THE

PROCEEDINGS

OF THE

LINNEAN SOCIETY

OF

NEW SOUTH WALES

FOR THE YEAR

1956

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CONTENTS OF PROCEEDINGS, 1956

PART 1 (No. 380).

(Issued 30th July, 1956.)

Corrigendum.

PROCEEDINGS, 1955, Part 3 (Vol. lxxx), p. 208, line 14, *for* PUMILIS, *read* PUMILUS.

CONTENTS.

MARINE BIOLOGICAL LABORATORY
LIBRARY
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PART 2 (No. 381).

(Issued 12th October, 1956.)

CONTENTS.

PART 3 (No. 382).

(Issued 21st February, 1957.)

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ANNUAL GENERAL MEETING.

28th MARCH, 1956.

The Eighty-First Annual General Meeting was held in the Society Rooms, Science House, Gloucester Street, Sydney, on Wednesday, 28th March, 1956.

Dr. F. V. Mercer, President, occupied the chair.

The minutes of the Eightieth Annual General Meeting, 30th March, 1955, were read and confirmed.

PRESIDENTIAL ADDRESS.

For the second time it is my privilege to deliver the Presidential Address of the Linnean Society of New South Wales. Now, more than before, I am conscious of the high honour which this Society has given me. More than ever, I realize the tremendous debt which the Society owes to Dr. W. R. Browne and Dr. A. B. Walkom. On behalf of the Society, I pay tribute to these men so they may know we do not take their activities for granted. Also I know you would wish me to express our gratitude to Miss G. L. Allpress for her loyal and able services.

During 1955 a number of changes in the personnel of the Council occurred. Professor P. D. F. Murray resigned from the Council as from 23rd March, 1955, and Mrs. Dorothy A. Thorp, B.Sc. (Lond.) (Mrs. Ronald Thorp) was elected in his place on 20th April, 1955. Mr. D. J. Lee ceased to be a member of Council as from 18th May, 1955, and Mr. A. J. Bearup, B.Sc., was elected in his place. On 22nd June, 1955, Dr. Lilian Fraser was elected a Vice-President in place of Mr. D. J. Lee. On 23rd November, 1955, Dr. J. W. Evans was elected a Member of Council in place of Dr. G. D. Osborne, who died on 5th October, 1955. Professor J. Macdonald Holmes resigned from the Council on 14th December, 1955.

During the year sixteen new members were added to the list, three members were lost by death, seven have resigned, and two were removed from the list under Rule VII. The numerical strength of the Society at 15th March, 1956, was: Ordinary Members 206, Life Members 28, Corresponding Members 2, Associate Member 1. Total 237.

Parts 1 and 2 of Volume 80 of the Society's Proceedings were published on 19th July and 5th October, 1955, respectively, and Part 3, the printing of which was unavoidably delayed, should appear during April, 1956. The entire cost of publication of the paper entitled "The Australasian Diptera of J. R. Malloch" was borne by the School of Public Health and Tropical Medicine, University of Sydney. An increase in printing charges was made as from February, 1956.

Library accessions from scientific societies and institutions totalling 2,007 (including 166 pamphlets presented by Dr. C. E. M. Gunther) exceeded the total for the previous year. Requests for library loans of periodicals and books to local and interstate institutions and Universities were as numerous as previously. Further subscribers to the Proceedings have received the Parts as issued. Sets of the Proceedings have been purchased by overseas institutions, and the demand for reprints continues to be keen. A duplicate copy of "The Australian Portrait Gallery and Memoirs of Representative Colonial Men", Sydney, 1844, was presented to the Fisher Library, University of Sydney. A collection of old maps and diagrams was handed to the Fisher Library, University of Sydney, on 13th October, 1955, for distribution to the Fisher Library, the Mitchell Library (eleven maps were received by that Library), and University Department Libraries, by the Librarian, Fisher Library. Exchange relations with two institutions were discontinued during the year. Exchanges of publications for our Proceedings were commenced with the following: Museum G. Frey, Tutzing, Germany (instead of Entomological Reprints); Musée d'Histoire Naturelle, Skopje, Jygoslavie; and Estacion Experimental de Aula Dei, Zaragoza, Spain; and reprints from the Proceedings were offered to the Department of Entomology, University of Queensland (entomological); Instytut Geologiczny, Warszawa, Poland (geological and palaeontological); Instituto Botanico, Madrid, Spain (botanical); Instituto de Aclimatacion, Almeria, Spain (zoological, including entomological); Institute of Polytechnics, Osaka City University, Osaka, Japan (botanical and zoological, including entomological); Academia Republicii Populare Romane, Bucuresti, Roumanis (zoological, including entomological) and Polski Zwiazek Entomologiczny, Warszawa, Poland (entomological). Council decided to purchase the following for the Library: Novitates Zoologicae, Vols. 7–20 inclusive, and "The Literature of Australian Birds: a History and a Bibliography of Australian Ornithology" by Hubert Massey Whittell.

No Ordinary Monthly Meeting was held in August, 1955. The following items of special interest were given at the Monthly Meetings:

May: Symposium—Notes on recent botanical researches in the Kosciusko region, by Mr. Barlow, Mr. Smith-White, Miss Briggs, Dr. Hotchkiss and Miss Macdonald.

June: Lecturette—Cicadas and their allies, by Dr. J. W. Evans.

July: Film of the 1939 Simpson Desert Expedition which was led by the late Dr. C. T. Madigan; shown by Professor R. L. Crocker.

September: Lecturette—The Differentiation of Secondary Cartilage, by Professor P. D. F. Murray.

November: Lecturette—Dr. James Stuart: Artist-Naturalist, by Messrs. A. Musgrave and G. P. Whitley.

We wish to express our thanks and appreciation to all who contributed to these programmes.

In consequence of the Science House Management Committee's successful application to the Fair Rents Court, a greatly increased revenue to the Society (£1,083, net share for the year) has been received.

