3·01, and $\frac{\text{D.}}{\text{P.E.}}$ = 0·16. This is a very close approximation to the expectancy, and indicates a single dominant factor for chaff colour in the cross.

"Hard Federation" × "Florence".

The F_1 of a cross between "Hard Federation" (brown chaff) and "Florence" (white) was intermediate in colour. In the F_2 the chaff of plants was classed as brown or white. There were 201 brown-chaffed plants where 196 were expected, and 60 white-chaffed plants where 65 were expected. The P.E. for this population on a 3:1 expectancy is 4·75, and $\frac{\text{D.}}{\text{P.E.}}$ = 1·0. The results indicate a single factor difference for chaff colour between "Hard Federation" and "Florence". Results in the F_3 confirm this.

The P.E. for a population of 223 on a 3:1 expectancy is 4·36, and $\frac{\text{D.}}{\text{P.E.}}$ = 0·4.

Fifteen F_4 rows were sown at Richmond in 1930 with inoculated grain. The seed was selected at random from F_3 families heterozygous for chaff colour. A study of the resulting infection indicated that there was no correlation between the inheritance of chaff colour and resistance to bunt.

TABLE 15.—Classification of families for chaff colour in the F_3 of a cross, "Hard Federation" × "Florence", on 1 : 2 : 1 expectancy.

Chaff Colour.	No. of Families.	
	Observed.	Expected.
Homozygous brown	51	55·75
Heterozygous brown	118	111·5
Homozygous white	54	55·75
Totals	223	223

DISCUSSION.

In the present work, "Florence" was crossed with four susceptible commercial Australian varieties of wheat. Each cross gave a similar result. A graph, representing the distribution of F_3 families in 5 per cent. classes for bunt infection, showed a trimodal curve in each case, indicating a single factor difference for bunt resistance.

In such types of Mendelian inheritance, heterozygous F_3 families segregate in the same manner as the F_2 generation. The F_3 heterozygous families in these studies did not average the 75 per cent. of bunted plants as was expected. An average of 42 per cent. was obtained.

This low percentage would seem to be due to the following: (1) The number of families and the number of plants in each family were comparatively low (av. = 20 plants). Remnants of the F_2 plants were kept for further inoculation studies with flag-smut, so that only a portion of the grain from each F_2 plant was available for the bunt tests. (2) Environmental conditions were such that a certain percentage of the susceptible plants escaped infection. In consequence the true behaviour of all the heterozygous plants was not demonstrated.

The results emphasize the necessity of having complete control of the environmental conditions, so that all susceptible plants may become infected.

The phenotypes in the "Florence" crosses were separated by the two minima on the assumption that the amount of overlapping of the heterozygous and homozygous families was equal.

"Florence" is resistant, but not immune, to bunt. Low percentages of infection may be due to factors which modify resistance (Briggs, 1929*c*). Gaines (1920) suggested that some varieties possessed the ability to retard the growth of the fungus. It is generally believed that "Florence" owes its resistance to its ability to grow away from the fungus.

Under field conditions, "Florence" would be expected to produce, on the average, less than 2 ears per plant (Forster and Vasey, 1931). In the experimental plots, the average number of ears produced was 3·4 per plant. This was mainly due to the grains being planted at 4-inch intervals in drills 2 links apart. Some of the late "tillers" of "Florence" became infected. These tillers would not have been produced under ordinary conditions. This "late-tiller" infection was regarded as resistance.

SUMMARY.

In a previous paper, the inheritance of resistance to bunt in a cross "Florence" × "Hard Federation" was studied. The data showed a single factor difference with dominance of susceptibility.

For these studies "Florence" was crossed with four susceptible commercial Australian varieties, namely, "Firbank", "Gullen", "Yandilla King" and "Marshall's No. 3".

The F_2 and F_3 generations derived from single F_1 plants were grown in 1931. Each cross gave similar results.

In the F_3 generation, the three classes, homozygous susceptible, heterozygous susceptible, and homozygous resistant, gave a close approximation to a 1:2:1 ratio. The results indicated a single factor difference with dominance of susceptibility, between "Florence" and each of the four susceptible varieties.

The occurrence of grass clumps in the progeny of the crosses was studied. Three of the crosses gave ratios of 13 normals : 3 grass clumps, indicating the action of an inhibiting factor. In the cross "Florence" × "Yandilla King", the F_2 counts approximated to a 55:9 ratio. F_3 results confirmed the assumption of the presence of a dominant inhibiting factor and two dominant factors for dwarfness.

Studies were also made in the inheritance of chaff colour in two of the crosses. In each case a single factor determined the inheritance of this characteristic. Correlation studies indicated the independent inheritance of chaff colour and bunt resistance in this cross.

The writer acknowledges valuable suggestions and help from Dr. W. L. Waterhouse, University of Sydney, and assistance supplied by the Principal and staff of the Hawkesbury Agricultural College, Richmond, N.S.W.

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

By Charles Oke.

(Twenty-five Text-figures.)

[Read 29th June, 1932.]

Rhysodidae.

Rhysodes burnsi, n. sp. Text-fig. 1.

Dark piceous; nitid. Antennae rather strongly, tarsi sparsely, clothed with yellowish setae. Golden coloured trichomes surrounding foveae near apex of pronotum, anterior angles of prosternum and base of head.

Head triangular; lateral lobes large, lightly hollowed in front, entire behind; median lobe starting from basal third of lateral lobes, widened between antennae and narrowed in front, with a fovea in front at apex, and one on either side, just behind apex. Eyes small, elongate, lateral. Antennae rather short and thick; first segment large, second to tenth moniliform, transverse, eleventh sharply conical, without transverse suture. Prothorax longer than wide, with three longitudinal sulci running into a transverse groove in front, the medial sulcus lightly dilated near basal third, the outer sulci widened and subfoveate at base, foveate at apex, and with a golden trichome. Elytra elongate, strongly arcuate at base, shoulders produced forward; each elytron with three deep sulci, the first vanishing before apex, the second meeting at apex, the third narrow and becoming very faint before apex; the striae with moderate sized, elongate punctures. Anterior tibiae with a small, blunt spur at apical fifth and a long thin spur at apex; intermediate and posterior with two small spurs at apex. Under surface smooth and shining. Metasternum deeply sulcate. Length, 7 mm.; width, 1·40 mm.

Hab.—N. S. Wales: Mt. Wilson (C. Oke), in log with ants.

Of the species given in the table (These Proceedings, 1904) it is nearest to *R. mirabilis* Lea, from which it differs, according to the figure and description, by the shape of the antennal segments, in the median ridges of pronotum narrower than the laterals, the foveae near apex and prothorax not so rounded off at each end. In some respects it is close to the description of *R. frontalis* Grouv., but the second and third antennal segments are the same shape in the present species, the apex of elytra is different and Grouvelle does not mention the foveae on the pronotum.

So far no Australian species of Rhysodidae has been recorded as an inquiline of ants. My unique specimen of this species was taken from a log in which was a numerous colony of ants. Unfortunately none of the ants were kept for identification, as the presence of the beetle was thought to be accidental. But the presence of well defined trichomes surrounding the foveae on the pronotum and on the prosternum would seem to point definitely to this species being a myrmecophile. The trichomes are well developed and are somewhat like those seen in some species of the Chlamydopsini.

I have much pleasure in naming this species after my friend Mr. A. N. Burns, in whose company I found this very interesting beetle. Type in Coll. Oke.

RHYSODES PLANATUS Lea.

As no exact locality for this and the following species has been given, it will be of interest to know where they occur.

Hab.—Victoria: Belgrave (C. Oke).

RHYSODES TRICHOSTERNUS Lea.

Hab.—Victoria: Macedon (H. W. Davey, C. Oke).

RHYSODES ICHTHYOCEPHALUS Lea.

Hab.—N. S. Wales: Dorrigo (C. Oke). First record from this State.

PAUSSIDAE.

ARTHROPTERUS ABNORMIS, n. sp. Text-fig. 2.

Reddish-castaneous, tarsi almost piceous. With very short clothing, longer and more noticeable on humeral angles, sides of prothorax, head and basal segment of antennae.

Head with irregular punctures, becoming dense on base; with two vague, longitudinal impressions between eyes; sides lightly produced behind eyes. Antennae with sides densely punctate and less polished than along middle; with only 9 visible segments; 1 subquadrate, lightly produced on inner apical angle, 2 invisible, 3–8 strongly transverse, 9 cuneiform, and only on inner side of middle, 10 large, a little longer down middle than 7–8 combined, notched on outer edge, which is longer than inner. Prothorax lightly transverse, widest near apex, strongly rounded to apex, lightly narrowed to base; median impression rather strong, not reaching base or apex; margins lightly reflexed near base; punctures fairly dense but irregular. Elytra about four times as long as prothorax; punctures of irregular size and shape, and more conspicuous near suture, where there are vague remnants of three or four striae on each elytron. Hind tibiae about two and a half times as long as wide, with the outer edge produced into a sharp point. Length, 9 mm.

Hab.—Victoria: Riddell (C. Oke).

Quite an ordinary looking species of *Arthropterus* except for the antennae, which almost suggest a teratological origin, only that both are exactly alike. Rather like the species I have as *A. howitti* Macl. in appearance, but the thorax smaller and shorter, and the elytra, besides antennae, different.

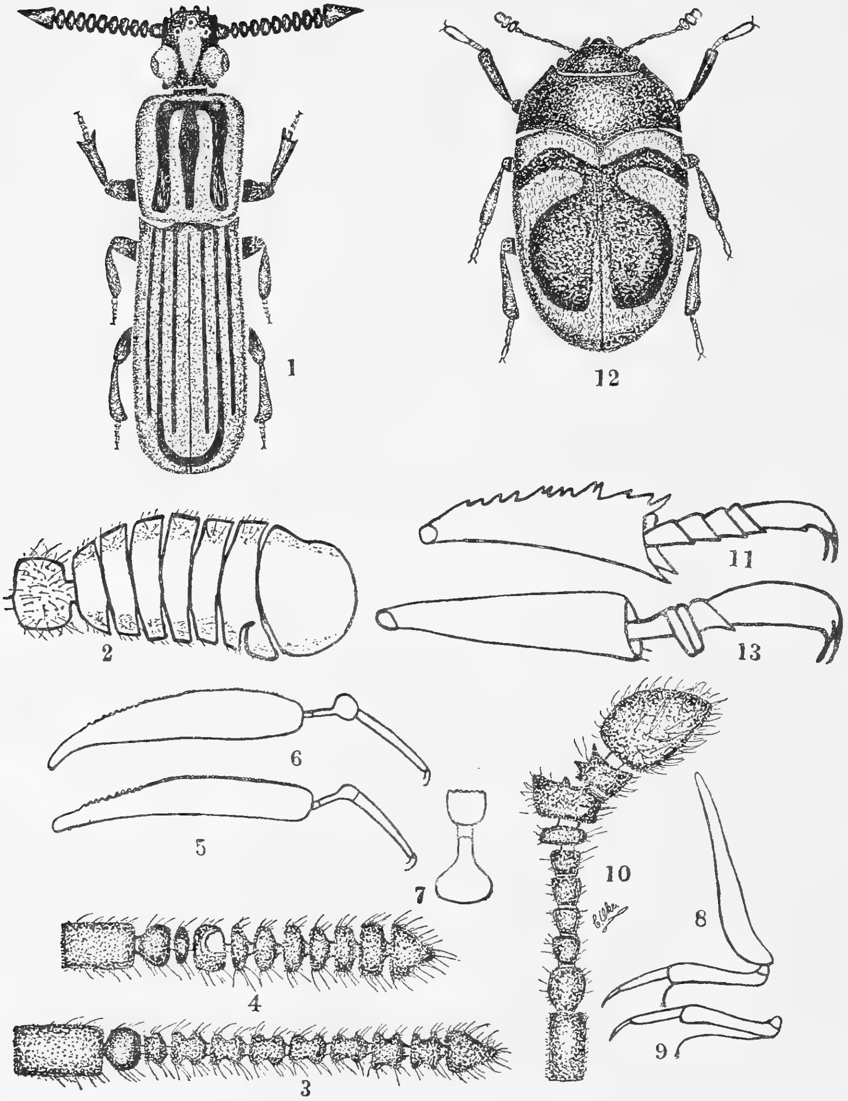
There are only nine visible segments, though I presume that the second is buried and invisible as usual; of these the subapical is only on one side of the middle. Possibly, as the presence of ten visible segments is a primary character of *Arthropterus*, a new genus should have been proposed for it. Type (unique) in Coll. Oke.

PSELAPHIDAE.

FARONINI.

SAGOLA RUGICORNIS, n. sp. Text-fig. 3.

Reddish-castaneous, tarsi paler. Moderately clothed with fairly long, reddish pubescence, with a few longer ones scattered about, becoming more noticeable near apex of abdomen.



Text-figs. 1-13.

1.—*Rhysodes burnsi*, n. sp. 2.—*Arthropterus abnormis*, n. sp. Antenna. 3.—*Sagola rugicornis*, n. sp. Antenna. 4.—*Sagola foveicornis*, n. sp. Antenna. 5.—*Batrisodes clavitarsis*, n. sp. Tibia and tarsus: side view of tarsus. 6.—*Batrisodes clavitarsis*, n. sp. Tibia and tarsus: usual view of tarsus. 7.—*Batrisodes clavitarsis*, n. sp. Tip of tibia and basal segments of tarsus, all that can be seen from this angle. 8.—*Eupines impedita*, n. sp. Tibia and tarsus. 9.—*Eupines impedita*, n. sp. Same tarsus with plate moved away from joints. 10.—*Bryaxis macquariensis*, n. sp. Antenna of male. 11.—*Enneboeus fossoris*, n. sp. Tibia and tarsus. 12.—*Enneboeus tarsalis*, n. sp. 13.—*Enneboeus tarsalis*, n. sp. Tibia and tarsus.

♂. Head with two small interocular foveae and a large impression towards front, separating the bases of the antennal tubercles, which nearly meet at their apices. The frons, antennal tubercles and antennae with large rugose punctures. Antennae longer and stouter than usual; segment 1 very stout, as long as next three combined, 2 subglobular, 3 smallest, 3–10 constricted in middle, 4–8 longer than wide, 9–10 lightly transverse, 11 subconical. Prothorax cordate, widest near middle; a fairly large medial fovea near base, connected with the lateral foveae by an impressed line; with fine sparse punctures. Elytra with punctures as on prothorax; sutural striae with a fovea at base and entire; discal striae represented by a small round fovea at base, and then a large elongate impression; an elongate fovea between sutural and discal striae. Abdomen with third segment longer than 1–2 combined; under surface with a large impression extending from third segment to apex. Metasternum convex, with a narrow medial sulcus. Middle trochanters compressed and produced into a blunt tooth. Length, 3·5 mm.

Hab.—Victoria: Warburton, Mt. Donna Buang (4,080 ft.), (C. Oke).

This species is remarkable for its peculiar antennae, which are quite unlike those of any other Pselaphid known to me. Each of the segments 3–9 is like a miniature cotton reel, roughly punctured, and, under a half-inch lens, appears to be covered with minute papillae. Type in Coll. Oke.

SAGOLA FOVEICORNIS, n. sp. Text-fig. 4.

Reddish-castaneous, suture infuscated, palpi almost flavous. Well clothed with rather long, reddish, semi-decumbent pubescence, with a few longer, stiff, erect setae scattered about.

Head subquadrate, with a large circular impression on apical two-thirds, connected with the base by two fine lines. Antennae stouter than usual, segment 1 twice as long as wide, 2 obconical, 3–10 transverse, 3 very small, 4 twice as long as, and slightly wider than, 5, with an impression or notch on its upper surface, 6–9 subequal, 10 a little wider, 11 a little longer, with a small, produced apex. Prothorax cordate, with a medial impression near base, connected with the lateral foveae by an impressed line. Elytra longer than wide; sutural area depressed; sutural striae well impressed and entire, with a fovea at base; discal striae represented by a very small fovea at base and a fairly large, elongate impression behind; a small fovea between sutural and discal striae; with fine, scattered punctures. Abdomen with third segment as long as 1–2 combined; convex beneath; metasternum strongly convex. Intermediate trochanters rather feebly compressed. Length, 2·60 mm.

Hab.—N. S. Wales: Dorrigo (C. Oke).

I believe the unique specimen from which this species is described to be a male, as the apex appears to be furnished with a small, indistinct operculum, though the metasternum and base of abdomen seem to be those of a female. The species is readily distinguished from the described species by the fourth joint of the antennae. Type in Coll. Oke.

EUPLECTINI.

MACROPLECTUS CALCARATUS Raffr.

Some specimens which I have identified as belonging to this species agree in all particulars with M. Raffray's detailed description except: "Caput . . . sulcis duabis obsoletis", and "pedum intermediorum . . . tibiis ad apicem incrassatis et valde calcaratus". In my specimens the frontal sulci are certainly not obsolete, and, when seen from in front, they appear unusually deep. The intermediate tibiae are slightly thickened to apex, but the spur is small and, as it is almost underneath the tibiae, on the inner side, it might easily escape notice at a casual glance.

The ♀ is slightly smaller than the ♂, with the head smaller and the legs unarmed.

Hab.—Victoria: Belgrave, Warburton (C. Oke).

MACROPLECTUS TUBERCULATUS, n. sp.

Reddish testaceous. Clothed with short yellowish pubescence, behind each coxa with thick pearly squamose pubescence. With fine indistinct punctures.

♂. Head large, transverse, wider than prothorax, narrowed in front; two large interocular foveae, opening in frontal sulci, which are deeply impressed and meet in front, the space between convex; antennary tubercles lightly raised; notched at base; foveate at base of ventral surface and carinate down centre. Antennae with joint 1 large, 2 smaller, 3–10 moniliform, 8, 9, 10 lightly transverse, 11 ovate, base truncate, apex acuminate, about as long as three preceding combined. Prothorax cordate, strongly rounded on sides, more strongly narrowed to apex than base; transverse impression expanded in middle and a large foveate impression on either side, a narrow longitudinal impression on centre of disc, indistinctly connected with the transverse impression. Elytra longer than wide, sutural stria distinct, a sulcate impression at position of dorsal stria, traceable to middle; base with four foveae. Abdomen with first three dorsal segments equal; first with two short carinules dividing width into three equal parts; ventral segments unequal, 2 long, 3, 4, 5 short, 6, 7 large, operculum oval; second with two round impressions behind coxae, from which a small tubercle protrudes, 3 with two small transverse impressions. Metasternum large, bifoveate close to middle coxae, behind these are two prominent tubercles, curved posteriorly; declivous at apex. Anterior tibiae almost straight; intermediate curved and with a spur near apex; posterior strongly curved and spinose at apex.

♀. Similar to ♂ but sternum simple, abdomen convex beneath and legs unarmed. Length, 1·80 mm.

Hab.—Victoria: Belgrave and Evelyn (C. Oke).

Very like *calcaratus* on upper surface, but different on ventral, as in that species the sternum and abdomen are simple and its intermediate trochanters are armed. The tubercles on the metasternum are very distinct, when looking straight down on them they appear as two black lines, but when seen from the sides they are seen as two prominent projections with their tops strongly curved backwards. The tubercles on the abdomen are much the same shape but smaller. Types in Coll. Oke.

BATRISINI.

BATRISODES CLAVITARSIS, n. sp. Text-figs. 5, 6, 7.

Bright castaneous. Well clothed with moderately long, yellowish pubescence, with a few longer setae scattered about. With fine, disperse punctures.

Head subquadrate, with two interocular foveae opening in front into a large triangular depression between the antennae. Antennae with all the segments elongate. Prothorax cordate, strongly rounded on the sides, widest in front of middle; disc strongly convex, with a faint groove on either side, with four foveae on the base and one on either side. Elytra rounded on the sides, strongly narrowed to base, where there are four large foveae; sutural striae entire, discal strong at base and traceable to about the middle. Abdomen with two short carinules on the base, each a little nearer middle than the sides; under surface flattened, with the apex lightly impressed. Metasternum sulcate and a little excavate posteriorly. Legs fairly long. Middle femora a little thicker than the others. Hind tibiae compressed and widened near middle. Posterior tarsi with apex of second segment suddenly widened near its middle and bent downwards; third cylindrical as usual. Length, 2 mm.

Hab.—N. S. Wales: Dorrigo (C. Oke).

There are five specimens in front of me all belonging to one sex, and I believe they are males. I have one specimen which is certainly a female and probably the female of this species, as it was taken with the above males and agrees in all particulars with them, except that its hind tarsi are quite ordinary and its abdomen is convex.

The hind tarsi are a remarkable shape, the widened part of the second segment being circular in outline, with the third segment bent underneath, so that the beetle would appear to walk on what should be the upper surface. Types in Coll. Oke.

BATRISODES GRACILICORNIS, nom. nov.

(= *B. tenuicornis* Lea, nom. praeoc.)

The name *tenuicornis* was occupied by Raffray (1904) for a species from Sumatra when proposed by Lea (1910).

The species is now recorded from Victoria: Mitchell Gorge (Oke).

BRACHYGLUTINI.

RYBAXIS VAGUS, n. sp.

Ferruginous, elytra and femora reddish-castaneous, antennae castaneous, segments 9–10 piceous, 11 very pale. Rather sparsely clothed with short, pale pubescence.

♂. Head a little longer than wide; with a large round impression, open in front, between antennae, and two large interocular foveae. Antennae rather stout and long; segment 1 cylindrical, stout, as long as next two combined, 2 ovate, 3–8 elongate, 3–5 equal, 6–8 diminishing, 9 scarcely longer than 8 but wider, 10 much larger, 9–10 obconic, 11 large, ovate-truncate. Prothorax cordate, widest in front of middle; lateral foveae large, medial fovea hardly visible, transverse impression strongly arcuate. Elytra about as wide at apex as long, narrowed to base, apices lightly rounded; sutural striae entire, discal nearly straight, traceable to near apex; shoulders raised; with minute, disperse punctures. Abdomen without basal impressions or carinae beyond elytra; under surface with a narrow carina down second segment; a thin, compressed tubercle on apex of third segment and overhanging the fourth; the apical segment with a large impression. Metasternum deeply excavate, sides of excavation carinate and produced into an obtuse tooth overhanging the hind coxae. Femora fairly thick. Anterior tibiae sinuate; intermediate with a strong, blunt, apical spur; posterior thickened to apex, where there is a long thin spur.

♀. Differs in having the antennal segments 9–10 thinner; metasternum not so excavate and without tubercles; abdomen simply convex beneath; middle tibiae without spur, but posterior tibiae spurred. Length, 2·40–2·75 mm.

Hab.—Victoria: Mitchell Gorge, Warburton, Fern Tree Gully (C. Oke); N. S. Wales: Dorrigo (C. Oke).

A very distinct species, probably nearer to *flavipes* than any of the described species, from which it differs in being of an entirely different colour, with armed metasternum and the hind tibiae spurred at apex. The spur of the hind tibiae is very thin but fairly long, and on some specimens it appears to be composed of several spines, or perhaps setae, compressed together. Types in Coll. Oke.

RYBAXIS TROCHANTERIS, n. sp.

Colour, clothing and upper surface as in preceding species.

♂. Metasternum widely flattened, with an oblique carina from middle coxae to beyond posterior coxae, a transverse carina between the latter; with an obtuse tubercle overhanging the posterior coxae; and a minute medio-basal tooth. Abdomen with the apices of segments 2 and 3 having a small, compressed sharp tooth overhanging the following segments. Intermediate trochanters unusually large and with a short, blunt tooth. Anterior femora lightly inflated; intermediate rather strongly inflated and hollowed on inner edge. Anterior tibiae with a minute tooth on inner side of apex; intermediate thick, constricted near base, with a small, triangular tooth about the middle on inner side, thence cut away to apex, where there is a small tooth; posterior with a long thin spur near apex.

♀. As in *R. vagus*, n. sp. Length, 2·50 mm.

Hab.—N. S. Wales: Dorrigo (C. Oke).

This species is exactly like the preceding one in appearance, indeed, I believe it is impossible to say to which species a female might belong, but, having caught a specimen of each sex close together I am presuming they belong to the same species. However, the two species are very different by the male characters in the legs and metasternum. The middle trochanters are larger than I have seen in any other Pselaphid. Types in Coll. Oke.

EUPINES IMPEDITA, n. sp. Text-figs. 8, 9.

Castaneous; elytra reddish, head almost black, ninth and tenth joints of antennae palest. Clothed with pale pubescence, more conspicuous on abdomen and under surface.

♂. Head with two round interocular foveae, vaguely impressed in front. Antennae with first joint stout and long, 1–4 decreasing in length, 5 cylindrical, as long as 1, 6–7 about same length as 3, 8 quadrate, small, 9 large, trapezoidal, 10 shorter than 9, transverse, 11 fairly large, ovate. Prothorax strongly rounded on the sides, widest in front of middle. Elytra with sides rounded. Metasternum flattened, entirely sulcate, with a few scattered punctures. Abdomen with second ventral segment strongly punctured, flattened in middle and with two minute tubercles, bent forward, close together, just behind its centre. Anterior trochanters acutely armed. Posterior tarsi with first joint minute, second long, about one-third length of tibiae, third a little shorter than second; from base of first joint, on under surface, a thin plate, or appendage, extends beyond second articulation and is then curled downwards; the other tarsi somewhat similar, but not so marked, nor so long.

♀. Differs in having the fifth joint shorter and the club smaller; by the metasternum not entirely sulcate and abdomen convex on the ventral surface. Length, 1·5 mm.

Hab.—Victoria: Warburton, Frankston (C. Oke), in tussocks.

This species is evidently allied to *E. tarsalis* Lea, and probably the two should be separated from *Eupines* in a new genus. Lea says of the second joint of the tarsi, "about one-third the length of tibiae and inflated to one side". This appears to be the case in the present species, as normally the plate is adpressed to the tarsus, but by careful manipulation the plate can be separated from the tarsus, and then it is seen to be a free plate joined only at its base. Type in Coll. Oke.

BRYAXIS MACQUARIENSIS, n. sp. Text-fig. 10.

Pale reddish-castaneous, appendages paler; head black and front of prothorax stained with black. Rather sparsely clothed with minute, pale pubescence.

♂. Head subquadrate, flat on vertex; with two fairly large interocular foveae and a narrow transverse impression between antennae. Antennae with segment 1 cylindrical, 2 oval, 3–6 longer than broad, 7 transverse, 8 large, produced to one side where 9 is joined, 9 transverse, smaller than 8, with two small teeth on inner edge, 10 largest, ovate. Prothorax cordate, rounded on sides, widest in front of middle. Elytra short, without impressions, but with scattered, moderate-sized punctures. Metasternum impressed posteriorly. Abdomen widely sulcate from middle of second segment to apex; the third segment with a granule on either side within sulcus, these furnished with a thin pencil of hairs, which is curved and directed forward. Trochanters unarmed. Anterior tibiae bisinuate (almost armed in middle); intermediate and posterior thickened towards apex and lightly curved. Length, 1 mm.

Hab.—N. S. Wales: Port Macquarie (C. Oke).

The subgenus *Bryaxis* of *Eupines* appears to be poorly represented in Australia as this is only the third species to be described, but each has remarkable antennae with one or more of the apical segments unevenly placed on the axis of the appendage. Only the ninth and tenth segments of *B. implumis* Lea are mentioned in the description and these show that they are very different from my insect. In his notes Mr. Lea says that the fifth joint is very different from that of *E. obliqua*, but no comparison is given. The punctate elytra seem to be at variance with the genus, though otherwise the characters are quite in keeping with those of the genus. Type (unique) in Coll. Oke.

TYRINI.

PALIMBOLUS FASCICULUS, n. sp.

Ferruginous, most of elytra and legs reddish-castaneous, apical segment of antennae pale. Densely clothed with long, pale and black setae; all foveae filled with golden pubescence.

♂. Head small, attenuate in front; with two interocular foveae, and an elongate impression in front; with moderate, but not very close, punctures. Antennae stout and coarsely punctate; segment 1 scarcely as long as next two combined, 2 subglobose, 3 obconical, 4–10 transverse, 6–9 slightly longer on inner edge than on outer, 11 large, longer than 9–10 combined. Prothorax suddenly widened, and carinate on sides, in front of middle; with a large medio-basal fovea and three foveae on either side; punctures as on head. Elytra with four foveae on the base; sutural striae entire, discal striae deep at base and vanishing about middle. Metasternum with a large excavation posteriorly. Abdomen on under surface hollowed from base to apex, the apex curved under and bears, on either side of subapical segment, a large reddish-golden fascicle.

Posterior coxae somewhat produced. Intermediate and posterior trochanters strongly armed. Posterior femora inflated and with a small tooth on inner edge. Intermediate tibiae with a small apical spur; posterior with a strong notch at apical third, the side of notch produced into a strong spur. Anterior tarsi with inner claw trifid.

♀. Antennae with segments 2–3 globose, 4 larger, quadrate, 5–8 transverse, decreasing, 9–10 large, transverse and with 11 forming a large club. Metasternum lightly excavate. Legs not armed. Length, 2·85 mm.

Hab.—N. S. Wales: Dorrigo (C. Oke).

This species should be easily recognized by its stout antennae, thorax, hind legs and abdomen. The antennae are stouter than in *robusticornis*. The spurs on hind tibiae are similar to those of *mirandus*, but the femora are thicker and with a small tooth near the middle of inner edge. From *metasternalis*, to which it is probably nearest, it differs, by description, in having the middle trochanters and the hind femora armed, the metasternum not armed and its abdominal fascicles. Types in Coll. Oke.

PALIMBOLUS EXCAVICORNIS, n. sp.

Dark castaneous; elytra, legs and three apical segments of antennae reddish. Densely clothed with long, luteous pubescence; foveae filled with short, glistening pubescence.

♂. Head with two round interocular foveae close to the eyes; antennal tubercles strongly raised and punctate in front. Antennae very stout, with large, close punctures; segment 1 longer than next two combined, 2–10 transverse, 2–8 diminishing in length, 9–10 larger, subequal, 11 very large, as long as three preceding combined, with a large excavation on lower surface. Prothorax subangulate, at widest part, in front of middle; with an elongate medio-basal impression, and two foveae on either side; some sparse punctures near base. Elytra arcuate at base; sutural striae entire; discal striae deeply impressed near base and vanishing beyond middle; each stria with a fovea at base. Metasternum widely and deeply excavate; with an obtuse tubercle behind intermediate coxae. Abdomen flattened. Posterior coxae notched and produced into a large blunt tooth, overhanging trochanters. Posterior trochanters produced into a conical tooth at base. Posterior femora strongly inflated, arched, with a sudden constriction near apex. Intermediate tibiae with a small apical spur; posterior with two small, blunt teeth near base and a very small, sharply conical tooth near middle. Anterior tarsi with inner claw trifid.

♀. Differs from the ♂ in having the antennae a little thinner and without the excavation on apical segment; the metasternum less excavate; abdomen convex and legs unarmed. Length, 3 mm.

Hab.—Victoria: Lorne (C. Oke, in moss, and in moss collected by Mr. C. J. Gabriel).

The hind tibiae of this species will distinguish it from the previously described ones. The basal teeth are small and close together, but are very distinct, though the median tooth is smaller and might be overlooked. The antennae are slightly thicker than in *robusticornis* with the apical segments paler and the eleventh segment is decidedly larger and more deeply excavate. Types in Coll. Oke.

HAMOTOPSIS CARINATUS, n. sp.

Ferruginous; elytra and appendages castaneous. Rather densely clothed with reddish pubescence.

Head with vertex quadrate, produced in front; with two round interocular foveae and an elongate one in front; with fairly large, close punctures. Antennae long and thick; segment 1 stout, cylindric, 2 thinner, subquadrate, 3 elongate, obconic, 4–8 globular, 9–10 much larger, scarcely transverse, 10 larger than 9, 11 very large, elongate-ovate, more rounded on outside edge than on inner; the whole punctured and with minute papillae. Prothorax about as wide as long, strongly rounded on the sides, widest in front of middle, a little narrower at apex than base; medial fovea small and connected with the large lateral foveae; a carinule from transverse impression to base; punctures larger than on head. Elytra strongly arcuate at base, with the shoulders slightly produced; sutural striae entire, discal wide at base, but vanishing before middle; punctures finer than on head. Abdomen with three basal segments equal and the three with an entire, longitudinal, medial carina. Metasternum deeply excavate posteriorly. Under surface with fine, disperse punctures. Legs coarsely and closely punctate. Femora thin, tibiae lightly sinuate. Length, 2·30 mm.

Hab.—N. S. Wales: Dorrigo (C. Oke).

On the under surface of the head are two strong projections; these appear to be the ends of the cardo, but only having a single specimen I hesitate to make certain. Differs from the description and figure of *H. australasiae* Raffr. in the formation of the antennae, in having the three basal segments of the abdomen carinate, and in the large, close punctures of the head and prothorax. Type in Coll. Oke.

SCHISTODACTYLINI.

SCHISTODACTYLUS BREVIPENNIS Lea.

(= *S. armipectus* Wilson, ? *S. foveiventris* Wilson.)

This species is widely spread in Tasmania and Victoria, and is quite common in the Dandenong and Warburton Ranges. It also occurs in the Blue Mountains in New South Wales.

Wilson, in redescribing the species as *armipectus*, relied on the spines on the prosternum to differentiate his species from *brevipennis*. On a recent visit to Adelaide the late Mr. A. M. Lea kindly allowed me to examine his type and some cotypes in his collection, and these all had the spines on the prosternum, though they were not mentioned in his description. I also have several specimens from Tasmania and these all have the spines. In January I obtained specimens of this species at Wentworth Falls, and this raises some doubts as to whether *foveiventris* is not the same as *brevipennis*. Mr. Wilson had to float off and clean his specimen; in doing this it would be very easy to lose the apical seta from each palp, and the description of the abdominal fovea does not differ from quite normal males. Some new localities for this species are: Tasmania: Magnet in moss, Stanley in grass (C. Oke), Launceston (H. V. Hickman); Victoria: Healesville, Beechworth, Ballarat, Bairnsdale, Fern Tree Gully (Oke), Emerald (J. E. Dixon, E. Nye, Oke); N. S. Wales: Wentworth Falls (Oke).

BYRRHIDAE.

PEDILOPHORUS FASCICULATUS Lea.

A specimen of this species from Lorne, Vic. (C. Oke), agrees very well with the type, except that the clothing on the pronotum is scarcely fasciculate, it is dense and matted together. On a second specimen, which appears to be abraded, the clothing is sparser and is nowhere fasciculate.

Now first recorded from the mainland.

PEDILOPHORUS ATRONITENS Lea.

This species was described from a unique specimen from Lorne, Vic., but it is not at all uncommon in that district, as I have taken a fair number of specimens, all being found in moss.

Most of the specimens are apparently not so dark as the type, as they have the disc of pronotum and elytra diluted with red, and only their edges are black.

PEDILOPHORUS COMATUS, n. sp.

Bronze-black; under surface black, legs piceous, mouth parts, antennae (two basal segments excepted) and tarsi reddish. Upper surface with long black hairs mingled with shorter brick-red hairs; under surface with short greyish pubescence.

Head rounded in front, with fine, close punctures. Antennae with third segment much longer and thinner than second, as long as fourth and fifth combined, the last four forming a moderate club. Prothorax transverse, very convex, with fine, subreticulate punctures. Scutellum distinct. Elytra strongly and evenly convex; punctures as on prothorax but becoming less distinct posteriorly. Under surface with small, dense punctures. Length, 3·5–4·5 mm.

Hab.—Victoria: Bacchus Marsh (C. Oke, in Termite's nest), Anakies (Rev. E. Nye, E. E. Nye, C. Oke), You Yangs (E. Fischer, Oke), Mt. Blowhard, at 6,000 ft. (in Coll. Lea).

This species is nearest to *P. mixtus* Lea, but differs in being larger, less metallic, with the clothing longer and black and reddish, instead of black and whitish; the third segment of antennae is also longer. The reddish hairs are somewhat golden in certain lights and have an obliquely vittate appearance, especially on the pronotum. On the type and some other specimens the legs are quite piceous, but in some others they are reddish. Types in Coll. Oke. Paratypes in South Australian Museum and Colls. Lea, Nye, Oke.

TENEBRIONIDAE.

COTULADES PILOSUS, n. sp.

Black; legs and mouth parts diluted with red. Clothed with long, black, hooked setae on upper surface, also with some short, white setae on front of head, legs and under surface, and forming two round premedial spots on elytra.

Head with coarse, dense punctures. Eyes small, prominent. Antennae fairly thick, third segment widest, decreasing to apex, apical segment small. Prothorax as long as wide, widest at apex, feebly decreasing to base; sides denticulate; with punctures a little finer than on head. Elytra widened to near apex, then suddenly narrowed to apex; with large, rough punctures. Under surface with rather large, sharp punctures. Length, 2·5–3·5 mm.

Hab.—Victoria: Beechworth (C. Oke).

A small species near *C. montanus* Bl. from which it differs by the prothorax not rounded on sides, its longer antennae, etc. On some specimens the elytral spots are very faint, but are fairly conspicuous on others. None of them show any signs of pale vittae on the prothorax. Type in Coll. Oke.

ENNEBOEUS FOSSORIS, n. sp. Text-fig. 11.

Pitchy-brown, legs and antennae reddish. Clothed with short, adpressed cinereous pubescence, this appearing to form a pattern on elytra. The whole upper surface with close minute punctures, but obscured by the clothing.

Oblong-elliptic. Antennae slender, club light. Prothorax transverse, much narrowed to apex. Elytra with sides parallel to near apex, feebly trisinuate at base; with rather small punctures forming definite striae. Tibiae moderately stout, with several spines at apex and spinose on outer edge, more strongly so on the anterior. Length, 4·25 mm.

Hab.—Victoria: Bendigo (C. Oke).

This species is at once separated from *ovalis* and *australis* by its spinose tibiae, these being evidently fossorial, which should, perhaps, exclude it from *Enneboeus*, but as I can find no other difference I prefer not to propose a new genus for it. The other three species are found under bark, generally on dead trees, but my specimens of this species were found under stones that were some distance, about fifty feet, from any vegetation other than grass. Types in Coll. Oke.

ENNEBOEUS TARSALIS, n. sp. Text-figs. 12, 13.

Dark brown, with clypeus, front of pronotum, parts of elytra, basal joints of antennae and legs testaceous. Subnitid. Clothed with short, pale adpressed pubescence. Upper surface with very fine close punctures.

Oval. Head with a vague impression between eyes. Antennae reaching to middle of prothorax; last three joints forming a moderate club. Prothorax strongly transverse, much narrowed to apex; trilobed at base. Elytra trisinuate at base, central sinus shorter and deeper than outer; with striate rows of rather small unevenly spaced punctures. Anterior tibiae non-spinose, others with a few spines at apex. Anterior tarsi in ♂ with joints stout and four basal joints transverse; in ♀ slender and longer. Length, 2·80–3·25 mm.

Hab.—Victoria: Emerald (C. Oke).

The pale markings on the elytra are a narrow mark across base, becoming larger on shoulders, an interrupted, sinuate, V-reversed shaped fascia, starting about middle of margin and produced forward towards, but not quite reaching, suture; from this mark to apex the margin is pale and the apical half of suture is very narrowly pale. There is quite a difference between the anterior tarsi of the sexes. That which I take to be the male has much stouter, though shorter, basal joints than the female, with a long stout apical joint. Types in Coll. Oke.

ENNEBOEUS OVALIS Waterh.

This species occurs under bark, generally on dead wood, where I have taken it in Victoria at Pakenham and in the Dandenong Ranges, also in New South Wales, at Dorrigo. It has not been previously recorded from the mainland.

PARATOXICUM NIGRICANS, n. sp.

Dark castaneous; base of head, pronotum and elytra dull black; clypeus and appendages reddish. Sparsely clothed with short, pale pubescence.

Head with fine, confluent, rugose punctures. Prothorax transverse, hind angles lightly produced; with fine, close punctures. Elytra elongate, almost parallel sided; with regular rows of small punctures, the interstices with fine, almost microscopic, punctures. Under surface with fine punctures, a little coarser on flanks of metasternum than elsewhere, finely strigose on sides of prosternum. Anterior tibiae lightly dilated to apex. Length, 4 mm.; width, 1·5 mm.

Hab.—Victoria: Bairnsdale, Belgrave (C. Oke), Traralgon (F. M. Burnet, C. Oke).

A smaller and narrower species than *P. iridescens* Champ., with the seriate rows of punctures much smaller and the interstices with very fine punctures, instead of smooth. The upper surface in the type and other specimens is a dull "velvety" black, but on one specimen, from Emerald, Vic. (where I have taken *P. iridescens*), is ferruginous, with a pale bluish iridescence. It is probably immature. Type in Coll. Oke. Paratype in Coll. Burnet.

SEIROTRANA BURNETI, n. sp. Text-fig. 14.

Oblong-ovate, strongly convex, nitid. Black, upper surface with a bronze tinge; tarsi and apices of tibiae and antennae diluted with brown. Legs clothed with dingy pubescence, apices of tibiae on inner side and tarsi with bright reddish tomentum.

♂. Head with frontal impression deep and strongly procurved, just behind which are two small, round foveae; with fine, close punctures, the base and under surface, in addition, with fine, transverse striae. Eyes large, strongly transverse. Antennae stout; segment 3 about one and a half times as long as 4, 4 and 5 subquadrate, 6–10 transverse, 8–9 produced to a sharp point on inner side, 11 ovate. Prothorax transverse, semicircularly emarginate at apex, sides widely rounded, base almost straight, angles not produced; very finely margined all around; disc convex, medial line absent; an elongate foveate impression about middle of either side near margin; punctures as on head. Scutellum rounded behind. Elytra a little wider at base than prothorax, humeral angles rounded off; with eight striae on each elytron: the seventh and eighth joining near, but not reaching, the base, the striae narrow but fairly deeply impressed, with moderately small, close punctures; interstices with very fine, sparse punctures. Epipleurae with small, sparse punctures. The legs, including the coxae, and apex of abdomen with fine, close punctures, rest of abdomen smooth. Anterior tibiae straight; intermediate dilated from base to apex, but hollowed out on inner side about apical third; posterior dilated from the base to near middle, there strongly scooped out and then thickened again to apex; from the top of the angulation to the apex of the tibiae there is a sharp-edged carina, with a fine stria on either side of it.

♀. Differs in having shorter and thinner, submoniliform antennae and the tibiae almost straight. Length, 15 mm.

Hab.—Victoria: Traralgon (F. M. Burnet, C. Oke).

A very distinct species approaching *S. uniformis* Cart. in facies, from which it is separated by its antennae, tibiae and each elytron with eight, instead of eleven, striae. It is with pleasure I name it after my friend, Dr. F. M. Burnet, who kindly gave me a pair taken *in copula*. Types in Coll. Oke.

Possibly this species should have been referred to the New Zealand genus *Pheloneis*, the main distinguishing character of which seems to be "antennae articulis apicalibus, ultimo excepto, transversis". But as this only applies to the male in *burneti*, and as there is very little, if any, difference in the anterior tarsi and the posterior intercoxal process of some *Seirotrana* and *Adelia* with which I have compared it, I think it is better put in *Seirotrana* as an aberrant species.

PTINIDAE.

DIPLOCOTES CRASSICORNIS, n. sp.

Ferruginous; head and prothorax darker than other parts. Sparingly clothed with short, yellowish pubescence; on the elytra this is confined to the punctures of the striae. Elytra, abdomen and two apical segments of antennae subnitid, the rest almost, or quite, opaque.

Head transverse behind antennae, rugosely sculptured. Eyes produced into a conical point on outer edge. Antennae very stout, segment 1 nearly as long as next three combined, 2 obconical, 3–9 moniliform, equal, 10 larger, 11 narrowly oval. Prothorax longer than wide, with a transverse groove near base, the groove produced forward and subfoveate at sides; a fine marginal line at base; sculpture as on head. Elytra oval; punctate-seriate, with a row of large punctures across the base. Sternum rugosely sculptured; prosternum carinate between coxae, with a small fovea at base; mesosternum deeply impressed in centre; metasternum flattened. Legs fairly long. Length, 2 mm.

Hab.—Victoria: Hattah (C. Oke) in nests of a small black *Iridomyrmex.*

Allied to *howittanus*, but darker, with the groove on the pronotum more strongly produced forwards on the sides, the sculpture coarser and the antennae much thicker than in that species, though the tenth segment is smaller in proportion. Type in Coll. Oke.

ENDOMYCHIDAE.

DAULOTYPUS UMBRATILIS, n. sp. Text-fig. 15.

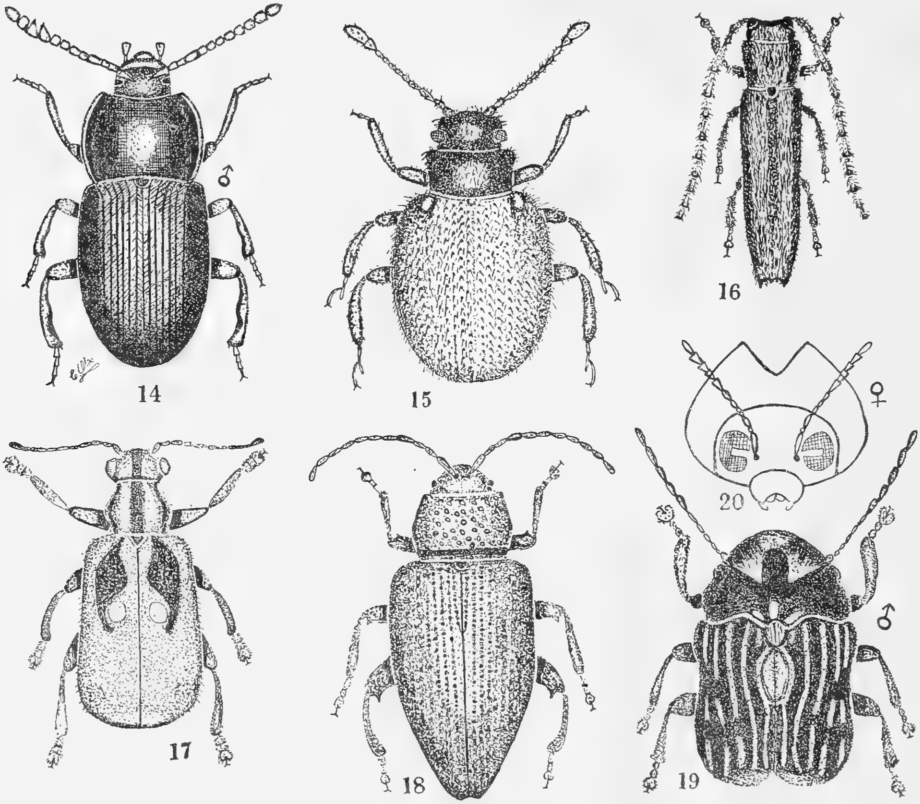
Reddish-flavous; head, prothorax and legs dark castaneous; antennae with segments 3–10 infuscated; tip of tenth, the whole of eleventh and the tarsi flavous. Well clothed with reddish, subdepressed pubescence; in addition with longer, erect setae.

Head transversely impressed behind antennae and with sparse, irregular punctures. Clypeus longitudinally impressed on either side; with a few punctures. Labrum bilobed. Antennae with segment 1 rather long; 3 decidedly longer than 4, a little longer than 2, shorter than 1; 5, 7, 9 subequal, longer than 4, 6, 8; 10 larger, lightly produced at apex on inner side; 11 ovate, more rounded and compressed on inner side. Prothorax nearly thrice as wide as long; sides narrowly margined and uneven; anterior angles rounded, posterior subdentate; a deep impression commencing near each hind angle and ending near apex; a narrow impression across base; with small, close punctures on sides, sparse and ill-defined on disc. Scutellum small, transverse. Elytra wider than thorax at base, widest just before middle, sides distinctly margined; shoulders rounded, a little raised; with regular rows of distinct punctures. Abdomen with first segment nearly as long as next four combined, the sixth very small, not incurved. Legs long, thin. Length, 3·25 mm.

Hab.—Victoria: Fern Tree Gully (C. Oke), in dark, shady places.

Of the three previously described species, the present one is nearest to *D. minor* Lea, but differs from a specimen of that species which I obtained at Dorrigo,

N. S. Wales, by its shorter and thicker antennae, the sides of the prothorax not quite the same, and the colour of the pronotum and head is not black. Type in Coll. Oke.



Text-figs. 14-20.

14.—*Seriotrana burneti*, n. sp. ♂. 15.—*Daulotypus umbratilis*, n. sp. 16.—*Itheum robustum*, n. sp. 17.—*Austrolema vitinea*, n. sp. 18.—*Microdonacia terricola*, n. sp. 19.—*Brachycaulus minor*, n. sp. ♂. 20.—*Brachycaulus minor*, n. sp. ♀

In figure 14 the left antenna is drawn as viewed from the side.

CERAMBYCIDAE.

TRITICOSMIA ARMATA, n. sp.

Black, elytra yellow-ochre, sides infuscated. Head with fairly long setae, more numerous on under surface. Sternum and abdomen with fine, silky, greyish pubescence.

♂. Head wider than prothorax, channelled down frons, which is roughly punctulate; mouth parts shining and with small asperate punctures, and marked off by a deeply impressed line; vertex with large rugose punctures; antennary tubercles prominent. Antennae thin and longer than body; basal joint suddenly inflated at apex and with a tubercle on its lower surface; third joint with a fascicle of black setae on its apex. Prothorax longer than wide; with four tubercles on the disc, and a larger one on each side; a strong transverse constriction at apical third; transversely rugulose. Elytra conjointly arcuate at base, shoulders rounded off but slightly elevated; wider than prothorax at base, narrowed to apex, there subtruncate; each elytron with six fine, lightly elevated carinae, counting suture and margin; finely granulate and opaque. Legs long and thin. Length, 11–18 mm.

♀. Differs in being larger, with shorter antennae, and in having the abdomen exposed beyond the elytra.

Hab.—Victoria: Launching Place (C. Oke), Warburton (J. E. Dixon, Oke).

This species is somewhat like *roei* in appearance, but is at once separated from that species by its armed antennae; the carinae on the elytra are also narrower and more numerous. Type in Coll. Oke. Paratypes in National and South Australian Museums and Coll. Dixon.

EARINUS VARIABILIS, n. sp.

Head, antennae, part excepted, meso- and metasternum and legs, base of femora excepted, black; prothorax, base of the third to eleventh joints of antennae and deflexed margins of shoulders pale yellow; base of clypeus, labrum, palpi, basal third of femora and abdomen ochreous-yellow; elytra dark blue, becoming purple towards apex. Five basal joints of antennae, prothorax, legs, under surface of head, sternum and abdomen thickly clothed with moderately long pale setae. Subopaque.

Head with medial sulcus from base to labrum; widely excavated between antennae; eyes deeply emarginate for antennae; with moderate semiconfluent punctures. Antennae thin, passing elytra; fourth joint shorter than third, fifth longer than third. Prothorax strongly transverse, with a constriction near base and apex; with a fairly large blunt tubercle on each side; disc slightly elevated on either side of centre and with a dark spot; punctures as on head. Elytra wider than thorax at base, not meeting towards apex, lightly emarginate on sides about apical third, obliquely rounded to the apices, which are themselves lightly produced; with two fine carinae on the disc of each elytron, becoming obsolete before apex, the base with indications of others; the shoulders lightly raised and nitid and impunctate; base with punctures as on head, becoming much finer before middle. Legs short, basal joint of tarsi not as long as next two combined. Length, 22 mm.; to end of elytra, 17 mm.

Hab.—Victoria: Whittlesea (C. Oke), South Australia (Blackburn's Coll.).

This species on a cursory examination appears to belong to *Bimia*, and the specimen in the South Australian Museum was in the Blackburn Collection queried as *Bimia*, but I think it should be referred to *Earinus*. The South Australian specimen is darker than the type, with the elytra a different shade of purple.

BIMIA BICOLOR White.

(= *B. femoralis* Saund., *nec* French.)

There is considerable confusion in Australia, but, as already pointed out by Blackburn, and by van de Poll, these two names belong to but one species. The confusion is really over the following species.

AKIPTERA WATERHOUSEI Pasc. ♂.

(= *Bimia maculicornis* v.d. Poll. ♀; = *B. femoralis* French (*nec* Saund.), ♂, ♀.)

In French's "Destructive Insects of Victoria" there are excellent figures of the sexes of this species. The male agrees perfectly with the figure given by

Pascoe. The female agrees with the description of van de Poll. There can be no doubt that these are the sexes of but one species. They have been taken together and bred from the same tree, but I have not heard of them actually mating. *Bimia* and *Akiptera* are very closely allied, the only difference is, apparently, in the antennae of the male.

ITHEUM VILLOSUM, n. sp.

Black, or nearly so. Thickly clothed with rather short, pale ashen-grey setae; in addition with numerous longer hair-like setae, these longest and most numerous on antennae, where they are somewhat reddish; on each elytron there are four lines of curved, white setae. The whole insect is closely punctate; punctures very fine on head, a little larger on prothorax and still larger on elytra.

Head channelled down centre. Antennal tubercles fairly prominent. Antennae reaching apical fourth of elytra. Prothorax elongate, a little wider near apex than base. Elytra one-fourth wider than prothorax at base, parallel-sided to near apex; apex lightly emarginate. Basal segment of posterior tarsi shorter and thinner than on *vittigerum*. Length, 5–7 mm.

Hab.—Victoria: Natya (C. Oke), Hattah (J. E. Dixon, C. Oke).

Similar to *I. vittigerum* Pasc. (for a specimen of which I am indebted to the late Mr. A. M. Lea) in shape, though generally narrower, but differs in colour of derm and clothing, in not having a pale vitta on each elytron, and the punctures sharper and deeper. From the description of *I. lineare* Pas. it differs in colour and the very different clothing. Taken in fair numbers on *Troidea irritans* R. Br. Types in Coll. Oke. Paratypes in Colls. Dixon, Nye, Lea and South Australian Museum.

ITHEUM ROBUSTUM, n. sp. Text-fig. 16.

Reddish-castaneous; head, some indefinite spots on thorax and elytra, femora, base of tibiae, the apex of fourth and most of the fifth to ninth segments of antennae piceous. Densely clothed with drab-coloured, decumbent pubescence; longer at apex of elytra; rather sparse on frons; and with rows of curved, white setae down elytra.

Head hollowed between antennae; with large, round, deep, close punctures. Antennae not quite reaching apex of elytra; segment 1 fusiform, 2 short, a little longer than wide, 3 longest, then gradually decreasing to apex. Prothorax longer than wide, subcylindrical; punctures larger and sparser than on head. Elytra elongate, widest at shoulders, which are rounded off, tapering to apex; with a well-marked subsutural stria and an elevated ridge down each elytron, and each with a lunate excision, a small, blunt spine on suture and a larger spine on outer edge; punctures as on pronotum. Legs of moderate length and fairly robust; claw joint long. Length, 9·50–10·50 mm.

Hab.—N. S. Wales: Dorrigo (C. Oke).

A large robust species with the general facies of *I. vittigerum* Pasc., but its larger size, coarser punctation and more shining derm will distinguish it. Type in Coll. Oke.

CHRYSOMELIDAE.

CRIOCERINAE.

AUSTROLEMA, n. gen. Text-fig. 17.

Elongate. Apterous. Head subvertical, rather small, transverse, constricted behind, a transverse sulcus between antennae. Eyes large, round, prominent, notched near antennae; with moderate sized facets. Antennae widely separated at the base; reaching a little beyond base of prothorax; fourth segment longest; basal segments elongate, towards apex subquadrate. Maxillary palpi short, of three segments; first short, cylindrical, second subtriangular, third conical. Thorax subcylindrical, without sulci or lateral margins; deeply constricted on sides near base. Scutellum small. Elytra oblong, much wider than prothorax; punctate. Prosternum invisible between coxae; mesosternum short, produced into a sharp process between coxae; metasternum long, sulcate posteriorly. Abdomen with first segment as long as next two combined. Epipleurae moderately wide at base, gradually narrowing and vanishing near apex of elytra. Anterior coxae rather large, prominent, touching; coxal cavities closed behind; intermediate placed in a slightly oblique position, lightly separated; posterior transverse, a little wider apart than intermediate. Legs fairly long. Femora moderately robust, unarmed. Tarsi broad, thickly spongiose beneath; segment 1 short, 2 transverse, 3 subcircular, 4 one and a half times as long as 3, thin; claws free at base and strongly appendiculate.

This genus is proposed for a peculiar looking little insect, somewhat resembling the genus *Lema*, though smaller and flatter than any species of that genus known to me.

In the table of genera given in the "Genera Insectorum" of Crioceridae, it would fall next to *Sigrisma*, as the antennae only just pass the base of prothorax, but the antennae of that genus are otherwise very different from the present genus, and, presumably, its claws are simple. The eyes of *Austrolema* have a deep V-shaped notch at base of antennae in an otherwise round and strongly convex surface.

Genotype, *A. vitinea*, n. sp.

AUSTROLEMA VITINEA, n. sp. Text-fig. 17.

Reddish-flavous; appendages flavous, antennae towards apex darkened; a round, median spot and a small part of apex on each elytron pale watery flavous; and the following markings black or nearly so: a broad stripe down head and pronotum, an elongate spot behind each eye, a narrow stripe on sides of pronotum and a blotch near base of each elytron. Well clothed with fairly long, fine, depressed, whitish setae, a few longer ones standing out on sides of prothorax and elytra. The whole upper surface finely shagreened.

Head depressed on either side of middle between eyes and leaving a short ridge in centre; with rather small, distinct punctures. Antennae with segment 1 cylindrical, curved, 2 oval, 3–5 elongate, 4 longest, 6–10 subquadrate, 11 shortly conical. Thorax suddenly widened and rounded on the sides about the middle, behind which there is an oblique notch; with fairly large, almost reticulate, punctures. Elytra oblong, lightly widened at apical third; with punctures a little larger than on prothorax. Under surface with fine, close punctures. Length, 3–3·5 mm.

Hab.—Victoria: Mitchell Gorge (E. Nye, C. Oke).

The black markings on the head and pronotum seem to be constant, but on the elytra the subbasal mark varies; it never touches the suture or sides, and only very narrowly the base near the scutellum, it spreads back to the pale median spot and generally stops there, though it sometimes passes beyond. On some specimens the elytral marks are sharp and clearly defined; in others they gradually merge into the paler shades.

An interesting little species, of which a few examples were obtained as the result of much energetic beating of climbing vines. Types in Coll. Oke. Paratype in Coll. Nye.

DONACINAE.

MICRODONACIA TERRICOLA, n. sp. Text-fig. 18.

Pale testaceous, fifth to eleventh segment of antennae infuscated. Under surface with minute pubescence, longer and more conspicuous on legs and antennae.

Head with a few large, deep, round punctures. Antennae long; segment 1 longest and thickest, 2–3 subequal, 4 longer, 5–11 subequal. Prothorax transverse, sides finely margined; with large, unequally distributed, round punctures. Elytra elongate, much wider at base than thorax, strongly narrowed to apex; striae with fairly large close punctures, interstices flat and smooth. Under surface with small, close punctures. Metasternum rather deeply notched behind. Legs fairly long; femora lightly inflated, anterior and intermediate each with a small sharp tooth, posterior with two slightly larger teeth opposite one another on the edges of the lower surface. Length, 3–3·50 mm.

Hab.—Victoria: Emerald (C. Oke), on the ground amongst grass.

This species is referred to *Microdonacia* with some doubts, as the prothorax is finely margined on the sides, but it agrees with the other characters given, and is close to *M. incerta* Bl., from which it differs in the fourth segment of antennae being shorter than the first, instead of longer, the punctures of pronotum not rugulose, and the tooth on front femora being the same as on intermediate and not obsolete. Type in Coll. Oke.

CRYPTOCEPHALINAE.

BRACHYCAULUS MINOR, n. sp. Text-figs. 19, 20.

♂. Parts of pronotum and elytra, base and central vitta on head, and sternum, blackish-brown; three spots on pronotum, scutellum, an obovate, post-scutellary mark (enclosed by carinae) and two spots (on carinae) on base of elytra of a dark golden-brown; rest of head, apex of pronotum, an interrupted, arcuate, post-median fascia and apex of elytra a brighter golden-brown; abdomen pale yellow; legs and antennae dingy-yellow.

Head with an impression down centre from base to centre of eyes, a transverse impression on clypeus. Eyes with an oblong excision in front. Antennae, when drawn over head, reaching base of prothorax; segment 1 long and curved, 2 small, transverse, 3, 4 equal, thin, 5 a little thicker, cylindrical, 6–10 about same length, but widened on inner edge, 11 a little longer, pointed. Prothorax transverse, strongly rounded in front, lightly bilobate on sides; disc raised into two strong elevations; with close, small, rugose punctures. Scutellum longer than width at base, not visibly notched at base, truncate at apex, where it is well elevated. Elytra with five more or less interrupted carinae on each elytron; whole surface finely granulate and with some indistinct punctures between carinae. Legs short and fairly thick; claw joint of tarsi short but distinct beyond the fourth. Apical segment of abdomen with a small shallow impression.

♀. Differs from the male in being larger and of a paler colour; the only blackish marks being behind the elevations on prothorax and partly outlining some yellowish marks which, with the scutellum, form a trident; the colour of the elytra is a pale rusty-brown with a wide medial yellowish fascia, and some spots on the carinae. The sculpture of the head and pronotum is the same as the male, but on the elytra there are three rows of sharp, moderate-sized punctures between the carinae. The antennae differ in being shorter, with segments 7–10 short and subquadrate. Apical segment of abdomen with a large, deep, foveate impression. Length, ♂ 2·70 mm.; ♀ 3·50 mm.

Hab.—Victoria: Inglewood (C. Oke, J. E. Dixon); Sea Lake (J. C. Goudie).

The smallest species so far described, being smaller than *B. posticalis* Lea, from which it is distinguished, *inter alia*, by its glabrous surface. The females resemble miniature specimens of *B. klugi* Saund., but differ in the antennae and scutellum. Types in Coll. Oke. Paratypes in South Australian Museum and Colls. Dixon, Goudie and Lea.

CHRYSOMELINAE.

EUGASTROMELA.

The species of this genus, though widely spread in Victoria, are rare beetles. The imagines are always found on the ground, either under cover or, more often, in moss.

Mr. Lea in his description of the genus says: "Glabrous except for antennae and tarsi." This is certainly not correct for the three Victorian species. They all have the under surface clothed with short, pale pubescence and the apices of the tibiae have a conspicuous patch of reddish silky pubescence.

To ascertain if the genus is really apterous, as presumed by its author, I have examined both sexes of *metasternalis* and *flavitarsis* and the male of *abdominalis*, and have found all specimens examined to be without wings.

EUGASTROMELA FLAVITARSIS Lea. Text-fig. 21.

♂. Differs from the ♀ in having the basal segment of anterior tarsi much larger and the metasternum depressed, with a short, semicircular carina on its apex. The basal segment of abdomen is lightly convex and the apical segment is impressed.

Hab.—Victoria: Ringwood, Belgrave, Gembrook, Traralgon, Moe (C. Oke).

Two specimens (♂, ♀), now in the South Australian Museum, were taken together at Moe, in moss on the ground, and as they are slightly immature in colour, I presume that they bred there, or, at least, completed their metamorphosis there. Allotype ♂ in Coll. Oke.

EUGASTROMELA ABDOMINALIS, n. sp.

Black; coxae and trochanters reddish; femora and tibiae diluted with red; antennae, labrum and palpi testaceous. Under surface, legs and antennae with very short, pale pubescence.

♂. Head with a sinuate impression near each eye running into the semicircular impression around the clypeus. Antennae with segment 1 thick, about three times as long as 2, 2 smallest, 3 longer than 4, 4–5 equal. Prothorax transverse, laevigate; with a row of elongate punctures on posterior margin. Elytra with eight uneven rows of large punctures and six obtuse tubercles on each elytron. Metasternum with a fine carina between intermediate coxae and with a semicircular carina from coxa to coxa, reaching the apex of the sternum in its centre, the space behind depressed. Abdomen constricted across middle; basal segment with a transverse impression, making the segment appear as though it were two segments.

♀. Differs in having the metasternum convex and without apical carina, and the basal segment of anterior tarsi narrower. Length, 4 mm.

Hab.—Victoria: Whittlesea, Killara, Warburton (C. Oke).

The basal half of the first abdominal segment is on a higher plane than the apical, and on the type (from Whittlesea) this is traversed by three fine lines, but on the specimen from Warburton there is only one line and the carina on metasternum is not so elevated. The specimen from Killara is a female and, though the basal half of the first segment is raised, it is without these fine lines, but has the transverse impression which makes the segment appear as though it were two. The elytron, though it has as numerous swellings, with the seriate rows of punctures "pushed" out of line as on *metasternalis*, has fewer conspicuous tubercles than that species. Types in Coll. Oke.

GEOMELA GABRIELI, n. sp.

Upper surface black or nearly so, with testaceous markings; sternum, front angles of prosternum excepted, reddish testaceous; anterior angles of prosternum, abdomen, epipleurae, legs and base of antennae flavous; antennae towards apex infuscated. Glabrous. Nitid.

Head with minute punctures; clypeal suture curved, foveate at the sides; an elongate fovea above each eye. Antennae of moderate length, segment 3 scarcely as long as 4–5 combined, 7–11 widened, 11 not much longer than 10. Prothorax more than three times as wide as long; with moderate-sized, unevenly distributed punctures. Elytra with rather small, but very distinct punctures in the vague striae; interstices flat and almost impunctate. Epipleurae rather wide at base, terminating just before apex, with some rather feeble, transverse impressions. Under surface with fine, close punctures. Abdominal lamellae narrow, strongly rounded behind. Length, 2·65–2·80 mm.

Hab.—Victoria: Lorne, in moss (C. Oke, and in moss received from Mr. C. J. Gabriel).

Very similar to *G. parvula* Wilson in size and outlines, being more rounded than *G. blackburni* Lea, but differs from that species by its colour and markings, in its stronger punctation of pronotum and sparser punctures of interstices.

The markings on the upper surface are hardly alike on any two specimens. But, taking the ground colour as black, the testaceous markings are labrum; on pronotum: a large medio-basal blotch and, generally, its anterior angles, but on two specimens, nearly the whole surface; on elytra: a narrow lateral margin, a broad sutural stripe, covering the suture and second striae from base to apical slope, where it is widened into a transversely placed oval blotch, and there is a light spot on the base of the fourth interstice, though it is sometimes continued as a stripe for about a quarter of the length of the elytra. I have much pleasure in naming this species after Mr. Gabriel, who has been very kind in obtaining moss for me from Lorne and other localities. Types in Coll. Oke. Paratypes in Colls. South Australian Museum, Dixon, Lea, Nye.

GEOMELA PARVULA Wilson.

There are several specimens of this species before me, including two that were identified by Mr. Wilson as his species, all from moss in the Dandenong Ranges. These show that the species varies slightly in its brownish markings, particularly in regard to suture and base of elytra, which, in some specimens, require a close scrutiny to detect. There is also a slight brassy gloss on upper surface, not mentioned in the description.

The species was described as a *Chalcolampra*, but it certainly belongs to *Geomela*, and is close to the species described above. Its front coxal cavities are open behind and its tarsal claws, although slightly swollen and faintly angulate at base, are not armed. The abdominal lamellae are rather narrow and strongly rounded behind.

GALERUCINAE.

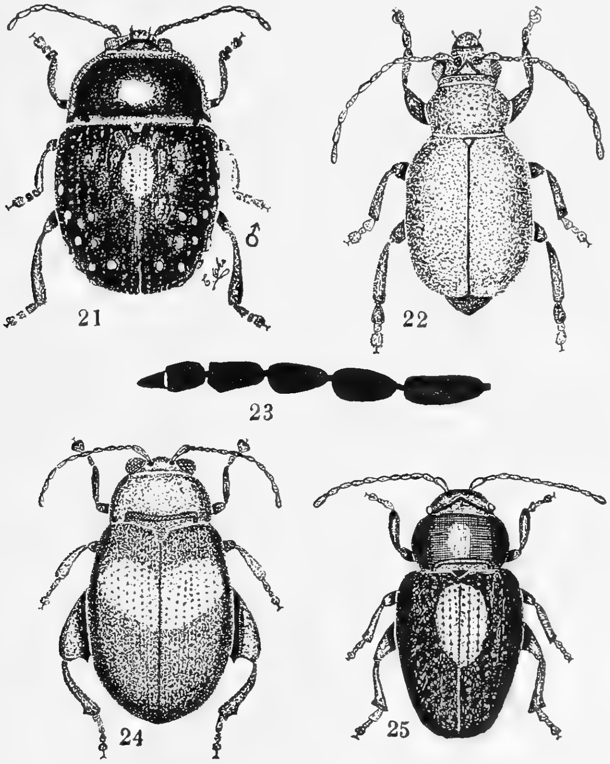
NEORUPILIA FUSCA, n. sp. Text-fig. 22.

Obscure yellowish-brown, apex of sixth to eleventh segments of antennae infuscated.

Head with a transverse, impressed line between the back of the eyes; between this line and the antennal ridges is a triangular fovea. Antennae long and thin, reaching hind coxae; all segments elongate. Prothorax transverse, strongly rounded on the sides, widest in front of middle; with very fine close punctures. Elytra short, leaving apex of abdomen exposed; with rather fine, close punctures and very fine, short, sparse pubescence. Length, 2·50 mm.

Hab.—Victoria: Belgrave (C. Oke).

A smaller and darker species than *N. flava* Lea and with different punctures. Type in Coll. Oke.



Text-figs. 21-25.

21.—***Eugastromela flavitarsis*** Lea, ♂. 22.—*Neorupilia fusca*, n. sp. 23.—*Tomyris* ***intermixta***, n. sp. Antenna of male. 24.—*Arsipoda montana*, n. sp. 25.—*Hyphalticoda* ***caesita***, n. sp.

EUMOLPINAE.

TOMYRIS INTERMIXTA, n. sp. Text-fig. 23.

Dark metallic bronze-purple with fiery reflections; legs, labrum and first four segments, and bases of fifth to eighth segments of antennae testaceous; tarsi, palpi and rest of antennae piceous; under surface dull brassy-green. Rather densely clothed with short, whitish pubescence, intermixed with rows of longer, blackish setae.

♂. Head with fine reticulate punctures. Antennae long, segment 1 thick and curved, 2 short, subglobular, 3–4 equal, 5 longest, 6–7 equal, obconic, 8–10 increasing from base to near apex on inner edge then obliquely cut away, 11 longer than wide, 12 short, conical. Thorax strongly transverse, rounded on sides, widest behind middle, strongly bisinuate at base; basal margin unusually distinct; punctures a little coarser than on head. Elytra with shoulders prominent; striae indistinct; surface subgranulate, more noticeable on basal third. Posterior tibiae deeply notched near apex. Apical segment of abdomen notched in middle; basal segment raised down centre, though scarcely carinate. Length, 6·50 mm.

Hab.—Victoria: Anakies (C. Oke), unique.

This species will be easily distinguished by its large size, clothing and antennae. Most of the elytra and centre of pronotum is dull, but the rest of the surface is shining. Type in Coll. Oke.

HALTICINAE.

ARSIPODA MONTANA, n. sp. Text-fig. 24.

Reddish-testaceous; antennae, four basal joints excepted, base of head and some indistinct marks on pronotum infuscated; elytra, a large transverse, medial plaga and apex excepted, black. Nitid.

♂. Elongate-oval. Subdepressed. Head smooth, interocular impression very feeble, with supra-orbital foveae. Antennae reaching hind coxae; lightly thickened towards apex; with segment 1 moderately long, curved, thickened to apex, 2 short, 3–10 cylindric, subequal in length, 11 a little longer. Prothorax transverse, lightly narrowed in front; distinctly margined all around, the anterior angles suddenly widened; with a strong transverse impression near base, ending one-fifth before sides and turned sharply back to base; with very fine close punctures. Elytra elongate, seriate-punctate, the punctures rather small and closely set; the interstices flat, with fine, close punctures; shoulders raised and smooth. Abdomen constricted across middle, apical segment emarginate. Posterior tibiae with a small tooth near apex, behind which is a feeble notch; apex with a sharp dark tooth.

♀. Differs in being larger and in having the abdomen convex beneath, with its apex rounded. Length, 4·25–5 mm.

Hab.—Victoria: Beechworth (C. Oke), Mt. Buffalo (F. M. Burnet); N. S. Wales: Mt. Kosciusko (C. Oke).

A very distinct species, which in Blackburn's table would fall between *A. podontioides* Bl. and *A. aenescens* Bl., from both of which it differs by its colours. It is also distinguished from the former by its shape and the sculpture of the pronotum, and from the latter by its smooth head. Types in Coll. Oke. Paratypes in Coll. Burnet.

ARSIPODA METALLICA, n. sp.

Black, with dark blue reflections in parts; base of head and pronotum metallic bronze; elytra metallic green with bronze reflections; tarsi and five basal joints of antennae testaceous. Nitid. Dorsal surface glabrous, ventral and antennae with fine, pale, silky pubescence.

♂. Head transversely impressed between eyes. Eyes large, very convex, facets coarse. Antennae passing hind coxae; segment 1 stout, same length as 5, 2 short, 3–4 longer, equal, 5–7 a little longer, 8–10 shorter, 11 acuminate and appearing to be of two joints. Prothorax transverse, apex truncate, base strongly bisinuate, sides obliquely narrowed to apex; finely margined all around, lateral lightly explanate and feebly reflexed; with an arcuate, transverse line near base, ending in an elongate fovea at either end; with fine close punctures. Scutellum small, rounded behind, smooth. Elytra with scutellar striole and ten, including the marginal, striae of moderate-sized punctures, the sixth and seventh interrupted by the shoulders and not reaching the base; interstices flat and with very fine punctures. Abdomen and legs with fine punctures. Apical segment of abdomen sinuately emarginate.

♀. A little wider than the ♂, with the apex of abdomen rounded. Length, 5 mm.

Hab.—Victoria: Ringwood, Fern Tree Gully, Killara, Warburton (C. Oke).

Of the size of *A. detersa* Bl., but the line at base of pronotum very distinct (absent in *detersa*), also colour different. In Blackburn's table it would be associated with *A. concolor* Bl., from which it differs in being broader and flatter, in the colour and the impression on head different, and in having the hind femora more strongly developed. The colours are constant in all the examples I have examined. Types in Coll. Oke.

HYPHALTICODA, n. gen.

Body oval, convex; finely pubescent; winged. Head transversely sulcate between eyes. Eyes round, prominent, facets rather fine. Antennae of eleven segments; rather close together at insertion; filiform; reaching hind coxae in male, shorter in female; third segment shorter than adjacent ones. Prothorax transverse, very finely margined all around; with a transverse sulcus near base, turned down to base at each end, some distance from margin. Scutellum small, rounded behind. Elytra a little wider at base than prothorax; seriate-punctate; finely margined to near apex; epipleurae moderately wide at base, becoming obsolete at apical fourth. Prosternum narrowly carinated between coxae; meso- and metasternum short, meta- slightly longer than mesosternum. First segment of abdomen longer than next three combined, 2–4 equal. Legs of moderate length; posterior femora inflated, convex below, channelled on inner edge; all the tibiae with a small mucro in the usual position.

This genus falls beside *Hyphaltica* in Blackburn's table (*Trans. Roy. Soc. S. Aust.*, xx, 1895), from which genus it is distinguished, *inter alia*, by the mucro of the intermediate tibiae being exactly as on the other legs, and the posterior femora being convex beneath and distinctly channelled on the inner edge.

Genotype, *H. caesita*, n. sp.

HYPHALTICODA CAESITA, n. sp. Text-fig. 25.

Dark blue; legs and antennae black with a bluish gloss; coxae and tarsi diluted with red. Upper surface glabrous, under surface with very fine, short, pale pubescence. Nitid.

♂. Head with an arcuate impression from back of either eye and meeting in front, just behind antennae. Antennae with the basal segments thin, becoming thicker towards apex. Thorax strongly rounded on the sides, a little wider at base than at apex; with very fine, microscopic punctures. Elytra obovate; seriate punctures small and fairly close together, interstices with fine punctures. Sternum and abdomen with moderate punctures. Abdomen lightly constricted across middle; apical segment incurved on apex, subapical with a shallow fovea.

♀. Differs in having shorter and thinner antennae, and the abdomen convex, with the apex rounded. Length, 2 mm.

Hab.—Victoria: Frankston (C. Oke). A very pretty little dark blue species found in fair numbers on, or mostly on the ground under *Amperea spartioides*.

The punctation of the pronotum is exceedingly fine and might easily escape observation, while the punctures of the elytra between the seriate rows, though fine, are easily seen. Type in Coll. Oke.

CONTRIBUTIONS TO OUR KNOWLEDGE OF THE ACTINOMYCETALES. III.

FURTHER OBSERVATIONS ON THE GENUS MICROMONOSPORA.

By H. L. JENSEN.
Macleay Bacteriologist to the Society.

(One Text-figure.)

[Read 29th June, 1932.]

In a recent paper (Jensen, 1930) the present writer described 10 strains of Actinomyces-like organisms of a type for which Ørskov (1923) had previously suggested the generic name *Micromonospora.* It was not at that time found possible to classify them as definite species. The present paper represents a study of a larger number of strains, 67 in all, and in addition to these a culture of "*Streptothrix*" *chalceae*, the organism for which Ørskov suggested the name *Micromonospora.* This culture was obtained from E. Pribram's Mikrobiologische Sammlung (formerly Kral's Bakteriologisches Museum), Vienna.

"*Streptothrix*" *chalceae* was first isolated from the air by Foulerton (1905), who gave it a very brief description without any morphological details. In a later contribution, Foulerton (1910) shows macroscopic pictures of the cultures, but gives no further information. According to Foulerton and to a few notes by Leiske (1921), it is a long-hyphed actinomyces with a red vegetative mycelium and no aerial spores, possessing diastatic and proteolytic properties. Näslund and Dernby (1923) also state that it has a strong proteolytic power, but otherwise they do not comment upon it. Ørskov (1923) mentions the red colour of the mycelium in nutrient agar, besides a brownish-black discoloration in certain other media, e.g., water agar. He, as the first, describes its peculiar mode of spore formation: no aerial spores, but formation of small, oval, refractive, spore-like bodies situated singly at the tips of small branches of the vegetative mycelium.

The present strain of *S. chalceae* appeared to have undergone such profound changes during the long period of artificial cultivation, that it showed hardly any resemblance to the earlier descriptions. Macroscopically it produced a heavy, tough, wrinkled growth in agar media and potato, first whitish, later changing to dirty greyish-yellow, with no aerial mycelium or a trace of white. In liquid media it grew as small firm granules of the same colour, gradually forming a surface pellicle. On filter-paper in asparagine-solution it grew well, but without attacking the paper. Milk was slowly digested without any coagulation. Microscopical examination showed a tangled mass of richly branching hyphae, 0·4-0·7 μ thick, often with a granular content, but without any spores. Neither did the direct microscopical observation of the development of agar colonies (Ørskov, 1923) reveal any spore formation of the *Micromonospora*-type. Short filaments of aerial mycelium were occasionally seen in quite young colonies, but they disappeared again after 3–4 days without forming aerial spores. As this organism thus seems, since its examination in 1923 by Ørskov, to have lost the very character upon which its identification first and foremost rests, viz., the spore formation, it cannot be identified directly with any of the other strains of *Micromonospora*.

Some of the 67 strains isolated by the writer were obtained from soil samples in the School of Agriculture, Sydney University; these are marked with numerals in Table I. Others were obtained from one particular soil (red clay from an orchard, of pH 7·9) with additions of cellulose or lignic acid; they are marked with capital letters followed by numerals. The medium for isolation was the dextrose-casein-agar previously described (Jensen, 1930); also the media for cultural study were the same as previously used. The temperature of cultivation was 30–32° C.

All strains are capable of liquefying gelatin and of hydrolyzing starch, although with varying rapidity. Nearly all digest milk,* mostly after a previous coagulation. Dextrose-asparagine-agar seemed of all solid media to give the most characteristic growth and spore formation. Nutrient agar and potato gave mostly an uncharacteristic growth consisting of a red, wrinkled mycelium without any spores. Morphological differences were found to be too slight to allow any real differentiation between the strains, but various cultural and physiological characters which might serve as a basis for species distinction, are listed in Table I. The constantly positive characters of diastatic action, digestion of milk and liquefaction of gelatin have not been included.

TABLE I.

Cultural and Biochemical Properties of Micromonospora.

Strain.	Colour of vegetative mycelium.	Sporulation.	Coagulation of milk.	Inversion of saccharose.	Reduction of nitrate.	Decomposition of cellulose.
P4	orange	very rapid	+	(+)	−	+
P3	”	”	+	(+)	−	−
C1	”	”	+	−	−	+
C2	”	”	+	+	−	+
C4	”	”	+	(+)	−	(+)
C7	”	”	+	+	−	+
L6	”	”	+	−	−	+
L7	”	”	+	−	−	+
125 VI	”	”	−	−	+	+
125 c	”	”	−	−	+	+
279 S3	”	”	−	−	+	+
163 III	”	”	+	−	−	−
176 XVII	”	rapid	−	−	+	+
129 V	”	”	−	−	−	−
279 S1	”	”	−	−	+	(+)
L1	”	”	+	+	−	(+)
P1	”	”	+	+	−	(+)
U IV	”	”	+	+	−	+
P8	”	”	−	+	−	+
P13	”	”	+	−	−	+
P15	”	”	−	+	−	+
P18	”	”	+	+	−	+
C6	”	”	+	+	−	+

(+) indicates a faint reaction.

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* A few strains did not show any digestion after two months, but they exhibited a proteolytic action on milk agar.

TABLE I—*Continued.*
Cultural and Biochemical Properties of Micromonospora.

Strain.	Colour of vegetative mycelium.	Sporulation.	Coagulation of milk.	Inversion of saccharose.	Reduction of nitrate.	Decomposition of cellulose.
C10	orange	rapid	+	+	−	+
L2	,,	,,	+	−	−	+
L3	,,	,,	+	−	−	+
L8	,,	,,	+	+	−	+
L11	,,	,,	−	−	−	+
P17	pink	,,	+	(+)	−	+
163 S1	orange	fairly rapid	−	−	+	−
P2	,,	,,	+	+	−	+
P6	,,	,,	+	−	−	+
P7	,,	,,	+	−	−	+
P12	,,	,,	−	−	−	+
L12	,,	,,	−	+	−	+
L14	,,	,,	+	(+)	−	+
L5	pink-orange	,,	+	(+)	−	+
P9	orange	slow	+	−	−	+
P10	,,	,,	+	(+)	−	+
P11	,,	,,	+	+	−	+
P14	,,	,,	+	+	−	+
P20	,,	,,	+	(+)	−	(+)
P21	,,	,,	+	+	−	+
P23	,,	,,	+	+	−	(+)
C5	,,	,,	+	+	−	−
C11	,,	,,	+	+	−	+
C12	,,	,,	+	+	−	−
L4	,,	,,	+	−	−	+
L9	,,	,,	+	+	−	+
L17	,,	,,	+	+	−	(+)
L18	,,	,,	+	+	−	−
L13	pink-orange	,,	+	−	−	(+)
P19	,,	,,	+	−	−	−
P5	,,	,,	+	−	−	+
176 XII	,,	,,	−	−	−	+
P22	,,	,,	+	+	−	−
C3	,,	,,	+	+	−	−
C8	,,	,,	+	(+)	+	+
U18	,,	,,	−	−	−	−
C9	pale pink	,,	+	(+)	−	+
125 II	brown	rapid	−	+	+	(+)
279 Sb	,,	,,	−	+	−	(+)
125 I	pale orange	very slow	−	−	−	−
279 S2	,,	,,	−	−	−	−
279 S4	,,	,,	+	−	−	−
176 IV	deep blue	very slow	−	−	−	−
125 a	,,	,,	+	−	−	−

(+) indicates a faint reaction.

It seems possible to distinguish only 4 broad groups of strains. Group 1, which is the largest, comprising 60 strains out of 67, includes strains which grow fairly rapidly on dextrose-asparagine-agar, producing a heavy, dense mycelium of various orange hues, mostly corresponding to "Light Salmon Orange", "Mikado Orange", "Orange Chrome", or "Cadmium Orange" (Ridgeway, Color Standards and Nomenclature). The intensity of the colour varies; it is often mixed with pink, and then often very pale or nearly white. Spores appear as a soft, glistening layer on the surface of the vegetative growth, of a colour corresponding to "Olivaceous Black", "Deep Slate Olive", or "Brownish Olive" (Ridgeway). In some strains the spore layer covers the whole surface within a week, and the dark colour spreads through the whole growth, but does not diffuse into the agar to any considerable extent. In other strains it may take a month or more to develop. There seems to be a certain association between pigmentation and abundance of spore formation, the strains with a pale pinkish-orange mycelium generally showing a slower sporulation. Most strains coagulate the milk previous to digestion, many of them invert saccharose, and some reduce nitrate to nitrite. When grown on filter paper, most strains are seen to attack the cellulose. The most actively cellulose-decomposing, rapidly sporulating strains (176 XVII, U IV, 125 c) produce a broad, greenish-black zone of disintegrated paper along the surface of the solution, others grow as extensive orange patches in which the paper appears corroded, softened and semi-transparent. The degree of attack also varies widely. There is no correlation between the four examined biochemical characters, which occur in no less than 10 different combinations (the most common of these is: coagulation of milk—inversion of saccharose—no reduction of nitrate—decomposition of cellulose), nor do these characters show any correlation with the pigmentation or the rapidity of sporulation. It seems necessary, therefore, to regard the whole group as one big "species-group" with a rather wide range of variation. "*Streptothrix*" *chalceae*, according to the data of previous authors (Foulerton, 1905; Lieske, 1921; Ørskov, 1923), seems to fall into this group with which it agrees in the following points: red vegetative mycelium without any aerial growth; no soluble pigments mentioned; comparatively strong proteolytic action (Näslund and Dernby, 1923). We will, therefore, at least until such a time when future study may show the possibility of further division of the group into more species, give it the name of *Micromonospora chalceae* (Foulerton), n. comb.

The second group (strains 125 II and 279 Sb) is distinguished from the first by the formation of a soluble pigment which first colours the initially orange mycelium deep brown to nearly black and afterwards diffuses into the medium, to which it imparts the same characteristic colour. The pigment is most distinct in dextrose-asparagine-agar or -solution, but very slight in gelatin or milk; it is thus different from the brown pigment produced by many species of *Actinomyces* in protein-containing media.* Sporulation is rapid and abundant, appearing as moist, brownish-black cushions on the surface of the growth. Milk is not coagulated, but slowly rendered semi-transparent, with a slight greyish-brown discoloration. Both strains invert saccharose, and one reduces nitrate to nitrite. They grow scantily on filter paper, producing small orange to brownish spots scattered over the whole strip of paper, which is not rendered transparent, but

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* In one strain—125 II—the pigment has shown signs of becoming less intense after two years' cultivation.

slowly softened, so that after two months it can be reduced to a pulp by shaking the tube. This group seems sufficiently well defined to be regarded as a separate species, *Micromonospora fusca*, n. sp.

The third group (strains 125 I, 279 S2, and 279 S4) attaches itself closely to the least vigorously growing and most slowly sporulating strains of Group 1. The growth on dextrose-asparagine-agar is slow and scant, the vegetative mycelium is thin and flat, of a pale pink to pale orange colour, spreading deeply into the medium and not until lately showing thin greyish spots or crusts of spores. In milk they grow as small orange granules; one strain coagulates the milk and redissolves it slowly with a faint acid reaction. Saccharose is not inverted, nitrate is not reduced, and cellulose is not decomposed. This group may be called *Micromonospora parva*, n. sp.

Finally, strains 176 IV and 125a develop slowly, like those of the previous group, but eventually they produce a quite heavy and dense vegetative mycelium of a deep greenish-blue colour, most nearly corresponding to "Dusky Green Blue" (Ridgeway). The blue pigment does not diffuse into the agar. Its formation seems to depend on the free access of air; on the bottom of solution cultures the strains grow as round, firm granules of a white to pale pink colour. One strain coagulates milk, but the coagulum is not redissolved within two months, although a slight proteolytic action is discernible on milk-agar. Saccharose is not inverted, nitrate is not reduced, and cellulose is not decomposed. This group might properly be called *Micromonospora coerulea*, n. sp.

Summary Description of the Species of Micromonospora.

We are now in a position to give the following generic definition of *Micromonospora*: Actinomyces-like organisms, forming a mycelium of delicate, non-septate hyphae, 0·3–0·8 μ thick, without aerial mycelium (or traces, then without spores), but producing spores singly on the distal ends of short lateral branches of the vegetative mycelium; spores spherical to oval, 1·0–1·2 × 1·2–1·5 μ. Mycelium and spores Gram-positive, not acid-fast. Aerobic organisms, most frequently met with in soil. The type species is *Micromonospora chalceae* (Foulerton).

I. Vigorously growing organisms, typically with copious spore formation on dextrose-asparagine-agar.
  A. Vegetative mycelium pale pink to deep orange, no typical soluble pigment .... *Micromonospora chalceae.*
  B. Vegetative mycelium orange changing to brownish-black, brown soluble pigment .... *Micromonospora fusca.*
II. Slowly and feebly growing organisms, with scant spore formation on dextrose-asparagine-agar, no soluble pigment.
  A. Vegetative mycelium pale pink to pale orange .... *Micromonospora parva.*
  B. Vegetative mycelium blue .... *Micromonospora coerulea.*

1. MICROMONOSPORA CHALCEAE (Foulerton), n. comb.

Vegetative mycelium on dextrose-asparagine-agar heavy, compact, raised, not spreading much into the medium. Spore-layer well developed, moist and glistening, brownish-black to greenish-black, this colour sometimes spreading through the whole mass of growth. Grows in liquid media as small firm orange granules or flakes. Starch is hydrolyzed. Gelatin is liquefied. Milk is digested with a faintly acid reaction, mostly after a previous coagulation. Many strains invert saccharose. Some strains reduce nitrate to nitrite. Most strains decompose cellulose. Proteolytic action seems stronger in this than in the other species of this genus. Optimum temperature for growth, 30–35° C. Thermal death point of mycelium, 70° C. in 2–5 minutes. Spores resist 80° C. for 1–5 minutes.

2. MICROMONOSPORA FUSCA, n. sp.

Vegetative mycelium on dextrose-asparagine-agar heavy, compact, orange, rapidly changing to deep brown and nearly black; spore-layer moist, glistening, greyish- to brownish-black. Deep brown soluble pigment. Grows in liquid media as small brown granules and flakes. Starch is hydrolyzed. Gelatin is liquefied. Milk is slowly digested; no coagulation. Saccharose is inverted. Reduction of nitrate, positive or negative. Cellulose is attacked to a slight extent.

3. MICROMONOSPORA PARVA, n. sp.

Scant growth on dextrose-asparagine-agar; vegetative mycelium thin, spreading widely into the agar, almost colourless to pale pink or orange. Sporulation scant, giving rise to thin greyish, moist crusts on the surface. Starch is hydrolyzed. Gelatin is liquefied. Milk is left unchanged, or coagulated and slowly redissolved with faintly acid reaction. Saccharose is not inverted. Nitrate is not reduced. Cellulose is not decomposed.

4. MICROMONOSPORA COERULEA, n. sp.

Slow growth on dextrose-asparagine-agar; vegetative mycelium dense, dark greenish-blue, with a hard and glossy surface. Sporulation very scant. The surface sometimes shows a thin white veil resembling aerial mycelium, but without aerial spores. Grows in liquid media as fairly large, firm, round, white to pink granules. Starch is hydrolyzed. Gelatin is liquefied. Saccharose is not inverted. Nitrate is not reduced. Cellulose is not decomposed.

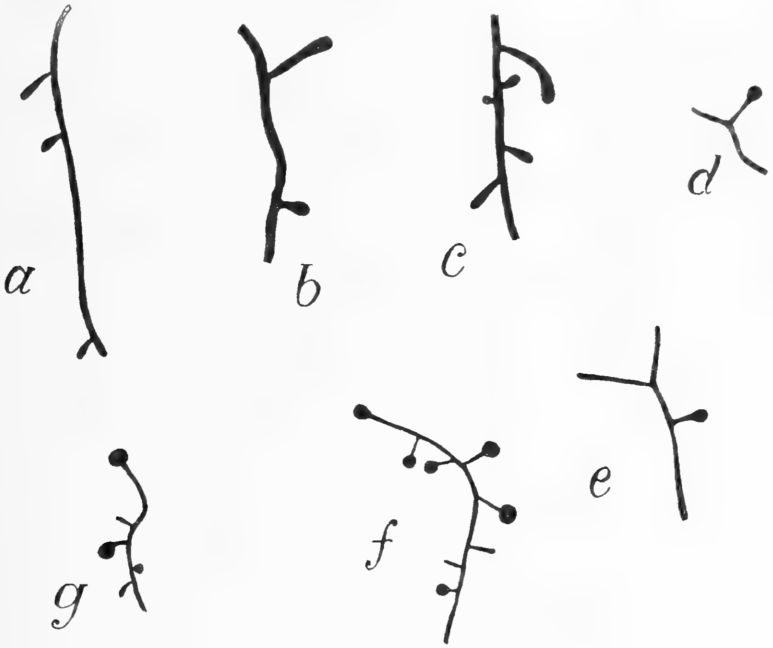
Relation of Micromonospora *to Other Genera of Actinomycetales.*

As to the relation of this genus to those other groups of Actinomycetales which it resembles most closely in its general appearance, viz., *Actinomyces* and certain forms of *Proactinomyces* (Jensen, 1931), it is noteworthy that there is a striking resemblance between the spore apparatus in *Micromonospora* and the formation of young mycelial branches in the other genera. As pointed out in a previous paper (Jensen, 1931), these branches arise as small external buds gradually stretching into filaments separated from the mother stem by basal constrictions and often assuming a club-like shape (Text-fig. 1, *a–e*). The conclusion lies near, that such club-like branches may further develop into those definite spores of reproductive capacity, which characterize *Micromonospora* (Text-fig. 1, *f–g*). Whether the ancestral forms of *Micromonospora* are to be sought among *Actinomyces* (in which case we would also have to assume a loss of the power of forming aerial spores in order to arrive at *Micromonospora*) or among forms of *Proactinomyces* with undivided vegetative mycelium (like the filamentous modification of *Proact. polychromogenes*, for instance), seems uncertain. It speaks for the former alternative, however, that *Micromonospora* in most biochemical respects agrees with *Actinomyces* rather than with *Proactinomyces*, as shown below:

	Micromonospora.	*Actinomyces.*	*Proactinomyces.*
Diastatic action	Constantly positive.	Constantly positive.	Positive or negative.
Liquefaction of gelatin	Constantly positive.	Constantly positive.	Positive or negative.
Digestion of milk ..	Constantly positive.	Constantly positive.	Positive or negative.
Decomposition of cellulose	Positive or negative.	Positive or negative.	Constantly negative.

Occurrence of Micromonospora *in Soils of Various Types.*

In a number of soils of various types, in which the numbers of bacteria and actinomycetes were determined by plate counts on dextrose-casein-agar, a special search was made for colonies of *Micromonospora,* which were identified by transfer to slants of dextrose-asparagine-agar. The results, recorded in Table II, show a certain evidence that these organisms are, at least relatively, most numerous in neutral to alkaline soils from districts with a low rainfall.



Text-figure 1.

a-c, Vegetative mycelium of *Actinomyces*; *a, Act. bobili,* dextrose-asparagine-agar, 2 d. 28° C.; *b, Act.* 6 S1, dextrose-casein-agar, 1 d. 28° C.; *c, Act. viridochromogenus,* 2 d. 30° C.; *d-e, Proact. polychromogenes,* filamentous form, dextrose-asparagine-solution, pH 8·3, 9 d. 30° C.; *f, Micr. coerulea,* filter paper, 18 d. 32° C.; *g, Micr. chalceae,* dextrose-asparagine-solution, 6 d. 32° C. Magnification, × 1,500.

SUMMARY.

A study of 67 strains of *Micromonospora,* isolated from soil, showed that these organisms exhibited only few morphological and biological differences which could be used for classification. On the basis of the character of growth in agar media and certain physiological differences, it was found possible to divide them into four species-groups, one of which is probably identical with "*Streptothrix*" *chalceae* (Foulerton). The other three are described as new species, *Micromonospora fusca, parva,* and *coerulea.* The first species (*M. chalceae*) was by far the most common. They seem to occur most frequently in neutral to alkaline soils from comparatively dry districts.

TABLE II.