A seventh and very successful trip to the Kosciusko area was made from 16th to 30th January, 1956, by a party of biologists and geologists under the auspices of the Joint Scientific Advisory Committee (comprising members appointed by the Linnean Society of New South Wales, and the Royal Zoological Society of New South Wales). Transport and accommodation were provided by the Departments of Geology and Botany, University of Sydney, and the Department of Tourist Activities and Immigration, N.S.W.

I wish to offer congratulations to Dr. Dorothy E. Shaw, M.Sc.Agr., who obtained the degree of Ph.D., of the University of Manitoba, Canada, in 1955.

Linnean Macleay Fellowships.

In November, 1954, the Council re-appointed Miss Nola J. Hannon, and appointed Miss Mary B. Macdonald to Fellowships in Botany for 1955.

Miss Hannon, during 1955, continued her investigations into the nitrogen economy of Hawkesbury Sandstone communities. Attention was given to the nitrogen levels in the early stages of the lithosere, and also the recolonization and nitrogen accumulation of an area of Hawkesbury Sandstone denuded of soil and plant cover about thirty-eight years ago. Since previous work has shown that the contribution of nitrogen from rainfall and free-living nitrogen-fixing organisms in these communities is very limited, the native legumes are being studied. Nodules on their root systems are commonly found in the field, and leaf analyses show that the legume tissue is considerably richer in nitrogen than most other species. *Acacia suaveolens* (Sm.) Willd., a widespread and common member of these communities, has been chosen as host plant for the study of legume-rhizobia inter-relationships. This species has been grown in the presence of an inoculum of soil taken from each of two hundred sites in the main types of communities in widely separated localities on Hawkesbury Sandstone. This had indicated that rhizobia are widespread in their occurrence, but the effectiveness of the symbiosis, as measured in terms of plant growth, shows considerable variation. This aspect of the symbiosis is receiving attention.

Miss Macdonald has been studying the family of freshwater Algae known as the Characeae. Early in the year she took part in the expedition to Kosciusko led by Dr. W. R. Browne, and was able to collect several interesting specimens there, and on the return to Sydney, *via* the south coast of New South Wales.

Her work during the year has been concerned with live cultures in the laboratory, and with herbarium specimens on loan from National Herbaria of Victoria and New South Wales. More than two hundred and fifty cultures have been established and maintained, representing most of the twenty-three species which have been collected during the year. Chromosome numbers have been definitely established for about fourteen species, and rough counts made for all remaining species in culture.

Cross-breeding experiments have been performed, probably for the first time in Characeae, and it has been established that *Protochara australis* Womersley and Ophel is non-reciprocally interfertile with *Chara australis* R.Br. A paper entitled "An Estipulodic Form of *Chara australis* R.Br. (= *Protochara australis* Woms. & Ophel)" by Miss Macdonald and Dr. A. T. Hotchkiss will appear in Part 3 of the Proceedings for 1955.

In November, 1955, the Council re-appointed Miss Nola J. Hannon and Miss Mary B. Macdonald to Fellowships in Botany for 1956.

Miss Hannon proposes to continue investigations to estimate the occurrence of legumes and rhizobia in the communities on Hawkesbury Sandstone, and, as far as possible, to obtain a measure of the effectiveness of their symbiosis; also to continue the work on an area of Hawkesbury Sandstone denuded of soil and plant cover about thirty-eight years ago.

Miss Macdonald was married on 21st January, 1956, to Mr. J. B. Williams. Mrs. Mary B. Williams proposes a continuation of her work on Australian Characeae, including the collection of further data on geographical range and occurrence of species and their behaviour in culture where possible; the collation of such data; investigation of conditions which will break the dormancy of Characeae spores; investigation of segregation characteristics of germinated hybrid spores from the cross between *Protochara australis* and *Chara australis*; and an attempt to synthesize an artificial polyploid by applying the chromosome doubling agent, colchicine.

We wish success to both Fellows in their research work.

Macleay Bacteriologist.

Dr. Yao-tseng Tchan terminated his appointment as Macleay Bacteriologist as from 31st July, 1955, completing five years as Macleay Bacteriologist. He was appointed Senior Lecturer in Microbiology at the University of Sydney, as from 1st August, 1955. Council expressed appreciation of his work, and congratulated him on his appointment. His work for the final period as Macleay Bacteriologist included concentration on the N-fixation of *Beijerinckia* in Northern Australia and New Guinea. Research on Northern Territory soil was continued for which a financial grant from C.S.I.R.O. was received. Many bacteriological analyses have been made, but the final conclusion still requires much more work. Some of the time was used for part-time teaching in the University.

Obituaries.

It is recorded with regret that the following members died during the year:

EDGAR ALEXANDER HAMILTON, who had been a member of the Society since 1928, died at Chatswood on 25th February, 1956, aged 78. He was a son of Mr. Alexander Greenlaw Hamilton, who was one of the early members of the Society, a member of Council for many years and President, 1915–17. Mr. E. A. Hamilton took a keen interest in the Society in his earlier years, but ill-health prevented his active interest in later years. He was a graduate of Hawkesbury Agricultural College, having entered the College in 1895. He was a member of the N.S.W. Naturalists' Society and a foundation member and President of the Orchid Society of N.S.W., for a number of years. For some years before his retirement he was Chairman of the Milk Board.

BENZOIN HOROWITZ, D.Agr.Sc., Principal Research Officer of the Division of Plant Industry, C.S.I.R.O., died on 10th October, 1955, while on an official visit in Queensland. Dr. Horowitz graduated as an Engineer of Agricultural Science and later as Doctor of Agricultural Science at the University of Cracow, Poland. After working on a number of plant breeding projects involving a wide variety of crops, he left Poland and arrived in Australia in 1941. In Australia, Dr. Horowitz took up an appointment with the University of Sydney and later with Drug Houses of Australia, Ltd. Under these appointments he was particularly concerned with aspects of the breeding, cultivation and commercial production of *Nicotiana rustica* as well as other drug and oil plants. Dr. Horowitz joined C.S.I.R.O. in 1949 and was stationed at the Waite Agricultural Research Institute, Adelaide, to collaborate in research on the economic establishment of oil crops in Australia. He was especially interested in safflower; he developed a considerable breeding programme with this crop and organized a chain of tests throughout the agricultural regions of Australia, thereby establishing an effective knowledge of the varieties and areas best suited to the establishment of the crop. Dr. Horowitz was extremely imaginative and hard working and his death was a serious loss to Australian agriculture. He had been a member of this Society since 1943.

GEORGE DAVENPORT OSBORNE died on 5th October, 1955, at Sydney. Dr. Osborne studied under the late Professor Sir Edgeworth David, and, following his graduation, joined the Department of Geology as Demonstrator. In 1925 he held a Linnean Macleay Fellowship, resigning in December, 1925, on his appointment to a Lectureship in the Department of Geology. In 1949 he was promoted to a Readership. He also acted for many years as Lecturer in Geology in the Sydney Technical College, and later as Lecturer to the Workers' Educational Association.

His enthusiasm, and his gift of interesting exposition as a teacher, particularly on excursions in the field, were an inspiration to many privileged to be under his instruction. He was a consistent worker in the cause of Science, and served on many committees and in a number of honorary positions to assist societies and associations. He was a member of this Society from 1921, a member of Council from March, 1942, till his death, and President, 1947–48.

Cytology and the Electron Microscope.

Selecting a topic suitable for the members of a society which was founded for the study of, and which is still actively concerned with, Natural History in all its aspects is not an easy matter, particularly for one who is not a "field" botanist. However, in choosing as the subject for my address "Cytology and the Electron Microscope", I hope to fulfil some of the objects for which this Society was founded. Before commencing I should like to stress that my address has been made possible only by the collaborative efforts of Dr. A. Hodge of the Division of Industrial Chemistry, C.S.I.R.O., Melbourne, and Mr. J. D. McLean of the Botany Department, University of Sydney.

The development of our knowledge of the world is based upon our senses—the sense of touch, of smell, of sight, of hearing and of taste. In the evolution of this knowledge the unaided senses have proved powerful "tools", but, sooner or later, further advancement is prevented by the limits imposed by their sensitivity. This point is well illustrated in the history of Botany by the way our ideas about the nature of plants have followed aids to our sense of vision.

Prior to the light microscope, the study of plant structure was of necessity limited to considerations of the external form of the organs and to gross tissue-differences. By the middle of the 17th century Botanists realized that plants had some sort of structure, in addition to the differentiation into organs, since in the apparently homogeneous organs layers of different composition could be seen. In the stem, for example, such components as wood, pith and rind were recognized. To explain the consistency of these layers it was believed that the woody parts consisted of a fibrous structure, the pith of a succulent homogeneous matrix, and the rind a heterogeneous unit composed of fibrous and pith-like materials. This was the level of knowledge on which the 17th century Botanists endeavoured to interpret the nature of the organism. It is not surprising that many of the views held appear fantastic nowadays. Thus the succulent nature of the pith along with the bleeding of juices from wounds and from cut stems was taken as proof that the pith is the living part of the plant containing canals analogous to the veins of animals.

Although a far more detailed knowledge of plant structure could have been obtained at this time by more careful observations and better interpretations, the study could never have progressed far because of the limits imposed by the resolution of the eye. The fundamental unit of the organism—the cell—lay hidden. The invention of the microscope increased the sense of sight and made possible that branch of knowledge called Cytology or the study of cells.

The Light Microscope.

The microscope did not immediately influence scientific thought. From 1590 to 1660 the new instrument was regarded more as a toy rather than a scientific instrument—something a gentleman might use to amuse his friends. Also the fact that it was rather cumbersome and difficult to handle did not encourage people to use it. Some instruments were up to six feet in length—more like a telescope than a microscope.

True high-power microscopy and the acceptance of the microscope as a scientific tool followed the introduction of short focus lenses by Robert Hooke (1635–1703) and van Leeuwenhoek (1632–1723). Hooke's microscope was the forerunner of the true compound microscope. It consisted of an objective and eyepiece lenses, and, since it was convenient to use, the microscope was now in a form suitable for systematic research.

By the end of the 17th century microscopes were in use with magnifications up to 150×. Gradually the magnifying power was improved. About 1810, German instruments with 170×–300× magnification were available. In 1812, Moldenhauer was using an instrument with 400× magnification, and in 1824 Sillique was making observations with a 500× microscope. Despite this gradual increase in magnifying power these instruments were relatively inefficient because the lenses were not corrected for chromatic and spherical aberration and the object was viewed dry and by reflected light.

Chevalier in 1823 solved the problem of spherical aberration, and Amice (1840) suggested the idea of an immersion lens, but its application had to wait until the adoption of substage illumination. Within a few years this improvement was introduced by Abbé. Between 1806 and 1856 Abbé evolved the light microscope in its present form. He introduced the substage condenser, the homogeneous oil immersion technique, and chromatic objectives, and placed the optical theory of the microscope on a firm basis. Since that time there have been no fundamental improvements in the performance of the light microscope.

The nineteenth century saw the general acceptance of the optical microscope by scientists, and as an outcome of this the appearance of the commercial manufacturers to supply the growing demand.* It is a chastening thought to remember that until the present century good microscopes were comparatively rare. Instruments were the product of individual craftsmen and were in limited supply. More often than not the operator of a microscope not only had to know his own special field, but also had to make his own instrument, to be able to grind lenses, and so on.

The twentieth century has yielded nothing new, apart from phase contrast (1935) and the ultraviolet microscope. It has been a period of refinement of the product combined with mass production such that superb microscopes are now freely available.