Relative Frequency of Micromonospora *in Various Soils.*

Soil.	pH.	Average annual rainfall, i.*	Actinomycetes.	
			Total, Mill. per gm.	Micromonosporae %
Red sandy loam, poor in organic matter, Riverina..	7·9	15·7†	13·9	4·7
Red sandy loam, poor in organic matter, Riverina..	6·8	15·7†	2·7	17·5
Red sandy loam, poor in organic matter, Riverina..	6·5	15·7†	1·7	4·5
Red-brown sand, poor in organic matter, Cowra..	5·1	23·4	1·8	0
Alluvial clay, rich in organic matter, Bathurst ..	6·0	23·6	2·2	5·3
Humus soil, very rich in organic matter, Glen Innes	5·3	31·3	26·1	0
Heavy loam, rich in organic matter, Sydney University	7·3	47·5	2·9	0
Heavy loam, rich in organic matter, Sydney University	6·6	47·5	6·5	1·0
Heavy loam, rich in organic matter, Sydney University	5·5	47·5	3·2	0
Heavy loam, rich in organic matter, Sydney University	4·8	47·5	5·4	1·5
Sand, rich in undecomposed plant residue, Rose Bay	4·8	47·5	0·24	0

*From New South Wales Statistical Register, 1929–1930.

†Average of 3 stations in the Riverina District.

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TRICHOPTERYGIDAE OF AUSTRALIA AND ADJACENT ISLANDS.

DESCRIPTIONS OF TWO NEW GENERA AND EIGHTEEN NEW SPECIES.

By CEDRIC DEANE, A.M.I.E.Aust.

(Seventeen Text-figures.)

[Read 27th July, 1932.]

In this paper, my third on the family, are described eighteen new species under eight genera, two of which are proposed as new. This brings the number of described species from Australia and adjacent islands to 57, and from the mainland and Tasmania only, including Groote Eylandt, to 41. Table I shows the distribution of the numbers of species over the world and includes those described in the present paper. It has been facilitated by the excellent manner in which the records have been left by Matthews, to whom we owe a great debt of gratitude for our knowledge of these creatures.

Table I. *Summary of Localities.*

Europe: British Isles, 23; Continental, 21; unlocated, 33. Total, 77.

Asia: Continental, 5; Islands, 12. Total, 17.

North America: United States, 23; Canada (incl. B.C.), 12; Mexico, 1; unlocated, 13. Total, 49.

Central America, 36.

South America, 14.

West Indies, 10.

Africa, 5.

Various Islands: Canary Islands, 12; New Zealand, 5; Sandwich Islands, 3; others, 6. Total, 26.

Miscellaneous, 10.

Australia and adjacent Islands: Federal Capital Territory, 1; Victoria, 11; New South Wales, 16; Queensland, 4; Western Australia, 3; Tasmania, 5; Norfolk Island, 1; Lord Howe Island, 3; Murray Island, 1; Papua, 3; Fiji Islands, 5; New Caledonia, 2; Rennel Island, 1; Groote Eylandt, 1. Total, 57.

Total world species, 301.

The uneven distribution, as shown by the table, is due to the lack of systematic collecting, and it will readily be appreciated that over large tracts of land surface the Trichopterygid fauna has been either unexplored or else, if specimens have been collected, they have not been described.

For the benefit of collectors and in the hopes that it may lead to more species becoming known to science, in Table II are listed the situations, in which Trichopterygidae have been found up to date.

Table II. *Environment of Trichopterygidae in Nature.*

1. In rotting leaves: *Leaduadicus*, *Epibaptus*, etc.
2. In fallen leaves: *Ptenidium*, *Actinopteryx*, etc.
3. On the under side of mouldy logs: *Philagarica.*
4. In fungi: *Isolumpia*, *Philagarica.*
5. Under bark: *Achosia.*
6. In rotten wood: *Ptilium.*
7. On the plant *Xanthorrhoea*: *Ptilium.*
8. In ants' nests: *Cnemadoxia*, *Rodwayia.*
9. Flying in sunlight: *Trichopteryx.*
10. Under log on sea beach: *Ptilium.*
11. Walking on mud on sea shore:
12. On river banks: *Actinopteryx.*
13. In river: *Hydroscapha.*

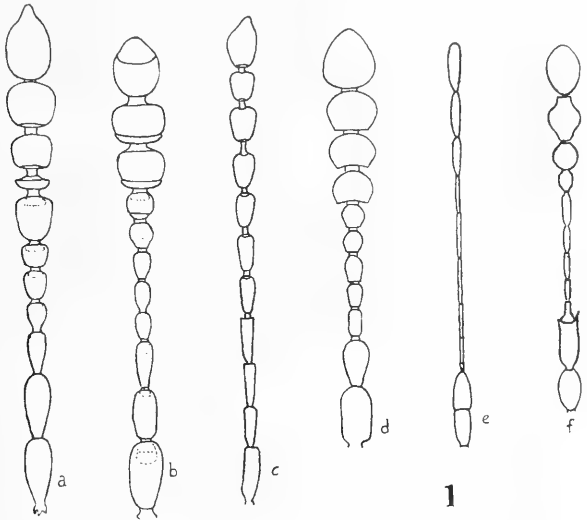
In searching through the materials mentioned under items 1, 2, 4, 5, and 6, the sieve, fly-wire mesh or finer, must be used to hold back the coarse débris and allow the beetles, together with the finer grains, to be spread out on a sheet of paper. The author uses three meshes and the small specimens fall through the finest.

On the question of the proper or most convenient place for the Trichopterygidae to occupy relatively to other families more or less allied, there has been a certain amount of agreement, in that their closeness to the Staphylinidae, Pselaphidae, Silphidae, Scydmaenidae, Scaphidiidae, and Histeridae is generally accepted. Consideration must necessarily be given to such characters as the antennae and palpi, and these should weigh most in this case, which is one of adjusting the several relative positions which are already assumed to be fairly close. The remarkable similarities and differences of the antennae and palpi will be seen in Text-figures 1 and 2. The following argument is offered in favour of the adoption of these structures as a basis: The organs used in performing the highest functions of which the creature is capable should be given priority. In botany the flower is essential and the reproductive organs are mostly used in determining families. In entomology, however, the reproductive organs are not so generally used for this purpose, but rather the organs of the head. In other words, it is appropriate in both branches of science to employ those organs which are the means whereby the individuals perform their highest functions. In the case of plants, reproduction characterizes and raises them above anything of which members of the mineral kingdom are capable. So in animal life, at any rate of the kind under consideration, the powers of the brain, whether we elect to call it that or something else, raise the members above those of the botanical world. The brain then performs through the sense organs, and hence these are used for our purpose.

It has been suggested by Mr. Oke that the apical slender portions of the palpi are apophyses, and there is certainly something of interest in the idea when we keep in mind the similar parts in the case of the allied families. However, in view of the structure of the bases of these appendages, and their mode of reception in the supporting segments, apparently designed to give mobility, I cannot agree that they are merely apophyses, and therefore accord them the full status of palp segments; that is to say, in the case of the Trichopterygidae. Now turning to Text-fig. 2, in the cases of the Scaphidiid (*a*), Pselaphid (*b*) and

Scydmaenid (*c*) examples chosen, it will be seen that each possesses a small appendage whose status as a full segment might be questioned. Evolutionists will find food for thought in reasoning this out.

With reference to the arrangement of the eight families, Staphylinidae, Pselaphidae, Scydmaenidae, Silphidae, Trichopterygidae, Scaphidiidae, Corylophidae and Phalacridae, so as to present their relative proximity to one another, it is my opinion that a linear arrangement is unsuitable; it leaves the members which it includes placed as a number of peas in a row, and, without information



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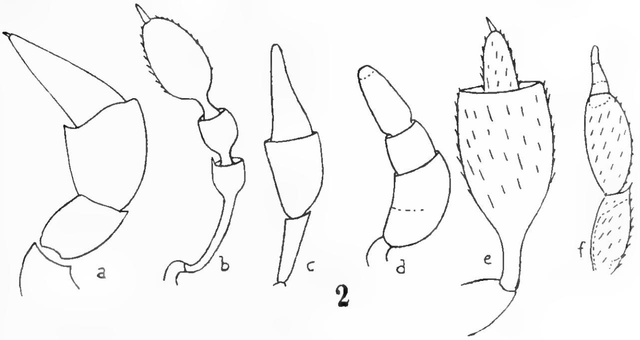

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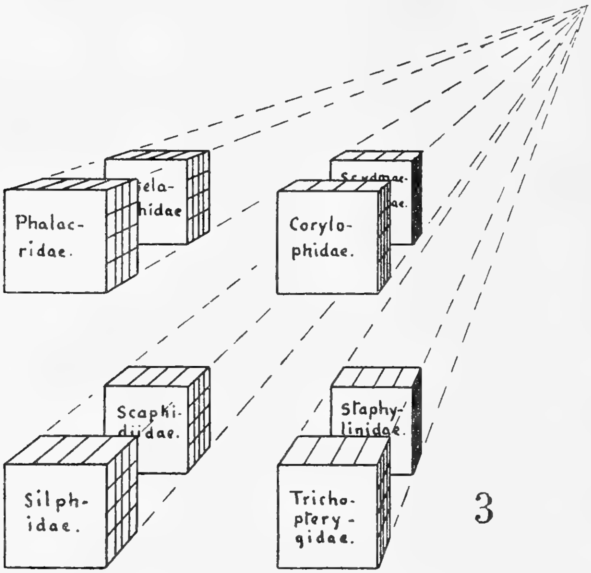
Text-figs. 1-2.

1.—Antennae of various families allied to Trichopterygidae. (*a*) Silphidae (*Catops* or *Choleva*); (*b*) Cryptophagidae (*Atomaria*); (*c*) Staphylinidae (*Conosoma rufipalpe*); (*d*) Scydmaenidae; (*e*) Scaphidiidae; (*f*) Trichopterygidae (*Philagarica pilosa*).

2.—Palpi of various families allied to Trichopterygidae. (*a*) Scaphidiidae; (*b*) Pselaphidae (*Palimbolus armatipes*); (*c*) Silphidae (*Catops* or *Choleva*); (*d*) Cryptophagidae (*Atomaria*); (*e*) Scydmaenidae; (*f*) Staphylinidae (*Conosoma rufipalpe*).

to the contrary, it would be presumed that the spacing were even. But in whatever order these items be arranged, it will be found that some of them become separated in the alignment more than is actually warranted by their characters. Moreover, any graphical representation by plane figures, such as triangles, pentagons, etc., though coming nearer the truth, is still inadequate, and a three-dimensional structure, such as is shown in Text-fig. 3, will be found more satisfactory.



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Text-fig. 3.—Relationship diagram.

In all cases except one the types of the species described herein are mounted on card; the exception is *Ptilium xanthorrhoeae*, a unique specimen and blind, which, owing to its peculiarities, needed special treatment and was mounted in Canada balsam after being drawn. On account of the loss of original shape of outline, to which the Canada balsam setting gives rise, mounting on card is preferred for the types, with balsam mounted specimens in addition where the number of available examples permits. The following species are mounted in Canada balsam: *Philagarica pilosa* Deane (3), *P. parvicornis* Deane (4), *P. parva* Deane (2), *P. pallida* Deane (2), *P. albipennis* Deane (1), *Epibaptus scutellaris* Deane (1), *Ptenidium* sp. (Launceston) (3), *Epoptia rotunda* Deane, *Ptilium xanthorrhoeae* Deane (1), *P. rennelensis* Deane (4), *Achosia femoralis* Deane (1), *A. cara* Deane (2), *A. gigas* Deane (1), *Cnemadoxia okei* Deane (2), *Actinopteryx colossus* Deane (4), *A. hercules* Deane (5), *Neotrichopteryx grandelytra* Deane (5), *Etronia convexa* Deane (5), *Trichopteryx jocosum* Deane (1), *T. australica* Deane (3), *T. convexior* Deane (3), *T. norfolkensis* Deane (2), *Paratuposa placentis* Deane (6), *Cnemadoxia leai* Deane (2).

On the affinity with the Staphylinidae it may be noted that the members of the subfamily Tachyporinae bear resemblances in several features, notably in the palpi, in which the subterminal segment is barrel-shaped and rather large, whilst the terminal is slender, and the combination of the two is approaching that of the Trichopterygidae in general appearance. The species *Conosoma rufipalpe* Macl., from National Park, N.S.W., identified by Mr. A. M. Lea, and the English species *Tachinus ruficollis* Grav., exhibit these features. In larger Staphylinidae of other subfamilies, e.g., in *Hyperomma*, *Eulissus* and *Amphichroum*, there is very little evidence of relationship. In the Tachyporinae the shape of the head, especially at the front, is also a point of likeness, and in addition the general form of the insect is not at all unlike that of some species of the genus *Trichopteryx*, which fact becomes even more noticeable when the latter are seen alive and active in the sunshine, under which conditions they have the habit of extending the abdomen considerably at times. The antennae, too, of the Tachyporinae, although not bearing any strong likeness to the typical Trichopterygidae, are nevertheless of a shape which more nearly approaches these than do most of the other subfamilies of the Staphylinidae.

Key to Genera of Trichopterygidae from Australia and Adjacent Islands.

1.	Posterior coxae large, subtriangular, contiguous	2
	Posterior coxae large, moderately separated	3
	Posterior coxae remote	5
2.	Antennae short, prothorax widest before base	*Paratuposa*
	Antennae moderate, prothorax widest at base	*Philagarica*
3.	Posterior coxae subquadrate, sternal process very large	*Rodwayia*
	Posterior coxae subtriangular, sternal process normal	4
4.	Posterior coxae deepest laterally, elytral apices narrow, eyes wanting	*Cochliarion*
	Posterior coxae deepest medially, elytral apices broad, eyes present	*Isolumpia*
5.	Metasternum not attaining sides of body	6
	Metasternum attaining sides of body	8
6.	Form ovate-convex, prothorax widest at base, sides of elytra tapering	*Actinopteryx*
	Prothorax widest before base	7
7.	Form quadrate-ovate, subdepressed, sides of elytra parallel	*Etronia*
	Form oblong-ovate, elytra subparallel, their apices inversely oblique	*Neotrichopteryx*
8.	Prothoracic lateral margins irregular, eyes prominent, head produced in front	*Epibaptus*
	Prothoracic lateral margins regular, eyes and head normal	9
9.	Widest substantially across elytra, these completely covering abdomen	10
	Characters otherwise	12
10.	Form wide	11
	Form narrow	*Ptenidula*
11.	Front abruptly convex, base of pronotum exposing mesonotum	*Epoptia*
	Without these characters	*Ptenidium*
12.	Widest across prothorax	*Trichopteryx*
	Prothorax not wider than elytra	13
13.	Lateral margins subparallel	16
	Lateral margins strongly arcuate	14
14.	Form wide, ovate, convex, posterior coxae moderately separated	*Leaduadicus*
	Form not so wide, scarcely convex, posterior coxae extremely remote	15
15.	Intercoxal process scarcely developed, sternite sutures conspicuous, posterior tibiae not reaching beyond apex of abdomen	*Achosia*
	Intercoxal process well developed, sternite sutures not conspicuous, posterior tibiae reaching just beyond apex of abdomen	*Cnemadoxia*
16.	Form broad, posterior tibiae reaching far beyond apex of abdomen, prothorax transverse	*Leaptiliodes*
	Characters otherwise	*Ptilium*

PHILAGARICA PARVICORNIS, n. sp.

Oval; highly convex, margin entire, widest across base of elytra, yellowish-brown, underside of same colour. Head almost concealed from above, widely rounded in front, nitid, glabrous. Eyes black, scarcely visible from above; facets coarse. Antennae short, 0·348 of length of body; club 2-segmented; scape short; pedicel rather large; segment 3 conic, rather short; 4 to 7 subcylindric; 9 scarcely thicker than 8; 10 nearly as large as 11, this ovate. Palpi with penultimate joint robust, subapical not deeply inserted. Pronotum highly convex, nitid, glabrous, almost vitreous; sides greatly rounded. Scutellum triangular, medium, glabrous, rather convex, hardly nitid. Elytra widest at base, full, convex, pubescent, close fitting, not dehiscent, suture not raised, projecting well beyond apex of abdomen. Wings pale-grey to white; stalk short. Prosternum glabrous, episterna strongly concave, uneven. Mesosternum glabrous, its episterna marked by thin dark border. Intercoxal process acute, both side and anterior margins strongly concave. Metasternum pilose. Legs medium; anterior coxae rather prominent, contiguous; intermediate separated; posterior contiguous or almost so. Abdomen pilose. Tarsi slender, normal to rather short; claws rather long. Length 0·542 mm.; width 0·262 mm.

Habitat.—Groote Eylandt, North Australia (N. B. Tindale). Type in South Australian Museum.

Differs noticeably from *P. agilis* Deane, in having the antennal club two-segmented, the segments being also shorter. The mesosternal intercoxal process is sharper and the sides as described. Colour also seems a constant feature. In outline, however, the two species resemble one another.

TRICHOPTERYX QUADRILATICA, n. sp. Text-fig. 5.

Subquadrate; lightly convex, broad, widest across prothorax, yellow, pubescent. Head medium, broadly rounded; clypeus produced a little downward, mouth parts prominent. Eyes deeply set, pearly white. Antennae with scape and pedicel large, scape ovate, pedicel subcylindric; segments 3 to 10 blackish-grey, club 3-segmented, the segments rather long. Pronotum widest at or just before base. Elytra quadrate, full, covering apex of abdomen. Prosternum orange-yellow, glabrous. Meso- and metasternum pilose. Metasternum with lateral margins reaching sides completely only on anterior two-thirds. Abdomen short. Anterior coxae globular, contiguous; intermediate coxae globular, nearly contiguous; posterior coxae lamelliform, remote, prominent, their trochanters ovate (thus differing from *T. australica* Deane). Legs broad, robust. Length 0·872 mm.; width 0·658 mm.

Habitat.—Fern Tree Gully, Vic. (R. R. Blackwood). Type in Coll. Deane.

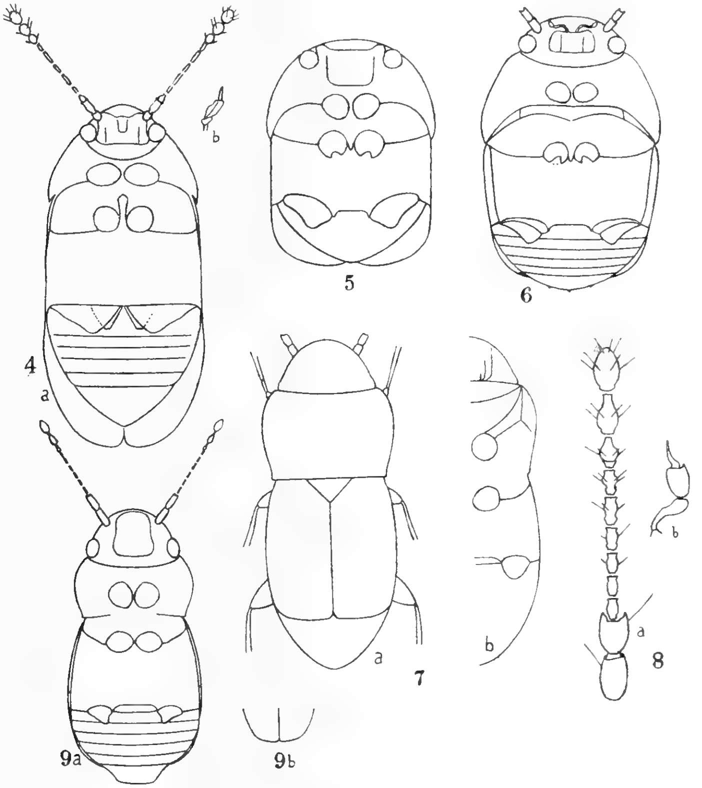
This species is very unlike any other with which the author is acquainted, differing from *T. australica* Deane notably in its broad form, colour and elytra completely covering abdomen.

TRICHOPTERYX GRANDIS, n. sp.

Ovate; convex, robust, black, pubescent, widest a little across prothorax. Head medium, rounded in front; mouth parts rather concealed; genae glabrous, nitid, somewhat flat anteriorly. Eyes black, nitid, rather small, hardly visible from above, prominent below. Antennae medium, clothed with grey hairs; scape and pedicel dark amber; scape thick near base, rounded at base; pedicel normal; flagellum slender; club 3-segmented; segment 9 oval, not so large as 10 or 11; terminal segment tapering to apex. Prothorax widest just before base; margins more convex near angles than at sides; anterior angles moderately acute. Scutellum normal. Elytra subquadrate, truncate; sides subparallel, gently curving; apices exposing pygidium; outer angles rounded. Prosternum very dark brown, glabrous; mesosternum nearly glabrous. Metasternum attaining sides, pubescent, honeycombed; posterior intercoxal margin not concave; excavations for reception of coxae not deep, margins raised. Abdomen with apex not visibly tridentate. Legs very dark amber; anterior coxae large, globular, oval, prominent, contiguous; intermediate coxae round, depressed, separated only by sternal process. Posterior coxae large, broad, strongly lamellate. Femora broad; tibia robust, subcylindric, strongly setaceous and spinose. Tarsi and their claws rather large; claws strongly bent. Length 0·84 mm.; width 0·53 mm.

Habitat.—Lorne, Vic. (from leaf débris collected by G. H. Moran). Type in Coll. Deane.

This species somewhat resembles *T. australica* Deane in general facies; it can, however, be readily distinguished from it by the absence of any noticeable tridentation to the apex of abdomen, by the raised margin of the metasternum immediately in front of the posterior coxae, by the character of the curvature of



Text-figs. 4-9.

4.—(*a*) *Philagarica pilosa* Deane; (*b*) *P. parva* Deane; maxillary palp, showing effect of too rapid dehydration. 5.—*Trichopteryx quadrilatica*, n. sp. 6.—*Actinopteryx tillyardi*, n. sp. 7.—*Achosia cara*, n. sp. 8.—*Leaptiliodes lacunosa*, n. sp., (*a*) antenna, (*b*) palp. 9.—(*a*) *Ptilium ligni*, n. sp.; (*b*) *P. orientale*, n. sp.; apices of elytra.

the sides of pronotum, and by the larger size and different coloration of undersurface and antennae. Moreover the posterior legs are larger in proportion and the pedicel is not so wide as the scape.

ACTINOPTERYX TILLYARDI, n. sp. Text-fig. 6.

Oval; highly convex, very dark brown, pubescent, widest across pronotum. Head broadly rounded in front, black with light brown fascia near base. Eyes silvery, scarcely prominent. Antennae rather small; scape and pedicel cylindric, yellowish-brown; flagellum dark grey; segments 9, 10 and 11 forming the club; terminal setae strong. Pronotum scarcely nitid, granulate; pubescence more or less regular; widest a little before base; sides evenly curved; basal margin convex in centre; posterior angles acute, light brown. Scutellum medium, apex a little acute, sides faintly concave on posterior half; indistinct. Elytra quadrate, subparallel; apices slightly dehiscent. Abdomen pilose, trispinose, little exposed above. Prosternum and mesosternum glabrous, dark brown, the latter finely honeycombed. Metasternum almost black, pilose, its episterna tapering anteriorly. Legs amber-coloured. Length 1·11 mm.; width 0·71 mm.

Habitat.—Canberra, F.C.T. (Dr. R. J. Tillyard; leaf débris from tree ferns). Type in collection of Division of Economic Entomology, Canberra.

A closely allied form has recently been taken in large numbers at Fern Tree Gully, Victoria, by the Rev. A. H. Westley and the author, differing slightly in the metasternal episterna. Pending further supply of specimens from intervening districts, I do not feel inclined to say whether the differences are specific or merely varietal.

ACHOSIA CARA, n. sp. Text-fig. 7.

Elliptic; highly convex, scantily pubescent, brownish-yellow, widest a little across elytra. Head somewhat hemispherical, front evenly rounded, thinly pubescent and light brown on anterior declivity, glabrous and yellow on posterior portion. Eyes small, cream-coloured, very indistinct. Palpi small, rather prominent. Antennae of normal length, regularly clothed with hairs; scape and pedicel rather long, subcylindric, light yellow, their apices light brown; flagellum cream-coloured; segment 3 short; 3 to 6 subcylindric, 7 and 8 barrel-shaped, 9 to 11 obovate; 8 to 11 increasing in size. Pronotum convex, transverse, widest before middle, anterior and posterior margins parallel, side margins convex except near posterior angles; sparsely pubescent, pubescence short, white; anterior angles obtuse, rounded, posterior angles almost acute; light brown at base. Scutellum broad, short, triangular; sides rectilinear; apex obtuse; brown, adorned with very few hardly discernible hairs. Elytra hardly convex, almost depressed, truncate, widest at middle, sides evenly curved; orange-yellow on basal two-thirds; brown on apical third; pubescent, pubescence white, longer than that on pronotum; suture distinct, little darker than disc, not elevated; apices close fitting. Abdomen with four dorsal segments exposed above, these brown, paler than apices of elytra; pygidium narrowly rounded. Prosternum convex on centre, apex of antecoxal sternite prominent; sternite sutures dark and distinct near coxal cavities, becoming invisible near lateral margins; deep yellow, glabrous, nitid. Mesosternum deep yellow, glabrous, nitid; intercoxal process small, distinct, acute. Metasternum convex, orange-yellow, brown at posterior margin; attaining sides throughout; lightly pubescent, pubescence golden. Anterior coxae globular, strongly contiguous, nitid, yellow; intermediate coxae globular, hardly contiguous, nitid, light brown; posterior coxae small, flat, very remote. Femora rather broad, pale yellow; tibiae of normal thickness, a darker shade. Tarsi slender, basal segments of posterior pair somewhat robust. Length 0·64 mm.; width 0·253 mm.

Habitat.—Lord Howe Island, Mt. Gower (A. M. Lea); under bark. Type in South Australian Museum, cotypes in South Aust. Museum and Coll. Deane.

This rather handsome insect differs notably from *A. femoralis* Deane in having the side marginal convexity of pronotum set more forward, with the anterior angles rounded, and the posterior angles more pronounced. Other details as described render it very distinct from that species. The apices of the elytra will be obvious from the diagrams given with the descriptions.

ACHOSIA GIGAS, n. sp.

Elliptic; hardly convex, scarcely nitid, robust, light reddish or yellowish-brown, strongly setaceous, setae white; a little wider across elytra than prothorax. Head rounded in front, of medium size, darker than prothorax, smooth, lightly convex, almost glabrous. Eyes black. Palpi distinct, almost prominent, largest segment oval, pearly; basal segment slender, sigmate, terminal very slender. Antennae 0·477 of length of body; scape and pedicel light brown, flagellum and club flavous; pedicel open at apex, terminal segments not very thick. Pronotum of same colour as elytra, broad, very lightly convex, widest across middle, base not wider than that of elytra; posterior angles well formed, although side margins evenly curved. Scutellum medium. Elytra widest at middle, subrectangular; apices very broad, widely rounded; strongly setaceous, not entirely covering abdomen, leaving three dorsal segments exposed. Prosternum yellowish-brown, glabrous, sternites distinct, convex between boundaries, their surfaces not mutually conformable. Mesosternum yellowish-brown, almost glabrous; intercoxal process distinct, slender. Metasternum reddish-brown, pubescent; posterior margin not deeply excavated for reception of coxae. Abdomen golden-brown, setaceous; pygidium not spinose. Legs yellow, unicolorous, normal. Length 1·09 mm.; width 0·5 mm.

Habitat.—Upper Williams R., N.S.W. (Lea and Wilson). Type in South Australian Museum, cotype in Coll. Deane.

LEAPTILIODES, n. gen. Text-fig. 8, *a*, *b*.

Elliptic; somewhat depressed, widest (very little) across elytra. Head broadly rounded in front, convex, laevigate. Eyes rather small, visible from above. Antennae rather short, about 0·4 of length of body, scape and pedicel rather long, segments 1 to 4 normal, 5 to 11 ovate, globular, increasing in size. Palpi prominent, apical segment almost obsolete (?). Pronotum lacunose, almost papillate, widest just before middle; anterior angles obsolete, posterior small; sides not marginate, anterior margin convex, posterior slightly reflex; base not as wide as that of elytra. Scutellum short. Elytra somewhat depressed, convex at sides, margins evenly curved, suture straight; truncate, apices broadly rounded, as elevated as centre. Abdomen lightly convex, dipping at apex, with at least four tergites exposed; apex rounded, not dentate. Prosternum with episterna inconspicuous. Mesosternum convex at centre; episterna oblique, small; sternal process small but sharp and rather prominent. Metasternum attaining sides, posterior marginal excavations for coxae shallow. Anterior coxae prominent, globular, small, contiguous. Intermediate coxae globular, contiguous; posterior coxae small, remote.

Anterior femora rather robust, intermediate and posterior normal; posterior scarcely reaching apex of abdomen. Tarsi slender. Genotype, *L. lacunosa*, n. sp.

A new genus has been made for this beetle on account of the following notable distinctions from *Ptilium*: (*a*) Antennae shorter and with no definite commencement of club; (*b*) pronotum with shallow depression occupying nearly the whole of the disc with slight rise in centre; (*c*) posterior margin of pronotum reflex; (*d*) base of pronotum narrower than base of elytra; (*e*) mesosternal episterna smaller and more oblique. The genus has been named in honour of Mr. A. M. Lea.

LEAPTILIODES LACUNOSA, n. sp. Text-fig. 8.

Elliptic depressed; yellowish-golden-brown, pubescent, pubescence golden. Head with pubescence fairly thick anteriorly, almost obsolete posteriorly; darker than rest of body. Antennae yellow, concolorous, each segment clothed with fine hairs, those on apical segment rather dark. Eyes pale, indistinct. Palpi stramineous. Pronotum light yellowish-brown with dark irregular patches a little in front of centre; pubescence very sparse and irregular. Scutellum subtriangular, sides slightly concave. Elytra more or less regularly pubescent, darker near outer apical angles. Abdomen much lighter than rest of upper surface. Undersurface yellow. Prosternum and mesosternum glabrous, vitreous. Metasternum pubescent. Legs yellow. Length 0·65 to 0·72 mm.; width 0·255 to 0·26 mm.

Habitat.—Ovalau, Fiji Islands (A. M. Lea). Type in South Australian Museum, cotypes in South Aust. Museum and Coll. Deane.

PTILIUM LIGNI, n. sp. Text-fig. 9.

Obovate; rather flat, widest (a little) across elytra, flavous, opaque, pubescent; pubescence short. Head rounded in front, curve conforming with eyes. Eyes creamy-white. Palpi with large segment pearly, terminal one long, curved, obliquely inserted. Antennae rather distant from eyes; scape and pedicel subcylindric, flavous, pedicel paler than scape; flagellum stramineous; terminal three segments forming the club; 10th and 11th acorn-shaped, much larger than 9th. Prothorax widest just before middle; posterior angles well formed. Scutellum normal. Elytra widest behind middle, margins inflexed on anterior three-quarters forming narrow epipleurae. Pygidium blunt, with tip exposed above. Pro- and mesosternum glabrous. Metasternum lightly pilose. Abdomen slightly darker. Anterior coxae oval, rather prominent, contiguous; intermediate coxae moderate, contiguous; posterior small, remote. Tarsi rather long. Length 0·575 mm.; width 0·271 mm.

Habitat.—Marysville, Victoria (C. Deane; in rotten wood). Type in Coll. Deane.

Not closely allied to any species. The abdomen, being orange-coloured, is darker than the sternum. The insect, although much lighter in colour than *P. wilsoni*, nevertheless has its anterior and intermediate tibiae much darker, an unusual feature.

PTILIUM ORIENTALE, n. sp. Text-fig. 9, *b*.

Elliptic-rectangular, scarcely convex, orange-yellow, opaque, pubescent, widest (a little) across elytra. Head full, rounded in front, not decumbent, lightly convex, brown, nearly black near eyes, thinly pilose. Eyes silvery-grey, set rather backward, of medium size. Antennae pale yellow, rather short, scape and pedicel rather thick in comparison to length; pedicel cylindric, open at apex; segments 3 and 4 thickening towards apex, subcylindric; 5, 6 and 7 barrel-shaped; 8 and 9 obovate; 9 larger than 8; 10 and 11 large, 11 larger than 10; flagellum dull. Pronotum finely punctate, widest at or just before middle, side marginal curvature greater anteriorly than posteriorly; anterior angles very obtuse, almost obsolete, posterior not well formed; base slightly wider than that of elytra. Scutellum normal to short. Elytra convex, entire, widest at or just behind middle; sides evenly curved; close fitting; apices not dehiscent; projecting just beyond apex of pygidium; opaque, very finely and faintly pilose, a dark brown longitudinal fascia on each elytron, fasciae a little oblique, being more widely separated anteriorly, there reaching almost to sides; their apices almost midway between sides and suture; length of fasciae more than one-third the length of elytron; suture dark brown. Wings black. Length 0·672 mm.; width 0·319 mm.

Habitat.—Glen Innes, N.S.W. (A. M. Lea). Type in Coll. Lea.

This rather handsome species possesses a slight resemblance in general facies to *P. torresensis* Deane, being readily distinguished by colour and markings as well as by the apices of elytra having internal angles, these being obsolete in *P. torresensis* Deane.

PTILIUM PARALLELUM, n. sp. Text-fig. 10.

Ovate parallel; form rather broad, scarcely convex, robust, widest across elytra, dark brown, pubescent; pubescence short, regular, white; surface faintly granulose. Head broad, front lightly curved; base wide. Eyes easily visible from above, black with silvery sheen, scarcely prominent, of medium size; facets coarse. Antennae flavous, 0·454 of length of body; club three-segmented, strongly defined; scape cylindric; pedicel barrel-shaped, brown at apex; segments 3 to 8 somewhat dusky, oval-cylindric; 9 and 10 nearly spherical in middle, of similar shape to each other; 10 larger than 9, 11 oval, larger than 10. Palpi not prominent. Pronotum subquadrate, widest just behind middle, base scarcely wider than that of elytra; sides lightly convex, not marginate; anterior strongly, posterior faintly obtuse; posterior margin somewhat sinuous; lightly convex both longitudinally and transversely. Scutellum rather narrow, not well defined; sides faintly concave. Elytra widest just before middle; apices dehiscent, rounded; outer angles rounded, sloping to sides; suture not raised. Pygidium a little exposed above; apex somewhat broadened. Mesosternal episterna oblique. Metasternum dark at lateral borders. Legs rather short; anterior coxae strongly contiguous; intermediate coxae normal, not deeply sunk; posterior coxal separation medium or less; anterior tibiae rather robust; posterior tibiae almost reaching apex of abdomen. Length 0·6 mm.; width 0·304 mm.

Habitat.—Taviuni, Fiji Islands (A. M. Lea). Type in South Australian Museum.

Differs from *P. latum* Deane, in form not so wide, size smaller, mesosternal episterna oblique, metasternal intercoxal plate not prominent, intermediate coxae less deeply embedded, legs smaller, posterior tibiae not reaching beyond apex of abdomen.

PTILIUM RENNELENSIS, n. sp. Text-fig. 11.

Parallel-elliptic; narrow, somewhat depressed, cylindric, widest a little across elytra, very dark brown, finely pubescent. Head black, subtriangular, rather produced in front, scarcely and irregularly pubescent, side margins slightly concave before eyes. Eyes rather small, black. Antennae light brown, hair clothing scarce; scape short, pedicel moderately so, segments 3, 4 and 5 thickening to their apices; 6 and 7 elliptic, 8 to 11 ovate; club not abrupt, gradually larger from 8th to terminus. Pronotum black, punctate, glabrous, widest before middle; posterior margins sinuous, slightly oblique; anterior angles obtuse, posterior angles almost obsolete. Scutellum narrow, dark brown, margins black. Elytra subparallel, widest at or just before middle; apices rather broad, not dehiscent; dark brown, pubescent; suture black. Pygidium with the tip sometimes just visible from above. Prosternum dark brown, slightly pubescent, pubescence very short, sternites indistinct. Mesosternum with intercoxal process distinct, prominent. Epipleurae developed on basal third of elytra. Metasternum without conspicuous intercoxal plate. Abdomen pale on apical segment. Legs light brown; intermediate coxae not contiguous; posterior coxae only moderately separated; femora moderate to broad; tarsi short, robust, thickening at base; claws strongly arcuate. Length 0·525 mm.; width 0·205 mm.

Habitat.—Rennel Island, Torres Strait; lat. 9° 46′ S., long. 143° 16′ E. (A. M. Lea; under log on beach). Type in South Australian Museum.

Differs from *P. flavoterminum* Deane and *P. torresensis* Deane as follows: From the former, which it more nearly resembles, in having antennal club not abrupt, tarsi shorter and more robust at base, colour as described; from the latter in having form narrower and more parallel, scutellum narrow and pedicel broader.

PTILIUM BREVIPENNE, n. sp. Text-fig. 12.

Rather elongate, widest across elytra, light brown, pubescent. Head subtriangular, sides gently curved, scarcely convex on top, produced a little and dipping in front. Eyes small, golden-yellow. Antennae with scape and pedicel yellow, segments 3 to 8 light brown, 9 to 11 darkened by clothing of blackish hairs; scape and pedicel short and thick, 3 and 4 cylindric, 5 irregular, 6 tapering at ends, 7 and 8 oval, 9 to 11 forming the club. Pronotum of same colour and clothing as remainder of upper surface, sides greatly rounded, anterior angles almost, posterior quite, obsolete. Scutellum with sides strongly concave. Elytra truncate, widest near apex, not dehiscent, shoulders rounded away. Abdomen long, several tergites exposed; tapering. Legs medium; posterior tibiae not reaching apex of abdomen. Length 0·715 mm.; width 0·247 mm.

Habitat.—Darling Ranges, W.A. (A. M. Lea). Type in Coll. Lea.

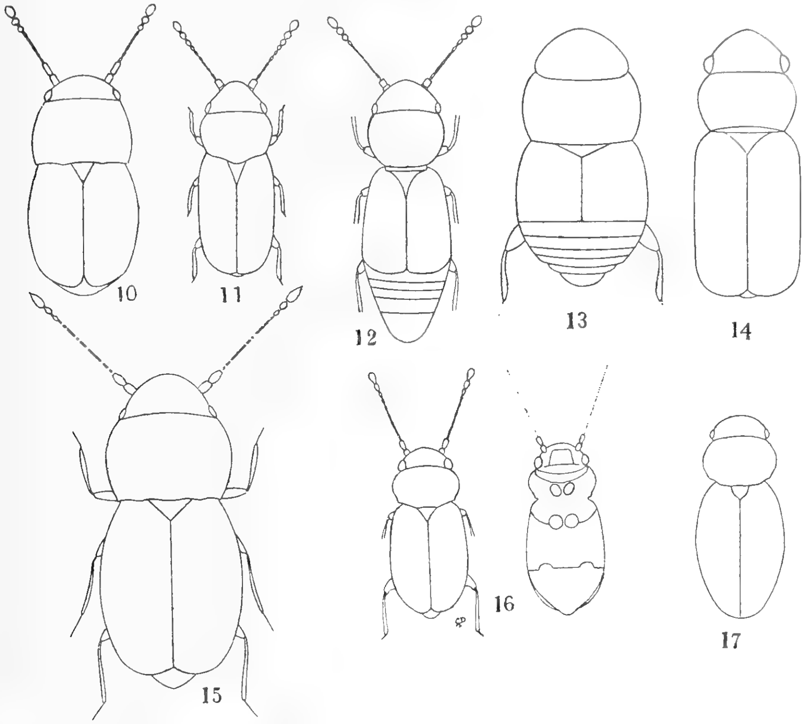
PTILIUM XANTHORRHOEAE, n. sp. Text-fig. 13.

Oval; faintly depressed, dull, translucent, yellow, widest across elytra. Head lightly convex. Eyes wanting. Palpi small, rather prominent, irregular. Antennae with scape large, barrel-shaped; pedicel smaller, thickening to apex. Pronotum with lateral margins evenly curved; anterior angles strong, slightly acute; posterior angles obtuse. Scutellum very short, wide, depressed. Elytra truncate, exposing six abdominal tergites; apices not rounded; suture closely fitting. Wings absent. Abdomen strongly tapering, lateral marginal spines strong; margin at apical three segments unconformable. Prosternal sclerite sutures strong, mesosternal feeble. Anterior and intermediate coxae of normal size, globular, contiguous; posterior moderately remote. Tarsal claws apparently single, long, slender. Length 0·53 mm.; width 0·27 mm.

Habitat.—Sydney, N.S.W. (A. M. Lea); in *Xanthorrhoea*. Type in Coll. Lea.

Ptilium leai, n. sp. . Text-fig. 14.

Elliptic parallel; subrectangular, widest across elytra, a little depressed along medial centre of elytra, not nitid, yellow with blackish shades, sparsely pubescent; pubescence short, irregular. Head narrowly rounded in front, convex near eyes, rugose, blackish-yellow. Eyes black, conspicuous, not large. Antennae with scape and pedicel rather large, lemon-coloured. Pronotum widest just before middle, sides almost evenly rounded, marginal convexity a little greater anteriorly; apical margin straight, basal slightly curved; finely rugose; blackish-yellow along anterior margin shading to a paler hue at base. Scutellum medium, clear yellow, glabrous, hardly nitid; sides faintly concave. Elytra yellow at and near base and apices, blackish-yellow over central half, subparallel, not tapering, side margins just curved, shoulders rounded, apices broad. Pygidium with only the extreme tip exposed above. Wings black. Legs yellow. Length 0·555 mm.; width 0·218 mm.



Text-figs. 10-17.

10.—*Ptilium parallelum*, n. sp. 11.—*P. rennelensis*, n. sp. 12.—*P. brevipenne*, n. sp. 13.—*P. xanthorrhoeae*, n. sp. 14.—*P. leai*, n. sp. 15.—*P. wilsoni*, n. sp. 16.—*P. simsoni* Matthews. 17.—*Ptenidula producta*, n. gen. and sp.

Habitat.—Sydney, N.S.W. (A. M. Lea; in *Xanthorrhoea*). Type in Coll. Lea.

A distinct species, differing from all existing ones in many characters, without any strongly marked departures; for these the descriptions must be consulted. The dark coloration of the centres of elytra may be due to their semitranslucency together with the black wings beneath.

Ptilium wilsoni, n. sp. Text-fig. 15.

Obovate; convex, widest across elytra, coarsely but not heavily pubescent, pubescence yellow, surface somewhat nitid-rugose, bay-brown, paler on basal two-thirds of elytra, paler on ventral surface except across middle of abdomen. Head convex, front and side margins forming one wide even curve from eye to eye, light brown. Eyes black, rather deeply set, of medium size. Palpi with terminal segment long, slender, slightly curved, transparent; the large segment ovate-elliptic, hoary, not prominent. Antennae 0·475 of length of body, golden-yellow, coloration uniform; scape and pedicel ovate, 10th segment somewhat flask-shaped, 11th acorn-shaped, pointed; bristles conspicuous. Pronotum convex, widest at middle, side margins nearly uniformly convex, posterior margin sinuous; posterior angles obtuse; base scarcely wider than that of elytra. Scutellum rather wide in proportion to its length, of same colour as basal two-thirds of elytra; side margins rectilinear. Elytra convex, widest at centre, side margins evenly curved; apices widely rounded, subtranslucent, dehiscent. Abdomen with pygidium exposed. Prosternum strongly sloping at episterna. Mesosternal process very inconspicuous. Metasternum smooth, almost glabrous; posterior margin faintly concave. Intermediate and hind coxae rather small, deeply set. Legs and tarsi normal; claws small but well formed. Length 0·65 mm.; width 0·29 mm.

Habitat.—Belgrave, Victoria (F. E. Wilson). Type in Coll. Wilson, cotype in Coll. Deane.

Although not very near *Ptilium simsoni* Matth., this species may be compared with it as follows: Form convex, whereas *P. simsoni* Matth. is flattened on centre of each elytron, the two, however, not being in the same plane; outline more oval; suture not raised or otherwise conspicuous; posterior angles of pronotum not so strong; 11th antennal segment pointed anteriorly; claws distinct; colour of a different hue, *P. simsoni* being much darker and between a walnut and a chocolate brown. In addition to the above the elytra of the new species are devoid of zonal divisions, whereas in the existing species the centre, sides and apical thirds are all differently sculptured, the sculpture, however, not being strong.

Ptenidula, n. gen. Text-fig. 17.

Elliptic; highly convex, widest across elytra. Head widely rounded, short, steeply sloping on forward declivity, a little recessed behind eyes; clypeus broad in front. Eyes visible from above, small, rather prominent. Antennae with pedicel and scape medium, club two-segmented, 9th segment scarcely larger than 8th. Pronotum not strongly transverse, convex, sides much rounded, anterior angles obsolete, posterior irregular, obtuse. Scutellum shield-shaped, indistinct, rather short. Elytra very convex, extending well beyond apex of abdomen, widest at middle; shoulders rounded, apices entire, close fitting; epipleurae somewhat developed. Prosternum convex, episterna very convex, unconforming. Mesosternum with intercoxal process conspicuous but not protruding; episterna convex and unconforming. Metasternum reaching sides posteriorly but scarcely so anteriorly; posterior margin excised at outer edges. Anterior coxae small, contiguous; intermediate small, separated; posterior small, not widely separated. Anterior femora broad, intermediate medium, posterior slender. Genotype, *P. producta*, n. sp.

This genus has its nearest ally in *Ptenidium*, of Erichson, which it somewhat resembles in shape of body and elytra; also in the contour along the posterior margin of the metasternum and the excisions at its lateral extremities. Colour, moreover, is a point of significance in that it draws attention on a casual inspection to the resemblance between the two genera. The new genus differs noticeably, however, in the nonconformity of the meso- and metasternal episterna. The form also is much narrower.

PTENIDULA PRODUCTA, n. sp. Text-fig. 17.

Reddish-black; surface smooth. Head black, slightly pubescent. Eyes silvery-black. Antennae dark brown, clothing normal. Pronotum nearly black, coarsely punctate, glabrous. Elytra pubescent, a lighter shade of brown at apices. Prosternum glabrous. Mesosternal episterna and metasternum glabrous. Legs walnut-brown. Length 0·55 to 0·59 mm.; width 0·246 to 0·25 mm.

Habitat.—Tweed River, N.S.W. (A. M. Lea). Type in Coll. Lea, cotypes in Coll. Lea and Coll. Deane.

PTENIDIUM MONTANUM, n. sp.

Ovate-elliptic; widest across elytra, highly convex, black with olive-brown apices to elytra, nitid, punctate, punctures shallow, delicately pilose, pilosity sparse and short. Head black, somewhat unevenly rounded in front, convex, nitid, narrowly marginate at sides; pilosity longer than on body. Antennae 0·474 of length of body; scape moderate, subcylindric; pedicel barrel-shaped, apex black and bispinose; segment 3 long, yellow, slightly swollen at base, subcylindric, slenderest of all; 4 and 5 subcylindric, dark yellow; 6 and 7 subelliptic; 8 elliptic, shorter than 7; 9 irregular, larger than 8; 10 obovate, narrow at apex; 11 ovate; 9 to 11 forming club; 10 and 11 much larger than 9. Pronotum black, widest behind middle, marginate at sides, highly convex, especially anteriorly; few coarse punctures on centre near base. Scutellum moderate, black, almost glabrous, sides faintly concave. Elytra black to very dark brown, widest before middle, marginate on anterior quarter; apices olive-brown, scarcely narrow, hardly rounded or dehiscent, impunctate. Legs brown. Length 0·91 mm.; width 0·51 mm.

Habitat.—Marysville, Victoria (C. Deane). Type in Coll. Deane.

Differs notably from *P. hughesae* Deane by head and pronotum marginate, greater convexity of pronotum, and punctation of the latter. The scutellum is more sharply defined.

PTENIDIUM TENEBRICOSUM, n. sp.

Obovate; widest across elytra, convex, black with dark brown apices to elytra, rather nitid, faintly and irregularly punctate, sparsely setose, setae white. Head black, broad, widely rounded in front, sides not marginate. Eyes black. Antennae 0·46 of length of body; scape and pedicel light brown, unicolorous, barrel-shaped, pedicel not spinose; segment 3 short; 4 to 8 subcylindric, slightly thickening anteriorly, 9 to 11 elliptic, 10 and 11 darker and larger than 9; terminal seta long, black on basal half. Pronotum widest at middle, sides uniformly curved, not marginate; black, nitid, convex, not punctate; anterior and posterior angles rounded. Scutellum black, glabrous, nearly equilateral triangular. Elytra widest just before middle, sides evenly curved; very faintly and irregularly punctate, punctures very shallow, almost obsolete; apices integral. Legs brown, femora rather wide, tibiae slender. Length 0·98 mm.; width 0·543 mm.

Habitat.—Lorne, Victoria (from leaf débris collected by G. H. Moran). Type in Coll. Deane.

In outline this species resembles *P. otfordensis* Deane, differing notably in having prothorax more convex, scutellum more sharply defined, apices of elytra entire, and clothing as described.

Omissions and Errors in Previous Papers.

1. *Philagarica pilosa* Deane: the outline drawing was omitted and is included herewith (Text-fig. 4*a*).
2. The genus *Leaduadicus* and the species *Trichopteryx walkomi* were named in honour of the late Mr. A. M. Lea, of Adelaide, and Dr. A. B. Walkom, of Sydney, respectively.
3. In the introductory remarks of the second paper, Mr. E. B. Blackbourne should read Mr. B. Blackbourn, of Melbourne.

The author is responsible and wishes to apologize for the above omissions and errors.

THE PHYSIOGRAPHY OF THE SHOALHAVEN RIVER VALLEY. V.

THE UPPER VALLEY AND THE STREAM SYSTEM.

By FRANK A. CRAFT, B.Sc., Linnean Macleay Fellow of the Society in Geography.

(Six Text-figures.)

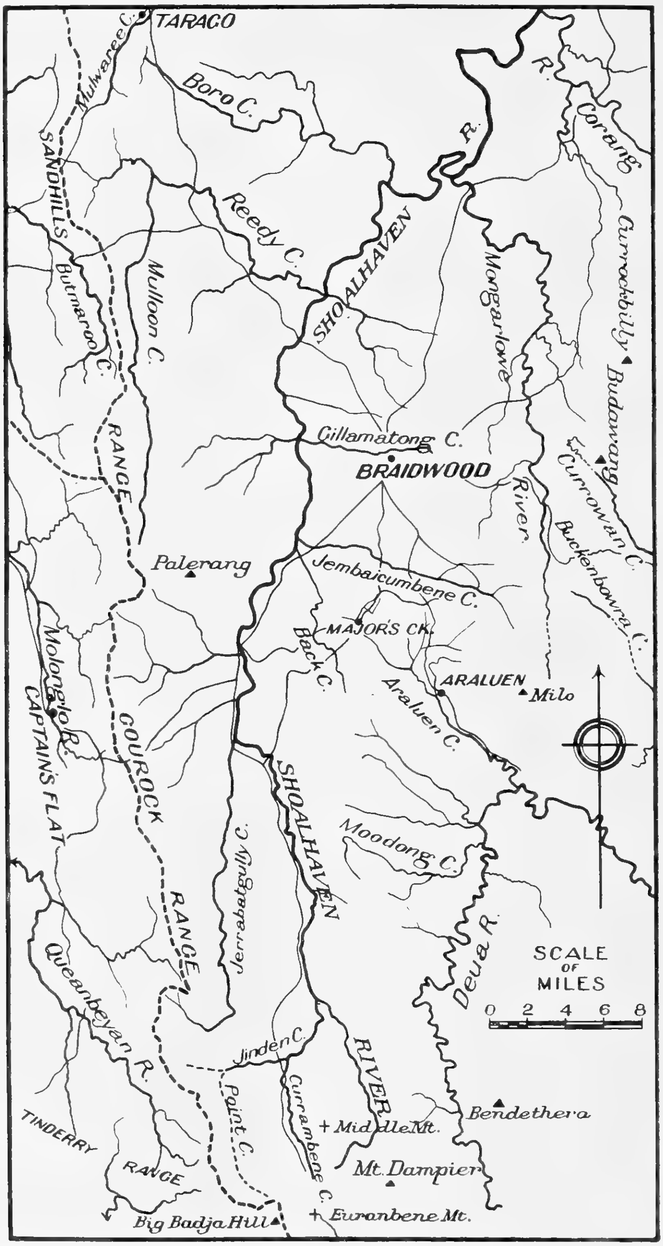
[Read 27th July, 1932.]

The upper valley of the Shoalhaven has not been trenched by modern canyons, but the Shoalhaven Plain extends southward between high ridges to split up into a number of parallel mature valleys as the head of the river is approached. These are separated from one another by hills and ridges which rise to a common level surmounted by the residuals of Gourock Range. The coastal slopes have been dissected by vigorous streams, but on the western side of Gourock Range the meridional valleys of the Murrumbidgee system bear a strong resemblance to that of the Shoalhaven, and the latter gives a key to much of the physiography of the Southern Tableland. In this account the magnetic meridian is used (declination 9° 30′ E.), and the term "coastal slopes" is used to designate the seaward fall to the east of the meridional course of the Shoalhaven River.

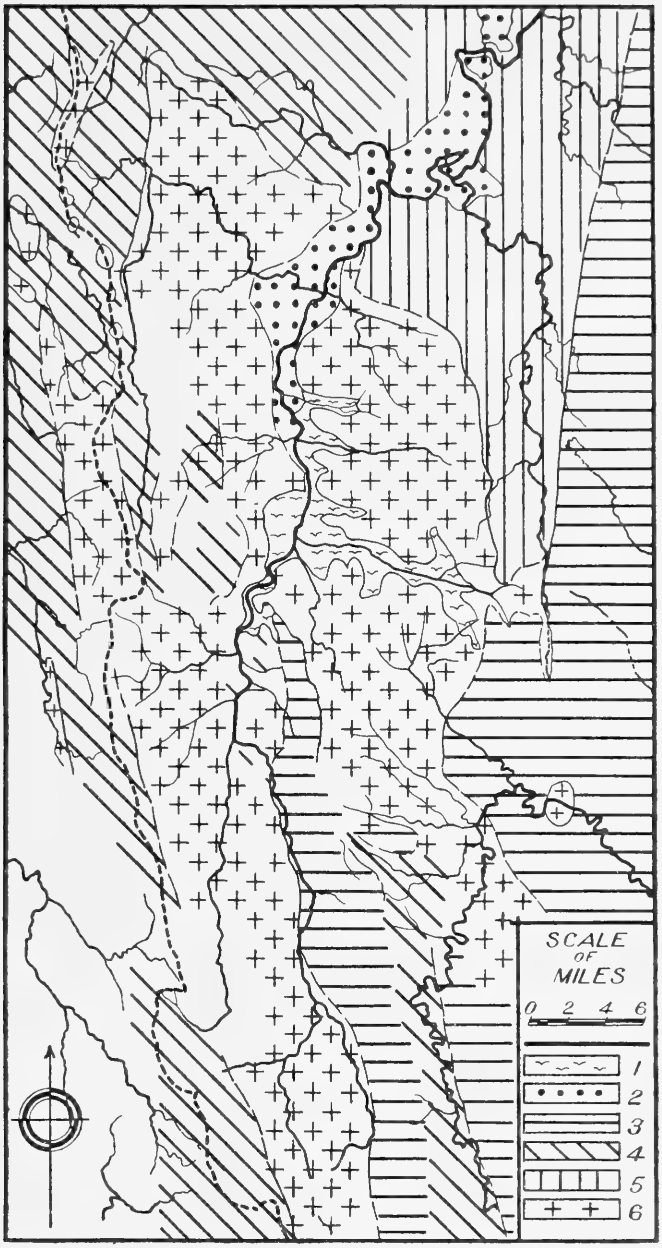
Geology and Surface Features.

The core of the area is a granitic intrusion which extends from the Braidwood district to the head of the river. In general it gives negative topographic features, gentle undulations and well marked terraces, although occasional residuals rise above the level of the surrounding plains. Part of this intrusion has been used in the formation of Araluen Valley which is deep, flat-bottomed, and partly enclosed by higher lands of sedimentary rocks. Porphyries are found along the western margin of the granites, but their principal development is to the west of the Shoalhaven, where they extend in an almost unbroken line from Tarago to the head of the river at Middle Mountain, along the eastern borders of Sandhills and Gourock Ranges. Although responsible for rough and broken country where they are being newly attacked, the porphyries show a generally subdued topography which is less mature than that of the neighbouring granites.

Ordovician sandstones and argillites extend into the Braidwood district from the north, and occupy the lower valley of Mongarlowe River. Like the granites, they form negative features with occasional higher ridges, but the upper Devonian sediments to the east rise high above the Shoalhaven Plain; the hard and massive nature of their quartzites gives the residuals of Currockbilly and Budawang, but towards the south these rocks merge into sandstones, and the strike ridge surmounting the coastal slope has been breached by attack from the east. There is also a progressive change in the amount of folding on this part of the Shoalhaven divide, for the steep eastward dips of Currockbilly and Budawang pass southward into the Deua basin, while the more westerly extension of the series at Major's Creek has only been slightly folded (David, 1893), and its continuation to Mt. Dampier is almost horizontal in most places. These rocks belong to the Lambie stage of the upper Devonian, and overlie older folded rocks containing limestones (I. Brown, 1930, 1931).

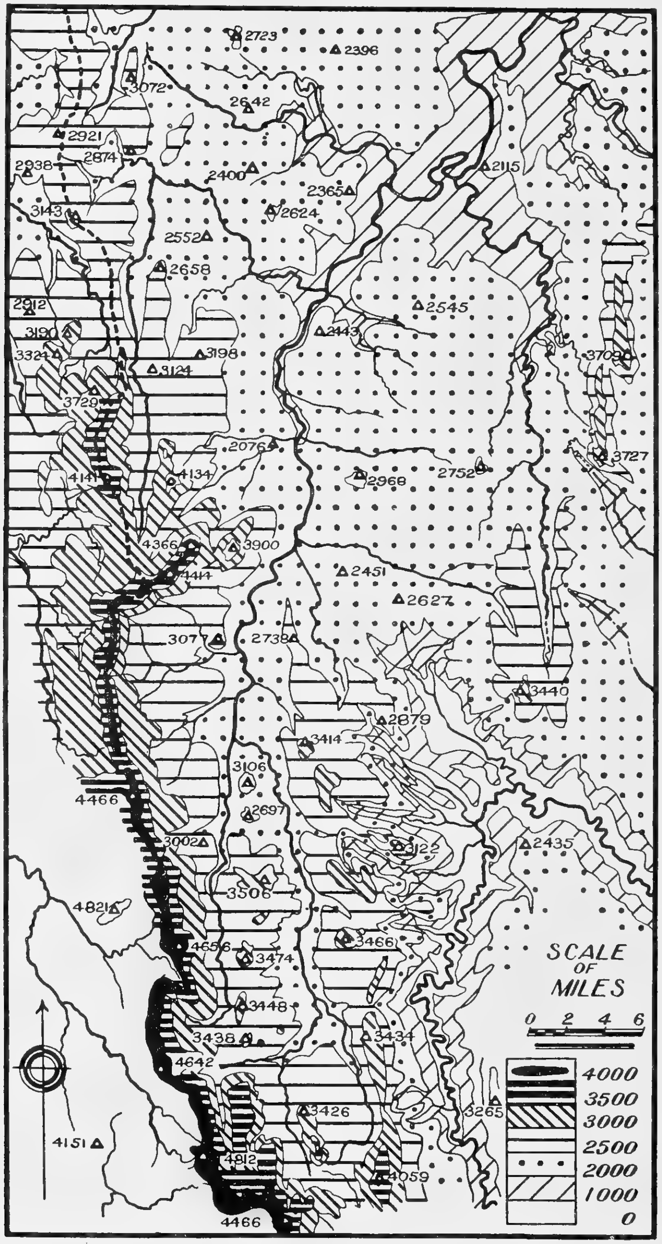


Text-fig. 1.—Locality map of the area. The heavy broken line indicates the position of the Main Divide, which bifurcates to enclose Lake George.



Text-fig. 2.—Geological sketch-map, based on the State Geological Map, 1914, and the work of Dr. Ida A. Brown. The numbers indicate: 1.—Alluvium, Pleistocene and Recent; 2.—Pliocene river drift; 3.—Upper Devonian; 4.—Middle Devonian and Silurian, possibly including older rocks; 5.—Ordovician; 6.—Granites and porphyries.

On the western divide there is a series of sandstones, limestones and slates, which are associated with hard quartzites. They have a general westerly dip on Sandhills Range, and their harder members are responsible for the scarps



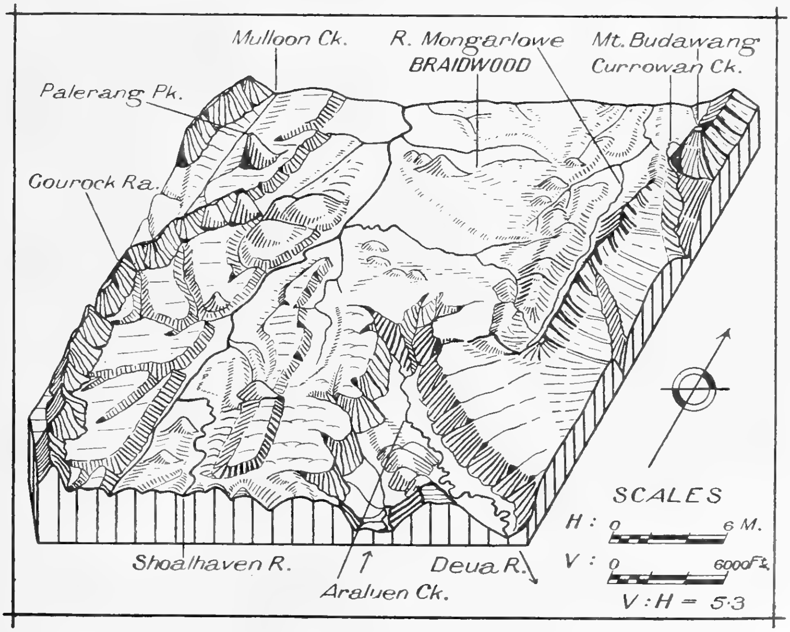
Text-fig. 3.—Orographic sketch-map, based on trig. heights, road traverses and photographs.

found to the west of Mulloon and Mulwaree Creeks. Gourock Range is capped with sedimentary rocks and massive quartzites which appear to have been lifted up by the granitic intrusions, as they occur at much higher levels than the sub-horizontal rocks on the eastern divide of the Shoalhaven, and they dip steeply westward: this is the oldest part of the existing highlands.

On the whole, we find that rock character and structure have had an effect on scenery similar to that in other parts of the Shoalhaven Valley, but as the head of the river is approached the higher levels between 3,400 and 4,000 feet are found to comprise a great variety of rocks—horizontal sandstones, porphyries, granites, and folded sedimentary and metamorphic rocks—which have been reduced to a common level in times past, giving a surface as complex as the Shoalhaven Plain: it will be referred to as the "older peneplain".

Topography and Physiography.

The Eastern Divide.—Passing southward from the head of Corang River, the horizontal Permian sandstones at 2,800 feet give place to broken hills of Devonian quartzite at a similar level, and then to a long ridge which rises from beneath the sandstones and continues their upper surface southward to Currockbilly Trig. (3,709 feet). The scarp faces westward and rises abruptly from the Shoalhaven Plain, while erosion on the coastal side has combined with a steep dip to give broken slopes and precipices. Beyond Currockbilly the ridge is lower and serrated, but it rises again to Budawang Trig. (3,727 feet), whence it falls to the gorge of Currowan Creek, which has cut across the eastern wall of Mongarlowe Valley and is extending into the Shoalhaven Plain. The lowest part of the divide between Currowan Creek and the Mongarlowe is on a broad



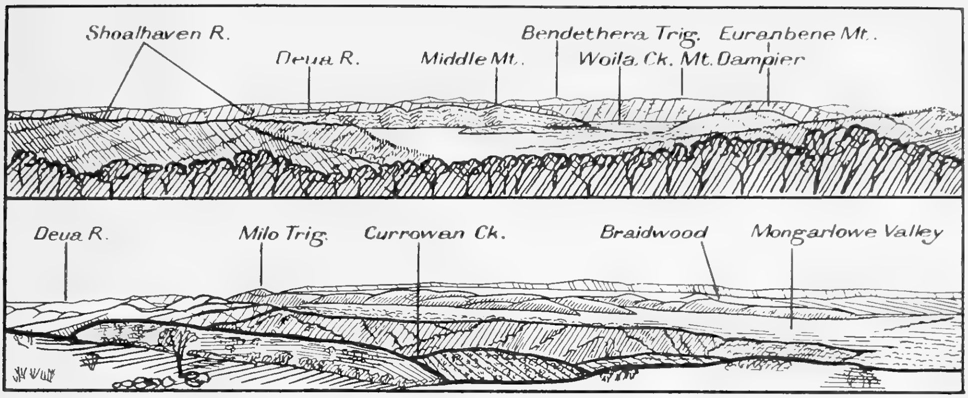
Text-fig. 4.—Block diagram of the country towards the upper Shoalhaven, to show the various surfaces of erosion and stream attack on the tableland.

plain about 2,210 feet, which compares with the high-level drift terraces at 2,200 feet found along the Mongarlowe immediately to the west. It thus appears that Currowan Creek attacked from the south-east along a line of weakness, and captured a small portion of the upland drainage area.

Still continuing southward there is a general rise on either side of the Mongarlowe, but swift tributaries of the Clyde fall down the steep beginning of the coastal slope and have pushed back the divide in places, giving it a serrated appearance. These conditions persist to the head of the Mongarlowe, where there is a depression in the divide about 2,600 feet between the level valley of that stream and the gullies falling to Deua River. But there is a much greater gap in the decomposed granites at the head of Araluen Creek with points as low as 2,300 feet: one of these low places is at the village of Major's Creek, where a small stream of that name falls rapidly to Araluen Creek and is cutting back into its divide, which lies on the edge of a wide plain at 2,300 feet falling gently to Back Creek and the Shoalhaven; the river is rather less than four miles to the north-west, and is flowing at 2,150 feet. This part of the Shoalhaven Valley has the appearance of being perched insecurely above the coastal gorges, and a similar position exists further to the east where small streams flow north-westwards across the Milo scarp: the largest falls to Jembaicumbene Creek, but the others change their direction and pass into gullies which lead steeply to Araluen Creek. That stream has been favoured in its attack on the tableland by its steep grade, by lines of weakness in the rocks, and by the readiness with which the granites decompose. It has enlarged itself at the expense of the Shoalhaven drainage, and is even threatening the upper Shoalhaven with capture.

Other gaps of a similar nature but of less consequence are found at intervals along the Shoalhaven-Deua divide. Perhaps the most impressive is opposite the horseshoe bend of Moodong Creek, which falls steeply to the Deua and appears to have encroached on the Shoalhaven drainage. The lowest point on this part of the divide is at 2,500 feet—200 feet above the level of the Shoalhaven and 2,000 feet above the more distant Deua—and the divide itself crosses a gentle plain which falls abruptly to Moodong Creek. In the less broken parts of the eastern divide high points rise above 3,400 feet and the crest line is little lower (Text-fig. 5); there is a rise southwards to Mt. Dampier at 4,060 feet, whence there is a gentle fall for some distance towards the Tuross, and then a steep plunge to its gorge.

Going from Mt. Dampier to the head of the river we find the Shoalhaven and Currambene Creek rising in level swamps between 2,800 and 2,900 feet on opposite sides of Middle Mountain (3,750 feet), and flowing northward through wide, gentle valleys. The plain continues on the southern side of the mountain, and parts of the Shoalhaven swamps drain southward into a steep-sided trench from 30 to 50 feet deep which has been cut in the earth plain by a wavering stream. At first this creek flows east-south-east, but it soon turns southward to fall into a steep-sided gully, and thence to the deep gorges of Woila Creek and Tuross River. Thus the divide has been virtually eliminated at this place, although a thick mantle of vegetation protects the surface from erosion; the trees and ferns are sufficient to prevent rapid enlargement of the earth trench whilst grass and swamp plants bind the plain, so the present position is essentially one of neutral equilibrium with Woila Creek gaining slightly. The remainder of the southern divide is high with an abrupt fall towards Tuross River and southward

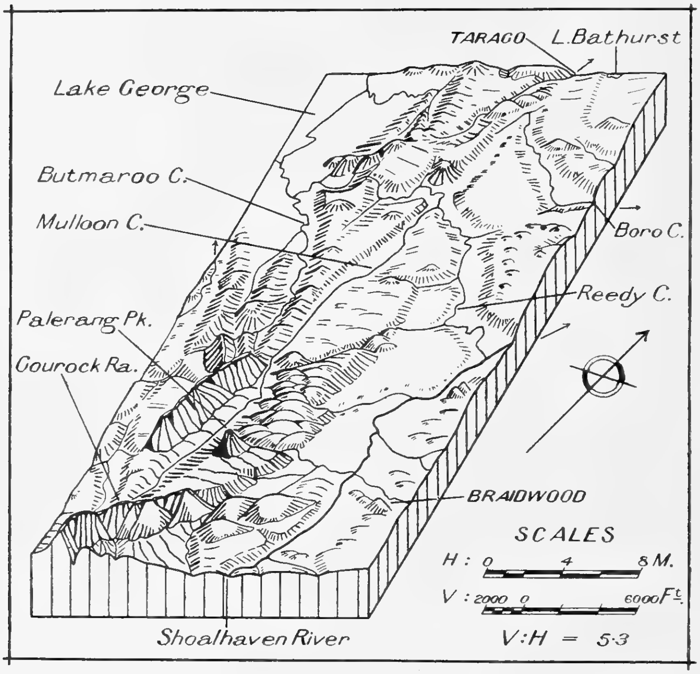


Text-fig. 5.—Topographic sketches from photographs, showing: I. A view from the heights two miles north of Big Badja Hill to illustrate the skyline of the older peneplain and its gentle northward fall. The streams on either side of Middle Mountain flow to the left, but Woila Creek passes on the far side of Euranbene Mountain through the breached divide and falls to Tuross River. II. A view from Budawang Trig. The gorge of Currowan Creek passes to the left across the eastern ridge of Mongarlowe Valley to the dissected coastal slopes. The ocean is in the left background.

from Big Badja Hill along the Main Divide: towards the north, Point Creek flows through a gorge cut in metamorphic rocks to emerge on a granitic plain above its junction with Jinden Creek, and its eastern divide shows a normal fall northward from 4,400 to 3,600 feet.

Summing up, we find that active erosion from the east and south has breached the divides of the Shoalhaven and, favoured by steep grades, lines of weakness and the stability of the Shoalhaven Plain at a high level, tributaries of the Clyde, Deua and Tuross are beginning to encroach on the Shoalhaven drainage. A definite progression of events is shown: in some cases the divide is being irregularly lowered; in others it has been breached and gorges are developing in the upland; at the head of the river diversion of drainage is actually taking place, although its ultimate result cannot be very spectacular.

The Western Divide.—The southern end of Gourock Range rises sharply from 4,000 feet at the head of Point Creek to 4,800 feet, and a peak some 500 feet higher is found to the north-west on Tinderry Range. The main ridge is level and uniform, with occasional high-level passes about 3,800 feet; its eastern slopes and branches are interesting because they comprise a triangular area of granite terraces between 2,800 and 3,200 feet, an elevation comparable with that of the high points between the Shoalhaven and Jerrabatgully Creek, which rise somewhat above 3,400 feet. The terraces slope towards the river, but isolated hills on their eastern edge rise above 3,000 feet, and indicate that the edges have been smoothed down subsequent to the formation of a level between 3,000 and 3,200 feet. It is possible that horizontal separation planes in the granite made the perfection of these terraces possible, and in any case the sharp westward rise when the sedimentary and metamorphic rocks are met proclaim Gourock to be an ancient feature rising above this erosion level, whose northward continuation is found in the gap to the west of Palerang Peak, the ridgy tableland on either side of that hill, much of the western divide of Mulloon Creek and the extension of that crest plane into the drainage areas of Butmaroo Creek and Molonglo River. Mulloon Creek cuts Gourock in two because it and a tributary of the Molonglo have encountered a granitic zone lying between them, and have reduced the divide at that place.



Text-fig. 6.—Part of the western divide of the Shoalhaven, to show the erosional levels and the development of Boro and Reedy Creeks.

When we come towards Reedy Creek we find the 3,000-foot level in Sandhills Range represented by isolated hills, while a notable terrace develops about 2,600 feet, beginning some 5 miles south of the junction of Mulloon and Reedy Creeks. To the east of these streams the granitic country has been lowered irregularly to 2,400 or 2,500 feet, although occasional points rise higher. The northward continuation of this terrace is one of the features about Tarago and Lake Bathurst where it is perfectly developed in sedimentary rocks at 2,400 feet, although its relative importance decreases in the valley of Mulwaree Creek, where it has been reduced in the formation of Goulburn Plains at 2,000 feet so that only occasional rounded hills survive. It is more important to the north-east of Lake George, although here again it has been limited by later erosion.

A description of the western divide would be incomplete without reference to a lineament which comprises the valleys of Mulloon, upper Boro and Mulwaree Creeks, although discussion of its significance can be taken later. The western side of this feature is a straight scarp between 300 and 400 feet high forming the edge of a high terrace and consisting of sandstone, quartzite and occasional limestones. On account of its general resistance it is little dissected, and such streams as the heads of Reedy and Mulwaree Creeks have cut steep notches in its base, although much wider valleys exist above 2,400 feet, thus giving "valley-in-valley" forms. Erosion is proceeding actively in the lower stage.

Considering the streams involved in the lineament we find that they follow the strike of the rocks; Mulloon Creek is established on the edge of the granites, although the northward continuation of the valley to Tarago does not follow this boundary slavishly, and parts of it are eroded entirely in sedimentary rocks. Thus the valley is bounded by a sharp western scarp and a more undulating and broken rise eastward, and although this side attains an elevation of 2,600 feet, it is cut across by the valleys of Boro and Reedy Creeks, both of which streams fall quickly and occupy rather narrow valleys in a weathered surface. The general impression of continuity is still given by this eastern ridge, and the character of the high terrace has not been materially obscured. So far as the valley floor is concerned, the divide of Mulwaree and Boro Creeks near Tarago is found at 2,340 feet; a wide fall leads to Boro Creek at 2,300 feet, whence there is a southward rise to the Reedy Creek divide at 2,400 feet. In that place the valley is flat-bottomed, a half-mile wide, and has evidence of past volcanic activity in the form of an ironstone knoll on the western edge and a surface covering of limonite and bauxite at 2,550 feet on the hills to the east where the Tarago-Braidwood road crosses them. Still further southward the valley floor falls to Mulloon and Reedy Creeks at 2,270 feet, and for several miles southward the former is level, although its grade is steeper in the higher land, and the stream flows at 2,800 feet to the north-west of Palerang Peak, where its course is again level.

In passing we may note the grade of Reedy Creek, which is fairly uniform between Mulloon Creek and the river and averages 30 feet per mile—a remarkable figure for such a large stream flowing in a valley like that of the Shoalhaven, and one which is not approached in other granitic parts of the same area, even by much smaller streams. Boro Creek forms the one exception to this rule, as the first 13 miles of its course away from the meridional valley fall at the same rate, although the lower 6 miles only average 13 feet per mile. The lower part has been assisted by tributaries, but it lies below 1,900 feet and is the immediate result of channelling in the Shoalhaven Plain. On the other hand, five-eighths of the steep upper fall lies above 2,050 feet, and is thus virtually outside the upper limit of the steepening due to the dissection of that level. If this steeper section developed at the same time as the Shoalhaven Plain its grade is distinctly anomalous, and is not reproduced by more normal tributary streams, such as those of Nerrimunga Creek. Boro Creek has not encountered very resistant formations during its downcutting, so it would appear that the upper part of the steep section has been formed comparatively recently, probably being one of those features which developed during the formation of the Shoalhaven Plain (2,050 foot level) in contradistinction to the streams responsible for that feature, such as Nerrimunga and Barber's Creeks. A similar but less clearly defined state of affairs exists along Reedy Creek.

Reverting to the western divide for a moment, it will be seen that there is a general northward fall of a high-level peneplain surface from the head of the river, with increasing complexity as new levels and terraces make their appearance in the northern margin. Gourock Range has been preserved by sedimentary and metamorphic rocks, and appears to be a survival of a very ancient tectonic feature.

The Shoalhaven Plain.—The upper valleys of the Shoalhaven fall from 2,900 feet at their head to 2,400 feet at the junction of Jinden Creek with the river; beyond this the valley increases in width and maturity, and the divide between the river and Jerrabatgully Creek is greatly reduced in places, the topography being that of a maturely dissected tableland. Further north the river falls gently, and the deposits of silt and drift on modern or little-elevated flood plains attain a width of a mile; as Braidwood is approached the ridges fall to 2,400 feet, with the granite residual of Gillamatong rising to 2,968 feet, only a little short of the high peneplain level. Still further northward the undulations continue to die out, until at the junction of Mongarlowe River the mature valley has expanded into a peneplain standing a little above 2,000 feet (the Shoalhaven Plain), with a gentle rise to the western divide, and a level expanse to the foot of the Currockbilly-Budawang ridge and to the tableland of horizontal sandstone at the head of Corang River. In earlier papers we have studied the development of this surface and its partial dissection to a depth of 400 feet in the pre-canyon stage between Oallen ford and Tallong: this trenching extends upstream along the Shoalhaven to a point immediately west of Braidwood. Where soft or decomposed rocks were encountered, as at the junction of Reedy Creek and upstream on the western bank in that section, a wide, shallow valley was formed, and was later filled with sand and pebble drift rising to 2,100 feet opposite Braidwood. Subsequent erosion has re-developed this feature, and has given extensive terraces between 1,870 and 1,900 feet at the junction of Reedy Creek, and at a higher level immediately above the Tarago-Braidwood road.

Thus we find the Shoalhaven Valley in this area to be a peneplain cut in a higher and older tableland which rises from 800 to 1,200 feet above it. The lower surface is of a composite nature with one set of levels at 2,000 feet and a higher series lying between 2,400 and 2,600 feet, with details that have been determined by rock structure and resistance. The older levels and terraces fall gently northward, and have their greatest height and least physiographic complexity at the head of the river.

The Stream System.

The principal streams of the Shoalhaven system follow the general northward slope, and they are well adjusted to geological structure. It is this structure which is responsible for their long meridional lines, as their expansion to the east or west has been limited by the hard strata encountered. The best developed tributary systems are those of Nerrimunga and Bungonia Creeks, where the hard ridges stand back from the river, and that of the Endrick, which originated in a fairly uniform sandstone tableland. These three tend towards the dendritic pattern, but there are others whose development has been very restricted; Mongarlowe River, Jerrabatgully and Mulloon Creeks are confined to simple trough valleys for long sections of their courses, and receive only short tributaries from their valley walls. In each of these cases hard strike ridges are the limiting factor, and the considerations involved are simple, as most of the streams of the Shoalhaven system existed before the coming of the late Tertiary basalts and drifts, and it is probable that their essential form survived from much earlier times, as the fall of the older peneplain seems to show. But there are specific questions which remain to be considered, especially the breaches in the Shoalhaven divide, the streams flowing south-eastward, and the course of Deua River. Before discussing them we may consider the factors which govern stream change in such a region as this.

Conditions of Stream Change and Capture.—The most recent account of the normal cycle of stream pattern development is that of Glock (1931), and the existence of such a cycle of development has been well established, provided that the streams commence on a new land surface which is structurally uniform. The pattern of greatest efficiency has a dendritic (branching tree) shape, but modifications of the ideal are introduced by varying rock characters and structures. Some of the tributaries of the Shoalhaven are close to the ideal; considering original slopes and fold structures we may regard the northward-tending streams as being normal, and those flowing south-east or south-south-east as having developed later when the original conditions had been considerably modified. For example, it is possible for Mulloon and Mulwaree Creeks and the Shoalhaven River to have originated simultaneously under the conditions of gentle northward slope which we have indicated, but Reedy Creek was not possible until the Shoalhaven had excavated a valley and brought eastward slopes into being. In a similar way it is difficult to imagine a set of conditions under which the Araluen Creek–lower Deua line originated at the same time as the Shoalhaven, Mongarlowe and upper Deua, and it is still harder to reconcile any scheme of this nature with the facts of topography and structure. We are bound to admit that certain of the streams are of more recent origin than the others, and this leads us to consider some of the conditions of stream change and capture.

At the present time, Australian thought on the matter seems to be in a state of flux, but it is possible to lay down conditions which will guide our discussions. If there is no great topographic barrier between them, the question of capture between streams involves two major considerations: one stream must be working at a significantly lower level than the other, with the higher not lowering its course appreciably, and the lower must be able to push back the common divide until the streams meet, when capture will take place. Much of the confusion in local thought is due to the assumption of revolutionary changes following late Tertiary plateau uplifts, and to contradictory ideas relative to the work of streams. Thus Dr. Marks challenges convention by regarding all divides as being essentially fixed regardless of their symmetry, but he states a probable recession of the order of 3 or 4 miles in the vicinity of Toowoomba (Q.), where a low-level stream is attacking a tableland scarp whose crest forms the divide; in the Shoalhaven Valley a similar recession of the head of Araluen Creek would divert the upper 36 miles of the Shoalhaven into the Deua, so the actual limits of action may be of less importance than local circumstances. This is also realized if we consider the conditions at Middle Mountain, where each mile of recession at the expense of the Shoalhaven would add only one mile to the length of the capturing stream.

When speaking of stream attack Marks writes (1930): "The actual head of a stream is only the end of its valley, the terminal valley side, and it must be graded by the same controls as determine the rest of the valley sides." This conception is illustrated in many basalt areas where streams rise in shallow amphitheatres, but it is not of general application. It is a common thing to find the head of a stream rising very little below its divide, even when the "terminal valley side" is steep. Where such a head comes from a zone of weakness—as in the nature of things it generally will—there is a tendency towards valley elongation in that direction as well as some retreat of the crest or head of the slope due to the grading of the valley sides, and this involves the creation of a new salient in the highland. It will be noticed that I am speaking more especially of attack on a tableland whose surface is approximately constant, and whose edge is the actual divide at the head of the stream. Marks also discussed this case, but his argument assumes that the grade of the "terminal valley side" will gradually decrease "as a uniform slope", and to produce an equivalent recession of the divide as the slope is lowered—"a much greater vertical depth of material has to be removed". The assumption is unsound, as the normal curve of erosion is concave upwards, and the grading of valley sides decreases the average curvature while retaining the more elevated part of the curve as the steepest slope. In other words, recession of a divide will be a gradually decreasing quantity as erosion progresses, but until the curvature of the slope of erosion approximates to zero (*i.e.*, until it becomes slight and uniform), the rate of decrease will only be a portion of that estimated by Marks's calculations based on straight line relationships, and the recession of the divide will progress more quickly and over a much greater range than he is inclined to admit. If attack is proceeding actively from both sides and each stream is lowering its course, the divide will be a cusp formed by the intersecting profiles of erosion, and we can agree with Marks that its lateral movement will be slight unless and until one stream is hung up at a relatively high level, when conditions will gradually approach those of a tableland which is being attacked on one side from a lower level. Davis shows the idea clearly in some of his diagrams (1908, p. 23), and admitting all his assumptions we cannot doubt his conclusions in these matters generally, although their reproduction in the field is an altogether different question.

In our own tablelands the number of captures indicated between active streams is small, especially if allowance is made for the configuration of the surface and the great length of time over which the streams have been working, and, although it is possible to infer the destruction of primitive systems over wide areas, and their replacement by the existing patterns, it is difficult to demonstrate cases of individual change involving radical departures from pre-existing conditions: when we have mentioned Mulloon Creek, the Deua and upper Murrumbidgee Rivers we have about exhausted the forms which look like such instances in south-eastern New South Wales, and although it is probable that unsuspected captures have taken place in this region, it is unlikely that first class streams were affected, and even the three instances quoted are comparatively unimportant. This state of affairs may be attributed largely to two things: in the first place, no rock has been sufficiently resistant to withstand the downcutting of a vigorous stream, and in the second zones of weakness are generally parallel to prevailing slopes and primitive stream courses. The first has far-reaching consequences, for except in the cores of the tablelands even the smallest streams that were revived by late Tertiary uplifts have graded their courses by cutting deep gorges almost to their divides, or, in the case of the longer streams, far upstream into the central masses. In this process hard rocks have suffered with the softer formations: thus the Cox and Kowmung Rivers in the Central Tableland have cut across hard quartzites near where these have stood above sea-level as hills since Upper Marine times, and they have continued their grading almost to their divides. An effect of like nature is revealed by Marks's studies in the Brisbane region, where short streams falling directly to the coast and others which take more roundabout courses through harder rocks have both cut down almost to base-level without any notable change in their mutual relationships, although subsequent denudation has widened the short valleys of the direct streams into plains, while those of the more powerful and less direct system in more resistant strata have retained much of their youthful appearance. A similar state of affairs has been noticed in various parts of the Shoalhaven Valley.

With respect to the second point I have mentioned, it is sufficient for the present to remark that eastern Australian conditions are vastly different from those obtaining in places where more complex fold systems and a more striking differentiation of resistances have gone hand in hand. Such conditions are emphasized in Davis's (1909) discussion of western Pennsylvania or Lobeck's (1924) illustrations of part of the Appalachian region with its highly diversified fold systems and related topography, but they hardly exist in this State, where we can regard the pre-Permian stratified rocks (and the Permian also in places) and the granites as having given surfaces of erosion on which parallel lines of weakness are ruled in three families—meridional, transverse, and oblique, the last-named ranging from NW–SE to NNW–SSE (David, 1914; I. A. Brown, 1928), and the younger rocks as giving gently warped surfaces on which streams may have been determined by original slopes, although obviously the matter cannot be discussed here.

To sum up: we agree with Dr. Marks that there has been no great rearrangement of drainage in the region as a consequence of late Tertiary uplifts, but dynamic stream change and capture are realities under rather limited conditions, and they may have played some part in the development of our drainage—a part determined by conditions of structure, slope and elevation.

Effect of Vegetation.—Another factor which exerts a great effect on erosion and stream change is the presence of vegetation, which covers almost the whole of our tablelands and tends to reduce erosion to a minimum even on steep slopes. When this covering is destroyed the soil and rock are attacked and cut away rapidly, especially on the deeply-weathered edges of the newer peneplain. We have noticed one particularly striking example of arrested erosion in the case of the earth gully to the south of Middle Mountain, where the banks are protected by trees, ferns and grass. Such a feature is not formed under present conditions, so we look back to a time in the past when the covering of vegetation was far less effective than it is now, and for conditions under which this would have been possible. Considering the upper valley of the Shoalhaven, we find that snow falls even in the high-level valleys during the winter months, and the climate must have been much more severe during the Pleistocene glaciation, which was estimated by David (1908) as being of the order of 200,000 and 10,000 years ago on Kosciusko, and was unfavourable for the growth of many plants now occurring on the highlands. We also find laterites and yellow earths in the middle valley of the Shoalhaven, and various stream and hill drifts point to conditions of sparse vegetation and storminess with which I hope to deal more elaborately in the near future.

Thus when we compare the present with the immediate past we find that there has probably been a great slowing up in the rate of erosion, which may be lower than it has ever been before under similar climatic conditions, and at the present day the landscape is changing comparatively slowly. This must be kept in mind when the past is being studied, or the present relative equilibrium will lead us to discount ideas of change which are perfectly legitimate on general reasoning. Two specific cases of apparent change may now be reviewed.

Mulloon and Reedy Creeks.—The topography of the drainage area of these streams has already been outlined; Reedy Creek flows from lower into rather higher land, and has a course opposed to that of the Shoalhaven, which it necessarily post-dates. In addition its grade is abnormally steep, and its valley through the higher land is comparatively steep-sided and narrow. On the other hand, Mulloon Creek follows the ancient slope of the land out of the old land masses, and the line of its wide valley continues through the uplands to Tarago, with the high points of the intervening divides showing a falling to the north. The valley does not narrow in those places, and small watercourses within it do not flow appreciably below the inclined planes leading from the divides: it appears that the planes are due to the uniform lowering of an originally horizontal surface. The grade of Mulloon Creek above its junction with Reedy Creek is gentle, and the wider upper members of the valley-in-valley forms on the western scarp rise above the Boro-Reedy Creek divide.

Taking all these facts together and considering the topographic discussion earlier in this paper, it appears that Mulloon Creek originally flowed northward to join Mulwaree Creek near Tarago after passing along a wide valley at a (modern) elevation of 2,400 feet in a gentle plain, with broken ridges of slightly greater altitude to the east. Boro and Reedy Creeks cut back from the Shoalhaven probably when its bed was about 1,800 feet (modern), took advantage of meridional, transverse and oblique lines of weakness which exist both in the granites and in the sedimentary rocks, and broke up the old high-level drainage line, the more southerly stream getting the greater part of the spoil. The most likely time for this to happen, as we have suggested, was after the channelling of the Shoalhaven Plain, but sufficiently long ago to allow a slight lowering of the sections of the captured line and the accumulation of recent gravels about the junction of Mulloon and Reedy Creeks. The implied presence of basalts on the divide between Boro and Reedy Creeks, and on the plains about Lake Bathurst further to the north may have assisted these changes, but on this point we cannot speak with any certainty.

Deua River.—The older peneplain level now above 3,000 feet extended to the east of the upper Deua where the strike ridges of Donovan (2,960 feet) and Bendethera (3,265 feet, Text-fig. 5) form a consistently high level, although the country at the head of the river is lower. This highland is on the same strike as Currockbilly and Budawang ridges (I. Brown, 1930—maps), and owes its preservation to the resistance of its rocks. At one time these sections of ridge to the north and south of the present lower Deua were continuous, and ancient peneplanation reduced the folded strata to the same level as their sub-horizontal and almost unaltered equivalents to the west between Major's Creek and Mt. Dampier. The lower Deua cut across the reduced folds from the then existing coast, taking advantage of the various lines of weakness, and it took part of the original meridional drainage. The effects of peneplanation which gave the Shoalhaven Plain are observed in the wide upland gap across the old Budawang-Donovan ridge, levels above the valley of Araluen Creek at 2,300 or 2,400 feet, and hills rising to a similar height along the Deua above its junction with Araluen Creek, although more recent dissection has destroyed most of the older surfaces in that part. However, the ancient meanders have persisted through the down-cutting, and they show that the present stream line antedates the most recent uplifts, and is at least of late Tertiary age. Oblique lines of weakness in the granites continue to be exploited by the streams between Moodong and Araluen Creeks, and the latter has cut back in a straight line until its head is within four miles of the Shoalhaven with a low divide separating the two. A review of conditions in this section discloses the following circumstances:

1. The older peneplain sloped gently northward, and when conditions favoured the maximum development of the Shoalhaven Plain, it stood 1,000 to 1,200 feet above sea-level (i.e., 700 feet above the subsequently developed plain at Major's Creek + 400 feet of that surface above sea-level, as the plain fell 300 feet to Tallong, which stood rather above sea-level).

2. The main streams flowed northwards over this surface, and the upper Deua may have passed northward to Mongarlowe River. Attack from the east or south-east was vigorous along lines of weakness and the high-level streams, far removed from their active lower courses, remained at a high level for a long period of time (cf. present conditions).

3. The lower Deua cut into the tableland scarp until it captured part of the northward drainage, discovered the granites, and continued to develop tributaries towards the north-west. Base-levelling ultimately reduced much of the country on either side of the Shoalhaven divide to 200 or 400 feet above sea-level, and the divide was breached in various places with the formation of level gaps, but without any appreciable stream change.

4. Further uplift during the latter part of the Tertiary Period elevated the tableland by 2,000 feet: the coastal streams became entrenched and Araluen, Currowan and Woila Creeks continued to invade the tableland. The two former have diverted small streams from the Shoalhaven, and threaten to capture the heads of the Shoalhaven and Mongarlowe respectively, while Woila Creek is encroaching on the swamps at the head of the main stream.

5. A favouring climate and the high development of plant organization has resulted in the whole surface being covered with trees and plants. These have reduced erosion to a minimum, and are holding up stream change and the further development of land forms.

6. With the Shoalhaven cutting back slowly into the tableland through hard rocks and losing the help of its tributaries as recession of the gorges proceeds, it seems that, in the course of time, Araluen Creek may capture the head of the Shoalhaven by way of Back Creek, because it has a steep grade, decomposed rock to deal with, a relatively short distance to travel (four miles), and a divide to deal with only 150 feet above a river which is filling its bed with sand and flowing through alluvial flats.

Summary and Conclusions.

There are two major levels towards the upper Shoalhaven—a high tableland between 3,000 and 4,000 feet with hard residuals and old tectonic features rising to 4,800 feet, and a lower level at 2,400 to 2,600 feet which rises towards the head of the river. It lies 800 to 1,000 feet below the higher surface, and its northward extension has been lowered by erosion to form the lowest or Shoalhaven plain about 2,000 feet which has, in its turn, been channelled to a depth of 400 feet. The trenches thus formed have been filled with drift, and have since been re-developed by erosion both before and after the commencement of the deep modern gorges. Attack is proceeding directly from the coast, and the levels of the Shoalhaven Valley are being invaded by gorges from the east and south. The original streams of the higher surface flowed northward, and their shapes were largely controlled by rock character and structure, but others have developed along parallel oblique lines to modify the original drainage to a limited extent. In addition to these things, the paper discusses the general conditions of stream change and capture, but consideration of the ages of the surfaces involved and of the history of the surrounding country is deferred to a final paper.

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NOTES ON AUSTRALIAN DIPTERA. XXXII.

By J. R. Malloch.

(*Communicated by F. H. Taylor.*)

[Read 31st August, 1932.]

Family Agromyzidae.

Genus Fergusonina Malloch.

Proc. Linn. Soc. N.S.W., 49, pt. 3, 1924, 337; *op. cit.*, 50, pt. 2, 1925, 90.

When I originally described this genus I had but one rather poorly preserved specimen before me. Subsequently I received another and better specimen of the genotype, and single specimens of three additional species, from which I described the species as indicated below. Until recently nothing was known of the larval habits, but in a recent shipment of reared material from Mr. W. B. Gurney there are examples of two species of the genus obtained from bud galls on seeds of *Eucalyptus maculatus.* It is very gratifying to me to learn that the genus named after the gentleman who was instrumental in having me work on the Australian Diptera is so clearly identified with an Australian plant and in all probability exclusively Australian.

Because of the condition of the type and the lack of material for comparison I erred in a few details of the original description and omitted some which did not at the time appear to me to be of consequence. These defects I correct herein and hope that the present paper will enable students to identify not only the genus, but all the species that have been described up to this time.

The postvertical bristles are placed close behind the ocellar triangle and are invariably divergent as shown in my original figure of the genotype; the ocellars are small, proclinate, and divergent, the frons is covered with short stiff hairs except on the large lunate or subtriangular central portion, which extends upward from the antennal bases to or above middle; the antennae are inserted close to or below lower margin of eyes, distant from these, and separated by a more or less well developed carina; the fronto-orbitals vary from two pairs to none, and the verticals are generally four in number, with the inner one on each side the smaller; antennae small, the arista almost bare; vibrissae developed or undeveloped; parafacials haired; proboscis small and stout; palpi of moderate length. Mesopleura and sternopleura setulose; mesonotum with two, rarely three, posterior pairs of postsutural dorsocentral bristles; scutellum with four bristles. Ovipositor of female in the form of a long slender chitinized cone, hypopygium of male rather inconspicuous. Costal vein weak beyond apex of third vein, sometimes practically indistinguishable on its apical section.

Genotype, *Fergusonina microcera* Malloch.

Key to the Species.

1. Third antennal segment black or fuscous, much darker than the basal two; costal vein quite well developed between apices of second and third veins and distinct under a transmitted light to apex of fourth vein; frontal orbits with the usual upper outwardly-directed bristles very weak or indistinguishable 2
   Antennae entirely yellow 3
2. Parafacials with but one series of short black hairs from about middle of frontal lunule to lower margin of eye; hind femur of male with some strong black setulae at apex on posterior side, stronger below; mesonotum with four conspicuous dull black vittae behind the suture .... *atricornis* Malloch
   Parafacials with two or more series of short black hairs on entire extent; hind femur in neither sex with strong black hairs at apex on posterior side; mesonotum without distinct postsutural black vittae .... *eucalypti*, n. sp.
3. Mesonotum entirely fulvous-yellow; cell between second and third wing veins not narrowed at apex 4
   Mesonotum with black marks on disc; cell between second and third wing veins generally distinctly narrowed at apex 5
4. Each frontal orbit with but one well developed outwardly-curved bristle on upper third .... *microcera* Malloch
   Each frontal orbit with two rather shorter outwardly-curved bristles on upper third .... *biseta*, n. sp.
5. Mesonotum with the disc broadly black, the usual vittae so closely contiguous that the yellow ground colour is obliterated; scutellum yellow, the base dark; all sclerites of the pleura largely blackened; all the frontal bristles, including the ocellar, two pairs of orbitals, and the inner vertical well developed, the latter about half as long as the outer verticals .... *scutellata* Malloch
   Disc of mesonotum with well defined blackish vittae, scutellum not black at base, the pleura less extensively blackened 6
6. Scutellum entirely yellow; mesonotum with six black vittae, the central pair much shortened posteriorly, the two on each side of them extending farther back, but not to posterior margin, all more or less broken at the suture; mesopleura with a slight dark mark near upper anterior angle, otherwise yellow .... *flavicornis* Malloch
   Scutellum blackened on each side at base; mesonotum with four black vittae, the outer one consisting of the two present in the above species, which are so closely contiguous that the yellow ground colour is completely obliterated, the central pair faint posteriorly but traceable to hind margin; mesopleura with an oblique black stripe from middle of anterior margin to lower posterior angle .... *gurneyi*, n. sp.

FERGUSONINA ATRICORNIS Malloch.

PROC. LINN. SOC. N.S.W., 50, 1925, 92.

I have seen only the type specimen of this species which is from Sydney, N.S.W.

FERGUSONINA EUCALYPTI, n. sp.

♂, ♀.—Very similar to *atricornis*, distinguishable principally by the characters listed in the foregoing key to the species. The head is yellow except a black spot on the ocellar triangle, and the third antennal segment; the hairs and bristles are black. The mesonotum has usually two vestigial black submedian vittae on the anterior margin which are placed so low that the head generally covers them; there are also usually traces of four reddish vittae anteriorly, but the reared material before me is not as well matured as it might be, so that it is impossible to tell whether these may, in perfectly matured specimens, become more conspicuous. The abdomen has a large black mark on the dorsum, which covers nearly all of the second, third, and fourth tergites in both sexes, which distinguishes the species from *atricornis*, in which the base of all except the first and apical tergites is broadly brown. The sheath of the ovipositor of the female is deep black, and the male hypopygium is yellow. Wings hyaline. Legs yellow.

Structurally quite similar to *atricornis*, but more robust, and with the outline of the vertex more emarginate on each side of the ocellar triangle. Both species have a short setulose hair behind the supra-alar bristle which is not evident in the other species now before me. Venation as in *atricornis*, and in other characters similar except as noted in the key. Length, 2·5 mm.

Type, male, allotype, and two paratypes, reared from galls on seed capsules of *Eucalyptus maculatus*, Bodalla, N.S.W., October, 1929 (Forestry Commission); paratype male, labelled, "from *E. maculata* bud galls", Bateman's Bay, 15.10.1931 (W. L. Morgan).

Mounted with one specimen and in alcohol are examples of the puparia. These are about 2 mm. in length and 1·25 mm. thick at the posterior extremity, tapered slightly in front, and of a glossy reddish-brown colour, the ventral surface slightly flattened, darker than the remainder and with about 20 transverse striae on each segment, which are minutely pitted, most distinct on central segments and shading off at both extremities and on the sides. The posterior spiracles are in the form of small round dark brown elevations situated at a distance apart equal to about twelve times the width of one disc. A fuller description must await the working out of the life-history of the species by someone in the field.

FERGUSONINA MICROCERA Malloch.

PROC. LINN. SOC. N.S.W., 49, 1924, 338; *op. cit.*, 50, 1925, 92.

The genotype was described from a female, and subsequently I described the male.

Localities.—North Harbour, and Sydney, N.S.W.

FERGUSONINA BISETA, n. sp.

♂. Very similar to the preceding species, distinguishable by its larger size, and the character mentioned in the foregoing key to the species. The type specimen is rather teneral, but it appears justifiable to consider the presence of two bristles on each frontal orbit as indicative of specific distinctness from the genotype. Length, 2·5 mm.

Type, reared with *eucalypti* from galls on seed capsules of *Eucalyptus maculatus*, Bodalla, N.S.W., October, 1929 (Forestry Commission).

FERGUSONINA SCUTELLATA Malloch.

PROC. LINN. SOC. N.S.W., 50, pt. 2, 1925, 92.

I have seen only the type specimen from Sydney, N.S.W. It is the darkest coloured species of the genus known to me.

FERGUSONINA FLAVICORNIS Malloch.

PROC. LINN. SOC. N.S.W., 50, pt. 2, 1925, 92.

Only the type specimen has been seen by me. Locality, Sydney, N.S.W.

FERGUSONINA GURNEYI, n. sp.

♂, ♀.—Differs from the preceding species in the markings of the mesonotum, in being deeper yellow in colour, in having the scutellum quite broadly blackened on each side at base, and the base of each abdominal tergite broadly black.

All the frontal bristles are well developed, there being two outwardly-curved orbitals on each side. The mesonotum differs from that of *flavicornis* in having only two pairs of posterior postsutural dorsocentrals, *flavicornis* having, at least in the type, a third, anterior pair. The second wing vein is not noticeably bent down at apex although it is slightly so in *flavicornis*. Length, 2 mm.

Type, male, and allotype, "From *Eucalyptus maculatus* bud galls", Bateman's Bay, N.S.W., 15.10.1931 (W. L. Morgan).

It may be worth noting that in the females of the genus the abdominal segment in front of the ovipositor forms a complete cylinder, and is not separated on sides.

Family OCHTHIPHILIDAE.

CHAETOLEUCOPIS, n. gen.

In Number xxvi of this series of papers (These PROCEEDINGS, 55, pt. 4, 1930, 488) I gave a synoptic key to the genera of this family, including in it all genera known to me at that time. In a recent lot of material received from Mr. W. B. Gurney there is one new genus to which I give the name *Chaetoleucopis*.

In the key just referred to the genus will run down to *Pseudoleucopis* Malloch, but in the latter there are two pairs of well developed fronto-orbital bristles, while in the new genus there is but one pair present. The postvertical and ocellar bristles are much weaker in the new genus than in the other, but they both agree in having the prescutellar acrostichals present, and in other characters, though the general structure of the head is more like that of *Leucopis* in the new genus than in *Pseudoleucopis*.

Genotype, the following species.

CHAETOLEUCOPIS DACTYLOPIVORA, n. sp.

♀.—Black, the head and thorax densely pale-grey-dusted, the frons viewed from certain angles showing black except on the orbits and triangle, mesonotum with two moderately wide dark brown vittae which are wider behind and disappear before the hind margin, the scutellum brown on disc, becoming grey apically. Abdomen shining black, very faintly greyish-dusted. Legs fuscous, extreme apices of femora and bases of tibiae yellowish, tarsi dirty yellow, apical two or three segments fuscous. Wings hyaline, veins brown. Knobs of halteres lemon-yellow.

Frons about 1·5 as long as its width at vertex, with some very short surface hairs, the orbits very narrow, sides slightly diverging in front, all four verticals and the single pair of orbitals well developed, about twice as long and strong as the ocellar and postvertical pairs; lunule broadly arcuate and large; antennae inserted a little below middle of eye in profile, third segment large and almost round, with the bare arista inserted near base on upper side; face slightly concave; cheek not more than half as high as width of third antennal segment, with some marginal hairs. Thorax with two presutural pairs of dorsocentral bristles, the anterior pair much shorter than the posterior; the hairs in about eight to ten series between the inner margins of the dark vittae anteriorly; basal pair of scutellar bristles distinctly shorter than the apical pair. Abdomen ovate, with short hairs and longer apical setulae on the tergites. Legs moderately stout, without femoral or tibial bristles. Wings as in *Pseudoleucopis*, the inner cross-vein a little beyond middle of discal cell, and the outer one 1·5 times its own length from inner; third and fourth veins parallel apically.

Length, 2 mm.

Type and one paratype, from *Dactylopius albizziae* ?, Eastwood, N.S.W., 9.11.1925 (E. H. Zeck).

Type will be returned to the sender for disposition in some Australian museum, and the paratype retained by the writer.

Mounted on a separate card with the two imagines there is an imperfect puparium which is of the same general type as those of *Leucopis* reared in North America by the writer, the posterior spiracles being upon two stalks which are about twice as long as their basal diameter, much tapered at apices and separated at bases by about the length of one of the stalks. There are no outstanding characters preserved in the one specimen available and it will require well preserved larvae to enable one to determine what characters, if any, are diagnostic.

Family NEOTTIPHILIDAE.

Genus TAPEIGASTER Macquart.

TAPEIGASTER MARGINIFRONS Bezzi.

Aust. Zoologist, 3, 1923, 74.

Three specimens of this species submitted by Mr. Gurney bear the data, "Found developing in fungus, Blackheath, N.S.W., 5.4.1931".

No puparia accompany the specimens, and the larval characters are unknown to me. A species of the genus has previously been recorded by Bezzi as feeding in fungi.

AUSTRALIAN HESPERIIDAE. II.

NOTES AND DESCRIPTIONS OF NEW FORMS.

By G. A. WATERHOUSE, D.Sc., B.E., F.E.S.

(Two Text-figures.)

[Read 27th July, 1932.]

Since the first part of this series was published in These PROCEEDINGS in 1927, I have collected and received many more specimens of this family, especially from Western Australia, collected by F. L. Whitlock, so I can give additional information from that and other States.

The recent visit to Australia of Brigadier W. H. Evans, one of the world's authorities on the family, has added considerably to my knowledge, more especially of those species which have reached Australia from New Guinea. General Evans brought with him a large number of species from the Australian Region for comparison.

General Evans was in Australia for about two months, and a portion of nearly every day of this period we spent together in the examination of species of this family. We examined very carefully the extensive collection at the Australian Museum, Sydney, which now possesses my own collection, recently presented to that Institution. We also spent over a week in Adelaide and in the South Australian Museum examined the Lower collection of Hesperiidae and also the types from the Tepper, Guest and Lucas collections in that Museum. This study has brought to light many new facts and at the same time has confirmed many of the statements put forward in the "Butterflies of Australia" in 1914.

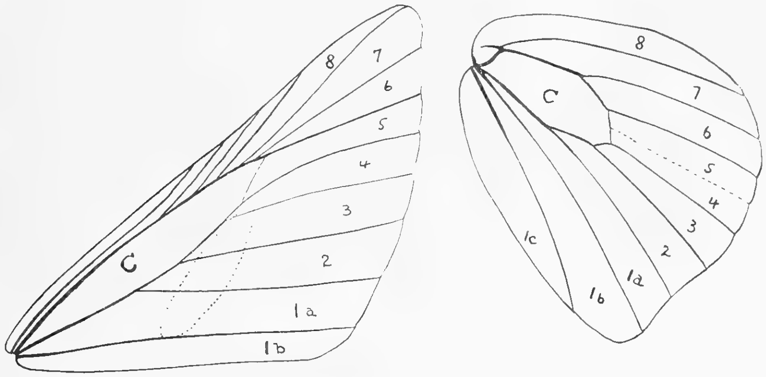
As a result of this work it has been decided that I should describe the new species and subspecies we found, leaving for the present the characterization of certain new genera which we have decided are necessary, but which require a fuller investigation by General Evans after he has examined the collections at the British Museum and elsewhere in England.

It has been necessary to nominate a type locality for many species, as in a number of cases this has been given by older authors in a very general way; even Lower in his papers usually omitted the locality of his type specimens, and in some cases did not even mark a specimen as type.

The names, unless alterations are made, are those of Waterhouse and Lyell (1914), modified in some respects as to the sequence of genera, as indicated in Waterhouse, 1927.

I adhere to numbers for the veins of the wings as this is a very convenient method. Should the student wish the names of the veins as in use through all the Orders of Insects, he is advised to consult Dr. R. J. Tillyard's "Insects of Australia and New Zealand", 1926. I have kept to the use of space 1a for the area above vein 1a, and 1b for the area below it in the forewing, and in the hindwing spaces 1a, 1b and 1c in that order from vein 2, as I consider that this method is clearer to understand. General Evans in his papers names these spaces the reverse way.

The scheme of markings on the wings of the Hesperiidae is more or less of one pattern with modifications for the different species. The forewing usually has a spot in the cell, often hyaline, a streak along space 1b, a spot towards the base in space 1a never hyaline, an outer spot in 1a hyaline, usually a large spot in space 2 hyaline, another smaller in space 3, sometimes small spots in spaces 4 and 5 hyaline, very often three small subapical spots in spaces 6, 7 and 8 hyaline, these last spots running more or less at right angles to the costa. In the male there is often a sex brand on the forewing running from near the dorsum to near the base of vein 4; this brand varies in length and width in those species in which it occurs and is set at different angles in different species. It is unusual to find hyaline spots on the basal side of the brand. The underside of the forewing is marked in a similar manner to the upperside but the sex mark is absent. The upperside of the hindwing often has a broad spot extending from vein 1a to vein 6 rarely hyaline, and there may be a smaller disconnected spot in space 6. The general colour of the underside of the hindwing is the same as the apical area of the underside of the forewing. There is usually a cell spot and often another in space 1a below it; the discal series of spots is between 1a and 6 and may be a straight band or a series of spots concentric with the termen; these spots may be irregular or nearly round and often have white or silver centres; sometimes there are smaller disconnected spots in spaces 6 and 7.



Text-figure 1, showing the method used of numbering the spaces in forewing and hindwing. C = cell. Numbers of spaces 9 to 12 in forewing omitted.

The new species and subspecies described in this paper have all been seen by General Evans, and he agrees that they are all worthy of names.

In addition to the very great assistance received from the South Australian Museum for the facilities given me in Adelaide, even allowing me to bring types to Sydney for comparison, I have to thank Messrs. F. L. Whitlock, L. Franzen, A. N. Burns, G. M. Goldfinch, J. Macqueen and A. L. Brown for many specimens. Unless otherwise stated the types are all in the Australian Museum, Sydney.

A list of the principal papers dealing with Australian Hesperiidae is given on the concluding page. Many notes are given on the coloured figures in Seitz Macrolepidoptera. Many of the figures in this work are said to be taken from the hitherto unpublished figures of Plötz, and I am of the opinion that others not so stated are from the same source. The figures of Plötz are usually too highly coloured and do not give an accurate representation of the insect. I have had for some years copies of the figures of the new Australian species described by Plötz.

Subfamily TRAPEZITINAE.

TRAPEZITES MAHETA Hewitson.

Hewitson's type is a male from Queensland and doubtless caught near Brisbane, the source of many of Hewitson's species. Two races, differing in the underside of the hindwing, can be recognized on the material available. I cannot recognize *obruta* Seitz, 1927, p. 1060, unless it be meant for *iacchoides* Waterhouse, as *maheta* seems to be constant in the number of silver spots on the hindwing below.

TRAPEZITES MAHETA MAHETA Hewitson.

Hesperia maheta Hew., *Ann. Mag. Nat. Hist.*, (4), 19, 1877, p. 80.

Males from Queensland agree with Hewitson's description of the underside: "Pale rufous grey, except the lower half of the anterior wing and the inner margin and anal angle of the posterior wing, which are dark brown." In Queensland males that I have seen, the underside is variegated with whitish-brown. In the female the underside is paler than in the southern race. Mr. L. Franzen has sent me specimens from near Brisbane in March and April.

TRAPEZITES MAHETA PRAXEDES Plötz.

Telesto praxedes Plötz, 1884, p. 378; *Trap. maheta*, Waterhouse and Lyell, 1914, p. 177, figs. 606-7, 614; *T. maheta*, Seitz, 1927, Pl. 167.*

Plötz states that his type is from Port Jackson (Sydney) and his figure agrees with Sydney specimens. In the male the underside of the hindwing is a uniform dark brown, excepting the usual silver and dark spots. In the female, the spot in 1a of forewing above is more heavily scaled than in the northern race.

ANISYNTA CYNONE Hewitson.

Hewitson's type is certainly a male, and from his description and figure is the race that occurs in South Australia. The species has only been caught in the autumn.

ANISYNTA CYNONE CYNONE Hewitson.

Cyclopides cynone Hew., 1874, fig. 17; *A. cynone*, Waterhouse and Lyell, 1914, p. 182, figs. 761-3; *Hesperilla gracilis* Tepper, 1882, p. 34, Pl. 2, fig. 7.

This race is distinguished by the rufous brown underside to the hindwing. The figure in Seitz, 1927, Pl. 171, is very poor, but probably represents this race.

ANISYNTA CYNONE GRISEA, n. subsp.

Astictopterus cynone, Anderson and Spry, 1894, p. 113.

This race, which occurs in Victoria, is distinguished on the upperside by being grey-brown rather than brown and the markings white instead of pale yellow. On the underside the apex of the forewing and the ground colour of the hindwing are distinctly grey-brown in contrast to the rufous brown of typical *cynone*. On the upperside of the forewing the spot in 1a is variable in size, there are always spots in 2 and 3 and usually smaller spots in 4 and 5, as well as the

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* For list of references to papers on Australian Hesperiidae, see concluding page.

three subapical dots. On the underside of the hindwing, the white spots are somewhat larger than in the typical race. Described from 6 males and 3 females from Kerang, in March, also recorded from Gunbower in April.

ANISYNTA ARGENTEO-ORNATA Hewitson.

Hewitson's type is a male from Swan River, W.A. Two races occur, all specimens from the mainland of Western Australia differing from those found on the islands off the coast.

ANISYNTA ARGENTEO-ORNATA ARGENTEO-ORNATA Hewitson.

Cyclopides argenteo-ornatus Hew., 1868, p. 41; Hew., 1874, figs. 18, 19; Seitz, 1927, Pl. 167.

In 1914, I had seen less than ten specimens from the mainland, but now have a long series taken at Bunbury by Mr. Whitlock in October and November, and I have caught it myself near Geraldton in September. In these the hindwing has on the underside a yellowish suffusion and the white spots are small and separate. The figure of the upperside in Seitz is good, but the figure of the underside is poor.

ANISYNTA ARGENTEO-ORNATA INSULA, n. subsp.

A. argenteo-ornata, Waterhouse and Lyell, 1914, p. 182, figs. 709, 710.

This chiefly differs from the mainland race above in that the spots of the forewing are somewhat paler and the cilia more chequered. On the underside the apex of the forewing and the ground colour of the hindwing are brown, the white spots of the hindwing in 1a to 6 are joined, forming a straight band which is extended in 1a towards the base and again extended in 7 towards the base, cell spot and spots in 7 and 8 are more elongated than in the mainland race. Described from 3 males and 2 females from Hermite Is., Monte Bello Group, in June. Specimens from East Wallabi Is. in November are similar. I have a female from Rottnest Is., near Fremantle, in October; there is a pair in the South Australian Museum from the same locality; these are much nearer this race than the typical race.

TOXIDIA SEXGUTTATA Herrich-Schaeffer.

This is a rare species; I have not seen more than fifteen specimens. The type is a female from Rockhampton. It was not represented in Lower's collection, the only specimen under that name being a female *T. crypsigramma* from Herberton in January. There are two races differing chiefly in the colour of the underside. The species varies in size. The brand of the male is narrow and extends from vein 1a to vein 3.

TOXIDIA SEXGUTTATA SEXGUTTATA Herrich-Schaeffer.

Hesperilla sexguttata H.-S., *Stett. Ent. Zeit.*, 1869, p. 80, Pl. 3, fig. 16.

Specimens of this race are larger than the northern race. A male from Gayndah has no spots on the upperside, indications of a pale discal band on the underside of the forewing. A female from Palmwoods in February has two subapical dots, quadrate spots in 2 and 3 and a faint spot above 1a on the forewing. Both on upper and undersides these two specimens are brown and are much darker than those found further north. Gen. Evans brought with him a male from Dawson River, ex Tring Museum, which has three subapicals, the upper being very faint, and a very small dot in 3 and is somewhat paler than the Gayndah male.

TOXIDIA SEXGUTTATA SELA, n. subsp.

T. sexguttata, Waterhouse and Lyell, 1914, p. 191, figs. 641-2.

The holotype male has two distinct subapicals with a third in 8 indicated, spot in 3 and a narrow one extending across 2, and a spot indicated in 1a; hindwing above unmarked. On the underside the spots in 3 and 2 are well indicated; a second male agrees with the holotype except that it has only one subapical dot. The female has three subapicals, spots in 3 and 2 and a faint one in 1a. Both on upper and underside these three specimens are yellowish-brown and are more narrow winged than the typical race; they are from Banks Is., in February and March. In addition, I have a pair from Cairns, in February. The South Australian Museum has the following: A very small male from Groote Is., in February, a normal female same locality and date, and a female from Winchelsea Is., in April. These specimens are not in the best condition and for the present may be referred here, though in colour they approach the typical race.

MESODINA CROITES Hewitson.

Hewitson's type is a female from Australia and it was nearly 40 years before it was known to be from Western Australia. In 1914 I only knew this species from a coloured drawing of the type in the British Museum, a male from Carnarvon and a pair from Pindar. During the last few years Mr. F. L. Whitlock has taken a series from September to November at Bunbury, which show that the type probably came from the south and probably at no great distance from Perth. The Pindar pair certainly constitute a good race.

MESODINA CROITES CROITES Hewitson.

Cyclopides croites Hew., 1874, fig. 14; *M. croites*, Waterhouse and Lyell, 1914, p. 180, fig. 757.

The specimens from Bunbury usually have the brown markings on the underside of the hindwing more developed than in fig. 757. The orange spot of the hindwing on the upperside is very broad and sometimes encloses two brown spots. The only definite localities are Bunbury and Carnarvon (one male). Seitz (1927, Pl. 167) figures a female and not a male as stated.

MESODINA CROITES PINDAR, n. subsp.

M. croites, Waterhouse and Lyell, 1914, p. 181, figs. 755, 756.

Having now a series from the south-west, I have no hesitation in claiming subspecific rank for the pair taken at Pindar in July, described and figured in 1914. They differ chiefly in having the markings on the upperside much paler and on the hindwing the central spot smaller. On the underside of the hindwing the markings are almost obsolete.

MOTASINGHA DIRPHIA Hewitson.

Hewitson's type is a female from Swan River, W.A. (Perth). He afterwards described the male and figured it with the female from the same locality. This species has a very extensive range in Australia, as it is found in Western Australia, South Australia, Victoria and New South Wales. Semper records a female from Cape York, but this record either refers to another species or is a mistake. I have much more material than in 1914 and can distinguish three races. In all the races, the female sometimes has on the upperside of the hindwing a round pale cell spot and more rarely two pale discal spots.

MOTASINGHA DIRPHIA DIRPHIA Hewitson.

Hesperilla dirphia Hew., 1868, p. 38; Hew., 1874, figs. 1-3.

The race from Western Australia is grey-brown on the upperside and the spots of the forewing are paler than in the other races, the male brand is usually broken up into five raised black streaks. On the underside of the hindwing the colour is variable, but is usually much darker than in the other races; except in one female (which has three) all my specimens have only one discal white spot. It flies in south-west Australia from October to December. I have recently received it from Bunbury.

MOTASINGHA DIRPHIA TRIMACULATA Tepper.

Hesperilla trimaculata Tepper, 1882, p. 32, Pl. 2, fig. 1 (male); *Hesp. quadrimaculata* Tepper, 1882, p. 32, Pl. 2, fig. 2 (female).

Tepper described the sexes from South Australia under different names. All my specimens have the spots on the upperside usually smaller than *dilata* and the colour of the underside of the hindwing is generally reddish-brown, usually with three white discal spots. In addition to Tepper's localities, I have seen specimens from Belair, Blackwood, Port Victor and Port Lincoln caught in October and November. I consider my specimens from Dimboola, Vict., belong here.

MOTASINGHA DIRPHIA DILATA, n. subsp.

M. dirphia, Waterhouse and Lyell, 1914, p. 195, figs. 628-630.

In this race, in both sexes the general colour on the upper side is more yellow-brown than in the other races, the spots of the forewing are much more irregular in shape, extending along the veins towards the termen; this is specially seen in the three subapical spots and the spots in 2 and 3 in the female. The male has the spot in 3, sometimes in 2, and the brand is usually continuous. The female has spots in 3 and 2 and usually two in 1a. On the underside of the hindwing the white cell spot is very prominent and ringed with brown-black, and there are at least three small white discal spots. I caught and bred this race at Waverley, near Sydney, from October to December, but owing to settlement its foodplant has been destroyed; but it can now be found near Long Bay. I have it also from the Blue Mts., near Blackheath.

MOTASINGHA ATRALBA Tepper.

This species belongs to the older fauna of south-western Australia and has no close representative in eastern Australia. At least three distinct races can be recognized.

MOTASINGHA ATRALBA ATRALBA Tepper.

Hesperilla atralba Tepper, 1882, p. 33, Pl. 2, fig. 5; *M. atralba atralba*, Waterhouse and Lyell, 1914, p. 195, fig. 649.

The male of this subspecies has a very narrow and obscure brand, extending from vein 1a to vein 3, and is not always easy to see, especially in the field. The type is a female from Ardrossan, on the western shore of St. Vincent's Gulf, S. Aust., and is now in the South Australian Museum, only the forewings remaining. In both sexes, there are sometimes two additional white spots in 1a, the termen of the forewing is more convex than in the other races, the cilia are markedly chequered and the underside of the hindwing is grey with obscure grey-brown rings.

I have found larvae and pupae of this race on *Gahnia lanigera* at Port Noarlunga, S. Aust. The egg is large, greenish, very faintly marked with numerous fine ribs and elliptical in longitudinal section, height about equals the smaller width. The larva, which resembles that of *M. dirphia*, makes a tent by drawing the leaves of the foodplant together, remaining inside, head downwards, during the day and feeding at night. It pupates in this shelter, fastened by the tail, head downwards, but is without the silken pad below the head, as is the case with pupae of *M. halyzia* and *M. aeluropis*, which also pupate head downwards.

This race has been found in South Australia, at Ardrossan, Port Lincoln (Meyrick), Moonta in November, and Port Noarlunga in April. It probably has a spring and an autumn brood, as larvae I found in April, though nearly full grown, had not pupated by June.

MOTASINGHA ATRALBA DACTYLIOTA Meyrick.

Telesto dactyliota Meyrick, 1887, p. 831; *M. atralba dactyliota* Waterhouse and Lyell, 1914, p. 196, figs. 648, 773.

Meyrick described the sexes from Port Lincoln, S. Aust., and Geraldton, W.A., but his description of the male does not apply to the South Australian race as he mentions the very broad sex mark. The type locality of the race must therefore be Geraldton. Meyrick and Lower (1902, p. 71) sink the name under *atralba*.

I have not seen a specimen from Geraldton, all my specimens being from much further south, but they agree with Meyrick's description. The male has a very broad brand between veins 3 and 1a, below 1a it becomes abruptly narrower, and almost reaches dorsum. My specimens are generally much larger than typical *atralba*, the spots smaller, the upperside of the hindwing with more greenish-grey scaling and the underside somewhat darker. My specimens are from Waroona, W.A., October to December and Stirling Ranges, W.A., in October.

MOTASINGHA ATRALBA NILA, n. subsp.

♂. Forewing smaller and darker than in *dactyliota* and the white spots much reduced in size, the holotype has no spot in 2, but two of six males have a trace of this spot; the brand is not so broad as in *dactyliota*, extends from above vein 3 and is only represented as a streak below 1a, but in some specimens this portion is wider. The hindwing is yellowish-brown and is almost devoid of greyish scaling over the ground colour. On the underside the wings are very much darker than in the other races and the apex of forewing and the hindwing are yellowish-brown, with the usual markings very obscured.

♀. Much larger than male, with spots larger and a double white spot in 1a upper small or absent. Underside as in male.

I have only seen specimens from Dirk Hartog Island, W.A., caught by F. L. Whitlock on 10th Aug., 1920. Types and paratypes in Australian Museum and one of the series sent to the British Museum. This race, as with others, shows that butterflies from the islands off the coast of Western Australia are somewhat different from those occurring on the mainland.

MOTASINGHA DOMINULA Plötz.

The locality given for this species is Tasmania. In 1914 I had only two small Tasmanian males from Mt. Magnet, which did not agree with the unpublished coloured figure of Plötz, of which I had a copy. I was then inclined to think the locality incorrect. Since 1914 I have seen a number of authentic Tasmanian specimens as large as his figure and agreeing fairly well with it and with his description. I now consider the mainland race distinct and also the small mountain race found in Tasmania. The number of spots on the forewing above is variable in both sexes, in all the races, the male brand is broad and consists of two parts, the outer is dull black and the inner jet black.

MOTASINGHA DOMINULA DOMINULA Plötz.

Telesto dominula Plötz, 1884, p. 379; *M. dominula* Seitz, 1927, Pl. 168.

This race is distinguished from the other two by its reddish-brown underside and the spots of the underside of the hindwing being typically dull white, and from the mainland race by the much larger spots, those on the disc forming a broad band only partly divided by the veins. I have seen several specimens from Billop, near Longford, in February, and have it also from Baghdad in December. These localities are not more than 1,000 feet elevation.

MOTASINGHA DOMINULA PRIA, n. subsp.

This is a very small mountain race and is grey-brown on the upperside and the markings are usually very small, the underside of the apex of the forewing and the ground colour of the hindwing are yellowish-brown. The underside of the hindwing has the silver band only faintly divided by the veins, the portion in 1a is narrower than the remainder. The type male has the subapical dots very small, a small spot in 3, a faint mark in cell and a minute spot in 3 of hindwing above. My series is from Cradle Mountain, Tas., at about 5,000 feet, in January, caught by Dr. Tillyard and Mr. G. H. Hardy. The Mt. Magnet males may be referred here.

MOTASINGHA DOMINULA DRACHMOPHORA Meyrick.

Telesto drachmophora Meyrick, *Ent. Mo. Mag.*, 1885, p. 82; *M. dominula,* Waterhouse and Lyell, 1914, p. 197, figs. 764–6.

This, the mainland race, is almost as large as the typical race and the general colour of the underside is almost the same as *pria*. The silver band on the underside of the hindwing is not continuous, but broken up into spots and that in 7 is rarely silvery, sometimes dull white, sometimes wanting. From northern localities the spots of hindwing are silvery, from Mt. Kosciusko they are sometimes dull white. A common species in January and February at an elevation of over 4,000 feet at Kosciusko, Barrington Tops and Ebor, N. S. Wales; not yet recorded from Victoria. The locality, Newcastle, is an error.

HESPERILLA CHRYSOTRICHA CYCLOSPILA Meyrick and Lower.

Telesto cyclospila Meyrick and Lower, 1902, p. 63; *Hesp. chrysotricha leucospila* Waterhouse, 1927, p. 280, Pl. 26, figs. 25–28.

Having recently examined all the specimens of *cyclospila* in the Lower collection at the South Australian Museum, together with my types of *leucospila,* I must sink my name as a synonym. In 1910, Lower lent me a male and a female from Port Lincoln, S. Australia, which were labelled types, and also a male from Melbourne. It was evidently intended that Port Lincoln should be the type locality, but the description of the male refers only to the Melbourne specimen in that there are seven spots on the underside of hindwing, whereas the two Port Lincoln males, including the specimen marked as type, in the Lower collection have only six spots. As the written description must be preferred to the labelled specimen, Melbourne must therefore be the type locality of *cyclospila*, though Victorian specimens do not all show seven discal spots. For the present it is best to consider that both Victorian and South Australian specimens should be kept under *cyclospila*. I have recently received specimens from Mr. A. N. Burns and Mr. A. L. Brown bred in November and December from Frankston, Victoria.

HESPERILLA DONNYSA Hewitson.

This species has a greater range than any other of the subfamily. I have now specimens from S. Queensland (one male), many localities in New South Wales and Victoria, from Tasmania and South Australia and from Bunbury and Geraldton in Western Australia. Though most of the specimens from New South Wales and eastern Victoria are similar, from other localities there are good geographical distinctions. In These PROCEEDINGS (1927, pp. 278–280) I reviewed this species and described three new races. In that paper I was rather doubtful where to place the South Australian specimens that were known. A further examination of the specimens in the South Australian Museum and in my own collection shows that races of *donnysa* and *chrysotricha* are found in South Australia. The race from there is not so well differentiated, but cannot be placed with either *flavescens* on the east of it or the Western Australian race on the west.

HESPERILLA DONNYSA DILUTA, n. subsp.

In These PROCEEDING for 1927 I was inclined to consider that *cyclospila* Meyrick and Lower (1902, p. 63) should be the name applied to this, the South Australian race of *donnysa*, but I am now convinced that that name belongs to the race of *chrysotricha* found in Victoria and possibly South Australia. The male *diluta* has the three subapical dots of the forewing paler than the other spots, the cell spot large, spots in 2 and 3 and two spots in 1a, the lower being the larger, yellowish hyaline. The spot on hindwing above is dull yellow. The underside of the hindwing is dull red-brown. Two of the three females have whitish dots in 4 and 5 of forewing on upperside, and the lower spot in 1a is very large and the small spot above it almost touches it. This race approaches the race *flavescens*, but it has not nearly the same amount of yellowish scales above and is much darker beneath. My specimens are from Goolwa, South Australia, in March. It is represented in the South Australian Museum by two males from Sheringa in October, one female from Goolwa in March, and one female from Adelaide in November.

HESPERILLA DONNYSA ALBINA, n. subsp.

This race is separated from the others in having the spots in 2 and 3 and the subapicals of the forewing whitish instead of yellow. In general it is much darker on upper and undersides. It occurs in the same localities as *H. chrysotricha* and on the upperside the females are very similar, so much so that in 1914, the only specimen of this race we had was selected for fig. 776, without examining the underside. In *chrysotricha* the underside is distinctly reddish, usually with silver spots on the hindwing. In *albina* the underside is brown with dark dots. It is easy to distinguish the males on the upperside and the genitalia of the two are markedly different. This race has been caught at Bunbury in October and November by Mr. F. L. Whitlock and must be very rare as, after a long search, he has only taken three males and four females. I have one female from Waroona and one from Stirling Ranges.

HESPERILLA IDOTHEA Miskin.

Miskin's type is a female from Victoria in the South Australian Museum from the Lucas collection. Though the species has a wide range at an elevation in New South Wales, Victoria and Tasmania, the material available does not indicate races, except in the case of South Australian specimens.

HESPERILLA IDOTHEA IDOTHEA Miskin.

Trapezites idothea Miskin, 1889, p. 152; *Trapezites dispar* Kirby, *Ann. Mag. Nat. Hist.* (6), 12, 1893, p. 435; *Hesp. idothea*, Waterhouse and Lyell, 1914, p. 187, figs. 716–8.

This race has, in the male, an obscure central suffusion on the upperside of hindwing and three black dots on the underside. Most authors have overlooked the fact that Kirby's description of *dispar* includes both sexes and the female is a direct synonym of *idothea*, both being from Victoria.

HESPERILLA IDOTHEA CLARA, n. subsp.

The male differs from the typical race in being larger and having a well developed elongate pale orange spot on the upperside of hindwing and an unmarked underside. I have two males from Mt. Lofty, S. Aust., caught in November by Mr. F. M. Angel; both have the cell spot of forewing curved, the type has the spot in 2 minute, in the other it is slightly larger. The South Australian Museum has specimens from the same locality in November and December. The female of this race is unknown.

Subfamily PAMPHILINAE.

This is the more appropriate name for this subfamily, and not Erynninae.

As a result of my work with General Evans and the examination of many hundreds of specimens of the species, together with the help of the numerous species and subspecies he brought from the islands to the north of Australia and elsewhere, I am convinced that there are more species than I had formerly admitted. The treatment of such species as *P. flavovittata* and *A. augias* in 1914 requires considerable modification, as I had considered that each name applied to a single extremely variable species. As Lower anticipated, several of our species become races of species earlier described from the Oriental Region.

It is very noticeable that, in this subfamily, there are found in the different genera very closely related pairs of species. In some cases these can be recognized by the different sex brand in the male and in others by the different genitalia. By earlier authors these characters were usually omitted in their descriptions, so it is not always easy to determine what species is meant. With females the problem is much more difficult. For some years I have been gathering together large series from as many localities as possible, so the problem has been somewhat simplified. In the case of the commoner species some hundreds of specimens were examined in the collections of the Australian Museum, Sydney, and the South Australian Museum, Adelaide, and either General Evans or I also this year studied the specimens in the National Museum, Melbourne, and the Queensland Museum, Brisbane. Messrs. L. Franzen and A. N. Burns have kindly given or lent many specimens of the rarer species of this subfamily.

TARACTROCERA Butler.

Catalogue Fabrician Diurnal Lepidoptera, p. 279, 1869.

This genus was separated by Butler on account of the very peculiar antennae, which have a flattened excavated club, somewhat spoon-shaped, and at most a minute apiculus. All the species are small, and throughout the Oriental Region constitute a very compact group distinguished by their peculiar antennae. In many cases an examination of the antennae is necessary to distinguish them from species of the genus *Padraona.*

In Australia, two sections are found, one represented by the common *T. papyria* Boisd. and its western race *agraulia* Hew., with a straight sex brand in the male; no allied species has been found beyond Australia. The other section, with orange markings, with sex brand of varying shapes or absent, contains species that are much rarer in Australia and have a very general resemblance to species of *Padraona.* They are probably not so rare as the numbers in collections would lead one to suppose, but are passed over in the field for the much more common species of *Padraona.* Collectors are advised to catch longer series of these small forms, for their efforts are sure to be well rewarded.

T. bavius anisomorpha has a general resemblance to *P. hypomeloma vaga, T. ina* to *P. hypomeloma hypomeloma, T. udraka ilia* to the northern races of *P. flavovittata* and *P. hespera.* The species of *Taractrocera* are not easy to distinguish from each other; the sex brand should be examined first of all. The females are much more difficult. Lower, when he described *T. anisomorpha,* included as sexes males of two distinct species.

TARACTROCERA DOLON Plötz.

Apaustus dolon Plötz, 1884, p. 165; *T. dolon*, Lower, 1911, p. 144; *T. dolon,* Waterhouse and Lyell, 1914, p. 201, figs. 876–7; *Bibla dolon*, Seitz, 1927, p. 1076, Pl. 170.

This is a small brown and pale orange species without a straight brand in the male but with raised sex scales over veins 1a, 2 and sometimes below 3. I have never been satisfied that the species known as *dolon* in Australia has been correctly named. Seitz undoubtedly copies the figure of Plötz, which shows the small brown rings on the underside of the hindwing as mentioned by Plötz. There is no Hesperid that agrees with this and it is possible that Plötz either had an aberrant specimen or wrongly drew it and then described from his coloured drawing. Otherwise the description and figure agree with the species as here determined. General Evans has the species from Sudest Is., but otherwise it is not recorded beyond Australia. All my males have the subapical spots of upperside of forewing joined and not divided by darkened veins. As it is a pale species it is probably passed in the field as a worn specimen of another species.

TARACTROCERA INA, n. sp.

♂. Upperside dull brown with orange markings; forewing with cell almost wholly orange and not connected with the three elongated subapical spots which are divided by darkened veins; spots in 5 and 4 one-third size of those in 3 and 2 and nearer termen; spot in 1a bent towards base; streak in 1b; no sex brand or raised scales on veins. Hindwing with a round spot in cell and band from 1a to 6, but in no specimen seen a spot in 6. Underside orange-yellow, with lower half of forewing brown-black and markings of upperside reproduced.

The holotype is from Port Darwin and is in the South Australian Museum from the Lower collection. It is the specimen that Lower described as the female of his *T. anisomorpha* and labelled so. It was very carefully examined by General Evans, Mr. Tindale and myself and is certainly a male. In general appearance it is somewhat like *T. dolon*, but is larger, the colour is clearer, the forewings are more pointed, has the subapicals divided by dark veins, lacks the raised sex scales and has different genitalia. I am uncertain if I have seen any females, but may possibly have included them amongst my specimens of *anisomorpha*.

I have seen seven males, the holotype from Port Darwin, a male from Port Darwin in May, now in the British Museum, two from Mackay (Burns) in March and April, one from Westwood (Burns) in September, one from Yeppoon (A. Musgrave) in October and one from Atherton in February.

TARACTROCERA BAVIUS ANISOMORPHA Lower.

Bibla anisomorpha Lower, 1911, p. 146; *T. anisomorpha*, Waterhouse and Lyell, 1914, p. 201, figs. 883–4.

General Evans considers that *anisomorpha* should stand as a race of *T. bavius* Mabille (*Bull.** *Soc. Ent. Belg.*, 1891, p. clxxxvi) from Timor. The female from Port Darwin described and marked as type female by Lower is a male of *T. ina* and is now the holotype of the latter species.

Additional localities to those given in 1914 are Port Darwin in May; Roper River in April, June and November; Fortescue River, N.W.A., and Gayndah, in the South Australian Museum; Burnside, N.A. in April, in the Australian Museum; Westwood, Qld., in January, February, September, November and December (A. N. Burns), and Mackay in March (A. N. Burns).

TARACTROCERA UDRAKA ILIA, n. subsp.

♂. Upperside of forewing brown with orange markings; cell and costal area above orange and joined to the large subapicals which are not divided by darkened veins; the subapicals together form a larger subapical spot than in any of the allied species, and are also joined to the broad orange discal band. Sex brand consisting of brownish scales irregularly bordering the internal edge of discal band from vein 1a to vein 4. Hindwing brown with orange cell spot and orange discal band. Underside dark brown with the orange spots of upperside reproduced.

Female as in male without brand, cell spot not joined to subapical spot and discal band broader.

This species is easily distinguished from its allies by its smaller size, squarer wings and broader orange markings.

A series of four males and two females from King River, N. Aust., in January, in Australian Museum, Sydney, and National Museum, Melbourne, in which the cell spot in the male does not always join the subapicals. Also in the South Australian Museum, a male from Port Darwin in November, which bears a label in Lower's handwriting, "*T. flavoguttata* Plötz male" and a female from Melville Is.

This is an entirely new record for Australia. Typical *T. udraka* Fruhstorfer is from German New Guinea (*Iris*, 1910, p. 96).

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* Frequently quoted as *Comptes Rendus Soc. Ent. Belg.*

PADRAONA Moore.

Lepidoptera of Ceylon, i, p. 170, 1881.

Species at present placed in this genus are somewhat divergent and the genus may eventually be divided. In most species there is a straight sex brand in the male, in *lascivia* and *ardea* this is replaced by raised scales on the veins. The clubs of the antennae are not flattened and there is a distinct apiculus.

PADRAONA ARDEA HETEROBATHRA Lower.

Apaustus heterobathra Lower, 1908, p. 316; *P. heterobathra* Lower, 1911, p. 154; *P. heterobathra*, Waterhouse and Lyell, 1914, p. 202, fig. 872.

This is the Australian race of *Ocybadistes ardea* Bethune-Baker (*Ann. Mag. Nat. Hist.*, (7), 18, 1906, p. 343) from Fak Fak, Dutch New Guinea. Though the male has no continuous brand, there are raised scales over vein 1a, on either side of vein 2 and below 3. Lower's types are from Kuranda.

PADRAONA HYPOMELOMA Lower.

Lower described both sexes, but his locality note (1911, p. 153) is badly punctuated and should read: Herberton and Kuranda, Queensland, in March, one female specimen (Dodd); Roseville, near Sydney, two male specimens in April (Waterhouse). He added that the types were in Coll. Lower. The two specimens in his collection are a male from Herberton (31st Jan., 1911) and a female from Kuranda (March, 1907), the latter labelled type female. In my collection is a male from Roseville (4th April, 1904) with a label in Lower's handwriting, "*O. hypomeloma* type male". As I write the Herberton male and my Roseville male are before me. The Roseville male has the upper two of the five spots of the discal band of the forewing half the size of the remaining three and the small somewhat ovoid spot lying on vein 6 of hindwing well separated from the oblique band, as in Lower's description. The Herberton male has the spot in 5 of forewing one-third the size, and the spot in 4 two-thirds the size of those in 3, 2 and 1a and on the hindwing the spot in 6 is elongate and nearly touches the oblique band. There are other minor differences that show that the description was taken from the Roseville male, rather than the Herberton male, which Lower no doubt received after his description was written. As further evidence that Sydney is the type locality, I have a letter from Lower to me dated 20th April, 1911, in which he says: "I am sending the female *hypomeloma*. I have no male, so that your male will be the type male, my female the other sex. You will perceive the female came from Dodd." This species differs from all its allies in having a white streak along the dorsum on underside of hindwing and so far no races have been found outside Australia.

PADRAONA HYPOMELOMA HYPOMELOMA Lower.

Ocybadistes hypomeloma Lower, 1911, p. 152; *Padraona hypomeloma*, Waterhouse and Lyell, 1914, p. 204, figs. 584, 873–4.

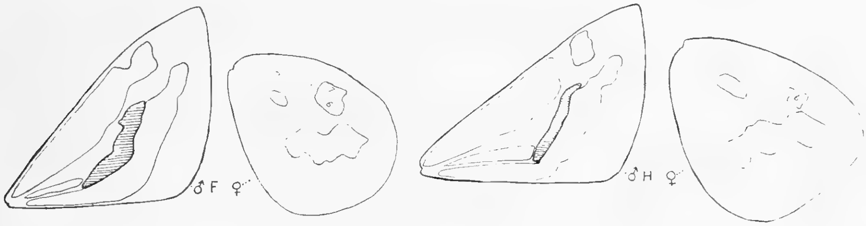
This race is typically from near Sydney, the subapical spots of the forewing are small, sometimes, as in the holotype male, just touching the costal streak, but usually some distance from the discal band. On the hindwing, the spot in 6 is small and separate from the discal band. On the upperside only, the female approaches the female of *P. lascivia*. I have recently taken a female at Port Macquarie in November and have seen specimens from Brisbane in March, April and September. I have also a female from Lindeman Is., in September, and a pair from Great Palm Is. in May. These specimens, as well as those from Kuranda and Herberton, only differ slightly from Sydney specimens.

PADRAONA HYPOMELOMA VAGA, n. subsp.

This race differs from that caught at Sydney in having the markings on the upperside much broader and bright orange and the underside darker. The holotype male has the subapical spots of forewing elongated and joined both to the costal streak and the discal band. On the hindwing, the spot in 6 is large, joins the discal band and is also extended into 7. My two other males have subapicals elongated, but not so closely joined to the discal band in the forewing and the spot in 6 of hindwing just touches the discal band. I have only one female which has correspondingly brighter and broader markings than the typical race and on the hindwing the spot in 6 joins the discal band and extends into 7. The four specimens are from Prince of Wales Is., in May and June (H. Elgner). Types in Australian Museum, KL 07893.

PADRAONA FLAVOVITTATA Latreille. Text-fig. 2, F.

The use of this name for several distinct Australian species has caused considerable confusion, and, as it is the earliest name given for a small yellow-banded Pamphiline species, it is desirable that the position should be made quite clear. The original description itself might well, without other evidence, be sufficient for at least half a dozen Australian species.



Text-figure 2.—Enlarged sketches of forewing of male showing sex brand shaded and outline of orange markings and underside of female with outline of spots. F = *Padraona flavovittata*; H = *Padraona hespera*, n. sp.

Latreille described *flavovittata* in 1824 from several specimens from Australia received from Alexander Macleay, that is before Macleay left England for Sydney. Macleay had been receiving butterflies from Australia for some time previously and such species as *Papilio aegeus* in 1805, *Papilio macleayanus* and *Heteronympha banksi* in 1814 were described from his collection. At that time these species could only have come from Sydney, and there is little doubt that the specimens of *flavovittata* were also from Sydney.

In 1832, Boisduval (*Voy. Astrolabe*, Lep., p. 165) quotes Latreille's description of *flavovittata*, and on the next page describes a new species *papyria* from Australia. As Mr. N. D. Riley points out (*Trans. Ent. Soc. Lond.*, 1926, p. 239), Boisduval must have seen Latreille's specimens when he wrote and could not have confused these two insects. Felder several times mentions the name *flavovittata* in comparison with larger species he was describing and always indicated it was a species with prominent orange markings.

Kirby in his catalogue apparently was the first to use the genus *Taractrocera* for this name, on what grounds cannot be ascertained. Plötz (1884, p. 164–5) placed species belonging to both *Taractrocera* and *Padraona* in the genus *Apaustus*, listing No. 56 as *maro* with *flavovittata* as a synonym, No. 57 *sunias* from Cape York, No. 58 *alix*, n. sp., from Australia, the last being a synonym of *papyria*. He mentions *agraulia* (p. 166) as unknown to him, and as far as I can ascertain omits *papyria* altogether from his writings.

Miskin in his catalogue marked the name *flavovittata* as unknown to him and applies the name *agraulia* Hew. with *sunias* Felder as a synonym, to the eastern species. Olliff also used *agraulia* for the eastern *Padraona*, but Semper used *flavovittata*.

When I began collecting in 1893, the name *agraulia* Hew., though described from Western Australia, was used for the eastern *Padraona* and the name *flavovittata* for the western race of *T. papyria*, that is the true *agraulia* of Hewitson. Who was responsible for this usage is now doubtful. Meyrick and Lower (1902, p. 100) use *flavovittata* for the western race of *T. papyria* and (p. 101) *sunias* Felder for the eastern *Padraona* with *walkeri* Heron and *agraulia* Hew. as synonyms (including at least two distinct *Padraona* under *sunias*). Lower (1911, p. 146) uses *flavovittata* with *agraulia* as a synonym for the western *Taractrocera*, and listed three species of *Padraona* from the east, viz.: *walkeri*, *rectivitta*, and *sunias*.

In 1914 (Waterhouse and Lyell, p. 203) it was pointed out that the name *flavovittata* should be used for the common *Padraona* from Sydney and that the type must have come from Sydney. Riley (l.c., p. 239), after an examination at the Paris Museum, fully agreed with this opinion. Further confirmation is now available, as General Evans has seen, in the Oberthur collection at Rennes, France, an eastern male with a broad sex brand with Latreille's label *flavovittata*. I have little doubt that this specimen is one of Latreille's original series, given by him to Boisduval and later acquired by Oberthur with other species from Boisduval's collection.

The position is further complicated, since General Evans has clearly proved to me that there are two very common closely allied species of *Padraona* flying together at Sydney. We found them both commonly in my garden at Killara, and at several other localities near Sydney.

These two species can be distinguished in the male by the size and shape of the sex brand on the forewing. The presence, in the Oberthur collection, of the male with broad sex brand at once settles the species to which the name *flavovittata* applies.

Besides the broad sex brand, in the male *flavovittata* the cell spot is usually joined to the subapicals and the underside of the hindwing is greenish. In the female, besides the greenish underside, there is a spot in 7 immediately above that in 6 and usually another in the base of 7.

Three races are known, and as it is now impossible to know what species previous authors had before them, few references are given.

PADRAONA FLAVOVITTATA FLAVOVITTATA Latreille.

Hesperia flavovittata Latreille, Encyclopédie Méthodique, ix, p. 768, 1824; *Ocybadistes walkeri*, Lower (in part), 1911, p. 148; *P. flavovittata flavovittata*, Waterhouse and Lyell (in part), 1914, p. 203, fig. 859.

The male has the sex brand broad and inwardly incurved in 1a, and stops at vein 4; the orange subapical spot is usually joined to the orange cell spot. On the underside the hindwing is greenish, more pronounced in fresh specimens.

The female is also greenish on the underside and on the hindwing the spot in 6 is separated from the discal band and there is another above it in 7 and also a small spot in the base of 7.

The description given by Lower (1911) under *walkeri* refers on the upperside to *hespera*, as the brand is described as narrow and nearly straight, but the underside being greenish refers to *flavovittata*. In the "Butterflies of Australia" (1914) the description and fig. 859 of the male apply to this species, but fig. 866 is a female *hespera*. This race is found from Brisbane along the coast of New South Wales, typically from Sydney, also in Tasmania, but is absent from Victoria. In the warmer parts it is found throughout the year.

PADRAONA FLAVOVITTATA WALKERI Heron.

Ocybadistes walkeri Heron, *Ann. Mag. Nat. Hist.*, (6), 14, 1894, p. 106.

This is a smaller and brighter race described with a broad sex brand in the male from Dammer Is. and Port Darwin, and is found as well along the Queensland coast from Claudie River to Rockhampton. The description and figures (Waterhouse and Lyell, 1914, p. 203, figs. 858, 865) refer to the corresponding race of *hespera*.

PADRAONA FLAVOVITTATA HYPOCHLORA Lower.

Ocybadistes walkeri var. *hypochlora* Lower, 1911, p. 149; *P. flavovittata hypochlora*, Waterhouse and Lyell, 1914, p. 204, figs. 860, 867.

This race is larger, paler, the yellow orange markings much broader and the markings on the underside somewhat obscured. The sex brand, as in the other races, is broad. It has only been found near Adelaide, from November to April.

PADRAONA HESPERA, n. sp. Text-fig. 2, H.

In the male this species and its races can be distinguished from the very similar *flavovittata* by the narrow sex brand extending above vein 4 and being almost at right angles to vein 1a, making a definite break between the discal band and the streak in 1a; the orange cell is not joined to the subapical spot. On the underside it is never greenish, not even in bred specimens, but excepting the lower half of the forewing, is orange-brown.

The female is similar to that sex of *flavovittata* but is smaller and squarer. The underside of the hindwing is brownish-orange, the spot in 6 is well defined and near the discal band and there is no spot in 7.

PADRAONA HESPERA HESPERA, n. subsp.

Ocybadistes walkeri Lower (in part), 1911, p. 149; *P. flavovittata flavovittata*, Waterhouse and Lyell, 1914, fig. 866.

♂. Upperside: Forewing brown-black with orange markings; cell spot large, occupying all the cell and extending above to costa; subapical spot large and well separated from cell spot and discal band. Sex brand straight, narrow, black from vein 1a to above vein 4 and not inwardly incurved in 1a. Pale orange streak in 1a. Hindwing brown-black with orange markings, cell spot ovoid, sometimes extended towards base, discal band irregular with a small separate spot in 6.

Underside markings as above, but somewhat obscured; brownish-orange (never greenish) excepting the lower half of forewing.

Female as in male with broader wings and without sex brand.

Typical specimens are from Sydney and it is found as far north as Brisbane. I have seen specimens from Tasmania.

PADRAONA HESPERA VESTA, n. subsp.

P. flavovittata walkeri, Waterhouse and Lyell (*nec* Heron), 1914, p. 203, figs. 858, 865.

This, the northern race, bears the same relationship to typical *hespera* from Sydney as *walkeri* does to typical *flavovittata*. It is smaller and brighter and was described and both sexes figured from Port Darwin in 1914 as *walkeri*. Those specimens figured are now designated the types of *vesta*. It is also found on the Queensland coast from Cairns to Mackay.

PADRAONA LASCIVIA Rosenstock.

The type is a male from Beaconsfield, Victoria, in the South Australian Museum from the Lucas collection. Further material from the north shows that there are two good races.

PADRAONA LASCIVIA LASCIVIA Rosenstock.

Pamphila lascivia Rosenstock, *Ann. Mag. Nat. Hist.*, (5), 16, 1885, p. 378, Pl. 11, fig. 1; *Padraona lascivia*, Waterhouse and Lyell, 1914, p. 202, figs. 587–8.

Typically from Victoria but extends through coastal New South Wales to southern Queensland. Lower sent specimens to Mabille who returned them as *neocles*.

PADRAONA LASCIVIA NEOCLES Mabille.

Pamphila neocles Mabille, *Bull. Soc. Ent. Belg.*, 1891, p. clxxvii.

The type is from Cooktown. Northern specimens are smaller and darker than those from the south, and the markings on the upperside have in some cases disappeared. The markings on the underside are better developed and the colour is deeper. Specimens from Cairns to Cape York belong to this race.

PADRAONA MARNAS AFFINIS Waterhouse and Lyell.

Ocybadistes affinis Waterhouse and Lyell, *Vict. Nat.*, xxviii, 1912, p. 227; *P. affinis*, Waterhouse and Lyell, 1914, p. 205, fig. 885.

General Evans has pointed out that the species that has passed as *marnas* in Australia for many years has been incorrectly determined. Though two *marnas*-like species occur in Australia and New Guinea, only one is found in the Moluccas, which is the type locality for *marnas* Felder. The less common *affinis* is then the race of *marnas* occurring in Australia. This is distinguished by the band on underside of hindwing being clear, untraversed by the veins. The Australian race differs from typical *marnas*, by having broader markings, particularly at the apex of the forewing. I have specimens from Palmwoods, Qld., taken by Mr. A. N. Burns in April. The holotype male was caught at Kuranda in June.

PADRAONA COLATTUS IRIS, n. subsp.

Telicota marnas, Meyrick and Lower, 1902, p. 103; *Ocybadistes marnas*, Lower, 1911, p. 148; *P. marnas*, Waterhouse and Lyell, 1914, p. 205, figs. 704, 886.

This is *marnas* of several Australian authors. Under the impression that this common species was Felder's *marnas*, the previous distinct species was described as *affinis*, which is, however, a race of true *marnas* from the Moluccas where only one species is found. The race *iris* has already been well described and figured. It is larger than the Australian *affinis*, the orange markings on the upperside are brighter and the band of the hindwing on the underside is divided by the darker veins. The locality of the holotype is Kuranda, taken in June with two other males and a female. It is found from Mackay to Cape York.

CEPHRENES DOBBOE AUTOLEON Miskin.

Pamphila autoleon Miskin, 1889, p. 147; *Telicota aruana* Lower (*nec* Plötz), 1911, p. 160; *C. aruana autoleon*, Waterhouse and Lyell, 1914, p. 207, figs. 694–5.

In the Aru Islands there is a pair of very closely related species, *dobboe* Plötz (*Berl. Ent. Zeit.*, 1885, p. 227) and *aruana* Plötz (*Stett. Ent. Zeit.*, 1886, p. 103). An examination of these two species shows that *autoleon* is a subspecies of *dobboe* and not of *aruana*. The genitalia also confirm this.

ASTYCUS Hübner.

As Scudder had unfortunately selected *augias* Linn. as the type of *Astycus*, *Telicota*, to which Moore assigned the same species as type, must give way. After an examination of several hundred *augias*-like specimens, General Evans has convinced me that I was wrong in considering them all as one very variable species. These *augias*-like species are briefly distinguished below.

ASTYCUS AUGIAS ARGEUS Plötz.

Hesperia argeus Plötz, 1883, p. 227; *Telicota augias* var. i, Lower, 1911, p. 155; *T. augias kreffti*, Waterhouse and Lyell (in part), 1914, p. 208.

A paler species than its allies, with more pointed wings and in the male a broad pale sex brand and the yellowish colour extending from the discal band of the forewing along the veins to the termen. On the underside it is less heavily marked. Found from Port Darwin, throughout coastal Queensland and rarely to Sydney. *A. augias* does not tend to form well defined races in the Oriental Region, but as Plötz has separated the Australian race from Cape York, I retain the name here. I have it from Darwin, Banks Is., Cairns, Mackay, Brisbane and the Richmond River.

ASTYCUS KREFFTI Macleay.

Macleay's type from Cape York is a male and is preserved in the Australian Museum, Sydney. The sex brand is slightly narrower than in *augias* and it is a much brighter species. It seems to have developed two races, which overlap from Kuranda to Mackay. They may, however, be distinct species. Probably *bambusae* from India and *pythias* from Java are races.

ASTYCUS KREFFTI KREFFTI Macleay.

Pamphila kreffti Macleay, *Trans. Ent. Soc. N. S. Wales*, 1866, p. liv; *Telicota augias kreffti*, Waterhouse and Lyell (in part), 1914, p. 208, figs. 703, 868.

A bright orange species occurring typically at Cape York, found commonly on the islands to the north, and southwards to Mackay. This is probably Lower's *augias* var. iii, 1911, p. 157. I have it from Port Darwin, Darnley, Murray, Banks, Prince of Wales Islands, and Cape York to Mackay.

ASTYCUS KREFFTI ANCILLA Herrich-Schaeffer.

Pamphila ancilla Herr.-Sch., *Stett. Ent. Zeit.*, 1869, p. 79; *P. olivescens* Herr.-Sch., *loc. cit.*, p. 79, Pl. 3, fig. 14; *Telicota augias* var. ii, Lower, 1911, p. 156; *T. augias kreffti*, Waterhouse and Lyell (in part), 1914, p. 208, figs. 683, 684, 702.

A larger and richer race with well developed markings on underside of hindwing, which is usually greenish in the female, on which the name *olivescens* is based. Typically from Rockhampton, but found along the coast from Kuranda to Sydney.

ASTYCUS MESOPTIS Lower.

Telicota augias mesoptis Lower, 1911, p. 157; *T. augias kreffti*, Waterhouse and Lyell (in part), 1914, fig. 869.

This species differs from *ancilla* in being darker on upperside, the markings orange-red and in the male a very narrow sex brand commencing from 1a beyond the middle towards the termen, instead of from the middle; the underside of the hindwing is ochreous with the markings fairly well defined. The female on the upperside of forewing has the basal area darkened. This species resembles the much smaller *A. brachydesma* Lower which has the underside very dark. Lower's types came from Kuranda and there are paratypes in the Australian Museum. It occurs from Cape York to Mackay.

ASTYCUS ANISODESMA Lower.

Telicota anisodesma Lower, 1911, p. 157; *T. anisodesma*, Waterhouse and Lyell, 1914, p. 211, figs. 701, 862.

In the male this species has a general resemblance to *ancilla*, but is much larger. The holotype, now in the South Australian Museum, was caught at Ballina, N. S. Wales, by myself. So far the female is undescribed and I am indebted to Mr. L. Franzen for my first specimens. The late Mr. R. Illidge had several specimens in his collection which he had identified as *A. ohara* Plötz.

♀. Upperside dark reddish-brown with orange-red markings. Forewing with a faint spot in cell; two subapical dots with sometimes a trace of a third; discal band of moderate spots, that in 1a narrow, spots in 2 and 3 and a dot in 4 which is sometimes absent. Hindwing with discal band narrow and divided by darkened veins.

Underside: Apex of forewing and hindwing dark olive-brown with markings of upperside reproduced, but paler, and band of hindwing almost obscured.

The female differs very much from the male and has a general resemblance in size to females of *A. ohara* and *Cephrenes sperthias*, but can readily be separated by the underside, though it certainly approaches the female of *ohara* above. The only authentic specimens I have seen, have been caught between Brisbane and Ballina from November to March.

ASTYCUS EUROTAS EURYCHLORA Lower.

Telicota eurychlora Lower, 1908, p. 314; *T. eurychlora*, Waterhouse and Lyell, 1914, p. 210, figs. 692-3, 861.

General Evans, who has seen the type of *eurotas* Felder in the Tring Museum, has shown me a specimen from the Moluccas and the genitalia, which are very different from all other *Astycus*, agree with those of *eurychlora*, which must now rank as a subspecies of *eurotas*. Though an *augias*-like species, it can be recognized by the almost uniform orange-brown hindwing beneath. Specimens from North Queensland are not easy to tell from *ancilla* without an examination of the genitalia. The types are from Ballina; I have it from Port Macquarie, but it is rare. Two Herbert River specimens are slightly different, as are two males and a female from near Cairns.

BAORIS IMPAR Mabille.

Pamphila impar Mabille, *Bull. Soc. Ent. Belg.*, 1883, p. lxvi.

This species was described by Mabille from a female from Australia or Oceania. General Evans considers that Mabille's type came from New Caledonia and is the oldest name for a group of races: *bipunctata* Elwes and Edwards from the Moluccas, *contigualis* Rothschild from New Guinea, Bismarcks and Solomons and *laraca* Swinhoe from Woodlark Is. The genus *Baoris* Moore has priority over *Parnara* for this species and its allies.

BAORIS IMPAR LAVINIA, n. subsp.

Parnara laraca Lower (*nec* Swinhoe), 1911, p. 162; *P. laraca*, Waterhouse and Lyell (*nec* Swinhoe), 1914, p. 211, figs. 743–4.

Colonel Swinhoe identified as *laraca* specimens from Port Darwin sent him by Lower, hence the use of that name in Australia. I have, through the kindness of General Evans, had an opportunity of seeing the various races and consider the Australian race worthy of a name. It is larger and not so dark as *laraca*, but smaller than *contigualis*. The race has been well described and figured. The holotype male has the cell spot of forewing divided, the lowest of the three subapicals moved towards the termen, a small spot in 4, a larger one in 3, a much larger one in 2, all pale yellow hyaline, and a yellow spot in 1a equal in size to that in 2. On the upperside of hindwing there are small yellow hyaline spots in 2 and 3 and a trace of a spot in 6. The underside is suffused with ochreous scales. The allotype female is larger and is not suffused with ochreous on upper and under sides and is the specimen used for fig. 774. This pair were taken *in cop.* on 26th March, 1909, at Port Darwin by Mr. F. P. Dodd, and I have a series from the same locality from February to May and September to December. One male and two females from Banks Is. in February are larger and approach the New Guinea race.

BAORIS BEVANI Moore.

Hesperia bevani Moore, *P.Z.S.*, 1878, p. 688.

In the South Australian Museum there are three specimens of this widespread species from Port Darwin. It is distinguished from the allied species by the presence of the upper spot in cell of the forewing and the small spot in 4 being moved towards the termen. This is a new record for Australia and the species has probably been introduced, as its larvae feed on rice.

BAORIS ZELLERI CINNARA Wallace.

Parnara colaca, Waterhouse and Lyell, 1914, p. 212, figs. 778–9.

This is a very wide ranging species from the Mediterranean to Australia. The oldest name in the Oriental Region is *cinnara* Wallace. The only name given in the Australian Region is *urejus* Plötz from Amboina. The species Lower (1911, p. 163) gives as *P. colaca*, is *Baoris guttatus bada* Moore, which General Evans considers has been introduced into Australia.

Subfamily ISMENINAE.

HASORA KHODA HASLIA Swinhoe.

H. haslia Swinhoe, *Ann. Mag. Nat. Hist.*, (7), 3, 1899, p. 107; *H. haslia*, Waterhouse and Lyell, 1914, p. 216, figs. 725–6.

General Evans tells me that *Ismene khoda* Mabille (*Bull. et Ann. Soc. Ent. France*, 1876, p. xxv, and p. 263) from Isle of Pines, New Caledonia, is the oldest name for this group of species which range from India to New Caledonia.

PARATA ALEXIS CONTEMPTA Plötz.

Ismene contempta Plötz, 1884, p. 56; *P. chromus contempta*, Waterhouse and Lyell, p. 217, figs. 729–30; *Ismene lucescens* Lucas, *Proc. Roy. Soc. Qld.*, Vol. xv, 1900, p. 138.

The Fabrician name *alexis* has priority over *chromus* Cramer as the oldest name for this species. General Evans very carefully examined the long series in the Lower collection and is satisfied that the three species listed by Lower (1911, pp. 169–171) as *chromus* Cramer, *contempta* Herrich-Schaeffer and *contempta* Plötz are all the same insect.

Note.—In the Genera Insectorum, 1904, Mabille described two species with locality Australia, that I had not been able to recognize. General Evans has seen the types in the Oberthur collection and tells me that *Padraona suborbicularis* Mabille, p. 141, is a *Dalla* from South or Central America, and *Ocybadistes suffusus* Mabille, p. 142, is a common New Guinea and Aru Is. *Astycus* that has not been found in Australia. Both names now leave our lists.

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NOTES ON THE MOSSES OF NEW SOUTH WALES. I.

ADDITIONAL RECORDS AND DESCRIPTION OF A NEW SPECIES OF BUXBAUMIA.

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[Read 27th July, 1932.]

Introduction.

A student of Bryology in New South Wales meets at the beginning of his studies with an almost insurmountable obstacle. No complete list is available of the species previously recorded, and many of the records are not in print at all.

Till the beginning of this century the classification of specimens collected was a hopeless task for all but the specialist. Some idea of the difficulties encountered may be gained by reading the preface of the Census Muscorum Australiensium by Watts and Whitelegge, published as supplements to the Proceedings of this Society. Part I appeared in 1902 and the second part three years later. As the result of this and the subsequent publications of Watts and Brotherus, the problems concerning the distribution and taxonomy of the New South Wales mosses have been simplified.

In the years between 1900 and 1917 the late Rev. W. W. Watts was an assiduous collector, and he gradually accumulated a great wealth of data on the occurrence and distribution of the various species. Among the mosses he collected were many which were new to New South Wales, and some new to science. At the time of his death Mr. Watts had started to arrange his notes and observations with the intention of writing a census which would form a supplement to the "Census of New South Wales Plants", published by Maiden and Betche in 1916.

Several years ago, when I became interested in the mosses, Mr. Cheel, the Curator of the National Herbarium, Botanic Gardens, Sydney, suggested to me that I should finish the census begun by Mr. Watts. This has now been done. Conditions at present, however, do not permit of the publishing of the whole work and it has been decided to bring out a series of short papers which will provide a list of the new records and thus bring the 1902-1905 census up to date.

A complete list of the Sphagnaceae will be found in a paper published by Watts (1912), as no new additional species have been found since that time. There have been no new records of the Andreaceae since the 1902-5 census.

The following lists have been arranged according to the scheme of classification adopted by Brotherus in Engler and Prantl, 1924, except that the species have been placed in alphabetical order.

Sub-Class BRYALES.
Order group EUBRYINALES.
Order FISSIDENTALES.

FISSIDENTACEAE.
FISSIDENS.

F. aristatus Broth., (A)*.—Manly (type; Watts).
F. bascilaris Hpe. et C.M., Linn.* 1853.—Armidale (Watts).
F. brevifolius H.f.W., Fl. N.Z.—Warrumbungle Ranges (Forsyth).
F. bryoidioides Broth., (A).—Penshurst (Cheel; type).
F. chloroloma Broth.—Brunswick River (Watts; type).
F. elamellus C.M. et Hpe., Linn. 1856.—Near Young, frequent (Watts).
F. Forsythii Broth., (A).—Barber's Creek, South Coast (Forsyth, 1899; type).
F. humilis Dix. et Watts, (A).—Newcastle (Burgess, 1910; type).
F. leptocladus C.M., Gen. M., p. 59.—Yarrangobilly (Watts, 1906).
F. oblongifolius H.f.W., *Lond. Journ. Bot.*, 1844.—Cook's River (A. A. Hamilton).
F. perangustus Broth.—Manly (Watts; type).
F. praemollis Broth.—Richmond River (Watts, 1901; type).
F. ridigusculus Broth., (A).—Moss Vale (Forsyth).
  var. *leptocladus*, Broth., *l.c.*
F. sordide-virens Broth., (A).—Cambewarra (Forsyth, 1901; type).
F. vittatus H.f.W., Fl. Tas.—Young (Watts).
F. Warningensis Broth.—Mt. Warning (Forsyth, 1900; type).

Order DICRANALES.
DITRICHACEAE.
PLEURIDIUM.

P. austrosubulatum Broth.; Roth., Auss. Eur. Laub., I, 2, p. 3, Tx. 5.—Rose Bay, Sydney (Forsyth; type).

P. gracilentum Mitt., Linn. 1860.—Young, Gladesville, etc. (Watts).

DITRICHUM.

D. strictum H.f.W., Fl. Ant., ii, p. 404.—Blue Mts. (Watts, 1903).

DISTICHIUM.

D. capillaceum (Sw.), Br. Eur.—Yarrangobilly (Watts, 1906).

DICRANACEAE.
TREMATODONTOIDEAE.
TREMATODON.

T. pygmaeus Broth., in Litt., 1911.—Mt. Kosciusko (Forsyth, Jan., 1899; type).

CAMPYLOPODIOIDEAE.
CAMPYLOPUS.

C. denticuspis Broth., (A).—Richmond River (Watts, 1901; type).

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* See list of contractions and references, p. 242.

DICRANOIDEAE.

DICHODONTIUM.

D. Wattsii Broth. (1912).—Yarrangobilly (Watts, 1896; type).

DICRANOLOMA.

D. Sullivani (C. M. Hedwig, 1897, p. 360).—Yarrangobilly (Watts, 1906).

Order POTTIALES.

POTTIACEAE.

TRICHOSTOMEAE.

TRACHYCARPIDIUM.

T. Novae-Valesiae Broth.; Roth., Auss. Eur. Laub.—Young (Watts; type).

ASTOMUM.

A. Wattsii Broth.; Roth., Auss. Eur. Laub.—Wyong (Watts; type).

HYMENOSTOMUM.

H. inflexum (Tayl.) Broth., Hpe. et C.M., Linn. 1853.—Parramatta (Woolls).
H. robustum Broth.—Fitzroy Falls (Forsyth, 1900; type).
H. Sullivani C.M., Gen. Musc.—Young and Armidale (Watts).

WEISSIA.

W. glauca Broth.—Barber's Creek (Forsyth, 1899; type).

TRIQUETRELLA.

T. albicuspes Broth.—Cowra, Yarrangobilly, etc. (Watts; type and co-types).

TRIDONTIUM.

T. Tasmanicum H.f.W., Hook fil., Fl. N.Z.—Yarrangobilly (Watts).

DIDYMODON.

D. Wildii (Broth.).—Narrabri (Musson).

BARBULA.

B. acrophylla C.M. Symb.—Nowra, Young, Tumut (Watts).
B. amoena C.M. Symb.—Young (Watts).
B. australasiae (Hook. et Grev.) Brid., C.M. Syn., i, 618.—Young, Armidale (Watts).
B. aristatula C.M.; *Pyramitrium*, Mitt. Cat.—Blue Mts. (Mrs. Calvert).
B. glaucula Broth.—Nowra (Watts, 1903; type).

ACAULON.

A. crassinerium Broth.—Cootamundra (Watts; type).
A. robustum Broth.; Roth., Auss. Eur. Laub.—Young (Watts; type).

CALYPTOPOGON.

C. Mniodes (Schwgr.) Mitt., Linn. 1859.—Mt. Wilson (Watts, 1911).

POTTIA.

P. brevicaulis (Tayl., *Lond. Journ. Bot.*, 1846) C.M.—Young.

Crossidium.

C. Geheebii Broth.—Cobar (Bauerlen, 1903).

Aloina.

A. Sullivaniana (C. M. Hedwig, 1898) Broth.—Warrumbungle Ranges (Forsyth).

Tortula.

T. acuminata Broth.—Waverley (type), Nowra (Watts).
T. asperifolia (C.M.) Broth.—Macleay River (Crawford).
T. brunnea Broth. et Watts (1912).—Yarrangobilly (Watts, 1906; type).
T. Baileyi Broth., C.M., 1890. No. 10.—Sydney, Nowra, etc.
T. calodictyon Broth.—Nowra (Watts; type).
T. crassinervis (Tayl.) Mitt., Linn. 1860.—Young (Watts).
T. evanescens Broth., (A).—Young (Watts; type).
T. Readeri (C.M. Symb., No. 190) Broth.—Warrumbungle Ranges (Forsyth).
T. vesiculosa (C.M. Symb., No. 185 as *Barbula*).—Frequent near Sydney.

Contractions and References.

Brotherus and Watts, 1912.—The Mosses of the Yarrangobilly Caves District. Proc. Linn. Soc. N.S.W., 1912, p. 363.
(A). ————, 1916.—Some New Species of Australian and New Zealand Mosses, IV. Proc. Linn. Soc. N.S.W., 1916.
C.M. Syn.—Synopsis Muscorum. Mueller. 1849-51.
C.M. Symb.—Symbolae ad Bryologicum Australiae, Hedwigia, 1897-8.
Fl. Ant.—Hooker's Flora Antarctica.
Fl. N.Z.—Hooker's Flora of New Zealand.
Fl. Tas.—Hooker's Flora of Tasmania.
Linn.—Proc. Linn. Soc. London.
Watts, 1912.—The Sphagna of Australia and Tasmania. Proc. Linn. Soc. N.S.W., 1912.
Watts and Whitelegge, 1902.—Census Muscorum Australiensium. Part i. Supp. to Proc. Linn. Soc. N.S.W., 1902.
————, 1905.—*Id.*, Pt. ii. Proc. Linn. Soc. N.S.W., 1905.

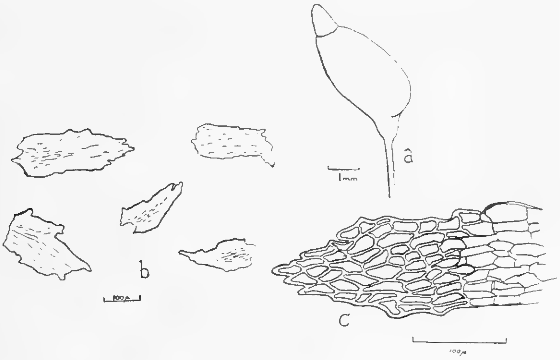
Buxbaumia Colyerae, n. sp.

This new species of *Buxbaumia* is of considerable interest because it is the first record of this Order of Mosses from the Australian continent, and because it throws some interesting light on the little known Tasmanian species which it closely resembles, but from which it differs specifically.

Previously an interesting problem of distribution had presented itself. *Buxbaumia indusiata* is well scattered in Europe and Asia, and the finding of what was apparently a closely related species in Tasmania naturally raised the question of its occurrence on the mainland. For nearly a century, however, this remained unanswered, but during a collecting trip to the North Coast Brush of New South Wales, I was so fortunate as to secure specimens of the species.

Plantis sexis reductis; foliis 10–20, parvissimis; 0·2–0·3 mm. longis; lanceolatis vel bi- vel trifidis, rufis, non ciliatis necque pilosis; cellulis grandis 15–45 μ inaequalis, prosenchymatis, in margine emenentibus. Seta c. 1·5–2·5 cm. alta, rufa nitida plana splendida. Theca suberecta ovata superficie superiore planiuscula immarginata, inferiore convexa, operculo conico. Sporis subglobosis, 6–8 μ; muris echinulatis subtiliter.

Gametophyte greatly reduced, leaves minute, just visible to the naked eye, lanceolate to occasionally slightly bi- or trifid, red-brown in colour, varying in number from 10–20; cells irregular, large, devoid of chlorophyll, margin irregular due to slightly projecting cells, leaves quite devoid of any hairs or cilia. The base of the plant a mass of matted rhizoids interspersed with fungal hyphae, seta bright red, smooth, shiny, about 1·5–2·5 cm. Capsule flattened above, lower surface gibbous, operculum conical. Towards maturity the columella appears to break down somewhat. The peristome is probably composed of smooth bladdery cells as in *Buxbaumia tasmanica*, but no very old capsules were available so this feature must remain in doubt. In the capsules sectioned no noticeable thickening was present, although in other respects the capsules appeared to be matured. Spores brown in the mass, ovoid, 6–8 μ; wall finely echinulate.



Text-fig. 1.—*Buxbaumia Colyerae*, n. sp. (*a*) capsule; (*b*) leaves; (*c*) single leaf enlarged.

It differs from *Buxbaumia tasmanica* mainly in the leaf structure. *Buxbaumia Colyerae* has leaves entirely devoid of cilia or hairs, these being features of the leaves of *Buxbaumia tasmanica*.

The systematic position of this species is almost certainly in the *indusiata* group (see Brotherus, Engler and Prantl). Although a careful examination of microtome sections and whole capsules failed to reveal stomata, it is considered that its general resemblance to *Buxbaumia indusiata* justifies its inclusion there, till a larger quantity of material is available for examination.

The specimens were collected at Williams River in the dense brush at the base of Barrington Tops in September, 1930. The plants were growing amongst the soil formed from a decomposing olivine-basalt, and had been caught in the roots of an upturned tree. In all, twelve capsules were seen and, although a careful search was made in the surrounding area, no further specimens were found. In August, 1931, I again visited the area and, although a week was spent in the district, no trace of the moss was seen. The same log was examined and the soil brought back to the laboratory in the hope of finding gametophytes. This was unsuccessful.

The genus to which this species belongs possesses an almost world-wide distribution but is comparatively seldom seen. This is probably accounted for by the smallness of the gametophyte, the plant only becoming noticeable when in fruit.

Buxbaumia indusiata and *Buxbaumia aphylla* are scattered sparsely throughout Europe and North America. In Asia the former has been found in Central China and the latter in Siberia. Of the other four species *Buxbaumia Piperi* Best., comes from Washington (U.S.A.), *Buxbaumia Javanica* C. Muell., from Java, *Buxbaumia tasmanica* Mitt., from Tasmania, and *Buxbaumia Minakatae* Sh. has been described from Japan.

Buxbaumia tasmanica is almost unknown. It was found by Mr. Archer at Chestnut, Tasmania, about 1850, and described by Mitten (*Journ. Linn. Soc. London*, 1860). Mr. Rodway, Government Botanist, Tasmania, informs me that not one capsule is available in any collection known to him. Apparently all that is left are the drawings which are in the possession of the New York Botanical Gardens, and the published description. The new species now described was at first thought to be identical with *Buxbaumia tasmanica*, but has been separated from it. It is named in honour of Miss G. Colyer, who discovered the material.

I desire to thank Mr. Rodway for his kindness in supplying the information about *Buxbaumia tasmanica*; Dr. Darnell-Smith, Director of the Botanic Gardens, Sydney, and Mr. Cheel, Curator of the National Herbarium, Botanic Gardens, Sydney, for granting free access to the records and collection of mosses under their charge; and Professor T. G. B. Osborn for the facilities made available in the Department of Botany, University of Sydney.

THE PHYSIOGRAPHY OF THE SHOALHAVEN RIVER VALLEY. VI.

CONCLUSION.

By FRANK A. CRAFT, B.Sc., Linnean Macleay Fellow of the Society
in Geography.

(Five Text-figures.)

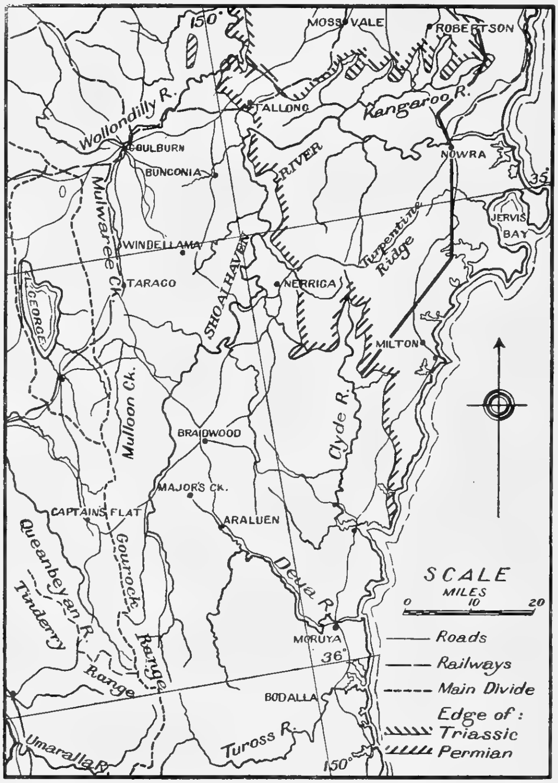
[Read 31st August, 1932.]

This paper may be regarded as a concluding part in the sense that it assembles and summarizes the principal results which have been obtained by a physiographic study of the Shoalhaven Valley, but it is also a prelude to wider considerations in beginning the application of those conclusions to the surrounding region. Among the ideas developed are some that may be used generally in the study of the eastern highlands of this State, such as the recognition of great terraces carved by the forces of normal erosion and leading up in steps towards the central plateau mass, as Andrews has described for New England, and the accidental direction of the present Main Divide, much of which has little physiographic significance in such areas as this. In addition, it appears that many coastal streams have been directed into depressions which occur at intervals along the flanks of the highlands, and the existing stream system is of great age, for the most part. A few parts of the coastal slopes (as distinct from the northward-falling Shoalhaven Valley) have been touched on, but the greater portion will be discussed by Dr. I. A. Brown, whose friendly criticism of this work has resulted in many improvements in its form.

Introduction.

The earlier papers of this series have provided a number of studies on the development of the various land forms and surfaces in the Shoalhaven Valley, so we are now in a position to generalize, and to extend our studies to the adjoining coastal slopes. The Shoalhaven basin includes the greater part of the vertical range of the New South Wales tablelands, as points within it rise to 4,800 feet and others immediately to the west are 500 feet higher, so it may be used to determine the growth and evolution of the southern highlands. Such a study is favoured by the disposition of the area, because its ancient features have been protected from the destructive influences of the steeper coastal streams, although erosional forms have been developed as the result of each significant earth movement. These forms provide a history which falls into three main stages: the first involved the formation and peneplanation of the Kanimbla (Hercynian) folds; the second ended with a surface of Triassic and Permian strata just above sea-level, and a southward rise in older rocks with wide valleys and incomplete peneplains cut down almost to the old level of deposition; the third witnessed a series of uplifts which brought the modern canyon cycle into being. Most of the existing surface has been above sea-level since the

Kanimbla folding, so the streams outside the Permian and Triassic areas may have a considerable age; nor is it remarkable that we should look for their beginning so far back in the past, as there has been an absence of great folding movements, while conditions of structure, elevation and, perhaps, of climate have limited their activities in changing their mutual relationships. It is better to regard the whole problem from the point of view of major events or cycles rather than from that of absolute time, because even the names of many of the usual chapters of geological history are missing from the region.



Text-fig. 1.—Locality Map. Cambewarra Range is between the Kangaroo and Shoalhaven Rivers, and the heavy line indicates the section of Text-fig. 2. The arrow shows the magnetic meridian.

Morphology.

1. *The Older Surfaces.*—The eastern part of the Wollondilly basin (Craft, 1928) marches with the territory of the lower Shoalhaven, and is essentially a plain rising to 2,400 feet which has been dissected maturely to a depth of 400 feet. The undisturbed surface of the Triassic Wianamatta shale lies at 2,350 feet: much of it was covered by Tertiary basalts which also filled its gentle valleys, although these were later re-developed and amplified, and they extend past Tallong into the Shoalhaven area at a uniform altitude of 2,000 feet. The

Wianamatta shales were deposited in a syncline of Triassic Hawkesbury sandstones whose edges rise a little above the shales except to the west, where the passage to the differentially uplifted country across the Wollondilly sees their surface exceeding 2,500 feet. There is no evidence that sedimentation extended much above the present upper surface of the Wianamatta, and we may regard such high points as Twin Hill (2,360 feet) at Tallong as survivals of the old levels of deposition.

When the lower Shoalhaven is approached from the north, it is found that the Hawkesbury Series thins rapidly and gives place to the Upper Coal Measures on the tableland surface without any marked change of elevation, except as the result of comparatively recent dissection. The Coal Measures are also thin on the points approaching closest to the Shoalhaven, although they thicken rapidly northward; there is no record of the basal Triassic beds, the Narrabeen Series, on the western part of this southern margin, although they appear in Kangaroo Valley. Similar conditions to these are noticed on the western edge of the formations near the Wollondilly River, and the modern extent of the Triassic and Coal Measure rocks gives a fairly accurate definition of the south-western limits of the basin in which they were deposited, although in the Nowra district it extended to the south of the modern Shoalhaven.

The underlying Upper Marine Series shows the maximum extent of the Permian depression; its western and south-western edges cut out rapidly, and again the modern limits seem to be close to the original edge, except in the Clyde basin, where Lower Coal Measure strata occur in patches, and where the Upper Marine Series may have occupied the whole space between the existing coast and the Clyde. Against Currockbilly Range there are coarse shore-line deposits which extend to the north and north-west through Nerriga district and towards Tallong, and here the Corang-Shoalhaven stream line appears to have originated near their edge. At the head of Corang River these rocks form a tableland about 2,800 feet, and before denudation removed older rocks immediately to the west, the latter must have risen to a similar height and have continued southward, although their surface may have had a slight northerly dip in sympathy with that of the newer strata. We have noticed the great extent of this level about 3,000 feet on the divides (Craft, 1932) and in the middle and upper parts of the Shoalhaven Valley, and we also know that there was extensive peneplanation of the Kanimbla folds before the deposition of the Upper Marine Series: we can picture the present 3,000-foot level in the older rocks as the completion of this peneplain, and the similar but slightly lower surface of the Upper Marine Series as an extension built up in the shallow Permian sea, whose floor shelved gently from the shore line. That subsequent differential uplift to the south has been slight is shown by the sub-horizontal beds south of Major's Creek, whose upper surface continues the 3,000-foot level and rises in sympathy with the base of the series. There is no sign of extensive transverse faulting to indicate that these rocks have been dropped below their original position relative to those at the head of the Corang.

It might be objected that some definite allowance should be made for vertical denudation acting on the highest points of the landscape and that, despite the probable limitation of later sediments, they may have extended over much of the higher surface. In the first case, distinctively harder rocks stand out above the general level to form the residuals of Currockbilly and Budawang, and those of Bungonia district and of Goulburn, but the character and disposition of the

Upper Marine Series in this section are similar to those of the Upper Devonian beds south of Major's Creek, and it is unlikely that denudational losses would have changed their mutual relationship. Apart from this, the rock types and structures of the 3,000-foot level are very diverse, and any considerable lowering since their peneplanation would have resulted in a much greater diversity of elevations than is now observed. The second case presupposes surface developments of the nature we have outlined, but antedating any later deposition, and would only add another stage which would not invalidate our reasoning.

This (older) surface rises southward to 4,000 feet at the head of the Shoalhaven, but it has a great extent in the Tuross and Umaralla basins, as will be seen presently. In the greater part of the Shoalhaven Valley there is no definite surface above 3,400 feet, but that level extends through Gourock Range into the Molonglo basin, and northward along the western divide of the Shoalhaven, although it is not to be confused with the residual hills of the Bungonia and Goulburn districts which rise to a rather similar altitude, and of which some, at any rate, seem to have been monadnocks since Permian times. The loftier points of the ancient Gourock mass rise 1,400 feet above the old peneplain, and the peak of Tinderry Range is 500 feet higher than these. The development of the older peneplain marks the beginning of present-day topography.

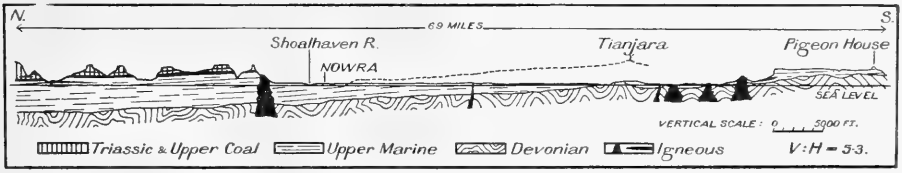
The Newer Peneplain.—It is probable that the extension of the Upper Coal Measures to the south of the lower Shoalhaven was virtually confined to the Nowra district, so the area treated in the preceding section has been above sea-level since the Upper Marine period. The older peneplain in the Shoalhaven Valley has been maturely dissected in stages, and the newer features extend through narrow isoclinal ridges into the coastal slopes and the Murrumbidgee country. If the Shoalhaven Valley is considered in detail, the three divisions can be distinguished at 2,400 to 2,600 feet, 2,200 feet and 2,000 feet respectively. Of these, the last is the best standard of reference owing to the reduction of the other two near the main streams; in the sectional papers it has been referred to as the "Shoalhaven Plain", although it also has considerable development in the Wollondilly basin north of Tallong, and about Goulburn, Lake George and Queanbeyan (Sussmilch's "Yass-Canberra Plain"). It is horizontal as far south as the lower Mongarlowe, whence it sends branches up the main streams into the higher lands; its even surface is marked by the presence of late Tertiary drift.

The highest of the divisions includes the upper surface of the Triassic rocks, together with the hills and higher plains along Mulwaree Creek and about Tarago, Reedy Creek and the Braidwood district, and the old levels in the high country west of Bungonia. These features rise from 2,350 feet in the north to 2,500 feet in the south, and 2,600 feet in the granite uplands near the western divide of the Shoalhaven. In the Nerriga district, residuals and old swampy valleys between 2,400 and 2,500 feet, and parts of Bulee Ridge, may belong to the same surface, and it extends up the Shoalhaven beyond the junction of Jinden Creek, where the sharper rise towards the head of the river coincides with splitting of the stream into its main sources.

So far as the intermediate stage is concerned, the peneplain at 2,200 feet in the Tallong district is well defined, and has some extension in the adjoining parts of the Wollondilly basin. Many hills in the Bungonia and Nerrimunga Creek districts rise to the same height, and further south there are terraces between the extreme levels of the first and third stages, including the plain divide of the Mongarlowe to the north-east of Braidwood (2,400 feet and less), the divide at Major's Creek (2,300 feet), and the plains about Lake Bathurst (2,300 feet or less).

The interpretation of these features appears to be somewhat as follows: When the upper surface of the Triassic strata was near sea-level, the older peneplain rose gently southward and was dissected until a lower surface was formed which was co-extensive with the Triassic surface of deposition. Limited epeirogenic uplift caused this newer surface to be dissected to a depth of 200 feet, with the erosional forms produced dying out towards the sources of the main streams, and leaving much of the first stage intact. The uplift continued, and further denudation resulted in the formation of the Shoalhaven Plain during a long period of stability. It affected much the same area as the second stage, and the two combined with still more recent erosion to continue the reduction of the first, and to form hilly slopes where they rose to merge with it. Thus the undulating topography of the Braidwood district contrasts with the clear-cut definiteness of the various levels at Tarago, Nerriga and Tallong—a condition to which the prevailing granites also contributed. The coastal slopes consist largely of a dissected continuation of the newer peneplain, as an examination of their topography shows.

The Lower Shoalhaven.—The tributaries falling to the lower Shoalhaven from the south run northward parallel to the major joints of the rocks rather than along the line of greatest slope, which now trends towards the north-east. Part of their southern divide—Turpentine Ridge—has swampy levels between 1,600 and 1,700 feet, which overlook the coastal plain behind Jervis Bay, and lie below the height of Tianjara Trig. Station (2,517 feet): they bear the same relationship to that feature as the Shoalhaven Plain bears to Corang Trig. (Craft, 1931*d*), and their decreasing elevation and greater dissection towards the river are largely due to comparatively recent erosion. These levels stand back about the same distance from the coast as Cambewarra Range—13 miles—although that feature is rather higher, and brings the level tableland close to the lower Shoalhaven (Text-fig. 2). Although the entrenched part of the river extends downstream to Nowra, there is no great rise of the country for some miles up the stream, which falls gently as it leaves the inclined plane. Away from the river, such heights as Nowra Hill rise to 600 feet, and they form a bench both here and to the south which has a steep seaward fall. Small streams and other forces of normal erosion have acted from the coast to cut limited flats and valleys, which extend a little further inland along the main rivers than elsewhere, and which form an irregular coastal plain. The Shoalhaven has also rebuilt the land surface which was reduced when sea-level was considerably



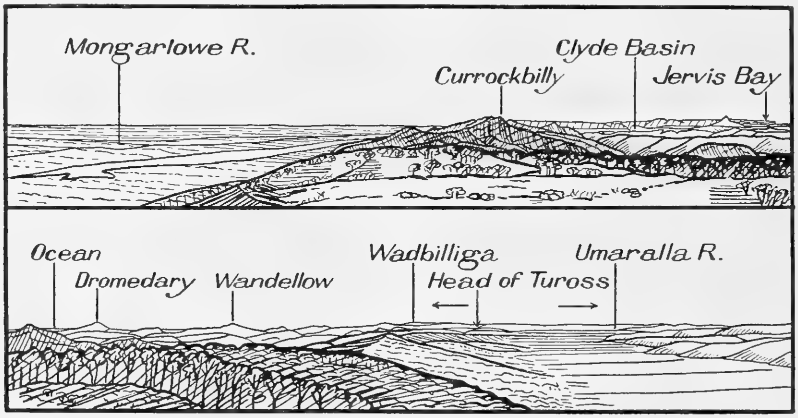
Text-fig. 2.—Section of the coastal plain and tableland in the Nowra district, after Jaquet and Harper. The 2,000-foot level is found on either side of the Shoalhaven River, and the broken line is added as an approximate profile of Turpentine Ridge to show the asymmetry of this part of the main valley.

lower than it is now, although deep offshore water and strong currents inhibited delta formation.

There are two features near the mouth of the river that cause some confusion: the headlands enclosing Jervis Bay project beyond the general coastline and the exact reason for their existence is still unknown, while the other matter concerns the thinning of the Upper Coal Measures and the Upper Marine Series. With these rocks, the tendency was towards a series of deposition planes falling northward and being slightly concave: they are partly responsible for the asymmetric valley near the mouth of the river, as the fall from Turpentine Ridge is essentially a dip slope, while the rise to the north of the stream is an erosion scarp capped by the harder volcanics and Triassic strata. The asymmetry becomes less notable as the river is ascended, and the basal Upper Marine beds rise to form the tableland surface 10 miles to the east of the great bend at Tallong. The pauses between the initial stages of the last great series of uplifts allowed part of the erosion of softer rocks about Nowra, and the formation of the wide upper valleys and terraces which extend into the tableland along tributaries of Kangaroo River. That stream was probably initiated near the edge of the Triassic rocks owing to a slight local dip to the south-west.