Three hundred years have passed during the evolution of the light microscope. In that time it has changed from a cumbersome oddity to a precision instrument, and from a toy to being the most essential of all biological equipment. It has increased the power of vision a thousand-fold and made possible the cell theory of organism. Unfortunately, further improvement is impossible because of the inherent limitations imposed by the wave length of visible light. Abbé in 1865 showed that the limits of resolution are inflexibly fixed by the wave length of the light used to view an object. With visible

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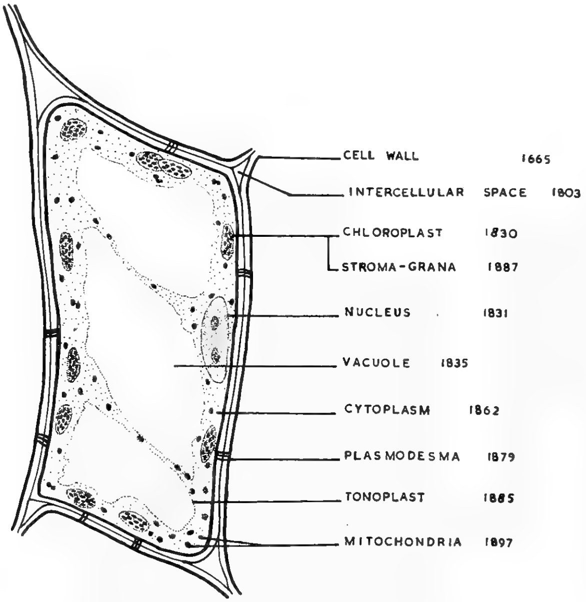
* Firms such as Beck (1830), Zeiss (1846), Spencer (1847), Leitz (1865) and Bausch (1872) came into being in response to the demand.

light the limit of resolution is *c.* 0·2μ; objects smaller than this must remain hidden. We have come full circle. The modern Botanist is in a position similar to that of his 17th century counterpart. His ability to observe is at the limits imposed by his sense of vision.

The Structure of the Cell.

The introduction of the light microscope did not immediately lead to discoveries about cell structure. This was due partly to the relatively long time taken in perfecting the microscope, and partly to the technique of viewing dry mounts by reflected light. It is not surprising, therefore, that until the beginning of the 19th century Botanical interest was centred around the structural inter-relationships of the tissues, and the cell wall. The so-called "juices" and slime which exuded from cut tissues were hardly studied; in fact they were considered of little consequence.



Text-figure 1.

Following Hooke (1665), who gave the first description of cellular organization in plants, Malpighi (1628–1694) and Drew (1628–1711) laid the foundations of plant anatomy and provided the perspective which was followed by Botanists until the 19th century. Interest was centred at the level of tissues and in the nature of the wall. At that time the true nature of the wall was not understood. Generally speaking, cells were regarded simply as cavities and the cell bounded by walls as in honeycomb or as globules of different kinds, while the tissue or organ was regarded as the unit manifesting the phenomena of Life. It was not until the early decades of the 19th century that the emphasis shifted to the slime or juice enclosed within the cell wall. This more or less coincided with increased availability of good microscopes and with the introduction of wet mounts. By the middle of the 19th century it had become clear that the phenomena of Life were really the properties of the slime and the cell the fundamental unit of the organism. The spectacular developments of the structure of the cell resulting from the development of the light microscope are summarized in Text-figure 1.

The general dissemination of first-class microscopes was certainly one of the major factors responsible for the rapid development of Cytology and theories of cell structure. Within a short space of fifty years the picture of the plant cell changed from that of a juice-filled cavity enclosed by a wall to a highly organized system consisting of many components, and the concept of the protoplast as the unit of living matter was firmly established. By the turn of the present century ideas on the structure of the plant cell were practically identical with those in current use. Thus during the past half century few, if any, fundamental discoveries relating to cell structure have been made by the light microscope. It does not follow that Cytology has been stationary. On the contrary, cytological research has been one of the most productive branches of Botany, covering a tremendous range of cell types. Striking confirmation of the cell theory has been given and the mechanism of mitosis and meiosis placed on a firm descriptive basis. Also, in alliance with Taxonomy and Genetics, Cytology has given us a deeper insight into the nature of species, and the geographical distribution of plants. However, because of the limits imposed by the optics of the light microscope, Cytology has reached an impasse, at least in so far as the fundamental problems of the origin and structure of the cell system and the problem of protoplasmic organization and differentiation are concerned. Such basic questions as the nature of the achromatic figure, the chromosomes and cytoplasm; or the problem of growth and self-duplication of vacuoles, mitochondria and chloroplasts; and the relationship between structure, function, and differentiation are beyond the scope of the Cytologist working with the optical microscope. Admittedly the use of phase contrast and ultraviolet microscopy will help, but here again the resolution is fixed as in the light microscope.

Ten–fifteen years ago Cytologists were faced with an unexciting future not unlike the outlook faced by the early Botanists before the advent of the light microscope. They could foresee only a tremendous field of comparative Cytology, and were without hope of tackling the fundamental problems of the nature of the cell. Fortunately, new techniques have been developed in the last few years which are likely to open new paths to the Cytologist as profitable as any that have been followed in the last three hundred years. In the Electron Microscope and the Cell Fractionation technique the Cytologist has tools which may prove more powerful and more penetrating than any he has had at his disposal in the past.

Cell Fractionation.

The Cell Fractionation technique provides a means for taking cells to pieces and of isolating the cell organelles. Cells are macerated by various means and the mass centrifuged at different speeds. The cell organelles separate according to their densities, so that relatively pure samples of nuclei, chloroplasts, mitochondria, and microsomes are obtained, while the supernatant contains many of the enzyme units of the less organized portions of the cytoplasm. Hence the Cytologist is in a position to study the function of the cell organelles described by the 19th century light microscopists. This is a tremendous advance towards an understanding of how the cell functions as an organized coordinated system. Already many exciting discoveries have been made, but I will discuss only a few relating to the function of the chloroplast.