In conclusion, it may be stated that the interaction of erosional forces and geological features has given the existing topography at the mouth of the Shoalhaven; that the horizontal tableland now about 2,000 feet originally extended to the south of the lower Shoalhaven, and that the first stages in the dissection of that surface produced the marginal terraces now found between 1,500 and 1,700 feet.

Clyde River (Text-figs. 2, 3).—The salient features of the Clyde Valley require only a brief description. Currockbilly and Budawang ridges fall sharply eastward to a peneplain cut in Devonian and early Palaeozoic strata, and showing a skyline of some regularity; the Upper Marine sandstones to the north stand as a high tableland above this surface, with Pigeon House (2,358 feet) as a detached residual of



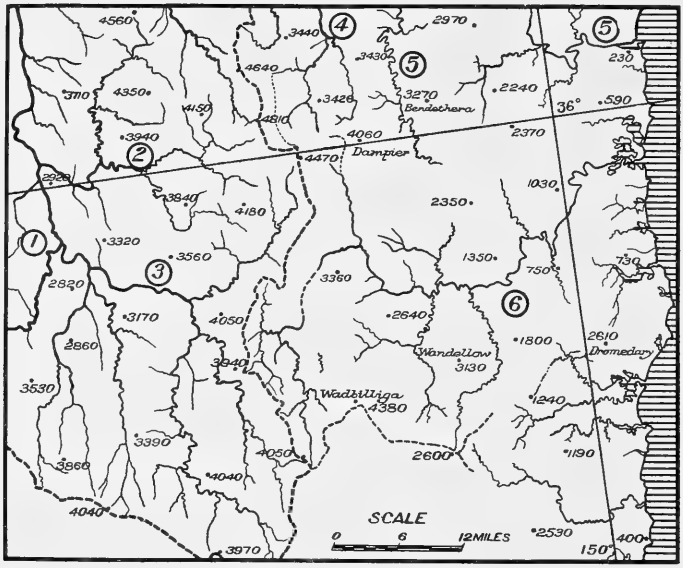
Text-fig. 3.—Top: Topographical sketch looking northward from Mt. Budawang. This shows the Shoalhaven Plain on the left, the residual ridge of Currockbilly, the sandstone tableland in the right background, and the falling and dissected peneplain of the Clyde basin. Bottom: View southward along the Main Divide from Big Badja Hill, to show the warped peneplain falling to the coast from its level western extension in the Umaralla valley.

their falling surface. Against its western edge the peneplain has an elevation of 2,000 feet, and is a counterpart of the Shoalhaven Plain, the relationship between the two showing clearly when viewed from the residual ridges (Text-fig. 3). It falls steadily towards the south-east, as Jaquet and Harper (1915) have already noticed, and near the mouth of the Clyde its higher points are found between 700 and 900 feet. There is a correspondingly steep and concave fall from the head of Mongarlowe River, so we find the Clyde and its principal western tributaries—Currowan and Buckenbowra Creeks—flowing down the prevailing slopes to enter the sea where the peneplain surface has been considerably depressed.

The pattern of the Clyde system is imperfectly shown on existing maps. The peneplain surface is considerably below the northern and western divides, so the present streams have preserved their mutual relationships over a long period of time—since far back in the Tertiary period, at any rate. The Clyde is the key stream, and may have developed along the western edge of the Upper Marine Series; it is parallel to the major joints of those rocks and to the general strike of the underlying folded strata, so there has been no lack of definite lines of weakness to help preserve its meridional course, on which the effects of the peneplain stage are still visible in the form of meanders that are now entrenched in the old surface. The unmapped tributaries from Currockbilly and Budawang run eastward, but there is one anomaly in the course of a stream which flows east of north for some 10 miles to join the Clyde against the general direction of that river; it appears to be a subsequent developed along a granite intrusion. The parallel courses of Araluen Creek, the upper parts of Currowan and Buckenbowra Creeks, and a portion of the Deua River appear to be developed along parallel regional lines of weakness which may be seen both in the granites and the sedimentary rocks.

Deua and Tuross Rivers (Text-figs. 3, 4).—Conditions over much of the Deua basin are not essentially different from those existing over the Clyde, but the upper Deua can be classed with the upper Shoalhaven as regards origin and development (Craft, 1932). The older peneplain is preserved on the eastern side of the meridional section in a series of high ridges which rise above 3,000 feet, and the stream line follows the strike of the upper Devonian rocks, and has possibly been influenced by parallel fault lines (I. Brown, 1930). The head of the river is in rough country, and the divide looks to be 2,500 or 2,600 feet above sea-level; it is much below Mt. Dampier and the Bendethera ridge, so there is a wide opening in the uplands between the Deua and Tuross Rivers. Canyons of the present cycle extend to this divide, but the Deua has a remarkably meandering course throughout its length, many of the great bends apparently being inherited from the newer peneplain stage. That feature slopes eastward towards the mouth of the Deua from the Bendethera ridge.

The Tuross heads in a part of the Main Divide whose high points rise above 4,000 feet (Text-fig. 4), but its first course is northward over an undulating granite plain whose general level is 3,200 to 3,400 feet—an extension of the older peneplain: the river turns eastward across this level, and falls into a gorge that characterizes much of its length, although there is a shallowing as the newer peneplain falls towards the coast. We have noted a tributary—Woila Creek—as rising in the same swamps as the Shoalhaven at an altitude of 2,900 feet (Craft, 1932), with much higher country on either side, so the whole western section of the Tuross drainage is associated with the older peneplain, which extends westward without a break into the Umaralla basin. Relics of a still higher level continue southward from Mt. Dampier (4,060 feet) to fall steeply to the gorges, while a similar fate overtakes the southern Tuross ridges about Wadbilliga Trig. (4,380 feet). It will be noticed that the upper Tuross is associated with the highest features developed as a regular level in the region, and there is an analogy between it and the Umaralla, upon both of which similar patterns have been imposed by rock structure. Their efficiency in working is shown by the even skylines of the various higher levels near, and to the west of, the Main Divide, and they contrast with the parallel streams of the upper Shoalhaven and Murrumbidgee, which were unable to reduce the highest elements of the most ancient landscape, as the high points of Gourock and Tinderry show. With the Umaralla and upper Tuross the rock character is less resistant and more uniform, and generally the violent contrast between alternating hard and soft zones is missing: the presence of that contrast rather than the inherent resistance of the most obdurate rocks has greatly hindered complete peneplanation in the other areas, and has made the development of symmetrical stream systems almost impossible.



Text-fig. 4.—Map to show the relationship of the Tuross and Umaralla Rivers, and the high points in their basins. The main streams are numbered: 1, Murrumbidgee; 2, Bredbo; 3, Umaralla; 4, Shoalhaven; 5, Deua; 6, Tuross.

The Coastal Slopes.—To appreciate the significance of the coastal slopes it is necesssary to take a broad view of the littoral. The position of Robertson is of great importance: basalt flows have built up the surface of the tableland in its vicinity by 400 feet, and a gentle slope to the north leads to a sharper fall towards Sydney. A similar feature appears southward, where a gentle fall gives place to a steeper slope into the Clyde valley and the hollow to which the Clyde, Deua and Tuross Rivers flow. The essentials of the position were noted by Harper (1905 and 1915), who saw a definite connection between the crest of the gentle arch and the Robertson basalts, and a similar explanation might be found for the Sassafras and Endrick valley flows, which occur where the slope changes from the unwarped tableland to the coastal depression, which is the great feature of the Clyde valley, on whose eastern side the newer peneplain has been cut off some 800 feet above sea-level in the erosion of the coastal plain. Late Tertiary basalts and sediments have been described between Jervis Bay and the mouth of the Tuross in places where more recent elevation has raised them by the order of 200 feet (I. A. Brown, 1925, 1928), and although their age has not been definitely established, it is generally believed that volcanic activity in this region did not extend into the Pleistocene. Thus it is necessary to place the essentials of the present coastal topography in the late Tertiary period, and to impose a similar upward limit on the process of tableland formation. The extension of the coastal plain since the latest basaltic period is not great, even in the country close to the lower Shoalhaven, so the process must be slow, and recent change has been almost confined to the enlargement of the canyons which furrow the coastal slopes. The older peneplain stands well back from the coastline, and does not attain any continuity until the eastern divide of the upper Deua and the headwater country of the Tuross are reached: very few residuals are found to the east of that locality, almost the whole expanse of the ancient surfaces having been reduced in the formation of the newer peneplain.

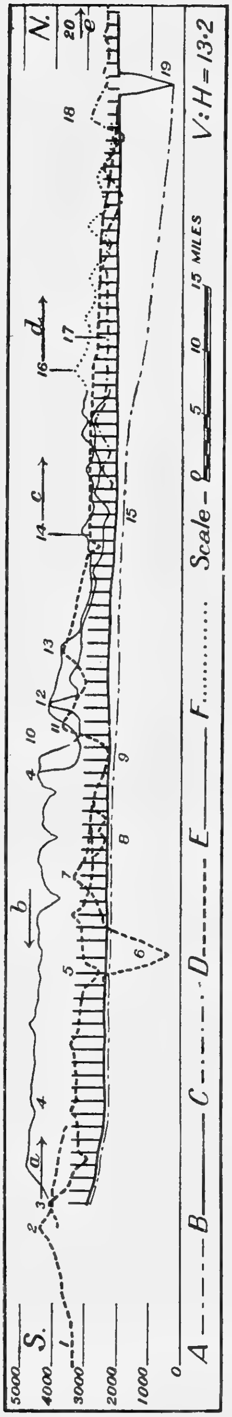
The depression we have noted in the Clyde valley developed in its present form before the erosion of the coastal plain; it is a counterpart of the Sydney basin, although on a less impressive scale, and it involves a relative lowering of 1,200 feet near the mouth of the Clyde. That river has maintained its course through a long period of time, so it was probably directed originally by a southward fall which was maintained during the newer peneplanation, and which was accentuated by warping during the main plateau uplift to give the existing bending and depression of the littoral.

History of the Land Surface.

The various surfaces or physiographic horizons developed in the Shoalhaven valley may thus be regarded as regional features; they are classified according to field continuity, and although each individual may occur extensively within narrow vertical limits, the bending or warping incidental to the various movements of elevation has served to disturb the original contour as one passes from east to west. Along meridional lines, much of the change in altitude can be ascribed to more ancient movements so far as the upper levels are concerned, and to erosional processes in the lower. The essential features of the valley may be summarized in a diagram (Text-fig. 5).

There is no doubt that the most notable peneplanation which has influenced or determined existing features was that preceding the deposition of the Permian rocks, because it eliminated the fold topography. The upper surface of the Upper Marine Series was co-extensive with its most highly developed phase, such hills as Currockbilly, Budawang, and those west of Bungonia being residuals even when Permian deposition was taking place, and there is no evidence of notable cross-faulting or sharp bending as one goes from north to south along the divides. On the contrary, the almost undisturbed upper Devonian rocks forming the eastern divide of the upper Shoalhaven have an erosion surface rising somewhat above that of the Upper Marine Series, so it would appear that our "older peneplain" is little removed from the surface which existed immediately after the deposition of the Permian rocks, and the more complete peneplanation of old highlands which must have proceeded during that period. The older peneplain was preceded to the south by a still higher level about 4,000 or 4,500 feet (modern) which was the most complete regional feature developed, and which may have been the original master peneplain formed by the reduction of the Kanimbla and earlier folds, although not much of it now survives in this area.

Coming towards more recent times, the restriction of the Upper Coal Measures and of the Triassic basin point to elevation around their margins coincidentally with the depression of areas in which sediments were being deposited. The southward rise of the older peneplain may be ascribed to this cause: it certainly antedates the three stages of the newer peneplain, which sends its horizontal surfaces into the inclined mass. The first stage of the newer feature was eroded to be co-extensive with the final surface of deposition of the Triassic rocks; the second followed limited uplift, as did the most recent, the Shoalhaven Plain, which was so perfected over limited areas that, towards the latter part of the Tertiary period, considerable areas of it were covered with stream drift. Since that time the amount of change has been small except in the areas affected by the more recent uplifts of the Kosciusko period, where revived streams have cut deep gorges. The place of the coastal slopes in this scheme is clear from preceding sections: the principal surface represented is the combined Triassic upper level and the newer peneplain, the latter being warped down



Text-fig. 5.—Profiles to show the physiographic development of the Shoalhaven Valley. The principal features are parallel to the magnetic meridian, so all are projected on to that line, hence the occasional passage from ridges to valley profiles. The capital letters stand for: A.—Shoalhaven River; B.—newer peneplain, taking the best-developed lower level in each district; C.—ridges west of Bungonia; D.—discontinuous profiles of various sections of the eastern divide, and the Main Divide in the extreme south; E.—Gourock Range and its two northerly extensions, of which the upper leads to F, the ridge extending west of Mulwaree Creek. The arrows indicate the direction of various features extending from their bases; *a.*—sub-horizontal beds of the upper Devonian (to 8); *b.*—mature valleys replacing the newer peneplain; *c.*—Upper Marine Series; *d.*—northerly residuals of upper Devonian quartzite, above 2,500 feet; *e.*—Triassic rocks. Numbers stand for: 1.—Tuross-Umaralla divide; 2.—Big Badja Hill; 3.—Mt. Dampier; 4.—Gourock Range; 5.—Moodong gap; 6.—valley of Deua at the junction with Araluen Creek; 7.—Milo Trig.; 8.—gap at Major's Creek (side on); 9.—gap at Currowan Creek; 10.—lowered divides of Mulloon Creek; 11 and 13.—Mts. Budawang and Currockbilly, quartzite residuals; 12.—Palerang Peak; 14.—head of Corang River; 15.—Reedy Creek; 16.—Mt. Allianoyonyiga (Tarago); 17.—plain of Lake Bathurst; 18.—Vessey Trig.; 19.—Shoalhaven River, Tallong; 20.—Tallong. Note the favourable conditions for stream capture between 5 and 9. Vertical shading represents the denudation involved in the erosion of the newer peneplain, and for simplicity only a few points or profiles are shown for each surface; the sectional papers should be consulted for further details.

southward, and considerably dissected in the production of gorges and of a limited coastal plain. Although timing has been based on the conventional geological periods of sedimentation, it is clear that no rigid definitions are possible in this case, and they would not be desirable under any circumstances if they were taken to imply that each of the later sedimentary periods must be represented by some forms in an ancient landscape, or that a cycle of erosion fitted into one period. There is an obvious connection between mountain building, erosion, and sedimentation, but there is no reason why landscape development should not progress through several periods of extraneous sedimentation, especially when the surface concerned has the form of a low tableland in an area of great temporary stability, and field evidence in such an area as the Shoalhaven Valley shows that land forms may survive from period to period with comparatively little change provided that the rock types are sufficiently resistant, and the streams sufficiently incompetent.

The Stream Systems.

The development of the Deua and upper Shoalhaven Rivers has already been discussed, and some of the points raised by the question of stream capture have been considered (Craft, 1932), so this section can be devoted to a general review of the Shoalhaven and neighbouring streams. When the Kanimbla folding influenced this part of the State its trends were roughly parallel to the existing coast (I. Brown, 1931), thus favouring the existence and the further development of meridional streams—a tendency that would be continued by reason of the subsequent Permian depression to the north-east, and which would lead us to infer that the present transverse or oblique courses of certain coastal streams across this folded belt have developed since the reduction of the folds, and since the inception of the Permian depression. On the other hand, such streams as the upper courses of the Shoalhaven and Deua, and the meridional section of the Murrumbidgee north of Cooma appear to be the lineal successors of the original drainage lines.

To the south and south-west of the Shoalhaven, the oldest surface, now somewhat above 4,000 feet, appears to have had a slight northward fall, since there is evidence that the northward trending Umaralla is of great age. That stream has cut the older peneplain (3,000 to 3,400 feet) as a plain in the higher level, the slopes between the two being definite facets, and the peneplain falls slightly and gradually along the modern direction of flow of the Umaralla in much the same way as the corresponding surface in the Shoalhaven Valley falls northward. The Umaralla-Murrumbidgee line passes the isolated mass of Gourock and Tinderry in a comparatively narrow valley in which the older peneplain has been considerably dissected, although its level may be picked up again in the residuals which rise above the Canberra plain. In other words, the Umaralla maintained a course during the older peneplanation like that followed at present, and thus appears to have been inherited from the old surface now found in a rather fragmentary condition about 4,000 feet.

How, then, must the Tuross be regarded? Its similarity to the Umaralla leads to the belief that it was developed under similar conditions as regards the headwaters, at least, because they still flow in gentle valleys above 3,000 feet, although the parts nearer the coast may be considerably more modern. Considering the disposition of hills and ridge crests rising above 4,000 feet, it would appear that the ancient surface which they represent extended over the upper Tuross and Shoalhaven country as well as over the adjacent Umaralla-Murrumbidgee region, in which case the northward fall deduced for the latter area may well have applied to the Tuross drainage. The originals of that stream would thus have fallen northward; in fact, the nature of the Kanimbla folds made a primitive meridional course inevitable in the relatively unfolded strip between the head of the Tuross, Mt. Dampier and Major's Creek, as in the gently folded country towards the coast.

But there were reasons why such a course should not persist. When the folds had been peneplaned and the resultant surface raised above sea-level, the inevitable eastward fall to the then-existing coast would cause streams to cut back from that direction along lines of weakness, assuming that they had not done so before, and attack the old meridional drainage, as in the later case of the Deua, setting up courses with a more direct passage to the sea.

Turning now to the Umaralla-Murrumbidgee stream line, we find that it was favourably situated for its own preservation, since it was able to exploit a persistent meridional line of weakness to the east of the Federal Territory granites, but no such line extended through the Tuross-Shoalhaven area. The Shoalhaven itself follows the western edge of the Upper Devonian rocks, a line of low resistance that is almost eliminated near the present head of the river by the convergence of the hard mass of southern Gourock, thus making the survival of any southern extension of the upper Shoalhaven a difficult matter. Altogether, there was a tendency for stream systems to develop about the head of the Shoalhaven at the expense of primitive drainages: of these newcomers, the Umaralla still discharged northward, but the Tuross developed more or less directly from the coast. Doubtless many of the original meridional valleys established along special lines of weakness have been exploited by later streams, but it would be extravagant to suppose that the original pattern could be reconstructed in detail from existing evidences.

In addition to the meridional and transverse streams there are others, such as a large part of the lower Deua, which pursue oblique courses along general lines of weakness. Professor David (1914) mentioned NNW-SSE trends (geographical meridian) in the northern edge of the Bathurst-Monaro tableland, and similar features have been recorded in the igneous rocks of the South Coast (I. Brown, 1928) and in the Ettrema gorges, to the north-east of Nerriga (Jensen, 1908). The present writer has noticed them in the Devonian and older rocks on either side of the Shoalhaven Valley, and in the associated granites, and it appears that attack along such lines, or along combined meridional and transverse features with a resultant trend in that direction, has resulted in the capture of certain meridional streams, such as Mulloon Creek and the upper Deua (Craft, 1932). This attack is still proceeding, so that the Shoalhaven above the vicinity of Major's Creek is threatened with capture and diversion to the Deua River. Oblique streams (NNW-SSE to NW-SE) thus form a definite family that is developing at the present day.

Coming now to the lower course of the Shoalhaven, it is found that the section immediately south of the great bend at Tallong lies immediately to the west of the Upper Marine Series, suggesting that it formed near that periphery. Where the river turns eastward there is a wide upland valley at 2,000 feet (Craft, 1931*c*), and a slight seaward fall is shown in the tableland on either side of the river. It is possible that the original Shoalhaven fell to the Triassic lake, as Taylor seems to suggest (1906), and when rocks of that age were finally raised above sea-level, its new lower course became established off the edge of the resistant Hawkesbury Series to follow a short slope to the ocean. Recent stream changes in this district are of a minor character (Craft, 1931*a*).

Summing up this aspect, the principal stream families of the region are found to be three in number, namely:

1. The Meridional, which developed along the slopes and may have originated along the Kanimbla folds, in some cases, and which fitted themselves to parallel structures. Examples are the upper Shoalhaven, the Mongarlowe and upper Deua Rivers, Mulwaree, Mulloon, and Butmaroo Creeks, and certain of the Murrumbidgee streams.

2. The Transverse and Oblique, which exploited joints and other lines of weakness, pushing back along later slopes at the expense of the older meridional streams. Examples are the lower courses of the Tuross and Deua Rivers, Reedy, Boro, Araluen, Currowan and Buckenbowra Creeks, all of which are subsequents.

3. Streams which developed off the edges of horizontal formations when the latter were raised above sea-level. This type includes the head and lower course of the Shoalhaven, much of the Wollondilly and part of Clyde River, although the latter is rather doubtful.

A fourth type—that formed to drain the peripheral depressions of the tableland—is not represented here. Those portions of the Hawkesbury and Clarence in Mesozoic areas are examples.

These ideas have certain incidental consequences. The primary divides were aligned east and west, and the present Main Divide is a more or less haphazard line separating the streams which finally discharged eastward under the combined influence of the Permo-Triassic depression and the modern coast from those which eventually fell westward into depressions on that side. Thus the parallelism of the Main Divide and streams on either side of it is to be expected, because the streams have followed old meridional slopes and lines of weakness over long periods of time, the watershed consists of some of the resistant or stable features thus disclosed, and few streams exist to cause its migration as the result of direct headward attack. In conclusion of this section, it is recognized that the disposition of the present streams has controlled the development of the newer (mainly Tertiary) peneplain, and it also corresponds generally with the gentle slopes of the older peneplain, whose sections are partly separated from one another by exceptionally high masses, and which were carved out of a rather higher master surface. It is clear that the streams had attained their present development well before the end of the Tertiary period; those in the older surfaces may have been little changed since Triassic times, and their ultimate origin is associated with the Kanimbla folding. Alteration by capture and the development of the newer transverse and oblique lines is most notable on the coastal margin.

General Physiography.

These studies involve the consideration of certain problems of surface development which present themselves in a sequence; such as the horizons on which Tertiary basalts occur, the relationship of peneplanation to the Southern Tableland, and the tectonic significance of that feature, although the succeeding pages can only be a brief introduction to the matters involved, which may be taken in order.

The Horizons of the Tertiary Basalts.

The general age of the basalts occurring on the New South Wales tableland has been referred to by Walcott (1920) as upper Miocene or lower Pliocene, but a considerable vertical range is indicated by the various occurrences in or near the Shoalhaven Valley. Thus the Robertson group is spread over a plain surface and has filled the gentle valleys eroded therein, and these latter were subsequently re-developed and enlarged at a level now found at 2,000 feet: under the circumstances, the general age quoted is satisfactory, as it allows time for the considerable amount of weathering and erosion involved. The occurrences near Tallong are less simple, because the higher basalt appears to have flowed down to the 2,000-foot plain after that feature had virtually attained its present stage of development, and the nearby valley at Caoura, cut below that level, was filled with lava before the inception of the modern canyons. The flows, sediments and bauxites of the higher level occupy a plain which ends in an abrupt valley side and overlooks the lower flow. Further south there is the pre-canyon basalt of the Endrick valley, with a lower limit of 1,680 feet, thus disclosing a mean range of 670 feet between its base and that of the Robertson flows, with no appreciable warping or faulting between them.

Turning to the coastal basalts and sediments between Nowra and the mouth of Tuross River, they are found to lie on the coastal plain (I. Brown, 1925, 1928), and to post-date the commencement of canyon formation, as the surface in which that plain is eroded rises even higher to the north and west, as we have already seen. Such a position of occurrence contrasts with that of the Robertson basalts, whose outlying members to the west-north-west occur on the tableland above the deep and moderately old terraced canyon of the Wollondilly, which they antedate. Harper (1915) believed that certain intrusions into the coal seams of the Illawarra district were of Pleistocene age, as they post-dated faults in the coal measures referable to the last great uplift: on similar grounds he also ascribed a like age to the Robertson basalts, but his case is hardly convincing. At any rate, it seems that the basalts may have a considerable time range, those of the Illawarra district and of the South Coast being younger than the pre-canyon flows of the tableland. It is hardly possible to separate these latter, as there is evidence of volcanic action during the accumulation of the Shoalhaven drifts between 1,650 and 2,100 feet (Craft, 1931*d*), and the higher basalts at Tallong apparently extended down from 2,200 feet to the Shoalhaven Plain at 2,000 feet (modern heights). Nor is it possible to say from physiographic evidence that the Robertson flows are earlier than these, because the Shoalhaven channels that were filled with drift and basalt may well have been eroded below the Shoalhaven Plain without the Robertson area being affected by such features, seeing that downward erosion there has been limited even to the present day. The amount of erosion which the various flows have suffered is also no criterion of age, as those are best preserved which occur in remote valleys, while the basalts in higher areas have either had wide valleys cut in them by the combined action of weathering or gentle streams, or they have been removed so completely that the only evidence of their former extent is in the presence of contact quartzite ("grey billy"), or isolated masses of bauxite.

It seems that Pleistocene uplift was limited to the order of 200 or 300 feet disclosed by the raised sediments and basalts of the South Coast (I. Brown, 1928), and that period has been spent in the excavation of the canyons. (There have also been oscillations of sea-level that scarcely affect the present considerations.) The considerable age thus inferred for the highly developed plains and valleys of the tablelands agrees well with the general tenor of our observations: the youthful-looking valley of the Endrick above Nerriga has changed little since the period of basalts (Craft, 1931*d*), while two of the head streams of the Shoalhaven—Point and Jerrabatgully Creeks—flow in steep-sided, narrow valleys in close proximity to the wide valleys and plains of the river. This is a case in which the familiar terms "juvenile" and "mature" lose their accustomed significance if used to describe relative valley ages on the basis of cross-sections.

Peneplanation and the Southern Tableland.

The conception of the whole Southern Tableland is largely determined by the foregoing considerations. At the close of the Palaeozoic era, the whole region had been peneplaned, although resistant features and structures mainly due to differential movement and faulting during the period of granitic intrusions rose to some height above the common level. It seems that further uplift supervened during the Mesozoic era, but there were no more great foldings, and the whole course of the more recent movements had been to produce a surface which has a broad, flat arch in section. The greatest uplift has been along a meridional line about the heads of the Snowy and Murrumbidgee Rivers, and the effect has been rather similar to that produced by inserting the blade of a knife under a cloth lying on a table, and lifting it gently. It is not surprising to find the elevation increasing towards the centre of the mass, because reduction would tend to be least complete there, and older positive movements must also have been greater away from the margins, seeing that these were first acted upon by forces of depression, and later the weight of a considerable body of newer sediments had to be overcome before there could be notable uplift on the periphery of the central mass. Viewed broadly, the south-eastern highlands of Australia were built of Palaeozoic rocks and formed a nucleus around which the present area of dry land tended to grow as forces of uplift became more widespread, and the Mesozoic and Tertiary rocks were lifted gently above sea-level.

As a result of the intermittent rising, there has been a continual attack on the upraised mass from the direction of its margins, and a number of incomplete peneplains have been formed of gradually decreasing extent, so that the most recent have a smaller area than that occupied by the oldest in respect to the pre-existing land mass, and the whole region falls into a series of terraces narrowing and rising towards a centre, where the oldest are still preserved at relatively high altitudes. The major terraces tend to be spaced at vertical intervals of 1,000 feet each, and in many localities they are separated from one another by steeper slopes or facets, especially towards the heads of the main rivers. The peripheral areas have been most reduced by the erosion of the more recent features, and the process has been revived by late Tertiary uplifts, which have caused the formation of limited coastal plains and the inception of a new terrace near sea-level, which is extending inland along the gorges.

This conception of the growth of the tableland gives an insight into the evolution of the stream system, whose distinctively modern form can be traced back to the cycle of erosion which reduced the Kanimbla folds and set up the main streams along meridional lines. As a result of the later uplifts there was a definite tendency towards a radial system diverging from the Kosciusko-Monaro highlands, with meridional elongations parallel to the reduced folds, and falling down the slopes to tectonic depressions. Transverse and oblique streams developed on the flanks of the rising mass as newer streams took advantage of easterly or westerly components in the slope, and attacked along parallel lines of weakness, finally capturing or destroying parts of the original drainage pattern. Complications have been introduced by selective erosion in specially favourable zones, as on the southern edge of the Federal Territory granites in the headwater country of the Murrumbidgee, but even streams developed by such an action are of considerable age, going at least far back into the Tertiary period, and they do not hide the essential character of the whole pattern.

The Manner of Uplift.

Reference has been made to the flat cross-section of the highlands in the vicinity of the Shoalhaven Valley; perhaps this is better appreciated when it is realized that the coastal slope of the tilted newer peneplain is of the order of 1° 30′, while a line from Wadbilliga Trig. (4,380 feet, on the oldest surface, above the older peneplain) to the modern coast line makes an angle of less than 2° with the horizontal. Such values represent the effect of widespread warping, and it is difficult to see how such an action could be brought about by purely compressive forces in the earth's crust, or how such forces could have acted without giving considerable marginal folding or faulting, of which there is no evidence in surface features, or in the post-Devonian rocks of the region we have studied. At the same time, the absence of notable tensional forces is evidenced by a corresponding absence of rifts and normal faults both here and to the north, and uplift has been due to vertical movements and readjustments.

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REVISION OF AUSTRALIAN LEPIDOPTERA. OECOPHORIDAE. I.

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[Read 31st August, 1932.]

Though the family name Oecophoridae was used by Stainton (*British Lepidoptera*, 1859), we owe its present definition, subsequently slightly expanded to include the "Depressariades", to Mr. E. Meyrick, F.R.S. (*Trans. Ent. Soc. Lond.*, 1883). This author also laid the foundations of our knowledge of the Australian genera and species in a series of papers (These PROCEEDINGS, 1882-1888), in which he described 756 species, of which less than one-seventh were previously known. More recently (*Gen. Insectorum*, 1922) he has published a revision of the whole family containing 2,765 species, of which about 1,500 are Australian. The classification has been recast and many corrections as well as additions have been made.

This great work will long remain the leading authority on the Oecophoridae, but no work on this family for a long time to come will approach finality. Especially is this the case with the species found in Australia, where the family is predominant. It still remains true, as Meyrick remarked in 1888, that no collection can be made in any untouched locality without the immediate discovery of new forms. He added, what is still true, that the generic classification of this mass of species is difficult; the points of structure, on which it is necessary to rely, are in some cases slight, in others difficult of observation, and some errors of judgment are unavoidable. A close study extending over many years has confirmed my admiration for the general accuracy of Meyrick's work, but has revealed many details, which in my opinion (no doubt I am sometimes mistaken) require alteration. Meyrick was not acquainted with all of the Australian species which have been described since 1888, and for some of the errors in his latest revision I have been myself responsible. Many hundred new species now await description, and to do this satisfactorily I find it necessary to examine critically all of those previously described, so far as I am able to procure examples. In this I have received much assistance from the South Australian Museum, which contains most of Lower's and many of Meyrick's recent types. Some of the latter have also been lent to me by Mr. Geo. Lyell. For the new species, apart from my own collecting, I am indebted to the same sources, to the National Museum, to Mr. W. B. Barnard, Mr. G. M. Goldfinch, and others. Unfortunately there are many described species and a few genera, which I have not seen or recognized. In this revision they are marked with a †.

In dealing with this mass of more than 2,000 species, conciseness is necessary, and the publication must be in parts. A key to the genera contained in each part will be given, and I hope at the end to give a general key to the whole. After the definition of each genus the species assigned to it will be enumerated in order. This is necessary (i) to indicate the right position of the new species, (ii) to indicate most briefly what alterations I consider should be made in the generic allocation of previously described species, and so save printing these in the text. The references will for economy of space be contracted as far as possible. I will assume the reader to be acquainted with Meyrick's revision.

The Oecophoridae are probably, as Meyrick suggests, descended from the Hyponomeutidae and themselves ancestral to the Cosmopterygidae, being also allied collaterally to the Gelechiadae and Xyloryctidae. The family is distinguished normally by the following characters: Head smooth or loosely scaled, side-tufts more or less raised. Tongue present. Antennae less than 1; in male usually ciliated, but sometimes simple; basal joint with a pecten in most genera, but this may be fugitive or absent. Labial palpi long, recurved, sickle-shaped, acute. Maxillary palpi minute or obsolete. Posterior tibiae rough-haired above. Forewings with 2 from or from near angle, 7 and 8 stalked or rarely coincident. Hindwings not over 1, elongate-ovate, sometimes broadly ovate or lanceolate, termen not indented or sinuate, 3 and 4 connate, 6 and 7 separate, parallel, 12 free.

To these characters there are some exceptions, for instance in *Sphaerelictis* the tongue is absent, in *Peritorneuta* the antennae are as long as forewings, in *Eupselia* the labial palpi are rather short, in *Tetraconta* the maxillary palpi are well developed, in a few the hindwings are over 1, or 3 and 4 of the hindwings are separate, or 6 and 7 of the hindwings are approximated at origin. These cases must be decided on a balance of characters, but rarely present any real difficulty. Usually the Oecophoridae may be distinguished from the Gelechiadae and Xyloryctidae by their neuration alone. If not, the peculiar shape of the hindwing in most Gelechiadae, the presence of an antennal pecten (always absent in the Xyloryctidae, rare in the Gelechiadae), the narrower hindwings, and the absence of any connection between the subcostal vein and the cell in the hindwings, will prove helpful. The Cosmopterygidae may be distinguished by the narrowly lanceolate hindwings with 6 and 7 approximated or stalked. The Hyponomeutidae have 7 and 8 of the forewings often separate, the posterior tibiae usually smooth, the palpi shorter, and the hindwings often over 1.

The classification of the genera is difficult. Meyrick places them in five groups, which are on the whole natural, though based on very fine distinctions. Although I recognize his fifth group the "Depressariades" as for the most part natural, the character on which it is based, "Antennae in male minutely and irregularly ciliated or simple", often fails. If antennal ciliations of ½ be considered minute, as would be necessary to include some species of *Eupselia* and *Eutorna*, it would include also some species of *Barea*, *Trachypepla*, *Elaeonoma*, *Eulechria*, and *Machimia*. If a stricter definition be adopted, it would still include *Mimodoxa* and *Macrobathra* as well as *Callithauma*. The genus *Sphyrelata* I do not place in this group, but in the "Eulechriades". The "Scaeosophides" are a small group with specialized hindwings. The "Oecophorides" are a natural section, though *Borkhausenia* approaches *Eulechria* so closely as to be sometimes confused with it: There is no natural division between the "Eulechriades" and the "Philobotides", indeed the line drawn between the two genera *Eulechria* and *Philobota* is, as I shall point out, an artificial one, though necessary. The same applies to the genera *Machimia* and *Heliocausta*, and these two with their allies appear to form a group apart from the great *Eulechria-Philobota* group, which contains most of our Australian species. On account of the enormous number of species in this last group the distinctions between the genera have to be very finely drawn. Although the genera may be on the whole natural, they are sometimes more or less artificial, and probably not always monophyletic. This is unavoidable in the present state of our knowledge. We must divide the species into manageable groups, which should be as natural as possible, and be content with an imperfect classification, until a better is possible.

I have indicated the known distribution of each species as concisely as possible. The localities are conceived as having radii of 25 or 30 miles, or on the inland plains of 50 or 60 miles, unless some well-defined break such as a high altitude intervenes. For instance, "Atherton" denotes the whole Atherton Tableland, and "Tweed Heads" ranges from Southport in Queensland to Cudgen and Murwillumbah in New South Wales. As to origin of the Australian genera and species, I can state here my views only very briefly. I conceive that the *Eulechria-Philobota* group developed in the Tertiaries in a subarid continent occupying roughly the present area of Western Australia, which for convenience I have termed "Austral Land". Meanwhile a long narrow island or series of islands, which I have termed "Tasman Land", extending from the Atherton Tableland to Tasmania, developed a wholly distinct fauna, ultimately derived from Papuan and Antarctic sources. After the union of these two land masses the Austral fauna, aided by progressive desiccation, assumed the ascendency. The Tasman fauna became restricted for the most part to the eastern Cordillera and Tasmania, and even there has been subjected to severe competition. During periods of heavy rainfall, of which the last occurred during the Pleistocene, some of its genera and species were able to traverse South to South-west Australia. More modern severe desiccation has divided the true Austral fauna into three sections: (1) those adapted to severe arid conditions and ranging over most of the continent, (2) those restricted to South-west Australia, (3) those restricted to South-east Australia. In the north the family is less dominant, though still well represented. In Pleistocene times an elevation of the Cape York Peninsula, Torres Straits, and southern New Guinea admitted a host of Indomalayan lepidoptera, of which, however, very few were Oecophoridae. On the contrary, a greater number of Australian genera of this dominant and aggressive group entered New Guinea, and a few spread far beyond.

Key to Genera.

1.	Forewings with 7 and 8 coincident	6. *Metaphrastis*
	Forewings with 7 and 8 stalked	2.
2.	Forewings with 7 to termen	3.
	Forewings with 7 to costa	4.
3.	Forewings with 2 and 3 coincident	9. *Mixodetis*
	Forewings with 2 and 3 separate	10. *Periallactis*
4.	Hindwings with 4 and 5 coincident	15. *Endrosis*
	Hindwings with 5 separate	5.
5.	Hindwings with 3 and 4 well separate	6.
	Hindwings with 3 and 4 nearly approximated, connate, stalked, or coincident	12.
6.	Antennae without basal pecten	7.
	Antennae with basal pecten	9.
7.	Hindwings with hyaline patch beneath cell	5. *Morphotica*
	Hindwings without hyaline patch	8.
8.	Maxillary palpi minute	3. *Heureta*
	Maxillary palpi relatively long, drooping	4. *Tetraconta*
9.	Thorax with a posterior crest	12. *Oenochrodes*
	Thorax without posterior crest	10.
10.	Palpi with apical tuft on second joint	14. *Palimmeces*
	Palpi without tuft on second joint	11.
11.	Palpi with second joint not nearly reaching base of antennae	11. *Paratheta*
	Palpi with second joint reaching base of antennae	13. *Artiastis*

12.	Forewings with 2 and 3 connate or stalked	13.
	Forewings with 2 and 3 separate	16.
13.	Antennae with basal joint forming a small eyecap	19. *Hoplostega*
	Antennae without eyecap	14.
14.	Palpi with second joint three times length of face	18. *Baryzancla*
	Palpi with second joint less than twice length of face	15.
15.	Palpi with small anterior tuft on second joint	20. *Goniobela*
	Palpi without tuft on second joint	21. *Leptocroca*
16.	Hindwings lanceolate	17.
	Hindwings not lanceolate	20.
17.	Antennae with basal pecten	7. *Satrapia*
	Antennae without basal pecten	18.
18.	Palpi with second joint reaching base of antennae	19.
	Palpi with second joint not reaching base of antennae	8. *Ochlogenes*
19.	Hindwings with 3 and 4 coincident	1. *Mimodoxa*
	Hindwings with 3 and 4 approximated, connate, or stalked	2. *Macrobathra*
20.	Hindwings broadly ovate	17. *Telanepsia*
	Hindwings elongate-ovate	21.
21.	Hindwings with 5 approximated at origin to 6	16. *Scotodryas*
	Hindwings with 5 not approximated to 6	22.
22.	Thorax crested	22. *Phanerolopha*
	Thorax not crested	23.
23.	Hindwings with 3 and 4 stalked, 5 connate	23. *Trinaconeura*
	Hindwings with 3 and 4 connate, 5 separate	24. *Borkhausenia*

1. Gen. MIMODOXA.

Low., *Trans. Roy. Soc. S. Aust.*, 1901, p. 96. Type, *M. dryina* Low.

Palpi long, recurved; second joint reaching base of antennae, slightly thickened with appressed scales; terminal joint as long as second, slender, acute. Antennae with basal joint elongate, somewhat thickened, without pecten, ciliations in male short or minute (in *M. dryina* ½, in *M. metallica* minute). Forewings with 7 and 8 stalked, 7 to costa. Hindwings broadly lanceolate; 3 and 4 coincident, 5, 6, 7 parallel, discocellular oblique between 6 and 7.

A simple development of *Macrobathra* differing in the loss of vein 4 of hindwings. Most of the known species are from the inland region of South-east Australia.

Six species: 1, *dryina* Low., *Tr. R.S.S. Aust.*, 1901, p. 97 (Milmerran, Q.; Broken Hill).—2, *loxospila*, n. sp. (Toowoomba).—3, *metallica* Low., *ibid.*, 1899, p. 111 (Broken Hill).—4, *empyrophanes*, n. sp. (Birchip).—5, *tricommatica*, n. sp. (Broken Hill).—6, *phaulophanes*, n. sp. (Kewell).

2. MIMODOXA LOXOSPILA, n. sp.

λοξοσπιλος, with oblique spots.

♂, ♀. 12–13 mm. Head white. Palpi blackish; basal two-thirds of second joint whitish. Antennae blackish; ciliations in male minute. Thorax grey-whitish. Abdomen dark fuscous; tuft whitish. Legs whitish; tibiae and tarsi with broad blackish bars; anterior pair grey. Forewings narrow, costa gently arched, apex pointed, termen very oblique; blackish with white markings; a broad greyish-white dorsal streak from base to beyond middle, indented in middle; an oblique streak from costa at one-fourth nearly reaching dorsal streak; a similar streak from midcosta; a costal spot before apex; an elongate spot above tornus nearly reaching dorsal streak; cilia white, on apex blackish, on tornus grey. Hindwings broadly lanceolate; dark grey; cilia over 1, grey.

Queensland: Toowoomba in October; two specimens received from Mr. W. B. Barnard, who has the type.

4. MIMODOXA EMPYROPHANES, n. sp.

ἐμπυροφανης, scorched-looking.

♀. 16–18 mm. Head reddish-brown; face whitish. Palpi reddish-brown-whitish; apical half or more of terminal joint fuscous. Antennae dark fuscous. Thorax dark fuscous. Abdomen grey. Legs fuscous ringed with reddish-brown-whitish; posterior pair mostly whitish. Forewings elongate, narrow, costa slightly arched, apex pointed, termen very oblique; dark fuscous; three costal spots, whitish more or less tinged with reddish-brown, first at one-fifth, second larger on middle, third at four-fifths; sometimes an additional spot on termen above tornus, and this may be confluent with third costal spot; cilia grey, on apex fuscous. Hindwings broadly lanceolate; grey; cilia 1, grey.

Victoria: Birchip in September, October, and May (Goudie); four specimens received from the National Museum, Melbourne, which has the type.

5. MIMODOXA TRICOMMATICA, n. sp.

τρικομματικος, with three commas.

♂. 17 mm. Head and palpi brown-whitish. Antennae fuscous; ciliations in male two-thirds. Thorax brown. Abdomen grey. Legs pale fuscous; posterior pair partly whitish. Forewings elongate, narrow, costa gently arched, apex pointed, termen extremely oblique; dorsal area grey-brown; three large whitish costal spots at one-fifth, two-fifths, and four-fifths, each preceded by a large dark fuscous spot completely occupying interval and giving off an inferior process bent forwards and partly enclosing each whitish spot; an apical fuscous spot; cilia grey. Hindwings lanceolate; grey; cilia 1, grey.

New South Wales: Broken Hill in September; one specimen. Type in South Australian Museum. This was confused by Lower with the very distinct *M. metallica*.

6. MIMODOXA PHAULOPHANES, n. sp.

φαυλοφανης, mean-looking.

♀. 14 mm. Head white. Palpi white; terminal joint except base fuscous. Antennae fuscous. Thorax pale fuscous. (Abdomen missing.) Legs pale fuscous with whitish rings. Forewings elongate, very narrow, costa gently arched, apex pointed, termen extremely oblique; pale fuscous; three suffused whitish costal spots at one-fourth, middle, and before apex; cilia whitish, apices grey. Hindwings lanceolate; pale grey; cilia 1, pale grey.

Allied to the preceding, but with apices of palpi fuscous, and forewings without defined fuscous markings.

Victoria: Kewell in October; one specimen. Type in Coll. Lyell.

2. Gen. MACROBATHRA.

Meyr., PROC. LINN. SOC. N.S.W., 1885, p. 799. Type, *M. chrysotoxa* Meyr.

Labial palpi long or very long; second joint reaching or exceeding base of antennae, slightly or moderately thickened with appressed scales; terminal joint as long as second or somewhat shorter ($\frac{3}{4}$–1), slender, acute. Maxillary palpi short, slender, appressed to tongue. Antennae with basal joint elongate, without pecten; ciliations in male very short or minute. Forewings with 7 and 8 stalked, 7 to costa. Hindwings with 3 and 4 stalked or rarely connate or closely approximated, 5, 6, 7 nearly parallel, discocellulars outwardly oblique from 4 to 5, inwardly oblique from 6 to 7.

The maxillary palpi are better developed than is usual in this family, but are considerably shorter than in *Tetraconta*. The antennal ciliations are usually from ¼ to ½, but may be much shorter. In the hindwings 5 arises from the middle or above middle of cell.

This is a large genus probably of considerable antiquity. Its immediate ancestor is probably *Tetraconta*, and with this genus, *Mimodoxa*, and *Heureta* it forms an isolated group in the Australian fauna. There is a close superficial resemblance to *Limnoecia* in the Cosmopterygidae, and there may be some real relationship. That genus is best distinguished by 6 and 7 of hindwings being approximated closely at base and diverging.

Besides the Australian species there is 1 known from New Ireland, 11 from India, 7 from Africa, and 1 from Madagascar. Meyrick suggests India as the country of origin, and explains the preponderance of the genus in Australia by favourable conditions and the predominance of *Acacia*, on which feed the larvae of most of the species. I think it is much more probable that the genus developed in Austral Land, and from thence has successfully invaded other regions. It is already known to be fairly well represented in Western Australia, which has never had any resident microlepidopterist, and no doubt many more species remain to be discovered there.

Eighty-seven species: 7, *porphyrea* Meyr., P.L.S.N.S.W., 1885, p. 820 (Sydney).—8, *isoscelana* Low., *Tr. R.S.S. Aust.*, 1893, p. 182 (Bunya Mts.; Barrington Tops; Mt. Lofty).—†9, *anemodes* Meyr., P.L.S.N.S.W., 1885, p. 819 (Wirrabara).—10, *phryganina*, n. sp. (Toowoomba).—11, *nephelomorpha* Meyr., *ibid.*, 1885, p. 820 (Dalby, Toowoomba to Hobart).—12, *brontodes* Meyr., *ibid.*, 1885, p. 821 (Rosewood; Toowoomba).—13, *unguinosa*, n. sp. (Toowoomba).—14, *lychnophora*, n. sp. (Bunya Mts.).—15, *syncoma* Low., *ibid.*, 1899, p. 112 (Broken Hill).—16, *astrota* Meyr., Exot. Micro., i, p. 216 (Atherton).—†17. *micropis* Low., *Tr. R.S.S. Aust.*, 1894, p. 102 (Duaringa).—18, *ceraunobola* Meyr., P.L.S.N.S.W., 1885, p. 818 (Bunya Mts. to Hobart).—19, *philopsamma* Low., *Tr. R.S.S. Aust.*, 1900, p. 47 (Adelaide).—20, *diplochrysa* Low., *ibid.*, 1894, p. 105 (Cape York to Brisbane).—21, *puncticulata* Turn., *ibid.*, 1896, p. 32 (Brisbane to Sydney).—22, *euspila*, n. sp. (Sydney).—23, *myriophthalma* Meyr., P.L.S.N.S.W., 1885, p. 822 (Brisbane to Melbourne). = *chrysospila* Turn., *Tr. R.S.S. Aust.*, 1896, p. 33.—24, *chrysospila* Meyr., P.L.S.N.S.W., 1885, p. 822 (Townsville to Sydney). = *chrysobaphes* Turn., *Tr. R.S.S. Aust.*, 1896, p. 32.—†25, *hexadyas* Meyr., P.L.S.N.S.W., 1906, p. 35 (Rosewood).—26, *rubicundella* Wlk., xxix, p. 649 (Brisbane; W.A.: Kimberley). = *rosea* Turn., *Tr. R.S.S. Aust.*, 1896, p. 33.—†27, *hyalistis* Meyr., P.L.S.N.S.W., 1888, p. 1679 (W.A.: York).—28, *drosera* Low., *Tr. R.S.S. Aust.*, 1901, p. 96 (Broken Hill).—29, *centrosphena*, n. sp. (W.A.: Albany).—30, *epimela* Low., *ibid.*, 1894, p. 106 (Duaringa, Brisbane).—31, *hemitropa* Meyr., P.L.S.N.S.W., 1885, p. 817 (Katoomba, Adelaide, Wirrabara).—†32, *gastroleuca* Low., *Tr. R.S.S. Aust.*, 1905, p. 109 (Broken Hill).—33, *synastra* Meyr., P.L.S.N.S.W., 1885, p. 815 (St. Helen's, Tas.; W.A.: York, Geraldton).—34, *xuthocoma* Meyr., *ibid.*, 1885, p. 813 (Sydney, Glen Innes). = *galenaea* Meyr., *Tr. R.S.S. Aust.*, 1902, p. 167.—35, *leucopeda* Meyr., P.L.S.N.S.W., 1885, p. 813 (Darwin, Eidsvold, Brisbane, Sydney).—36, *rhodospila* Meyr., *ibid.*, 1885, p. 814 (Toowoomba, Sydney).—37, *synacta* Meyr., Exot. Micro., ii, p. 364 (Yatala, S.A.).—38, *alternatella* Wlk., xxix, p. 644; Meyr., P.L.S.N.S.W., 1885, p. 812. = *obliquata* Luc., *P.R.S.Q.*, 1901, p. 90 (Gympie to Hobart; W.A.: Perth, York).—†39, *parthenistis* Meyr., P.L.S.N.S.W., 1888, p. 1678 (W.A.: Carnarvon).—†40, *harmostis* Meyr., *ibid.*, 1888, p. 1678 (W.A.: Geraldton).—†41, *homocosma* Meyr., *Tr. R.S.S. Aust.*, 1902, p. 167 (Duaringa).—42, *melanota* Meyr., P.L.S.N.S.W., 1885, p. 809 (Toowoomba, Sea Lake).—43, *baliomitra*, n. sp. (Sydney).—44, *psathyrodes*, n. sp. (Bunya Mts.).—45, *phernaea* Low., *ibid.*, 1899, p. 112 (Broken Hill).—46, *niphadobola* Meyr., *ibid.*, 1885, p. 81 (Herberton, Brisbane, Rosewood, Toowoomba). = *vexillariata* Luc., *P.R.S.Q.*, 1901, p. 90.—47, *bigerella* Wlk., xxix, p. 644 (Brisbane, Toowoomba, Bunya Mts., Pt. Lincoln). = *crymalea* Meyr., P.L.S.N.S.W., 1885, p. 816.—48, *arrectella* Wlk., xxix, p. 643 (Darwin; Cairns to Sydney). = *argonota* Meyr., P.L.S.N.S.W., 1885, p. 811; *decataea* Meyr., Exot. Micro., i, p. 216; *opposita* Meyr., *ibid.*, ii, p. 364.—49, *leucozancla*, n. sp. (Cape York).—50, *tetraleuca*, n. sp. (Charleville).—51, *stenosema*, n. sp. (Darwin).—52, *callispila* Turn., P.L.S.N.S.W., 1916, p. 334 (Darwin, Cape York).—53, *honoratella* Wlk., xxx, p. 1030 (Duaringa to Brisbane). = *chlorosoma* Meyr., P.L.S.N.S.W., 1885, p. 810.—54, *callipetala*, n. sp. (Darwin, Cape York, Cairns).—55, *exaeta* Turn., *ibid.*, 1916, p. 335 (Cairns).—56, *aneurae*, n. sp. (Charleville).—†57, *zonodesma* Low., *ibid.*, 1900, p. 414 (Broken Hill).—†58, *notozyga* Meyr., Exot. Micro., i, p. 217 (Atherton).—†59, *sarcoleuca* Meyr., *ibid.*, i, p. 296 (Duaringa).—60, *polypasta*, n. sp. (Charleville).—61, *chryseostola*, n. sp. (Rockhampton).—62, *endesma* Low., P.L.S.N.S.W., 1900, p. 415 (Duaringa).—63, *trithyra* Meyr., *ibid.*, 1885, p. 808 (Toowoomba, Sydney, Cooma, Mt. Lofty).—64, *platychroa* Low., *Tr. R.S.S. Aust.*, 1897, p. 270 (Brisbane, Katoomba, Gisborne, Castlemaine).—65, *melanargyra* Meyr., P.L.S.N.S.W., 1885, p. 817 (Brisbane, Stanthorpe).—66, *lamprotypa*, n. sp. (Brisbane, Toowoomba, Melbourne).—67, *anacampta* Meyr., Exot. Micro., i, p. 217 (Atherton, Brisbane).—68, *constrictella* Wlk., xxix, p. 467 (Sydney, Beaconsfield, Mt. Lofty; W.A.: Waroona, Bridgetown); Meyr., P.L.S.N.S.W., 1885, p. 818.—69, *pompholyctis* Meyr., *ibid.*, 1888, p. 1677 (W.A.: York, Waroona, Merredin).—†70, *aphristis* Meyr., *ibid.*, 1888, p. 1677 (W.A.: Northampton, Carnarvon).—71, *euryleuca* Meyr., *ibid.*, 1885, p. 808 (Rockhampton to Brisbane).—72, *melanomitra* Meyr., *ibid.*, 1885, p. 807 (Bathurst, Mt. Lofty, Wirrabara, Quorn).—73, *platyzona*, n. sp. (Toowoomba).—74, *xanthoplaca* Meyr., *Tr. R.S.S. Aust.*, 1902, p. 167 (Melbourne, Castlemaine; W.A.: Mullewa).—75, *dispila*, n. sp. (Cape York).—76, *desmotoma* Meyr., P.L.S.N.S.W., 1885, p. 806 (Brisbane to Melbourne).—77, *heminephela* Meyr., *ibid.*, 1885, p. 806 (Dalby to Hobart).—†78, *dasyplaca* Low., *Tr. R.S.S. Aust.*, 1894, p. 103 (Tasmania).—†79, *anemarcha* Meyr., P.L.S.N.S.W., 1885, p. 805 (Launceston).—†80, *asemanta* Low., *Tr. R.S.S. Aust.*, 1894, p. 103 (Tasmania).—81, *mesopora* Meyr., P.L.S.N.S.W., 1885, p. 804 (Yeppoon to Gisborne).—82, *paracentra* Low., *Tr. R.S.S. Aust.*, 1893, p. 182 (Brisbane, Gisborne).—†83, *crococosma* Meyr., Exot. Micro., ii, p. 509 (Cairns).—84, *allocrana* Turn., P.L.S.N.S.W., 1916, p. 1336 (Innisfail).—†85, *heterozona* Meyr., *ibid.*, 1888, p. 1676 (W.A.: Northampton).—86, *trimorpha* Meyr., *ibid.*, 1888, p. 1675 (W.A.: Geraldton, Carnarvon).—87, *euryxantha* Meyr., *ibid.*, 1885, p. 803 (Duaringa).—88, *rhythmodes* Turn., *ibid.*, 1916, p. 335 (Cairns).—89, *monostadia* Meyr., *ibid.*, 1885, p. 803. = *gonoloma* Low., *Tr. R.S.S. Aust.*, 1894, p. 104 (Rockhampton, Duaringa, Rosewood, Toowoomba).—90, *chrysotoxa* Meyr., P.L.S.N.S.W., 1885, p. 804 (Brisbane to Hobart).—†91, *hamaxitodes* Meyr., *ibid.*, 1885, p. 802 (Sydney).—92, *nimbifera*, n. sp. (Macpherson Range).—93, *embroneta*, n. sp. (Brisbane).

62. MACROBATHRA ENDESMA LOW.

Head white; side-tufts and posterior margin dark fuscous. Antennae grey; basal joint expanded towards apex, dark fuscous; ciliations in male minute. Abdomen pale grey. Among allied species this may be distinguished by the small size (10–11 mm.) and wholly white tegulae (not fuscous at base).

53. MACROBATHRA HONORATELLA Wlk.

I identified this with *M. chlorosoma* Meyr. in 1901 by comparison of my own series with Walker's type in the British Museum. In his revision Meyrick identifies it with *M. endesma* Low. This cannot be, if Walker's dimensions are correct—"length of body 3 lines; of the wings 8 lines". This would correspond to about 6 mm. and 17 mm., rather more than the size of the former species, but very much larger than the latter. Walker's description is probably inexact, but the posterior thoracic dark spot is present in the former species, which is a common Brisbane insect, and very likely to have been received from Mr. Diggles.

48. MACROBATHRA ARRECTELLA Wlk.

This is a common Brisbane species and occurs here and elsewhere in two forms. The less common form, in which the sub-basal fascia of forewings is interrupted above middle, has been described as *arrectella* Wlk. and *opposita* Meyr.; the form with the fascia complete as *argonota* Meyr. and *decataea* Meyr.

52. MACROBATHRA CALLISPILA Turn.

The sub-basal fascia of forewings is considerably broader than in *M. honoratella*, the abdomen is more decidedly yellow, and the basal area of the hindwings in the male is suffused with whitish and irrorated with fuscous. It is very similar to *M. exaeta*, but in addition to this last character may be distinguished by the black spot on base of tegulae.

88. MACROBATHRA RHYTHMODES Turn.

This may be distinguished from allied species by its fuscous head, face, and palpi, and the broad yellow band on forewings extending well beyond middle.

82. MACROBATHRA PARACENTRA Low.

This is a true *Macrobathra* very like *M. mesopora*, but without the anterior fascia on forewing.

MACROBATHRA MONOXANTHA Meyr.

Exot. Micro., ii, p. 509.

This, if I have identified it correctly, is a *Limnoecia*.

10. MACROBATHRA PHRYGANINA, n. sp.

φρυγανινος, like a dry stick.

♀. 16 mm. Head and thorax brown. Palpi brown; terminal joint fuscous anteriorly. Antennae fuscous with brownish annulations. Abdomen fuscous. Legs brown; hairs on posterior tibiae pale ochreous. Forewings narrow, costa strongly arched, apex pointed, termen very oblique; basal half dark brown, apical half pale brown, border well defined from two-fifths costa obliquely outwards, sharply angled in disc to end on mid-dorsum, from its apex a short suffused pale longitudinal streak; a whitish spot on one-fifth costa; cilia brown. Hindwings fuscous-brown, towards apex fuscous; cilia fuscous.

Queensland: Toowoomba in December; one specimen received from Mr. W. B. Barnard.

13. MACROBATHRA UNGUINOSA, n. sp.

unguinosus, oily.

♀. 15 mm. Head white. Palpi whitish; terminal joint fuscous anteriorly. Antennae blackish. Thorax dark fuscous. Abdomen grey. Legs fuscous; tibiae and tarsi ringed with whitish. Forewings narrow, costa slightly arched, apex acute, termen extremely oblique; brown-whitish with patchy fuscous irroration; a sharply defined transverse fuscous basal fascia; patches of irroration on costa before and beyond middle, on tornus, termen and apex; cilia brown-whitish, on tornus grey. Hindwings and cilia grey.

Queensland: Toowoomba in October; one specimen received from Mr. W. B. Barnard.

14. MACROBATHRA LYCHNOPHORA, n. sp.

λυχνοφορος, carrying a light.

♂, ♀. 19–21 mm. Head ochreous-whitish sometimes suffused with fuscous-brown. Palpi fuscous; second joint mostly whitish or whitish only at base. Antennae fuscous; in male annulated with whitish, ciliations minute. Thorax fuscous. Abdomen greyish-ochreous. Legs fuscous with ochreous rings. Forewings rather narrow, costa gently arched, apex pointed, termen very oblique; dark fuscous; an oblique whitish fascia from costa near base to one-fourth dorsum, often suffusedly produced along dorsum to tornus, but this fascia is often reduced by fuscous suffusion to a narrow line on its normal anterior edge; usually a whitish dot on midcosta; a round snow-white costal spot at four-fifths; cilia fuscous, on tornus sometimes ochreous. Hindwings broadly lanceolate; grey; cilia three-fourths, grey.

This species is exceptionally variable in the occasional suffusion of the sub-basal fascia, but the shining white apical spot appears to be constant.

Queensland: Bunya Mts. (3,000 ft.) in January; five specimens; New South Wales: Allyn River in December (Goldfinch).

22. MACROBATHRA EUSPILA, n. sp.

εὐσπιλος, prettily spotted.

♂. 12 mm. Head ochreous-whitish. Palpi ochreous-whitish; extreme apex fuscous. Antennae with basal joint dark fuscous (remainder broken off). Thorax dark fuscous. Abdomen dark fuscous; tuft grey-whitish. Legs dark fuscous; posterior tarsi mostly whitish. Forewings with an expansile tuft of long whitish hairs from base beneath; broadly lanceolate; dark fuscous; markings clear pale yellow edged with blackish; a broad sub-basal fascia contracted on costa; a spot on midcosta; another opposite to it on dorsum beyond middle; a minute dot in disc at three-fourths; a subterminal fascia, broad on costa, narrowing abruptly in disc; cilia fuscous. Hindwings lanceolate; grey; cilia over 1, grey.

Very distinct, but nearest *M. myriophthalma* Meyr.

New South Wales: Sydney (Woy Woy) in March; one specimen (Nicholson). Type in Coll. Goldfinch.

29. MACROBATHRA CENTROSPHENA, n. sp.

κεντροσφηνος, with central wedge.

♂, ♀. 16–18 mm. Head and thorax grey. Palpi whitish-grey; basal half of second joint dark fuscous. Antennae dark fuscous; ciliations in male ½. Legs dark fuscous, posterior pair grey; tibiae and tarsi with whitish rings. Forewings elongate, suboblong, costa moderately arched, apex rounded, termen obliquely rounded; grey; markings dark fuscous; a slender transverse sub-basal fascia; a transverse wedge from mid-dorsum moderately broad at base; narrowing to an apex just below one-third costa; a moderate fascia from two-thirds costa to tornus, suffused at extremities; cilia grey, apices grey-whitish. Hindwings and cilia grey.

Western Australia: Albany in February and March; two specimens received from Mr. W. B. Barnard, who has the type.

43. Macrobathra baliomitra, n. sp.

βαλιομιτρος, with spotted girdle.

♀. 11 mm. Head grey-whitish; back of crown and side-tufts dark fuscous. Palpi white; apex of second joint, and terminal joint except base, fuscous. Antennae fuscous. Thorax fuscous; tegulae except base white. Abdomen grey; median dorsal area pale ochreous-brown; tuft and underside grey-whitish. Legs fuscous; tibiae and tarsi with white rings; posterior tibiae mostly white. Forewings narrow, not dilated, costa gently arched, apex pointed, termen very oblique; dark fuscous; markings white; a broad oblique fascia near base sparsely irrorated with fuscous throughout, posterior edge from one-fourth costa to near mid-dorsum; a small spot on midcosta; a spot on dorsum before tornus, irrorated with fuscous; a spot on costa before apex; cilia fuscous. Hindwings lanceolate; grey; cilia 1, grey.

The two costal spots are clear white. The irroration of the fascia and dorsal spot is a peculiar character.

New South Wales: Sydney in April; one specimen. Type in Coll. Lyell.

44. Macrobathra psathyrodes, n. sp.

ψαθυρωδης, delicate.

♀. 12 mm. Head grey-whitish; side-tufts and posterior edge fuscous. Palpi whitish; terminal joint ¾, outer surface fuscous. Antennae dark fuscous sharply annulated with white. Thorax white; anterior edge fuscous. Abdomen pale grey. Legs fuscous with whitish rings. Forewings elongate, narrow, costa slightly arched, apex obtusely pointed, termen extremely oblique; dark fuscous with white markings; a rather narrow oblique fascia from one-fifth costa to one-third dorsum; a small spot on midcosta and another smaller above middorsum; a larger spot on three-fourths costa, opposite to it a smaller spot on tornus; cilia dark fuscous, towards tornus grey. Hindwings lanceolate, pale grey; towards base thinly scaled and translucent; cilia 1½, pale grey.

Distinguished by its small size, absence of posterior spot on thorax, annulated antennae, narrow forewings, with anterior dorsal spot not touching margin.

Queensland: Bunya Mts. (3,500 ft.) in October; one specimen.

49. Macrobathra leucozancla, n. sp.

λευκοζαγκλος, with white sickles.

♂. 17–18 mm. Head ochreous-whitish. Palpi whitish; terminal joint sometimes slightly irrorated with grey. Antennae grey-whitish, including basal joint; ciliations in male minute. Thorax whitish; a narrow line on anterior edge and a posterior spot blackish. Abdomen grey; base of dorsum ochreous-tinged. Legs fuscous with ochreous-whitish rings; anterior tibiae and tarsi whitish. Forewings with costa slightly arched, apex pointed, termen very oblique; blackish with whitish markings; a small spot on one-fifth costa and a larger and broader spot on one-third dorsum opposite; a spot on midcosta, another larger on dorsum before tornus, and a large costal subapical spot; cilia blackish, on tornus grey.

Distinct by the whitish head, palpi and forelegs. The allied *M. arrectella* has the posterior margin of head, basal joint of antennae, and a broad anterior spot on thorax blackish.

North Queensland: Cape York in April; two specimens received from Mr. W. B. Barnard.

50. MACROBATHRA TETRALEUCA, n. sp.

τετραλευκος, four times white.

♂. 16–17 mm. Head white; side-tufts and posterior edge blackish. Palpi white; apex of terminal joint fuscous. Antennae blackish with whitish annulations; ciliations in male minute. Thorax white; anterior edge and a posterior spot blackish. Abdomen grey. Legs fuscous with whitish rings. Forewings with costa gently arched, apex obtusely pointed, termen very oblique; blackish with white markings; a moderate fascia from one-fifth costa to one-fourth dorsum, constricted on costa; a rounded spot on midcosta, and another larger on costa at four-fifths; a large triangular spot on dorsum before tornus; a minute tornal dot; cilia fuscous-grey, on dorsal spot whitish. Hindwings broadly lanceolate; grey; cilia 1, grey.

Similar to *M. honoratella*, but the markings are white without ochreous tinge, the antennae annulated with whitish almost to apex, the median costal spot of forewings larger, and the abdomen grey.

Queensland: Charleville in September; two specimens.

51. MACROBATHRA STENOSEMA, n. sp.

στενοσημος, with narrow markings.

♀. 15–16 mm. Head white; side-tufts and posterior margin dark fuscous. Palpi whitish; second joint with some fuscous suffusion towards apex; terminal joint almost as long as second, sides fuscous. Antennae whitish, towards base annulated with dark fuscous; basal joint expanded at apex, dark fuscous. Thorax white; anterior edge dark fuscous. Abdomen pale ochreous suffused with grey towards apex. Legs fuscous with whitish rings. Forewings rather narrow, costa gently arched, apex pointed, termen oblique; dark fuscous with white markings; a uniformly narrow fascia from one-fourth costa to one-third dorsum; a triangular spot on midcosta, and another on dorsum before tornus; a larger spot on four-fifths costa; cilia dark fuscous, on dorsal spot whitish. Hindwings broadly lanceolate; grey; cilia 1, grey.

This may be distinguished by its antennae from both *M. honoratella* and *M. arrectella*. The sub-basal fascia is less oblique, narrower than in the former, and not constricted on costa.

Northern Territory: Darwin; two specimens received from Mr. G. F. Hill.

54. MACROBATHRA CALLIPETALA, n. sp.

καλλιπεταλος, prettily winged.

♂, ♀. 13–15 mm. Head pale ochreous. Palpi pale ochreous; terminal joint as long as second, towards apex fuscous. Antennae dark fuscous with 3 or 4 white rings in middle; ciliations in male minute. Thorax dark fuscous. Abdomen dark fuscous; tuft in male pale ochreous. Legs fuscous with whitish rings. Forewings rather narrow, costa gently arched, apex pointed, termen very oblique; dark fuscous; markings pale ochreous edged with blackish; a moderate sub-basal fascia from one-fifth costa to one-fourth dorsum; a spot on midcosta, and another on dorsum at two-thirds; a larger spot on costa before apex; cilia dark fuscous. Hindwings broadly lanceolate; grey; cilia 1, grey.

The midcostal and dorsal spot are usually well separated, but sometimes connected by a blackish spot. In one example they are completely fused, forming a second fascia. In the natural position the median white rings of the antennae lie over the sub-basal fascia. The wholly fuscous thorax and uniformly yellow markings are distinctive characters.

North Australia: Darwin. North Queensland: Cape York, in April and June; Cairns, in August. Six specimens.

56. MACROBATHRA ANEURAE, n. sp.

♂, ♀. 15–18 mm. Head white, sometimes with pale fuscous suffusion or irroration; face white. Palpi white; apex of second joint and anterior edge of terminal joint sometimes fuscous. Antennae fuscous with a few whitish annulations towards base; ciliations in male ½. Abdomen whitish-grey. Legs fuscous with whitish rings. Forewings rather narrow, costa gently arched, apex rather obtusely pointed, termen very oblique; pale fuscous; markings white; a moderate slightly oblique sub-basal fascia, sometimes partly suffused with pale ochreous externally and towards dorsum; a small triangular spot on midcosta and another on dorsum before tornus, both sometimes partly suffused; a larger triangular spot on costa before apex; cilia grey, bases paler and irrorated with pale fuscous. Hindwings broadly lanceolate; grey; cilia 1, grey.

The pale fuscous colour of this species is distinctive.

Queensland: Charleville in September; locally abundant among *Acacia aneura*; twelve specimens.

60. MACROBATHRA POLYPASTA, n. sp.

πολυπαστος, much sprinkled.

♂, ♀. 18 mm. Head whitish; crown sometimes pale brown. Palpi whitish; terminal joint and apex of second joint fuscous. Antennae dark fuscous annulated with whitish; ciliations in male minute. Thorax pale brown or fuscous; margins and a transverse postmedian line sometimes narrowly white. Abdomen whitish-grey. Legs fuscous with whitish rings; posterior pair mostly whitish. Forewings narrow, costa gently arched, apex rather obtusely pointed, termen very oblique; fuscous-brown; two broad transverse fasciae, white finely irrorated with fuscous-brown; first sub-basal, edged anteriorly with fuscous, extending to one-third; second median, anteriorly irregularly indented in middle; a triangular white subapical costal spot, giving off a fine white strongly sinuate line to termen above tornus; cilia fuscous-brown, on tornus grey. Hindwings broadly lanceolate; grey; cilia 1, grey, more or less ochreous-tinged.

Not near any other species.

Queensland: Charleville in September; two specimens.

61. MACROBATHRA CHRYSEOSTOLA, n. sp.

χρυσεοστολος, in golden clothing.

♂, ♀. 18 mm. Head white; side-tufts ochreous-brown. (Palpi broken off.) Antennae dark fuscous with white annulations. Thorax white; anterior margin and a posterior spot ochreous-brown. Abdomen ochreous. Legs fuscous tinged with ochreous-brown; tibiae and tarsi with whitish rings. Forewings narrow, elongate, not dilated, costa nearly straight, apex round-pointed, termen very oblique; ochreous-brown with some patchy fuscous irroration; markings white;

a very slender basal fascia prolonged slightly on dorsum; a broad fascia, its anterior edge straight, sub-basal, slightly oblique, posterior edge from one-fourth costa to one-third dorsum, wavy, outwardly curved; a small spot on midcosta; a minute median subdorsal dot; a large spot on three-fourths costa almost or quite continuous with a similar spot on two-thirds dorsum; a more or less developed spot before upper part of termen; cilia ochreous, apices paler, a median line, an apical bar, and a supratornal spot fuscous. Hindwings lanceolate; cilia over 1, ochreous, on tornus and dorsum grey.

Queensland: Rockhampton in July; two specimens received from Mr. G. M. Goldfinch, who has the type.

66. Macrobathra lamprotypa, n. sp.

λαμπροτυπος, brilliantly marked.

♂, ♀. 14–18 mm. Head reddish-brown; face whitish. Palpi whitish-brown; terminal joint about as long as second, fuscous except at base. Antennae blackish annulated with silvery-grey; ciliations in male ½. Thorax dark fuscous. Abdomen fuscous; tuft ochreous-whitish. Legs dark fuscous with ochreous-whitish rings. Forewings with costa gently arched, apex pointed, termen oblique; blackish; a dark leaden-metallic basal fascia; a rather narrow oblique fascia from one-fifth costa to one-third dorsum, silvery-white becoming silvery-grey on dorsum; a silvery-white spot on midcosta; a silvery-violet bar from two-thirds dorsum, more or less constricted in middle, slightly outwardly oblique to beyond midcostal spot; a curved fascia from four-fifths costa to tornus, constricted in middle, white suffused more or less with rosy-violet, in middle silvery-metallic; cilia fuscous. Hindwings broadly lanceolate; grey; cilia 1, grey.

Queensland: Brisbane in August and September; Toowoomba in October. Victoria: Melbourne. Five specimens. I have reared one example from a larva feeding on *Acacia penninervis.*

73. Macrobathra platyzona, n. sp.

πλατυζωνος, broadly girt.

♀. 20 mm. Head white. Palpi white; terminal joint black. Antennae black. Thorax black. Abdomen pale ochreous. Legs blackish; tibiae and tarsi ringed with whitish-ochreous. Forewings narrow, costa moderately arched, apex pointed, termen very obliquely rounded; black with white markings; a broad suboval transverse sub-basal fascia; a broad streak from two-thirds costa obliquely inwards, ending abruptly above middle of disc; a tornal spot; a dot above mid-dorsum and another at apex; cilia blackish, on apical spot white, on tornus pale ochreous. Hindwing fuscous; cilia grey, towards tornus ochreous-tinged.

A fine and distinct species.

Queensland: Toowoomba in October; one specimen received from Mr. W. B. Barnard, who has the type.

75. Macrobathra dispila, n. sp.

διςπιλος, two-spotted.

♂. 15–16 mm. Head whitish-ochreous; side-tufts and posterior margin dark fuscous. Palpi pale ochreous with slight fuscous irroration; terminal joint four-fifths, fuscous except towards base. Antennae dark fuscous; ciliations in male minute. Thorax dark fuscous. Abdomen pale ochreous; sides fuscous; tuft grey. Legs dark fuscous with ochreous rings. Forewings with costa moderately arched, apex pointed, termen very oblique; dark fuscous; a large oval oblique white spot from costa at one-fifth to near dorsum at one-fourth; a subtriangular white spot on costa at four-fifths; cilia dark fuscous. Hindwings broadly lanceolate; grey; cilia 1, grey.

North Queensland: Cape York in April, May and June; four specimens received from Mr. W. B. Barnard, who has the type.

92. MACROBATHRA NIMBIFERA, n. sp.

nimbiferus, clouded.

♀. 20 mm. Head white. Palpi white; terminal joint pale fuscous anteriorly. Antennae brownish, towards base dark fuscous. Thorax fuscous; tegulae and a transverse postmedian bar grey-whitish. Abdomen pale grey. Legs fuscous; tibiae and tarsi ringed with grey-whitish; posterior tibiae mostly ochreous-whitish. Forewings not narrow, costa moderately arched, apex pointed, termen very oblique; whitish; an oblique fuscous basal fascia, sharply defined, its anterior edge from near base of costa to one-fourth dorsum; a grey spot on costa at two-thirds; a median grey spot on fold suffusedly connected with dorsum and basal fascia; apical third of wing suffused with grey, except a triangular spot on costa before apex, and a dot on termen below middle, which are white; cilia grey. Hindwings broadly lanceolate; grey; cilia 1, whitish-grey.

Queensland: National Park (3,000 ft.) in December; one specimen.

93. MACROBATHRA EMBRONETA, n. sp.

ἐμβοvητος, thunderstruck.

♂. 17 mm. Head white, centre of crown grey. Palpi white irrorated with dark fuscous. Antennae dark fuscous; ciliations in male 1/5. Thorax grey. Abdomen whitish-grey; tuft ochreous-whitish. Legs dark fuscous; tibiae and tarsi with white rings. Forewings lanceolate, obtuse; fuscous, towards dorsum grey; a blackish streak from base of costa to tornus, giving off a branch in mid-disc towards but not reaching apex; cilia grey, on costa and apex fuscous with white bars. Hindwings broadly lanceolate; grey; cilia 1, grey.

Queensland: Brisbane in December; one specimen.

3. Gen. HEURETA, n.g.

εὑρετος, discovered.

Tongue present. Palpi with second joint reaching base of antennae, thickened with appressed scales, somewhat rough anteriorly; terminal joint ¾, slender, acute. Antennae without basal pecten; ciliations in male moderately long (2). Forewings with 7 to costa. Hindwings ovate-lanceolate; 3 and 4 widely separate, nearly parallel, 5 from above middle of cell, discocellular between 6 and 7 inwardly oblique.

Differs from *Macrobathra* in the neuration of the hindwings. Only the type species is known: 94, *cirrhodora* Meyr., Exot. Micro., i, p. 296 (Birchip).

4. Gen. TETRACONTA, n.g.

τετρακοντος, with four darts (palpi).

Tongue present. Maxillary palpi long (about ½ length of face), apparently two-jointed (probably really three-jointed), drooping; second joint slightly dilated and loose-scaled; terminal joint minute. Labial palpi long, slender; second joint exceeding base of antennae; terminal joint not much shorter than second. Antennae without basal pecten; basal joint long and dilated towards apex;

ciliations in male minute. Forewings with 7 to costa. Hindwings with 3 and 4 separate, 5 from middle of cell, 6 and 7 separate, parallel.

The solitary species has all the appearance of a *Macrobathra*, but with important structural differences. The large maxillary palpi are very unusual in the family.

95. TETRACONTA CLEPSIMORPHA, n. sp.

κλεψιμορφος, of misleading appearance.

♂, ♀. 11–14 mm. Head white anteriorly, black posteriorly and laterally; face and maxillary palpi white. Labial palpi white with some fuscous irroration; terminal joint except apex fuscous. Antennae fuscous. Thorax white. Abdomen blackish; tuft and underside whitish. Legs blackish; tibiae and tarsi with whitish rings. Forewings narrow, costa gently arched, apex pointed, termen very oblique; black with white markings; a moderately broad oblique fascia from one-fifth costa to one-third dorsum; a spot on midcosta, another on costa before apex, and a third on tornus, varying in size; sometimes a spot on dorsum opposite median costal spot, which then appears to form an interrupted fascia; cilia black, on tornus grey. Hindwings broadly lanceolate; grey; cilia over 1, grey.

Queensland: Toowoomba in October; ten specimens received from Mr. W. B. Barnard, who has the type.

†5. Gen. MORPHOTICA Meyr.

Exot. Micro., i, p. 297.

Tongue present. Palpi very long; second joint exceeding base of antennae, thickened with appressed scales; terminal joint longer than second, very slender, acute. Antennae with basal joint long, without pecten; in male moderately ciliated. Forewings with 7 to costa. Hindwings ovate-lanceolate; an elongate hyaline patch beneath cell, 2, 3, and 4 somewhat approximated towards base.

I have not seen this genus, of which only the type species is known. It appears to be near *Heureta*, but with longer palpi, and some differences in the hindwings.

†96, *mirifica* Meyr., *Exot. Micro.*, i, p. 297 (Darwin).

†6. Gen. METAPHRASTIS Meyr.

PROC. LINN. SOC. N.S.W., 1907, p. 134.

Tongue present. Palpi with second joint reaching base of antennae, scales appressed; terminal joint as long as second, slender, acute. Antennae with stalk somewhat rough-scaled on dorsum towards base, without pecten; ciliations in male moderately long. Forewings with 2 from angle, 7 and 8 coincident. Hindwings elongate-ovate; 3 and 4 coincident, 5, 6, 7 parallel.

Also represented only by a single species, which is unknown to me. Meyrick regards it as a derivative of the Palaearctic genus *Dasycera*.

†97, *acrochalcha* Meyr., P.L.S.N.S.W., 1907, p. 134 (W.A.: Albany, York).

7. Gen. SATRAPIA Meyr.

PROC. LINN. SOC. N.S.W., 1885, p. 823.

Tongue present. Palpi smooth; second joint not reaching base of antennae; terminal joint shorter than second, acute. Antennae with basal pecten; ciliations in male long. Forewings with 7 to costa. Hindwings lanceolate; 3 and 4 connate, 5 from above middle of cell, nearer 6 than 4, 6 and 7 separate, diverging. Only the type species is known.

98, *thesaurina* Meyr., P.L.S.N.S.W., 1885, p. 823 (Sydney, Melbourne, Adelaide.)

8. Gen. OCHLOGENES Meyr.

PROC. LINN. SOC. N.S.W., 1885, p. 797. Type, *O. advectella* Wlk.

Head with smoothly appressed scales. Palpi smooth; second joint not reaching base of antennae; terminal joint shorter than second. Antennae without pecten; ciliations in male short. Forewings narrow; 7 to costa. Hindwings under 1, ovate-lanceolate; 3 and 4 connate, 5 from lower angle of cell.

Two species: 99, *advectella* Wlk., xxix, p. 647 (Duaringa to Launceston; W.A.: Albany).—100, *cirrhostola*, n. sp. (Macpherson Range).

100. OCHLOGENES CIRRHOSTOLA, n. sp.

κιρροστολος, clothed in pale yellow.

♂. 10 mm. Head whitish-ochreous. Palpi whitish-ochreous; base of second joint externally, and extreme apex of terminal joint fuscous. Antennae whitish-ochreous annulated with fuscous; ciliations in male ½. Thorax whitish-ochreous with some fuscous scales anteriorly. Abdomen pale grey; tuft whitish-ochreous. Legs fuscous; middle and posterior tarsi with whitish-ochreous rings; posterior pair except tarsi whitish-ochreous. Forewings narrow, suboblong, costa gently arched, apex rounded, termen obliquely rounded; whitish-ochreous irrorated with fuscous, very sparsely in disc, more densely towards margins; stigmata blackish, rather elongate, first discal just before middle, plical well before it, second discal at two-thirds; cilia whitish-ochreous with median and terminal lines of fuscous irroration. Hindwings narrowly elongate-ovate; whitish-grey; cilia whitish-grey.

Queensland: National Park (2,500 ft.) in open forest in November; one specimen.

9. Gen. MIXODETIS Meyr.

Trans. Roy. Soc. S. Aust., 1902, p. 172. Type, *M. ochrocoma* Low.

Palpi rather short and stout, curved, ascending; second joint not nearly reaching base of antennae, slightly rough anteriorly, with a slight anterior angular projection at apex; terminal joint shorter than second, stout, slightly rough anteriorly. Antennae with basal pecten; in male shortly ciliated. Forewings narrow, 7 to termen. Hindwings lanceolate, cilia over 2; 2 to 7 nearly parallel.

Three species: 101, *ochrocoma* Low., P.L.S.N.S.W., 1899, p. 100 (Broken Hill).—102, *calyptra* Low., *ibid.*, 1899, p. 100 (Broken Hill).—103, *lasiomela* Low., *ibid.*, 1899, p. 101 (Broken Hill).

10. Gen. PERIALLACTIS Meyr.

Tr. R.S.S. Aust., 1902, p. 172. Type, *P. monostropha* Low.

Palpi moderately long, slender, recurved; second joint not reaching or just reaching base of antennae, smooth, but sometimes loose-scaled towards apex (*monostropha*); terminal joint shorter than second. Antennae with basal pecten; ciliations in male moderately long. Forewings lanceolate; 7 to termen. Hindwings ovate-lanceolate or lanceolate; 3 and 4 widely separate (*panarga*, *homopasta*) or separate but somewhat approximated (*monostropha*, *aclina*), 5 approximated at base to 4, or even connate (*panarga*).

A natural genus, which although small shows some range of variation. The termination of 7 of forewings below apex makes it difficult to believe that this and the preceding genus are rightly placed here.

Four species: 104, *monostropha* Low., *Tr. R.S.S. Aust.*, 1897, p. 57 (Gisborne); Meyr., *ibid.*, 1902, p. 173.—105, *panarga*, n. sp. (Toowoomba).—106, *homopasta*, n. sp. (Toowoomba).—107, *aclina*, n. sp. (Gisborne).

105. Periallactis panarga, n. sp.

παναργος, wholly white.

♂. 13 mm. Head and thorax whitish (rubbed). Palpi whitish; second joint scarcely reaching base of antennae, outer surface grey; terminal joint 2/3. Antennae white, becoming grey towards apex; ciliations in male 2½. Abdomen pale grey. Legs: anterior pair fuscous; middle pair grey; posterior pair whitish. Forewings lanceolate; white; cilia white. Hindwings lanceolate; whitish; cilia 1½, whitish.

Queensland: Crow's Nest, near Toowoomba, in November; one specimen.

106. Periallactis homopasta, n. sp.

ὁμοπαστος, uniformly sprinkled.

♂. 12 mm. Head whitish. Palpi whitish; second joint not reaching base of antennae, grey on external surface; terminal joint ½. Antennae whitish, towards apex pale grey; ciliations in male 3. Thorax whitish irrorated with fuscous. Abdomen pale grey. Legs: anterior pair fuscous; middle pair grey; posterior pair whitish. Forewings lanceolate; white rather densely and evenly irrorated with fuscous; cilia white irrorated with fuscous, apices grey. Hindwings lanceolate; grey; cilia 1½, grey.

Queensland: Crow's Nest, near Toowoomba, in September; one specimen.

107. Periallactis aclina, n. sp.

ἀκλειvος, inglorious.

♀. 14 mm. Head and thorax fuscous-brown. Palpi with second joint not reaching base of antennae, terminal joint 2/3; brownish, apex of second joint and terminal joint except apex fuscous. Antennae pale brownish. Abdomen brownish. Legs fuscous-brown; posterior pair whitish-brown. Forewings lanceolate; pale brown with a few marginal blackish scales, more numerous towards apex; stigmata blackish, first discal at one-fourth, plical well beyond it, second discal at two-thirds; cilia pale brown. Hindwings broadly lanceolate; whitish; cilia 1, whitish.

Victoria: Gisborne in March; one specimen received from Mr. Geo. Lyell, who has the type.

11. Gen. Paratheta Meyr.

Trans. Roy. Soc. S. Aust., 1902, p. 173. Type, *P. syrtica* Meyr.

Palpi rather short, slender, curved, ascending; second joint not nearly reaching base of antennae, smooth-scaled; terminal joint shorter than second. Antennae with basal pecten; in male shortly ciliated. Forewings narrow; 7 to costa. Hindwings ovate-lanceolate; 3, 4, 5 separate, nearly parallel.

Meyrick has recorded also one species from North America.

Two species: 108, *euspila*, n. sp. (Sydney).—109, *syrtica* Meyr., *Tr. R.S.S. Aust.*, 1902, p. 174 (Brisbane to Hobart).

108. Paratheta euspila, n. sp.

εὐσπιλος, well spotted.

♂. 14 mm. Head white. Palpi with second joint not reaching base of antennae, terminal joint ¾; white mixed with blackish. Antennae white with fine blackish annulations; ciliations in male nearly 1. Thorax and abdomen whitish-grey. Legs fuscous; posterior pair whitish. Forewings narrow, costa moderately arched, apex pointed, termen very obliquely rounded; white, margins rather densely and broadly irrorated with grey; stigmata blackish; first discal at one-third, large transversely, and confluent with plical, which lies slightly before it; two dots placed transversely in middle, one subcostal, one median, and a median dot at two-thirds, sometimes lengthened obliquely; cilia grey. Hindwings ovate lanceolate; whitish, at apex greyish-tinged; cilia 1, whitish.

New South Wales: Sydney in September; one specimen received from Mr. G. M. Goldfinch, who has the type.

12. Gen. Oenochrodes Low.

Trans. Roy. Soc. S. Aust., 1907, p. 115.

Palpi moderately long, recurved, ascending; second joint reaching base of antennae, thickened with appressed scales, rough in apical half anteriorly; terminal joint shorter than second, slender. Antennae with basal pecten; in male shortly ciliated. Thorax with a posterior crest. Forewings with 7 to costa. Hindwings elongate-ovate; 3 and 4 widely separate, 5 from below middle of cell.

Allied to *Artiastis*. There is only one known species: 110, *crossoxantha* Low., *Trans. Roy. Soc. S. Aust.*, 1907, p. 115 (Sea Lake, Hoyleton, Pinnaroo).

13. Gen. Artiastis Meyr.

Proc. Linn. Soc. N.S.W., 1888, p. 1674. Type, *A. tepida* Meyr.

Palpi moderately long, recurved, ascending; second joint reaching base of antennae, with appressed scales; terminal joint shorter than second, slender. Antennae with basal pecten; ciliations in male long. Forewings with 7 to costa. Hindwings ovate-lanceolate; 3 and 4 widely separate, 5 from middle at cell.

Four species: †112, *heliacma* Meyr., P.L.S.N.S.W., 1888, p. 1674 (Bathurst; Petersburg, S. Aust).—113, *tepida* Meyr., *ibid.*, 1888, p. 1674. = *leptomera* Low., *ibid.*, 1900, p. 412 (Brisbane to Melbourne).—114, *ptochopa* Meyr., *ibid.*, 1888, p. 1675 (Toowoomba to Tasmania).—115, *philoscia* Meyr., *Tr. R.S.S. Aust.*, 1902, p. 174 (Brisbane to Gisborne and Quorn).

14. Gen. Palimmeces Turn.

Proc. Linn. Soc. N.S.W., 1916, p. 338.

Palpi long, curved, ascending; second joint very long, much exceeding base of antennae, anteriorly with long loose hair forming an apical tuft; terminal joint ½. Antennae with basal pecten; in male shortly ciliated. Forewings with 7 to costa. Hindwings elongate-ovate; 3, 4, 5 closely approximated at origin.

Probably allied to *Artiastis*. There is only one species: 111, *ithysticha* Turn., P.L.S.N.S.W., 1916, p. 339 (Toowoomba, Glen Innes).

15. Gen. Endrosis Hb.

Verz., p. 401.

Palpi rather long, curved, ascending; second joint reaching base of antennae, smooth; terminal joint shorter than second. Antennae with basal pecten; ciliations in male moderately long. Forewings narrow; 7 to costa. Hindwings lanceolate, cilia 1½; a small dorsal hyaline area near base; 3 and 4 stalked, 5 absent.

The type species is found in or near houses throughout the world, and has been artificially introduced. There is a second species in South Africa.

116, *lactella* Schif., *Syst. Verz. Schmet. Wien*, p. 139; Meyr., P.L.S.N.S.W., 1897, p. 426 (probably throughout Australia).

16. Gen. SCOTODRYAS, n.g.

σκοτοδρυας, a dusky woodnymph.

Tongue present. Palpi moderately long; second joint with appressed scales, but somewhat rough anteriorly, reaching base of antennae; terminal joint about 2/3, rather thick, acute. Antennae without basal pecten; ciliations in male rather long. Thorax smooth. Posterior tibiae with long hairs on dorsum. Forewings with 2 from near angle, 7 to costa. Hindwings with 3 and 4 connate, 5 from above middle, arising from much nearer 6 than 4 (¾), 6 and 7 well separate at origin, at first parallel, then diverging.

The affinities of this genus are uncertain. In spite of the neuration of the hindwings I see no relationship to the Hyponomeutidae.

117. SCOTODRYAS HOLOCAUSTA, n. sp.

ὁλοκαυστος, wholly scorched.

♂, ♀. 16–18 mm. Head, thorax, and palpi reddish-brown. Antennae grey; ciliations in male 2½. Abdomen grey; apices of segments whitish. Legs reddish-brown; posterior pair paler. Forewings suboblong, not dilated, costa moderately arched, apex rounded, termen obliquely rounded; reddish-brown; a hemispherical dorsal blotch from ¼ to ¾, reaching middle of disc, darker brown, slenderly outlined by a whitish line which is sometimes broken in middle; cilia reddish-brown. Hindwings whitish, more or less suffused with grey except at base; cilia grey, on dorsum and tornus whitish.

Queensland: Mt. Tambourine in November; National Park (3,000–3,500 ft.) in December. Victoria: Melbourne; Beaconsfield in December. Seven specimens.

(To be continued.)

NOTES ON EROSIONAL PROCESSES AND STREAM GRAVELS.

By Frank A. Craft, B.Sc., Linnean Macleay Fellow of the Society in Geography.

(One Text-figure.)

[Read 31st August, 1932.]

Introduction.

It was found impracticable to include the material of these sections within the compass of regional papers, so they have been grouped for convenience under a common heading. The four parts may be stated briefly as follows:

i. *Land Forms in Granite Areas.*—A stream system working down on to granite will induce mature land forms therein while surrounding rocks remain at higher levels, and an increase in relief following the revival of streams flowing over a granite peneplain will result in an increased rate and depth of weathering.

ii. *Differential Erosion in Horizontal Rocks.*—The rules governing the widening of valleys in the horizontal rocks of the Blue Mountain plateau are examined, and the conclusion reached that the existing broad valleys were cut when their lowest points were not far above sea-level.

iii. *The Material carried by certain Highland Streams.*—The conditions for shaping ellipsoidal and flattened stream gravels are determined in terms of the power and behaviour of transporting streams, and it is suggested that there are limiting conditions for the attainment of maximum pebble size in any stream.

iv. *Surface Deposits and past Climates in the Shoalhaven Valley.*—Tertiary drifts in this area accumulated under conditions of mild storminess or of uniform rain, and recent gravel deposits in the valleys were due to erosion of a landscape which was inadequately protected by vegetation at the time of the most recent Kosciusko glaciation.

i. *Land Forms in Granite Areas.*

The topography of granite areas has received some attention from Australian physiographers: thus Marks (1912) described parts of the Burdekin valley in which granites take on lower and more rounded forms than the neighbouring rocks, but Browne (1928) stated that—(although) "we often see granite making the uplands, with rocks of inferior resistance forming the valleys and lowlands, occasionally the reverse is found, granite being at the lower level". He concluded that the phenomena were "independent of the age or the relative inherent resistances of the rocks concerned to mechanical erosion", that the topography in which granite forms the uplands may be regarded as normal, while its presence as lowlands may be due to cleavage, original position and extent, or to the effects of "antecedent deep weathering". Sussmilch (1931) inclined to the opinion that the Bathurst granite is a strong formation, while Andrews (1904) noted that the siliceous granites of New England form the majority of the highest points in that region.

Thus there has been a tendency to stress the effect of rock type and structure on topography in such cases, but it also appears that the presence and development of streams have had a considerable effect on the final surface in granite areas, of which the uniform Braidwood-Araluen mass may be used as an example. In general, its weathered surface forms part of an undulating plain between 2,100 and 2,400 feet above sea-level, but residuals and terraces in the Shoalhaven Valley to the south-west of Braidwood rise to 3,000 feet, and elsewhere the wide, flat-bottomed valley of Araluen Creek has been eroded to less than 500 feet above sea-level. East of Braidwood a narrow belt of granite crosses the Mongarlowe-Shoalhaven dividing ridge at 2,900 feet and comes to the general level of that feature, although a few miles to the north weak and fissile Ordovician slates rise above the deeply weathered granite plains, the control in that instance being chemical weathering. These facts suggest that a well developed stream system finds granite to be no great obstacle to its downcutting, and it may develop wide valleys or plains while neighbouring sediments of inferior mechanical resistance are left at higher levels. Marks's examples in the Burdekin valley, the granite peneplain in the Tuross-Umaralla area to the east of Cooma, and the middle valleys of Cox's River are all low-lying parts occupied by numerous streams which originated, in general, on sedimentary or metamorphic rocks above the original level of the granites themselves. On the other hand, the higher ridges to the west of the Murrumbidgee River between Cooma and the Cotter junction (Browne, 1928) and those of north-eastern New England (Andrews, 1904) appear to be long-established divides, and the streams have avoided them in favour of consequent slopes or special lines of weakness, leaving the granite ridges virtually free from some of the most destructive forces of chemical weathering, and thus liable only to a slow reduction. Very rapid erosion of neighbouring rocks in the first place is the essential condition for this action, and the small area of granite surviving as peaks in most districts shows that, as a rule, Browne's conclusion as to their normal behaviour is scarcely established.