Scientific interest in photosynthesis began with Stephen Hales (1677–1761), who in his "Vegetable Staticks" (1727) wrote: "Plants very probably draw through their leaves some part of their nourishment from the air and may not light also, by freely entering surfaces of leaves and flowers contribute much to ennobling the principles of vegetables." By the end of the 18th century, as the outcome of the researches of Priestley, Ingen-Houss, Senebier, and de Saussure the concept of photosynthesis as a decomposition of carbon dioxide by green leaves in light was established. Much later Sachs (1865) formulated the view that carbon assimilation was a property of the chloroplast in association with chlorophyll. Subsequent work added refinements and detail, such that the theory of photosynthesis and the role of the chloroplast as set out in text-books of Botany until about ten years ago, centred around carbon dioxide. The process was pictured as consisting of several steps which may be summarized as:

$$\text{Chloroplasts} + CO_2 + \text{light} \rightarrow \text{"reduced" } C + O_2 + \text{chloroplasts}$$
$$\text{"reduced" } C + H_2O \rightarrow CH_2O$$
$$6\ CH_2O \rightarrow \text{sugar} \rightarrow \text{starch}$$

The essential feature of the theory was a photochemical reaction directly involving carbon dioxide. This, as can be seen, is only a more exact way of describing the concept developed during the latter part of the 18th century.

That this theory must be incorrect followed from experiments with chloroplasts obtained by a Cell Fractionation technique. Hill (1937) showed that isolated chloroplasts could yield oxygen in the absence of carbon dioxide, indicating that the light reaction was probably concerned with water, not carbon dioxide.

Thus, as the consequence of a new technique, a concept of over 150 years standing has been proved wrong. It is not surprising that the last ten years has seen a rebirth of interest in the problem of photosynthesis and the chloroplast. Much of this interest has been concerned with the role of carbon dioxide. For a few years progress was disappointingly slow. Isolated chloroplasts could not be made to react with carbon dioxide even though they were quite active in photolysing water. So much so that many biochemists and botanists came to believe that the carbon dioxide reaction, or part of it, does not occur in the chloroplasts. In fact, a viewpoint that the chloroplasts were solely concerned with the light reaction, that is the photolysis of water, started to gain support. Only last year, however, Allen, Arnon, Capindale, Whatley and Durham (1955) were able to demonstrate a complete photosynthesis cycle in isolated chloroplasts. At the present moment it is believed that in the chloroplast light energy is absorbed by the chlorophyll and the energy activated system is used in the photolysis of water. Next carbon dioxide is incorporated and reduced by the product of the previous reaction. These steps can be visualized as:

1. Chloroplast + light $\rightarrow$ Activated Chloroplast
   activated chloroplast + $H_2O \rightarrow \frac{1}{2}\ O_2$ + H_2-chloroplast
2. H_2-Chloroplast + CO_2 + $H_2O \rightarrow CH_2O$ + H_2O + chloroplast
3. 6 $CH_2O \rightarrow$ Sugar $\rightarrow$ Starch

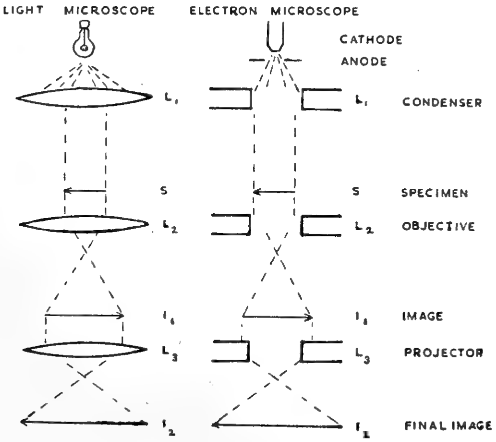
The behaviour of isolated chloroplasts (and also of mitochondria and microsomes) is giving the Cytologist a clearer picture of the cell organelles. The chloroplast must contain several multi-enzyme systems which are capable of carrying out a photosynthesis reaction independently of the cell. That is, the chloroplast appears to be a relatively autonomous unit, as had been postulated from time to time by Cytologists. Just how this concept is to be related to the Cell Theory, and how the cell maintains an environment suitable for the existence of the chloroplast is not clear. These are problems for the future. This much is clear, however, a complete understanding of the chloroplast in relation to the cell will not be reached without the Cell Fractionation technique.

Earlier it was pointed out that direct answers to many basic cytological problems are not possible because of the limitations of the light microscope. The problem of cell organization and the inter-relationships of structure and function are beyond the cytologist working with the light microscope. The development of the electron microscope with resolutions some hundred-fold greater than that of the best oil immersion objective may be the technique the Cytologist needs for tackling these fundamental questions. Already it has proved of considerable value in many different fields too numerous to mention here. However, the sorts of problems which are being solved by the electron microscope can be illustrated with reference to the structure and function of chloroplasts. Earlier I discussed the function of chloroplasts as determined by the Cell Fractionation technique. While the results obtained in this way have been spectacular, we are as yet completely ignorant of the way in which the chloroplast is capable of the complex series of reactions known as photosynthesis. This problem is an aspect of the general problem of the inter-relationship between structure and function at the molecular and submicroscopic level. Since the electron microscope is theoretically capable of resolving molecules, the means of investigating this fascinating field of function and structure at the molecular level are available. Before discussing some of the observations which have been made with this new technique a brief description of the instrument will not be out of place.

The Electron Microscope.

As pointed out by Abbé the only way of seeing beyond the limit imposed by the wave length of visible light is to use an illumination of a shorter wave length. Now electrons accelerated through a few thousand volts can be used as a kind of illumination. Under acceleration they have associated wave lengths which are nearly 100,000 times smaller than the wave lengths of visible light.

In structure the electron microscope is similar to the light microscope, but uses the flow of electrons instead of light rays. The similarity between the two can be appreciated from an examination of Text-figure 2.



Text-figure 2.

The path of the beam of electrons is controlled by means of electric and magnetic lenses which act on the electrons as glass lenses act on visible light. Each instrument uses a source of illumination and the image is formed by a condenser, objective and projective lens systems. Unlike the light microscope the final image is not viewed directly, but is formed on a fluorescent screen and subsequently photographed.

Some idea of the potentialities of the electron microscope can be appreciated from Table 1 which shows the relative dimensions of certain objects.

TABLE 1.