The Bathurst district provides an interesting series of problems. It is a hollow between higher tablelands to the east and west, and has been described as a senkungsfeld (or downfaulted block) by Andrews (1910) and by Sussmilch (1931). It is likely that a downwarp formed the original eastern margin of the hollow, but Sussmilch notes that the edge of the senkungsfeld coincides approximately with the edge of the granite comprising it (p. 82), a fact that seems to bear a definite relationship to the course of the Macquarie River along the greatest elongation of the mass. Craft (1928, p. 224) noted the widening of the tributary valley of Solitary Creek when it passes on to the Bathurst granite, and Browne (1928) shows a distinct rise in the same locality as the granites of the valley floor give place to the sedimentary rocks of the uplands. Thus the Bathurst "senkungsfeld" may be of erosional and not of tectonic origin, and its lowering was probably due to a well developed stream system giving conditions favourable for greater weathering and erosion in the granites than in the enclosing sedimentary and metamorphic rocks, as in the similar case of Araluen Valley. The hill scarps marking the passage from higher to lower land resemble many of the residual ridges in the Goulburn and Marulan districts, such as Mts. Towrang and Vessey, which lie on the edges of other granitic intrusions, and the appearance of the Bathurst features when viewed from below is reminiscent of ridge lines in the Shoalhaven Valley of the Braidwood district, which are not due to faulting. It is unwise to call the Bathurst slopes "fault scarps" on appearances which are typical of unfaulted areas.

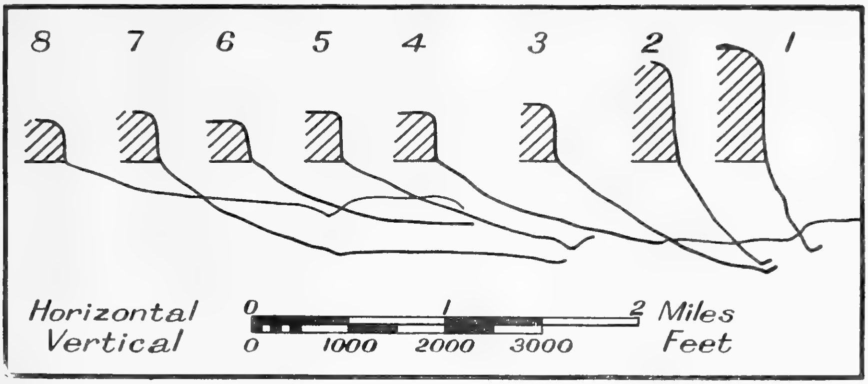
The question of surface weathering is also important: W. R. Browne believes that weathering of granites on a peneplain surface may proceed to such an extent and to such a depth that stream revival will result in the rapid erosion of wide, mature-looking valleys—an idea whose application to Bathurst finds no favour with Sussmilch. The present writer believes that maximum weathering often occurs under conditions of some relief; thus the granite plains near Tallong show tors and rocky slopes, while the mature country near Braidwood and about the head of Tuross River has similar outcrops on the ridges and slopes, although alluviated valleys in those places are smooth, and the surface existed in its present form before the close of the Tertiary period. As a contrast, many of the steep ridges falling to the Pleistocene Araluen Valley are deeply weathered in places where it is not possible for talus to come, and they have reached a state similar to that described for the Bathurst area, or parts of the Cox valley east of Hampton. It seems that weathering is accelerated by increase in relief due to stream revival, probably because of the increased freedom of circulation enjoyed by the groundwater, and deep weathering of ridges and slopes is accompanied by the deposition of alluvium in the valleys. It follows that such conditions are not a reliable indication of ancient landscapes or of prolonged peneplanation, as has been suggested for the Bathurst area.

ii. *Differential Erosion in Horizontal Rocks.*

It is well known that soft rocks overlying a highly resistant formation can be shaped into a mature landscape by erosive forces using the upper surface of the more resistant strata as a base-level of erosion, but there seems to be some confusion regarding the process of valley formation in an area of horizontal rocks where the capping is the most resistant feature. The term "benching" has been used locally to indicate the process of erosion in this case and the production of flat-bottomed valleys, but it is unsatisfactory in use and associations: thus one writer mentions "bluff, wall-like benching", and another speaks of "benching high above base-level" in a similar connection, the terminology in both cases being at fault.

An examination of valleys in the Blue Mountain area where soft Permian rocks are exposed under an impervious, resistant capping of Triassic sandstones, discloses that valley widening is associated with the retreat of both the crowning precipices and the talus slopes, although the latter tend to become more gentle as the process develops (Text-fig. 1). Here the principal work is the undermining of the sandstones so that pieces will split off along vertical joint planes and fall into the valley beneath: this is accomplished by oversteepening of the soft rock surfaces immediately below the precipices by normal erosion, and the unstable slopes thus formed give way in the course of time, and bring down sections of the precipices. The process is assisted by wind erosion at the base of the hard rocks, but the nature of the capping practically inhibits the action of other normal forces of erosion and weathering.

As the thickness of soft rock exposed decreases when compared with that of the resistant capping, the rate of widening tends to decrease, and to be more dependent on wind action. This is shown by the prevalence of caves under such circumstances immediately below the hard rocks, and by the rounding of the top edges of the precipices, which are also carved into monuments by the combined forces of wind and rain. In some instances the convex weathering slope thus induced may extend downward almost to the base of the original precipice, and



Text-fig. 1.—Profiles of valleys developed in essentially horizontal rocks; the shaded portions represent hard Triassic sandstones which are underlain by softer material. They are taken (with the exceptions noted) perpendicular to cliff lines and streams where these are parallel, and there are no considerable tributaries. Nos. 1 and 3 are each 4 miles above the point where the base of the resistant sandstone comes down to river level on their respective streams, and as the rocks are similar, they are directly comparable. Higher terraces on the valley floors show the effect of hard layers of sandstone, and the shorter members each represent half of a symmetrical valley. Nos. 1 and 2 are after Carne's "Western Coalfield", whose sections include many profiles of such valleys of varying depth, in each case the slope of the talus being of the order of 10° when the valley floor is enlarging laterally, as in Nos. 4 to 7. Localities: 1.—Grose River at Mt. Caley, with basalt capping; 2.—Grose River at Blackheath; 3.—Wollondilly River, E. side, ¾-mile above Cox's River; 4.—Narrow Neck, Katoomba, and Megalong Valley to NW; 5.—Megalong Valley, Katoomba, a SW line; 6.—Blackheath Glen, Medlow Bath; 7.—Jamieson's Creek, with the tributary valley of Reedy Creek flattening the lower part; 8.—Narrow Neck, Katoomba, and the divide between Megalong and Galong Creeks, Megalong Valley. Height above sea-level is variable. Vertical exaggeration = 2·64.

then the widening of the valley depends on the wearing away of the hard capping, assisted to a minor extent by the sapping action already referred to. In all cases the overlying strata have a definite protective effect on the soft rocks, although these latter constitute a zone of weakness, and the final rate of valley widening lies somewhere between the rate in the hard rocks and that in the softer if each were freely exposed, and it tends to decrease as the valley becomes wider. The effect of competent tributaries will be readily appreciated, as the valley formed along each tends to become not much inferior to that of the main stream, but where tributaries are missing or where erosion is approaching master divides, the crowning precipices are continuous for scores of miles.

A traverse of the cliff edges between Wentworth Falls and Wallerawang shows the various stages: the widening of Jamieson's Valley is proceeding; that of the high-level Kanimbla is tending to a standstill, and in the upper valley of Cox's River to the north of Wallerawang the crowning precipices are much fretted and dismantled, with a great development of caves at their bases. Caves are also found in the Permian rocks close to the stream along Piper's Flat, in a westerly direction from the town. The main valley northward contracts gently, but there is no abrupt narrowing as it passes entirely on to the hard sandstones at the head of the stream, although they have an absolute control of its widening thereabouts. Monuments are perfectly developed for many miles, and convex erosion slopes extend downwards to the base of the sandstones at the first exposures of the underlying softer rocks.

Examples could be multiplied indefinitely, but all serve to illustrate the attack along the principal line of weakness—the exposed base of the hard rocks. When the valley floors are considered, it is found that they are not confined to resistant strata or to any particular geological horizon: thus the head of Cox's River flows gently over a wide floor, and passes from Triassic sandstones to Permian clays, shales and fissile sandstones without any topographic break. Piper's Flat Creek is mainly on shales below massive conglomerates, and a similar state of affairs exists at Marangaroo and in Lithgow Valley generally. Passing down the Cox to the Kanimbla levels, streams are found flowing from Permian sandstones to granites without any marked change in topography, although much of the granite surface is decomposed and forms an undulating plain in which gorges are being carved from downstream. Apart from these instances in which streams have established their grades on weaker rocks or below zones of hardness, there are still more impressive cases. In the formation of Kanimbla Valley, Megalong Creek has cut through 300 feet of granites, while the plain of Ganbenang Creek to the north-west is eroded in similar rocks from 1,000 to 1,500 feet below the base of the Permian strata, which occur as outliers on the adjoining ridges. Turning again to the Wallerawang district, we find that Black Springs Creek, a tributary to the Cox system, has cut through the Permian sandstone and conglomerate into the underlying Devonian strata, in which it has established a mature valley 400 feet below the base of the newer series opposite its extreme outlier,—a valley which opens broadly on to those near Wallerawang carved in the newer rocks.

All of this leads to one conclusion: there are no rocks here which have been sufficiently resistant to act as a base-level of erosion while the valleys above them were being widened, and there has been no widespread "stripping" of soft rocks from underlying strata in order to undermine the sandstone capping of the tablelands and produce the level valleys. The streams have established their grades through many classes of rock, and their present state of development in the wide valleys can only have been attained through their coming close to a base-level. In the absence of rocks or horizons to prevent downcutting for any lengthy period, this base can only have been sea-level, and the wide valleys have undergone considerable uplift since their formation.

The process of valley widening under these conditions is rapid when compared with that in the hard sandstones if those have a great thickness, but it is not necessarily so from the point of absolute time. Narrow valleys with cliff sides are found in the Permian sandstones of the Endrick Valley (Shoalhaven system) cut to a depth of 500 feet, and with Tertiary basalt on their floors (Craft, 1931). In this case there was some sapping in the widening of the valleys, and these are of considerable age despite their youthful appearance. On the grounds of general resemblance there is no reason why the narrow valleys eroded in the Hawkesbury sandstones of the Macdonald, Colo, Wolgan and Grose Rivers should not be of a similar age, and the widening of valleys by differential erosion where soft underlying rocks are exposed beneath a massive capping would be looked upon as a fairly slow process. For it to approach the stage reached in the

Blue Mountains tableland a long period of stability would be required or, if the work were carried on far above the ultimate base-level, enormously resistant basement rocks would be needed in an area so close to the coast in order to resist the attack of swift invading streams, and in the process all soft material would be stripped from the valley floors. A comparison of these requirements with the existing field evidence again leads to the conclusion that the wide Blue Mountain valleys were developed with their floors much closer to sea-level than they are at present. The importance of tributaries is realized when the middle Cox or the Hunter is studied: in either case, regularly spaced tributaries have been responsible for pushing the highland masses far back from the main streams.

iii. *The Material carried by certain Highland Streams.*

There is considerable variation in the shape and size of material carried by streams—a variation that may be explained in terms of the rivers themselves and the conditions under which they flow, if it be assumed that the rocks concerned are capable of supplying large fragments for the streams to carry. Taking the question of shape first, it is found that the ultimate form assumed by pebbles is that of a surface of revolution approximating to an ellipsoid (*i.e.* with circular sections in one direction and elliptical sections in all others), although its field occurrence is governed by fairly strict rules.

David (1887, p. 40) observed rounded pebbles in the Tertiary drifts of north-western New England, while fragments of similar material in the post-Pliocene gravels are angular or subangular—conditions which prevail right along the eastern highlands of the State. Pebbles of a uniformly ellipsoidal shape are found in the older river drifts of the Nepean-Hawkesbury in the Sydney basin, on the higher terraces of the Wollondilly above its junction with the Nattai, in some of the lower terraces about the junction of the Cox and Wollondilly Rivers, above the channel of the modern Shoalhaven in the gorge at Tallong, and in the Tertiary drifts in level channels above that river. Many other examples could be quoted, but in each the shape is independent of the rock type involved, since granites, quartzites, schists and sandstones are all reduced to a common form and to a size depending largely on local circumstances: all are found where there was a tendency to pronounced deposition in former times, and there is a frequent association with red sand and clay. The basal layer of the Tertiary Shoalhaven drift may be used to illustrate the ideal conditions for shaping the pebbles.

The stratum referred to is a stream conglomerate 5 to 6 feet thick with a matrix of fine gravel or clay: it occurs over a distance of 12 miles between 1,720 and 1,760 feet above sea-level, and its even upper surface is mostly overlain by laminated clays. The pebbles in the conglomerate vary in major diameter from 3 to 12 inches, with many larger specimens up to 24 inches in some localities at the bottom of the deposit, although there is a predominance of moderate grades, about 9 inches. Some quartzite pebbles may have come from the conglomerates of the eastern divide, but the sub-angular shape of the larger fragments in those beds, and the small amount of erosion which they have suffered in the period involved, show them to be only minor factors in the supply of material, and the large stuff especially was derived from the granite and quartzite stream channels immediately above the zone of deposition. Even that which has come from the distant sources has been swept along the gentle grades of a mature landscape, and has been subjected to the same processes as the material from close at hand, the result being a uniformly ellipsoidal shape of pebbles throughout these drifts in contrast to the flattened types of the modern stream channels right from the head of the river. In the Tertiary channels, with a quantity of rock fragments moving slowly down slight gradients or along essentially horizontal surfaces with a balance of conditions favouring deposition, the nature of the motion was clearly defined. Only under rare circumstances would the velocity of the stream be sufficient to carry large stones forward over any distance without their being more or less continuously in touch with the river bed, or with material covering it; the low speed of progression would combine with friction between the fragments and the underlying material to make them rotate, and this would be all the more readily done if the river bed were screened, and the pebbles were still angular. With the disappearance of angularities the pebbles would be rolled along, gradually taking a circular section at right angles to their greatest length, as they necessarily travel broadside on to the current, and protuberances at one end would be eliminated by that extremity pointing downstream and being subjected to greater abrasion for the time being. The ellipsoidal shape of the pebbles is thus due to rotation, and its attainment must be greatly facilitated by the intermittent motion under the conditions described allowing periods of time for the weathering of edges and angles; in fact, the rounded form is intimately associated with such periods of rest, and permanent deposition is only one stage removed.

Turning to the swifter streams, the rotational factor is found to lose its importance with the increase of horizontal velocity; individual pebbles skid as they are carried forward, and the smoothing of edges does not change the general flattish shape appreciably. The heaviest material is rolled along the river bed and attains an ellipsoidal form, but if it is carried into canyons it is quickly reduced in size and broken up in swift whirls and cataracts. For a summary of active stream conditions there is no better place than Oallen ford on the Shoalhaven, a few miles above the place where the river enters the gorges. The largest pebbles (12 inches or more in diameter) are roughly ellipsoidal, but the great bulk of the material is of small size and is rather flattish, with fresh and well-rounded edges; there is no accurate sorting of the smaller stones, but all grades are mixed indiscriminately together until the top of the gravel banks is reached, where there are finer pebbles and sand. These conditions contrast with those of the ellipsoidal gravels, in which a few definite grades of pebbles predominate in each locality, and the change in size from place to place in the same horizon is limited, reminding one of Marshall's conclusions (1928) relative to the grading of beach gravels, and the persistence of certain definite sizes. The modern gravels enjoy only brief periods of rest, and the abrasion and impact to which they are subjected quickly remove any surface decomposition, and the resultant clean, polished surfaces are not readily attacked by forces of weathering. Thus the flattish form is associated with quick streams, brief periods of rest and comparatively little weathering of the fragments.

The actual mechanics of reduction have been investigated by Marshall (1928) for beach gravels of a specific rock. He recognized three principal actions: abrasion, or the rubbing of pebble against pebble; impact, or the blows of larger on smaller fragments; and grinding, or the reduction of small grains by contact with, and pressure of, pebbles of relatively large size. He states that the second of these actions is much more important than the first, although its effectiveness depends largely on the presence of coarse pebbles, and grinding is able to reduce the material supplied by impact as quickly as it is provided, while sand is not formed in quantity as the result of these actions. In addition, it is clear that among heterogeneous rocks the softer will be quickly reduced by the actions described. The coastal rivers of New South Wales support his conclusions in detail: they discharge fine material which has built up the silt flats of their lower courses, and has tended to fill their estuaries with mud (the introduction of sand into such channels as those of the lower Hunter and the Nepean-Hawkesbury is a recent matter, and is due to increased erosion of hillsides following settlement). But it is clear that conditions similar to these did not always exist, as the old gravels on the Glenbrook-Wallacia fold and the nearby Penrith-Windsor plain show. Their pebbles are ellipsoidal in form, and exceptionally large specimens attain a major diameter of 18 inches. At first sight it would appear that they were carried by more powerful streams than those existing at present, which only bring mud or hill sand, but further consideration shows the incorrectness of such a view: the uniformly ellipsoidal form of the pebbles is evidence that they were carried by slow streams under conditions which tended to favour deposition before the site of their final resting place was reached, and their continued existence was due to the fact that the streams were not powerful enough to destroy them.

At the present time, the rivers concerned are able to reduce all the material supplied to them in the normal way, and a vast quantity is poured into the gorge sections of the Cox, Kowmung and Wollondilly Rivers. In places along the first two there are long terraces of freshly broken slate and quartzite, whose extent and disposition are altered by each great flood: at other points masses of granite, generally of a cubic form with edges up to 18 inches are delivered by torrents to act as millstones and grind up the less resistant material, but only a small fraction of their number ever reaches the junction of the Cox and Wollondilly Rivers, and even where the level valley is entered, some miles above that point, the few survivors of the more resistant types have been rounded and greatly reduced in size. Unfortunately, it is not possible to estimate the number of pebbles passing into the lower Cox, but the coarse ellipsoidal gravels forming its present sides and bed are old, and are overlain by fine brown silt, many feet deep. The Cox has cut its channel in these deposits, and is not dropping new pebbles in place of those which have been removed, so the inference is that only a few new pebbles come this far, although there is movement on the channel bottom in time of flood.

Summing up these considerations, it is clear that the streams are being constantly supplied with rock waste in their canyon sections, and they have both the power and the mechanism for its comminution within short distances, so that the final product discharged is silt or mud. A comparatively recent increase in power is indicated in order to allow of this and the erosion of a new channel in the old silts and coarse gravels, while these latter indicate less favourable conditions for reduction than those existing at the present day. Further downcutting is only proceeding slowly, because the river has already established a channel fairly well suited to its mechanical requirements in times of flood.

Similar actions in the Shoalhaven River are even more striking on account of the larger rock masses supplied to it, and one outstanding inference can be drawn—that the power of a stream is to be gauged by the fineness of the material which it discharges, and any increase in the volume or power assists it greatly in breaking down the rock fragments with which it is supplied, provided that their initial size is not increased disproportionately. So far as power is concerned, it is probable that there is a critical value at which a maximum pebble size is possible in an active individual stream: if the power is reduced below this point, the size decreases owing to the inability of cutting or erosion to supply coarse material from the landscape that will give the maximum pebbles obtainable with the rock involved, even with the reduced forces of abrasion and impact. On the other hand, an increase in power beyond the critical point may supply the stream with coarser material, but the facilities for reducing it will be so increased that the resultant pebbles will be of smaller size than the maximum, and further increases in power may tend to eliminate them entirely, although in this connection much depends on the nature of the stream channel, whether it be level and smooth, or broken and obstructed.

iv. *Surface Deposits and past Climates in the Shoalhaven Valley.*

In speaking of changes in the power of a stream, the term "power" has been used with reference to a river's ability to move and reduce the rock material supplied to it. The greater proportion of such work is done in times of flood (i.e. great temporary increases in volume), and for the most part the stream is incapable of shifting any but the finest material. It follows that references made to increase of power imply the setting up of periods of heavier rainfall and more violent floods than heretofore, and not necessarily to an increase in the annual precipitation. So far as the ellipsoidal pebbles are concerned, their existence and presence argue that the streams which transported them were of some volume and power, and their form indicates the absence of relatively frequent periods of violent motion such as shape the modern stream gravels. In other words, the ellipsoidal pebbles were formed when rainfall was abundant at intervals, at least, and when violent floods were rare or altogether absent. The laminated clays and plant beds included in the Tertiary drift confirm this idea for those deposits in general, and they may represent periods of minimum storminess and stream power.

So far as the more modern stream deposits are concerned, the tendency in eastern New South Wales is towards their erosion. This is expressed in the form of gullies or channels cut in the alluvials, or in narrower terraces within the older features, the latter being marked both in the littoral belt and in the more level portions of the highlands, being distinct from recent erosion due to settlement and deforestation. In the preceding section it was concluded that there had been a recent increase in the effective power of the streams, but the origin of the alluvials presents other problems, as the deposits of the Shoalhaven Valley show.

The recent alluvials in that area are found along the flatter parts of the tributaries and of the Shoalhaven itself above the vicinity of Braidwood: they consist of 1 to 3 feet of fine drift or clay overlain by 3 to 10 feet of pebbles, with a surface covering of 1 to 3 feet of fine drift or silt. In some localities the bottom layer contains pebbles, but of a smaller size than those found above it, and the major pebble horizon cuts out as the head of each stream is approached, and the master channel is replaced by a number of more steeply graded tributary gullies or depressions. The grade at which the material was deposited varies considerably, from the approximately horizontal beds along parts of the Shoalhaven above the Braidwood district to some in the vicinity of Tallong, where local gradients may be as steep as 1 in 60, but in each place the great feature is the distinctness of the pebble horizon, whose material is uniformly fresh throughout, and which generally does not mix with the underlying or overlying deposits,

When examined in more detail, the bottom layer is found to consist of white or other light-coloured clays or sandy clays, with occasional rounded stones, and only one or two isolated instances have been observed (in the Tallong district) in which there is any trace of carbonaceous matter: the pebble beds also lack evidence of plant growth, roots or stems of trees, and only on the surface of the upper fine material is there anything approaching normal soil. The pebbles have had their edges smoothed, but they occur in various shapes and sizes from the coarse rounded material of Jembaicumbene and upper Reedy Creeks (middle valley) with diameters up to 12 or 14 inches, to those of the Marulan district or of the upper Shoalhaven, where many individuals attain a diameter of 9 inches, but few exceed it. The coarser pebbles are more rounded than the smaller, which are flattish or of irregular shape, but even near the heads of gentle local streams flowing in areas of low relief, as in the Marulan district, the rounding of edges is marked. The shape of the fragments, together with the unsorted and jumbled nature of the deposits, shows that the material was borne along by swift and turbulent streams that were greatly overloaded, and the circumstances suggest highly irregular flow such as is found in semi-arid regions.

There is also another aspect of the problem: present erosion in the old plateau landscapes is limited by the covering of trees and plants which bind the soil and prevent any but the slowest erosion except in stream channels, but when the channels were being alluviated, the drift material was derived from the landscape as a whole, and even that portion coming from areas of very low relief is fresh and relatively coarse—a state of affairs which is not reproduced under the stormy conditions of the present time. It may be inferred that the pebbles came from a surface whose vegetation was sparse, and afforded an insufficient protection from storm erosion, as the remarkable lack of vegetable matter in the drifts also appears to show. So far as time is concerned the deposits are recent, because they post-date the modern valley contour and approximate closely to modern grades, the difference rarely exceeding two or three feet on either side except where there has been gorge-cutting from the direction of the Shoalhaven.

These conditions of deposition may be correlated with the newer period of glaciation on Mt. Kosciusko, which David (1908) believes to have been of the order of 10,000 years ago, and which would be expected to introduce a cold climate into the surrounding region, with a variable rainfall of low annual value. This would militate against a continuous mantle of vegetation like that of the present day, and would favour erosion by intermittent streams incapable of shifting their full loads into the gorges. Part of the material carried after rainy periods would be deposited along the more level channels to cover the finer material dropped by preceding weaker streams, and the quick run-off would not allow of sorting, although the type of motion would make for the rounding of edges on the rock fragments. The coming of a more genial climate would explain the fineness of the top layer as there would be a more even distribution of rainfall, more plants and decreased erosion, and the gradual covering of all the drift with a deposit of hill wash in favourable positions. The dissection of the deposits has been accomplished by virtue of a general increase in stream power: this indicates a greater rainfall at some seasons, and probably an all-round increase following the disappearance of the glacial anticyclone from the southern highlands.

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MYCOTROPHISM IN THE RUTACEAE.

I. The Mycorrhiza of Eriostemon Crowei F.v.M.

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(Twenty-two Text-figures.)

[Read 28th September, 1932.]

Introduction.

The Rutaceae is a family with which the mycotrophic habit has not so far been associated, but our observations have revealed an endotrophic mycorrhiza in the following species: *Zieria Smithii* Andr., *Eriostemon Crowei* F.v.M., *Eriostemon lanceolatus* Gaertn.* Subsequent examination may indicate that the existence of mycorrhiza in the Rutaceae is more widespread than is suspected and, furthermore, that the mycorrhizal condition will be discovered in other families and genera, in which this habit has not yet been noted. The present communication provides a detailed cytological examination of the mycorrhiza of *Eriostemon Crowei*, but observations made on the other species of the Rutaceae recorded above, indicate a close agreement in detail.

The mycorrhiza of *Eriostemon Crowei* is characterized by arbuscules, sporangioles and vesicles; it therefore falls into the mycorrhizal type which is seen in the majority of herbaceous angiosperms, excluding the Ericaceae and certain specialized groups, and, as Gallaud has recorded, is very widely distributed. This type of mycorrhiza is quite distinct from that of the Orchidaceae, the endophyte of which is characterized by numerous septa, and by the "pelotons" in the mycorrhizal cells. The endophyte of the former mycorrhiza shows probable affinities with the Phycomycetous fungi, that of the latter with the Basidiomycetes.

Occurrence of the Mycorrhiza.

Eriostemon Crowei is a common component of the shrub stratum of the *Eucalyptus piperita–E. haemastoma* sclerophyllous forest of the Hawkesbury Sandstone habitats near Sydney. The habitat is typically a loose sandy soil, with low water content (average of three estimations on air-dry soil taken from depth of 5 inches, i.e., area of large number of rootlets, was found to be 0·77%), and also a low humus content. The humus content as determined by ignition was found to be 3·2% at depth of 5 inches, while the average hydrogen-ion concentration was pH 5·7 at the surface of the soil and pH 6 at 5 inch depth. The surface layer of the soil, especially in shady situations under *Eucalyptus* spp. and *Angophora lanceolata*, is often composed of decaying vegetable matter, and

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* Since this paper was completed a similar mycotrophic habit has been observed by the authors in two additional genera of the Rutaceae, *Boronia* and *Correa*.

favours fungal growth. The mycorrhiza is typically endophytic, and is practically confined to the young primary fibrous laterals, of which very few do not reveal some degree of infection.

The mycorrhiza was first discovered on the roots of very young seedlings, only two or three inches high, but subsequent examination of larger plants in full flower and fruit, disclosed its presence on their rootlets also. Macroscopically the wholly infected rootlets or infected portions of roots with discontinuous infected areas, can readily be distinguished from uninfected, by their pale yellowish, and somewhat oily appearance. Infection does not extend to the apical meristematic portion of the rootlets. Root hairs are comparatively scanty in development and are quite short.

The old secondarily thickened roots are relatively free from the endophyte; only in very few was any trace of the mycorrhiza seen and in those cases the fungus was in its last stages of digestion. As the primary cortex is discarded during secondary growth, the occasional infections of the secondary cortex are probably made directly from the soil.

That the mycotrophic condition of *Eriostemon Crowei* is not exceptional and local, but typical and widespread, is suggested by the fact that plants from widely separated habitats showed no noticeable variations of the endophyte structurally or developmentally.

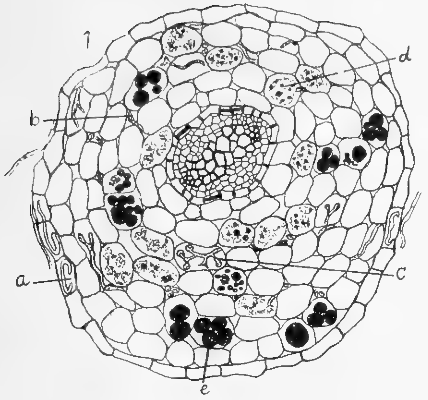
The Root. Text-fig. 1.

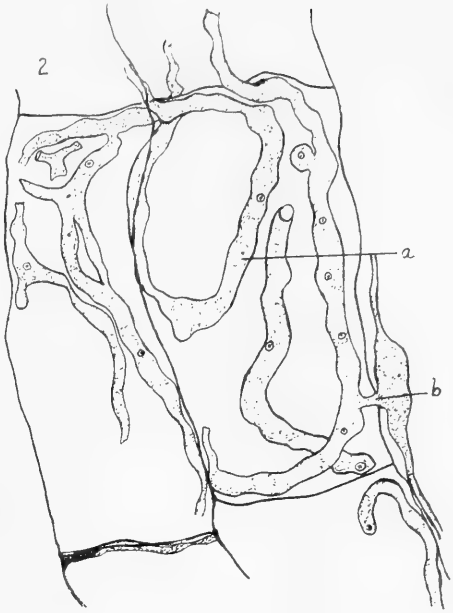
Within the epidermis with its scanty root hair development is the cortex, usually four to six rows of large cells in width, with thin walls, intercellular spaces, and scanty cytoplasmic contents represented by the primordial utricle containing the nucleus. The endodermis is characterized by well-developed Casparé strips, while the stele is typically diarch. The endophyte is distributed throughout the epidermis and cortex, but no trace has been seen either in the endodermal cells or within the stele. In the epidermis the fungus is intracellular only, while in the deeper cortical layers the fungus is both intercellular and intracellular, chiefly intercellular. This distribution of the endophyte within the host brings the mycorrhiza of *Eriostemon Crowei* within the first series of Gallaud's classification of endotrophic mycorrhizas, for all other series are entirely intracellular (Gallaud, 1905).

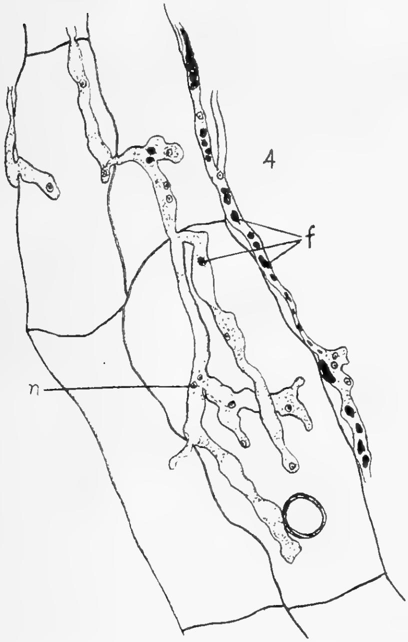
Methods of Examination.

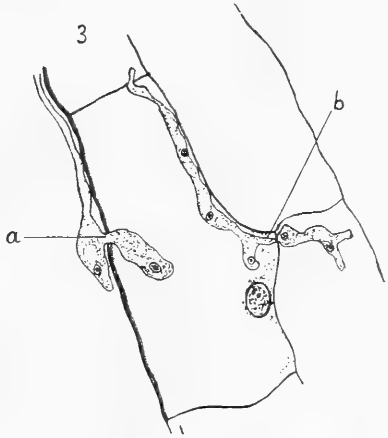
The fixatives employed were strong chromo-acetic solution, or strong Flemming's. In the latter case many of the sections were left unbleached, in order to study the distribution of the fatty substances throughout the endophyte and the host cells. The most suitable sections were 15μ in thickness, for they rendered it possible to trace hyphae for fairly long distances in longitudinal sections of the rootlets. Thinner sections were cut when necessary for more detailed cytological study of the fungus and its vesicles.

The following stains were employed: Safranin and Gentian Violet, Thionin and Orange G (Stoughton, 1930), Pianese III B (Vaughan, 1914), and Haidenhain's Iron-Alum-Haematoxylin. Unbleached osmic-acid preparations were stained in Orange G (saturated solution in absolute alcohol). The Thionin-Orange G combination gave excellent differentiation of the mycelium, but for detailed cytological study of the fungus in all its stages, the Pianese III B and Iron-Alum-Haematoxylin were much superior to any other combinations used by us.









Text-fig. 1.—T.S. of young rootlet showing diarch stele, endodermis, Casparé thickening of radial walls, cortex composed of relatively large parenchyma arranged in 4–6 rows, and epidermis. Fungal mycelium is seen on the surface, also forming coils in the epidermal cells (*a*) and developing both intracellularly and intercellularly within the cortex (*b*), and forming arbuscules and sporangioles within the cells (*c*). Disintegrating sporangioles are seen at (*d*) and large fat globules staining black with osmic acid at (*e*). × 135.

Text-fig. 2.—Mycelium of the coenocytic endophyte within the epidermis and outer layer of the cortex; the coiling of the hyphae in the epidermis, their wide lumen and sparse contents are showing at (*a*), also the infection-tube formed by the superficial hyphae (*b*). × 735.

Text-fig. 3.—Infection tube penetrating the wall of the epidermal cell, and entering the lumen of the cell at (*a*); a thin-walled hypha is spreading inwards into the cortex at (*b*) and the constrictions of the hypha are shown. × 735.

Text-fig. 4.—Intracellular branching hyphae within an outer cortical cell showing the thin wall, the nuclei (*n*) and the irregular form; further in, fat masses (*f*) are seen in the intercellular hypha. × 735.

Morphology of the Endophyte.

(*a*). *Extra-epidermal hyphae and penetration* (Text-figures 2, 3, 4, 5).

The fungus forming the mycorrhizal condition in *Eriostemon Crowei* is probably widely distributed in the sandstone habitats around Sydney, and has developed a symbiotic relationship with the roots of certain Rutaceous hosts. Its entrance to the root system is possible through the root-hairs, or through the epidermis directly, or through the germinating seed if infected. Our studies indicate that infection is readily made through the epidermal cells; no infection of root-hairs was observed, while the question of seed infection has not yet been investigated fully. The surface of the rootlets harbours abundant mycelium which is septate, branched and has thick brown walls. Branching is associated with a swelling somewhat resembling an appressorium, which firmly fixes the mycelium to the surface of the root. From these swellings the infecting hyphae are usually developed (Text-figs. 2, *b*; 3, *a*). At the point of infection of an epidermal cell the hypha is considerably distended compared with the ordinary distributing hyphae on the root surface (Text-figs. 2, 3). The actual penetration of the walls usually involves a distinct constriction of the hyphae (Text-figs. 3, 4). In order to secure some idea of the frequency of penetration the external hyphae were carefully micro-dissected by means of a fine glass needle mechanically controlled and the short infecting strands recorded. Roots from three different plants were employed. The following table gives the records of these dissections.

Table showing approximate number of penetrations of parts of a Mycorrhizal root.

Plant.	Length of Root.	No. of Penetrations.	Mean per mm. of Root.
A	3mm. 5mm. 3mm.	14 31 8	4·8
B	4mm. 4mm. 5mm.	10 14 20	3·4
C	3mm. 6mm. 3mm.	9 15 12	3·6

From this table it is indicated that rootlets vary in regard to the frequency of penetration. The mean diameter of the rootlets is approximately 0·37mm., the mean number of penetrations per sq. mm. of surface is 4·1 for A, 2·9 for B, and 2·56 for C. These figures indicate that the internal portion of the fungus is in frequent communication with the soil.

(*b*). *Epidermal hyphae* (Text-figs. 2, 3, 5).

Once the epidermal cell is penetrated a remarkable change occurs in the fungus, for the endophytic hyphae are non-septate, thin-walled, hyaline, irregular, generally of greater diameter (5–6μ instead of 2–4μ), and with little cytoplasm and other cell contents (Text-figs. 2, 3). Within the epidermal cells the hyphae frequently form an elaborate coil, branches extending from one epidermal cell to another. From the epidermis certain hyphal branches develop inwards to the cortex, and rapidly spread transversely and longitudinally, mainly along intercellular spaces (Text-fig. 5). From one centre of infection the hyphae spread throughout a considerable length of cortex; and while they are usually non-septate, occasional septation appears. The epidermal hyphae not only differ from the internal hyphae in their size, septation, wall structure and cytoplasmic contents, but also probably chemically, for in unstained preparations they are generally yellowish and somewhat waxy in their appearance, and are not readily stainable with those combinations which reveal the contents and cytological details of the more deeply seated hyphae. They are frequently almost devoid of cytoplasm, have few nuclei and little fat, are wholly intracellular, as compared with the intercellular distribution of the cortical hyphae (excepting the arbuscules and sporangioles). They do not spread far from the centre of infection in a vertical direction.

In the mycorrhiza of *Eriostemon Crowei* there is, therefore, a remarkable dimorphism of the hyphae, the extra-epidermal, epidermal and cortical hyphae being quite different from each other, so much so that were continuity of the three forms not determinable, one might be tempted to the conclusion of double infection by different mycelia. Peyronel (1923) who is responsible for this theory of root infection by two distinct fungi was impressed by the dimorphism

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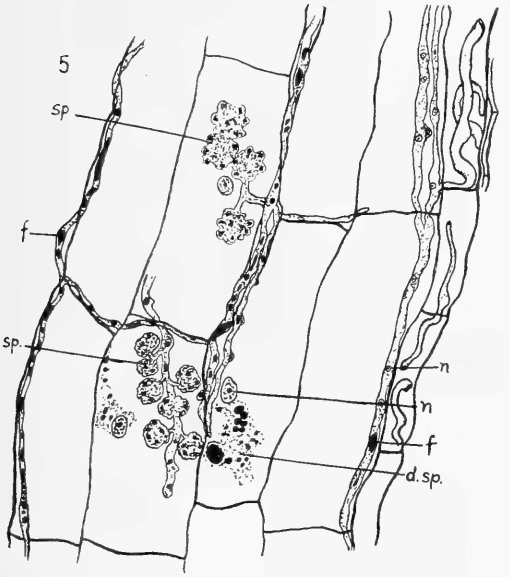
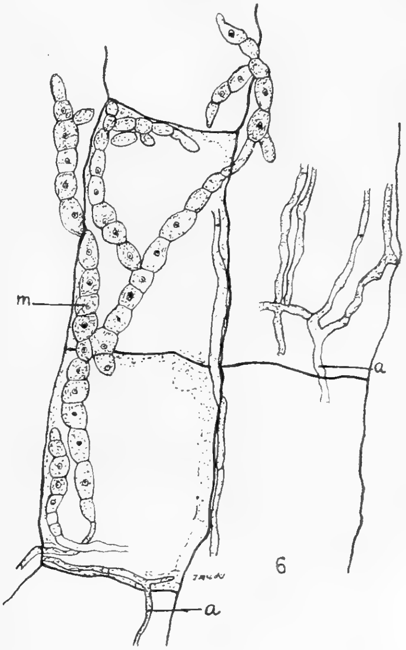




Text-fig. 5.—Portion of a longitudinal section of the epidermis and cortex. The coiling of the hyphae within the epidermal cells, the spreading of the cortical hyphae transversely and longitudinally, the young sporangioles (*sp.*), the remains of disintegrated sporangioles (*d.sp.*), fat masses (*f*) and nuclei (*n*) are shown. × 300.

Text-fig. 6.—A portion of the moniloid mycelium (*m*) of a *Rhizoctonia* form in the outer layer of the cortex. Each cell of the moniloid portion is uninucleate; the ordinary hyphae of this endophyte are also shown at (*a*). × 735.

of the mycelium in the mycorrhiza of the Wheat. The dimorphism was in his opinion sufficiently marked to suggest the presence of two independent fungi; and he was convinced that endotrophic infection in the majority of mycotrophic plants is of a composite character, involving two endophytes, one usually less developed—the *Rhizoctonia* type of Orchids, the other more abundantly developed, and with Phycomycete characters. The latter type produces vesicles and arbuscules, the former the characteristic "pelotons" of the Orchidaceous endophyte; Peyronel isolated the Orchidaceous *Rhizoctonia* type of endophyte from *Triticum sativum, Zea Mais, Hordeum vulgare, Arum talicum, Beta vulgaris,* etc. The *Rhizoctonia* form from wheat was reinoculated into aseptic seedlings and produced a mycorrhiza with "pelotons", but without the arbuscules and vesicles usually present in wheat mycorrhizas, and in addition Peyronel found large numbers of vesicles which characterize the phycomycetous form, on dead roots of wheat, maize, etc.

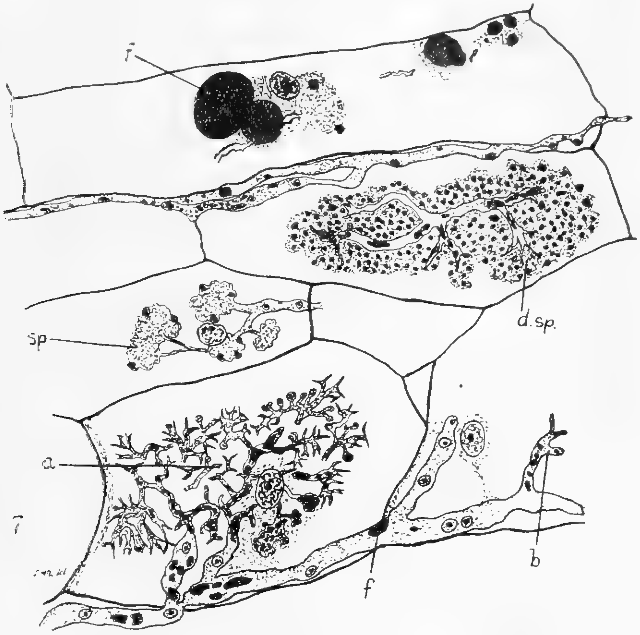
The observations of Mollberg (1884) on *Epipactis* and *Platanthera* describing characteristic "pelotons" in addition to vesicles in the roots; of Gallaud (1915) who described "pelotons" of the Orchidaceous type in the roots of *Tamus* and *Psilotum* along with typical arbuscules; of Petri (1918-1919) who, observing the decay of the mycorrhiza of the Vine and Olive in moist chambers, thought he had secured evidence of the same mycelium producing arbuscules and vesicles within the mycorrhizal cells, yet forming superficial conidial fructifications analogous to those seen in cultures of the Orchid fungi by Burgeff and Bernard, all point to the actual presence of mycelium of two distinct types in the mycorrhizas of some plants. However, these authors attributed the differences in structure and behaviour to a different response of one endophyte to physiological differences in the cells of the root; and concluded that the fungi forming endophytic mycorrhizas all belonged to one group.

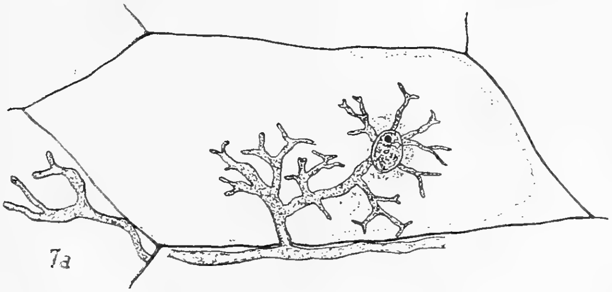
Peyronel, however, seems to have been the first to enunciate explicitly the "double infection hypothesis", recognizing that some mycorrhizas were formed as the result of infection by two distinct fungi, a primary infection by an arbuscule-forming fungus, and a secondary infection by a *Rhizoctonia* type similar to that of Orchids. Infection by the *Rhizoctonia* form of fungus is confined to the epidermis and outer cortex, and supervenes upon infection by the arbuscule-producing form. Peyronel regards the second endophyte as a quasi-parasite or saprophyte, rather than a true symbiont. It can readily be grown upon artificial media, but the endophytes belonging to the arbuscule-forming group have not been isolated, although a similar mycelium bearing arbuscules and vesicles has been observed in dead roots and in soil, and probably lives saprophytically. In *Eriostemon Crowei* we are able to support Peyronel's statement of double infection by two distinct fungi, for, in addition to the arbuscule-vesicle-sporangiole forming endophyte which is abundant, especially throughout the entire cortex, and shows the very striking hyphal dimorphism referred to above, there is another endophyte which is confined to the epidermis and outer cortical layer, which develops very characteristic moniliform intracellular hyphae. It is very like the *Rhizoctonia* figured by Peyronel (1924) and isolated from Wheat. Although we have not observed the formation of "pelotons" within the cells, we are convinced that the moniloid mycelium is distinct from the usually coenocytic arbuscule-vesicle forming type which constitutes the endophyte in the mycorrhiza.

In isolation experiments we have obtained a similar *Rhizoctonia* form, but so far have not succeeded in isolating the arbuscule-producing endophyte. Text-figure 6 shows the moniloid mycelium of the second endophyte. While there is no definite zonation of the endophyte within the cortex itself, we may differentiate the epidermal stage from the cortical owing to the differences discussed above.

(*c*). *The Cortical Hyphae* (Text-figs. 4, 5).

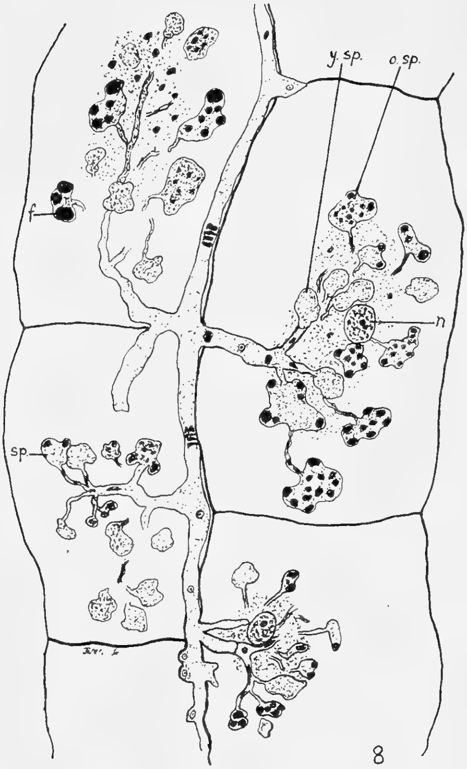
Once within the cortex the hyphae spread rapidly both in a transverse and a longitudinal direction for some considerable distance from a centre of infection. The spread of the endophyte within the cortex is mainly intercellular, but it





Text-fig. 7.—Portion of a longitudinal section showing an inter-cellular hypha containing fat (*f*) and forming complex arbuscules (*a*) from lateral branches within the cell. The arbuscules contain dense cytoplasm, nuclei and fat masses, and their ultimate branches are extremely attenuated. A very young arbuscule is seen at (*b*), young sporangioles (*sp.*) with small fat globules and dense cytoplasm, and the residuum of hyphae and fungal cytoplasm and large fat globules (*f*), liberated from the sporangioles are also shown in other cortical cells. × 735.

Text-fig. 7*a*.—A fairly simple type of arbuscule developing from a branch of an intercellular hypha. Note the position of the nucleus of the cortical cell. × 735.



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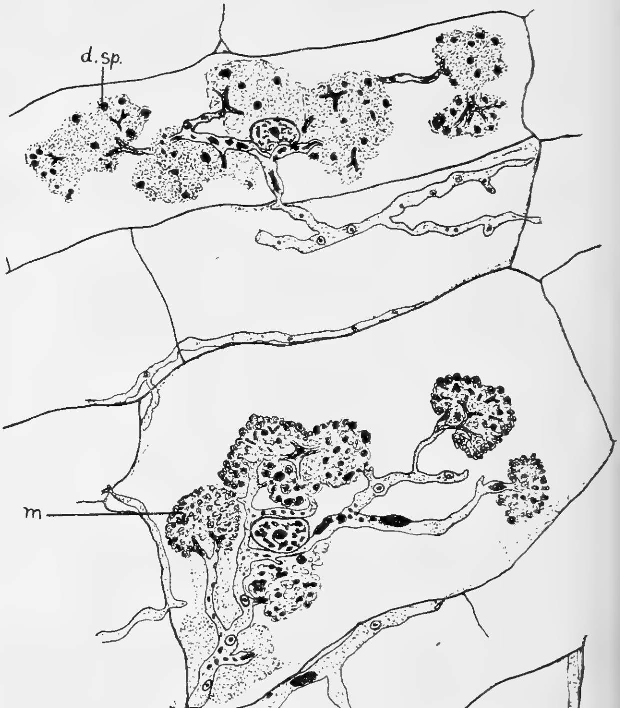

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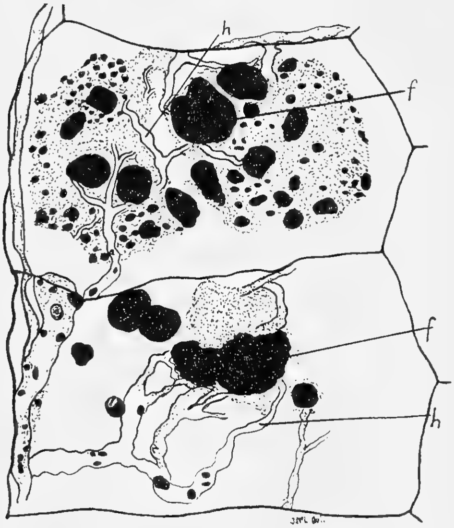

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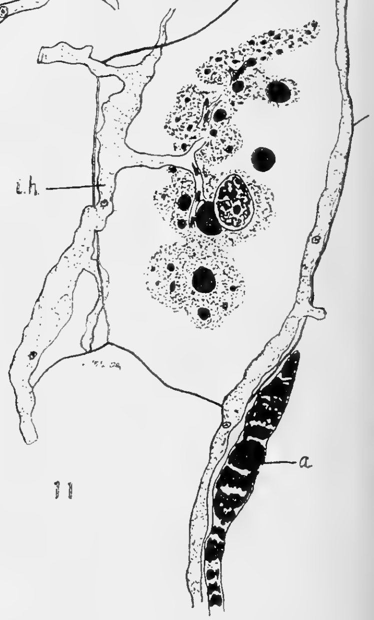

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seems capable of readily penetrating cell walls and thus travelling throughout cell cavities (Text-fig. 4). Several hyphae may occupy an intercellular space completely and may somewhat distort the cells in the neighbourhood of the spaces or may even split the longitudinal walls owing to some action upon the middle lamellae. Text-figure 4 shows that the migrating hyphae readily penetrate the walls of the host cells, and are generally constricted at the point of penetration. These cortical hyphae may be designated "distributing hyphae", because they spread the endophyte throughout the cortical region.

The distributing hyphae are thin-walled, of irregular diameter, and frequently simulate an anastomosing structure recalling the laticiferous system of a *Taraxacum*. The cytoplasm is dense, finely granular, with small vacuoles throughout, numerous nuclei with a prominent nucleolus and little chromatic material in the nuclear vacuole, nuclei occasionally in pairs, especially when hyphae are growing rapidly, and variable, but generally large, quantities of fatty material. In some hyphae considerable lengths are stained black with the osmic acid of Flemming's solution (Text-figs. 4, 5), while in others the fatty compounds occur in small rounded or elongated masses. These hyphae lose most of their contents and become practically devoid of fats at the time the arbuscules are developing into the sporangioles.

(*d*). *The arbuscules and sporangioles* (Text-figs. 7, 7*a* to 14, 16).

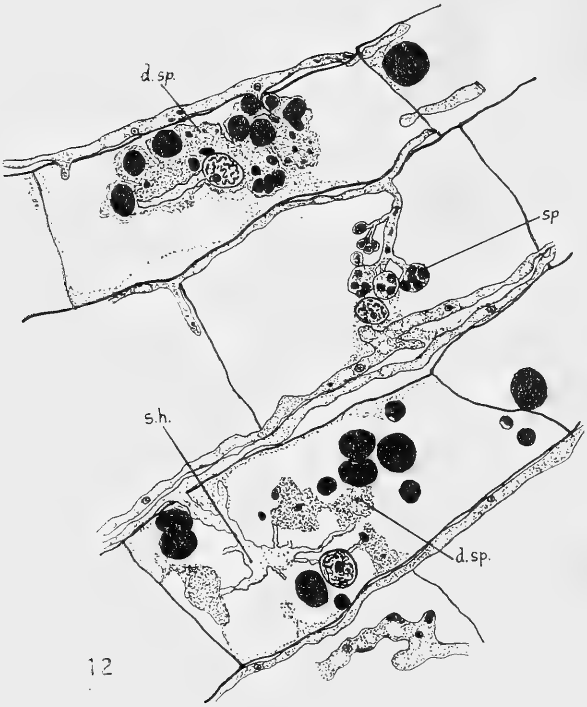
From the intercellular cortical hyphae lateral branches are developed into the cells and produce the characteristic arbuscules and sporangioles. These structures are not confined to any particular region of the cortex as in *Lolium temulentum* investigated by McLennan, but are distributed throughout all the various cell-layers between the epidermis and the endodermis. The arbuscules are not only formed from branches of the intercellular hyphae but also from the intracellular hyphae. In the former case they are usually lateral, in the latter terminal (Text-figs. 7, 7*a*). In structure the arbuscules are occasionally simple but usually very complex, the early branching being irregular or racemose, the later being regularly dichotomous resulting in a system of very delicate terminal branches (Text-fig. 7). Arbuscules of a very simple type also occur, and several may be developed within one host-cell from a single intercellular hypha only or from an intracellular hypha as well. The arbuscule develops within the cell cavity, and the nucleus, hitherto situated in the primordial utricle, moves towards and takes up a position in close proximity to it. Frequently, the nucleus appears to lie within the complex arbuscule, and at this stage of development the size and chromatic reaction are apparently identical to those of the nucleus of an uninfected host-cell.

Text-fig. 8.—Portion of a tangential section of the middle cortex showing an intercellular hypha which has given rise to several arbuscules of a fairly simple type; the arbuscules are developing the sporangioles (*sp.*), and fat globules (*f*) and cytoplasm are accumulating in them. × 735.

Text-fig. 9.—Cortical cells containing sporangioles which are showing a mamillated structure (*m*) owing to the accumulation of fat globules and cytoplasm within them. In the other cortical cells intracellular hyphae and disintegrating sporangioles (*d.sp.*) are seen; in the latter the membrane which is clearly seen in the young stage is indefinite or dissolved. × 735.

Text-fig. 10.—Cortical cells containing dense sporangioles in various stages of disintegration; the large fat masses are being formed at (*f*). Remnants of the hyphae of the arbuscule are seen at (*h*). × 735.

Text-fig. 11.—Disintegrating sporangioles with fat masses; some hyphae (*i.h.*) devoid of fat while one (*a*) contains an excess. × 735.



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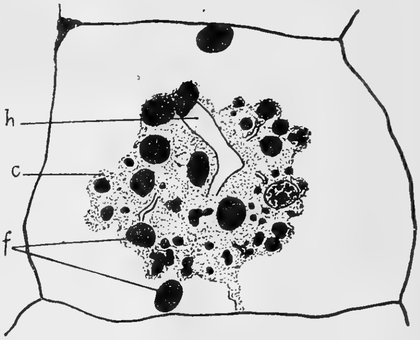

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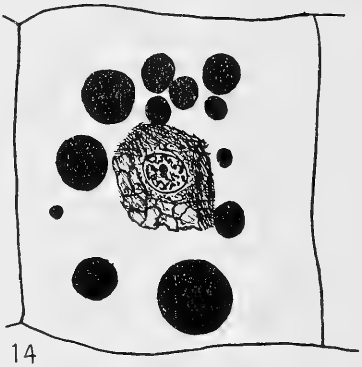

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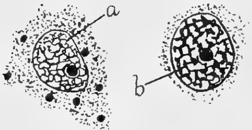

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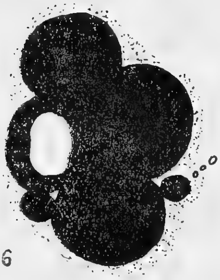

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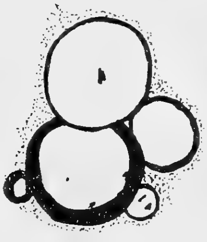

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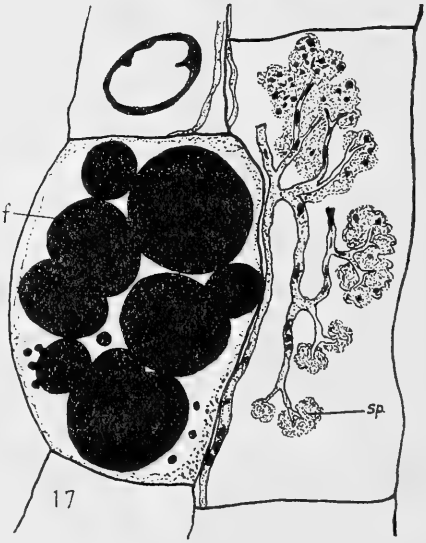

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The arbuscules at this stage contain dense cytoplasm, nuclei and a considerable quantity of fat, but they rapidly become transformed into sporangioles, apparently by the swelling of the ends of the ultimate branches of the arbuscules. The sporangioles vary in shape and size; some of the very large ones are probably formed by coalescence of a number of small ones. They are usually filled with cytoplasm and fat in their early stage, and appear to have a distinct membrane at first, as if the tips of the finer hyphae had simply become distended by pressure of the accumulating contents (Text-figs. 8, *sp.* and 9); when seen in a mass they appear more or less papillated structures containing cytoplasm and fatty material (Text-fig. 9, *m*). The fatty substances stain black with osmic acid, so that up to this stage there is no micro-chemical change in the fats present in the endophyte. The sporangioles ultimately burst, their membrane becoming very indefinite. Whether this disruption is attributable to the mechanical pressure of the accumulating cytoplasm and fat within them, or whether it is due to some enzymatic action of the host cytoplasm on the sporangiole membrane, one can only surmise. It is noteworthy that in cells with several groups of sporangioles derived from different arbuscules, or different parts of the same one, there is frequently a distinct difference in their development, some being devoid of fat, others abundant in fat, others disrupted and their fat liberated. If the disruption of the sporangioles be caused by the action of a hydrolyzing enzyme produced by the host cytoplasm, then one might reasonably expect the same degree of disintegration throughout, unless there be a time-factor involved in the hydrolysis of the sporangiole membrane or in the development and maturation of the sporangioles themselves.

With the rupture of the sporangioles, their contents, cytoplasm and fat, lie in the cell cavity. The fat globules lie in the mass of fungal cytoplasm derived from the sporangioles and the hyphal branches forming the original arbuscule collapse, and appear colourless and practically empty. From their uniform staining the globules are apparently homogeneous, and are spherical, and still stain black with the osmic acid of Flemming's solution. Text-figs. 9, *d. sp.*, 10, 11 and 12 show the ruptured sporangioles and the liberation of their contents. At this stage the cell-contents are a dense mass of finely granular fungal cytoplasm, numerous fat globules, fragments of shrivelling hyphae, the nucleus and the cytoplasm of the host which can seldom be distinguished from the fungal

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Text-fig. 12.—Various stages of the sporangioles and fat accumulation and liberation. Young sporangioles (*sp.*) which are accumulating fat; disintegrating sporangioles (*d.sp.*) which are liberating fat into the cortical cell, and the shrivelling hyphae (*sh.*) of the arbuscules are shown. × 735.

Text-fig. 13.—Mass of cytoplasm (*c*) and fat (*f*) liberated from the sporangioles. Portion of a hypha is also shown at (*h*). × 735.

Text-fig. 14.—Final stage in digestion of the fungal cytoplasm and hyphae within a cortical cell. Note the reticulate residue, the large fat globules and the nucleus of the cortical cells. × 735.

Text-fig. 15.—Nuclei from the midst of a sporangiole complex; (*a*) before liberation of cytoplasm and fat, (*b*) after liberation and during digestion of the fungal cytoplasm. In (*b*) the chromatin appears very much more granular and stains more deeply. The nucleus is much larger than that of an uninfected cortical cell. × 735.

Text-fig. 16, 16*a*.—Stages in the transformation and translocation of the fat globules from the cortical cells. Finally only a thin dark-staining membrane seems to be left. × 735.

Text-fig. 17.—Portion of a L.S. of the outer cortex of root, showing large fat globules (*f*) in a sub-epidermal cell distending the cell-walls, and sporangioles (*sp.*) at various stages of development, some showing the accumulation of fat, others as yet devoid of it. × 735.

cytoplasm. The outstanding features are the numerous globules and the great amount of fungal cytoplasm (Text-figs. 10, 11). The globules seem to coalesce and form larger ones of different sizes which, in contrast to those described by McLennan (1926) for *Lolium temulentum*, retain their staining capacity with osmic acid. In *Lolium*, McLennan records that the globules are positive to osmic acid while in the hyphae of the arbuscules, but in the sporangioles and when liberated into the cell cavity, they lose this staining property, so that some chemical change has taken place in them. In *Eriostemon Crowei* this change in micro-chemical reaction takes place at a much later period, usually after the digestion of the hyphal mass and fungal cytoplasm in the host cell is well advanced. The fat content of the cell reaches its maximum when all the sporangioles have liberated their contents, and appears to remain constant during the disintegration and digestion of the hyphae of the arbuscules and the fungal cytoplasm, so that there is no discharge of fats excepting through the sporangioles within a cell.

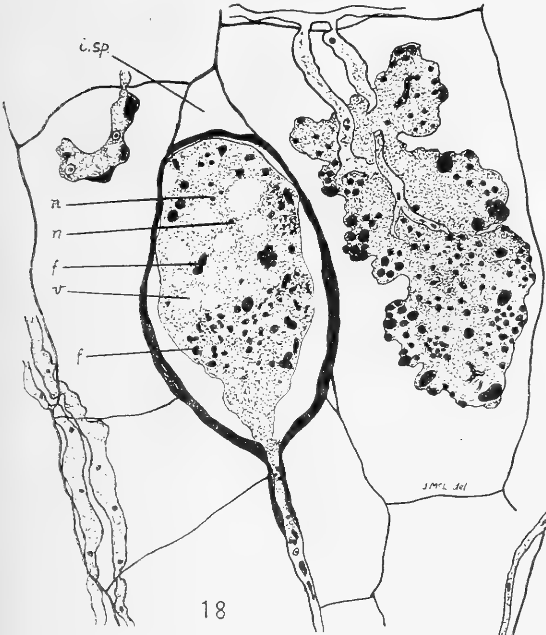
All stages from the developing arbuscules, through the young sporangioles, the bursting sporangioles, to the coalescence of the small fat globules to form a few large ones, and the digestion of the hyphae and fungal cytoplasm, may be seen throughout the cortical cells of a single rootlet in longitudinal section (Text-fig. 12), but there is no characteristic zonation of these phenomena, as described for *Lolium* roots. In each rootlet the endophyte passes through the same stages of development; the rootlet may die or undergo secondary thickening; in both cases any living portion of the endophyte is relegated to the soil; young lateral roots are readily infected during their early growth from the parent root from which they arise.

Within the mass of extremely granular cytoplasm and disintegrating hyphae lies the nucleus of the host cell (Text-fig. 11), which by now has undergone a marked transformation. It has increased greatly in size, but does not show any metamorphosis such as the lobing commonly seen in Orchidaceous mycorrhizas; it remains typically ovoid and there is no indication of fragmentation as recorded in other mycorrhizas. The nucleolus undergoes enlargement and there is a great increase in chromatic material which becomes dense, granular, and stains deeply. At this stage the nucleus resembles one in the early prophase of mitosis (Text-figs. 11, 15). The following measurements show the difference in size between the nuclei of infected and uninfected cells.

	Av. of 100 nuclei.	
	Infected Cells.	Uninfected cells.
Length	8·7μ	5·5μ
Breadth	7·0μ	4·6μ

The length of nuclei of uninfected cells ranges from 7·4μ to 3·7μ, the breadth from 6·7μ to 3·7μ; for infected cells the respective ranges are 18·5μ to 4·5μ and 9·25μ to 4·5μ. These data reveal an average increase of 58% in length and 52% in breadth in the nuclei of infected cells. As this results in a very considerable increase of nuclear volume, and as the chromatic material becomes more abundant, it is apparent that during the processes of liberation of the fat globules from the sporangioles, and the digestion of the fungal hyphae in the host cells, the nucleus displays an interesting growth phase, which may be the direct result of either abnormal nutrition (as compared with an uninfected cell) or of chemical stimulation. The chemical processes involved in the transformations of the endophyte must involve intense physiological activity within the cell and are partly expressed as nuclear growth. Probably both factors, abnormal nutrition and chemical stimulation, are responsible for these nuclear phenomena.

Gradually the cytoplasm of the disrupted sporangioles becomes less and less granular, and the whole mass decreases in bulk, so that by the time small fat globules have aggregated to form the few large globules, only a small quantity remains (Text-figs. 12, 13). The other cell contents at this stage are the nucleus of increased size and chromatin content, a few fragments of collapsed hyphae, and the host cytoplasm associated with the nucleus and the disintegrating endophyte. The hyphae, the remnants of the sporangioles and the fungal cyto-



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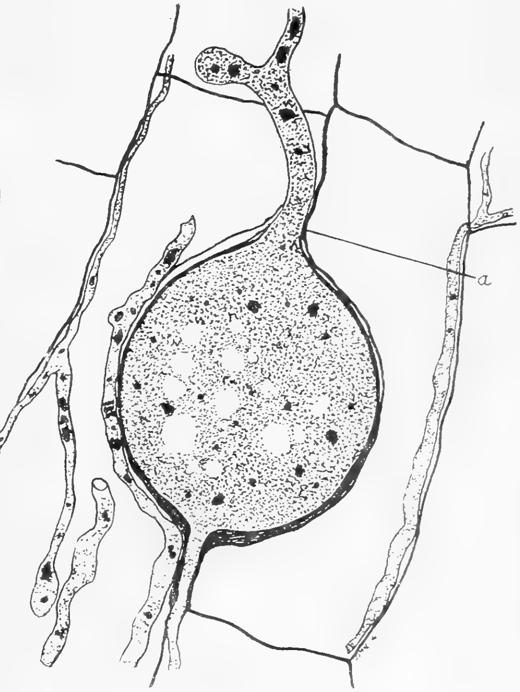

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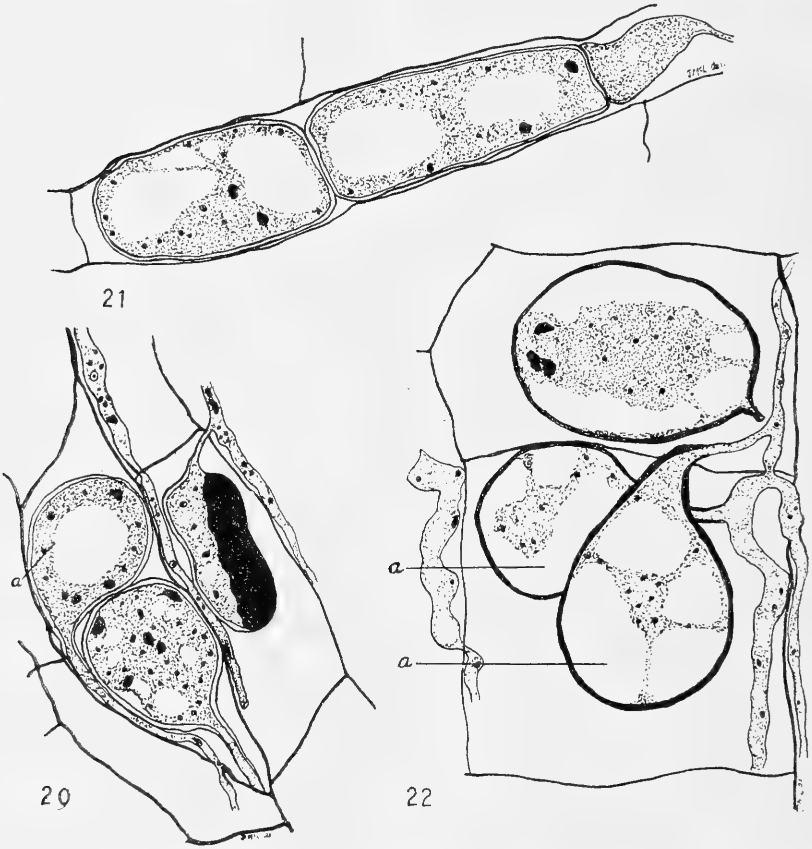
Text-fig. 18.—Fat accumulation in a complex of sporangioles, and a terminal vesicle (*v*) showing the thick wall; the numerous nuclei (*n*) and irregular fat masses (*f*) are depicted. The vesicle is developed within and distends the intercellular space (*i.sp.*), thus compressing the cortical cells around it. × 735.

Text-fig. 19.—An intercalary vesicle developed within an intercellular space. The hypha grows onwards from the apex at (*a*). Fat masses are seen in the vesicle, and in the hyphae. A spherical vesicle is somewhat exceptional in *Eriostemon* mycorrhiza. × 735.

plasm gradually lose their identity and disappear into a dense mass which generally loses all semblance of structure, but is occasionally reticulate (Text-fig. 14): it stains deeply, especially with haematoxylin, and is chemically different from the fat globules which still stain black with the osmic acid. Changes then begin to appear in the large fat globules; lighter areas suggesting vacuolation appear in them when stained with the osmic acid, indicating a change in the reaction from osmic-positive to osmic-negative (Text-figs. 16, 16*a*). As the osmic acid-positive reaction is typical of true fats and lipoids (Cramer, in Lee, 1921), it seems that, owing to the change in the large globules, their chemical nature gradually alters and they lose the power of being oxidized by osmic acid. In all stages of their history these globules are soluble in chloroform and readily stain with Malachite green. Although in their later phase, apparently associated



Text-fig. 20.—A complex of three vesicles, two being terminal and developed within an air-space, and one being formed on a lateral branch of a hypha within a cortical cell. At (*a*) vacuolation is apparent. × 735.

Text-fig. 21.—A linear series of 3 vesicles developed within a single cortical cell. The shape of these vesicles conforms to the cell lumen. × 735.

Text-fig. 22.—A group of 3 vesicles, all formed within cortical cells on branches of the same intercellular hypha. At (*a*) advanced vacuolation is seen. Gradually the vesicles are reduced to empty sacs. × 735.

with their digestion and removal from the cell, they do not react like typical fats and lipoids, they nevertheless possess the properties of fatty substances.

While they are osmic-positive they also stain pink with Sudan III in glycerine when fresh sections are treated, but in their final stage when they are partly or wholly osmic-negative they stain yellow with this reagent.

From these microchemical reactions it seems that true fats are present in the hyphae, arbuscules, sporangioles and within the cell cavity after disruption of the sporangioles, and even until the hyphal complex and cytoplasm of the sporangioles are well on the way to digestion. Their positive reaction is gradually lost owing to their removal from the cells when they are probably no longer true fats. Frequently, after the removal of the large fat globules from the host cell in which they were accumulated, there is left a mere shell which stains dark with osmic acid (Text-fig. 16*a*).

The large globules of fatty material which accumulate in the cells of the host root, owing to liberation from the ruptured sporangioles, are ultimately removed, presumably by the host. Similar globules have been observed occasionally in the epidermis and frequently in cells of the outermost cortical layer (Text-fig. 17). They are often so large that they distend the cell-membranes. As these cells do not show any trace of the presence of arbuscules, of disintegrating sporangioles, or of hyphae, it must be assumed that they have been translocated there from other cells in which they had been previously accumulated.

This observation indicates movement of fatty substances from infected to non-infected cells of the root, and their re-formation in a similar chemical form. Why fats should be accumulated in the superficial layers of the root, rather than entirely in the inner layers next the stele, is a problem not readily solved.

We have observed no trace of fat-accumulation in the phloem of the stele, when sections are made from material fixed in strong Flemming's solution; therefore, if these substances are removed from the cortex of the root and are employed in growth or flowering of the plant, they are not represented within the stelar tissues as osmic-positive fatty substances, but as some more readily diffusible osmic-negative material, the identity of which we have not determined.

In addition to the osmic acid-positive fat globules there also occur other globules (probably oil) throughout the cortex; these are generally much smaller than the large fat globules, and do not react to the osmic acid. They stain readily with Malachite green. Their distribution is indefinite and they represent another form of oil or fat either formed by the fungus or by the host. They probably represent a secondary form of the fatty substances formerly liberated from the sporangioles.

(*e*). *Vesicles.*

(i). *Development* (Text-figures 18, 19, 20, 21, 22).—These structures are common in some roots, especially in the outer half of the cortical region; we have seen as many as twelve in a single longitudinal section of a 3mm. portion of a root. They are developed most commonly within the intercellular spaces and only rarely within the cell cavity. They are large ovoid, occasionally spherical, bodies averaging 68μ in length and 53μ in breadth. Typically terminal on an intercellular hypha, they occasionally develop in an intercalary position, the hypha swelling up to form the vesicle, and then budding out at the apex to continue the growth of the hypha again (Text-fig. 19). Their development within the intercellular spaces causes an encroachment on the surrounding cells and the walls in consequence are generally distorted by their growth pressure

(Text-figs. 18, 19). Vesicles also develop within the cell cavity when they conform generally to the shape of the cell (Text-fig. 21). They may occur in groups of 2 or 3, within the cells or in the intercellular spaces, arising terminally upon a main hypha or upon lateral branches (Text-figs. 20, 21, 22). In their incipient stage the wall is thin and they are filled with dense granular cytoplasm containing a few nuclei and a number of small fatty globules (osmic acid-positive). As the vesicle grows to maturity the nuclei increase in number, either by transfer from the hyphae or by division, and vacuoles appear in the cytoplasm. The cytoplasm frequently aggregates at the base and apex of the vesicles, and the wall becomes thickened when the vesicle develops to its full size. This appears to be the complete development in the living roots of *Eriostemon*, for degeneration then ensues. The vacuolation proceeds, with the removal of the fatty materials, the cytoplasm and nuclei, and finally only the thick wall remains about the empty and collapsing vesicle (Text-fig. 22, *a*).

(ii). *Function.*—The vesicles have been variously interpreted as vegetative, reproductive or storage structures. Gallaud (1905) regarded the vesicle as a normal phenomenon of all endotrophic mycorrhizas except those of the Orchidaceae, and considered them to be storage organs. The consensus of opinion, however, supports the view that the vesicles are reproductive organs of the fungus which have become more or less aborted within the host tissue. This view receives some support from Peyronel's (1923) observation that vesicles are formed in large numbers in the dead roots of *Triticum sativum*, *Zea Mais*, etc., in the soil, many of them "remplis de spores à tous les degrés de maturation". In consequence he regards them as sporangia, and records a peculiar modification of their outer wall, especially at their apex, to form numerous "canalicules" and fine "crévasses" which render it very fragile. His figures show vesicles with spores within the dead roots of Maize. He comments on the striking resemblance between the endophyte and the Phycomycetes and on the morphological similarity of the vesicles to the sporangia of *Endogone macrocarpa* figured by Tulasne. Our studies of the vesicles of the endophyte of *Eriostemon Crowei* confirm the striking resemblance to *Endogone* species studied by Thaxter (1922).

McLennan (1926) records in some of the vesicles of *Lolium temulentum* numerous spherical bodies, each of which appears to be nucleated and suggests that the vesicles are sporangia containing spores. This occurrence of spore-like bodies in the vesicles within the living tissues of *Lolium* seems to be exceptional, as their development is generally arrested. As the endophyte is most commonly found on young roots, many of which die, it is possible that the maturation of the vesicle normally occurs when the fungus is living a saprophytic existence in the soil or in dead roots.

The vesicles have also been interpreted as cysts which are liberated into the soil on the death and disintegration of the root, and which give rise to a new mycelium which is capable of infecting roots.

It must be admitted that the general morphology of the vesicles and the fact that they become filled with food reserves, develop in the outer cortex, and at times produce spore-like bodies, are in harmony with a reproductive function; but it must be remembered that as yet there has been no experimental confirmation of this function.

In *Eriostemon* no trace of spore-like bodies has been observed in the vesicles of the living roots of the host, and the vesicles examined all seem to pass through the same development, culminating in the withdrawal of the contents and collapse. It would seem that the abortion of these bodies is normally produced by the physiological interaction of the host and probably through the attenuation of the mycelial strain forming the mycorrhiza—so that they become nothing more than storage organs for the temporary accumulation of food reserves which are later transferred to the host. However, it may be possible to isolate vesicles from dead root-tissues of *Eriostemon Crowei*; and to test their functional capacity to form a mycelium directly or after producing a mass of "spores".

(*f*). *Physiology of the Mycorrhiza.*

The physiological relationship between the components of the mycorrhizal associations observed in the various phyla of the plant kingdom has naturally attracted the attention of investigators, and numerous hypotheses have been formulated to account for the associations. It is to be expected that many differences of interpretation of the relationships should appear, because, although all endotrophic mycorrhizas fall into two different categories, nevertheless differences in the reactions between the two components of the mycorrhiza may exist.

The various mycotrophic hypotheses seem to fall into the two following categories: (*a*) parasitism, and (*b*) mutualism. According to the former hypothesis, the endophyte is a parasite within the cells of the host's roots. According to Bernard's views (1904) the relationship of the endophyte and host, in the Orchidaceae at any rate, is one of chronic parasitism which persists from the time of seed germination to the adult condition, a "maladie parasitaire chronique qui commence à la germination et persiste en général jusqu'à l'état adulte; maladie bénigne", and a natural state for this family. He postulates the maintenance of a remarkable balance between the fungus and the orchid plant; a reciprocal relationship which appears to him to border on disease. The digesting cells of the root were compared with the phagocytes of the animal body, and the fungus was kept in check by the process of digestion comparable to phagocytosis.

Gallaud (1905) also regarded the relation of endophyte to host as parasitism. the fungus living an independent existence within the host and deriving its nutriment from the host cells. In coming to this conclusion he was impressed by the scarcity of hyphal connections between the internal cells of the roots containing the fungus and the external mycelium.

McDougall (1899) believed that the endophyte obtained all or a large amount of its nutriment from the cells of the root, although, as only a small percentage of host-cells are infected by the fungus and its digestion takes place, the host may receive some advantage. He regarded the endophyte essentially as an internal parasite, but owing to the digestion probably giving some benefit to the higher plant, looked upon this association as symbiotic in which definite benefit accrued to the higher plant at least.

The latter hypothesis of mutualism or symbiosis, has probably the greatest number of exponents. Frank (1885) believed that the endotrophic fungus functioned in the place of root hairs, and provided the plant with mineral salts and organic matter and nitrogenous materials from the humus; in return, the host supplied carbonaceous materials to the endophyte. This hypothesis was later somewhat modified to the effect that the higher plant secured nitrogenous food by the digestion of the fungus in certain cells.

Stahl (1900) hypothecated the absorption of mineral salts by the endophyte. and endeavoured to establish a causal relation between low transpiration and the mycotrophic habit, and high transpiration and the absence of the mycotrophic condition.

Kusano (1911) regards the fundamental relationship as an exchange of nitrogenous material from the fungus to the host. Some indirect support of this view has been provided by Weevers (1916) who, studying the distribution of ammonium salts in mycorrhizal plants and Leguminous tubercles, found that they were lacking or present in very small amounts in the former, and concluded that nitrogen fixation, if facilitated by the root fungus, must be brought about in a different way from that in the Leguminosae; that the mycotrophic plants with the assistance of the fungus are able to use organic nitrogenous compounds from the soil.

The nitrogenous hypothesis has been supported by numerous investigators, often without any experimental evidence; but direct evidence of nitrogen fixation by endophytic fungi isolated from the roots of higher plants has been provided by Ternetz (1907) and Neilson-Jones and Smith (1928). Ternetz succeeded in isolating eight pycnidia-producing forms from the roots of the Ericaceae referable to the genus *Phoma*, and found that their capacity for nitrogen fixation was variously developed. Duggar and Davis (1916) in similar experiments with a *Phoma betae*, isolated from soil and grown on a medium containing a known amount of nitrogen, found a degree of nitrogen fixation comparable to that of the *Phoma* species studied by Ternetz. The values ranged from 3·022mg. to 7·752mg. per 50 grams of culture fluid in 25 days.

Rayner (1922) isolated from *Calluna* roots a pycnia-bearing fungus which showed similar characters to those isolated by Ternetz from other Ericaceae, and assumed that it was capable of nitrogen fixation. This viewpoint was supported by the fact that pure culture seedlings, inoculated with the endophyte and grown on an agar-medium lacking combined nitrogen, developed as vigorously as controls to which potassium nitrate had been added at the rate of 0·5 grm. per litre. The deduction from this experiment seems reasonable, but Neilson-Jones and Smith, using the strain of *Phoma radicis callunae* isolated by Rayner from *Calluna*, and eliminating every conceivable source of error, confirmed experimentally Rayner's assumption of nitrogen fixation, securing values approximating to those of Ternetz for other species or strains of *Phoma* from other members of the Ericaceae.

Therefore, so far as the family Ericaceae is concerned, the nitrogen fixation hypothesis of the endophytic mycorrhiza appears reasonably established, but the position is different in other mycotrophic plants.

McLennan (1926) provides quite a different interpretation of the physiological relationship between the endophyte and the root cells in *Lolium temulentum*. She has observed that the fat present in the internal mycelium of the endophyte is transferred to the sporangioles within the host cells, and is later discharged into the cell cavity through disruption of their membrane. The fat is subsequently removed from the host cell, and is utilized by the higher symbiont, leaving a structureless refringent residuum formed by the digestion of the cytoplasm and the hyphae of the ruptured sporangioles. From this evidence McLennan concludes that the nutritive exchange is carbonaceous rather than nitrogenous—the fat or oil being used by the higher plant for its nutrition. She further concludes that the fungus apparently derives little or no benefit from the association and that "the green plant is parasitic on the lowly member, being the agressive partner of the union".

Fraser (1931) has described an interesting type of mycorrhiza in *Lobelia dentata* in which the infection of the roots is by means of rhizomorphs, and the endophyte is wholly intercellular throughout the cortex and does not develop arbuscules or sporangioles. Her figures indicated the accumulation of a "large number of small darkly staining droplets of reserve food material" in the endophyte when treated with osmic acid. These droplets are ultimately transferred to the cortical cells of the host and appear in the primordial utricle especially as small droplets similar in staining properties to those of the endophyte. "Concurrently with this change the latex vessels in the phloem come to contain material which stains darkly with osmic acid", the inference being that the translocation of these osmic-acid-positive droplets from the roots is by way of the laticiferous vessels of the phloem.

From the figures and from the fact that the droplets stain "darkly" with the osmic acid, it would appear that they are fatty bodies, probably true fats. If this be so, the endophyte of *Lobelia dentata* accumulates fat, which is subsequently given up to the higher symbiont on the disintegration of the fungus and the nutritive exchange is primarily carbonaceous in character. Physiologically, therefore, the endotrophic mycorrhiza of *Lobelia* seems similar to that of *Lolium* and *Eriostemon Crowei* in regard to the nutritive relations of the symbionts, but morphologically it belongs to an intercellular type without arbuscules or sporangioles and producing rhizomorphic infection strands.

Our study of the endophytic fungus of *Eriostemon Crowei* has revealed a striking parallelism between *Lolium* and *Eriostemon* in the relationship of endophyte to higher plant. This homoplasy is all the more striking when we realize that these mycotrophic plants belong to families so remote from each other systematically and morphologically as the Gramineae and the Rutaceae. As is to be expected, there are differences in detail but the same fundamental development in the physiological relations of the symbionts is apparent. There is an accumulation of fats in the intercellular hyphae of the cortical region of the root; these fats react positively to the osmic acid; their origin is a matter for speculation, but probably they are synthesized by the active hyphae of the endophyte from organic materials derived either from the host or from the humus of the soil, or from both sources. These fats are transferred to the developing arbuscules, which are later transformed into sporangioles, and accumulate in numerous small globules. They still retain their positive reaction to osmic acid. Subsequently changes take place in the globules, which lose their true fat properties (as indicated by failure to stain with osmic acid) and disappear from the host cell. A residuum of the disintegrated fungal cytoplasm and hyphal complex of the sporangioles remains within the host cell, often associated with an enlarged nucleus of the latter and its cytoplasm. There is no doubt that in the mycotrophic *Eriostemon Crowei* the fatty substances accumulate within the various parts of the endophyte, are given up to the host cell and ultimately disappear from it, presumably being used by the plant. These processes and nutritive exchange proceed during the life of the rootlets of the host, the endophyte in the young or recently infected rootlets developing to the sporangiole condition, while in the older rootlets it is giving up its nutriment to the plant. We have not determined any definite synchronization between fat liberation into the host cells and flowering and fruiting of the higher plant. All the processes of development of the endophyte are as readily seen in the minute rootlets of tiny seedlings a few inches high as in those of a mature plant in full flower or fruit.

We are not, therefore, in a position to state that the function of the endophyte in *Eriostemon Crowei* is to supply necessary carbonaceous food for the higher symbiont during flowering and fruiting as seems to be possible for *Lolium*. As

Eriostemon is an apparently normal chlorophyll-bearing plant capable of synthesizing its own supplies of carbonaceous substances like any non-mycotrophic plant, the fats which are produced by the fungus and removed by the host subsequent to the disruption of the sporangioles would appear to us to represent merely a subsidiary supply, although fairly considerable. We cannot believe that the supply of fats by the fungus would be adequate for flowering and fruiting of the host. We are inclined to regard the presence of the endophyte, in this instance, as a form of incipient or benign parasitism, in which the host is able to dominate the development of the fungus, and finally to bring about the digestion of the intracellular portions of the fungus, namely, the arbuscules and sporangioles. In short the initial parasitism by the endophyte is transformed into parasitism by the host.

In its early stages the endophyte is probably parasitic, for the superficial and epidermal hyphae contain much less cytoplasm and nutritive material than the cortical hyphae, while some of the hyphae in the epidermis are almost empty. The rapid growth and migration of the endophyte, therefore, seem to depend principally on the absorption of food from the cells of the host, the excess of food from the mycelium being stored in the cytoplasm as osmic-positive fats. However, the numerous connections between the internal and external hyphae probably provide organic material for the fungal synthesis, and subsequent growth, and water and inorganic salts for the host, as it does not seem probable that the whole of the water and mineral requirements of the plants are provided by the scanty root hair system.

The arbuscules probably represent haustoria for the more efficient absorption of food supplies from the cells of the host, and the subsequent development of the sporangioles and fat accumulation in them are caused by some chemical or physiological action of the host cytoplasm upon them. It is chiefly at the time of sporangiole development that the dominant effect of the host becomes apparent; for, up to the time of arbuscule formation, the behaviour and growth of the fungus are compatible with parasitism. From the beginning of sporangiole development, the relation of host and endophyte becomes changed but the cause of this change can only be surmised.

Judging from its morphological characters, especially the structure of the vesicles, the endophyte seems to resemble species of the genus *Endogone*, but its isolation (if possible) may assist us to identify it. Isolation work is proceeding, with a view to (*a*) identification of the fungus, (*b*) attempts to synthesize the mycorrhiza by inoculation of aseptically raised seedlings, (*c*) discover whether the mycotrophic condition in *Eriostemon* is obligatory, and (*d*) test the capacity of the endophyte for fixation of nitrogen.

SUMMARY.

1. It has been demonstrated that *Eriostemon Crowei* F.v.M. and other species and genera of New South Wales Rutaceae are mycotrophic.

2. A detailed cytological examination of the endophyte has been made and the mycorrhiza falls into Gallaud's first series, for the hyphae are both intracellular and intercellular.

3. The surface of the root is reticulated in places with the mycelium of a fungus, which is septate, brown in colour and with thick walls and scanty cell contents. It adheres closely to the epidermal cells, branches frequently and develops swellings resembling appressoria from which the infecting hyphae arise.

4. Root infection takes place through the epidermis directly, and the infecting hypha frequently forms a closely coiled mass within the epidermal cells. These epidermal hyphae are thick walled and generally have sparse contents and poor staining capacity.

5. The migration of the endophyte takes place in a transverse and a longitudinal direction, chiefly along the intercellular spaces, but frequently through the cell-walls or cavities. These cortical hyphae are irregular, thin walled, with abundant granular cytoplasm, numerous nuclei and fat masses. Dimorphism of the hyphae is apparent in the arbuscule-producing endophyte, the epidermal hyphae being quite different in appearance from the cortical hyphae, which alone form the arbuscules and sporangioles.

A second endophyte with moniliform hyphae occurs in the epidermis and cortex of the roots; there is, therefore, double-infection by an arbuscule-forming endophyte and by a *Rhizoctonia* form. A *Rhizoctonia* form has been isolated from roots, but the arbuscule-forming type has not yet been isolated.

6. Arbuscules, both simple and complex, are formed from the intercellular hyphae or from the intracellular hyphae within the cortex. Later the arbuscules develop into groups of sporangioles.

7. Fats which react positively to the osmic acid of Flemming's fluid are present in the intercellular hyphae, in the arbuscules, and in the developing sporangioles. Ultimately the fat accumulates in the sporangioles, and is later liberated into the host cavity on their disruption. Sometimes hundreds of small globules are present in a cell. Later they coalesce to form several very large globules. They still react positively to osmic acid and appear homogeneous.

8. The large fat globules later stain unevenly with osmic acid, and finally do not stain at all. Thus the globules are no longer true fats. At the same time their reaction to Sudan III in glycerin changes from pink to a yellowish-brown colour. They still stain with Malachite green and are still soluble in chloroform. They ultimately disappear from the cell, and are probably used by the host. Large fat globules also appear in uninfected cells of the epidermis.

9. As these processes can be seen in very small seedlings as well as in mature plants in full flower and fruit, we cannot co-ordinate the disappearance of the fats with the period of flowering and fruiting of the higher plant, as McLennan is able to do for *Lolium*.

10. The remnants of the sporangioles and hyphae become disintegrated and reduced to a structureless but occasionally reticulate residuum which remains in the cell.

11. After the liberation of the fat from the sporangioles, definite changes become evident in the host nucleus which increases in volume, and shows very pronounced chromatic increase, but no structural hypertrophy, e.g., lobing, etc.

12. Vesicles are developed chiefly in the intercellular spaces of the outer cortex but occasionally within a cortical cell; they are usually terminal, occasionally intercalary or lateral. They contain a large amount of cytoplasm, numerous fat masses and nuclei. Later they develop a thick wall and become vacuolated, and subsequently lose all their contents to the vegetative hyphae or the sporangioles.

13. At first, fat accumulates in all parts of the fungal body, but whether at the expense of the organic materials of the host cells or through synthesis by the fungus itself, from materials removed from the humus of the soil by the numerous infecting hyphae, we cannot say. Ultimately this fat accumulates in the sporangioles within the cells of the host, is liberated into the cell cavities

and is removed by the host. Thus there is an undoubted exchange of fatty materials from the fungus to the host.

14. While the entrance of the fungus to the host root indicates parasitism, the fact remains that the endophyte is controlled and largely digested by the host cells, which receive considerable quantities of fat and, therefore, in the final resort, the higher plant is parasitic upon its endophyte.

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THE GASTEROMYCETES OF AUSTRALASIA. XV.

THE GENERA MESOPHELLIA AND CASTOREUM.

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(Plate vi.)

[Read 28th September, 1932.]

A study of the literature shows that those who have worked with the Gasteromycetes have had difficulty in classifying the genera *Mesophellia* and *Castoreum* (including *Diploderma*). Thus de Toni (1888, p. 48) placed *Mesophellia* under the subfamily Podaxineae, "*Diploderma*" under the Diplodermeae, and *Castoreum* under the Sclerodermeae; and this arrangement was followed by Cooke (1892, p. 222, 232, 242). Fischer (1900, p. 338, 342) placed *Castoreum* under his "Ungenuegend bekannte Gattungen" of the Sclerodermaceae, and "*Diploderma*" and *Mesophellia* under a similar section of the Calostomaceae. Lloyd (1905, p. 5) placed *Castoreum* and *Mesophellia* under his tribe 5-Anomalae (defined as "not allied to previous tribes or to each other"), but did not mention "*Diploderma*". And in later papers he frequently commented on the difficulty of assigning these genera to a satisfactory position, claiming that their spores and glebal colour suggested affinities with the Phallales, and their hypogaean habit with the Hymenogastraceae. Dodge (1929) considered *Mesophellia* to be an Ascomycete, and placed the genus under the tribe Mesophellieae of the Elaphomycetaceae (one of the hypogaean Tuberales).

As will be shown, these genera exhibit little relationship to the Sclerodermaceae, less to the Diplodermeae (as defined by de Toni), and none to the Calostomaceae, Podaxaceae or Elaphomycetaceae, but are in reality members of the Lycoperdaceae.

I have recently worked over 34 collections loaned by Dr. J. B. Cleland, Adelaide, and Mr. L. Rodway, Hobart, and from this material (representing about 160 plants altogether), have been able to work out the following particulars regarding the species of these two interesting genera.

Structure of the Mature Plant.

In *Mesophellia* plants are hypogaean, being exposed apparently accidentally by marsupials or as a result of cultural operations. The peridium of the species studied is two- or three-layered, and encloses a pulverulent gleba of capillitium and spores. The exoperidium is in the nature of a firm, relatively thick (2–3 mm.) tissue composed exteriorly of sand, earth or vegetable debris cemented to a firm fibrous tissue in which the hyphae appear to be aggregated into fascicles. The exterior, especially, varies considerably in appearance, toughness and thickness, according to the substratum in which the plant has developed. The endoperidium is a firm, parchment-like membrane, about 0·25 mm. in thickness (2 mm. thick in *M. castanea*), composed of a pseudoparenchyma of closely woven, partly gelatinized hyphae. Between these layers lies (in *M. arenaria* and *M. pachythrix*) a loosely woven layer, somewhat cellular in composition. Dehiscence occurs through the gradual weathering of these membranes.

The gleba is olivaceous in colour, and consists of a prominent central core, capillitium, and spores. This central core is the characteristic feature of the genus, and is held in place by lateral strands (trabeculae) of the same tissue, which extend to and are firmly attached to the inner wall of the endoperidium. (See the exception noted under *M. castanea.*) Although firm, this tissue can be cut readily with a razor, for it is not of a "texture of the finest grained hard wood" as stated by Lloyd (1905, p. 39), but rather of a "cheesy" consistency. Sections show it to be composed of partly gelatinized hyphae firmly compacted together. The trabeculae holding the core in position are few and large in *M. arenaria*, very numerous and slender (appearing as fine hair-like strands) in *M. pachythrix*, and delicate groups of capillitium threads in *M. castanea*. The function of the central core is unknown, but it is possibly merely undifferentiated primordial tissue, unused during development of the gleba. This belief is partly supported by the fact that the core varies considerably in size in different plants, being scanty in some, whereas in others it occupies the greater part of the gleba. Capillitium and spores occupy the space between the endoperidium and central core. The threads of the capillitium vary in thickness in different plants, ranging from 3 μ to 10 μ, small plants possessing thin hyphae, larger ones coarser threads. They are copiously developed, hyaline or tinted, septate, somewhat swollen at the septa, possess clamp connections, and are arranged in palisade fashion, with their long axes parallel with the trabeculae of the central core. The spores are elliptical, and each is provided basally with a short pedicel, the remnant of the sterigma by which it was attached to the basidium.

In *Castoreum* the peridium is of the same three-layered type; but the endoperidium is externally fibrous and does not consist of firmly cemented sand particles as in *Mesophellia*. In *C. cretaceum* the exoperidium is reduced to a tenuous layer of hyphae closely adherent to the endoperidium. In this genus the endoperidium is from 1 to 2 mm. in thickness. In *C. radicatum* and *C. tasmanicum* it is leathery and tough, whereas in *C. cretaceum* it is woody and brittle. Dehiscence in all three species is effected by the apical portion becoming torn into lobes, which in *C. cretaceum* become lanceolate and upturned, giving to old plants a castellated appearance. A prominent rooting strand is present in *C. radicatum* (in fact in the type collection this is prolonged into a cord several centimetres in length), and to a lesser extent in *C. tasmanicum*, but is apparently wanting in *C. cretaceum*. The capillitium is well developed, and composed of hyaline, septate threads, which lack the parallel arrangement present in *Mesophellia*.

Spores in the three species examined show the same general resemblance to *Mesophellia*, but are distinctly larger in *C. tasmanicum* and *C. cretaceum*. They are provided with a prominent gelatinous tunic, which gives to the spores, when mounted dry or in water, a wrinkled or warted appearance. Traces of this structure are present on the spores of *Mesophellia*, but can be seen usually only when spores are heated in lactic acid solution and stained with anilin blue or some similar reagent.

In *Mesophellia arenaria* and *Castoreum tasmanicum* (at least) the spores are borne on considerably inflated basidia (on short sterigmata) which are irregularly arranged around small glebal cavities. No definite hymenium is formed, the basidia being irregular in size and shape. Apparently two spores are attached to each basidium, since I have not observed a greater number than this. I have not been able to examine immature specimens of the other species described in this paper.

Systematic Position of the Genera.