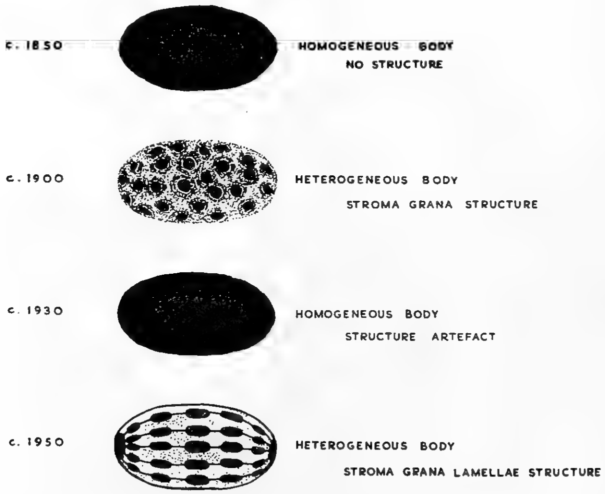
Object.	*Dimensions in Ångström Units (approximate).*		
Plant cell	1,000,000	Light Microscope	Electron Microscope
Chloroplast	50,000		
Typhoid bacillus	2,500		
Tobacco mosaic virus	400		
Hæmoglobin	70		
Egg albumen	40		
Amino acid molecule	7		
Carbon dioxide molecule	4		

Since the electron microscope is theoretically capable of "seeing" molecules, it must have tremendous possibilities for examining the structure of living matter. The impasse reached with the light microscope and the success of the electron microscope is shown by the development of our knowledge of the structure of the chloroplast.

The Structure of the Chloroplast.

The chloroplasts, which we have previously seen are the site of photosynthesis, occur in the cytoplasm of the cells of the green parts of plants. Excluding the algae, the chloroplasts of most plants are uniform in shape, being disc-like or flat ellipsoids. According to Möbius (1920), who examined more than 200 species, they range in size between 3μ and 10μ, with approximately 50 per cent. having a diameter of 5μ. In the higher plants the number per cell varies between 15 and 100 (Haberlandt, 1914). Algal chloroplasts are strikingly different in external form, being much larger, up to 100μ in length. They are extremely variable, ranging in shape from lobed, serrated, ribbon-like to latticed in different species.

This important organelle was first studied extensively by von Mohl (1851) although its presence in the cell had been noted earlier. Von Mohl showed conclusively that chlorophyll is contained only in chloroplasts. He concluded that the mass of the chloroplast consisted of protein compounds, since the residue remaining after extracting the chlorophyll with alcohol stained yellow with iodine. Later Pringsheim (1879) suggested this amorphous ground substance had a spongy structure with the chlorophyll dispersed as discrete droplets in the cavities of the sponge. Subsequently Meyer (1883) and Schimper (1885) termed the amorphous region "stroma" and chlorophyllous regions "grana". Tschirch (1884) argued that a skin or membrane must enclose the chloroplast otherwise they would coalesce in the cell or be damaged by cell acids. Long before this time Nägeli (1846) postulated a chloroplast membrane.



Text-figure 3.

At the turn of the century the concept of the chloroplast as a membrane-enclosed system of discontinuous grana embedded in a continuous stroma was firmly held (Text-figure 3). Then came a change of opinions and the concept of structure within the chloroplast fell into disrepute. It was argued that the structures observed in cell organelles were fixation artefacts. According to Liebaldt (1913), Guillermond, Mangenot and Plantefol (1933), Sharp (1934), the chloroplast in vivo consists of a homogeneous optically empty colloidal system, and the stroma-grana structure only develops after fixation or injury. (Text-figure 3.)

In 1932 Heitz revived the older concept of the chloroplast as a stroma-grana structure. Two comprehensive works by Heitz (1936) and Weier (1936) demonstrated grana in some hundreds of species. In addition Heitz showed that the grana are cylindrical, not spherical, in shape; and according to the species range in size from about 0·3μ to 2·0μ. A similar size range was reported by Baas-Becking and Hanson (1937). The number per chloroplast is variable ranging between 5 and 100. According to Heitz the grana propagate by division.

Following Metzner's work (1937) most investigators believed that all the chlorophyll of the chloroplasts is in the grana and none in the stroma. Unlike the chloroplasts of the higher plants, grana occur infrequently in algal chloroplasts. In the opinion of Weier (1938) and Beauverie (1938) these chloroplasts are always homogeneous.

In addition to reviving the older stroma-grana concept, Heitz (1936) suggested that the grana are not solid or homogeneous cylindrical bodies, but are composed of a layered structure. The idea that laminae occur in chloroplasts was also proposed by Menke (1938) and Menke and Koydl (1939) to explain the birefringence of algal chloroplasts. It should be pointed out that Heitz's proposal referred to the grana, whereas Menke's suggestion applied to chloroplasts which do not contain grana.

Support for the existence of laminae in grana-free chloroplasts was obtained by Menke who observed the way microtome slices of *Anthoceros* chloroplasts disintegrated in water. The slices disintegrated by the separation of layers or laminae. Menke believes that grana, in other chloroplasts, are regions of the laminae where the pigments become concentrated. This new point of view was strengthened by observations with ultraviolet light of slices of both grana-free and grana-stroma type of chloroplasts. The grana regions showed strong absorption which was taken to mean a localization of chlorophyll in these areas.

A further argument in favour of a lamellar structure was obtained by Strugger (1951) from investigations on the swelling of chloroplasts in water. Since swelling always occurs in a direction normal to the long axis, Strugger concluded the presence of lamellae oriented transverse to the long axis of the chloroplast. Both Heitz (1936) and Strugger (1951) claim that the individual grana in chloroplasts are arranged as a stack of coins. To account for the arrangement and the swelling properties of chloroplasts Strugger suggested that the grana are held in position by carrier lamellae as is illustrated in Text-figure 3.

More recently Mevuis and Düvel (1953) claim that the grana are not necessarily arranged in a pile, but the deeper ones may be displaced relative to the ones nearer the surface. This, however, does not alter the essential points of structure proposed by Strugger.

The changing views on chloroplast structure obtained by the light microscope are summarized in Text-figure 3.

Such is the position reached with light microscopy. It is a position which cannot be extended by further work with the light microscope, since all the controversial points of structure apparently lie beyond the resolutions of even the perfect light microscope.