Such features as the pulverulent gleba, copious capillitium, and absence of a definite stem, indicate that these genera belong to the family Lycoperdaceae. The three-layered peridium of the majority of species shows their position lies between the tribes Lycoperdeae and Geastreae. Although it might be claimed that the central core of *Mesophellia* shows a relationship to the Geastreae, the nature of the two structures is entirely different, for in *Mesophellia* this structure is composed of pseudoparenchyma, whereas the columella of *Geaster* is formed of loosely woven hyphae. The different capillitium and spores strengthen the belief that both genera are sufficiently removed from genera of the Lycoperdeae and Geastreae to warrant their being placed under a separate tribe of the Lycoperdaceae. The genus *Abstoma* shows a general resemblance to *Mesophellia* and *Castoreum* in several particulars; resembling *Mesophellia* in the nature of the exoperidium, endoperidium and method of dehiscence, and *Castoreum* by the gelatinous (although coloured) tunic enclosing the spore. It differs in the nature of the threads of the capillitium. But as the relationships of *Abstoma* are more with those of *Mesophellia* and *Castoreum* than with other genera of the tribe Lycoperdeae, I believe it should be removed from its present position and placed with these two genera, under a third tribe of the Lycoperdaceae; and propose emending my previous classification of the family (1927, p. 253) as under:

I. Tribe LYCOPERDEAE: Peridium 2-layered, dehiscing by an apical stoma (irregular or wanting in *Calvatia* and *Mycenastrum*); capillitium attached or free, simple or freely branched; spores globose, typically echinulate (rarely smooth); basidia clavate, sterigmate, 4-spored.
    (Containing the genera 1. *Calvatia*, 2. *Lycoperdon*, 3. *Bovistella*, 4. *Bovista*, 5. *Disciseda*, and 6. *Mycenastrum*.)

II. Tribe MESOPHELLIEAE: Peridium commonly 3-layered, indehiscent, or rupturing irregularly at the apex; capillitium unbranched; spores globose or elliptical, usually with a gelatinous tunic; basidia inflated, sterigmate, apparently 2-spored.
    Spores globose, reticulated .... 1. *Abstoma* G. H. Cunn.
    Spores elliptical, smooth or irregularly roughened.
        Gleba with a central core .... 2. *Mesophellia* Berk.
        Gleba without a central core .... 3. *Castoreum* Cke. et Mass.

III. Tribe GEASTREAE: Peridium 4-layered, endoperidium dehiscing by an apical stoma; capillitium attached, unbranched; spores globose, typically echinulate; basidia sterigmate, 4-8-spored.
    (Containing the genus *Geaster*.)

All genera of the tribe Mesophellieae are confined to this biological region. *Abstoma* is represented by *A. reticulatum*, confined to Australia, and *A. purpureum*, confined to New Zealand; *Mesophellia* and *Castoreum* each contain three species which are confined to Australia and Tasmania. Lloyd (*Myc. Notes*, 1924, p. 1305) recorded *Mesophellia* from California; but examination of the type (a portion of which was kindly forwarded by Dr. C. L. Shear) shows that Lloyd's *M. Taylori* was erected upon an unexpanded *Geaster*.

1. MESOPHELLIA Berkeley.

Trans. Linn. Soc., Bot., xxii, 1857, p. 131.—*Inoderma* Berk., *Jour. Linn. Soc.*, Bot., xviii, 1881, p. 386.—*Potoromyces* Muell. ex Hollos, *Noev. Koez.*, i, 1902, p. 155.

Plant subglobose or elliptical, solitary or caespitose, dehiscing by irregular weathering of the peridium, hypogaean. Peridium usually of 3 well developed layers; exoperidium firm, thick (1–3 mm.), brittle, exteriorly of sand, earth or vegetable debris firmly cemented together, interiorly of finely compacted fibrous tissue; central layer of loosely woven rather coarse hyphae arranged in a somewhat cellular fashion; endoperidium thin, 0·25 mm. (to 2 mm. thick in *M. castanea*), tough and parchment-like, pseudoparenchymatous, free from the exoperidium. Gleba of capillitium and spores, lying between the endoperidium and a central firm core which is held in position by trabeculae of the same tissue attached to the endoperidium; capillitium threads copiously developed, usually hyaline, septate, arranged in parallel series. Spores elliptical, smooth (or with a trace only of a gelatinous tunic), with a short, persistent basal pedicel.

Habitat.—Hypogaean, growing solitary or caespitose, buried in sandy soils, becoming exposed by marsupials or as a result of cultural operations.

Type species, Mesophellia arenaria Berk.

Distribution.—Australia; Tasmania.

The genus is characterized by the peculiar, sclerotioid central core, which occupies the greater part of the gleba. This structure is held in place by lateral strands of the same tissue (trabeculae), attached to the wall of the endoperidium, and between them lie the capillitium and spores. The abundant hyphae of the capillitium are arranged in a conspicuous palisade manner, parallel with the trabeculae of the central core.

The genus contains three known species, which closely resemble one another. Separation may be effected by the nature of the central core, for in *M. arenaria* this is held in place by a few coarse lateral strands, in *M. pachythrix* the strands are very numerous and appear as slender, delicate, hair-like processes, whereas in *M. castanea* they are apparently absent, being represented by bundles of capillitium loosely intertwined. The numerous other species which have been recorded are synonyms of these, of species of *Castoreum,* or were based on unexpanded Geasters or Lycoperdons.

The claim made by Dodge (1929) that the genus belongs to the ascomycetous family Elaphomycetaceae is without foundation. I have examined immature specimens of *M. arenaria* (and also of *Castoreum cretaceum*) and find the spores to be attached by short stout sterigmata to inflated basidia which are irregularly arranged around small glebal cavities. That the spores are basidiospores is substantiated by the fact that in all species examined, of both genera, each is provided with a short basal stump or pedicel, which is the remnant of the sterigma by which it was attached to its basidium. Furthermore, the capillitium in all species is provided with clamp connections, a feature confined, to my knowledge, to the Basidiomycetes.

I have found the structures illustrated by Dodge and considered by him to be evidence of the fact that the genus is an Ascomycete. They are undoubtedly ascomycetous in origin, but as the mycelium from which they arise is coloured and closely septate, and as the spores are of a different shape, slightly smaller, smooth and not provided with stumps of pedicels, it is evident they belong to an ascomycete saprophytic or more probably parasitic upon the gleba.

1. MESOPHELLIA ARENARIA Berkeley. Pl. vi, figs. 1, 2, 6.

Trans. Linn. Soc., Bot., xxii, 1857, p. 131.—*Inoderma arenaria* Berk., *Journ. Linn. Soc.*, Bot., xviii, 1881, p. 386.—*Diploderma glaucum* Cke. et Mass., *Grev.*, xv, 1887, p. 99.—*D. sabulosum* Cke. et Mass., *Grev.*, xxi, 1892, p. 38.—*Potoromyces loculatus* Muell. ex Hollos, *Noev. Koez.*, i, 1902, p. 155.—*Mesophellia* *sabulosa* (Cke. et Mass.) Lloyd, *Lyc. Aus.*, 1905, p. 40.—*Diploderma parvispora* Lloyd, *Myc. Notes*, 1919, p. 901.

Plant subglobose, or more frequently elliptical, 2–5 cm. long, 1–3 cm. diameter, solitary or caespitose. Exoperidium 1–3 mm. thick, firm but brittle, exteriorly of sand or earth particles cemented together, interiorly of coarse fibrous tissue; endoperidium thin, 0·25 mm., dingy white or pallid bay-brown, parchment-like, tough. Gleba olivaceous, seldom ferruginous; capillitium threads hyaline or tinted only, copious, unbranched, septate; central core attached by a few coarse, flattened trabeculae, which may attain a thickness of 2 mm. or more. Spores elliptical, 7–12 × 4·5–6 μ, apex bluntly rounded, base acuminate, with a persistent stump of a pedicel, tinted, smooth (or with traces only of a gelatinous tunic).

Type locality.—Tasmania.

Distribution.—Australia; Tasmania. South Australia: Kangaroo Island, 10/24, Prof. T. G. Osborn* (2 coll.); same locality, 10/26, Prof. Wood Jones* (2 coll.); Mt. Compass, 5/26, J. B. Cleland*.—Western Australia: Applecross, near Perth, 2/28, H. Perry (Herb. Dept. Agr. W. Aus.).—Tasmania: Mt. Field, 2/20, L. Rodway* (det. by Lloyd as *M. castanea*); Brown's River, 1/28, J. B. Cleland* (3 coll.); no locality, L. Rodway (2 coll., det. by Lloyd as *M. castanea*); no locality, L. Rodway (det. by Lloyd as *M. arenaria*).

The species varies considerably in the nature of the exoperidium. This may be a strongly developed sand-case, consist of sand particles firmly cemented to the exterior of a well developed fibrous tissue, appear as a tenuous but brittle layer of earth mixed with hyphae or covering the exterior of a hyphal membrane, or be composed of vegetable debris cemented to the surface. I feel convinced, however, that these differences are not specific, but result from the nature of the substratum in which plants are growing. Apparently plants develop some little depth below the surface, for all collections examined are recorded as being hypogaean, obtained from the vicinity of scrapings made by wallabies, bandicoots or rabbits, or turned up during ploughing operations. And this is supported by the fact that no external point of attachment is apparent.

As Lloyd (*Myc. Notes*, 1917, p. 639; 1921, p. 1057) has stated, and as the illustration by Cooke (1892, Pl. 15, f. 117) shows, *Diploderma glaucum* is but a synonym of this species. *Diploderma sabulosum* is likewise a synonym, since it differs only in the exoperidium being strongly covered with sand, a condition which, as I have shown above, cannot be considered specific. *Diploderma parvispora* was based on a half specimen forwarded to Lloyd by Dr. Cleland. I have examined the half retained by Dr. Cleland and find it to be typically a specimen of *M. arenaria*; for although the central core has disappeared, abundant remnants of the trabeculae remain fixed firmly to the endoperidium.

2. MESOPHELLIA PACHYTHRIX (Cooke and Massee). Pl. vi, figs. 3, 7.

Lloyd, *Lyc. Aus.*, 1905, p. 40.—*Diploderma pachythrix* Cke. et Mass., *Grev.*, xviii, 1890, p. 50.

Plants subglobose or tuberous, to 3 cm. diameter. Peridial characters as in the preceding species. Central core attached to the endoperidium by very numerous, slender, thread-like trabeculae which average from 0·1 to 0·25 mm. diameter. Gleba olivaceous, capillitium copious, threads as in the preceding species. Spores elliptical, 7–9·5 × 3–4·5 μ, apex bluntly rounded, basally acuminate,

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* An asterisk denotes that the collection in question is in the herbarium of Dr. J. B. Cleland, The University, Adelaide, South Australia.

and furnished with a stump of a pedicel, tinted, smooth (or with traces of a gelatinous tunic).

Type locality.—Tarwin, Victoria.

Distribution.—Australia; Tasmania. South Australia: Near Dashwood's Gully, 10/29, J. B. Cleland*; Blackwood Gully, near Kuitpo, 4/29, J.B.C.*—Tasmania: No locality, L. Rodway* (det. by Lloyd as *M. arenaria*).

This differs from the preceding species in the smaller spores and in the fine trabeculae holding the central core in position. The latter are so numerous (several scores being present in a representative specimen) and of such fine dimensions that they were described originally as threads of the capillitium. Under the microscope they are seen to be composed of fascicles of hyphae partly gelatinized and firmly compacted together. Cooke and Massee described the spores as minutely warted; most are apparently smooth, though some exhibit, if examined dry or in water, small irregularities which are rudiments of the gelatinous tunic so characteristic a feature of the next genus, as may be seen if spores are mounted in lactic acid solution and heated.

3. MESOPHELLIA CASTANEA Lloyd.

Myc. Notes, 1917, p. 640.

Plants subglobose or depressed globose, to 3 cm. diameter. Exoperidium wanting; endoperidium 1·5–2 mm. thick, firm and woody, avellaneous. Gleba avellaneous; capillitium threads copious, of unbranched, septate, tinted hyphae; central core held in place by slender trabeculae composed of loosely woven fascicles of a few capillitium threads, numerous. Spores elliptical, tinted, 7–10 × 3–5·5 μ, base with stump of a pedicel, with distinct traces of a gelatinous tunic present.

Distribution.—Australia. South Australia: Aldgate, C. C. Brittlebank (type, in Lloyd herb.).

The species was erected upon a half specimen now in the herbarium of the late C. G. Lloyd at Washington, D.C. It differs from the preceding in the apparent absence of trabeculae; but these are in reality present, but so slender as to be invisible unless examined under the microscope. They appear as distinct strands of loosely woven parallel bundles of capillitium. Through the courtesy of Dr. C. L. Shear, I have been able to examine a fragment of the type, and from this and Lloyd's description, have drawn the particulars given above. There is now no trace of an exoperidium on the specimen, but the clean nature of the endoperidium suggests this has been lost during collecting or subsequently, for there is no reason to believe, as Dodge suggested, that this differs from others in the genus in the absence of this structure.

Excluded Species.

(*a*). *Mesophellia ingratissima* (Berk.) de Toni, in Sacc. *Syll. Fung.*, vii, 1888, p. 57. = *Inoderma ingratissimum* Berk., *Jour. Linn. Soc.* Bot., xviii, 1881, p. 386.

As apparently no type exists (Lloyd, 1905, p. 40), and as the description is such that it is not possible to determine whether this belongs to *Mesophellia* or *Castoreum*, this name should be deleted from our records. The plant was said to be strongly scented, a feature noted by Dr. Cleland as present in collections of *Castoreum radicatum*, and one which suggests the possibility of the latter being the plant referred to by Berkeley.

(*b*). *Mesophellia sabulosa* (Cke. et Mass.) Lloyd = *M. arenaria.*

(*c*). *M. Scleroderma* Cke. et Mass., *Grev.*, xiv, 1885, p. 11.—This is a synonym of a plant Lloyd named *Gallacea Scleroderma*, a member of the Hysterangiaceae.

2. Castoreum Cooke and Massee.

Grev., xv, 1887, p. 100.—*Diploderma* Link, *Mag. Ges. Nat. Freunde*, vii, 1816, p. 44, *pro parte*; ex Cke. et Mass., *Grev.*, xv, 1887, p. 99.

Plant subglobose, with or without a rooting strand, hypogaean or epigaean; dehiscing by irregular rupture of the apical portion into few or many irregular lobes or laciniae. Peridium usually of 3 layers; a thick exoperidium of closely woven hyphae (reduced to a tenuous layer in *C. cretaceum*); a central layer of loosely woven rather coarse hyphae; and an endoperidium which is tough, thick, leathery, pseudoparenchymatous and often suberized. Gleba coloured, of capillitium and spores, but without a central core; capillitium threads hyaline, not arranged in parallel fashion, well developed (scanty in mature plants of *C. cretaceum*), septate. Spores elliptical, covered with a loose or close-fitting gelatinous tunic, which gives to them an irregularly verrucose or wrinkled appearance.

Habitat.—Growing partially or completely buried in sandy soils.

Type species, Castoreum radicatum.

Distribution.—Australia; Tasmania.

This genus is separated from *Mesophellia* by the absence of a central core, different method of dehiscence, and the prominent gelatinous tunic which covers the spores (present in rudimentary form in *Mesophellia*). The radicate strand is likewise a feature of the genus (absent from *C. cretaceum*) and, in the type collection, is prolonged into a strongly developed mycelial cord several centimetres in length. This would appear to be an abnormal condition, present only in the type collection, since in the plants described below, the rooting strand is reduced to a structure a few millimetres long.

Cooke and Massee (*Grev.*, xv, 1887, p. 100; ibid., xvi, 1887, p. 2) and Lloyd (*Myc. Notes*, 1917, p. 641) placed species of the genus under *Diploderma*. But this name is invalid, for it was applied by Link to an unexpanded specimen of *Geaster* (*Astraeus*) *hygrometricus*. Consequently the name for the genus becomes *Castoreum*.

The genus is confined to Australia and Tasmania, and would appear to be limited to the following three species, the others recorded being synonyms of these, of *Mesophellia*, or based upon immature specimens of *Geaster* or *Lycoperdon*.

Key to the Species.

Spores 8-12 μ long .... 1. *C. radicatum* Cke. et Mass.
Spores 14-18 μ long.
  Exoperidium well developed, 1 mm. or more in thickness .... 2. *C. tasmanicum* G. H. Cunn.
  Exoperidium thin, represented by a tenuous layer of hyphae attached to the endoperidium .... 3. *C. cretaceum* (Lloyd) G. H. Cunn.

1. Castoreum radicatum Cooke and Massee. Pl. vi, fig. 10.

Grev., xv, 1887, p. 100.—*Diploderma avellaneum* Lloyd, *Myc. Notes*, 1917, p. 641.—*D. castoreum* Lloyd, *l.c.*, p. 642.—*D. radicatum* (Cke. et Mass.) Lloyd, *Letter 65*, 1917, p. 11.

Plants subglobose, to 2 cm. diameter, attached to the substratum by a small basal rooting strand, dehiscing by the tardy rupture of the apical portion into two or three unequal lobes. Exoperidium to 2 mm. thick, of coarsely woven, rather coarse hyphae, externally partly covered with loosely adhering particles of earth or sand, or velutinate, bay-brown or umber, internally fibrous and bay-brown; endoperidium 1–2 mm. thick, tough and leathery, pseudoparenchymatous, bay-brown. Gleba pallid ferruginous; capillitium threads hyaline, copiously developed, septate. Spores fusiform, 7–12 × 4·5–6 μ, both ends rounded, or the apical end acuminate, base with a stump of a pedicel, covered with a coarsely and irregularly warted, close fitting, gelatinous tunic.

Type locality.—St. George's Bay, Tasmania.

Distribution.—Australia; Tasmania. Victoria: Portland, J. Dixon (type collection of "*Diploderma avellaneum*"; herb. Vic. Dept. Agr.).—South Australia: Willunga Hill, 5/26, J. B. Cleland*.—Tasmania: St. George's Bay, G. Wintle (Cke. et Mass., *l.c.*); Brown's River, 1/28, J. B. Cleland* (4 collections); Blackman's Bay, 2/28, L. Rodway*; no locality, L. Rodway*.

Diploderma avellaneum Lloyd is identical with *C. radicatum*, as I have ascertained by examination of the "type" collection in the herbarium of the Victorian Dept. of Agriculture. *D. castoreum* was erected by Lloyd in error, as later he altered the name to *D. radicatum*, his intention being to place *C. radicatum* under *Diploderma*, which he persisted in using.

Although in the original description of *C. radicatum* the spores were given as being 12 × 5–6 μ, Lloyd (*Myc. Notes*, 1917, p. 642) claimed they were 16 × 8 μ. In order to determine this point I requested Miss Wakefield to examine spores of the type at the Royal Herbarium, Kew; this she has kindly done and found them to be 10–12 × 5–5·5 μ.

Dr. Cleland in his collecting notes recorded that plants were strongly aromatic when freshly gathered. It is probable that this odour attracts marsupials, which dig plants out of the ground, since most are collected in the vicinity of scrapings made by these animals.

2. Castoreum tasmanicum, n. sp. Pl. vi, figs. 4, 8.

Plants subglobose, or depressed globose, to 3·5 cm. diameter, solitary or caespitose, attached by a small basal rooting strand, which may be well developed or almost wanting, dehiscing by the rupture of the apical portion into a few irregular lobes. Exoperidium 1–2 mm. thick, of closely woven hyphae, externally minutely velutinate, or partially covered with vegetable debris or earth, bay-brown or umber, internally fibrous, chestnut-brown; endoperidium 1–1·5 mm. thick, bay-brown or ferruginous. Gleba pallid ferruginous; capillitium threads copious, hyaline, septate. Spores elliptical, or elliptic-obovate, 14–18 × 8–10 μ, tinted, apex rounded, base often truncate, with a stump of a pedicel, covered with an irregularly warted, prominent gelatinous tunic.

Type locality.—Brown's River, Tasmania.

Distribution.—Tasmania: Brown's River, 1/28, J. B. Cleland* (4 collections); no locality, L. Rodway*.

This species closely resembles the preceding, but is separated by the much larger spores. "*Diploderma*" *insolitum* Lloyd is said to possess spores of the same size, but appears to differ in the presence of certain peculiar bodies in the gleba. I am unable to verify these points, since no type material is available in Australia.

3. Castoreum cretaceum (Lloyd), n. comb. Pl. vi, figs. 5, 9.

Diploderma cretaceum Lloyd, *Myc. Notes*, 1920, p. 1057.—*D. dehiscens* Lloyd, *Myc. Notes*, 1925, p. 1361, *nomen nudum*.

Plants subglobose to shortly elliptical, 1–1·5 cm. diameter, without a rooting strand, dehiscing by the apex becoming torn into numerous (12–18) upright laciniae. Exoperidium closely adherent to the endoperidium, appearing as a tenuous friable layer of loosely aggregated hyphal cells and earth particles; endoperidium 0·25–0·5 mm. thick, tough, woody, brittle, bay- or chestnut-brown, pseudoparenchymatous. Gleba pallid olivaceous; capillitium threads scantily developed, fragile, thin, septate. Spores elliptical, 13–16 × 5·5–7 μ, apex acuminate, or rounded, base with a distinct persistent stump of a pedicel, covered with a coarsely verrucose, loosely fitting gelatinous tunic.

Type locality.—Mt. Field, Tasmania.

Distribution.—Australia; Tasmania. South Australia: Willunga Hill, 8/27, J. B. Cleland*.—Tasmania: Mt. Field, L. Rodway (type collection); no locality, L. Rodway (det. by Lloyd as *D. cretaceum*); no locality, L. Rodway ("type" collection of *D. dehiscens*); no locality, L. Rodway (det. by Lloyd as *D. dehiscens*).

This differs from the preceding species in several particulars, as absence of a rooting strand, tenuous exoperidium, method of dehiscence, and scanty capillitium. It resembles *Scleroderma* in the method of dehiscence and scanty capillitium, and this resemblance is strengthened by the fact that in one immature specimen the gleba was composed of tenuous tramal plates. The spores show that it is more closely related to the genus *Castoreum*. The capillitium is copiously developed in young plants, but as plants approach maturity, the threads appear to become gelatinized and tend to break up readily.

Diploderma dehiscens is a synonym of this species, as in the type collection of the latter are present plants which exhibit the same method of dehiscence, and in all other respects both appear to be identical.

Excluded Species.

(*a*). *Diploderma alba* Cke. et Mass., *Grev.*, xvi, 1887, p. 2.—This was probably based upon an unexpanded *Geaster* or *Lycoperdon*.

(*b*). *D. avellaneum* Lloyd = *Castoreum radicatum*.

(*c*). *D. castoreum* Lloyd = *Castoreum radicatum*.

(*d*). *D. cretaceum* Lloyd = *Castoreum cretaceum*.

(*e*). *D. dehiscens* Lloyd = *Castoreum cretaceum*.

(*f*). *D. fumosum* Cke. et Mass., *Grev.*, xvi, 1887, p. 2.—Probably based upon an unexpanded *Geaster* or *Lycoperdon*.

(*g*). *D. glaucum* Cke. et Mass. = *Mesophellia arenaria*.

(*h*). *D. insolitum* Lloyd, *Myc. Notes*, 1917, p. 641.—This species was erected upon the numerous persistent bodies of peculiar form present in the gleba. Otherwise it appears to resemble *C. tasmanicum*. As I have shown, material is no longer available for study in Australia, so that the identity of the species, and the nature of these bodies, must remain at issue until further material is forthcoming.

(*i*). *D. melaspermum* Cke. et Mass., *Grev.*, xx, 1891, p. 35.—Probably based upon some unexpanded puff-ball.

(*j*). *D. pachythrix* Cke. et Mass. = *Mesophellia pachythrix*.

(*k*). *D. parvispora* Lloyd = *Mesophellia arenaria*.

(*l*). *D. radicatum* Lloyd = *Castoreum radicatum*.

(*m*). *D. sabulosum* Cke. et Mass. = *Mesophellia arenaria*.

(*n*). *D. suberosum* Cke. et Mass., *Grev.*, xv, 1887, p. 100.—Probably based upon an unexpanded *Geaster* or *Lycoperdon*.

The spores of *D. alba*, *D. fumosum*, *D. melaspermum* and *D. suberosum* were stated to be subglobose, spinose or smooth, and usually deeply coloured, which precludes their belonging to *Mesophellia* or *Castoreum*, but suggests they were based upon unexpanded specimens of *Geaster* or *Lycoperdon*.

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EXPLANATION OF PLATE VI.

Fig. 1.—*Mesophellia arenaria*, five-eighths natural size.—Showing the exterior covered with coarse sand particles.

Fig. 2.—*M. arenaria*, five-eighths natural size.—Showing the central core held in place by coarse trabeculae.

Fig. 3.—*Mesophellia pachythrix*, five-eighths natural size.—Specimen sectioned to show the prominent central core held in position by the very numerous and slender trabeculae.

Fig. 4.—*Castoreum tasmanicum*, five-eighths natural size.—Upper plant shows the rooting base, lower specimen the thick endoperidium and fibrous exoperidium.

Fig. 5.—*C. cretaceum*, five-eighths natural size.—Unexpanded plants on the right, expanded specimens on the left.

(Photographs by H. Drake.)

Fig. 6.—Spores of *Mesophellia arenaria*.

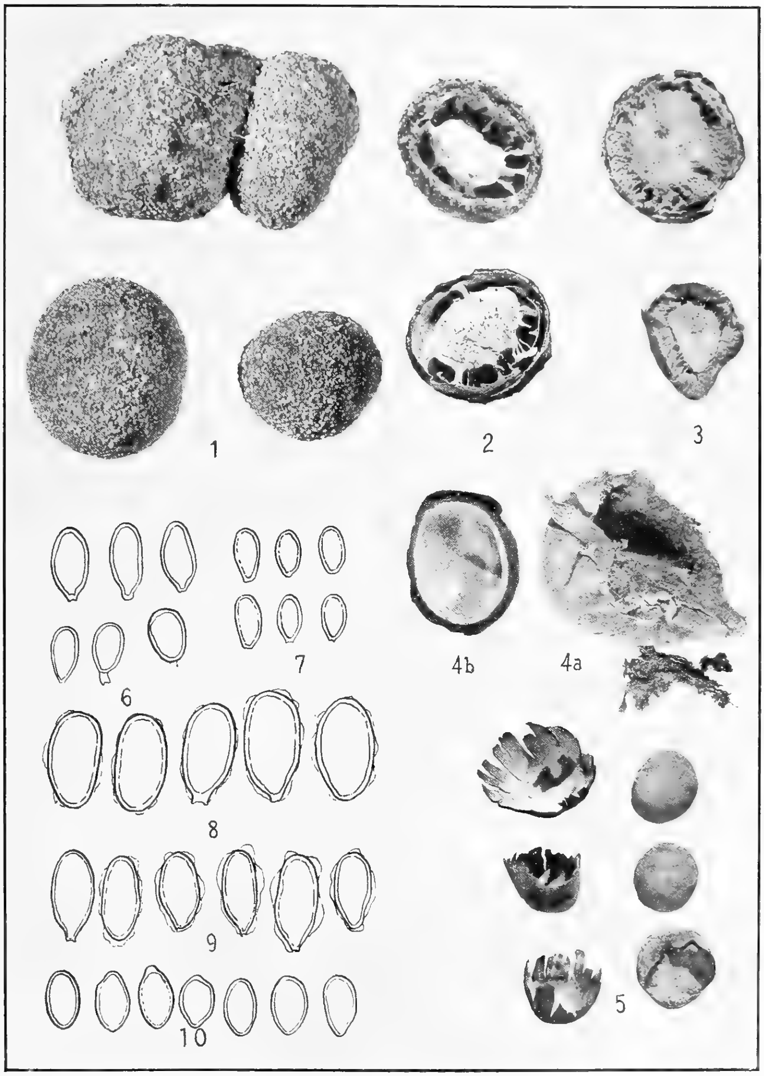
Fig. 7.—Spores of *M. pachythrix*.

Fig. 8.—Spores of *Castoreum tasmanicum*.

Fig. 9.—Spores of *C. cretaceum*.

Fig. 10.—Spores of *C. radicatum*.

(Spores × 1000.)



Gasteromycetes of Australasia: *Mesophellia* and *Castoreum*.

LATE MIDDLE DEVONIAN DIASTROPHISM IN SOUTH-EASTERN AUSTRALIA.

By Ida A. Brown, D.Sc., Linnean Macleay Fellow of the Society in Geology.

[Read 26th October, 1932.]

Introduction.

Several writers on the stratigraphy of the Devonian rocks of south-eastern Australia have implied that orogenic movement took place in this region between the deposition of Middle and Upper Devonian sediments, but no one has stressed its importance. Recent work on the Devonian sediments of the South Coast of New South Wales led the writer (1931) to a consideration of the correlation of these formations with others of Devonian age in New South Wales and Victoria, and to a study of the palaeogeography of the region during Devonian time.

As a result of this study the writer considers that the importance of late-Middle Devonian diastrophic movements has not been fully appreciated, and the present note is intended to call attention to this phase of Middle Palaeozoic orogeny, and to suggest its correlation with earth-movements of similar age in the Northern Hemisphere.

Of necessity the paper is based largely on the work of others, some reference to which is made in the text. A detailed bibliography of Australian Devonian geology up to the time of its publication (1922) is given in W. N. Benson's paper "Materials for the Study of the Devonian Palaeontology of Australia", and some later references may be found in the paper by the present writer (1931) on "The Stratigraphical and Structural Geology of the Devonian Rocks of the South Coast of New South Wales". The writer is indebted to Professor L. A. Cotton, M.A., D.Sc., Assistant-Professor W. R. Browne, D.Sc., Mr. L. L. Waterhouse, B.E., and Mr. W. S. Dun, for helpful discussion of various aspects of the paper, without in any wise committing them to agreement with all or any of the views expressed therein.

It is hoped that the paper will stimulate examination of the relations of the Middle and Upper Devonian sediments in those parts of the State which still await investigation.

Evidence of Diastrophism in South-eastern Australia.

Evidence of diastrophic movements between the deposition of Middle Devonian and Upper Devonian sediments in south-eastern Australia may be considered under the following headings: (i) Differences in the distribution of land and sea during the two epochs. (ii) Variation in the lithological characters of the sediments. (iii) Differences in the amount of folding in the two series. (iv) The visible angular unconformity between the two series in Victoria. (v) The palaeontological break.

(i). The distribution of land and sea during the Devonian period is indicated to some extent by the distribution of rock-outcrops of that age on the present land-surface. The Lower Devonian consists chiefly of igneous rocks, the volcanic flows, tuffs and breccias of the Snowy River in Victoria. In the Walhalla–Wood's Point district in Victoria (E. W. Skeats, 1928) and in the Yass district of New South Wales (J. Mitchell and W. S. Dun, 1920) there is a conformable passage from Silurian into early Devonian sediments, suggesting that there was no important orogeny at the close of the Silurian. Devonian sediments overlie pre-Silurian formations with a marked unconformity.

Middle Devonian sediments occupy a somewhat similar but more extensive zone than that of the Lower Devonian; outcrops occur in Victoria at the Bemm River, Buchan, Bindi, Limestone Creek, Tabberabbera and the base of Mount Tambo. In New South Wales Middle Devonian sediments occur near Tumut, in the Murrumbidgee district near Yass, at Lake Bathurst Railway Station, Tarago, and in the region between Capertee and Mudgee. In the limestones of Kingsdale and Baw Baw, near Goulburn, formerly considered to be of Devonian age, the writer recently found a brachiopod, determined by Mr. W. S. Dun to be *Pentamerus knightii*, similar to that of Jenolan, and of Silurian age. No Middle Devonian sediments underlie the Upper Devonian of the south coastal portion of New South Wales, which was probably a land area during the Middle Devonian epoch. It is considered, therefore, that the Middle Devonian sediments were deposited in a gulf running from Gippsland, Victoria, northwards into New South Wales, including the Yass, Tarago, and Mudgee–Capertee districts.

Upper Devonian sediments overlie and extend beyond the Middle Devonian beds of Gippsland, Victoria, but no Upper Devonian beds are known in association with the Middle Devonian of the Upper Murrumbidgee near Yass. Upper Devonian sediments occur at intervals along the South Coast and adjacent tablelands of New South Wales, where they rest unconformably on pre-Devonian formations. They extend in a northerly and westerly direction through the central portion of the State, outcropping at Hartley, Mt. Lambie, Bathurst, Capertee, Wellington, Forbes, Parkes, Nymagee, Cobar, Canbelego and elsewhere.

This distribution of outcrops suggests some such relations of land and sea as those indicated in the palaeogeographic maps already given by the writer (1931, pp. 488–491), on which are shown the minimum areas covered by the sea.

The relation of the Devonian rocks of south-eastern Australia to those of the Tamworth, New England, district is obscure. On account of palaeontological evidence W. N. Benson (1922, plate xiii; 1923, pp. 25–26) suggests that they were formed in a gulf which probably was separated from that of the south-eastern province. Since newer formations occupy the region between the two provinces, it is unlikely that their palaeogeographic relations will ever be manifested.

The sea in which the Tamworth Devonian beds were deposited probably extended into Queensland and included the Silverwood–Lucky Valley area (H. C. Richards and W. H. Bryan, 1924).

(ii). The variation in the lithological characters of the sediments of Middle and Upper Devonian ages indicates important changes in the prevalent geographical and climatic conditions.

Middle Devonian sediments of Victoria, southern New South Wales and also of the Tamworth district consist of coralline limestones, indicating deposition under special conditions in warm, clear sea-water, with which are associated shales and tuffaceous and other igneous material.

The early Upper Devonian beds of Victoria and southern New South Wales consist of products of igneous action, together with red shaly and sandy sediments of lacustrine or estuarine origin. These formations are followed by marine arenaceous sediments; no massive coralline limestones occur in the Upper Devonian of south-eastern Australia. In the New England district there is evidence of igneous activity in the early Upper Devonian Baldwin Agglomerates, which, however, occasionally show signs of water action (W. N. Benson, 1915, p. 578). The Barraba Series, of which the Baldwin Agglomerates are a basal stage, is apparently conformable with the Middle Devonian of the Tamworth district, and consists of arenaceous and argillaceous marine sediments, without any coralline limestones.

Thus there are very marked lithological differences between the Middle and Upper Devonian sediments, both in south-eastern Australia and in the New England district. The occurrence of thick deposits of coarse conglomerates, grits and sandstones of Upper Devonian age following the finer argillaceous and calcareous sediments of the Middle Devonian is itself an indication that earth-movements took place at the close of the Middle Devonian, which exposed a land-surface that was rapidly worn down in the succeeding epoch.

(iii). Differences in the amount of folding in the Middle and Upper Devonian sediments are modified to some extent by the contact-metamorphic effects of post-Devonian granitic intrusions. Nevertheless, viewed broadly, the Middle Devonian beds are more highly folded than those of Upper Devonian age. This is well illustrated in the Victorian occurrences at Tabberabbera (Howitt, 1875; Skeats, 1929), at the foot of Mt. Tambo (Whitelaw, 1899, p. 20), and elsewhere. In New South Wales, the Lower and Middle Devonian of the Upper Murrumbidgee near Yass are thrown into a series of anticlines and synclines such as that illustrated by L. F. Harper (1909, Plate v).

The Middle Devonian limestones of the Tarago district are folded about meridional axes, the limbs of the folds having an average dip of 40 to 50 degrees (Carne and Jones, 1919, pp. 131–144). An interesting feature in this district is that the amount of folding in the Silurian beds at Baw Baw and Kingsdale, near Goulburn, is quite comparable with that of the Middle Devonian beds of the Tarago district. The exact field-relations of the two series have not yet been worked out.

In the Mudgee–Capertee district the (Middle) Devonian limestones trend more to the north-north-west, the amount of dip varying from 50 to 60 degrees (Carne and Jones, 1919, pp. 307–325).

Except locally in the neighbourhood of large igneous intrusions, Upper Devonian sediments of south-eastern Australia are not nearly so strongly folded as those of Middle Devonian age. In Victoria the Upper Devonian beds of North Gippsland are described by R. A. F. Murray (1877), A. W. Howitt (1875–77) and others as a gently dipping series. In the Eden district, New South Wales, they are horizontally bedded or gently folded (I. A. Brown, 1931), although to the north towards Yalwal (E. C. Andrews, 1901) the dips are greater on account of proximity to granitic intrusions and to the downwarped area of Permo-Carboniferous deposition.

The isolated outcrops over central New South Wales are gently folded as a rule. Thus, according to E. C. Andrews (1910, pp. 26–27) "the (*upper*) Devonian appears to have formed a gently-arched dome over the Forbes–Parkes district, the dome from Jemalong Gap to the Parkes waterworks being about 30 miles across". The limbs of this fold dip at angles of 10 to 15 degrees, "while the underlying (*Silurian*) rocks dip westerly at angles varying from 45° to 80°".

Greater dips are recorded by C. A. Süssmilch (1906, p. 137) for the Upper Devonian near Orange, but in the type-locality at Mt. Lambie the dips are not great, except within the contact-aureole of intrusive granite.

In describing the folding of the Upper Devonian of Canbelego and Cobar districts E. C. Andrews states (1915, p. 43): "This folding movement was peculiar, for, despite the fact that the beds were only folded gently, as a whole, nevertheless small patches of rock of Devonian age have been sharply compressed within the older sediments." . : "In this connection it is interesting to note that the Devonian sediments in the western areas of the State as a rule have been folded only in a minor degree with sharp compression over very small areas." This variation in the degree of folding supports the belief that a period of diastrophism, peneplanation and subsidence occurred between the Middle and Upper Devonian.

(iv). The angular unconformity between the Middle and Upper Devonian sediments of Gippsland, Victoria, was recognized by early geologists (R. A. F. Murray, 1877; A. W. Howitt, 1875), and has been confirmed by later workers (H. Herman, 1898; O. A. L. Whitelaw, 1899; E. W. Skeats, 1929; and others). Good exposures showing almost horizontally bedded Upper Devonian unconformably overlying folded Middle Devonian beds occur along the Mitchell River below Tabberabbera, Victoria.

No such angular unconformity has yet been recorded in New South Wales. It has been suggested elsewhere (I. A. Brown, 1931) that the relations may be revealed in the Mudgee–Capertee or in the Goulburn–Tarago districts, where Middle Devonian limestones are in close proximity to Upper Devonian sediments. In the New England district, however, W. N. Benson (1915, p. 577) considers that there is no angular unconformity between the Barraba Series of Upper Devonian age and the underlying Middle Devonian.

(v). Palaeontological evidence is controlled to some extent by the conditions of sedimentation. Thus, during the Middle Devonian in south-eastern Australia, the conditions of limestone formation were favourable to the preservation of an abundant and varied marine fauna, which failed to survive the arenaceous and argillaceous conditions of the Upper Devonian.

Nevertheless it is significant that, of almost 280 species (besides Foraminifera and Radiolaria) comprising nearly 200 genera listed by W. N. Benson (1922), only about 20 forms are recorded as being possibly common to the Middle and Upper Devonian. The majority of these are indeterminate forms which may include several species, while the exact stratigraphical horizon and age of most of the others is open to some doubt.

Coelenterata and brachiopoda predominate in the Middle Devonian, whereas the Upper Devonian fauna consists largely of brachiopoda, lamellibranchiata and gasteropoda, the reef-building corals being absent from the Upper Devonian of south-eastern Australia. It is highly probable that the forms listed by W. N. Benson (1922, p. 105) from the Capertee region come from both Middle and Upper Devonian beds. Recently L. L. Waterhouse (1931, p. xlvi) has collected typical Middle Devonian fossils, including *Receptaculites*, *Loxonema*, and *Stromatopora* from the limestones of Coco Creek, Capertee.

Typically Upper Devonian fish, comparable with those of the Upper Old Red Sandstone of Scotland, are known from Taggerty and Freestone Creek, Victoria (E. S. Hills, 1931) and from the Forbes, Parkes and Canoblas districts, New South Wales (E. S. Hills, 1932), the genus *Bothriolepis* being present in each locality.

Although land plants made their appearance earlier, it was not until the Upper Devonian that they were at all abundant, when *Archaeocalamites*, *Archaeopteris*, *Sphenopteris* and several species of *Lepidodendron* appeared. These genera also occur in the Upper Devonian of Scotland. *Lepidodendron australe* is confined to the Upper Devonian series of south-eastern Australia. The writer has shown previously (1931) that in this area the beds containing *L. australe* form only the uppermost stage of the Upper Devonian, the Lepidodendra of the lower stages being specifically different.

In the New England district of New South Wales, W. N. Benson has found specimens of *Lepidodendron australe* near Nundle in the upper part of the Middle Devonian (Upper Bowling Alley Series) (1913, p. 579), and also near Tamworth, chiefly in the Barraba Series of Upper Devonian age, but extending downwards to an horizon which he believes "must be very close to the horizon on which the Moore Creek limestone would occur, if it were developed in this region" (1915, p. 581). The specimens, collected by E. F. Pittman and T. W. E. David (1899, p. 17, Pl. ii) came from a locality north-east of Tamworth, very close to the base of the (Upper Devonian) Barraba Series as mapped by W. N. Benson (1915, Pl. 1).

The origin and affinities of the Devonian faunas of Australia have been discussed by W. N. Benson (1922).

Late Middle Devonian Diastrophism in other parts of the World.

Earth movements during the Devonian period have been recognized both in Europe and in North America. In Europe the marine Devonian were deposited in a geosyncline extending from the south of England eastward through central Europe. In some localities the stratigraphical relations are masked to a considerable extent by subsequent folding and metamorphism, but the sequence has been worked out in detail in the Rhine Valley, Belgium and elsewhere (F. Frech, 1897, Pt. 1, Vol. 1, pp. 34–55; J. W. Evans, 1929*a*, 1929*b*).

The Lower Devonian consists of shaly and sandy sediments, the Middle Devonian of limestones, marls and marly-shales characterized by the presence of *Calceola sandalina* in the lower portion and *Stringocephalus Burtini* in the upper division. The lithological characters of the Upper Devonian vary considerably: there are some limestones near the base, but there is a greater amount of clastic material than in the Middle Devonian. The forms *Spirifer verneuilii* (*disjunctus*), *Rhynchonella cuboides*, *Goniatites*, *Clymenia* and *Cypridina* are characteristic.

Although there is no recorded angular unconformity between the Middle and Upper Devonian marine beds, there are lithological variations comparable in general with the Australian facies, and a definite palaeontological break occurs between the two series.

Probably the main geosynclinal area was continuously under the sea, but the marked variation in the distribution of Middle and Upper Devonian sediments denotes movements of the strand-line and possibly diastrophic movement along the continental margin.

This phase of Devonian orogeny is most clearly illustrated in the relations between the terrestrial, lacustrine and littoral Old Red Sandstone deposits of Devonian age in Wales, Scotland, and the Orkney Isles, and in Norway and Spitzbergen.

In Britain, according to A. Geikie (1903, p. 1007) the Old Red Sandstone has two subdivisions, of which "the lower passes down conformably into the Upper

Silurian deposits, the Upper shading off in the same manner into the base of the Carboniferous system, while they are separated from one another by an unconformability". The unconformable relations between the lower or middle and the upper Old Red Sandstone of Scotland have been recognized by all workers on the subject. The angular unconformity is illustrated in many well-known pictures and sections, such as those of the Orkney Isles (Geikie, p. 1011), The "Old Man of Hoy" (Grabau, p. 415), and the Pentland Hills (Wills, 1929, p. 295). That the break between the two series represents a considerable time interval is indicated by the palaeontological break and by the fact that "Fragments not only of the Lower Old Red Sandstone volcanic rocks, but also of the granite, dykes and sills intrusive in them can be recognized in the conglomerates of the Upper Old Red Sandstone" (J. W. Evans, 1929*a*, p. 142). This stratigraphic discontinuity is indicative of vast physiographic changes (*vide* L. J. Wills, 1929, pp. 291–309).

Somewhat similar relations obtain in North America, where outcrops of Devonian rocks have been grouped by H. S. Williams (1888) into four provinces, of which probably the most typical is the Eastern Continental Province. This extends from eastern New York in a general south-westerly direction down the Ohio Valley and southward into Tennessee, Mississippi, Alabama and Georgia. In this province the Middle Devonian includes the Onodaga and Hamilton with typical fauna. "In the early Upper Devonian time the sea retreated northward from its greatest southward extension of Hamilton time, and later again transgressed toward the south and south-west until it extended much farther than it had in the earlier period, this retreat and readvance being recorded in the unconformity at the base of the Upper Devonian black shale which is commonly exhibited south of the Ohio River and to some extent to the north of that stream" (S. Weller, 1909). Detailed descriptions of this unconformity occur in numerous papers in the State Geological Survey Bulletins, *The Bulletin of the Geological Society of America*, and in the *Journal of Geology*.

It is considered by some geologists that even where no angular unconformity is evident the enormous thickness of arenaceous deposits comprising the Portage and Chemung of Upper Devonian age is indicative of a previous period of orogenic movement, during which large areas were uplifted to provide a source of supply for the subsequent formations.

The Upper Devonian fauna is also distinct from that of the Middle Devonian, and consists largely of new immigrant elements closely allied to those of the Upper Devonian of Europe, in which *Hypothyris* (*Rhynchonella*) *cuboides*, *Manticoceras intumescens*, *Pugnax pugnus* (*Rhynchonella pleurodon*), and *Spirifera disjuncta*, are dominant forms (H. S. Williams, 1890; S. Weller, 1909).

Evidence of folding during the Devonian is recorded from eastern Canada and the United States of America. R. T. Chamberlin (1914, p. 330) classes the movements during the Devonian as the "Devonides" and includes the Gaspé folding between the Hamilton and the Mississippian, and the Appalachian folding after Hamilton time. E. Blackwelder (1914, p. 640) considers that the importance of this late Middle Devonian disturbance is sometimes ignored, although it is actually one of the major orogenic epochs in North America, and suggests for it the name "Brunswickian". Regarding the age, he states (p. 641): "Although there are some discrepancies in the evidence and hence some disagreement among writers on the subject, the testimony of the unconformities on the one hand, and of thick clastic formations on the other, indicates that the Brunswickian disturbance culminated after the middle of the Devonian but considerably before its close."

C. Schuchert (1910, 1930) and E. O. Ulrich (1911) also recognize a break between the Middle and Upper Devonian of North America. In view of this evidence, it is difficult to understand the conclusion of H. Stille (1924) that no important orogeny occurred at the close of the Middle Devonian.

Summary and Conclusions.

It is considered that there is evidence in south-eastern Australia that an important period of diastrophism occurred in Middle Palaeozoic time, during which the palaeogeography was entirely changed. That this orogeny occurred between the deposition of Middle Devonian and Upper Devonian sediments is indicated by (i) marked differences in the distribution of land and sea during the two epochs, (ii) variation in the lithological characters of the sediments of the two series, (iii) differences in the amount of folding of the two series, (iv) the visible angular unconformity in Victoria, (v) the palaeontological break.

At the end of the Middle Devonian the sea finally retreated from the gulf extending from eastern Victoria northwards into New South Wales, in which sediments had been deposited from Lower Palaeozoic until Middle Devonian times.

The south-coastal portion of New South Wales was compressed against the continental mass to the west, and the Middle Devonian beds of the Murrumbidgean gulf were folded in a meridional direction. Probably epeirogenic uplift accompanied this orogenic movement and a period of terrestrial peneplanation followed, during which the Middle Devonian folds were partially truncated before the deposition of Upper Devonian sediments.

During the early Upper Devonian a considerable amount of volcanic material was extravasated and lacustrine conditions prevailed along the new borders of the continent. Gradual subsidence followed and the sea transgressed over a large area of central and southern New South Wales and eastern Victoria, the greater part of which had not been under the sea since Silurian time. Only at the southern and possibly the northern extremities of the Middle Devonian gulf, that is, in the Tabberabbera, Victoria, and Capertee, New South Wales, districts, were the Upper Devonian sediments deposited over those of Middle Devonian age.

This area of Upper Devonian sedimentation gradually developed into the geosyncline of later Palaeozoic and Mesozoic deposition as distinct from the meridional gulf of earlier Palaeozoic time.

The late Middle Devonian diastrophism thus appears to have been one of the major orogenic epochs in the tectonic history of south-eastern Australia.

The change in the palaeogeography was accompanied by a change in the climatic conditions, which no doubt influenced the lithological nature of the sediments of Upper Devonian age. With these changes there was an immigration of a littoral fauna which was essentially distinct from that of the previous epoch. Somewhat different conditions prevailed in the New England district of New South Wales, where sedimentation was practically continuous from Middle Devonian until Middle Carboniferous time. Lithological and palaeontological variations comparable with those of south-eastern Australia occur within the sediments, but there is no angular unconformity in the sequence. Nevertheless, the Baldwin Agglomerate at the base of the Upper Devonian is possibly conglomeratic, and may represent a kind of "Flysch Facies" due to the rapid wearing down of a recently elevated landsurface, and thus may be indicative of earth-movements along the bordering continent. Somewhat similar conditions of sedimentation existed in

Queensland and a parallel tectonic history is also recorded. Thus W. H. Bryan (1925, p. 21) considers that "though they were preceded and followed by orogenic movements of great intensity, the Middle Palaeozoic periods themselves seem to be free from major earth-movements as far as Queensland is concerned".

Brief comparison with the relations of Middle and Upper Devonian sediments of Europe and North America suggests that conditions similar to those in south-eastern Australia existed also in the northern hemisphere, epi-Middle Devonian diastrophism being indicated in the marine sediments by lithological and palaeontological changes and in the terrestrial and littoral deposits by angular unconformity and palaeontological distinctions.

It is therefore considered that the diastrophism at the close of the Middle Devonian is of more than local importance, and that it may be regarded as one of the major orogenic epochs of the Palaeozoic era.

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NEW SPECIES OF CORYLOPHIDAE (COLEOPTERA).

By Cedric Deane, A.M.I.E.Aust.

(Seven Text-figures).

[Read 26th October, 1932.]

There has been a scarcity of information regarding the Australian Corylophidae; Lea's paper (Proc. Linn. Soc. N.S.W., Vol. x, Ser. 2, 1895) constitutes the bulk of the literature. The drawings herewith are, I believe, the first to appear of the Australian members of the group. Matthews' monograph of the world's representatives should also be consulted.

Help has been afforded by auxiliary microscope equipment kindly put at my disposal by Mr. H. P. Colwell, M.I.E.Aust., as a result of which I have been able definitely to establish the tarsal formula as 3-4-4 for the new species of *Sericoderus.*

I must mention here my gratitude to Mr. John Clark, F.L.S., Mr. F. E. Wilson, F.E.S., and Mr. C. Oke, of Melbourne, for assistance in the loan of literature, and especially to Mr. Clark and Mr. Wilson for their generous advice and material, which have enabled me to arrive at my conclusions.

SERICODERUS.

In general appearance, both on dorsal and ventral surfaces, the new species herein proposed under *Sericoderus* agree sufficiently with some of the Australian species previously described under this genus to warrant their being included provisionally with them.

Owing to the difference between the forms inhabiting one part of the world from those of another, I have thought it advisable to give for the new species in common those characters which may be considered to be of generic status. These are as follows:

Generic Characters.—Ovate, convex, somewhat robust, margin entire, widest across base of pronotum. Head completely concealed from above by hood of pronotum; small, somewhat rostrate; rostrum broad, blunt, subquadrate. Eyes large, rather receding, coarsely faceted, not widely separated. Antennae of medium length, incrassate, clavate; scape and pedicel large, scape larger than pedicel, segments 3 to 7 small, 8 to 10 large, forming the club. Pronotum rather large, broad at base, forming acute posterior angles; evenly rounded in front from side to side; entirely without anterior angles. Scutellum small, shield-shaped. Elytra wider at base than apex, almost covering abdomen. Pygidium widely rounded at apex. Prosternum strongly arcuately concave posteriorly. Mesosternum very short, receding. Metasternum large, not attaining sides; episterna and epimera distinct, the former long, curved, tapering posteriorly; hind margin convex at centre, concave at outer thirds. Abdomen with six visible ventral segments, basal one rather long, remainder evenly spaced; pygidium rounded, not dentate. Anterior coxae of medium size, oval, oblique, contiguous. Intermediate coxae small, globular, separated, situated in rather close proximity to anterior pair. Posterior coxae of medium size to small, subtriangular, somewhat transverse, widely separated, very distant from intermediate. None of the coxae prominent. Femora broad; tibiae rather narrow, usually reversely arcuate somewhere on basal half. Tarsi 3-segmented in the anterior, 4-segmented in intermediate and posterior pairs; claws well formed. Wings broad; hair fringes very short on front margin, on hind margin equal to about one-fifth of width of membrane.

In commenting on the position of this genus it is impossible to give any close relationships to any of the other Australian genera on account of its wide divergence; the prosternum, however, has in the protecting hood for the head a feature in common with *Clypeaster*, from which, except for the antennae, it differs less in most respects than it does from *Corylophodes* and *Aphanocephalus*.

SERICODERUS INCRASSATUS, n. sp. Text-fig. 1.

Oval, convex, widest across base of pronotum, lightly pubescent, dark reddish-brown. Head rather narrow; muzzle short, blunt; eyes rather large. Antennae with scape and pedicel and segments 3 to 7 yellow; 8 to 10 brown, of nearly equal width, clothed with hairs. Pronotum convex, more so than elytra. Scutellum small. Elytra tapering, black near and at apex. Prosternum and mesosternum yellow; metasternum and abdomen darker. Legs yellow, rather long; posterior coxae small. Length 1·25 mm.; width 0·885 mm.

Habitat.—Fern Tree Gully, Victoria (Deane, Oke, Blackwood).

Type in National Museum, Melbourne, cotypes in colls. Deane and Oke.

This species is found in rotting leaf debris, and is probably common under tree-ferns in the hills and mountains, also in the neighbourhood of Warburton and Gembrook.

SERICODERUS QUADRATUS, n. sp. Text-fig. 2.

Subquadrate, convex above, robust, pubescent, brown. Head narrow, muzzle narrowed in centre; mouth parts, scape and pedicel yellow; flagellum dark brown, clothed with brownish-black hairs; three apical segments not close fitting, subapical two truncate anteriorly. Pro- and mesosternum yellow. Metasternum dark brown, lightly convex. Abdomen rather flat. Legs yellow. Posterior coxae large. Elytra parallel. Length 0·91 mm.; width 0·65 mm.

Habitat.—Melton, Victoria (Deane; in rubbish).

Type in National Museum.

This species is most readily distinguished from the previous one by its quadrate form, elytra parallel instead of tapering, and the posterior coxae being much larger. The abdomen is almost completely concealed from above by the elytra. In addition, the antennae, rostrum and metasternal episterna are of different form, as depicted in the figures; but these are not readily determined on a casual examination with a hand lens.

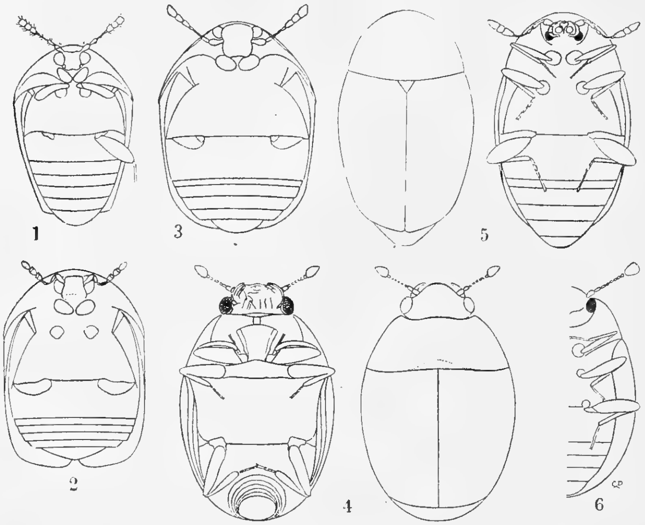
SERICODERUS LATUS, n. sp. Text-fig. 3.

Obovate, convex, widest a little across base of pronotum, pubescent, yellowish-brown. Head with muzzle broad, subquadrate, and constricted at centre. Eyes black. Antennae with scape, pedicel and segments 3 to 7 yellow, 8 to 10 dark purplish-brown increasing in width, forming the club. Pronotum with front and sides forming one continuous curve; posterior margin convex at centre, strongly concave near angles. Scutellum small, brown, triangular; sides concave. Elytra subparallel; apical outer angles greatly rounded; slightly dehiscent. Ventral surface, except legs and posterior halves of abdominal segments, brown, remainder as above. Wings broad; hair fringes short. Length 0·84 mm.; width 0·615 mm.

Habitat.—Bogan R., N.S.W. (J. Armstrong).

Type in coll. Deane, cotypes in coll. Armstrong.

Differs from *S. incrassatus* by antennae not so conspicuously clothed with hairs, elytra less tapering, coxae of different form, and posterior femora much flatter. In addition, the much smaller size and different arrangement of coloration render this insect easily distinguishable from the genotype.



Text-figs. 1-6.

1.—*Sericoderus incrassatus*, n. sp. 2.—*S. quadratus*, n. sp.
3.—*S. latus*, n. sp. 4.—*Ittrion prosternalis*, n.g. et sp.
5.—*Clypeaster* sp. 6.—*Aphanocephalus punctatus* Blackb.

ITTRION, n. gen. Text-fig. 4.

Oval, highly convex, robust; margin entire, except for head when elevated; widest across middle. Head medium to broad, not covered by prothorax. Eyes set somewhat outwards, visible from above, except when head retracted, then scarcely so; of medium size, not close together. Antennae rather short, clavate, 9-segmented; scape large, concealed; pedicel rather large; segments 3 to 8 small, 7 and 8 consecutively very slightly wider; apical segment very large, this one only forming the club. Pronotum convex, widest at base, not emarginate; sides evenly curved, continuous with sides of elytra; posterior angles a little acute, anterior obtuse; front margin concave, excavated slightly for reception of head; hind margin almost straight. Scutellum invisible. Elytra convex, widest at anterior quarter, side margins curved under, forming epipleurae; basal angles obtuse; apices close fitting, not dehiscent, exposing pygidium; medial apical angles right angles or a little acute; outer apical angles obsolete. Prosternum convex, with a prominent shield process, standing out a little from body, open in front, forming a pocket. Mesosternum short convex. Metasternum convex, long, not attaining sides of body, bounded by episterna; posterior margin excavated for reception of coxae. Abdomen convex; basal segment large, immobile; remaining segments of peculiar setting, nearly their complete section being visible from the ventral aspect, apical tergite wholly visible from below when abdomen contracted, all sclerites except basal tergite being presented ventrally. Anterior coxae of medium size, well separated. Intermediate coxae transverse, remote. Posterior coxae transverse, remote, well defined, not lamellate, flush with metasternal and abdominal sternites. Legs rather small; femora, especially anterior, broad; anterior tibiae recurved; tarsi 4-segmented, normal. Wings with complex folding. Genotype, *I. prosternalis.*

The insect described under this genus does not bear any close resemblance to any other with which I am familiar. In *Aphanocephalus* (formerly *Eleothreptus*) *punctulatus* Blackburn, there is a swelling or prominence of the prosternum which is faintly suggestive of the process which is a strong feature in the new species, and in the antennae it shares in common the single segmented club. In other respects, however, it is widely different. Superficially from above it has somewhat the facies of *Corylophodes*, but on closer examination the similarity fades.

ITTRION PROSTERNALIS, n. sp. Text-fig. 4.

Glabrous, smooth, nitid, reddish-brown. Apical segment of antenna broad, supported eccentrically, pointed; clothed with short, thick, cream-coloured setae. Metasternum with thinly scattered shallow irregular punctures. Wings present. Length 1·095 mm.; width 0·72 mm.

Habitat.—Bogan R., N.S.W. (J. W. T. Armstrong).

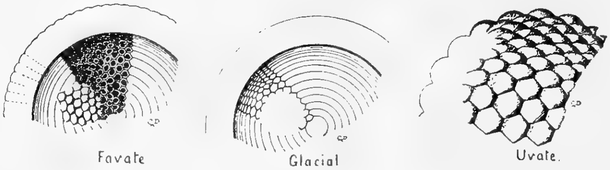
Type in coll. Deane; cotype in coll. Armstrong.

Key to Genera of Corylophidae.

1.	Club of antenna unisegmental; pronotum not entirely concealing head; lateral margins of elytra curved under very conspicuously	2
	Club of antenna 3-segmented; pronotum entirely concealing head; lateral margins of elytra not as above	3
2.	Apical segment of antenna truncate; scutellum visible; incurved margins of elytra strongly epipleuriform; abdomen simple; size large	*Aphanocephalus*
	Apical segment of antenna pointed; scutellum invisible; incurved margins of elytra not strongly epipleuriform (see note below); abdomen irregular	*Ittrion*
3.	Form somewhat narrow; rostrum small; antennae irregular; anterior margin of pronotum noticeably reflex; elytra almost or completely covering abdomen	*Clypeaster*
	Form rather wider	4
4.	Anterior margin of pronotum only faintly emarginate; elytra exposing more than the apical segment of abdomen; upper surface pubescent; rostrum sometimes large, thick	*Sericoderus*
	Upper surface smooth, glabrous, nitid, highly convex; rostrum not so conspicuous	*Corylophodes*

Note.—The incurving of the elytral margins in the case of the genus *Ittrion* is gradual from upper to lower surface, there being no edge or margin separating the surface of the elytron proper from the epipleura.

It must be understood that the above key is only tentative; it is not intended that it should place any restriction on the allotting of further new species or prescribe the characters that they should possess before being allowed inclusion in the genera mentioned; the family has hardly been touched upon, as far as Australian species are concerned, only a few species having been described, and it is too early to establish a table on a more permanent basis. The characters outlined, however, will serve to promote a familiarity with the genera.



Text-fig. 7.

In examining the structure of very small beetles in general I have been struck with the circumstance that with most parts the details are as elaborate as in the larger forms. For instance, the antennae may have just as many segments, and these may be no simpler in their individual structures. The same can be said of palpi, tarsi, etc. But when we come to examine the eyes it is found that the facets break away from the rule, the number of facets falling

Table Indicating Size and Type of Eyes of Insects.

Order.	Family.	Genus.	Size.	'h.'	Eye.	
					Type.*	Facets.
Lepidoptera	Papilionidae	Troides	1	11·8	Favo-Uvate	31,900
Coleoptera	Cicindelidae	Megacephala	3	7·9	Glacial	12,265
,,	,,	Cicindela	5		Favate	5,400
,,	Carabidae	Tachys	7	5·9	Uvate	87
,,	Trichopterygidae		10		,,	225
Diptera	Syrphidae	Eristalis	3	10·5	Favate	27,100
,,	,,	,,	3	9·9	Setose-Uvate	15,830
,,	Sepsidae	Sepsis	6	4·7	Favo-Uvate	2,320
,,	Asilidae	Blepharotes	1	11·8		16,700
Odonata		Austroaeschna	1	15·7	Favate	25,800
Hemiptera	Cicadidae	Cyclochila	1	14·1	,,	21,200
,,	Reduviidae	Pristhesancus	2	9·4	,,	1,800
,,	Pentatomidae	Dindymus	3	9·4		726
Hymenoptera	Pompilidae	Salius	1	11·1		22,810
,,	Formicidae	Myrmecia	1	9·4	Uvate	2,219
Orthoptera	Mantidae	Tenodera	1	13·4	Favate	7,220
Mecoptera	Bittacidae	Harpobittacus	2	6·7	Favo-Uvate	3,750
Neuroptera			1			
Dermaptera		Labidura	2	15·7		495
Isoptera	Termitidae		4	11·8	× × ×	129
Thysanoptera		Thrips	10	4·7	Uvate	26
Thysanura			3			12

'h' = minor diameter of facet in ten-thousandths of an inch.

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* Text-fig. 7 illustrates the terms used under this heading.

far short of the numbers possessed by the large beetles; in actual size, the eye elements or ommatidia are not proportionally smaller in the minute beetles (see accompanying table). In fact there seems to be a limit of size, and beyond this ommatidia of smaller dimensions do not appear to exist. It may be that maintenance of a satisfactory minimum is necessary in order to allow the light rays to have free play for their vibrations, and if the dimensions were not of sufficient magnitude it would result in the insects being devoid of powers of vision. Hence a standard is maintained.

TWO NEW AUSTRALIAN SPECIES OF *POLLENIA*.

By G. H. Hardy,
Walter and Eliza Hall Fellow in Economic Biology,
Queensland University, Brisbane.

(Two Text-figures.)

[Read 28th September, 1932.]

The presence of crinkly yellow hairs on the thorax is associated with all the species of *Pollenia* seen by me in Australia. Sometimes these hairs are plentifully represented, sometimes not easy to detect. I have not seen genus *Dexopollenia* Bezzi, which also has this character and is apparently allied. The genus *Acanthomyza* Malloch may be allied too, as it was described from Australia on a unique specimen in bad condition. It is not possible at present to give characters that will reliably distinguish these genera, but none of the forms known to me can be placed other than in genus *Pollenia*, as they apparently are not closely allied to Malloch's or Bezzi's forms referred to. *Pollenia hirtipes* Malloch differs from the following species on the characters to be deduced from the illustration given by that author and on the chaetotaxy. Elsewhere in the literature, I can find no description that may apply to the new forms below.

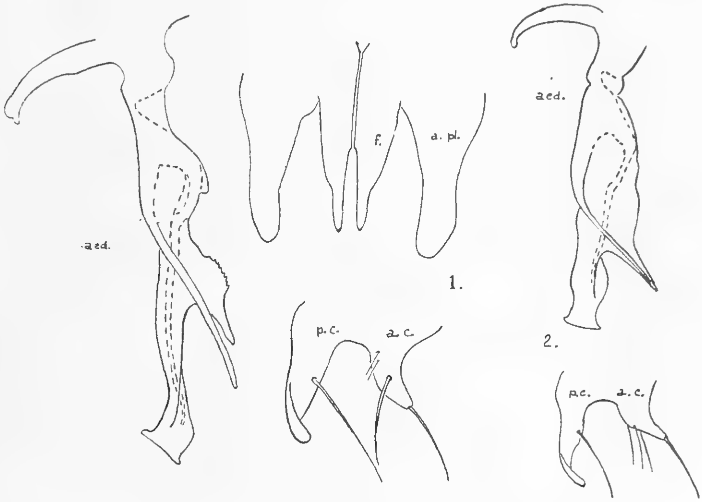
Some of the species of *Pollenia* and allies appear to be very local in distribution and need to be searched for in a suitable locality, and in my endeavour to discover the breeding localities of Calliphoras, I have accidentally discovered breeding localities of these species of *Pollenia*. Stray specimens are being taken by various collectors, and occasionally one of these becomes described without reference to the Australian species as a whole, making subsequent recognition very difficult. There is danger, therefore, of the genus drifting into a confused state, such as has already happened with *Calliphora* and other genera well represented in Australia. As I have had need to study the genitalia of two species of *Pollenia*, I am anticipating any possible confusion in the future by publishing the figures and am giving field data sufficient to lead to the discovery of more specimens.

POLLENIA FLINDERSI, n. sp. Text-fig. 1.

On the male the eyes are separated by about the width of the ocellar triangle. The frons is yellowish when seen from above, and black when viewed from below. This same bicoloured nature is to be found on nearly the whole of the head. The bristles are black and the hairs yellow. The antennae are reddish, stained apically with black. The female has a similarly coloured head with eyes situated wide apart. At the summit the frons is wider than three times the width of the ocellar tubercle, and the eyes diverge conspicuously from there, as is the case with the typical species of the genus.

The thorax dorsally is plentifully supplied with yellow hairs amongst the bristles which are situated as follows: 2 presutural, 2 postsutural acrostichals;

2 presutural, 3 postsutural dorsocentrals, but a third presutural may be placed anteriorly to these; 3 humeral; 1 posthumeral; 1 presutural; 2 notopleural; 2 intraalar; 3 supraalar; 2 postalar; on female 3, on male 4 marginal, and 1 discal scutellar; all these being situated each side of the median line. The pleural hairs are yellow like those on the dorsum, but in places these tend to become crinkly, especially near the wings. There are two sternopleural bristles, the usual row of mesopleural and hypopleural bristles, and two pteropleurals.



Text-figs. 1-2.
1.—*Pollenia flindersi*, n. sp.; *aed.*, aedeagus; *a.c.*, anterior clasper; *p.c.*, posterior clasper; *f.*, forceps; *a.pl.*, accessory plate.
2.—*Pollenia calamisessa*, n. sp. Aedeagus and claspers.

The abdomen is black, not shining, as it is covered with a yellow tessellation. The hairs above are black, those below are yellow. The bristles along the margin of the segments are stronger on the male than on the female, and on the former some bristle-like hairs are developed, scattered over some of the tergites. The aedeagus is very long and slender, but of the normal *Pollenia* formation. The claspers are simple, normally with four long bristles on the anterior clasper, but this is liable to variation, one such case being illustrated in the figure. The forceps are small and simple, and the accessory plates rather broad. The legs are black and without marked features. The wings are hyaline, with normal venation.

Hab.—Victoria: Flinders, 4 males, 1 female; January, 1931. All these were taken at flowering shrubs in a rough patch of vegetation near the golf course, late in the afternoon.

Notes.—This species is very much lighter in tone than the other Australian forms before me. In this and many other features it corresponds to *Pollenia rudis* Fab., the type of the genus, but differs slightly in the bristles of the thorax, and the eyes of the male are much wider apart. The specific name is based on that of the navigator after whom the type locality is called.

POLLENIA CALAMISESSA, n. sp. Text-fig. 2.

On the male the eyes are approximate for a considerable distance; those of the female are wide apart, the frons being normal in width. The head is black with a grey pulverulent covering seen from above. Most of the hairs on the male are black, on the female yellow, and in other respects the characters conform to those of *P. flindersi*, with the antennae of the male mainly black.

The thorax dorsally is shining black, with black hairs and bristles. The latter correspond to those of *P. flindersi*, except there are three postsutural acrostichals and only three marginal bristles on the scutellum of both sexes. There is a strong trace of grey pulverulent covering over the dorsum, and this is weakly continued over the black shining abdomen. The pleura has traces of yellow hair in places, some of these being crinkly, but on the abdomen and the legs all hairs are black.

The aedeagus is short and stouter than that of *P. flindersi*, the apical part beyond the slender strut being conspicuously so, but the claspers and forceps compare with those on that species and the accessory plates are much narrower, being only half the width.

Hab.—Queensland: Brisbane, 10 males, 2 females, December, 1929. All these were taken resting on reeds along a watercourse near a permanent waterhole, 15 miles from Brisbane, along the Southport Road. In this same spot, and with the same habit, another species of *Pollenia* was taken in October, 1927.

THE EMBRYOLOGY AND SEEDLING DEVELOPMENT OF *AEGICERAS MAJUS* GAERTN.

By GLADYS CAREY, B.Sc., Demonstrator in Botany, University of Sydney, and LILIAN FRASER,* M.Sc., Linnean Macleay Fellow of the Society in Botany.

(Thirty-two Text-figures.)

[Read 26th October, 1932.]

Introduction.

For many years vivipary has been recognized as a feature of the mangroves of the world. Treub (1883) was the first to undertake an investigation of the development of the seedlings by tracing the embryology of *Avicennia officinalis* Linn. in all its stages. Later Haberlandt (1896) examined the methods of nutrition of the viviparous embryos and the seedlings of *Bruguiera eriopetala, Rhizophora mucronata* and *Aegiceras majus.* His observations regarding *Aegiceras majus* were made on material in which the youngest ovule was already 7 mm. long. The writers, having had access to much younger material, find that the early stages in the development of the seed show several additional points of interest. These, combined with Haberlandt's detailed account of the older embryo, give a complete account of the growth of the seed and seedling of this species. In addition, they afford an interesting comparison with the stages of development in *Avicennia officinalis* as described by Treub.

Aegiceras majus Gaertn. is a low shrub or small tree. It is frequently found associated with *Avicennia officinalis* Linn. on the marshy flats or the sloping banks of the coastal rivers in the Sydney district. This has already been recorded by Collins (1921). Where it is present in any abundance it may form a definite belt behind a zone of *Avicennia.* The size of the plant varies considerably, and there appear to be two fairly well defined growth forms present. Those plants which grow on the tidal flats skirting the coastal harbours, and whose roots are hence swept twice daily by salt water, are as a rule small rigid shrubs rarely exceeding 5 feet in height. The smallest plants are 1–2 feet high and are found in the most exposed situations. More sheltered plants growing along the banks of tidal rivers in brackish water may attain a height of 10–12 feet and are much more slender than the robust harbour forms. The habitat of this species is thus an area submerged by the rising tide under salt or brackish water.

Aegiceras majus is known as the "river mangrove". It extends north into Queensland, and is found also along the coasts of the old world tropics. Although it is frequently not as abundant as *Avicennia officinalis,* it can be distinguished easily from it at a distance by the bright green colour of the foliage.

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* The work was commenced when this writer held a Science Research Scholarship in Botany of the University of Sydney.

This genus is the only member of the Myrsinaceae which is present in the mangrove flora. Its characteristic flowers have been so fully described by systematists (Engler and Prantl, 1891) that any further description is unnecessary. The flowering period begins in early winter (May-June) and extends over several months. The phases immediately following fertilization proceed slowly, so that it is not till early December that endosperm formation is begun in the embryo sac. From this time development proceeds more rapidly, so that in late January the young embryo is sufficiently developed to emerge into the cavity of the ovary, and by March or April is about 3 cm. in length and ready to be shed from the tree. Owing to the fact that the period of fruit development extends over about a year, flower buds may be initiated before all the fruits of the previous season have been shed.

The smaller or "shrub" forms are found to produce larger fruits than the "tree" forms. The fruits are about ½–1 cm. longer, and proportionately thicker than those produced on the larger trees.

The Gynoecium.

The gynoecium is a flask-shaped structure, the style merging imperceptibly into the ovary. The latter has a conical loculus into which projects a free basal placenta (Text-fig. 1). Many of the cells in the wall of the ovary and in the style and placenta contain a substance, in the form of finely divided droplets, which, after fixation in formalin acetic alcohol, becomes yellow. This substance was tested by means of the standard microchemical methods (Haas and Hill, 1928, p. 79), and was found to give reactions for both proteinaceous and fatty material.

The stylar region of the gynoecium is studded with schizogenous glands (G, in Text-fig. 1). These may also be present occasionally in the ovary wall. Another feature of the style is the occurrence of young sclereids in whose walls are numerous simple pits. Here and there in the walls of the loculus, and particularly on the lower part of the expanded apex of the placenta, are glandular hairs. These hairs each have a globular head composed of a number of densely protoplasmic cells, borne on a stalk of 2–4 cells (Text-figs. 2*a*, 2*b*). Thus they differ appreciably from those which have been figured by Solereder from the foliage of the same species, and described by him (1908, pp. 610–611) "as especially peculiar in having their lateral walls fused with the wall of the depression and in the arrangement of the ray cells in surface view, which remind one of certain corals (*Fungia discus*)".

The placenta, arising at the base of the ovary, has, at the time of fertilization of the ovules, a short stalk which projects into an expanded apex. This in longitudinal section has the appearance of an arrow-head (Text-fig. 1). A trans-

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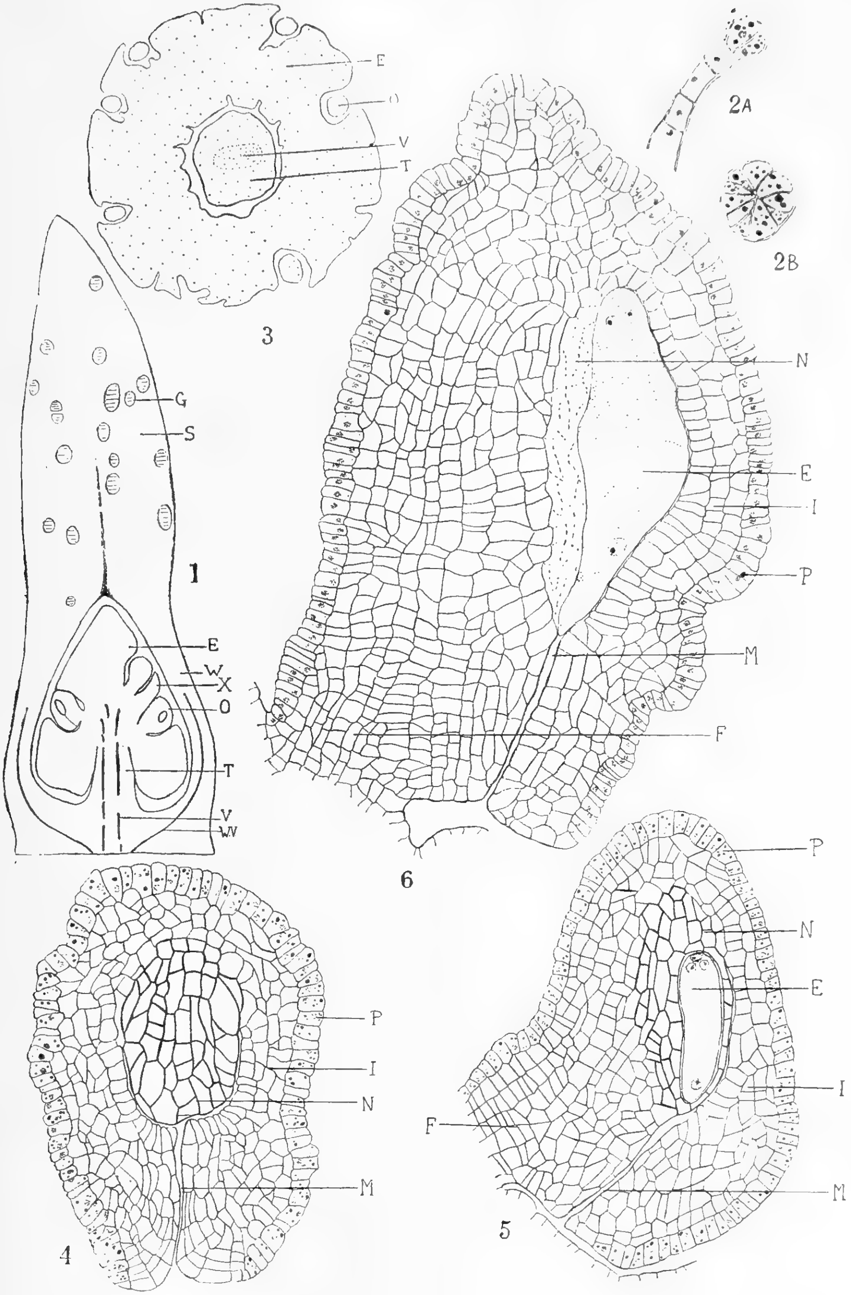
Text-fig. 2.—A, glandular hair from the wall of the ovary or placenta. B, surface view of the head of a glandular hair. × 250.

Text-fig. 3.—A transverse section of the expanded part of the placenta. E, lower part of the expanded apex of the placenta; O, ovule; T, stalk of placenta; V, vascular strand. × 49.

Text-fig. 4.—A tangential section of a young ovule. P, peripheral layer of the integument; I, integument; N, nucellus; M, micropyle. × 250.

Text-fig. 5.—A radial section of a young ovule at the time of fertilization. I, integument; P, peripheral layer of the integument; N, nucellus; E, embryo-sac; F, funicle; M, micropyle. × 250.

Text-fig. 6.—A radial section of an ovule enlarging after fertilization. I, integument; P, peripheral layer of integument; N, nucellus in process of being resorbed; E, embryo-sac; F, funicle; M, micropyle. × 250.



Text-fig. 1.—A longitudinal section of the ovary and part of the style. G, schizogenous gland; S, style; W, ovary wall; E, expanded part of the placenta; V, vascular strand of the placenta; WV, vascular strand of the ovary wall; X, projection of placenta tissue between ovules; O, ovule; T, stalk of placenta. × 19.

verse section passing through the upper region of the stalk (Text-fig. 3) shows the expanded apex as an apparently free tissue around the stalk. In this expanded apical region numerous ovules are embedded (Text-figs. 1, 3) so that there are projections of the placenta between them.

The Ovule at Fertilization.

Each ovule is anatropous and has a single massive integument (Text-fig. 5). Through this integument extends a long narrow micropyle which, as the funicle is very short, faces the placenta. The outermost layer of the integument is clearly differentiated from the inner layers, as the cytoplasm of the cells is denser, and globular food-bodies with the same staining properties as those mentioned previously in the placenta are clearly visible. The cells of the integument below the embryo-sac and those in the funicular region are arranged in fairly regular rows (Text-figs. 4, 5). As will be seen later, these cells are potentially meristematic.

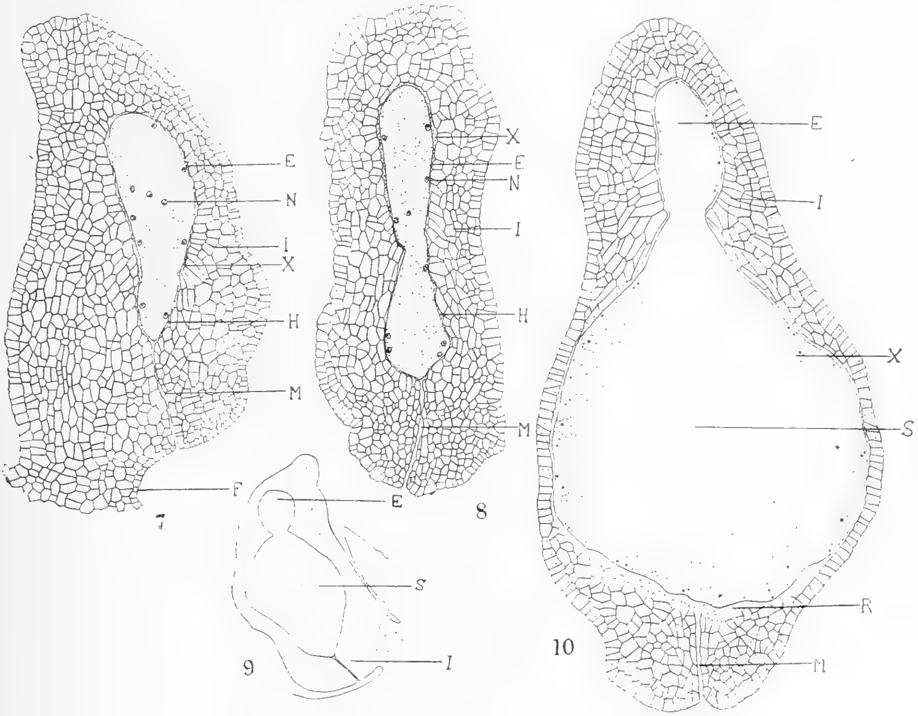
There is no trace of vascular tissue in the funicle, so the ovule is without a conducting strand. The only vascular supply is found in the placenta, and here the centrally placed tracheids can be traced to a position almost level with the uppermost ovule (Text-fig. 1).

The nucellus is composed of cells which are larger and thicker-walled than those of the integument which invests it. Also the degree of fusion of the integument and the nucellus varies slightly. Text-figure 4 shows the nucellus free on both sides to about the median region of the embryo-sac, but frequently the nucellus on the outer side of the embryo sac is free to a point level with the base of the sac (Text-fig. 5).

The embryo-sac is elliptical in section and is excentrically placed in the nucellus, so that, on the side of the ovule remote from the funicle, there are only one or two rows of cells between it and the integument. The embryo sac previous to fertilization shows the eight nuclei typical of most dicotyledonous embryo-sacs.

Post-fertilization Stages.

Fertilization may occur in a number of ovules simultaneously in any one ovary. After fertilization, the ovule enlarges and the embryo sac increases in size at the expense of the nucellus. The nucellus on the side of the embryo-sac remote from the funicle, being thinner than that on the funicular side, becomes resorbed first. At one stage of its development, therefore, the embryo-sac appears to have nucellar tissue on the inner side only (Text-fig. 6). All traces of the nucellus are, however, soon lost and at this stage the embryo-sac is bounded only by the integument. The cells of the integument seem to offer a greater resistance to the growth of the embryo-sac than do the cells of the nucellus, as they are not affected by the resorbing action of the sac. This resistance causes the further extension of the embryo-sac, therefore, to be directed into the micropyle (Text-fig. 7). At the same time cell-division begins in the integument in the micropylar region, and proceeds with increasing rapidity. The embryo-sac continues to invade the micropyle, and so pushes down into this meristematic region (Text-figs. 7, 8). Successive divisions in this tissue result in the rapid elongation of the micropylar part of the integument, but the bulk of the tissue so formed is resorbed by the advancing embryo-sac. This resorption proceeds transversely as well as longitudinally in the micropylar region of the ovule, so that the integument here, i.e., below the original embryo-sac, is gradually reduced to a single layer, except at the outer end of the micropyle. In this region it still remains massive and cell-divisions take place so that the tissue keeps pace with enlarging sac. Meristematic activity extends gradually from the region of the micropyle to the adjacent cells of the funicle, so an increase in size takes place here also. Remnants of the inner part of the integument persist for some time between the embryo-sac and the intact outer layers of the integument. At this stage in the development, the greater part of the ovule is occupied by the enlarged embryo-sac (Text-figs. 9, 10), whilst towards the apex of the ovule the outline of the original embryo-sac is retained by the integumental cells. At quite an early stage the cells of the



7 8 9 10

Text-fig. 7.—A radial section of a fertilized ovule showing the embryo-sac commencing to grow into the micropyle. I, integument; X, resorbed nucellus; E, embryo-sac; N, endosperm nuclei; H, haustorial part of the sac; M, micropyle; F, funicle. × 124.

Text-fig. 8.—A tangential section of a fertilized ovule at a slightly older stage than that shown in Text-fig. 7. I, integument; X, resorbed nucellus; E, embryo-sac; N, endosperm nuclei; H, haustorial part of the sac; M, micropyle. × 124.

Text-fig. 9.—A radial section of a fertilized ovule showing the embryo-sac much enlarged in the micropylar region. E, original position of embryo-sac; S, extension of the sac into the micropyle; I, integument. × 41.

Text-fig. 10.—A tangential section of a fertilized ovule at a stage similar to that shown in Text-fig. 9. I, integument; E, original position of embryo-sac; S, extension of the sac into the micropyle; X, endosperm nuclei; R, resorbed integumental tissue; M, micropyle. × 114.

funicle and the adjacent massive micropylar integument become filled with the characteristic proteinaceous food material.

During the enlargement of the embryo-sac the endosperm nucleus has undergone repeated divisions, giving rise to numerous small nuclei. The nuclei at first lie scattered throughout the embryo-sac (Text-figs. 7, 8), and can be clearly distinguished from the larger zygote nucleus, which is at the micropylar end of the sac. However, as the embryo-sac enlarges, the cytoplasm at the centre becomes very attenuated and the nuclei move to the periphery, at the same time increasing in size. This enlargement of the nuclei can be seen if Text-figures 7 and 8 (× 124) are compared with Text-figure 10, which is drawn on a slightly smaller scale (× 114) and yet shows obviously larger nuclei. At this stage the zygote nucleus can no longer be identified, but it apparently retains its position at the micropylar end of the advancing embryo-sac as the initial embryonal tissue makes its appearance in that position.

Several fertilized ovules may reach this stage of development, but one ovule, usually one situated towards the apex of the placenta, soon becomes dominant.

In the now single layer of the integument, divisions at right angles to the surface of the ovule take place so rapidly that this tissue falls into folds around the embryo-sac (Text-fig. 11A). At the same time cell wall formation begins at the periphery of the sac and advances inward till an endospermic tissue is formed. This tissue is composed of small cells at the periphery merging into larger central cells (Text-fig. 11B). The position of the original embryo-sac is still visible (Text-fig. 11A), and can be traced through the various stages of development till the time when the folds in the integument are straightened out by the growing embryo and endosperm. Meanwhile meristematic divisions continue in the funicle (F, in Text-fig. 11A) and in the adjacent part of the integument, and result in the widening of that area. The cells composing it are filled with reserve food material similar to that described in the integument of the young ovule. This material stains strongly with most reagents, e.g., safranin and haematoxylin, and is present in such quantities that after staining no detail of cell structure can be made out unless the sections are so destained that all other parts become almost colourless.

The embryo itself remains indistinguishable previous to the formation of endosperm tissue in the embryo-sac. It can be observed at the micropylar end of the embryo-sac, when endosperm cell formation is completed, and is at first quite close to the periphery of the sac (Text-fig. 12).

The small endosperm cells comprising the peripheral zone in the embryo-sac are more densely protoplasmic than the inner cells, and become meristematic

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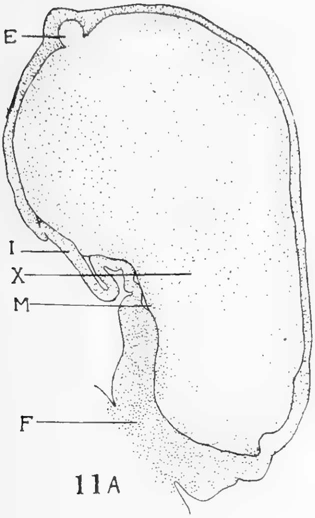
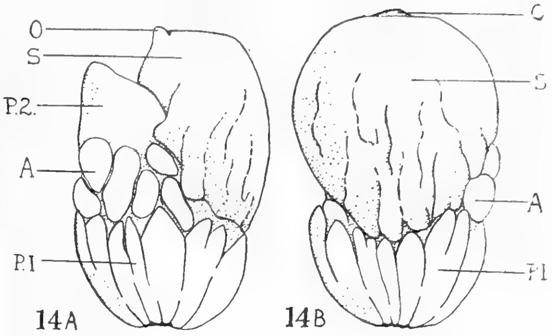
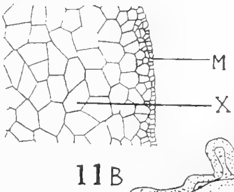
Text-fig. 13.—A young embryo embedded in the endosperm. X, inner primary endosperm; R, endosperm in process of being resorbed; E, embryo; S, suspensor; M, meristematic region of the endosperm; C, crushed inner layer of the integument; I, integument. × 280.

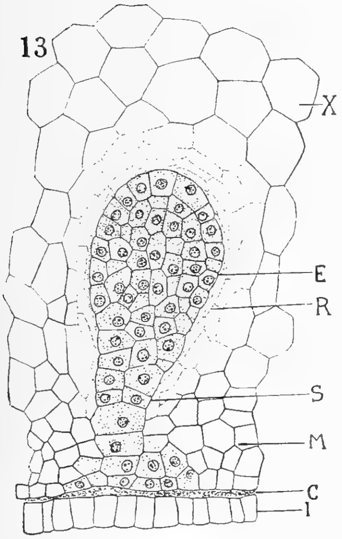
Text-fig. 14.—A. A view of the expanded portion of the placenta on which can be seen the aborted ovules (A) and a fertilized ovule at the stage shown in Text-fig. 12. O, position of original embryo sac; S, enlarged portion of the sac; P1, furrowed basal part of the expanded apex of the placenta; P2, tip of the placenta. × 10 approx.

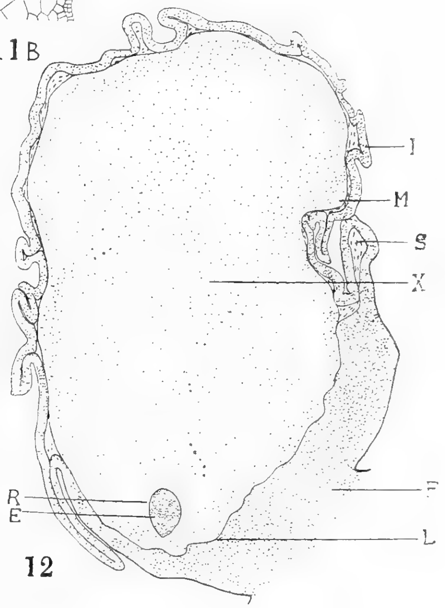
B. A view of the placenta and developing seed taken at right angles to that shown in Text-fig. 14A. O, position of original embryo sac; S, enlarged part of the sac; A, aborted ovules; P1, furrowed basal part of the expanded apex of the placenta. × 10 approx.











Text-fig. 11.—A. A radial section of a fertilized ovule in which endosperm tissue has been formed. I, outer layer of the integument; E, original position of the embryo-sac; X, inner endosperm; M, outer endosperm; F, funicle. × 30.

B. Part of Text-fig. 11A shown in full cell detail. M, outer endosperm; X, inner endosperm. × 30.

Text-fig. 12.—A radial section of a developing seed showing the enlarging embryo and the differentiation of the endosperm into an outer and an inner region. I, outer layer of the integument; S, fragments of the inner part of the integument; M, meristematic region of the endosperm; X, inner primary endosperm; R, resorbed zone of the endosperm; E, embryo; F, funicle; L, endospermic lobes. × 30.

soon after their formation. By their activity new cells are formed, at first mainly in radial rows at right angles to the outer wall of the embryo-sac, but later cells are cut off in all directions in this peripheral zone. The new cells remain small, and thus a very distinct zone is formed around the margin of the endosperm (Text-fig. 13). Meristematic activity in this peripheral zone of the endosperm continues rapidly, with the result that the endosperm tissue increases in size. The result of this increase in size is particularly striking in the lower part of the ovule. Here the endosperm is in contact with the massive meristematic and food-filled tissue of the funicle and with the basal part of the integument in the micropylar region. When the outer endosperm becomes meristematic it also assumes a haustorial function. By continued cell division it forces its way into the massive tissue in a series of lobes (L, in Text-figs. 12, 15). These lobes in their mature condition have been fully described by Haberlandt. They increase in length and width, boring steadily into the adjacent tissues; sometimes branching into finger-like processes; sometimes twisted so that in section there appear to be isolated islands of meristematic haustorial endosperm in the tissue of the integument or funicle. It is evident that these endospermic folds resorb the integumental cells with which they come in contact, but there is very little evidence of crushing or alteration of tissue in advance of the folds. They are in very close contact with the cells of the funicular and integumental tissue they invade. In contrast with this, traces of crushed cells are often seen between the endosperm and integument on the flanks and top of the endosperm.

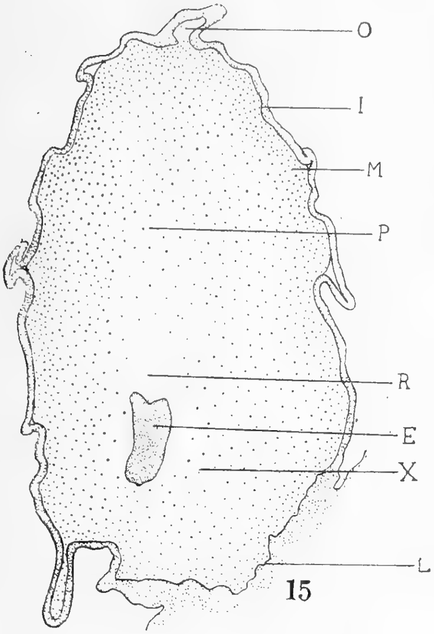
In spite of the haustorial action of the endospermic folds, the thickness of the invaded tissue of the integument and funicle is maintained and even increased by continued cell division in all planes. Cell division in the rest of the peripheral zone of the endosperm, i.e., in the upper part of the seed, away from the micropyle and funicle, is not so marked as in the lower part. It results in a general increase in size of the developing seed.

Meristematic activity in the endosperm is practically limited to the outer 6–7 rows of cells, so that a secondary tissue is formed behind the meristematic region by its continued advance. The cells of this tissue remain small and thin-walled and constitute what may be referred to as the secondary endosperm, in contrast with the large-celled primary endosperm filling the centre of the embryo-sac.

At the same time the remaining single row of cells constituting the major part of the integument continues to divide rapidly in a plane at right angles to the surface of the ovule, so that it becomes more and more wrinkled over the surface of the endosperm, in spite of the continued growth of that tissue (Text-fig. 12).

The embryo rapidly increases in size, and by the time meristematic activity is established in the peripheral endosperm, the divisions of the fertilized egg have resulted in the formation of an embryo such as is shown in Text-figure 13.

A study of the seed at this stage of development (i.e., at the stage indicated in Text-fig. 12) shows that the much enlarged embryo-sac is not spherical, but is rather spheroidal in shape. Looking at the seed in radial view, it appears fairly narrow, lying obliquely on the placenta, with the original embryo-sac visible at the apex (Text-fig. 14A), while from another aspect at right angles to the first (Text-fig. 14B), it appears much wider and the heavy folding of the integument is more clearly shown. The growth of the seed is already pushing the apex of the



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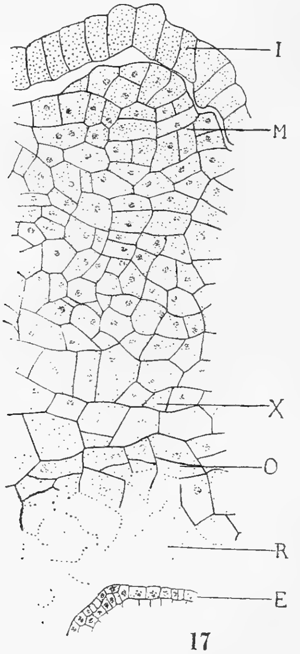
Text-fig. 15.—A radial section of an older seed than that shown in Text-fig. 12. O, position of the original embryo-sac; I, integument; M, meristematic region of the endosperm; E, embryo; X, endosperm which has been attacked by enzymes; L, endospermic lobes; R, primary endosperm in process of being resorbed; P, unaltered primary endosperm. × 30.

Text-fig. 16.—The original embryo-sac of Text-fig. 15 shown in detail. I, integument; E, endosperm. × 262.

arrow-shaped head of the placenta to one side of the loculus of the ovary. The lobing and furrowing characteristic of the lower part of the apex of the placenta is also clearly shown in Text-figures 14A and 14B. In the median region of the expanded apex of the placenta (Text-fig. 14A) many aborted ovules can be seen.

The Growth of the Embryo.

The embryo increases in size at the expense of the neighbouring endosperm cells. These endosperm cells are first altered by the action of enzymes secreted by the embryo, since, although they are quite undeformed, cells at a considerable distance from the embryo show evidence of alteration by their reaction to stains. The altered endosperm cells are then crushed by the growth of the embryo and their contents are resorbed. Around the growing embryo, therefore, there are a number of zones. Firstly, adjacent to the embryo, are the structureless remains of the cells whose contents are being resorbed, cell walls are disintegrating and nuclei are no longer visible (R, in Text-fig. 17); further out is a zone of cells whose contents appear homogeneous, due to enzyme action, and which are slightly deformed by the pressure of the growing embryo (U, in Text-fig. 17); further out still, is the zone of undeformed cells which are in the process of alteration by enzyme action (X, in Text-fig. 17), and this grades into the unaltered endosperm. The altered zones are readily distinguished in stained sections, since they stain practically uniformly with dyes such as anilin blue and Delafield's haematoxylin. At the periphery of the endosperm the meristematic zone of densely protoplasmic cells is evident (M, in Text-fig. 17), while between this zone and the integument, crushed fragments of the cells which composed the inner layers of the integument can sometimes be made out.



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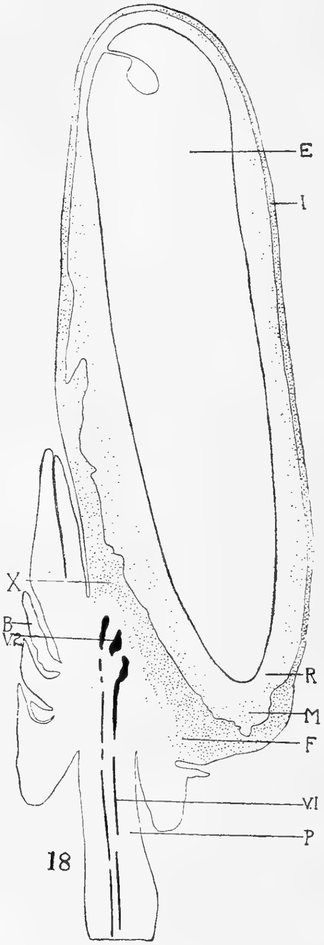

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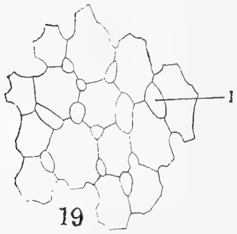

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Text-fig. 17.—Part of the developing seed shown in Text-fig. 15 shown in full cell detail. I, integument; M, meristematic region of the endosperm; X, endosperm which has been attacked by enzymes; O, slightly deformed endosperm; R, resorbed endosperm; E, embryo. × 250.

Text-fig. 18.—A radial section of a seed and the placenta showing a much enlarged embryo which extends the full length of the seed. I, integument; E, embryo; R, inner endosperm in the process of resorption; M, outer meristematic and haustorial endosperm; F, funicle; B, aborted ovules; P, placenta; V1, conducting tissue; V2, vascular tissue just below the funicle. × 19.

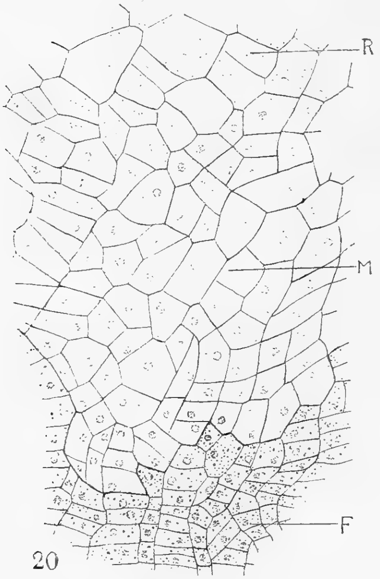
Text-fig. 19.—A small portion of a tangential section of the stalk of the placenta showing intercellular spaces (I). × 267.

The young embryo grows rapidly, and by the time it is 0·4 mm. in length it begins to show signs of the development of cotyledons (Text-fig. 15). Text-figure 15 also shows the original position of the embryo-sac at O, at the apex of the ovule. This part is shown in detail in Text-figure 16. The integument (I) is thicker here than on the flanks of the ovule, and the position of the original embryo-sac is filled with a small-celled prolongation of the endospermic tissue (E).

As the embryo increases in size the primary endosperm becomes wholly resorbed and the secondary endosperm is next attacked. The subsequent growth of the embryo is very rapid, and to accommodate it and provide the necessary food material, the growth of the haustorial and meristematic endosperm is also very rapid, the haustorial lobes becoming very much increased in size and complexity. Continued divisions of the cells of the massive region of the funicle and integument enable this tissue to maintain its dimensions and so still provide the food supply for the haustorial and primary endosperm and the embryo. Divisions in the meristematic endosperm along the flanks and over the apex of the ovule enable it to keep pace with the rapidly enlarging embryo, but during this process it becomes very thin (Text-figs. 18, 21). This enlargement of the embryo and endosperm causes the folds in the integument to be stretched out (Text-fig. 18), so that this layer soon fits very tightly over the surface of the endosperm.

The haustorial folds of the endosperm are now very numerous. In most cases there are a relatively few major haustoria such as are shown in Text-figure 21, and from these, numerous small subsidiary haustoria develop into the integument and funicle. At the stage shown in Text-figure 21, these haustoria have rather blunt apices consisting of a number of small cells. Occasionally one finds narrow haustoria one or two cells wide forcing their way into the funicle. The major folds seem to be developed chiefly vertically in a plane tangential to the placenta, since they are best seen in tangential longitudinal sections. Transverse sections taken just below the vascular strand of the placenta (about X, in Text-fig. 18) show the subsidiary folds excellently, and the position of a major fold may be indicated by a wide shallow extension of the endosperm. Radial sections frequently miss the major folds altogether, and show only the smaller ones (Text-fig. 18). When the embryo is nearing maturity and has emerged into the cavity of the ovary, the cells at the ends of the haustoria tend to grow out separately for short distances. This development is specially well seen in transverse sections taken just above the vascular strand of the placenta, and has been very adequately described by Haberlandt. In transverse sections which include the vascular strand of the placenta, individual haustorial lobes are less numerous and less deeply penetrating than in sections taken higher up. The endosperm tissue encroaches on this part of the funicle in an almost unbroken front. In contrast to this Haberlandt found that in the ovules examined by him the haustorial lobes were more pronounced here than elsewhere.

The contact between the cells of the endospermic folds and the cells of the massive tissue they invade is, as was described before, very close, so that without a knowledge of the previous history of the two tissues, one would have difficulty in distinguishing them as of separate origin. In Text-figure 20 a small section of this region is shown in detail; at F, are the thin-walled dividing cells of the funicle, which are filled with darkly staining reserve food and are arranged in more or less definite rows; at M, are the cells of the haustorial endosperm, also



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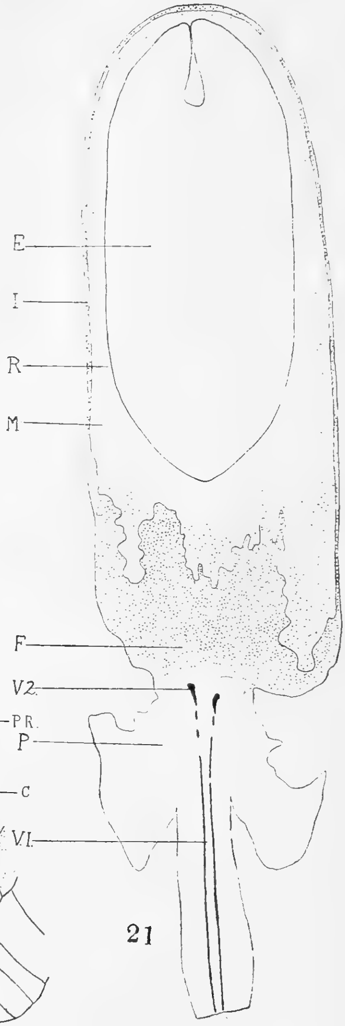

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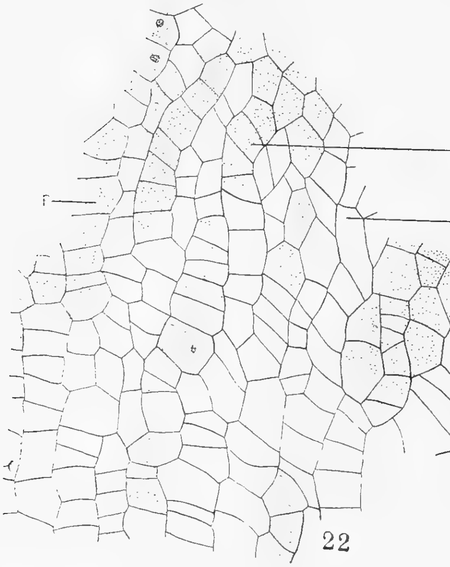

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Text-fig. 20.—Part of a radial section of a seed showing the full cell detail of the meristematic region of the funicle (F). M, haustorial endosperm; R, inner endosperm. × 250.

Text-fig. 21.—A longitudinal section passing through the placenta and tangentially through the upper part of the embryo. The embryo is slightly older than that shown in Text-fig. 18. E, embryo; I, integument; R, inner endosperm undergoing resorption; M, haustorial endosperm; F, funicle; V1, vascular tissue of the placenta; V2, vascular tissue just below the funicle; P, placenta. × 19.

Text-fig. 22.—A detailed study of the part of the placenta adjoining the funicle, showing rows of cells filled with proteinaceous material. F, funicular cells; PR, cells of the placenta filled with proteinaceous material; C, clear cells of the placenta. × 250.

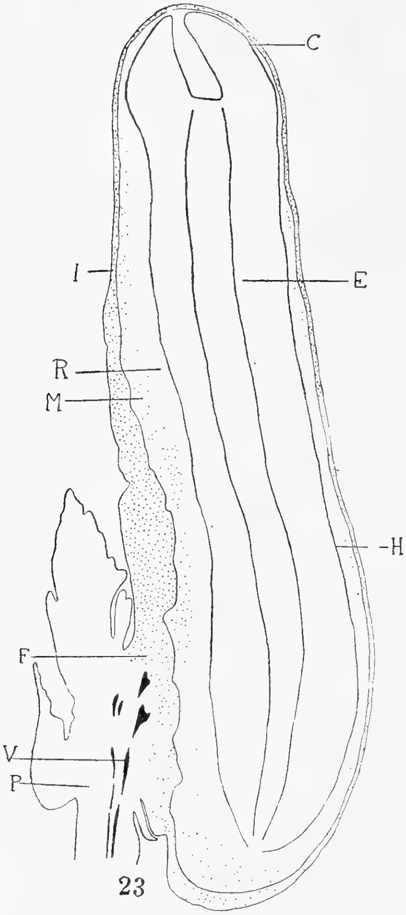
in fairly regular rows, but distinct from the rows of the funicular cells they invade. These cells are thin walled and densely protoplasmic, but stain less darkly than the cells of the funicle, since they have no reserve food. Behind this actively meristematic zone is the region where divisions have ceased and upon which the growing embryo is encroaching. Haberlandt (1895) has given a detailed account of the embryo at about this stage of development, but since the embryos examined by the present writers differ slightly from those described by him, Haberlandt's observations will be discussed later, and a complete description is given here of the facts as observed by us.

During the period of enlargement of the embryo, the stalk of the placenta increases in length (cf. Text-figs. 18 and 21). This process seems to be simply one of cell expansion, the individual cells becoming larger and broader, and air spaces appearing between them (Text-fig. 19).

To accommodate the increase in size of the funicle, meristematic divisions take place in the adjacent part of the placenta. New elements are added to the vascular strand which extends towards the funicle but never into it, or into the integument. It is obvious, therefore, that food material for the growing embryo must first pass across the small cells of the funicle and thence be absorbed by the haustorial endosperm. The cells of the funicle are small, fairly thin walled and stain darkly because of the presence of food material within them. The cells of the placenta are similar in size and shape, but food material is stored only in a few scattered cells, so that the tissue as a whole does not stain darkly. The two tissues are, therefore, fairly sharply differentiated from one another. Where they merge it is often found that rows of cells filled with proteinaceous food material and rows of clear cells alternate over a short area (Text-fig. 22).

By the time the embryo has reached a length of 5 mm. (Text-fig. 18) the cotyledons are fully differentiated. They are short and fleshy, and in longitudinal section appear triangular. Occasionally they are slightly twisted around one another. The meristem of the radicle is also distinguishable at this stage, but remains dormant and undifferentiated until the embryo begins to germinate. The embryo by this time has become a deep green, due to the presence of chlorophyll in the cells of the cotyledons and the cortex of the hypocotyl. In older specimens multicellular hairs, as described by Haberlandt (1895), are present around the young radicle. The plumule remains as an undifferentiated meristem between the cotyledons until the young plant becomes established in the soil.

Up till the stage shown in Text-figures 18 and 21, increase in size is due to cell divisions throughout the whole embryo, but now growth becomes practically confined to the lower part of the hypocotyl. The radicle, therefore, becomes gradually pushed down to a position below the apex of the placenta (Text-fig. 23). The integument and endosperm keep pace with this extension in length by continued cell division. But eventually the elongation of the hypocotyl causes the radicle to break through the integument at the lower end of the ovule so that it emerges into the cavity of the ovary. At the same time the stalk of the placenta continues to elongate, so that the integument and the endosperm remain as a close fitting cap over the cotyledons and upper part of the hypocotyl. This condition is shown in Text-figures 24 and 25 (see also Haberlandt, 1895, Text-fig. 8). The embryo by this time completely fills the ovary, and the placenta, endosperm and integument are crushed very closely against it. As the embryo approaches its mature size (Text-fig. 25) it becomes curved, with the placenta along the concave side. This bending appears to be due to the fact that the



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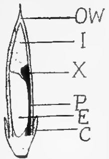

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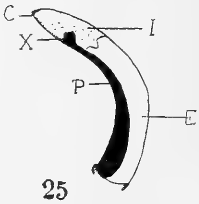

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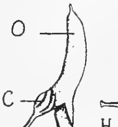

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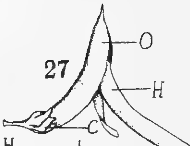

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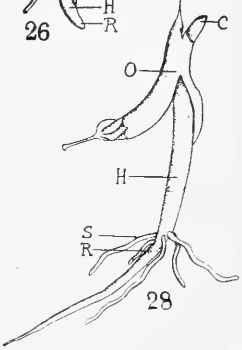

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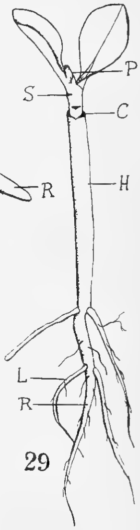

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Text-fig. 23.—A radial section of a seed older than that shown in Text-fig. 18. The extension of the hypocotyl has carried the base of the embryo below the level of the apex of the placenta. E, embryo; C, cotyledons; I, integument; R, inner resorbed endosperm; M, haustorial endosperm; H, hypocotyl; F, funicle; P, placenta; V, vascular tissue. × 19.

Text-fig. 24.—A diagram showing the young embryo within the ovary. Part of the ovary wall is removed. OW, ovary wall; I, integument; X, upper part of the placenta and aborted ovules; P, placenta; E, embryo; C, persistent calyx. × 0·7.

Text-fig. 25.—An embryo removed from the fruit. C, tip of the cotyledons; E, embryo; I, integument; X, upper part of the placenta and aborted ovules; P, placenta. × 0·95.

Text-fig. 26.—An embryo emerging from the fruit. R, radicle; H, hypocotyl; C, persistent calyx; O, ovary wall. × 0·6.

Text-fig. 27.—A later stage in the emergence of the embryo from the ovary wall. R, radicle; H, hypocotyl; O, ovary wall; C, persistent calyx. × 0·76.

Text-fig. 28.—An older embryo which has developed secondary roots (S). The cotyledons are emerging from the ovary wall (O). R, radicle; C, cotyledons; H, hypocotyl. × 0·76.

Text-fig. 29.—A well established seedling. P, shoot; S, leaf scar; C, cotyledons; H, hypocotyl; R, main root; L, lateral roots. × 0·48.

stalk of the placenta is unable to extend as rapidly as does the hypocotyl, and consequently causes the embryo to arch away from it.

The embryo has by this stage become packed with starch, which is stored as compound grains throughout the pith and cortex of the hypocotyl. It also contains a considerable amount of proteinaceous reserve food material similar to that described in the funicle of the young ovule. A section taken through the funicle and endosperm at this stage shows that the endosperm is practically all resorbed, and that the walls of the invading haustoria become thickened as described by Haberlandt (1895), and the apices of the haustorial lobes tend to branch into the funicle in finger-like processes one cell wide. The thickening of the walls causes the cells to draw away at the corners, leaving air spaces, till finally they become almost separated from each other and from the funicular cells. When the embryo is mature, the endosperm and integument are almost completely dried up, and remain fitting like a cap over the cotyledonary end of the embryo. In the specimens examined by us the funicle never became wholly depleted of its characteristic proteinaceous reserve food.

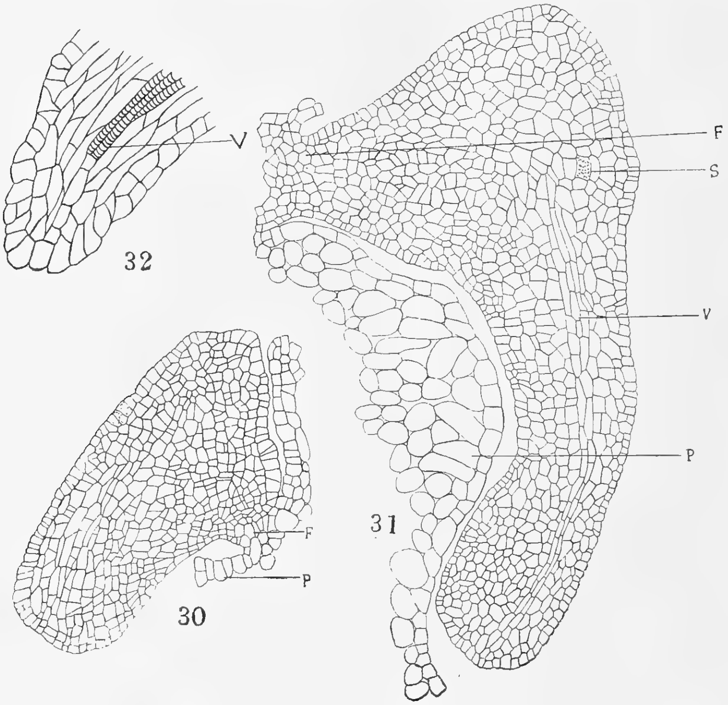
An account of the emergence and establishment of the seedling has already been given by Collins (1921) in connection with her work on the mangrove vegetation of the Sydney district (N.S.W.), but for the sake of completeness a brief description of the stages in the development of the embryo up to the time of its establishment in the soil will be included here.

Rapid growth continues in the hypocotyl until the embryo is nearly 3 cm. in length. At about this time the fruit falls from the parent plant, but no great check occurs in the process of elongation of the embryo. It soon bursts through the wall of the ovary (Text-figs. 26, 27) and the radicle end of the embryo emerges. If it should have fallen in a suitable place the radicle quickly grows down into the mud and secondary roots are formed which securely anchor the young plant (Text-fig. 28). The cotyledons then emerge from the ovary wall, casting off the integument, and the plumule grows up between them and expands (Text-fig. 29). The reserve food in the hypocotyl begins to disappear as the young plant increases in size, but a considerable amount is still present at the stage shown in Text-figure 29.

"Appendages."

Curious structures which occupy the position of ovules on the placenta and at first resemble them in certain respects are occasionally met with in sections of ovaries. In a young ovary they present an appearance such as is shown in Text-figure 30. Each has a short funicle-like stalk (F) and is somewhat elongated downwards. The tissue composing it, however, is quite homogeneous, there being no indication of integument or embryo-sac, so that the structure cannot be regarded as an ovule, unless possibly as an abnormal development of nucellar tissue. The outermost layer of cells contains proteinaceous material and stains deeply, resembling the peripheral layer of the integument of normal ovules.

As the ovary increases in size and the fertilized ovules develop, these "appendages" elongate rapidly downwards along the furrows of the expanded part of the placenta. As they grow they become slightly twisted, so that it is impossible to obtain a complete view of a fully developed "appendage" in any one section. That shown in Text-figure 31 is by no means a large specimen. The central cells of the elongated part of this structure become long and narrow, and finally develop close spiral thickenings on their walls, so that a full grown "appendage" appeared to have a well developed vascular strand down the centre. These spiral elements reach almost to the tip of the structure, as shown in Text-figure 32, but they extend back through the "appendage" only as far as will bring them into close proximity with a schizogenous gland, which occurs in a position approximately analogous to that of the embryo-sac in the normal ovule. The "vascular tissue", therefore, does not pass through the funicle-like stalk and so has no connection with the conducting elements of the placenta.



Text-fig. 30.—A young "appendage". F, funicle-like stalk; P, placenta. ×148.

Text-fig. 31.—A later stage in the development of the structure shown in Text-fig. 30. F, funicle-like stalk; S, schizogenous gland; V, elongated cells which later develop spiral thickenings; P, placenta. × 148.

Text-fig. 32.—The tip of an "appendage" older than that shown in Text-fig. 31. V, cells with spiral thickenings. × 250.

The presence of one or more schizogenous glands (S, in Text-fig. 31), similar to those occurring in the ovary wall, is remarkable since no other glands develop at any time in the placenta or normal ovules.

Discussion.

1. *Comparison with Haberlandt's description.*

In his description of the embryology of *Aegiceras majus*, Haberlandt (1895) states that the mature fruit attained a total length of 7 cm., whereas in the Sydney district the mature fruits do not as a rule exceed 3·5 cm. in length, and the "river" forms have even shorter, more slender fruits. As Sydney is almost the extreme southern limit of the distribution of *Aegiceras*, it is probable that the plants here are much less robust than those growing in the tropics, and that the fruits are correspondingly smaller. This difference in size is probably responsible for some of the discrepancies between Haberlandt's description and that of the present writers.

Haberlandt states that in ovules whose embryos were 7 mm. long the "Schleimendosperm", i.e., the inner endosperm which is in the process of being resorbed, attains a thickness of 0·2 to 0·3 mm. opposite the placenta. In ovules of similar size examined by the writers, the width of this endosperm was never more than 0·1 mm. Since, however, the mature fruits of the form examined by Haberlandt were about twice the size of those examined during the present investigation, Haberlandt's embryo 0·7 mm. in length was probably at an earlier developmental stage than an embryo of similar size collected near Sydney. Also, it might be reasonable to expect a more massive endosperm in the tropical form than in the southern form.

Haberlandt gives the following description of the inner endosperm (p. 107): "Die innere, dem Embryo anliegende Endospermschicht besteht in jüngeren Samen, deren Embryonen die Mikropyle noch nicht durchbrochen haben, aus ziemlich dickwandigen, mit zahlreichen grossen Tüpfeln versehenen Zellen, welche in ihrem Aussehen etwa den Endospermzellen von *Lupinus* gleichen; . . . Später nimmt diese endospermschicht den Charakter der Schleimendosperme an." This by no means corresponds with the condition observed by the present writers. In this investigation the inner endosperm is found to be uniformly thin walled at all stages of the development of the embryo, and never at any time resembles the endosperm of *Lupinus*, and pits, if present, are quite inconspicuous.

He also suggests that the "Schleimendosperm" may be of the nature of a water reservoir. But the observations here recorded show conclusively that this endosperm is nothing other than endospermic tissue slightly altered by the action of enzymes secreted by the growing embryo, and in the process of being resorbed. Both primary and secondarily formed endosperm are used up in this fashion.

In the Buitenzorg specimens the cells of the haustorial endosperm are shown by Haberlandt (Text-figs. 1–5) as being roughly half the size of the cells of the placental (i.e., funicular, in the present terminology) tissue they invade. In the specimens here described, it was found that the cells of the haustorial endosperm were little, if any, smaller than the adjacent cells of the funicle. Another difference between the Sydney material and that examined by Haberlandt is that in the former the cells of the funicle and massive micropylar part of the integument are filled with a proteinaceous reserve food material. In unstained sections this appears as a dense yellowish mass completely filling the cells. It also absorbs dyes very readily and holds them most tenaciously. This reserve food material appears at a very early stage in the development of the ovule; it is not at any time completely exhausted by the embryo, so that even in mature ovules a proteinaceous residue still remains. Haberlandt's figures (Figs. 2–5) and description of a section through the embryo of a fruit 17 mm. or more long, show placental (i.e., funicular, in the present terminology) cells as large brown-walled cells, poor in protoplasm; the presence of proteinaceous material within them is not mentioned. In the present investigation it was found that the walls of the funicular cells remain relatively thin, so long as the associated haustoria remain functional.

2. *The nutrition of the embryo.*

In the Sydney district the time elapsing between flowering and maturation of the embryo is 9–10 months. Growth is slowest during the early developmental stages up till the time of formation of cellular endosperm. This was found to take about 7 months. As soon as the endospermic haustoria have been initiated, growth becomes relatively much more rapid. From the foregoing description of the development of the embryo, it would seem reasonable to attribute this slow initial growth to the fact that food material for the developing embryo must pass through a zone of meristematic cells. In such a case food material would be obtained with greater difficulty than if the funicle had been equipped with a vascular system, and consequently the growth would be comparatively slow. Once the endospermic haustoria are formed, however, the obtaining of food material would be much facilitated; consequently the embryo would increase rapidly in size.

3. *Comparison with* Avicennia officinalis.

As Haberlandt pointed out, there is a general resemblance between the embryos of *Avicennia* and *Aegiceras* in that, in both cases, there has been a modification of the endospermic tissue to meet the requirements of a large viviparous embryo. In *Avicennia* (Treub, 1883), a single endosperm cell, much enlarged and branched, functions as the haustorium. In *Aegiceras*, lobes of endosperm grow into the funicle tissue and function as haustoria. But there is a further resemblance between the two, which a study of the youngest stages of development of the embryo of *Aegiceras* has brought to light. In *Avicennia officinalis* the nucellus is quickly resorbed and the endosperm and embryo-sac pass gradually out through the micropyle, with the exception of a single endosperm cell which remains within the integument and grows and branches, functioning as a haustorium. In *Aegiceras majus* there is a similar tendency. The nucellus is resorbed at an early stage and the embryo-sac commences to enlarge into the micropyle. It never succeeds in growing completely out, however, since cell division in the integument enables that tissue to keep pace with the growth of the embryo-sac, until the embryo is almost mature.

4. *"Appendages."*

The function of the elongated "appendages" found in some ovaries remains obscure. They bear no resemblance to normal ovules, except in the presence of a funicle-like stalk and the size of their cells.

Summary.

1. *Aegiceras majus* Gaertn., a mangrove occurring in the Sydney district, is characterized by vivipary.

2. The carpels enclose a conical loculus in which develops the basal placenta. This placenta is expanded at the apex into an arrow-shaped head in which numerous anatropous ovules are embedded.

3. Each ovule has a massive integument. The cells in the micropylar region are potentially meristematic. The funicle is very short, and is composed of cells which are also potentially meristematic. No vascular tissue passes across the funicle to the integument.

4. The embryo-sac is elongated and is excentrically placed in the nucellus.

5. After fertilization the embryo-sac enlarges, crushing and resorbing the nucellus. It then commences to grow down into the micropyle.

6. The integument cells in this region divide rapidly radially and longitudinally. The embryo-sac continues to increase in size, absorbing the integument tissue as rapidly as it is formed.

7. Meanwhile the endosperm nucleus has divided many times so that numerous nuclei are found at the periphery of the enlarged embryo-sac.

8. The cells of the integument continue to divide, the successive divisions being so rapid that numerous folds are formed. At about this time cell formation commences at the periphery of the sac and advances inwards so that an extensive endosperm tissue is laid down. The outline of the original embryo-sac is still maintained by the cells of the integument.

9. The fertilized egg divides to form a short suspensor and embryonal tissue at the micropylar end of the sac.

10. The peripheral cells of the endosperm then become meristematic, causing general enlargement of the endosperm, until it completely fills and straightens out the integument.

11. Meanwhile the funicle has become widened by cell division, and the lower part of the endosperm grows into it in extensive folds. These folds assume a haustorial function.

12. The embryo grows rapidly, and the endosperm and integument increase in size by cell division, so that the embryo remains for a considerable period enclosed within them.

13. Finally the embryo grows through the endosperm and integument at the lower end, and the radicle and lower part of the hypocotyl emerge into the cavity of the ovary.

14. At the same time the placenta increases in length, enabling the relative position of the upper part of the embryo to remain unchanged with regard to the placental tissue, so that food continues to pass to the growing embryo.

15. The fruit is then shed from the tree. Under favourable conditions the hypocotyl continues to elongate, causing the radicle to break through the wall of the ovary and emerge.

16. Secondary roots are produced and the plant is established in the mud. The cotyledons break through the ovary wall and the plumule grows up between them.

17. Certain abnormal "appendages" which may occur on the placenta in the position of ovules are described.

18. Haberlandt's description of the endosperm of *Aegiceras majus* is discussed. A comparison is drawn between the mode of development of the embryo in *Aegiceras majus* and in *Avicennia officinalis.*

The authors wish to express their thanks to Professor T. G. B. Osborn, of the Department of Botany, Sydney University, for suggestions and kindly criticism throughout the course of this work.

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THE AUSTRALIAN SPECIES OF *GRAPHOMYIA* (DIPTERA, MUSCIDAE).

By I. M. Mackerras, B.Sc., M.B., Ch.M.,
Commonwealth Council for Scientific and Industrial Research,
Canberra, F.C.T.

[Read 30th November, 1932.]

The genus *Graphomyia* R.-D. includes a fairly compact assemblage of flies, which for the most part have a superficial resemblance to large and ornate species of *Musca*. Like that genus, the greatest number and variety of species are found in the tropical parts of the old world, nine of the twenty-two species at present recognized being African and nine Oriental. The genotype, *G. maculata* Scop., is the only one which is widespread, being recorded from Europe and Africa and represented by a subspecies in the Oriental and Australasian regions. One species has been described from Mexico and one from Chile.

In the Oriental region, one species, *G. luteicornis* Senior-White, occurs in Ceylon; one, *G. maculata rufitibia* Stein, in Formosa; two, *G. fascigera* Stein and *G. atripes* Malloch, in Sumatra; four, *G. maculata rufitibia* Stein, *G. mellina* Stein, *G. vittata* Stein and *G. adumbrata* Wied., in Java; and two, *G. confluens* Stein and *G. rufiventris* Stein, in Ceram. No species, so far as I can discover, has been recorded from India. The distribution indicated is suggestive, but practically all the species are rare and it would not be safe to discuss the zoogeography of the group until a great deal more collecting has been done in various parts of the region.

Only one species, *G. eximia* Stein from New Guinea (*Nova Guinea*, xiii, Zool., 2, 1919, 199), has been described from the Australasian region. Malloch (these Proceedings, l (2), 1925, 46) states that he has seen a species from Australia, but gives no details concerning it. I have only seen the two species which are described below. It is clear that the genus entered Australia from the north, probably at a relatively recent date, and that it represents the "tail" of a widespread Malayan distribution.

Nothing is known of the biology of any of the species except *G. maculata* Scop., the larvae of which are saprophagous.

I am indebted to Mr. F. H. Taylor for the loan of the specimens recorded below from his own and the Ferguson collection, and to Dr. A. B. Walkom and Mr. A. Musgrave for copies of descriptions which would otherwise not have been available to me.

Genus Graphomyia R.-D.

The Australian species of *Graphomyia* may be distinguished from other Muscinae by the following characters: propleura, prosternum and mesopleura bare; hypopleura with fine hairs on upper part below and anterior to spiracle; acrostichal bristles reduced to one pre-scutellar pair; cell R_5 rather widely open and vein M_1 (distal section of M_{1+2}) with a rounded bend.

Graphomyia maculata rufitibia Stein.

The specimens before me agree very well with Stein's description of *G. rufitibia* Stein from Formosa and Java (*Ann. Mus. Nat. Hung.*, xvi, 1918, 147).

He had at first considered that his specimens represented a variation of *G. maculata* Scop., but later, because of their constantly slightly smaller size and more definite markings, he described them as a distinct species. There is a female of the typical form of *G. maculata* Scop. from France in the Ferguson collection. It does differ from the Australian specimens, but so slightly that I can only regard them as worthy of subspecific rank. I have reduced Stein's name accordingly. I give a description, based on Australian material, to facilitate identification by Australian workers.

♂. Eyes separated by about one-eighth of head-width, densely covered with short fine pale-brown hairs; frons black, parafrontals and parafacials shining silvery-white.

Thorax greyish-white, with an elongate-triangular median black stripe from suture to scutellum, a pair of slightly divergent narrow submedian black stripes extending from anterior end of thorax to a point mid-way between suture and scutellum, and a broad pair of sublateral black stripes which do not extend quite to anterior margin or to scutellum, and are narrowly interrupted at suture. Scutellum greyish-white, with a broad median black patch and black side margins. Pleurae covered with ashy tomentum, bristles and hairs black.

Abdomen covered with silvery tomentum. First visible tergite with a median black vitta which does not quite reach the hind margin, and with a broad sickle-shaped brown patch on each side extending along lateral and posterior margins but not reaching mid line. Second tergite with a narrow incomplete median black vitta and large sublateral brown patches. Third tergite with a narrower median black vitta, with a large black spot near the posterior edge on each side, and with brown sublateral patches extending the full length of tergite. Fourth tergite mostly covered with silvery tomentum, but with irregular submedian brown patches. Ventral aspect of tergites silvery and pale yellow; sternites silvery.

Legs with femora black, covered with ashy tomentum; tibiae brown; tarsi black. Wings faintly yellowish, veins bright brown; bristles on R_{4+5} extending from base two-thirds of way to r–m above and one-third of way to r–m below. Length, 7·5 to 8 mm.

♀. Eyes finely and rather scantily pubescent, separated by about one-third of head-width; frons black, with a median grey stripe commencing at the sides of the ocellar triangle and narrowing towards the antennae. Parafrontals and parafacials creamy-white. Thorax more yellowish than in ♂, but otherwise similar.

Abdomen covered with greyish-white tomentum and bearing the following brownish-black marks: first visible tergite with a median triangular vitta not reaching the apex of the segment, and with broad sickle-shaped patches extending from the lateral margins almost to mid line close to but not touching the posterior border; second tergite with a median lozenge-shaped vitta and irregular submedian and sublateral stripes extending from the anterior to the posterior border of the segment; third tergite with a narrow median vitta, submedian posterior black spots, and broad irregular sublateral patches extending the length of the segment; fourth tergite with small irregular patches. Insertion of abdominal hairs marked by small brownish-black spots, which are more conspicuous than in ♂. Venter, legs and wings as in ♂. Length, 7·0 to 7·5 mm.

One ♀ from Broadwater, New South Wales, differs from the others in the more strongly contrasted abdominal markings, but is otherwise similar.

Distribution: Brock's Creek, N.A., 22 Apr., 1929, T. G. Campbell, 1 ♂, 1 ♀, the latter labelled "caught on fresh horse manure"; Cairns, N.Q., A. P. Dodd, 1 ♀, labelled "ex corn"; Townsville, N.Q., F. H. Taylor, 2 ♀♀; Broadwater, N.S.W., Sept., 1928, D. S. North, 1 ♀; Nyngan, N.S.W., J. W. T. Armstrong, 1 ♂ (coll. Ferguson); Sydney, N.S.W., 8 Jan., 1923, Ferguson, 1 ♀ (coll. Ferguson); Wahroonga, near Sydney, N.S.W., 20 Nov., 1926, Ferguson, 1 ♀ (coll. Ferguson).

GRAPHOMYIA CAMPBELLI, n. sp.

A small, distinctively marked species, which appears to be nearest to *G. fascigera* Stein from Sumatra (*Tijdschr. Entom.*, lxii, Suppl., 1920, 66), from which it is, however, abundantly distinguished by the absence of any dark spot on the squame, by the presence of two posterior sterno-pleural bristles, by the entirely dark legs and by the abdominal markings.

♂. Eyes separated by about one-twelfth of the head-width, densely covered with pale brown hairs, which are longer than those of *G. maculata rufitibia* Stein. Frons black, linear above and widening to a narrow triangle above the antennae; frontal bristles eight, ending about three-fifths of distance from lower end of frons, interspersed with fine black hairs which extend the full length of frons. Parafrontals and parafacials white. Antennae brownish-black, third segment slightly paler; arista dark brown. Face dark brown, covered with ashy tomentum; cheeks with a brown patch near anterior margin, remainder ashy with a yellowish patch below the brown patch; two strong bristles at vibrissal angle and another just above; cheeks with numerous strong black hairs. Proboscis and palpi dark brown to black. Occiput black, with a narrow white postocular stripe which widens laterally.

Thorax covered with silvery tomentum, which is so reduced by the black markings as to form narrow dorsocentral and lateral stripes. The median and submedian black stripes of *G. maculata* Scop. are so broadened in this species as to have become almost completely confluent, forming a very broad median stripe, which narrows abruptly to half its anterior width midway between the suture and the scutellum; in certain lights the median area in front of the suture can be seen to be composed of a very narrow black median stripe bordered by grey. The sublateral black stripes are broad and continuous and are not interrupted at the suture. Scutellum covered with silvery tomentum, with a broad triangular black patch covering three-quarters of its extent, and with black side margins. Dorsocentrals 2 + 4. Pleurae grey, with brown to black patches; bristles and hairs black.

Abdomen orange, with black markings and patches of pale yellow tomentum. First visible tergite blackish-brown, with a faint greyish patch on each side of mid line towards apex. Second tergite with a narrow median black stripe, and with narrow submedian and broader sublateral pale yellowish patches overlying the orange. Third tergite similar to the second, but with, in addition, a pair of apical submedian black spots. Fourth tergite mainly covered with pale yellowish tomentum. Ventral aspects of tergites pale orange and silvery; sternites brown.

Wings hyaline, veins brown; hairs on vein R_{4+5} restricted to base below, extending one-quarter of distance to r–m above. Squames greyish-white, with creamy borders. Halteres pale yellow. Legs black, femora with some ashy tomentum. Length, 6 mm.

Holotype ♂. Brock's Creek, North Australia, 21 Apr., 1929, T. G. Campbell, in the collection of the Division of Economic Entomology, Canberra.

CONTRIBUTIONS TO OUR KNOWLEDGE OF THE ACTINOMYCETALES. IV.

The Identity of Certain Species of Mycobacterium and Proactinomyces.

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

(Four Text-figures.)

[Read 30th November, 1932.]

In a previous paper (Jensen, 1931) the present writer showed that two microorganisms previously classified as *Mycobacterium actinomorphum* and *Mycobacterium agreste* should correctly be placed in the new genus *Proactinomyces.* Since then, some work has been carried out on the morphology and biology of saprophytic mycobacteria and corynebacteria isolated from Australian soils, and authentic cultures of a number of related organisms have been obtained for comparison. Several of these have, on closer examination, been found, like the two organisms mentioned above, to belong to *Proactinomyces,* as previously defined (Jensen, 1931): organisms starting their life-cycle with the formation of a definite, more or less extensive vegetative mycelium which sooner or later divides, by formation of septa, into more or less bacterium-like, rod-shaped to coccoid elements, and generally producing an aerial mycelium in which no definite spores are formed. The following strains were examined: 1. *Mycobacterium agreste* Gray and Thornton (1928); 2. *M. crystallophagum* Gray and Thornton (1928); 3. *M. erythropolis* Gray and Thornton (1928); and 4. *Bacillus mycoides corallinus* Hefferan (1904),* from the National Collection of Type Cultures, Lister Institute of Preventive Medicine, London; 5. *Mycobacterium salmonicolor* den Dooren de Jong (1927); and 6. *M. opacum* den Dooren de Jong (1927), from the laboratory of Keuringsdienst van Waren, Rotterdam, Holland; and 7. *Microbacterium mesentericum* Orla-Jensen (1919), from the Biotechnical-Chemical Laboratory, Polytechnical School, Copenhagen, Denmark.

The media and the methods for cultivation and study were the same as described in the previous paper (Jensen, 1931), except that nutrient agar with 1% soluble starch was used for testing the diastatic activity.

Descriptions of the Organisms.

Proactinomyces corallinus (Hefferan), n. comb.

Synonyms: *Bacillus mycoides corallinus* Hefferan (1904).—*Serratia corallina* (Hefferan) Bergey (1923–30).—*Streptothrix corallinus* (Hefferan) Reader (1926).—*Mycobacterium agreste* Gray and Thornton (1928).—*Actinomyces agreste* (Gr. and Th.) Bergey (1930).—*Proactinomyces agrestis* (Gr. and Th.) Jensen (1931).

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* This organism was identified as a "*Streptothrix*" by Reader (1926).

Six strains were compared:

1. *Bac. corallinus* Hefferan } from the Lister Institute.
2. *Myc. agreste* Gr. and Th. }
3. AII, from garden soil, Sydney University.
4. Sc, from humus soil from Scone, N.S.W.
5. 271 } from red loam soils from the Riverina district, N.S.W.
6. 276 }

Since this comparison, as shown below, proved all the strains to be identical in all essential points, they must apparently be regarded as one single species, for which *corallinus*, on the grounds of priority, must be accepted as the valid specific name.*

Morphology.—All strains, like those previously described (Jensen, 1931), show by direct agar-microscopy according to the method of Ørskov (1923) essentially the same mode of development on dextrose-asparagine-agar: after 1–2 days small branching mycelia which after 2–3 days divide into rods of various length and arranged in angular positions, and later into quite coccoid elements. This process of division starts in the interior of the colonies and proceeds gradually towards the edges; the young colonies have a characteristic star- or burr-like appearance owing to a number of rhizoid projections which are the last to undergo division. Young mycelia show constantly a number of small refractive external granules which by high focussing are seen to rise into the air, and which doubtless represent a rudimentary aerial mycelium; they disappear again within a few days. Text-figure 1 shows the main features of the cycle of development. The rapidity with which this cycle is passed through varies considerably with the medium and the temperature (cf. Reader, 1926), and to some extent also with the strain. For instance, strains Sc and 271 appear almost exclusively as cocci on dextrose-nutrient-agar after 24 hours at 28–30° C., whereas strain 276 shows less tendency to coccus-formation, but a pronounced belt-staining. The cells of the freshly isolated strains were $1{\cdot}0$–$1{\cdot}2\mu$ thick, as also reported by Gray and Thornton (1928); in *Myc. agreste* and *Bac. corallinus* they were somewhat thinner, probably owing to the longer period of artificial cultivation (cf. Hefferan (1904), who reports that the cells of the freshly isolated "*Bac. mycoides corallinus*" were originally as big as those of the anthrax bacillus, but that they gradually decreased somewhat in size). In the latter strain they were also somewhat more curved than in the others. None of the strains was acid-fast in nutrient or synthetic agar (as also found by Gray and Thornton), but in milk they exhibited a partial acid-fastness after 3–7 days.

Cultural characters.—The type of growth in various media is shown in Table 1. There are no very appreciable cultural differences between the strains. The intensity of the pigment varies somewhat, as was also the case with the 74 strains studied by Gray and Thornton (1928). The quantitative differences in the vigour of growth and the formation of a soluble yellow pigment in one strain (271) would hardly justify a separation into different species.

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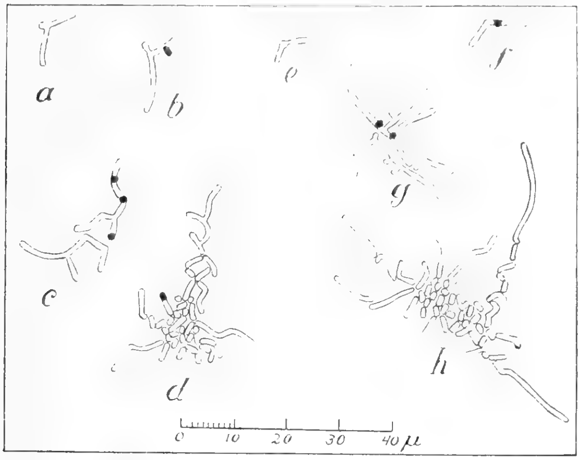
* I cannot here forgo the remark that Bergey's (1923-30) morphological description of *Serratia corallina* (syn. *Bac. mycoides corallinus* Hefferan) disagrees entirely with the descriptions by Hefferan (1904) and Reader (1926). Bergey characterizes it as a small, motile, gram-negative rod with one polar flagellum. One cannot help wondering whether the description has not been confused with that of *Bac. corallinus* Slater (1891), a non-spore-forming, motile, red-pigmented organism which would seem entitled to the name *Serratia corallina* according to Bergey's system of classification.

TABLE 1.—*Comparative Cultural Features of Strains of* Proactinomyces corallinus.

Medium.	*Mycobacterium agreste.*	*Bacillus mycoides corallinus.*	AII.	276.	Sc.	271.
Dextrose-asparagin-agar. 28–30° C.	Good, restricted, convex, myceloid edges, folded, pinkish-orange, becoming pale coral-red.	Good, restricted, convex, myceloid edges, slightly folded, pale pinkish-orange.	Abundant, convex, smooth, glistening, cream-coloured becoming pale pink.	Abundant, convex, smooth, glistening, pale pink, later greyish-orange.	Fair, restricted, myceloid edges, smooth, glistening, pale pink.	Fair, restricted, convex, becoming folded, pink, with yellow soluble pigment.
Dextrose nutrient agar. 28–30° C.	Good, restricted, convex, folded, undulate edges, pinkish cream-coloured, later deep coral-red.	Good, restricted, convex, folded, undulate edges, cream-coloured, later pale coral-red.	Similar to dextrose-asparagin-agar, still more abundant, pinkish-orange.	Similar to dextrose-asparagin-agar, still more abundant, grey pinkish-orange.	Good, convex, myceloid edges, smooth, soft, pink, later becoming coral-red.	Good, convex, myceloid edges, soft, smooth, pink, becoming deep red.
Potato. 28–30° C.	Good, spreading, granular, pink, later deep orange.	Good, spreading, raised, granular, orange.	Fair, spreading, raised, granular, dull greyish-orange.	Good, spreading, raised, granular, glistening, greyish-orange.	Good, spreading, smooth, glistening, greyish-pink.	Fair, spreading, granular, greyish-pink with yellow tinge.
Broth. 28–30° C.	Turbid, with voluminous pinkish-cream coloured sediment and fragile surface scum.	Slightly turbid with pinkish-cream-coloured surface granules and voluminous sediment.	Turbid, later becoming clear, with thick fragile cream-coloured scum and sediment.	Turbid with voluminous pinkish-cream-coloured sediment; no surface growth.	Clear with pink sediment and surface granules, later forming a pellicle.	Turbid, later becoming clear, with cream-coloured sediment, becoming pink.
Milk. 28–30° C.	Pink flakes and granules, forming a red sediment; milk slightly cleared in old cultures (6–8 weeks).	Pink granules and sediment, becoming red; milk slightly cleared in old cultures, yellowish.	Greyish-yellow to pinkish flakes and sediment; milk semi-transparent in old cultures.	Greyish-yellow to pink flakes and sediment; milk semi-transparent in old cultures.	Pink pellicle, later red sediment; milk viscid and semi-transparent in old cultures.	Pink sediment and granules; milk very slightly cleared in old cultures.
	(Clearing of milk not due to proteolytic action; formol-titration shows no increase in amino-N.)					
Nutrient gelatin. 16–18° C.	Both strains identical; filiform, granular, yellowish growth in stab; raised, wrinkled, red surface colony; no liquefaction.		No liquefaction.	No liquefaction.	No liquefaction.	No liquefaction.



Text-fig. 1.—Development of *Proact. corallinus* on dextrose-asparagine-agar at 16-18° C. *a, Bac. mycoides corallinus,* 18 h.; *b,* same, 23 h.; *c,* same, 42 h.; *d,* same, 3 days; *e, Myc. agreste,* 18 h.; *f,* same, 23 h.; *g,* same, 42 h.; *h,* same, 3 days. × 700. Aerial mycelium heavily shaded.

Physiological features are shown in Table 2. There is a certain amount of variation here, but not more than among the 74 strains studied by Gray and Thornton, which were obtained by a selective method (accumulation in a nutrient solution with phenol or cresol as the sole source of carbon) and therefore all capable of decomposing aromatic compounds. It might perhaps be

TABLE 2.—*Comparative Physiological Features of Strains of* Proactinomyces corallinus.

	Bacillus corallinus.	*Mycobacterium agreste.*	AII.	276.	Sc.	271.
Proteolytic action ..	—	—	—	—	—	—
Diastatic action	—	—	—	—		?
Invertase action	—	—	—	—	∓	—
Decomposition of cellulose	—	—	—	—	∓	—
Decomposition of phenol	—	+	?	—	—	?
Utilization of paraffin ..	+	+	+	+	+	+
Utilization of N as*:						
$NaNO_3$	2	2	3	3	2	3
$(NH_4)_2HPO_4$ ..	2	3	3	4	2	4
Asparagine ..	3	3	4	4	2	4
Peptone	3	4	4	5	4	4
Reduction of nitrate ..	+	+	—	?	+	+
Formation of indol† ..	+	+	—	+	+	+
Acid in dextrose-broth ..	—	—	—	—	—	—
Acid in glycerin-broth ..	—	—	—	—	—	—
Growth anaerobically ..	—	—	—	—	—	—

*Basic solution: Dextrose 1·0%; K_2HPO_4 0·1%; $MgSO_4$ 0·05%; NaCl 0·05%; in distilled water; N-compound 0·2%. Character for growth: 0, no growth; 1, trace or very scant; 2, scant; 3, fair; 4, good; 5, excellent.

†By Salkowski's test.

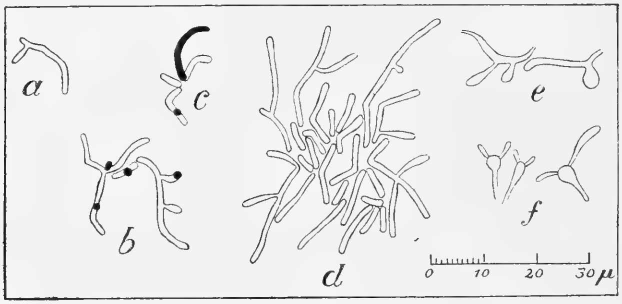
suggested to retain the name *agrestis* for the phenol-decomposing strains, but it would hardly be logical to give this property a special preference before other physiological properties (cf. Gray and Thornton, 1928).

PROACTINOMYCES SALMONICOLOR (den Dooren de Jong), n. comb.

Synonyms: *Mycobacterium salmonicolor* den Dooren de Jong (1927).—*Flavobacterium salmonicolor* (den Dooren de Jong) Bergey (1930).

Morphology.—This organism, of which den Dooren de Jong gives a rather incomplete description, is closely related to *Proact. corallinus.* On dextrose-asparagine-agar after 18–24 hours at 18–20° C., long branching rods are formed, 1·0–1·3μ thick, with small refractive granules of aerial mycelium, sometimes stretching into quite long filaments; after 2–3 days small definite mycelia are present, and after 5–6 days these have largely divided into short rods and cocci; the colonies have the same burr-like appearance as those of *Proact. corallinus.* Many cells at the edge of the colonies show, after 3–4 days, club- or pear-shaped swellings, up to 2·5–3·0μ thick; after 5–6 days many of these swollen cells are seen to "germinate" with the formation of two more slender sprouts (Ørskov (1923) gives an almost identical-looking picture of "*Streptothrix rubra*"; it is questionable, indeed, whether these two organisms are not really identical). At 28–30° C. the development is more rapid. In dextrose-asparagine solution we find, after 20 hours, long branched rods, 1·0–1·4μ thick and up to 30–35μ long, but after 2 days irregular, club- or pear-shaped rods looking like big diphtheroids. In dextrose-nutrient-agar only short rods and cocci, 1·2–1·5μ, are found after 2 days at 30° C., but in milk the long branching rods are still present after 3 days. The organism is not acid-fast in synthetic media or in young cultures on nutrient agar, but partly so in milk after 3–7 days and nutrient agar after 4–6 weeks.

The course of development is shown in Text-figure 2.



Text-fig. 2.—Development of *Proact. salmonicolor* on dextrose-asparagine-agar at 16-18° C. *a*, 18 h.; *b*, 23 h.; *c*, same, long filament of aerial mycelium; *d*, 44 h.; *e*, 3 days; *f*, 7 days. × 700. Aerial mycelium heavily shaded.

Cultural characters.—Cultivation at 28–30° C., unless otherwise stated. *Dextrose-asparagine-agar*: Good growth, restricted, rather flat, edges lobate, surface warty, glistening, first pale orange, later pure ochre-yellow; consistence crumbly. After 5–6 weeks the growth is paler with many small round raised yellow "secondary colonies"; cultures obtained by plating from these do not seem to differ from the original. *Dextrose-nutrient-agar*: Excellent growth, spreading, flat, dense, edges lobate, surface folded, glistening, yellow gradually changing to deep orange-red. *Potato*: Good growth, raised, warty, crumbly, glistening, at first buff, changing to orange and finally to almost blood-red. *Nutrient gelatin*, 20–22° C.: Scant arborescent growth in stab; small wrinkled orange surface colony; no liquefaction. *Nutrient broth*: Fair growth; thin pellicle and granular sediment, at first cream-coloured, later red; broth clear at first, slightly turbid after 3 weeks. *Milk*: Good growth; pellicle of small cream-coloured granules after 2 days, later a thick orange sediment; milk is not coagulated, but appears slightly cleared after 5 weeks, the reaction becoming alkaline.

Physiological features.—Saccharose is not inverted, although readily utilized with sodium nitrate as a source of nitrogen. Starch is not hydrolyzed. Cellulose is not decomposed. Paraffin is readily utilized as a source of carbon. Phenol is not utilized. Nitrate is reduced to nitrite. Indol is not formed. No acid is formed from dextrose or glycerin. No growth in oxygen-free atmosphere. Nitrate, ammonium salts, asparagine and peptone are utilized almost equally well with dextrose as source of carbon, although the growth is most rapid with peptone.

The morphology of this organism shows conclusively that Bergey's (1930) classification of it as *Flavobacterium* is unjustified. This genus comprises small non-spore-forming, usually gram-negative rods, characterized by formation of a yellow pigment and by feeble powers of attacking carbohydrates, gas never being formed and acids rarely. Bergey omits to mention the tendency to branching, which den Dooren de Jong (1927) states to be present, and moreover the present organism produces a luxuriant growth on dextrose and saccharose with inorganic sources of nitrogen; this can hardly be called a "feeble power of attacking carbohydrates", since it is not fair to gauge this power by the formation of acids or gas in the case of organisms which oxidize carbohydrates completely to carbon dioxide and water (cf. Merrill, 1930).

PROACTINOMYCES OPACUS (den Dooren de Jong), n. comb.

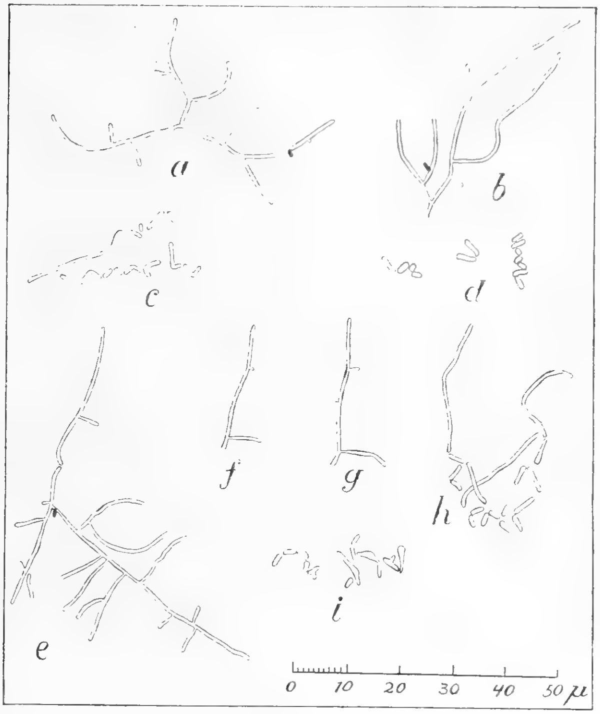
Synonyms: *Mycobacterium opacum* den Dooren de Jong (1927).—*Mycobacterium crystallophagum* Gray and Thornton (1928).—*Actinomyces crystallophagus* (Gr. and Th.) Bergey (1930).

Morphology.—The two strains *Myc. opacum* and *Myc. crystallophagum* are morphologically identical. They form in dextrose-asparagine-agar after 1–2 days at 16–18° C., quite extensive mycelia composed of richly branching hyphae, 0·6–0·9μ thick; short, simple filaments of aerial mycelium are seen, but no spores are formed in these. The mycelia are fragile and appear in stained preparations mostly as branched filaments of varying length. After 3–4 days the young colonies are round, dome-shaped, and surrounded by a flat fringe of long branching filaments which, during the following days, undergo a division giving rise to rod-shaped cells in angular arrangement and gradually growing shorter, finally quite coccoid. Text-figure 3 shows the course of development. At 28–30° C. the development is similar, but more rapid; this is also the case in nutrient agar, milk and potato. There is at the higher temperatures a tendency to formation of swollen, club-like cells, and the strain *opacum* is somewhat less prone to the formation of typical cocci than the other. Both strains exhibit a partial acid-fastness in milk, *opacum* also to a slight extent in nutrient agar.

Table 3.—*Comparative Cultural Features of Strains of* Proactinomyces opacus *and* Proactinomyces erythropolis.

Medium.	*Mycobacterium opacum.*	*Mycobacterium crystallophagum.*	*Mycobacterium erythropolis.*
Dextrose-asparagine-agar. 28–30° C.	Good growth, raised, spreading, edges myceloid, surface folded, pale cream-coloured changing to pale pink ; consistence firm, pasty.	Abundant growth, spreading, raised, edges myceloid, surface folded, glistening, white with pale pink tinge ; consistence soft, pasty.	Good growth, raised, spreading, edges lobate, surface highly folded, dull, white, becoming pinkish-cream-coloured ; consistence firm, pasty.
Dextrose nutrient agar. 28–30° C.	Good growth, raised, spreading, surface folded and granulated, dull white changing to pale buff ; consistence rather dry and coherent.	Abundant growth, restricted, raised, edges lobate, surface highly folded, white, glistening, changing to pale buff ; consistence pasty.	Abundant growth, spreading, convex, edges entire, surface smooth, glistening, pinkish-cream-coloured ; consistence soft and moist.
Potato. 28–30° C.	Good growth, raised, restricted, surface highly folded (lichnoid), dull cream-coloured, becoming greyish-pink ; consistence curd-like.	Good growth, raised, spreading, surface highly folded and wrinkled, pale cream-coloured, later pink tinge ; consistence curd-like.	Good growth, convex, spreading, surface slightly folded, glistening, pinkish-cream-coloured ; consistence soft and moist.
Nutrient gelatin. 16–18° C.	Scant growth in stab, white, filiform, later finely arborescent ; small white wrinkled surface colony ; no liquefaction.	Scant growth in stab, cream-coloured, finely granulated ; small raised and wrinkled pinkish-white surface colony; no liquefaction.	Scant growth in stab, cream-coloured, filiform ; small raised and finely wrinkled pinkish-white surface colony ; no liquefaction.
Nutrient broth. 28–30° C.	Thin, silky, white pellicle developing into a thick fragile cream-coloured scum ; voluminous sediment of same colour ; broth remains clear.	Thin white pellicle developing into a thick fragile cream-coloured scum ; voluminous sediment of same colour ; broth at first turbid, later clear.	Flaky pinkish-white sediment and surface scum, becoming cream-coloured; broth turbid, becoming clear after two weeks.
Milk. 28–30° C.	White, later pale pink to cream-coloured flakes and granules, forming a voluminous sediment ; milk partially cleared in old cultures ; reaction alkaline.	White to cream-coloured flakes and granules along the tube, voluminous cream-coloured sediment ; milk very slowly cleared, becoming viscid in old cultures.	Pinkish-cream-coloured flakes and granules along the tube ; voluminous sediment of the same colour ; milk slowly and gradually cleared, becoming viscid in old cultures.

(The characteristic changes brought about in milk cultures by these strains as well as other non-proteolytic proactinomycetes do not indicate a digestion due to proteolytic action, since formol-titration does not show any increase in the content of amino-N.)



Text-fig. 3.—Development of *Proact. opacus* on dextrose-asparagine-agar at 16-18° C. ***a***, *Myc. opacum*, 24 h.; ***b***, 44 h., edge of colony; *c*, 6 days, edge of colony; ***d***, 7 days, 28° C.; *e*, *Myc. crystallophagum*, 44 h.; *f*, same specimen, 48 h.; *g*, same specimen, 50 h.; *h*, 6 days, edge of colony; *i*, 4 days, 28° C. × 700. Aerial mycelium heavily shaded.

Cultural characters.—As Table 3 shows, these two strains are also very similar in cultural respect; *crystallophagum* is somewhat more soft and moist than *opacum* and has more tendency to produce a turbidity in liquid media, where the latter grows mostly as large discrete flakes, leaving the medium clear. Possibly the two strains represent "plane" and "perrugose" varieties of the same species.

Physiological features, listed in Table 4, show a complete identity, except for the ability of *crystallophagum* to decompose phenol. However, here as well as in the case of *Proact. corallinus*, we may doubt whether this single physiological difference is sufficient for a species differentiation. It seems, therefore, that the two strains must be regarded as a single species, the valid name of which will be *Proactinomyces opacus*.

PROACTINOMYCES ERYTHROPOLIS (Gray and Thornton), n. comb.

Synonyms: *Mycobacterium erythropolis* Gray and Thornton (1928).—*Actinomyces erythropolis* (Gr. and Th.) Bergey (1930).

Morphology.—When grown on dextrose-asparagine-agar this organism is hardly distinguishable from the previous group, apart from a somewhat more pronounced tendency to production of swollen, club-shaped cells; in certain other media its

TABLE 4.—*Comparative Physiological Features of Strains of* Proactinomyces opacus *and* Proactinomyces erythropolis.

	Mycobacterium opacum.	*Mycobacterium crystallophagum.*	*Mycobacterium erythropolis.*
Proteolytic action	—	—	—
Diastatic action	—	—	—
Invertase action	—	—	—
Decomposition of cellulose	—	—	—
Decomposition of phenol	—	+	+
Utilization of paraffin	+	+	+
Utilization of N as*:			
$NaNO_3$	4	4	3
$(NH_4)_2HPO_4$	4	4	3
Asparagine	4	4	3
Peptone	5	4	4
Reduction of nitrate	+	+	—
Formation of indol	—	—	—
Acid in dextrose-broth	—	—	—
Acid in glycerin-broth	—	—	—
Growth anaerobically	—	—	—

* Basic solution: Dextrose 1·0%; K_2HPO_4 0·1%; $MgSO_4$ 0·05%; NaCl 0·05%; in distilled water; N-compound 0·2%. Character for growth: 0, no growth; 1, trace or very scant; 2, scant; 3, fair; 4, good; 5, excellent.

mycelial growth is more marked than is the case with the previous: in milk, long branching mycelia are present after 3–7 days, and no cocci are formed in broth (cf. Gray and Thornton). It is not acid-fast in synthetic or nutrient agar, but somewhat acid-fast in milk after 3 days.

Cultural and physiological features (see Tables 3 and 4) are similar to those of *Proact. opacus*, apart from the absence of nitrate reduction and a characteristic semi-transparent, watery growth on sugar-free nutrient agar (cf. Gray and Thornton, 1928).

The last three strains (*opacum*, *crystallophagum*, and *erythropolis*) show by direct microscopical examination of the young agar colonies a very clear picture of the formation of mycelial branches (cf. Jensen, 1931): minute granules appear outside the hyphae, grow into a small pear-shaped bud attached to the main stem by a thin stalk, and stretch into a lateral branch (see Text-figure 3, *e–g*).* One cannot help being struck by the resemblance of this phenomenon to the formation of what are described as "reproductive bodies" by Löhnis (1921); the pictures of *Myc. tuberculosis* according to Meirowsky and of *Bact. coli* according to Hort, as reproduced by Löhnis, are particularly instructive, as well as the more recent observations by Cunningham (1931) on "reproductive bodies" in *Bac. saccharobutyricus* and by Stoughton (1929) on "stalked gonidia" in *Bact. malvacearum*. Löhnis (1921) describes the phenomenon in the following words:

"If the gonidia are not liberated by the partial or complete dissolution of the cell wall, but remain confined within the cell, they develop into either buds or branches" (p. 127). . . . "Two to four or more gonidia may be produced within

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* Reader (1926) gives a microphotograph showing exactly the same phenomenon in a young culture of *Proact. corallinus*.

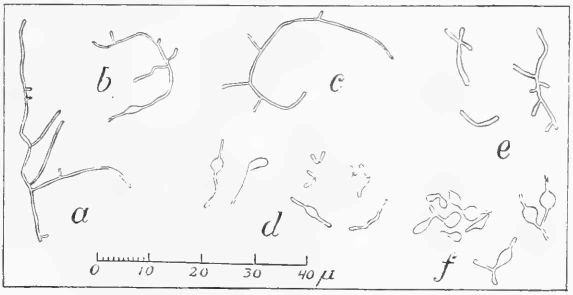
each cell; . . . They may start growing while still within the parent cell, forming buds and branches or directly new vegetative cells within the cell membrane. . . Sometimes they remain temporarily attached to the parent cell by a comparatively long stem" (p. 163).

While the final judgment on the nature of these phenomena may still be held in suspense, there can be no doubt as to their objective existence, and the conclusion might not be unjustified, that this formation of alleged reproductive bodies and gonidia in the "true" bacteria is a phenomenon homologous to the formation of branches in *Proactinomyces* and *Actinomyces*, and the spore formation in *Micromonospora.*

PROACTINOMYCES MESENTERICUS (Orla-Jensen), n. comb.

Synonym: *Microbacterium mesentericum* Orla-Jensen (1919).

Morphology.—This organism, of which Orla-Jensen gives a morphologically and culturally rather incomplete description, proved to be a typical *Proactinomyces.* On dextrose-asparagine-agar, nutrient agar, Saboureaud's agar* and broth it grows at 16–18° C. as extensive mycelia composed of richly branching hyphae of a somewhat variable thickness, 0·4–0·8μ; no aerial hyphae are seen. With increasing age the hyphae divide into fragments of varying size and shape, partly diphtheroid rods, but no real cocci. There is, particularly in the richer media, a tendency to formation of large, swollen, fusiform to almost spherical cells, up to 3·5μ in diameter and staining intensely with carbol fuchsin; when transferred to fresh media, they germinate and produce a new mycelium. On nutrient agar at 28–30° C. the organism appears after 1 day exclusively as irregular, branching rods of varying thickness (cf. Orla-Jensen, 1919, Pl. L). After 2 days and in older cultures the microscopical picture is entirely dominated by big lemon-shaped to spherical swollen cells. In milk, long rods and even definite mycelia are still seen at 30° C. after 10 days. The various cell types are reproduced in Text-figure 4. There is no acid-fastness in any medium. It is characteristic of this as well as of other non-acid-fast proactinomycetes (*Proact. actinomorphus* and *flavescens*, Jensen, 1931), that their cells, when examined by the direct agar-microscopy method of Ørskov (1923), are much less refractive to the light than those of previously described partially acid-fast organisms.



Text-fig. 4.—*Proact. mesentericus.* *a*, dextrose-asparagine-agar, 20 h. 16° C.; *b*, same, 4 days 16° C.; *c*, Saboureaud's agar, 24 h. 16° C.; *d*, same, 4 days 16° C.; *e*, dextrose-nutrient-agar, 20 h. 28° C.; *f*, same, 3 days 28° C. × 700.

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* Milk is boiled for 5 min. with 0·2% HCl, and filtrated; the filtrate is neutralized, and added 1% peptone, 1% dextrose, 0·3% urea, and 1·5% agar.

Cultural characters.—This organism grows decidedly better at 16–18 than at 28–30° C.; the following description, therefore, refers to the former temperature unless otherwise stated.—*Dextrose-asparagine-agar*: Fair growth, narrow, raised, granular, very pale yellow, glistening; condensation water clear, with small granules. At 30° C. only scant growth consisting of small irregular white granules, growing deeply down into the agar.—*Dextrose-nutrient-agar*: Good growth, restricted, with undulate edges, surface with high transversal folds, cream-coloured; the consistence is firm and cartilaginous after 2 days, later more loose and brittle. Growth at 28–30° C. rather scant; smooth, soft, glistening, cream-coloured smear.—*Saboureaud's agar*: Excellent growth, spreading, at first flat and smooth, pale straw-yellow, perfectly hard and cartilaginous, later raised and strongly folded, of a loose, curd-like consistence, bright lemon-yellow. Growth at 28–30° C. only fair, restricted, folded, cream-coloured, soon becoming soft and smeary.—*Potato*: Scant growth; restricted, soft, cream-coloured smear.—*Nutrient gelatin*: Good growth; finely arborescent, cream-coloured growth in the stab; raised, folded, pale yellow surface colony. No liquefaction.—*Broth*: Good growth; voluminous, flaky, whitish sediment; broth clear.—*Milk*: 28–30° C. Small cream-coloured granules along the tube; the milk undergoes no visible changes within 4 weeks. No proteolytic action.

Physiological features.—Saccharose is inverted. Starch is hydrolyzed. Cellulose is not decomposed. Nitrate is reduced to nitrite. Indol is not formed. No growth in oxygen-free atmosphere. N is utilized as sodium nitrate, ammonium phosphate, and asparagine, although these are inferior to peptone as sources of N. The fermentative properties of this organism were studied in detail by Orla-Jensen.

Key to Identification of Species of Proactinomyces.

The species of *Proactinomyces* described here and in a previous paper (Jensen, 1931) may be classified according to the following key:

I. Partially acid-fast organisms with strongly refractive cells. Non-proteolytic and generally non-diastatic; constantly capable of utilizing paraffin.
  A. Initial mycelia very small, rapidly dividing into rods and cocci. (Transition to *Mycobacterium.*)
    1. Slowly growing organism; cells 0·5-0·7μ in diameter .... *Proactinomyces minimus*
    2. Rapidly growing organisms; cells 1·0-1·2μ in diameter.
      a. Cystites* not formed. Rapid formation of cocci .... *Proactinomyces corallinus*
      b. Cystites formed. Less rapid formation of cocci .... *Proactinomyces salmonicolor*
  B. Initial mycelia well developed, richly branching, dividing into rods and generally into cocci.
    1. Vegetative mycelium soft, without macroscopically visible aerial mycelium.
      a. Vegetative mycelium red; may produce variants with undivided vegetative mycelium and visible white aerial mycelium, or yellow and white variants .... *Proactinomyces polychromogenes*
      b. Vegetative mycelium white to pale pink.
        x. Growth on nutrient agar opaque, cream-coloured; cocci in broth culture .... *Proactinomyces opacus*
        xx. Growth on sugar-free nutrient agar watery; no cocci in broth culture .... *Proactinomyces erythropolis*

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* In the present writer's opinion, the term "cystites" (Enderlein, 1925) may conveniently be used as a collective term for the swollen cells which characterize many of these organisms as well as the corynebacteria, without it being necessary to commit oneself to Enderlein's definition of them as cells with a "polydynamic elemental nucleus" (polydynamen Mych.).

    2. Vegetative mycelium hard, yellow, with white aerial mycelium; hyphae divide into chains of acid-fast cocci .... *Proactinomyces paraffinae*

II. Non-acid-fast organisms with weakly refractive cells; no distinct formation of cocci. Constantly diastatic.

- *A.* Non-proteolytic. No aerial mycelium; marked formation of cystites .... *Proactinomyces mesentericus*
- *B.* Proteolytic organisms.
    1. Growth on nutrient agar with rapid formation of unbranched diphtheroid-like rods; no typical cystites; broth turbid .... *Proactinomyces actinomorphus*
    2. Growth on nutrient agar with extensive mycelia; simple unbranched rods not formed; cystites present. Broth clear .... *Proactinomyces flavescens* (*Transition to Actinomyces.*)

The pathogenic *Act.* (*Proact.*) *asteroides*, *caprae*, and *farcinicus* obviously belong to Group IB. The same is doubtless the case with numerous other acid-fast, non-proteolytic actinomycetes isolated from and possibly etiologically connected with actinomycotic affections. Such organisms have been described by Cornwall and Lafrenais (1922), Pijper and Pullinger (1927), Kulikowska (1930), and numerous earlier authors summarized by Henrici and Gardner (1921). The fact that similar organisms occur as widespread saprophytic forms suggests that they might easily be encountered as secondary infections in morbid affections. In Group IA we would probably have to place the organisms studied by Vierling (1921; cf. Haag (1927) who recognized as actinomycetes a number of paraffin-decomposing, weakly acid-fast, mycobacterium-like organisms similar to those studied by Vierling).

SUMMARY.

A number of organisms previously described as species of *Mycobacterium* were found, on account of their definite mycelial growth in the initial stages of their life cycles, to have their proper place in the genus *Proactinomyces.*—*Myc. agreste* Gray and Thornton and *Bac. mycoides corallinus* Hefferan were found to be so similar that they must be regarded as one species, *Proact. corallinus.*—*Myc. salmonicolor* den Dooren de Jong is closely related to this and should be called *Proact. salmonicolor.*—*Myc. opacum* den Dooren de Jong and *Myc. crystallophagum* Gray and Thornton proved to be identical; this species should be called *Proact. opacus.*—*Myc. erythropolis* is closely related to this; its proper name should be *Proact. erythropolis.*—*Microbacterium mesentericum* Orla-Jensen showed a very distinct mycelial growth and should be called *Proact. mesentericus.*—These organisms, together with some species, previously described by the present writer, form two separate groups. Group I consists of non-proteolytic organisms with strongly refractive cells showing a partial acid-fastness in milk and sometimes in other media, and constantly capable of decomposing paraffin; some species of this group form a transition to *Mycobacterium.* Group II comprises mostly proteolytic forms with weakly refractive, non-acid-fast cells; from this group there is a close transition to *Actinomyces.*

The author wishes to express his thanks to Dr. R. St. John-Brooks, Curator, Lister Institute of Preventive Medicine, London, to Dr. L. E. den Dooren de Jong, Keuringsdienst van Waren, Rotterdam, Holland, and to Mr. C. Ledoux, Biotechnical-Chemical Laboratory, Polytechnical School, Copenhagen, Denmark, for their courtesy in forwarding cultures of the organisms examined here.

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ON THE GROWTH AND REACTION TO GRAZING OF THE PERENNIAL SALTBUSH, *ATRIPLEX VESICARIUM*. AN ECOLOGICAL STUDY OF THE BIOTIC FACTOR.

By T. G. B. Osborn, University of Sydney; J. G. Wood, University of Adelaide; and T. B. Paltridge, Field Officer, Council for Scientific and Industrial Research.

(Plates vii–ix; five Text-figures.)

[Read 30th November, 1932.]

In this paper, the second of a series[1] dealing with investigations at the Koonamore Vegetation Reserve, the dominant plant over much of the shrub steppe formation (*Atriplex vesicarium*, the perennial saltbush) is discussed in relation to its arid environment. In particular the results of a new biotic factor, grazing by sheep, are considered.

The location of the Koonamore Vegetation Reserve and the general purpose of the investigations have already been described (Osborn, 1925). It is the Arid Flora Research Station of the University of Adelaide, to whom it was given in 1925 by Messrs. Hamilton, Wilcox Ltd., the then owners of Koonamore.

In a paper to appear shortly we shall deal with the results of five years work on the Reserve. The present investigation has been conducted from this base and has been carried out at intervals during the period April, 1928, to June, 1931. During this time the work has been supported by a grant from the Commonwealth Council for Scientific and Industrial Research.[2] The investigations herein described could not have been carried out without the kindness of the owners of the neighbouring sheep stations who readily allowed us access to their paddocks. It is not possible to mention all to whom our thanks are due, but we are particularly indebted to R. E. H. Hope, Esq., owner of Koonamore, and his manager, Mr. J. Hardy; to the owners of Melton and their manager, Mr. W. Smith; to the directors of the Mutooroo Pastoral Company; and to C. Wade, Esq., of the Panarammattee Pastoral Company. To these, and the many others who have helped us, we offer our sincere thanks.

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[1] The first was "On the Autecology of *Stipa nitida*, a study of a fodder grass in Arid Australia". Proc. Linn. Soc. N.S.W., lvi, 1931, 299-324.

[2] My thanks are due to the Council for Scientific and Industrial Research for the generous grant which enabled the Koonamore investigations to be carried on upon an extended scale after my departure from Adelaide. I am also much indebted to the Council of the University of Adelaide for allowing me facilities for continued work at Koonamore after my appointment to Sydney.—T.G.B.O.

INTRODUCTORY.

The harmful results that may follow from the grazing by stock upon the perennial flora in dry regions has been the subject of considerable study, particularly in the United States of America. As early as 1910 Griffiths showed, as a result of his observations on a protected stock range in Arizona, that the indigenous perennials, which were popularly supposed to be in process of being driven out by aggressive annuals, were really succumbing to overstocking. He found that the perennial vegetation would return with protection.

Sampson and Malmsten (1926) showed that frequent and close cropping by stock was detrimental to both perennials and herbaceous plants on Western forest reserves. It led to soil impoverishment and erosion. Their work showed, amongst other things, that rotational grazing was important in preserving the natural plant cover.

The methods involved in the study of the reaction of shrubby perennials to grazing must necessarily differ somewhat from those employed in the study of herbaceous flora. Nelson (1930), in a paper contributed to the symposium on Range Ecology held by the Ecological Society of America, described the quadrat methods used. We have utilized information gained from quadrats, of which we have established a number, some under complete protection, others subjected to grazing in the open paddocks. These will be described shortly, but for the purpose of the present inquiry we have found the method less suitable than a modification of the line transect described below. We have also utilized a metre quadrat frame dropped at regular intervals along transect lines, but this, too, has been found unsuitable for perennial shrubs of the *Atriplex* type. The community that we have investigated is too open and the plants too gregarious for a method of dropped quadrat sampling to give a reliable picture of the community. Such a method we have found valuable in the study of herbaceous plants, e.g., in our work on *Stipa* (Osborn, Wood and Paltridge, 1931).

Over considerable portions of arid Australia saltbush is the most valuable plant. It is true that when other forage is available (grass and "herbage" in "good seasons"), saltbush is taken by sheep in the way of a browse and is not consistently grazed. It is palatable because of its salt content, and its protein content is high. In time of drought, it is the only fodder plant available to sheep. Moreover, it is the only perennial ground cover over vast areas and its destruction leads to a calamitous amount of drift and erosion.

Since the settlement of Australia by white peoples, a profound change has occurred in the biota (Osborn, 1929). This is everywhere marked, but in the arid portions it is particularly severe. An indigenous flora, evolved in an environment in which close grazing animals were absent, has been subjected to more or less intense grazing by large stock, sheep in particular, and rabbits. The changes that may be produced by an unduly severe incidence of stocking are profound. These have frequently been referred to because in a severe state the cumulative influence of the stock effect and an arid climate may destroy the whole plant community. Hitherto no attempt has been made to evaluate just what changes do occur in the permanent flora as a result of this new biotic factor. The purpose of the present paper is to give an account of these changes.

THE SALTBUSH COMMUNITY.

The chief physiographic features of the north-east of South Australia are the rocky hills and the wide open valleys and peneplains between them. The soils of the hills are shallow and show immature profiles. They are derived from the quartzites and mudstones of Upper and Lower Precambrian age which form the basis of the ranges. The vegetation consists of a climax desert scrub of various sclerophyllous and xeromorphic species dominated usually by *Acacia* spp.

The soils of the plains, or properly speaking plateaux, are derived from these hills under a modern cycle of arid erosion. As a result of internal drainage these soils contain a good deal of silt and may be classed as sandy loams. The profile is a mature one with much travertine limestone in the B horizon. An analysis and profile has been given by us in a previous communication (1931, p. 308).

On these soils and on the gentler slopes of the hills, *Atriplex vesicarium* forms a true shrub steppe, in the main forming a pure community (Pl. vii, fig. 1), but occasionally mixed with other species, especially of *Kochia*, some of which assume local dominance (Osborn and Wood, 1923). Trees are very rare, but occasional bushes of *Eremophila* spp. and *Cassia* spp. may be found when the water relations are suitable. Following rains, various grasses and a host of ephemeral plants, the "herbage" of the Australian pastoralist, are to be found. Many of these develop most abundantly in the mounds of sand accumulated around the base of the saltbush. However, the only true permanent vegetation is the saltbush itself, or its other chenopodiaceous allies.

Atriplex vesicarium is an erect shrub whose average height and diameter (the mean of some 5,000 observations) is 32 and 34 cm. respectively. Occasionally much larger bushes are found. One growing on quadrat 100 at the Koonamore Vegetation Reserve, under complete protection from grazing for 5 years, is 160 cm. in diameter, though only 30 cm. high. This is an unusually large and sprawling bush, but several others may be found on the quadrats in the Koonamore Vegetation Reserve that are more than 100 cm. in diameter and a few of them reach 50–55 cm. high.

The plant has the characteristic anomalous secondary thickening of the Chenopodiaceae. The stems are rarely as much as 1 cm. in diameter; they are usually much more slender twigs. At all ages the wood is brittle and under stress it snaps easily with an almost clean transverse fracture. It is, therefore, easily damaged by mechanical means.

Generally only very young plants show anything like a main axis. The seedling and young plant (Text-fig. 1) show the early development of many buds from the basal part of the stem. The majority of plants show a number of slender, freely branching stems rising from the base which is usually surrounded by a mound of fine soil and sand deposited by the wind. This is always the case on grazed country, but in virgin areas the light surface layer of soil is sometimes more evenly distributed. It will be readily understood that a low-growing free-branching shrub such as *Atriplex* will hold the soil and accumulate a mound about itself. However, the plant is not a hemicryptophyte, but is chamaephytic in its growth form.

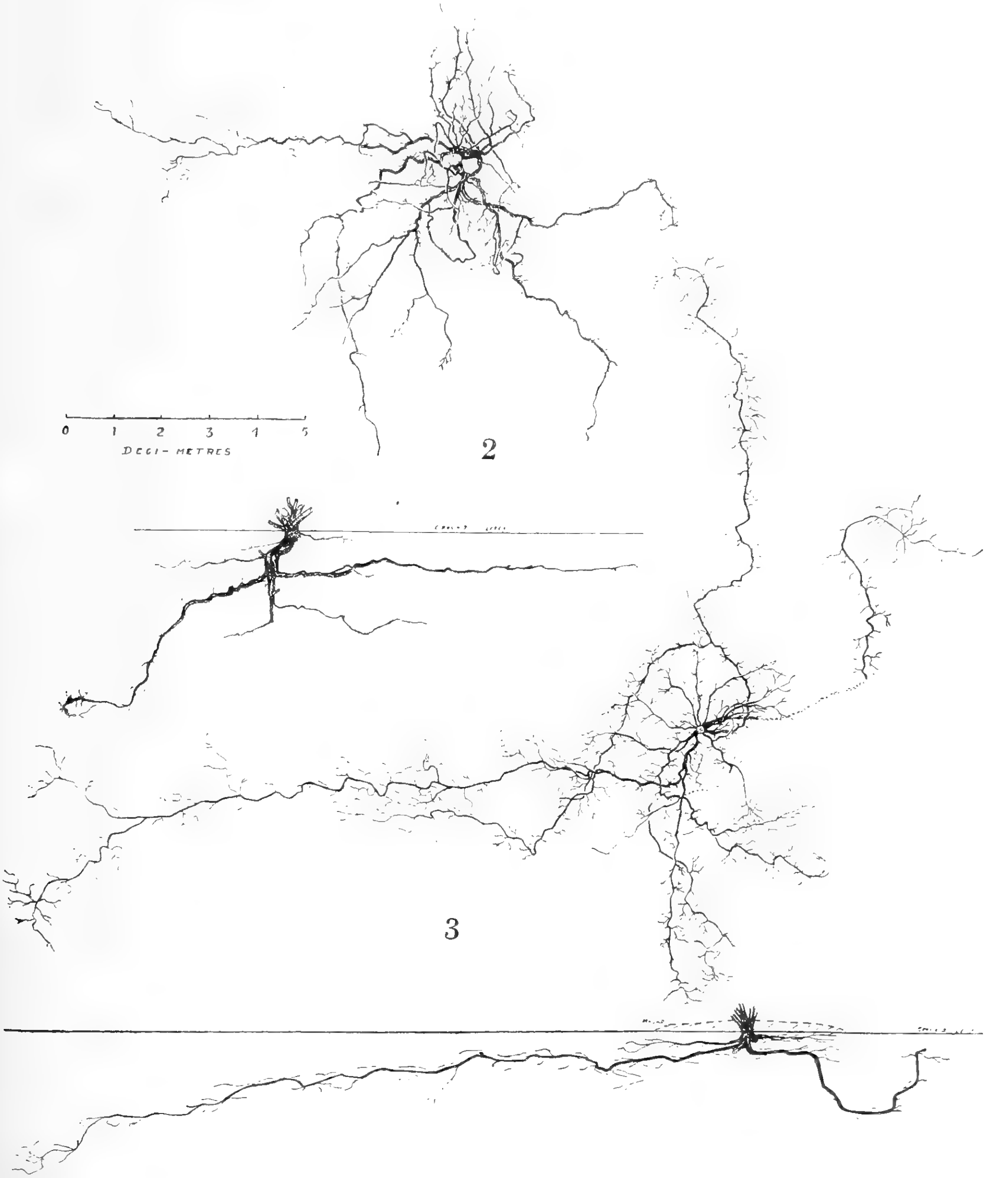
The stems appear whitish-grey, even greenish-grey after rain, though many dead twigs are generally present. These are a dark grey when they lose their bark, which they do rapidly after death. The leaves are obovate to broad lanceolate, 1–2·5 cm. long and 0·5–1 cm. wide. They are rather thick and fleshy to the touch when turgid. The leaf is never really green, but always more or less grey and scurfy-looking owing to its dense cover of non-cuticularized hairs. These give the leaf a mealy white appearance which becomes more pronounced as the leaf loses water. Wood (1923 and 1932*b*) has shown that the plant has a low transpiration rate and that the leaves resist desiccation owing to a pentosan colloid complex (1932). The wilted leaves are freely shed by the plants until a state of complete defoliation is reached (cf. Pl. vii, figs. 1 and 2, which shows an *Atriplex* covered peneplain in a wet season and during drought). At Frome Downs, a station about 60 miles to the north of Koonamore, which was visited by one of us (T.B.P.) in October, 1929, it was estimated, as a result of an extensive series of transect observations, that 95% of the plants were leafless.

Text-fig. 1.—Seedling and young plant of *Atriplex vesicarium* showing early development of lateral shoots from the basal nodes. × ⅓. Miss C. Ure, *del.*

These plants were in true virgin country, not yet stocked by sheep owing to lack of facilities for watering. Such plants are by no means all dead, like others described below; some would regenerate in good seasons throwing new shoots from the base of the stems. This drought deciduous habit is not usual in Australian arid plants, though it is paralleled in the case of such plants as *Astragalus* and *Fouquieria* (Maximov and Yapp, 1929).

Unlike that of most perennial plants in arid regions, the root system of *Atriplex vesicarium* is very shallow, never penetrating the nodular layer of travertine limestone, and mostly living within 10–20 cm. of the surface. It will be seen from Text-figures 2 and 3 that the surface extension is considerable, some of the longer roots being 2 metres in length. There is no tap-root, but a number of spreading laterals which branch at intervals. These tertiary members rarely branch, but produce numerous groups of short-lived feeding roots which are deciduous in time of drought, and renewed in wet periods.

The root system is probably largely non-functional during prolonged dry periods, but the plant possesses a secondary method of water absorption through its leaves. Wood (1925) has shown that shoots of *Atriplex vesicarium* gain weight when kept in an atmosphere of 85% saturation with water, a figure that

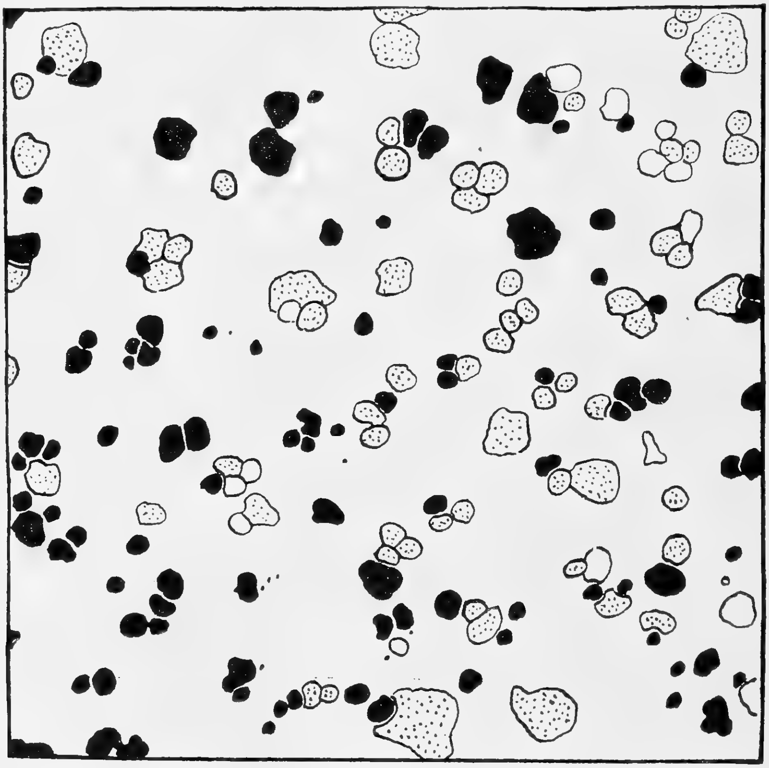


Text-figs. 2, 3.—Root systems of two plants of *Atriplex vesicarium* in plan to show the extensive development of surface roots bearing many fine lateral feeding roots, these being deciduous in drought. T.B.P. *ad nat. del.*

is the mean maximum humidity for the year at Koonamore. The regular occurrence of high maximum humidities, even during drought, is a feature of the climate at Koonamore (see below). The foliar absorption of water is possible because of the non-cuticularized leaves, and their high osmotic pressure. This Wood (1932*b*) has shown to be as high as 50 atmospheres. The high osmotic pressure is due in part to the concentration of sodium and potassium chlorides in the leaves, which ranges from 20 to 30% of the dry weight (Wood, 1925). The roots are evidently selectively permeable to these chlorides, for the soil in which they grow contains only 0·02% NaCl.

Atriplex vesicarium is a dioecious species. The fruiting bracteoles are much enlarged and in the typical form covered by a pair of convoluted bladdery appendages. There is a good deal of variation in this feature, even on the same plant. Probably more than one ecotype exists, and possibly hybridization with other *Atriplex* species occurs, but the matter will not be dealt with here.

The shrub steppe community formed by *Atriplex* is an open one. The plants generally occur in clumps or groups of individuals of all ages with bare soil between them. This gregarious habit is due to the collection of fruits and



Text-fig. 4.—Chart of a quadrat of 100 sq. metres (Salt Creek No. 1) showing canopy area of the saltbush, and gregarious habit of growth. The bare ground between the bushes was at this time well covered by the annual *Gnephosis cyathopappa*. Healthy bushes shown black, wilting and partially defoliated plants stippled, dead bushes in outline only. Plate vii, figure 3, is a photograph of this quadrat. 19.viii.1928.

wind blown soil around the established plants (cf. *Stipa nitida*, Osborn, Wood and Paltridge, 1931), and not to any capacity of the plant to reproduce vegetatively. Text-figure 4 represents a quadrat with 10-metre sides set out and surveyed in a large open paddock (Sept., 1928). It shows well the gregarious habit of the plants and the open soil between them. The number of plants recorded as almost defoliated is to be noted. Plate vii, figure 3, shows the general appearance of the quadrat. The guide strings are stretched and the area divided into metre squares.

CLIMATIC FACTORS.

This section contains data as to the climatic factor relative to the growth of saltbush for the period covered by this investigation. A discussion of the full data will be given in a forthcoming paper on the general work of the Reserve.

Rainfall.

A table showing the rainfall month by month, the number of rainy days and of falls greater than 25 points, was included in our previous paper. It is sufficient to recall that the period covered by this work was one of exceptional drought and that an average annual rainfall at Koonamore (812 points) did not occur during the time of the investigation. From August, 1928, to November, 1929, both inclusive, only 176 points of rain fell. The five months, October, 1928, to February, 1929, were absolutely rainless and the next five months were without an effective fall, which we have defined as a fall of more than 25 points. A lighter fall is incapable of doing more than wet the surface of dry soil.

Temperature.

Temperature data were also given in the paper cited and need not be repeated here. The mean maximum temperature in the hot season ranges from 80° to 90° F. and from 60° to 70° in the winter. On an average for 8 years the number of frost days per annum is 53·5. A characteristic and important feature of the temperature is the high diurnal range, the mean annual range for which is 30·1° F. The greatest variation occurs during the summer months. This diurnal range has an important bearing on the humidity.

Humidity.

The humidity data are of special interest owing to the fact that high relative humidities are frequently recorded. This has an important bearing upon the water relations of *Atriplex vesicarium* because of its capacity for absorbing water through its leaves from nearly saturated air.

Relative Humidity.

Years.		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Ann.
1927 to 1931	Mean Max	93	82	83	87	87	91	91	87	87	81	80	84	85
	Mean Min.	37	35	34	39	43	51	47	42	37	35	31	35	39

It will be seen that the mean maximum humidity exceeds 80% in every month of the year. On the other hand, the mean minimum humidity falls below 40% each month, except May–August, which is the winter season.

The length of time during which high humidities prevail each day is obviously a feature of importance. The following table is derived from thermo-hygrograph records taken during the three-year period 1928–1931. It shows the mean number of hours per day in each month in which the humidity is greater than 80% and also, as an indication of the more rigorous arid conditions, less than 40%.

Table showing Mean Number of Hours per Diem when Relative Humidity >80% and <40%.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean number hours humidity >80%	In- suff. data.	3·9	4·5	7·2	9·6	8·7	8·1	6·2	4·7	3·8	3·8	3·1
Mean number hours humidity <40%		6·9	5·9	3·1	2·4	1·0	1·8	4·1	6·0	6·9	8·9	7·6

The time during which the maximum humidity is highest lies between midnight and 7 a.m., reaching a maximum usually about the time of sunrise. The time of lowest humidity is between 2 p.m. and 4 p.m.

This variation in the humidity is a consequence of the high diurnal range in temperature and, since the relative humidity varies with the temperature, a more accurate picture of the degree of saturation of the air is given by the saturation deficit. The Meyer ratios, P/sd, have been plotted for Australia by Prescott on a map showing the isologs (1931, fig. 9). The ratio for Koonamore is about 25–30.

It is more important for an understanding of the water relations of *Atriplex* to know the mean saturation deficits throughout the year. The highest relative humidity is recorded at the time of minimum temperature and vice versa. The mean saturation deficits for each month given below are therefore calculated from the mean maximum humidity and the mean minimum temperature and mean minimum humidity and mean maximum temperature respectively.