Another line of work relating to structure within the chloroplast should also be mentioned. Hubert (1936), Frey-Wyssling (1937) and Baas-Becking and Hanson (1937) attempted to derive the molecular structure of the grana from certain physical properties such as fluorescence and birefringence of chloroplasts and chlorophyll solutions. From this work it was deduced that the grana-lamellae may consist of bimolecular films of lecithin and chlorophyll in association with films of protein. Although these earlier molecular schemes for structure are not stoichiometrically correct it is of some interest to note the electron microscope data of Hodge and McLean and Mercer (1955) show that lamellae have a compound three-layered structure (Plate iii, figs. 1, 2, 3).

Electron Microscope Studies.

The first electron microscope investigation of chloroplasts was reported by Kausche and Ruska (1940). Since then there have been numerous papers dealing with chloroplast structure. The earlier ones were concerned with the appearance of isolated chloroplasts and fragments after drying directly on the object slide. The interpretation of data obtained in this way is notoriously difficult. Kausche and Ruska noted that numerous thin lamellae of varying size can arise from a chloroplast. They considered these lamellae to correspond to the carrier lamellae postulated by Menke (1940) and Strugger (1951) from light microscope work. Later Algera *et al.* (1947) suggested the lamellae observed with the electron microscope might be breakdown products of phosphatidic composition, whereas Frey-Wyssling and Mühlethaler (1955) believe them to be myelin sheets formed from the stroma.

The electron microscope has confirmed the existence of grana in dried whole preparations of chloroplast. Granick and Porter (1947) found from 40 to 60 grana per chloroplast in tobacco. Each granum appeared as a dark, dense body, embedded in the matrix of the chloroplast. Later several investigators, Frey-Wyssling and Mühlethaler (1949), Frey-Wyssling and Steinmann (1953) and Leyon (1953), showed that the dense grana described by Granick and Porter (1947) are composed of lamellae in disc-like plates. Steinmann (1952) estimated about 30 lamellae, each 70 Å thick, per granum in *Aspidistra* chloroplasts, whereas Lyon found from 15 to 60 lamellae per granum in *Beta* and *Aspidistra*. By 1953 electron microscope data had shown definitely that grana consist of lamellae, but there was a divergence of opinion regarding the nature of the stroma and the carrier lamellae postulated by the light microscopists.

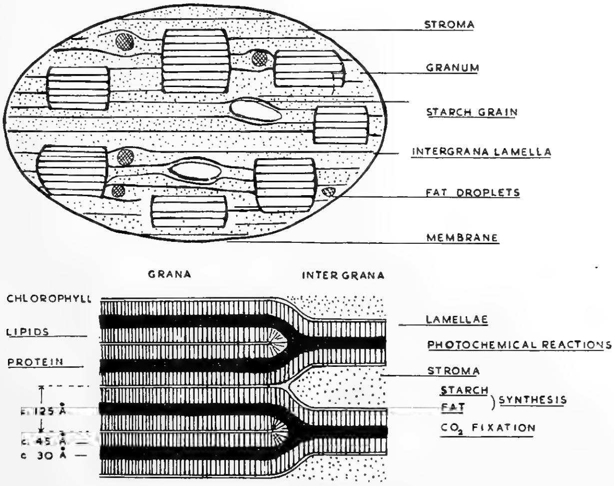
The most striking results obtained with the electron microscope followed the introduction of the ultra-thin sectioning technique. With a special microtome it is possible to cut sections only a few hundred Ångströms thick. Fixation, embedding and sectioning procedures are basically similar to those used in ordinary microtoming, except that plastic is used in place of paraffin. Using this technique Cohen and Bowler (1953), Leyon (1953), Finean, Sjöstrand and Steinmann (1953) and Palade (1953), demonstrated conclusively that both the grana and stroma regions of the chloroplast consist of alternating light and dark lamellae. In tobacco chloroplasts, according to Cohen and Bowler, the dark lamellae are *c.* 240 Å thick whereas the light lamellae are from 70 to 350 Å with an average of 110 Å. Steinmann (1952) reports a value of *c.* 70 Å for the dark lamellae in the grana of *Aspidistra* chloroplast. In a later paper Finean, Sjöstrand and Steinmann (1953) showed that the spacings of the lamellae, as obtained by the electron microscope, are of the same order as those obtained from X-ray diffraction studies of OsO_4 fixed chloroplasts.

It is clear that the electron microscope work makes some of the ideas on structure based on light microscope observations untenable. Carrier lamellae do not exist in the way envisaged by light microscopy, nor are they aggregated at the grana. According to Steinmann and Sjöstrand (1955) the carrier lamellae run continuously throughout the chloroplast with the grana arranged between them. Each elementary granum lamella is interpreted, on the basis of the swelling data of chloroplasts obtained by Frey-Wyssling and Steinmann (1953), as a closed bubble structure.

Electron microscope data described by Hodge, McLean and Mercer (1955, and unpublished) confirm the lamellar structure for both grana and stroma regions. These authors, however, reach a somewhat different conclusion for the structure of the grana type of chloroplast, at least in *Zea mays*. In this plant two types of chloroplast occur. Those in the mesophyll cells are of the grana type, whereas those in the parenchyma sheath are grana free (Plate i, fig. 2; Plate ii, fig. 1). Both types are enclosed by a conspicuous membrane. Both grana and stroma lamellae and the lamellae of the grana-free chloroplasts appear to have the same compound structure. Each lamella consists of a dense central region—the P-zone, *c.* 30 Å thick, surrounded by two less dense zones *c.* 45 Å thick, the L-zones which are bordered by the C-zones. The total thickness of the lamella is therefore *c.* 125 Å. For reasons which need not be given here it is believed the P-zone is protein, the L-zone mixed lipid and the C-zone chlorophyll (Plate iii, figs. 1, 2, 3).