Saturation Deficits in Inches of Mercury.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean maximum temperature ..	92·4	91·0	83·3	82·1	63·4	61·9	59·4	65·8	67·6	80·1	84·3	86·7
Mean minimum humidity ..	37	35	34	39	43	45	47	42	37	35	31	35
Saturation deficit	0·95	0·95	0·75	0·68	0·33	0·27	0·27	0·36	0·41	0·65	0·81	0·85
Mean minimum temperature ..	57·8	61·4	55·1	46·6	38·7	35·7	34·6	35·8	36·8	45·4	53·8	55·4
Mean maximum humidity ..	93	82	83	87	87	91	91	87	87	81	80	84
Saturation deficit	0·04	0·05	0·07	0·04	0·03	0·02	0·02	0·02	0·03	0·05	0·08	0·06

These figures for the saturation deficits bring out clearly that every month, even during a severe drought and during the hot summer months, the air becomes almost saturated with water vapour for a portion of each day. This fact, we believe, accounts for the success and ubiquity of the saltbush. On the other hand, the aridity of climate is indicated by the high values of the saturation deficits during the daytime.

These data as to the high relative humidity and the length of time for which it is maintained throw an unexpected light on the environmental conditions under which *Atriplex vesicarium* grows. They show that even during a drought it is more favourably situated for obtaining water than might be expected. Nevertheless, during a drought of the extreme severity experienced during these investigations, permanent wilting, defoliation or even death, is the fate of the majority of the plants. There remains to consider the effect of grazing by sheep during such a severely adverse period.

METHODS.

The fundamental idea underlying these investigations upon the effect of grazing on saltbush may shortly be stated as follows. In any paddock the most intense influence of grazing and trampling by sheep (the "stock effect") will be felt around the watering place, since all the animals visit the dam or bore once or twice a day for water. Along lines radiating from the watering place the intensity of the stock effect becomes progressively less and less as the sheep pass away from the drinking place out into the paddock scattering as they go. It is a matter of observation, and so of common knowledge, that the average distance that sheep travel from water in the saltbush country is seldom greater than three miles, while the great majority are found congregated within two miles of the drinking places. During a wet winter, conditions may be different. The sheep may travel much further and remain for days in a distant portion of the paddock, depending on casual waters or the succulence of the herbage for moisture. But such conditions are exceptional. Owing to the size of the paddocks, seldom less than 4 × 5 miles, and often much larger, and the infrequency of the watering places (the sinking of wells or the excavation of dams is a costly process), there may be considerable areas virtually ungrazed or in a virgin state.

Around each watering place there can be defined four zones, as follows, differing from each other in the intensity of the stock effect:

1. The *A Zone*, immediately around the watering place, where inevitably the stock effect is very severe, in which the saltbushes are largely or entirely trampled out.
2. The *B Zone*, beyond A, in which the majority of the sheep feed, subjected to fairly heavy grazing and a good deal of trampling. The width of this zone depends upon the number of sheep carried in the paddock and also upon the physiography of the country around the watering place.
3. The *C Zone*, a lightly stocked area beyond the B Zone, which the sheep only visit occasionally and which is, therefore, not subjected to frequent grazing or trampling. The extent of this zone, as in the case of the B Zone, depends on the degree of stocking and on the physiography.
4. The *D Zone*, the area lying beyond the distances to which sheep normally travel. For the purposes of this investigation it has been considered as virtually ungrazed country. It affords a control or standard by which the stock effect may be gauged in the other zones.

Two desiderata were required to judge the effect of grazing upon saltbush within the four zones. These were (1) a classification of the bushes according to a scale of vegetative vigour, and (2) an inquiry into the variation in the numbers of bushes in each class of the defined scale.

As a measure of vegetative vigour, the degree of foliation of the bushes was utilized. The plants were grouped in the field into the following six classes:

1. "Dead" bushes: plants which had shed all their leaves. To determine whether a bush is really dead or not is a difficult matter, for apparently dead plants may throw up new foliage shoots after rain. As a matter of convenience all defoliated plants were grouped together. Some of these were undoubtedly dead, others moribund, but others were probably only in an anabiotic state. There is a colour difference between a dead twig and a living one. When dead the twig sheds its bark, the wood becomes dark on the outside and, when broken, is white and dry. The living defoliated twig is covered with a grey scurfy bark; when fractured it is yellowish and more or less sappy.
2. Very sparsely foliated bushes: plants with leaves on less than 20% of the shoots.
3. Sparsely foliated bushes: plants having less than 50%, but more than 20% of the shoots foliated. Vegetative vigour lacking. Leaves lacking the greenness of the turgid state, distinctly grey, even white in a bright light. Terminal shoots showing curling suggestive of wilting, well seen in the male inflorescences which bend over and become dry. Fallen leaves are common below the bush.
4. Well foliated bushes: plants with 50% or more of the twigs foliated, but lacking the uniform vigour of the next class, that of the fully foliated plants. In this class were also included certain plants which, though they have rather less than a 50% foliation, showed a vigorous development of new greenish shoots.
5. Fully foliated bushes: plants of whatever size bearing abundant foliage up to the apices of almost every twig. Leaves turgid and green-grey. Flowers or fruits, when present, turgid, the terminal male inflorescences standing erect on sappy stems. In this class were included occasional plants with a small degree of defoliation on some twigs, but vigorous growth and abundant fruit and flowers on all other branches.
6. Seedlings: in addition to seedlings proper, very young plants less than a decimetre high and obviously immature were included here.

Types of these six classes are illustrated on Plate viii. It should be noted that these photographs were taken on the same day, within a short distance of each other, also that during the preceding twelve months only 88 points of rain had fallen.

In the field the plants counted were grouped under these six headings and in the many readings made by the field officer considerable proficiency in classifying the bushes was obtained. Clearly the classes are purely arbitrary and grade into one another, but we seldom had any difficulty in deciding to which class a given bush belonged.

For the statistical treatment of the results these six classes have been reduced to four. There was an advantage in maintaining a more finely divided scale of classification in the field than was needed for the subsequent treatment of the figures. It helped to keep the observer on the alert. The four classes are:

1. Defoliated plants: plants classed as "dead" in the field notes. In presenting the results it is preferable to use a purely descriptive term which has no other implication.

2. Wilting plants: includes all those bushes listed as "sparsely foliated" and "very sparsely foliated". The remaining foliage of these plants had entered on a phase of permanent wilting, and the greater part of the plant is in the anabiotic state if not actually moribund.

3. Healthy plants: includes all plants listed as "well foliated" or "fully foliated". Such plants are obviously in a state of vegetative vigour and contrast sharply with the two preceding classes.

4. Seedlings: as defined above.

Having established a scale of vigour, a search was made for a method which would give sufficient samples of the plant population in the four zones to admit of statistical treatment. In the large areas investigated, quadrat methods are unsatisfactory. Finally a modification of the line transect was adopted. Any method adopted had to be one that a solitary observer[1] could use. Laying or stretching a tape over an extent of saltbush for a distance of two miles or more was out of the question. The method adopted, then, was as follows:

Starting from a watering place the observer took a compass bearing and walked into the paddock placing pegs at 100 pace intervals along the line of march. The pegs used were 6 feet high with the top 2 feet painted white. The lines were of variable length according to circumstances. Some extended as much as 2½ miles from the watering place, others less. The ungrazed country, classified as D Zone, lay beyond the ends of the transects, 4 to 5 miles from the water.

The unit of length adopted was the observer's full stride, which we term the pace. This is a long one, 1·5 yards (54 inches). The full stride was deliberately adopted because it was found easier to maintain this at a constant length when continually stopping and starting than any arbitrary pace.

Having established his line of pegs the observer would return to the starting point and "pace" along the line, always keeping two or more pegs in line before him. On specially prepared record sheets he entered every bush which was *actually crossed* by his line of march, the unit being the pace. Notes were also made as to the vigour and size of each bush recorded. The record sheets were uniform foolscap size; portion of one, transcribed from an actual page, is shown in Text-figure 5.

It will be seen that the transect is really a strip transect of a width determined by the observer, who had to judge whether or not a particular bush was actually cut by his line of march. Obviously there might be a certain amount of selection but, since all records were made by the same individual, the error, if such there be, is likely to be uniform. The results are remarkably consistent, e.g., the D Zone in St. Patrick's was surveyed twice, in August, 1929, and November, 1930, when the mean number of plants per 100 paces was 181 ± 19 and 181 ± 21 respectively.

From each watering place three or four such line transects were laid down radiating into the paddock. It was by no means easy to get clear runs of salt-

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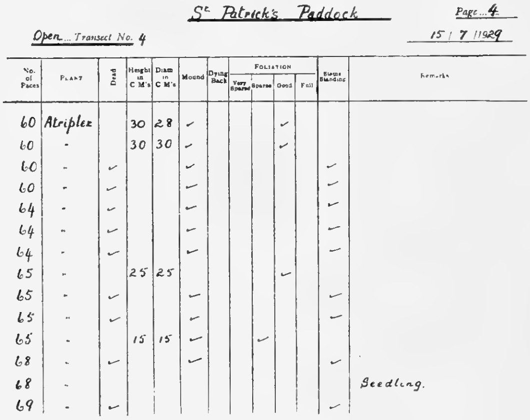
[1] This is a fitting place to pay tribute to the energy and enthusiasm of the field officer, T. B. Paltridge, who lived three years at the Koonamore Vegetation Reserve. Paltridge set out and surveyed all the transect lines described in this paper as well as several other systems not mentioned here. We have jointly and individually visited most of the transects with him more than once and have discussed the work with him in the field at all stages of its progress. To Paltridge, however, fell the task of recording the data under difficult conditions and sometimes with no small physical discomfort.—T.G.B.O. and J.G.W.

bush about 2 miles long without some physiographic variations, i.e., flooded areas, watercourses or rocky outcrops, and at the same time avoid feeding grounds from other waters. The five transect systems described are free from objections of this type. In the case of the Melton transects to be described later, a variation of the line transect was used. The original line from the watering place was laid down and counts made along it as usual, but, in addition, at every 200-pace interval a cross transect at right angles to the main transect was run for 300 paces. This method is considered to be superior to the system of radiating lines, as more samples within the different zones can be obtained.



St. Patrick's Paddock Page 4

Open Transect No. 4 15 / 7 / 1929

No. of Paces	Plant	Dead	Height in C M's	Diam in C M's	Mound	Dying Back	Foliation				Stems Standing	Remarks
							Very Sparse	Sparse	Good	Full		
60	Atriplex		30	28	✓				✓			
60	-		30	30	✓				✓			
60	-	✓			✓						✓	
60	-	✓			✓						✓	
64	-	✓			✓						✓	
64	-	✓			✓						✓	
64	-	✓			✓						✓	
65	-		25	25					✓			
65	-	✓			✓						✓	
65	-	✓			✓						✓	
65	-		15	15	✓			✓				
68	-	✓			✓						✓	
68	-											Seedling.
69	-	✓									✓	

Text-fig. 5.—Portion of an actual record sheet.

For comparison of the different classes of plants in the different zones, the number of bushes per 100 paces was treated as a unit and sheets drawn up showing the total number of plants, the number of defoliated, of wilted, of healthy plants and of seedlings per 100 paces.

There were now available for each zone a number of 100-pace unit samples of the population and from these figures the following statistics were calculated for each class: the mean per 100 paces, the standard deviation of the mean, and the standard error of the mean. Comparisons of the mean number of plants of any class in different zones could then be made by use of the difference of means and their standard error of difference, a difference being regarded as significant if the difference of the means exceeded twice the standard error of difference. A standard error of grouping was also calculated and the grouping is sufficiently fine in all cases dealt with except in that of the seedlings, which, unless otherwise mentioned, are not considered in the following discussion of the results. Sufficient samples were obtained to take into account any variations due to physiographic influences.

RESULTS.

In the following tables the ± sign is given before the standard deviation and standard error of the means, and also the standard error of difference, in the first line only. It is to be understood as referring to all figures in the respective columns. In the columns giving the difference of the means a significant difference is printed in bold type with a + or − sign preceding it, denoting a significant increase or a significant decrease in the mean numbers of plants in the classes considered.

The first desideratum is a comparison of the grazed and ungrazed country. It is difficult in a general way to make a direct comparison, for example, between the heavily-grazed zones in different paddocks on account of different intensities of stocking. It has been pointed out previously that the extent of the heavily-grazed zone varies with the number of sheep watering on any particular place. But, in the first instance, it seemed desirable to present all our data in a uniform fashion and then to point out where the grouping has been too coarse on account of lighter stocking in certain instances.

Quite apart, therefore, from our knowledge of the grazing intensities about different watering places, we have grouped the four zones as follows:

A Zone (Pl. ix, fig. 1).—The heavily trampled and over-grazed zone close to the watering place (0–300 paces).

B Zone (Pl. ix, fig. 2).—Moderately heavily grazed zone, extending to 1 mile from the well (300–1,200 paces).

C Zone (Pl. ix, fig. 3).—Lightly grazed zone (1,200 paces to end of transect line; usually another mile).

D Zone (Pl. ix, fig. 4).—Unstocked zone (at least 4 miles from the watering places).

Five main transect systems have been carried out on Koonamore and two neighbouring sheep stations. These represent four different systems of stocking. The names and characteristics of the systems are outlined below. Stocking figures furnished to us by courtesy of the different station managers only served as very rough guides. They give the number of sheep in the paddock month by month. But, as there may be two or more watering places in the one paddock, it is impossible to say how many sheep are actually watering at a particular bore. We do not, therefore, give any actual figures of numbers of sheep, but from all the information at our disposal classify the type of stocking as heavy, light and so on.

The five transect lines are:

Koonamore Station.

1. Alderman's Paddock System. Heavily and consistently stocked.
2. St. Patrick's Paddock System. Lightly stocked, being held as a reserve or ram paddock.
3. X-Ray Well System. Heavily but intermittently stocked owing to the uncertain water supply obtainable from the well.

Melton Station.

4. Putt's Well System. Heavily and consistently stocked.

Mutooroo Station.

5. West Bore Hole Dam System. Very lightly stocked.

The D Zone (Unstocked).

The saltbush community in this zone represents approximately the virgin state of the community untouched by sheep, and, since it serves as the basis for comparison with the other grazed zones, will be considered first.

As might be expected, the "open transects" taken at approximately the same time in different regions are all comparable and show no significant differences in the mean number of plants for the different categories as the following tables show.

November, 1930.

	Melton System.			St. Patrick's System.			Differences.	
	M	σ	S.E.	M	σ	S.E.	M	S.E. of D.
Total Plants	163	±13	±5·8	181	±21	±6·6	18	±8·9
Defoliated Plants	94	15	6·9	115	26	5·8	21	9·2
Wilting Plants	24	5	2·4	16	5	1·2	**+ 8**	2·8
Healthy Plants	43	17	7·4	45	12	2·7	2	7·9
Seedlings	3	1·7	0·7	7	6	1·1	4	1·3
	N=5			N=20				

Only in the case of the wilting plants is there a significant increase in these two transects, and the means in this class are low. The difference between the total plants and the defoliated plants is barely significant.

The X-Ray transects run in April, 1930, are comparable with those at Mutooroo run at the same date.

	X Ray System.			Mutooroo System.			Differences.	
	M	σ	S.E.	M	σ	S.E.	M	S.E. of D.
Total Plants	173	±25	±9·4	149	±38	±10·1	24	±14·0
Defoliated Plants	126	17	6·6	101	29	7·7	**+25**	10·2
Wilting Plants	23	14	5·3	32	14	3·8	9	6·5
Healthy Plants	18	9	3·3	16	10	2·7	2	4·2
Seedlings	6	4	1·6	—	—	—	6	—
	N=7			N=14				

Again there is no significant increase in any category, except perhaps in the case of defoliated plants which are somewhat greater in the X-Ray System, but the difference of the means is barely significant.

If, however, an open system from the first group is compared with that of the second, e.g., St. Patrick's with X-Ray, it will be seen that significant differences have taken place in the vigour of the community, notably in the increase in the number of healthy plants. This is due to the rains between the two periods at which the transects were run. This difference is best seen in a comparison of the two sets of results from the ten transects run in the unstocked country in St. Patrick's Paddock. One set was obtained in August, 1929, towards the end of 12 months, in which only 88 points of rain fell, no fall being greater than 25 points, and the other in November, 1930, after a year's good season with effective rains. These are compared in the following table:

	August, 1929.			November, 1930.			Differences.	
	M	σ	S.E.	M	σ	S.E.	M	S.E. of D.
Total Plants ..	181	±19	±4·5	181	±21	±6·6	0	±7·9
Defoliated Plants ..	83	13	2·9	115	26	5·8	**+32**	7·6
Wilting Plants ..	65	12	2·7	16	5	1·2	**−49**	2·9
Healthy Plants ..	17	10	2·2	45	12	2·7	**+28**	3·4
Seedlings	15	8	1·9	7	6	1·1	8	2·2
	N = 20			N = 20				

Here it will be seen that there is no significant increase in the mean number of total plants, but there is an increase in the number of defoliated plants and of healthy plants and a decrease in the number of wilting plants, i.e., some of the wilting plants have formed vigorous bushes following the rains and others have died.

Summarizing the results of the analysis of the bush in unstocked country, these transects in widely separated regions enable us to show that at any period the composition of the community from the point of view of vigour remains the same. The outstanding feature of the community is the large number of defoliated and moribund plants.

The A Zone (Heavily overstocked zone).

This zone is formed immediately around the watering places, usually for a distance of about 300 paces. The inevitable heavy stock effect due to the congregation of sheep at the troughs results in the complete removal of the permanent vegetation for some distance. From this bare area the number of bushes per 100 paces increases rapidly until this zone merges into the B Zone or heavily grazed zone. The A Zone is, therefore, really a composite of several very narrow zones, the plant cover of which ranges from zero to an area well covered with bushes, according to the decreasing degrees of severity in the stock effect. The A Zone cannot, then, be treated statistically, since the standard deviations are necessarily large. Its features are shortly described below.

The number of bushes is low compared with either the grazed or the ungrazed zones. Such bushes as exist are either healthy, for they are necessarily very widely spaced, or else moribund and in process of being knocked out by the sheep. Obviously the extent of this zone will vary with the degree to which the paddock is stocked. Its width, indeed, is a valuable guide to the severity of the stocking. Further, this bare area, even though relatively small, may have an influence of the utmost importance on the surrounding vegetation. The removal of the plant cover from a localized area such as this may initiate an area of sand-drift or an area in which dust storms originate. The effect of the drift started in this way is cumulative and the denuded area gradually extends owing to the blast of sand killing and removing plants that, but for its action, would tend to encroach on the bare area. When the surface soil is removed, there remains a hard unproductive subsoil—often composed largely of travertine limestone—which is practically incapable of supporting vegetation and from which the run-off following rain is high. Plate vii, figure 4 shows a denuded area extending more than a mile from the bore. This waste was developed within a short time, whilst our investigation was in progress, as a result of watering 6,000 sheep for three months during a drought at what was, at the outset, a newly sunken well with saltbush right up to the troughs. The control of stocking should certainly aim at preventing an undue extension of the bare area. Occasional "spelling" of a watering place, i.e., closure of all access by stock to the dam or drinking troughs, is beneficial. The trampling by sheep plants a considerable number of saltbush fruits around the outer portions of this zone (cf. X-Ray System below). Given the opportunity these will develop into bushes that will check the drift.

The B Zone (Heavily-grazed zone).

This zone, as described previously, is taken in the first instance as extending to 1,200 paces (1 mile) from the watering place. Considerations of the changes in this zone must take account of the degree to which the paddocks have been stocked. The changes in composition of this zone are made clear by comparison with the state of the ungrazed country. Tables showing this comparison in different paddocks are presented below.

1. *Melton System*, under heavy grazing conditions, run in November, 1930.

	B Zone.			D Zone.			Differences.	
	M	σ	S.E.	M	σ	S.E.	M	S.E. of D.
Total Plants ..	181	±51	±9·1	163	±13	±5·8	18	±10·9
Defoliated Plants ..	66	38	8·3	93	15	6·9	**−27**	10·7
Wilted Plants ..	21	14	3·1	24	5	2·4	3	3·9
Healthy Plants ..	74	15	3·3	43	17	7·4	**+31**	8·1
Seedlings	6	6	1·4	3	1·7	0·7	3	1·6

N=30

Compared with the ungrazed country, the heavily-grazed zone shows a significant decrease in the mean number of defoliated plants and a significant increase in the mean number of healthy plants.

2. *St. Patrick's System*, under light grazing conditions.

For this paddock, two sets of readings of the transect system are available, the first run in October, 1929, towards the end of fifteen months' severe drought and the other, after the rains, in November, 1930, after 12 months of average rainfall. For uniformity, in the first instance the B Zone is taken as the same length as in the other systems, namely, for 1,200 paces from the well. Comparisons of this grazed zone with the unstocked country are shown in the following tables:

October, 1929.

	B Zone.			D Zone.			Differences.	
	M	σ	S.E.	M	σ	S.E.	M	S.E. of D.
Total Plants ..	189	±65	±10·8	181	±19	±4·5	8	±11·2
Defoliated Plants ..	54	40	6·6	83	13	2·9	**−29**	7·2
Wilting Plants ..	91	49	8·2	65	12	2·7	**+26**	8·6
Healthy Plants ..	40	23	3·8	17	10	2·2	**+23**	4·4
Seedlings	5	5	0·8	15	8	1·9	10	4·0
	N=36							

November, 1930.

	B Zone.			D Zone.			Differences.	
	M	σ	S.E.	M	σ	S.E.	M	S.E. of D.
Total Plants ..	207	±42	±7·0	181	±21	±6·6	26	±9·6
Defoliated Plants ..	81	33	7·7	115	26	5·8	**+34**	9·4
Wilting Plants ..	35	15	3·3	16	5	1·2	**+19**	3·5
Healthy Plants ..	90	45	9·0	45	12	2·7	**−45**	9·4
Seedlings	4	4	0·9	7	6	1·1	3	1·4
	N=36							

The results in the two cases are the same; that is, that both during drought and during a rainy season the heavily-grazed zone shows a significant decrease in the mean number of dead plants and a significant increase in the mean number of healthy plants as compared with the ungrazed country. There is no marked alteration in the total number of plants, though the 1930 reading does show an increase. In both cases there is also a significant increase in the mean number of wilting plants in the grazed zone. This increase, however, is largely fictitious, for it is due to too coarse grouping of the two grazed zones. St. Patrick's Paddock has been very lightly stocked and it is known that the maximum grazing does not extend as far as 1,200 paces. It will be seen later that a large percentage of the plants are classed as wilting in the C, or lightly grazed, zone and this is reflected in figures above.

Shortening the zone by 400 paces in the case of St. Patrick's Paddock because of light stocking we get the following figures for the 1929 series:

	B Zone.			D Zone.			Differences.	
	M	σ	S.E.	M	σ	S.E.	M	S.E. of D.
Total Plants ..	175	±39	±4·9	181	±19	±4·5	6	±6·7
Defoliated Plants ..	35	17	3·5	83	13	2·9	**−48**	4·5
Wilting Plants ..	74	32	6·5	65	12	2·7	9	7·0
Healthy Plants ..	61	11	2·3	17	10	2·2	**+44**	3·0
Seedlings	5	5	1·0	15	8	1·9	10	3·4
	N=20							

In this case the shortening of the B Zone, which we know actually does occur, brings the results exactly in line with the figures obtained from the Melton transects, namely, that there is a significant decrease in the mean number of defoliated plants and a significant increase in the mean number of healthy plants.

3. *The X-Ray Well System,* under intermittent heavy grazing conditions. Transects run in November, 1930. Comparisons of the heavily grazed and ungrazed zone are shown in the following table:

	B Zone.			D Zone.			Differences.	
	M	σ	S.E.	M	σ	S.E.	M	S.E. of D.
Total Plants ..	196	±34	±6·8	173	±25	±9·4	23	±11·6
Defoliated Plants ..	86	24	4·7	126	17	6·6	**−40**	8·1
Wilting Plants ..	23	18	3·6	23	14	5·3	0	6·3
Healthy Plants ..	62	61	12·2	18	9	3·3	**+44**	12·6
Seedlings	29	20	4·0	6	4	1·6	**+23**	4·3

N=36

Under these conditions the same effects are found, namely, that there is a significant decrease in the mean number of defoliated plants and a significant increase in the mean number of healthy plants in the grazed zone. In addition an important fact is the significant increase in the mean number of seedlings. This is the only case where a reliable measure of seedling variation has been obtained in our investigations. It is due to the intermittent nature of the stocking which allows seedlings to grow from seed planted by the trampling of the sheep.

There remain for consideration two somewhat special cases of the B Zone. One is a system in Alderman's Paddock, where the stocking is heavy but the feeding grounds are restricted owing to the presence near the well of steep and rocky hills on which sheep do not feed. The second is a system on Mutooroo where the stocking is exceedingly light.

4. *Alderman's Transect System* shows no differences from the other figures presented, except that there is a significant decrease in the mean number of total plants in the grazed zone compared with the ungrazed zone. Owing to this difference in total numbers the number of plants in the different categories are expressed as percentages of the total numbers of plants. The decrease in total numbers is due to the consistent heavy stocking of this paddock, which tends to remove the dead plants by mechanical means. The figures for the B Zone (to 1,200 paces from the dam) and the ungrazed country are shown in the following table:

	B Zone.			D Zone.			Differences.	
	M	σ	S.E.	M	σ	S.E.	M	S. E. of D.
Total Plants ..	136	±40	±6·8	181	±19	±4·5	**−45**	±9·3
Defoliated Plants %	16	7·3	2·7	45	6	1·4	**−29**	3·0
Wilting Plants %	41	13	2·1	36	5	1·9	5	2·8
Healthy Plants %	25	12	2·0	9	5	1·1	**+16**	2·3
Seedlings % ..	16	13	2·1	8	4	1·0	8	2·3

N=36

These figures confirm those given previously, namely, that the B Zone is characterized by a significant decrease in the number of defoliated plants and a significant increase in the number of healthy plants when compared with the ungrazed country.

5. *Mutooroo Transect System* shows a variation in the B Zone from those so far considered. This has been so lightly stocked that it differs little from the ungrazed country; but the figures are interesting in that they show the first effect of grazing on virgin country, which consists in the removal of dead bushes. The stocking has not been sufficiently heavy to cause an improvement in the vigour of the bush. Comparisons of the grazed and ungrazed zones are given in the following table:

	B Zone.			D Zone.			Differences.	
	M	σ	S.E.	M	σ	S.E.	M	S.E. of D.
Total Plants ..	104	±40	±9·0	149	±38	±10·1	**−45**	±13·5
Defoliated Plants ..	69	29	6·4	101	29	7·7	**−32**	10·5
Wilting Plants ..	27	13	3·0	32	14	3·8	5	4·8
Healthy Plants ..	9	5	1·4	16	10	2·7	7	3·3
Seedlings	—	—	—	—	—	—	—	—
	N=18							

The features of the heavily-grazed zone are, then, a large increase in the mean number of healthy plants and a corresponding decrease in the mean number of defoliated plants. This zone is regularly stocked in all paddocks carrying sheep, though not necessarily consistently, as sheep tend to herd together and the mob will feed in different parts of this region at different times.

The first effect of grazing, as seen in Mutooroo, consists in the mechanical removal of dead bushes. The second effect under heavy grazing is the marked improvement in the vigour of the bush compared with the unstocked bush. This improvement of the bush is due to pruning; the constant removal of the terminal buds stimulates development of lateral shoots so that more compact, vigorous bushes result. These bushes stand in marked contrast to those of the ungrazed country which are sparse and twiggy. This result in the B Zone is, indeed, one of the most important results that have been brought to light in these investigations, viz., that under moderately heavy stocking the mean total number of plants per 100 paces is not increased compared with the ungrazed country, but the health and vegetative vigour of the community is increased and the area thus becomes more valuable for grazing. Obviously the grazing must not be too heavy or the stock effect will become destructive to the community and thus bring about A Zone conditions leading to an extension of the bare area.

A third point of importance is that intermittent stocking is valuable in that it allows seedlings to become established. This point is well shown by the figures of the X-Ray Well System. It would appear that heavy intermittent stocking is the most desirable type of stocking in saltbush country.

Lastly, light stocking shortens the width of the B Zone, cf. the St. Patrick's System, as it actually reduces the number of vegetatively vigorous plants. We shall return to this point in considering the C Zone.

The C Zone (Lightly-stocked zone).

As in the case of the B Zone, the extent of this zone depends upon the intensity of stocking, but in the first instance the C Zone is taken as extending from 1,200 paces to 2,000 or 3,000 paces, that is, up to about 2½ miles from the watering place.

1. *Melton System.*—This system illustrates the typical effect of light grazing and a comparison of this zone with the ungrazed country is given in the following table:

	C Zone.			D Zone.			Differences.	
	M	σ	S.E.	M	σ	S.E.	M	S.E. of D.
Total Plants ..	211	±44	±14·0	163	±13	±5·8	**+48**	±15·2
Defoliated Plants ..	103	23	7·3	93	15	6·9	10	10·0
Wilting Plants ..	53	15	4·7	24	5	2·4	**+29**	5·3
Healthy Plants ..	55	32	10·4	43	17	7·4	12	12·4
Seedlings	1·4	2·2	0·7	3	1·7	0·7	1·6	1·0
	N=15							

Compared with the ungrazed country this lightly-stocked zone shows a significant increase in the mean number of total plants and a significant increase in the number of wilting plants.

2. *St. Patrick's System.*—As in the case of the B Zone, two series in different years are available and these are given in the first instance uniform with the others, that is from 1,200 paces to the end of the transect.

October, 1929.

	C Zone			D Zone.			Differences.	
	M	σ	S.E.	M	σ	S.E.	M	S.E. of D.
Total Plants ..	222	±48	±14·4	181	±19	±4·5	**+41**	±15·0
Defoliated Plants ..	104	19	5·7	83	13	2·9	**+21**	6·4
Wilting Plants ..	93	44	13·1	65	12	2·7	**+28**	13·3
Healthy Plants ..	18	13	4·0	17	10	2·2	1	4·5
Seedlings	8	3·5	1·0	15	8	1·9	7	2·1
	N=16							

October, 1930.

	C Zone.			D Zone.			Differences.	
	M	σ	S.E.	M	σ	S.E.	M	S.E. of D.
Total Plants ..	184	±49	±13·8	181	±21	±6·6	3	±15·6
Defoliated Plants ..	119	36	10·4	115	26	5·8	4	11·6
Wilting Plants ..	31	23	6·3	16	5	1·2	**+15**	6·4
Healthy Plants ..	39	11	1·4	45	12	2·7	6	3·2
Seedlings	1·2	2·2	0·6	7	6	1·1	5·8	1·3
	N=9							

In both cases a significant increase in the mean number of wilting plants per 100 paces is apparent in the lightly-grazed zone compared with the unstocked country. A significant increase in the number of plants is shown in the 1929 transects, but not in the 1930 transects: this is probably due to the fact that the 1930 figures are less reliable, since only 9 samples for this zone are available in this year. The 1929 figures also show an increase in the number of defoliated plants. It was pointed out, in dealing with the B Zone of this transect system, that this grouping is artificial and does not express the true relation of the zones which are telescoped under light stocking and do not extend outwards from the watering place so far as they do when heavier stocking occurs. Taking the C Zone as extending from 800 paces only, instead of 1,200 paces (it will be remembered that the B Zone of this system was so shortened), we obtain the following figures:

	C Zone.			D Zone.			Differences.	
	M	σ	S.E.	M	σ	S.E.	M	S.E. of D.
Total Plants ..	234	±55	±10·6	181	±19	±4·5	**+53**	±11·5
Defoliated Plants ..	93	27	5·2	83	13	2·9	10	6·0
Wilting Plants ..	109	50	9·6	65	12	2·7	**+44**	9·9
Healthy Plants ..	26	21	4·0	17	10	2·2	9	4·9
Seedlings	7	4	0·8	15	8	1·9	8	4·0
	N=27							

This somewhat finer grouping shows a significant increase in the mean total number of plants and in the wilting plants in the lightly grazed zones and is exactly comparable with the Melton results.

3. *Alderman's Transect System.*—As the St. Patrick's System needed a modification of the uniform width of the zones owing to light stocking, so also the Alderman's System needs modification because of the heavy stocking and peculiar physiographic conditions of this paddock. It has been mentioned previously that the feeding ground of this water is restricted, owing to the presence of high hills near the bore, and in addition this paddock has always been heavily stocked. We know that the heavily-grazed zone around this watering place extends for about 2 miles. This is shown clearly in the analysis of the figures for the different classes of plants on the original uniform basis (that is, B Zone extending one mile from the bore, the C Zone about two). The figures on this basis are shown in the following table, in which the B and C zones are compared, using percentages since the total numbers of plants in the two zones are not the same:

	B Zone (300–1,200 paces).			C Zone (1,200–2,000 paces).			Differences.	
	M	σ	S.E.	M	σ	S.E.	M	S.E. of D.
Total Plants ..	136	±4·0	±6·8	193	±76	±13·6	**+57**	±15·2
Defoliated Plants %	16	7·3	2·7	21	12	2·1	5	3·4
Wilting Plants %	41	13	2·1	44	13	2·3	3	3·1
Healthy Plants % ..	25	12	2·0	27	13	2·3	2	3·0
Seedlings % ..	16	13	2·1	6	3	0·9	10	2·2

It will be seen that there is an increase in the total number of plants, but no increase in any other category. In other words, the composition of the two zones is the same so far as vigour is concerned and the effect of lighter stocking has not been reached. The B Zone was therefore lengthened to 2,000 paces from the well (which corresponds with our knowledge of the usual feeding grounds) and the C Zone taken beyond this from 2,000–3,000 paces. The C Zone compared with the unstocked country then falls into line with the Melton and St. Patrick's transect system, as is seen in the following table:

	C Zone.			D Zone.			Differences.	
	M	σ	S.E.	M	σ	S.E.	M	S.E. of D.
Total Plants ..	246	±60	±16·2	181	±19	±4·5	**+65**	±16·8
Defoliated Plants ..	30	9	2·5	45	6	1·4	**−15**	2·9
Wilting Plants ..	49	12	3·2	36	8	1·9	**+13**	3·7
Healthy Plants ..	16	14	4·0	9	5	1·1	7	4·1
Seedlings	4	7	2·2	8	4	1·0	4	2·4

4. *The Mutooroo System.*—These paddocks have been so lightly stocked that no C Zone is present. Beyond 1,200 paces from the well the community has the same structure as regards vigour as the country further distant from the well. The following comparison is between zones between 1,200 to 2,000 paces from the well and 2,000 and 3,400 paces from the well. There is no difference, as will be seen:

	C Zone.			D Zone.			Differences.	
	M	σ	S.E.	M	σ	S.E.	M	S.E. of D.
Total Plants ..	137	±42	±8·3	149	±38	±10·1	12	±12·7
Defoliated Plants ..	102	25	5·0	101	29	7·7	1	9·6
Wilting Plants ..	23	10	1·9	32	14	3·8	9	4·3
Healthy Plants ..	12	12	2·4	16	10	2·7	4	3·6
Seedlings	—	—	—	—	—	—	—	—
	N=14			N=14				

It will be seen from the foregoing that the outstanding features of the lightly-grazed zone are an increase in the mean total number of plants per 100 paces and an increase in the mean number of wilting plants when compared with the unstocked country. That is to say, under light grazing conditions, the community shows a deterioration when compared with the virgin ungrazed community. The bushes are overcrowded, due to occasional trampling which results in the planting of seed, and the plants have not even the vigour of the ungrazed communities, which, as has been shown, is small compared with the heavily-grazed zones. This increase in wilting plants probably follows from undue competition as a result of overcrowding of the bushes.

It follows, therefore, that light grazing of saltbush is more harmful to the vigour of the community than heavy stocking or than no stocking at all.

SUMMARY.

1. The investigations described in this paper were carried out at the Koonamore Vegetation Reserve, in the north-east of South Australia, during the period April, 1928, to June, 1931. They form part of a more extensive programme having as its object the study of the arid flora of this area. The Reserve forms the Arid Flora Research Station of the University of Adelaide. The work described herein has been carried on with the aid of a grant from the Commonwealth Council for Scientific and Industrial Research.

2. *Atriplex vesicarium* Heward, the perennial saltbush, is the dominant plant over the extensive shrub steppe formation that is developed in the north-east of South Australia and many other portions of arid Australia. The community is an open one composed of gregarious low-growing bushes (32 × 34 cm.) with much bare ground between the small groups.

3. The plants have usually a number of slender, brittle stems branching freely at the base. The leaves are non-cuticularized, tomentose with densely packed bladdery hairs and somewhat succulent, but with a high osmotic pressure (50 atmos.). The transpiration rate is low and the leaves are able to absorb moisture from the air with 85% saturation. The root system is extensive but superficial (10–20 cm.). Deciduous feeding roots are a feature of the main framework, and the root system is probably non-functional during droughts.

During prolonged rainless periods the leaves pass into a state of permanent wilting, which is delayed by their capacity to gain water from damp air. Ultimately they are exfoliated and the plant passes into a leafless state of anabiosis.

4. Climatic data given show that the diurnal range of temperature is great and, as a consequence, the relative humidity at times of low temperature is surprisingly high. The mean annual maximum is 85%, a figure that is maintained for an average of 3 hours in summer to as much as 9·5 hours in winter.

It follows, therefore, that the saturation deficit is low (0·08 to 0·02 inch of mercury) for at least a portion of each day. Under such conditions *Atriplex* leaves absorb water. On the contrary, of course, the saturation deficit is high (0·95–0·65 for a portion of each day from October to April inclusive) which indicates the aridity of the climate. The period covered by the investigation has been one of severe drought which has accentuated the stock effect.

5. The north-east district of South Australia is leased as large sheep stations which are subdivided into paddocks seldom less than 20 square miles in area. These are provided with one or more watering places, dams or bores. Natural

permanent water is almost unknown. As the distance that sheep travel from water is seldom more than 3 miles, it follows that those portions of a paddock near water are grazed and trampled by sheep (stock effect) much more intensively than others remote from the water which may be seldom or never grazed at all.

6. Starting then at a watering place and walking to the most remote portion of the paddock, saltbush will be traversed that is subjected to all degrees of stocking intensity, ranging from the inevitable over-stocking at the drinking place to practically virgin country. Four zones of decreasing severity in stock effect are recognized:

The A Zone, immediately around the watering place.
The B Zone, on main feeding grounds of the sheep.
The C Zone, beyond B, which is only lightly grazed.
The D Zone, still more remote and virtually ungrazed.

This last zone gives a measure of a saltbush population on which the sheep portion of the biota does not operate.

7. Systems of transect lines have been run from several watering places on different stations to secure variation in type of country and management. Along these lines the number of saltbushes and the vegetative vigour of each bush according to a predetermined scale has been ascertained. The unit of length is the "pace" (a stride of 1·5 yards). Transect lines have been run for distances of from 1,200 to 3,000 paces from different waters. The results so obtained have been considered in groups of successive 100-pace intervals. A sufficient number of such 100-pace intervals has been obtained from each zone to allow of a comparison of the zones by the difference of the means. Transect readings obtained in the D Zone, 3–5 miles from water, provide the standard of the unstocked community.

8. As would be expected, the D Zones in different areas are comparable, showing neither a significant difference in the mean number of bushes per 100 paces, nor in the health and vigour of the community. A characteristic feature of the community during the drought is the high proportion of defoliated and dead plants. The A Zone is not treated statistically owing to the wide variations in the readings. This is only natural round the drinking place, owing to the excessive stock effect.

9. The B Zone, moderately heavily grazed, shows no significant difference in the mean number of plants per 100 paces when compared with the ungrazed country, but does show a significant increase in the mean number of healthy plants and a corresponding significant decrease in the mean number of defoliated and dead plants. We thus reach the important conclusion that there is a measurable increase in the health and vegetative vigour of the community as a result of moderately heavy grazing even during a drought.

10. The C Zone, lightly grazed, on the other hand, shows a significant increase in the mean number of bushes and in the mean number of wilting plants per 100 paces. The lightly stocked saltbush community is thus less healthy than the moderately heavily stocked community or even than the community that is not stocked at all. This we attribute to the planting of seed by the hooves of sheep and the failure to remove moribund plants by light trampling, thus leading to an overcrowded community in which the competition is unduly severe.

11. Evidence is presented from an intermittently but heavily stocked water, the X-Ray Well transect system, that this type of stocking is most beneficial to the vegetative vigour of the saltbush. It prunes the bushes, tramples out the weakly ones, plants seed which has time to germinate and form established plants before the next stocking period.

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EXPLANATION OF PLATES VII-IX.

Except where otherwise stated all photographs taken by T.B.P.

Plate vii.

Fig. 1.—Shrub-steppe of *Atriplex vesicarium* photographed by T.G.B.O. on 19th August, 1923. Rainfall 583 points during previous twelve months.

Fig. 2.—Photograph taken from approximately same position as that in Fig. 1, during August, 1929. Rainfall 88 points during previous twelve months.

Fig. 3.—View over Salt Creek No. 1 quadrat from N.E. corner peg. The strings are stretched dividing the area into 1-metre squares. Note the gregarious habit of the *Atriplex* and the high proportion of sparsely foliated (wilting) bushes. Photographed 19th September, 1928.

Fig. 4.—General view taken from the windmill tower of a well showing complete destruction of *Atriplex* owing to unduly heavy stock effect. Most of this damage was done within three months. Photographed by T.G.B.O., 7th June, 1929.

Plate viii.

Note.—Photographs in Figures 1-5 were taken in Alderman's Paddock, Koonamore Station, on 26th August, 1929.

Fig. 1.—"Dead" bush, i.e., defoliated type.

Fig. 2.—"Very sparsely foliated bush", a constituent of the "wilting" class.

Fig. 3.—"Sparsely foliated bush", a constituent of the "wilting" class.

Fig. 4.—"Well foliated bush", a constituent of the "healthy" class.

Fig. 5.—"Fully foliated bush", a constituent of the "healthy" class.

Fig. 6.—"Seedling" saltbush, photographed 4th December, 1929.

Plate ix.

Note.—All photographs on this plate were taken along the Putt's Well transect system, Melton Station, on 30th November, 1930.

Fig. 1.—The A Zone, heavily trampled and overgrazed. Photograph taken within 200 paces of the well. Note that all *Atriplex* bushes have been destroyed.

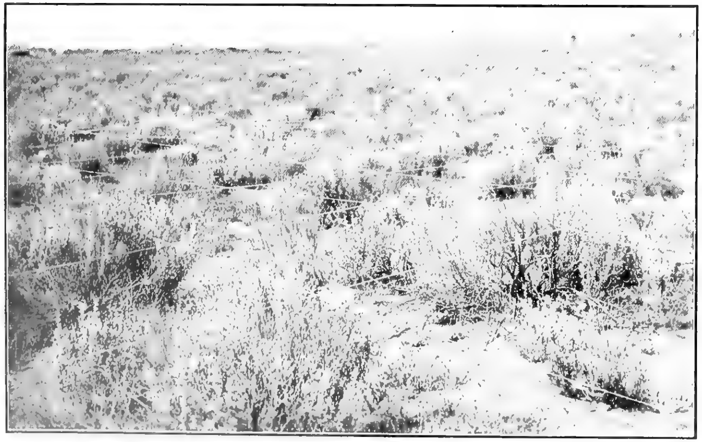
Fig. 2.—The B Zone, moderately heavily grazed. Photograph taken between 600 and 800 paces from the well. Note the healthy stand of *Atriplex*, most of the bushes showing vegetative vigour.

Fig. 3.—The C Zone, lightly and occasionally stocked. Photograph taken between 1,500 and 1,700 paces from the well. Note the overcrowded state of the community, with a high proportion of lightly foliated bushes.

Fig. 4.—The D Zone, virtually ungrazed. Note the almost leafless state of the bushes which are less crowded than they are in the C Zone.

1.—August, 1923.

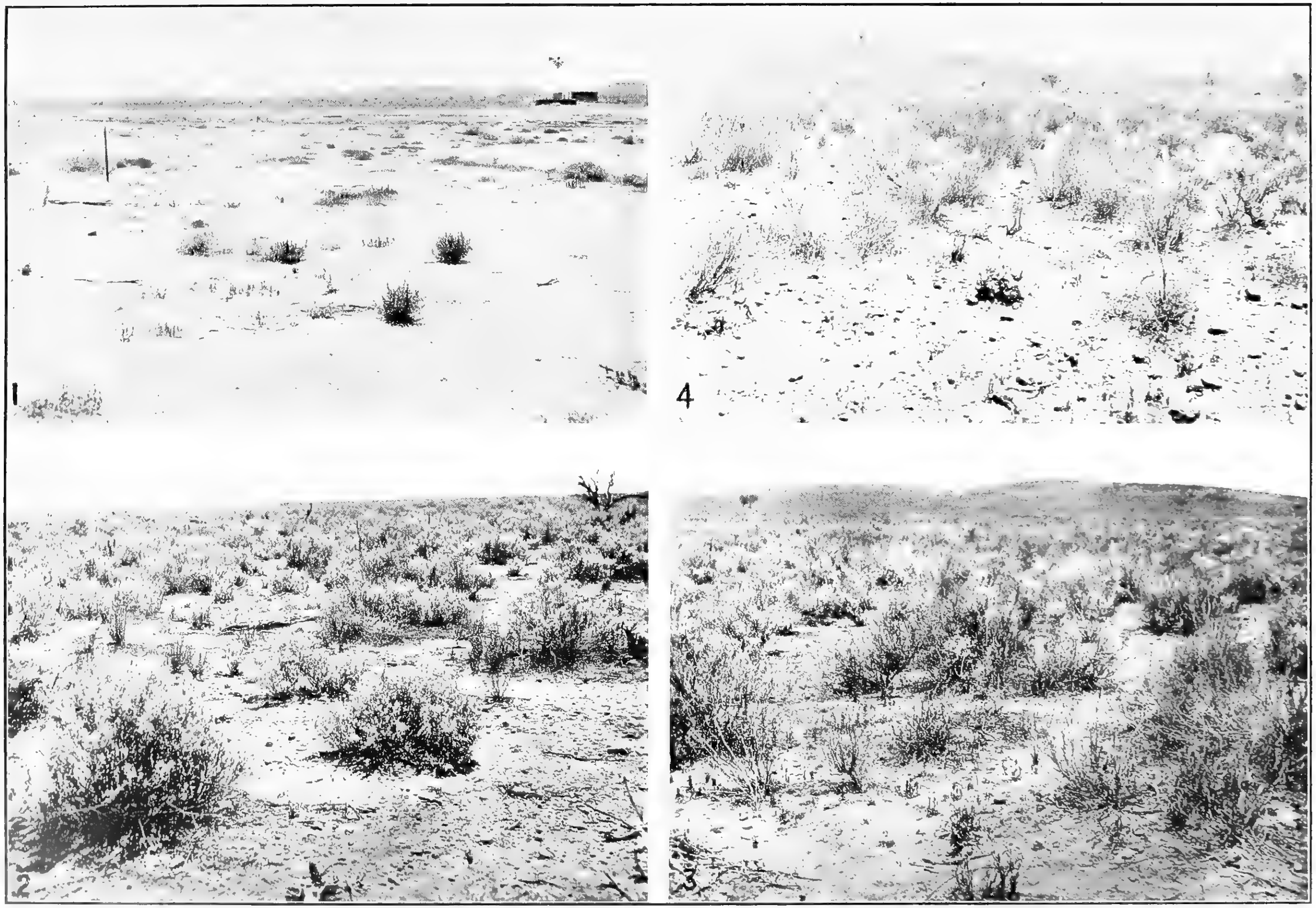
2.—August, 1929.



3 – Salt Creek open transect.

4 —Heavy stock effect.

Saltbush plants, classified according to a scale of vegetative vigour.



Photographs taken along Putt's Well transect system, Melton Station, all on 30th November, 1930.
1.—"A" Zone. 2.—"B" Zone. 3.—"C" Zone. 4.—"D" Zone.

THE GEOGRAPHIC DISTRIBUTION OF *TILLETIA* SPP. ON WHEAT IN AUSTRALIA IN 1931.

By J. G. Churchward, B.Sc.Agr.

(Two Text-figures.)

[Read 30th November, 1932.]

Introduction.

Bunt or stinking smut of wheat has been known since early times and annually causes losses, more or less severe, in all wheat-growing countries.

The two common species causing the disease are *Tilletia tritici* (Bjerk.) Winter, the rough-spored type, and *Tilletia levis* Kuhn., with a smooth spore wall. Recently, Mitra (1931) has reported a new species of bunt, *Tilletia indica*, on wheat in India. It has a reticulate spore wall like *T. tritici*, but differs from the latter in having no smell of rotten fish when crushed, and in attacking only portion of the grain. The chlamydospores, with an average diameter of 35μ, are considerably larger than those of *T. tritici* (20μ).

No extensive survey of the species of *Tilletia* causing bunt of wheat has hitherto been made in Australia, and work of this nature is very desirable. Bunt can be controlled readily by pickling the seed wheat, but the relatively high cost of this operation has already been stressed in an earlier paper (Churchward, 1931). Furthermore, the fact that bunt is present in all the wheat-growing States in Australia indicates that some farmers either do not "pickle" their wheat, or do it carelessly. For these reasons the best solution of the problem would seem to lie in the production of bunt-resistant varieties; obviously one of the prime requisites in breeding resistant varieties is to know the geographic distribution and relative prevalence of the two species of *Tilletia* causing the disease, as it is known that wheat varieties do not necessarily react in the same manner to both. Wheat varieties differ also in their resistance to several known physiological forms of bunt. This differential reaction has not been demonstrated in Australia and the present survey would serve as an introduction to future work on these lines.

Little work has been done previously in studying the geographic distribution of the species of bunt. In America, Coons and Potter (1918) reported that the States of the Upper Mississippi Valley and the Great Plains area were fairly free of *T. tritici*. Tisdale et al. (1927) later found this species in the Mississippi Valley, but it was confined to the durum wheats.

T. tritici was the only species found in the State of Washington prior to 1918, and in the following year an extensive survey showed *T. levis* to be present in only two of the 631 fields examined (Kienholz and Heald, 1930). In 1927-28 the amount of *T. levis* was found to have increased, though *T. tritici* was still predominant.

In general, it seems that *T. tritici* is most common west of the Rocky Mts., but may be found eastward as far as Illinois. *T. levis* is found from coast to coast, but is most prevalent in the east.

Both species are known to occur in Canada. The durums appear to be more susceptible to *T. tritici* than to *T. levis* (Hanna and Popp, 1930). Both species are found in the Hard Red Spring wheats, but *T. tritici* is more common in the crops of the northern areas, while *T. levis* predominates in the south.

1

2

Fig. 1.—The distribution of *Tilletia tritici* in Australia in 1931.
Fig. 2.—The distribution of *Tilletia levis* in Australia in 1931.
The shaded area indicates the approximate limits of the wheat-growing area. Each square represents a centre from which one or more collections have been made.

There were noted only few references to the distribution of the species in Europe. According to Gram (1929) *T. tritici* is the predominant species of bunt in Denmark, the incidence of *T. levis* being almost negligible. Butler states that *T. levis* is rare in England. In Bulgaria, *T. levis* occurs practically over all the country while *T. tritici* is restricted to two separate highland areas; one in the middle of the Danubian Plain, the other in the extreme north-west (Atanasoff, 1929). Andreyeff (1928) has shown that, in the North Caucasian Region, 90% of the total infection is due to *T. levis*. The incidence of *T. tritici* increases from south to north.

Results of Survey.

At the close of the 1931 wheat season, with the co-operation of certain wheat exporting firms and Departments of Agriculture of the various States, collections of bunt were made in all the principal wheat-growing districts of the five States in Australia. Some collections were made in the field, others were obtained from bulk smutty wheat, from various country centres or on arrival at shipping port.*

From each of these representative lots a random sample was taken, and from this 10–20 bunt balls were selected. The contents of a ball were broken into a drop of 50% aqueous solution of lactic acid and the spore suspension examined. The results are summarized in Table I and the distribution of the species of *Tilletia* of wheat is graphically represented in Figures 1 and 2.

The shaded areas indicate the approximate limits of the wheat belts in the various States. Each black square represents a centre from which one or more collections have been made. The composite collections comprise numbers of bunt balls taken from many samples of wheat and are, therefore, truly representative of each district.

Table I shows that bunt is present in all of the principal wheat-growing districts of the five States and that *T. levis* predominates. Both species were found in all of the States except Victoria; here only *T. tritici* was collected. Even though the samples examined from a wheat cleaning plant in Melbourne proved to be *T. tritici* only, it is probable that, had collections been received from more centres, *T. levis* would have been found.

TABLE I.—*The species of bunt of wheat in different localities of five wheat-growing States of Australia.*

Locality and Number of Samples.	Species of *Tilletia* present.	Locality and Number of Samples.	Species of *Tilletia* present.
	Queensland.		
Amby (1)	*levis*	Millmerran (3)	*levis*
Hodgson (2)	*tritici* and *levis*	Greenmount (1)	*tritici* and *levis*
Dalby (3)	*levis*	Nobby (4)	*tritici* and *levis*
Goombungee (1)	*levis*	Clifton (7)	*tritici* and *levis*
Oakey (3)	*tritici* and *levis*	Ellinthrop (2)	*tritici* and *levis*
Kingsthorpe (1)	*levis*	Allora (6)	*tritici* and *levis*
Aubigny (1)	*tritici* and *levis*	Berat (2)	*tritici* and *levis*
Boora Mugga (4)	*tritici* and *levis*	Cunningham (2)	*tritici* and *levis*
Cecil Plains (1)	*tritici* and *levis*	Warwick (4)	*tritici* and *levis*
Umbrian (1)	*tritici* and *levis*	Yangan (6)	*tritici* and *levis*
Pittsworth (5)	*tritici* and *levis*		

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* It is desired to acknowledge the assistance rendered and the facilities placed at my disposal by the Field Instructors of the various State Departments of Agriculture, by the staff of the Hawkesbury Agricultural College, and by Bunge (Aust.) Pty. Ltd., Dalgety & Co. Ltd., John Darling & Son, Ltd., and Louis Dreyfus & Co.

Locality and Number of Samples.	Species of *Tilletia* present.	Locality and Number of Samples.	Species of *Tilletia* present.
New South Wales.			
Gravesend (3)	*tritici* and *levis*	Derriwong (1)	*tritici* and *levis*
Inverell (1)	*levis*	Cumnock (1)	*levis*
Wee Waa (2)	*levis*	Larras Lee (1)	*levis*
Somerton, Manilla (2)	*levis*	Wagga Wagga (2)	*tritici* and *levis*
Tamworth (2)	*tritici* and *levis*	Leeton (1)	*tritici* and *levis*
Warrah Ridge (1)	*levis*	Goolgowi (1)	*tritici* and *levis*
Wangarbon (1)	*levis*	Goorawin (1)	*tritici* and *levis*
Gilgandra (1)	*levis*	Lake Cargelligo (1)	*tritici*
Victoria.			
Melbourne (composite)	*tritici*	Werribee (composite)	*tritici*
Rutherglen (2)	*tritici*	Sea Lake (1)	*tritici*
Horsham (2)	*tritici*		
South Australia.			
Millicent (1)	*tritici*	Port Rickaby (1)	*tritici* and *levis*
Wolseley (2)	*tritici*	Minlacowie (1)	*tritici*
Pinaroo (1)	*levis*	Maitland (1)	*tritici*
Parilla (1)	*levis*	Kilkerran (2)	*levis*
Parrakie (1)	*levis*	Paskeville (1)	*tritici* and *levis*
Wilkawatt (1)	*levis*	Kadina (3)	*tritici* and *levis*
Karri (1)	*tritici*	Wallaroo (1)	*tritici* and *levis*
Monarto (4)	*tritici* and *levis*	Port Germein (1)	*tritici* and *levis*
Sutherlands (1)	*tritici* and *levis*	Black Rock (1)	*tritici*
Eudunda (1)	*tritici*	Moocra (1)	*tritici*
Murray Bridge (1)	*tritici* and *levis*	Bruce (1)	*tritici* and *levis*
Woodchester (1)	*tritici*	Carrieton (1)	*tritici*
Owen (1)	*levis*	Ungarra (1)	*tritici*
Gawler (2)	*tritici* and *levis*	Karkoo (1)	*tritici* and *levis*
Wasleys (1)	*tritici* and *levis*	Wharminda (1)	*tritici* and *levis*
Alma (2)	*tritici* and *levis*	Dutton Bay (1)	*tritici*
Dublin (2)	*tritici* and *levis*	Warramboo (1)	*tritici* and *levis*
Saddleworth (1)	*tritici*	Denial Bay (1)	*tritici* and *levis*
Blyth (1)	*tritici* and *levis*	Streaky Bay (1)	*tritici* and *levis*
Jamestown (1)	*tritici*	Nowral (1)	*tritici* and *levis*
Gladstone (2)	*tritici*	Tarke (2)	*tritici* and *levis*
Bute (1)	*tritici* and *levis*	Petersville (1)	*tritici*
Port Pirie (1)	*tritici* and *levis*	Perlubie (2)	*tritici* and *levis*
Wandearah (1)	*levis*	Mundalla (1)	*tritici*
Western Australia.			
Collie (1)	*tritici*	Beverley (1)	*tritici*
Broome Hill (1)	*levis*	Quairading (2)	*levis*
Tarin Rock (1)	*tritici* and *levis*	Burgess Siding (1)	*levis*
Lake Biddy (2)	*levis*	Hammersley (1)	*levis*
Newdegate (2)	*levis*	Nangeenan (2)	*tritici* and *levis*
Harrismith (2)	*tritici* and *levis*	Nungarin (1)	*tritici* and *levis*
Dudinin (1)	*tritici* and *levis*	Elabbin (1)	*tritici* and *levis*
Traysurin (2)	*tritici* and *levis*	Merriden (2)	*levis*
Wickipin (2)	*levis*	Burracoppin (1)	*levis*
Kulin (3)	*tritici* and *levis*	Carrabin (1)	*tritici* and *levis*
Gnarming (2)	*levis*	Bodallin (1)	*levis*
Kondinin (1)	*levis*	Moorine Rock (1)	*levis*
Bullaring (2)	*levis*	Perilya (1)	*levis*
Notting (1)	*tritici* and *levis*	Warralakin (1)	*levis*
Bendering (2)	*levis*	Campion (2)	*levis*
Corrigin (1)	*tritici* and *levis*	Mukinbudin (1)	*tritici* and *levis*
Ardath (2)	*levis*	Northam (1)	*tritici*
Brookton (2)	*tritici* and *levis*		

Western Australia—*Continued.*

Locality and Number of Samples.	Species of *Tilletia* present.	Locality and Number of Samples.	Species of *Tilletia* present.
Tammin (2) ..	*tritici* and *levis*	Koorda (1) ..	*tritici* and *levis*
Cunderdin (1) ..	*tritici* and *levis*	Gobbin (1) ..	*levis*
Frenches Siding (1)	*levis*	Cleary (1)	*tritici* and *levis*
Rossmore (2) ..	*tritici* and *levis*	Dalgouring (2) ..	*tritici* and *levis*
Goomaling (1) ..	*tritici*	Watheroo (1) ..	*tritici* and *levis*
Dowerin (1) ..	*levis*	Nugadong (1) ..	*levis*
Amery (1) ..	*levis*	Wubin (1)	*levis*
Benjabbering (1)	*levis*	Caron (1)	*tritici* and *levis*
Wyalkatchem (1)	*tritici* and *levis*	Three Springs (1)	*levis*
Trayning (1) ..	*tritici* and *levis*	Tardun (1) ..	*tritici* and *levis*
Burabadji (1) ..	*tritici* and *levis*	Wilroy (1) ..	*levis*
Goddard (1) ..	*tritici* and *levis*	Pindar (1)	*levis*
Elphin (1)	*tritici* and *levis*	Beatty (2)	*tritici* and *levis*
Manmanning (1)	*tritici* and *levis*	Mullewa (3) ..	*levis*
Kondut (1) ..	*tritici* and *levis*	Ardingly (3) ..	*levis*
Ballidu (2) ..	*levis*	Tenindewa (2) ..	*levis*
Damboring (1)	*levis*	Eradu (1)	*levis*
Cowcowing (1) ..	*levis*	Ajana (1)	*levis*
		Various sources	*tritici* and *levis*

Hitherto, it was generally held that there was little or no *T. tritici* in Western Australia, but the survey made by the writer indicates that the species is present and is fairly widespread. The invasion may have been a recent one.

In South Australia most of the collections came from typical mallee country and many from the newer mallee areas, where the standard of farming is not yet as high as is desired. The fairly wide distribution of bunt in these areas may possibly be correlated with the absence of pickling.

This is supported by the fact that in New South Wales, where dry pickling is practised by almost all wheat growers, bunt is not very abundant, although collections were obtained from most of the wheat-growing districts. It was believed formerly that *T. tritici* was the more common species in New South Wales. The results of the survey would indicate, however, that *T. levis* is the predominant species.

In Queensland *T. levis* was found in all centres from which collections were made. *T. tritici* was missing from only five collections.

Conclusions.

The results of the survey made by the writer show quite clearly that two species of *Tilletia*, namely *T. tritici* and *T. levis*, are widely distributed and prevalent in most of the wheat-growing areas of Australia. This fact has an important bearing on the development of disease-resistant varieties, as it has been shown by Johnston (1924), Kienholz and Heald (1930), and Holton (1930) that varieties do not necessarily react in the same way to the two species of bunt. Varieties may be resistant to one species but more susceptible to the other. Furthermore, Kienholz and Heald have shown that when one of the species is brought into a region in which the other seemed to predominate, varieties hitherto resistant to bunt may become infected. It was shown by Kienholz and others also that there are intergrading forms between the two species as indicated by the degree of reticulation of the spore wall. This suggests the possibility of inter-specific hybridization which might easily complicate the breeding problem and change its aspect from time to time.

The writer has found the same variation in collections made in Australia. It seems highly probable, therefore, that interspecific hybridization occurs here. Furthermore, it is now well known that there are many physiologic forms or parasitic strains within both species. While a thorough study of this physiologic specialization has not yet been made in Australia, it seems very likely that it must be taken into consideration in breeding work, and experiments are now under way to determine the number and distribution of forms, as well as the possible origin of new forms through hybridization.

The writer acknowledges the kind assistance and advice he has received from Dr. E. C. Stakman, University of Minnesota, and Dr. W. L. Waterhouse, University of Sydney.

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AUSTRALIAN HESPERIIDAE. III.

DESCRIPTIONS OF NEW FORMS.

By G. A. WATERHOUSE, D.Sc., B.E., F.E.S.

[Read 30th November, 1932.]

Since my earlier paper in These PROCEEDINGS this year, further notes have been received from General Evans and a fuller investigation has been made in Sydney of the following three species, which I refrained from including in my previous paper.

TRAPEZITES SYMMOMUS Hübner.

Zutrage exotischer Schmetterlinge, 1823, figs. 225, 226.

The figures are of a male from New Holland, as stated by Hübner. The underside is almost identical with Fig. 732 in the *Butterflies of Australia*, 1914. This latter figure was taken from a Sydney specimen. There is little doubt that Hübner's type came from near Sydney. The following races can be readily distinguished.

TRAPEZITES SYMMOMUS SYMMOMUS Hübner.

T. symmomus, Waterhouse and Lyell, 1914, p. 175, figs. 731, 732.

Typically this race is from Sydney, where it is found from November to April. Specimens from as far south as Moruya and north to Brisbane will be included, as well as those from the Blue Mountains.

TRAPEZITES SYMMOMUS SOMA, n. subsp.

T. symmomus, Anderson and Spry, *Victorian Butterflies*, p. 114, fig., 1894.

♂. Upperside: Forewing with the hyaline spots slightly larger than in the typical race, usually (as in the holotype) an inclined spot in 1a, upper part hyaline, lower part scaled, often joined to the prominent orange spot in 1a nearer base; hindwing, similar to the typical race. Underside, similar to the typical race, but the bluish spots on the hindwing much more prominent.

♀. Differs from the typical race in the same way as the male.

Types in the Australian Museum, from Frankston, Victoria, caught in February and March. I have other specimens from Wandin and Healesville. Mr. A. L. Brown has bred it from *Xerotes* from January to March.

TRAPEZITES SYMMOMUS SOMBRA, n. subsp.

This race differs from the typical race in being slightly paler on the upperside. On the underside the general colour is paler, the spots of the hindwing are much smaller and fewer in number, slightly bluish in the holotype male, but larger in the females.

The type series in the Australian Museum consists of two males and three females from Herberton, Qld., caught in December and January by Mr. F. P. Dodd. There is also a male from Kuranda (September).

EUSCHEMON RAFFLESIA W. S. Macleay.

King's Survey, Australia, ii, Appendix, p. 463, 1827.

The type specimen of this species has been lost. A careful examination of the places visited in Eastern Australia during the voyage on which this species was caught shows the most likely locality to be Port Macquarie, where the species is still common close to the town.

EUSCHEMON RAFFLESIA VIRIDIS, new form.

E. rafflesia, Waterhouse and Lyell, 1914, p. 224, figs. 590, 591.

Upperside: hyaline yellow spots larger than in specimens from Port Macquarie; greenish subapical patch of scales on forewing more extensive. Underside: the greenish submarginal bands very broad (especially in some females). In Port Macquarie specimens these bands are narrow and bluish-green.

The holotype male is Fig. 590 in the *Butterflies of Australia* from Kuranda, April, 1902. It is in the Australian Museum, together with four males and three females from Kuranda in March and April, 1902 (R. E. Turner).

NETROCORYNE REPANDA Felder.

Reise Novara, Lep., p. 507, Pl. 70, fig. 10, 1867.

Felder's type is a male from Moreton Bay. Similar specimens are found on the east coast as far south as Sydney. *Goniloba vulpecula* Prittwitz, *Stett. Ent. Zeit.*, 1868, p. 187, Pl. 3, fig. 2*a* and *b*, is a male from New Holland and is the same race.

NETROCORYNE REPANDA EXPANSA, n. subsp.

♀. Upperside, darker than the typical race, hyaline spots of forewing larger; the one on hindwing smaller; the pale streak between the cell spot of forewing and costa as long as or longer than the cell spot. Underside, darker than the southern race.

The holotype is from Kuranda (February) and is in the Australian Museum; also females from Mount Molloy in December, and Herberton.

SABERA ORIDA FULIGINOSA Miskin.

Pamphila fuliginosa Miskin, *Proc. Roy. Soc. Qld.*, 1889, p. 147.

General Evans has pointed out to me that Miskin's species must stand as a race of "*Thymele*" *orida* Boisduval (*Voyage Astrolabe*, Lep., p. 162, 1832) from Offack, New Guinea.

BACTERIOLOGY ACCOUNT.

BALANCE SHEET at 31st December, 1931.

LIABILITIES.	£	s.	d.	ASSETS.	£	s.	d.	£	s.	d.
Amount bequeathed by Sir William Macleay	12,000	0	0	Consols				15,820	0	0
Accumulated Income Capitalized	3,820	0	0	Cash: Commercial Banking Company..	634	19	8			
Income A/c at 31st December, 1931	655	12	3	Savings Bank	14	12	7			
				In hand	6	0	0			
								655	12	3
	£16,475	12	3					£16,475	12	3

INCOME ACCOUNT. Year Ended 31st December, 1931.

	£	s.	d.	£	s.	d.		£	s.	d.
To Salary				600	0	0	By Balance from 1930	534	3	2
„ Storage and Cartage	53	15	6				„ Interest	796	0	9
„ Expenses	19	3	4							
				72	18	10				
„ Petty Cash				1	12	10				
„ Balance to 1932				655	12	3				
				£1,330	3	11		£1,330	3	11

Examined and found correct. Securities produced.
F. H. Rayment, F.C.A. (Aust.),
Auditor.
4th February, 1932.

G. A. Waterhouse,
Hon. Treasurer.
7th January, 1932.

ABSTRACT OF PROCEEDINGS.

ORDINARY MONTHLY MEETING.

30th March, 1932.

Dr. C. Anderson, M.A., President, in the Chair.

The President drew the attention of members to the Annual Public Meeting of the Association for the Protection of Native Races, to be held in the Aeolian Hall, 264 Pitt Street, on 21st April, at 7.45 p.m.

The Donations and Exchanges received since the previous Monthly Meeting (25th November, 1931) amounting to 56 Volumes, 522 Parts or Numbers, 33 Bulletins, 13 Reports and 102 Pamphlets, received from 177 Societies and Institutions and 4 private donors, were laid upon the table.

PAPERS READ.

1. The Gasteromycetes of Australasia. xiv. The Family Tulostomataceae. By G. H. Cunningham.

2. A Review of the Tipulidae of Australia (Diptera). i. By C. P. Alexander. (*Communicated by Dr. I. M. Mackerras.*)

3. The Occurrence of *Atrax venenatus* on the Comboyne Plateau. By E. C. Chisholm, M.B., Ch.M.

4. Notes on New South Wales Orchids. ii. By Rev. H. M. R. Rupp, B.A.

SPECIAL GENERAL MEETING.

27th April, 1932.

Dr. C. Anderson, M.A., President, in the Chair.

On the motion of the Honorary Treasurer, Dr. G. A. Waterhouse, the following alterations to the Rules of the Society were unanimously adopted:

Rule ii, line 5, *omit the words* "not resident in New South Wales"
Rule vi, line 2, *for* January *read* March
Rule vii, line 3, *for* January *read* March
 line 5, *for* February *read* April
Rule xi, line 3, *for* half past four *read* five
 lines 3-5, *delete the words* "and between the hours of half past nine a.m. and twelve noon on Saturday,"
Rule xxix, *replace existing rule by the following*:
 "The Council shall meet at least once during each month, except January, at such hour and place as shall be appointed by the Council."
Rule xl, lines 5-6, *for* the Government Savings Bank of New South Wales *read* a Government Savings Bank.
Rule xlv, *for* lines 1-2 *read* "The Society's financial year shall commence on the first day of March in each year, and at the beginning of each financial year the Trea(surer) . . ."

ORDINARY MONTHLY MEETING.

27th April, 1932.

Dr. C. Anderson, M.A., President, in the Chair.

Mr. John Andrews, B.A., Artarmon; Mr. E. J. Bryce, Lindfield; Mr. J. G. Churchward, B.Sc.Agr., Longueville; Mr. H. F. C. Davis, Newtown; Mr. E. Jarvis, North Queensland; and Miss Ellen C. Morison, B.Sc., Pymble, were elected Ordinary Members of the Society.

The President announced that the Council had elected Dr. W. R. Browne, Dr. H. S. H. Wardlaw, Mr. E. Cheel and Professor T. G. B. Osborn to be Vice-Presidents for the Session 1932-33.

The President also announced that the Council had elected Dr. G. A. Waterhouse to be Honorary Treasurer for the Session 1932-33.

The Donations and Exchanges received since the previous Monthly Meeting (30th March, 1932) amounting to 16 Volumes, 109 Parts or Numbers, 6 Bulletins, 6 Reports and 2 Pamphlets, received from 69 Societies and Institutions, were laid upon the table.

PAPERS READ.

1. The Larvae of the Australian Sheep Blowflies. By Mary E. Fuller, B.Sc.
2. Notes on Australian Diptera. xxx. By J. R. Malloch. (*Communicated by Dr. G. A. Waterhouse.*)
3. A Preliminary Account of the Protura of Australia. By H. Womersley, A.L.S., F.E.S. (*Communicated by Dr. R. J. Tillyard.*)
4. Rainfall Reliability in Australia. By J. Andrews, B.A. (*Communicated by Prof. J. Macdonald Holmes.*)
5. Geographical Studies in the Blue Mountain Tableland. By F. A. Craft, B.Sc., Linnean Macleay Fellow of the Society in Geography.
6. On the Production in Australia of two new Physiologic Forms of Leaf Rust of Wheat, *Puccinia triticina*. By W. L. Waterhouse, D.Sc.Agr.

NOTES AND EXHIBITS.

Miss Lilian Fraser exhibited examples of Mutations in fungi, or saltations, as they are usually called, which are not uncommon. They may occur naturally, or may be due to increase in temperature or change of culture medium. The saltant may remain constant or may revert to the parental type, e.g., on reculturing at lower temperatures or on a different medium.—*Alternaria* sp. was found as an infection in laboratory cultures. The parental form has a fluffy greenish-brown aerial growth; it has been in culture for two years, and single spore cultures regularly develop saltations which are all of the one kind. The saltant is dark purplish-brown when grown on potato dextrose agar and has much less aerial mycelium than the parental type. It also grows more vigorously than the parental type at 25° C., but slightly less vigorously at 19–20° C.—Three distinct saltants of *Botrytis cinerea* were shown: (*a*) a dark-coloured saltant with numerous sclerotia; (*b*) a light-coloured flat growing saltant; and (*c*) a light-coloured saltant with brown sclerotia. Mutants in *Botrytis cinerea* are not unusual and may be either constant or inconstant. In the present instance they are probably due to the high concentration of sugar in the medium on which the cultures were grown.—A culture of *Penicillium* sp. was shown on which had developed a saltant with a more fluffy white aerial growth than the parental form.

Mr. J. R. Kinghorn contributed the following note: It appears that Crocodiles in North Australia, particularly *Crocodilus porosus*, are prone to a disease of the skin which affects it to such a degree that it is useless when tanned as leather. The disease, known to one hunter as Newrick, his own name for it, makes its appearance as hard, flat lumps on the undersurface of the crocodile, which, when the hide is tanned, become so brittle as to break into pieces when bent, thus rendering the leather useless for commercial purposes. Crocodile hides are much in demand in Australia, having taken the place of the imported Alligator hides from the U.S.A. The diseased beasts cannot be identified from unaffected ones until killed or trapped and examined, and therefore the hunter wastes much time, material and money in collecting specimens. Australian tanners and leather merchants do not like dealing in Australian hides on account of this disease, and prefer to import hides from the Malay Peninsular and Archipelago. As "Newrick" disease is widely distributed and affects a large percentage of Crocodiles in the north, perhaps more particularly in the Gulf country, the loss to Australia is great. One hunter suggested that impure water and bad food were the cause, and that if Crocodiles could be farmed, as in America, the disease would disappear. Mr. Kinghorn suggested that the problem is worthy of investigation, perhaps by some member of this Society, or by the Council for Scientific and Industrial Research. He exhibited a complete untanned hide, a small piece of skin, and a tanned skin—all infected with the disease.

Mr. Gilbert P. Whitley made some remarks on *Ompax spatuloides* Castelnau, a supposed Ganoid fish described under unusual circumstances in the third volume of the Society's Proceedings. Castelnau's name, in his opinion, had no nomenclatural status, having been based upon a fallacious specimen apparently manufactured from portions of three distinct fishes with the addition, perhaps, of the jaws of a Platypus. The genus and species being mythical, he suggested that the name *Ompax spatuloides* should be expunged from the list of Australian fishes.

SPECIAL GENERAL MEETING.

25th May, 1932.

Dr. C. Anderson, M.A., President, in the Chair.

It was unanimously resolved that the alterations to Rules approved at the Special General Meeting of 27th April, 1932, be confirmed.

ORDINARY MONTHLY MEETING.

25th May, 1932.

Dr. C. Anderson, M.A., President, in the Chair.

Miss Thistle Y. Harris, B.Sc., Rose Bay, Mr. Donald Martin, Burwood, and Mrs. Pearl R. Messmer, Lindfield, were elected Ordinary Members of the Society.

The Donations and Exchanges received since the previous Monthly Meeting (27th April, 1932) amounting to 18 Volumes, 164 Parts or Numbers, 3 Bulletins, 3 Reports and 8 Pamphlets, received from 79 Societies and Institutions and 2 private donors, were laid upon the table.

PAPERS READ.

1. New Guinea and Australian Coleoptera. Notes and New Species. No. 2. By H. J. Carter, B.A., F.E.S.

2. Inheritance of Resistance to Bunt, *Tilletia tritici* (Bjerk.) Winter, and other Characters in certain Crosses of "Florence" Wheat. By J. G. Churchward, B.Sc.Agr. (*Communicated by Dr. W. L. Waterhouse.*)

3. Some Notes on the Biology and Morphology of the Immature Stages of *Harpobittacus tillyardi.* By G. A. Currie, B.Sc., B.Sc.Agr. (*Communicated by Dr. R. J. Tillyard.*)

Dr. H. S. H. Wardlaw gave a short account of Laboratories visited by him abroad.

NOTES AND EXHIBITS.

Dr. Walkom called the attention of members to the account of a special general meeting of the Linnean Society of London (*Proc. Linn. Soc. London*, Session 1931-32, p. 17), held on 19th November, 1931, to celebrate the centenary of Robert Brown's discovery of the nucleus of the Vegetable Cell. This account contains much interesting information concerning Robert Brown.

ORDINARY MONTHLY MEETING.

29th June, 1932.

Dr. C. Anderson, M.A., President, in the Chair.

Mr. A. A. Lawson, Artarmon; Miss Winifred R. Mankin, M.Sc., Newtown; Mr. R. N. Robertson, Lewisham; Mr. K. E. W. Salter, Homebush; and Mr. A. R. Woodhill, B.Sc.Agr., Northwood, were elected Ordinary Members of the Society.

The President drew the attention of members to the meeting of the Australian and New Zealand Association for the Advancement of Science, to be held in Sydney in August.

The Donations and Exchanges received since the previous Monthly Meeting (25th May, 1932) amounting to 11 Volumes, 327 Parts or Numbers, 17 Bulletins, 8 Reports and 87 Pamphlets, received from 70 Societies and Institutions and 2 private donors, were laid upon the table.

PAPERS READ.

1. Notes on Australian Coleoptera, with Descriptions of New Species. ii. By C. Oke.

2. Fossil Plants from Mount Piddington and Clarence Siding, N.S.W. By A. B. Walkom, D.Sc.

3. Contributions to our Knowledge of the Actinomycetales. iii. Further Observations on the Genus *Micromonospora.* By H. L. Jensen, Macleay Bacteriologist to the Society.

4. Notes on Australian Diptera. xxxi. By J. R. Malloch. (*Communicated by Dr. G. A. Waterhouse.*)

NOTES AND EXHIBITS.

Mr. E. Cheel exhibited specimens of a grass collected by Mr. J. M. Hamilton between Tulloona and Warialda, forwarded by Rev. E. N. McKie of Guyra for identification. The grass is of special interest, as it is identical with the species *Thellungia advena*, described as a new genus by Dr. Otto Stapf from specimens sent to the Royal Herbarium, Kew, England, which Dr. Thellung of Zurich found had sprung up among the wool refuse of the worsted mill, Derendingen, near Solothurn, Switzerland (*Kew Bulletin*, 1920, p. 96). In describing the grass Dr.

Stapf suggested that it was of Australian origin, and it is of special interest to note that it has previously been collected at Yallaroi Station, between Moree and Warialda, in March, 1897, and Gilgil Creek, Moree, in March, 1898, by Mr. W. S. Campbell. Mr. W. M. Carne also collected it at Moree in May, 1914. The specimens have a superficial resemblance to *Sporobolus*, but differ in the number of florets. Mr. Hubbard, who came out to Australia from Kew (England) to make a special study of Australian Gramineae, identified the species which had been separated from the genus *Sporobolus*, with which it had been previously confused by the late Mr. E. Betche in the National Herbarium collection.

Mr. G. P. Whitley exhibited a series of deep-sea fishes obtained by the "Dana" Expedition and reported upon by Dr. C. Tate Regan, also a flying-fish, *Exonautes cribrosus* (Kner), parasitized by a crustacean (*Pennella*) to which barnacles (*Conchoderma*) were attached. This specimen was captured between Sydney and Auckland and was similar to one mentioned in *The Australian Museum Magazine*, iii, 1927, pp. 139-140.

Mr. F. A. McNeill exhibited a series of enlargements from standard film of natural history subjects taken on the islands of the Capricorn Group, Queensland, by Mr. Noel Monkman.

Dr. J. McLuckie exhibited specimens of two species of *Cordyceps*: *C. Robertsii* Hooker and *C. Gunnii* Berkeley, collected by Mr. A. Burges and himself. *C. Robertsii* was frequently found around the roots of trees growing along creek banks at Bola Creek, National Park. It had previously been recorded by Cheel and Cleland from Fitzroy Falls, N.S.W. *C. Gunnii* was found burrowing in soft sandy or shaly banks. It had been recorded from the banks of the Murrumbidgee and from near Albury.

The Rev. H. M. R. Rupp exhibited specimens of the orchid, *Cryptanthemis Slateri*, described by him in a paper earlier in the year.

The Secretary exhibited, on behalf of the Rev. E. N. McKie, of Guyra, N.S.W., specimens of two plants collected in the vicinity of Guyra, both of which had been submitted to the authorities at the Royal Botanic Garden, Kew. One specimen, according to Sir Arthur Hill, who has recently monographed the genus *Lilaeopsis*, is the long-lost *Lilaeopsis fistulosa*, which was collected by Caley at Parramatta in January, 1804. The only existing specimen of that species was Caley's specimen in the Natural History Museum, South Kensington, labelled *Hydrocotyle fistulosa* in Caley's handwriting. The specimen exhibited, which is in fruit, was collected at Guyra in December, 1930, growing in a soakage at the outlet of a spring in black clay of basaltic origin, altitude 4,400 feet. The second specimen was submitted by Sir Arthur Hill to Mr. J. Groves, who pronounced it to be identical with or very closely related to *Chara scoparia*, an alga which, so far as known, is confined to a very limited area in Central Europe. The occurrence of this plant at Guyra is of interest from the point of view of plant distribution. It was collected at a freshwater dam five miles south-west of Guyra in February, 1932.

Dr. C. Anderson, on behalf of the trustees of the Australian Museum, exhibited a photograph of a long-snouted Crocodile, *Mystriosaurus* (*Steneosaurus*) *Mandelslöhi*, from the Jurassic slates of Holzmaden, Germany. The specimen, which is almost complete and has a length of about seven feet, is exhibited in the Australian Museum. The family to which it belongs, the Teleosauridae, flourished in the Jurassic and possibly survived into the Cretaceous or even the Eocene.

ORDINARY MONTHLY MEETING.

27th July, 1932.

Dr. C. Anderson, M.A., President, in the Chair.

The Donations and Exchanges received since the previous Monthly Meeting (29th June, 1932) amounting to 8 Volumes, 76 Parts or Numbers, 4 Bulletins, 7 Reports and 4 Pamphlets, received from 62 Societies and Institutions and 1 private donor, were laid upon the table.

PAPERS READ.

1. Trichopterygidae of Australia and Adjacent Islands. Descriptions of two new Genera and eighteen new Species. By C. Deane.

2. The Physiography of the Shoalhaven River Valley. v. The Upper Valley and the Stream System. By F. A. Craft, B.Sc., Linnean Macleay Fellow of the Society in Geography.

3. Notes on the Mosses of New South Wales. i. Additional Records and Description of a new Species of *Buxbaumia*. By A. Burges, B.Sc.

4. Australian Hesperiidae. ii. Notes and Descriptions of new Forms. By G. A. Waterhouse, D.Sc., B.E., F.E.S.

NOTES AND EXHIBITS.

Rev. H. M. R. Rupp exhibited a series of some of the rarer terrestrial orchids of Australia.

Mr. F. A. McNeill exhibited an impression of portion of a frond of *Thinnfeldia* in a hard coarse sandstone from Bronte, Sydney.

ORDINARY MONTHLY MEETING.

31st August, 1932.

Dr. C. Anderson, M.A., President, in the Chair.

Mr. Ralph Ellis, Berkeley, California, U.S.A., and Mr. F. J. Gay, Homebush, were elected Ordinary Members of the Society.

The President announced that the Council had elected Mr. W. S. Dun a Corresponding Member of the Society.

The Donations and Exchanges received since the previous Monthly Meeting (27th July, 1932) amounting to 28 Volumes, 141 Parts or Numbers, 9 Bulletins, 3 Reports and 5 Pamphlets, received from 89 Societies and Institutions and 1 private donor, were laid upon the table.

PAPERS READ.

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

2. The physiography of the Shoalhaven River Valley. vi. Conclusion. By Frank A. Craft, B.Sc., Linnean Macleay Fellow of the Society in Geography.

3. Notes on Erosional Processes and Stream Gravels. By Frank A. Craft, B.Sc., Linnean Macleay Fellow of the Society in Geography.

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

NOTES AND EXHIBITS.

Mr. David G. Stead exhibited a number of lantern slides of Western Australian trees.

The Secretary called attention to the Basic Report issued recently by the Parks and Playgrounds Movement of New South Wales.

ORDINARY MONTHLY MEETING.

28th September, 1932.

Mr. E. Cheel, Vice-President, in the Chair.

Mr. E. T. Edwards, B.Sc.Agr., Potts Point, Sydney, and Mr. C. J. Magee, B.Sc.Agr., M.Sc., Rose Bay, Sydney, were elected Ordinary Members of the Society.

The Chairman announced that the Council is prepared to receive applications for four Linnean Macleay Fellowships tenable for one year from 1st March, 1933, from qualified candidates. Applications should be lodged with the Secretary, who will afford all necessary information to intending candidates, not later than Wednesday, 2nd November, 1932.

The Donations and Exchanges received since the previous Monthly Meeting (31st August, 1932) amounting to 15 Volumes, 77 Parts or Numbers, 10 Bulletins, 1 Report and 11 Pamphlets, received from 59 Societies and Institutions and 2 private donors, were laid upon the table.

PAPERS READ.

1. Mycotrophism in the Rutaceae. i. The Mycorrhiza of *Eriostemon Crowei* F.v.M. By J. McLuckie, M.A., D.Sc., and A. Burges, B.Sc.
2. Two new Australian Species of *Pollenia.* By G. H. Hardy.
3. The Gasteromycetes of Australasia. xv. The Genera *Mesophellia* and *Castoreum.* By G. H. Cunningham, Ph.D.

NOTES AND EXHIBITS.

Mr. T. C. Roughley exhibited a photograph of a goldfish (*Carassius auratus*) affected with "White Spot" disease, caused by a ciliate infusorian *Ichthyophthirius multifiliis.* This disease, introduced from abroad, has during recent years become very widespread amongst aquarium fishes in Australia, and has been particularly prevalent during the late winter and early spring of this (1932) and the previous year. As the result of experiments carried out at the Technological Museum, Mr. Roughley gave details of the life history of the parasite and suggested effective remedies. At a temperature varying from 60° F. to 65° F. the parasite grows to maturity on the fish in from seven to eight days. This was determined by liberating a cyst, from which the young were hatching out, into an aquarium containing healthy fish. In four or five days the spots were noticeable on the body and fins; on the seventh day they were conspicuous, and a few of the adult parasites were found on the bottom of the aquarium, whilst on the ninth day the spots had all disappeared. This temperature (60° F.–65° F.) appears to be most favourable for the development of the parasite in Australia, for it is most prevalent during the latter half of August and during September, when the temperature of the water in aquaria is usually within that range. The adult parasite is very variable in shape, though usually oval; it is white in colour, and measures from $^1/_{70}$ to $^1/_{30}$ of an inch; it leaves the fish by bursting the covering membrane and swims about in the water for from one to five hours at the above temperature. The parasite then settles on the bottom and forms a cyst, from which the young, which may number from about a hundred to over two thousand, and which measure about $^1/_{500}$ of an inch long and from $^1/_{900}$ to $^1/_{1000}$ of an inch wide, emerge in approximately 24 hours. These freshly liberated young parasites swim actively about in the water in search of a fish to which to attach.

In the treatment of the disease, Mr. Roughley experimented with the use of mercurochrome in a 2 per cent. solution in water. By the addition of 10 drops to each gallon of water in the aquarium the disease was completely eradicated in a month at an average temperature of 59° F. The adult parasite may continue to swim about in the mercurochrome solution for from 30 minutes to 2 hours, but in no case were any found to form a cyst, and therefore reinfection was completely prevented. At higher temperatures the life history of the parasite is speeded up, and the duration of the treatment with mercurochrome may be reduced considerably.

In America, this parasite causes a considerable mortality amongst important edible freshwater fishes in the wild state, and every effort should be made to prevent its liberation into the headwaters of our rivers and into the Murray River system, for once there heavy losses are bound to occur amongst our valuable freshwater edible fishes.

Mr. W. W. Froggatt exhibited specimens of Coccid galls, *Cylindrococcus aplior*, growing out of the bark of large stems of *Casuarina* sp., Gilgandra, N.S.W. They were collected by Geo. A. Withers, Esq., Forest Officer. These galls are much larger than the normal galls which are found upon the young branchlets of She-oaks.

Mr. E. Cheel exhibited fresh flowering specimens of a white-flowering form of *Kennedya*, having very similar foliage characters of *K. rubicunda*, which seem to indicate that it is probably an albino form of that species. He also exhibited fresh specimens of three species of *Plantago media* L., naturalized in the Outer Domain. Specimens of *P. major* L., and *P. lanceolata* L., were also exhibited for comparison.

Mrs. Messmer sent for exhibition a series of plants collected by the Rev. H. M. R. Rupp in the Pilliga District.

Dr. G. A. Waterhouse called the attention of members to the publication by the Royal Zoological Society of New South Wales of the Bibliography of Australian Entomology, 1775–1930, by Mr. A. Musgrave, and the Chairman, on behalf of members, offered congratulations to Mr. Musgrave on the completion of this important work.

ORDINARY MONTHLY MEETING.

26th October, 1932.

Dr. C. Anderson, M.A., President, in the Chair.

Mr. F. de V. Kelly, Sydney, and Mr. R. N. McCulloch, Double Bay, Sydney, were elected Ordinary Members of the Society.

Candidates for Linnean Macleay Fellowships, 1933–34, were reminded that Wednesday next, 2nd November, is the last day for receiving applications.

The President referred to the death of Mr. T. G. Sloane, who had been a member of the Society since 1887, and who had contributed some fifty papers on Australian Carabidae to the PROCEEDINGS.

The Donations and Exchanges received since the previous Monthly Meeting (28th September, 1932) amounting to 4 Volumes, 56 Parts or Numbers, 1 Bulletin, 1 Report and 5 Pamphlets, received from 41 Societies and Institutions, were laid upon the table.

PAPERS READ.

1. The Embryology and Seedling Development of *Aegiceras majus* Gaertn. By Gladys Carey, B.Sc., and Lilian Fraser, M.Sc.

2. New Species of Corylophidae (Coleoptera). By C. Deane.

3. Late Middle Devonian Diastrophism in South-eastern Australia. By Ida A. Brown, D.Sc., Linnean Macleay Fellow of the Society in Geology.

NOTES AND EXHIBITS.

The Secretary conveyed information received from Mr. A. E. Wilson, of Kogarah, regarding flowering of native plants grown from seed: (*a*) *Callistemon lanceolatus* plants from seed collected in October, 1930, now bursting into bloom (October, 1932); (*b*) red-flowering *Melaleuca* plant from seed collected on the banks of the Gwydir River and sown in February, 1931, now bearing flower-heads (October, 1932).

ORDINARY MONTHLY MEETING.

30th November, 1932.

Dr. C. Anderson, M.A., President, in the Chair.

The President announced that the Council had reappointed Mr. F. A. Craft, B.Sc., Dr. H. Claire Weekes and Miss Lilian Fraser, M.Sc., to Linnean Macleay Fellowships in Geography, Zoology and Botany respectively for one year from 1st March, 1933; and had appointed Dr. I. V. Newman, M.Sc., to a Linnean Macleay Fellowship in Botany for a period of one year from 1st March, 1933.

The Donations and Exchanges received since the previous Monthly Meeting (26th October, 1932) amounting to 17 Volumes, 174 Parts or Numbers, 12 Bulletins, 2 Reports and 54 Pamphlets, received from 78 Societies and Institutions and 1 private donor, were laid upon the table.

PAPERS READ.

1. Contributions to our Knowledge of the Actinomycetales. iv. The Identity of certain Species of *Mycobacterium* and *Proactinomyces*. By H. L. Jensen, Macleay Bacteriologist to the Society.

2. On the Growth and Reaction to Grazing of the Perennial Saltbush, *Atriplex vesicarium*. An Ecological Study of the Biotic Factor. By Prof. T. G. B. Osborn, J. G. Wood and T. B. Paltridge.

3. The Geographic Distribution of *Tilletia* spp. on Wheat in Australia in 1931. By J. G. Churchward, B.Sc.Agr.

4. The Australian Species of *Graphomyia* (Diptera, Muscidae). By I. M. Mackerras, B.Sc., M.B., Ch.M.

5. Australian Hesperiidae. iii. By G. A. Waterhouse, D.Sc., B.E., F.E.S.

NOTES AND EXHIBITS.

Mr. E. Cheel exhibited the following species of plants not previously recorded for this State, which are suspected as being harmful to stock or a menace to farmers and pastoralists as weed-pests:—

Astragalus hamosus, a native of dry exposed places from Spain to Tauria and Mauretania, commonly known as "Hooked-podded Milk Vetch" or "Caterpillars", collected by J. S. Phillips at Neurea near Dripstone.—*Alhagi maurorum*, native of the deserts of Egypt, Syria, Mesopotamia and other eastern countries. This plant is commonly known as "Moor's Alhagi" or "Hebrew Manna", and was collected by W. J. Nixon at Reefton in December, 1927.—*Bartsia* (*Bartschia*) *trixago*, collected by B. A. Smith at Walla Walla, and by P. H. Chauncy at Ganmain.—*Centaurea Isnardi*, a weed commonly known as "Jersey Star Thistle", collected by M. J. Steinbrocker at Uppingham, Koorawatha.—*Centaurea picris*. This species was originally collected at Henty (see These Proc., 1921, 503), but has since been found at Reefton, Cumnock, Tamworth and Inverell.

Specimens of *Boronia dentigeroides* Cheel and *Boronia subulifolia* Cheel were also exhibited, which were recently collected at Clyde Mountain and Currockbilly Range near Braidwood in excellent flowering condition.

DONATIONS AND EXCHANGES.

Received during the period 26th November, 1931, to 30th November, 1932.

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

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LIST OF MEMBERS, 1932.

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.G.S., 32 Benelong Crescent, Bellevue Hill.
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.
1925 Barnard, Colin, M.Sc., Council for Scientific and Industrial Research, Division of Plant Industry, Box 109, Canberra, F.C.T.
1919 Barnett, Marcus Stanley, c/o Colonial Sugar Refining Co., Ltd., O'Connell Street, Sydney.
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.
1923 Bone, Walter Henry, 6 Deans Place, Sydney.
1926 Branch, Kenneth James Fergus, B.Sc., 99 North Steyne, Manly.
1912 Breakwell, Ernest, B.A., B.Sc., Department of Education, Box 33A, G.P.O., Sydney.
1927 Bredero, William Adrien Lewis, Box 127, Post Office, Orange, N.S.W.
1923 Brough, Patrick, M.A., B.Sc., B.Sc.Agr., "Kinross", Billyard Avenue, Wahroonga.
1921 Brown, Horace William, 871 Hay Street, Perth, W.A.
1924 Brown, Miss Ida Alison, D.Sc., Geology Department, The University, Sydney.
1911 Browne, William Rowan, D.Sc., Geology Department, The University, Sydney.
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(1932.)

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(Issued 16th May, 1932.)

Vol. LVII. **Nos. 239-240.**
Parts 1-2.

THE

PROCEEDINGS

OF THE

LINNEAN SOCIETY

OF

NEW SOUTH WALES

FOR THE YEAR

1932.

Parts I–II (Pages i–xxv; 1–100).

CONTAINING THE PROCEEDINGS OF THE ANNUAL MEETING AND PAPERS READ IN MARCH-APRIL.

With three plates.
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SYDNEY:
PRINTED AND PUBLISHED FOR THE SOCIETY BY
AUSTRALASIAN MEDICAL PUBLISHING CO., LTD.,
Seamer Street, Glebe, Sydney,
and
SOLD BY THE SOCIETY,
Science House, Gloucester and Essex Streets, Sydney.

1932.
PRICE 6/6.

Registered at the General Post Office, Sydney, for transmission by post as a periodical.

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PROCEEDINGS, 1932, PARTS 1-2.

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(Issued 15th September, 1932.)

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THE PROCEEDINGS OF THE LINNEAN SOCIETY OF NEW SOUTH WALES

FOR THE YEAR

1932.

Parts III–IV (Pages 101–290).

CONTAINING PAPERS READ IN MAY-AUGUST.

With two plates.

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PRINTED AND PUBLISHED FOR THE SOCIETY BY
AUSTRALASIAN MEDICAL PUBLISHING CO., LTD.,
Seamer Street, Glebe, Sydney,
and
SOLD BY THE SOCIETY,
Science House, Gloucester and Essex Streets, Sydney.

1932.
PRICE 8/6.

Registered at the General Post Office, Sydney, for transmission by post as a periodical.

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