In *Zea mays* chloroplasts, as the lamellae enter a grana region they bifurcate without any change of compound structure, to give, generally, twice the number of lamellae in the granum. This is distinct from the structure described by Finean, Sjöstrand and Steinmann and Mühlethaler who regard the stroma lamellae as distinct from the bubble-like granum lamellae, extending continuously throughout the plastid. Since there is no apparent difference between the stroma and grana lamellae in *Zea mays*, Hodge, McLean and Mercer suggest that the lamellae be referred to as grana and intergrana lamellae respectively and stroma be confined to the homogeneous matrix lying between the intergrana lamellae.

Text-figure 4 shows the structure of the chloroplast based on data by Hodge, McLean and Mercer. The bubble structure of the grana suggested by Finean, Sjöstrand and Steinmann (1955) is considered to be an artifact arising from an osmotic disorganization of the chloroplast during fixation. In a paper concerned with the swelling properties of chloroplasts, Mercer, Hodge, Hope and McLean (1955) showed that the osmotic swelling of *Nitella* chloroplasts in hypotonic solutions caused a disorganization of the lamellae which fused together to form vesicles. Incidentally it seems possible that the so-called "myelin sheets" observed by Frey-Wyssling and Mühlethaler (1949) could have formed in this way. A somewhat similar osmotic disorganization is observed in *Zea* chloroplasts. Swelling causes a disorganization of the lamellae system with vesicle formation in both grana and intergrana regions. At low degrees of swelling the lamellae tend to shear at the junction between the grana and intergrana regions, separating the lamellae of the grana into pairs, which with slight swelling would resemble a bubble structure. Plate i, figure 1, and Plate ii, figure 2 show the internal disorganization of chloroplasts isolated according to a procedure to give photosynthetically active chloroplasts.



Text-figure 4.

This is a suitable point to raise the controversial point of the chloroplast membrane which was first proposed by Nägeli in 1846. Subsequently its existence has been denied and confirmed many times both by light and electron microscopists. As recently as 1955 Frey-Wyssling was of the opinion that the chloroplast membrane is only a phase boundary. It seems likely from the studies on the swelling of chloroplasts described by Mercer, Hodge, Hope and McLean (1955) that some of the conflicting electron microscope observations on whole chloroplasts may be related to the extreme lability of chloroplast structure and the ease with which lamellae form membraneous structures. Disorganization of the lamellae may account for the membrane structures observed in many electron micrographs of specimens dried on the objective grid. Following the introduction of the thin sectioning technique a distinct membrane has been observed in several different species by Wolken and Palade (1953), Sager and Palade (1954) and Mercer, Hodge, Hope and McLean (1955). On the other hand Leyon (1953) and Frey-Wyssling (1955), also using thin sectioning, deny the existence of a membrane. Leyon considers the stroma to be continuous with the cytoplasm and concluded the boundary between the two is a "phase" boundary and not a true membrane. Recent observations by Hodge, McLean and Mercer, unpublished, indicate that these conflicting opinions may result from the different appearance of the membrane in young and old chloroplasts. In young developing chloroplasts of *Nitella* and *Zea mays* the membrane is particularly distinct. As the chloroplasts mature the membrane becomes indistinct, and at maturity, in *Zea mays*, it is extremely difficult to distinguish the membrane from the enclosing layer of cytoplasm, although under favourable circumstances it can always be recognized. Consequently there seems little justification for denying the existence of a chloroplast membrane because it is apparently absent in mature plastids.

Although existing knowledge is somewhat conflicting, the electron microscope has given a clearer picture of chloroplast structure than that obtained by the light microscope. It now seems that the mature chloroplast is surrounded by a differentially permeable membrane about 90 Å thick, enclosing upwards of 50-60 grana. Each granum is approximately cylindrical in shape, and approximately 4000 Å–7000 Å in diameter and 4000 Å–9000 Å in height, but extreme variability occurs within a single chloroplast. The grana consist of numerous highly oriented compound lamellae each approximately 125 Å thick, rather than a system of discrete discs. On leaving the grana, the grana lamellae fuse in pairs to give single intergrana lamellae which connect the grana one with another. The space between the intergrana lamellae is filled with a relatively homogeneous material—the stroma (Text-figure 4).

One point emerges clearly from this work, and that is, whatever the real structure of the chloroplast, the elucidation of this structure will not be solved by the light microscope, since the elementary structural units are beyond the limits of resolution of this instrument.

Structure and Function in the Chloroplast.

Earlier, some of the functional properties of the chloroplast, as determined by material isolated according to a cell fractionation technique, were outlined. One of the questions which emerged from this discussion was "What is the relationship between the function of the chloroplast and its structure?". Now that we have examined the structural aspects are we any nearer an answer?

The functional behaviour of isolated chloroplasts indicates that the photosynthetic system must be capable of carrying out three basic reactions: one concerned with the photolysis of water; a second concerned with the initial CO_2-fixation; and a third concerned with the interaction of reactions one and two. A fourth could be mentioned, the conversion of sugar to starch, since it frequently, but not invariably, occurs in a photosynthesizing system.

Comparatively little is known about the essential structures of a photosynthetic system. Fortunately in a Presidential Address it is permissible to speculate with a minimum of facts. It might be argued that since chloroplasts are not universally present in all photosynthetic organisms—they are absent from the blue-green algae for example—the chloroplast cannot be the basic photosynthetic unit. Nor can grana be the essential unit since these are not present in all chloroplasts, not occurring for example in the algae. It would appear that the only constant structural feature are the lamellae. Yet if the lamellae alone represented the photosynthetic system, one might expect isolated chloroplasts which contain numerous lamellae to be photosynthetically very active; whereas in practice it is extremely difficult to demonstrate complete photosynthesis in isolated chloroplasts, even though they retain the ability to photolyse water for many hours after isolation. Is it possible that during isolation the structure essential to CO_2-fixation is destroyed? Assuming this to be so, it is interesting to examine the structure of chloroplasts, isolated according to correct procedure for obtaining photosynthetically active chloroplasts. As seen from Plates i and ii, isolation caused considerable disorganization of the stroma and intergrana lamellae, but there is less change in the grana. It is tempting to suggest that CO_2-fixation is dependent upon the stroma region while the lamellae are the site of the photo-chemical reactions.

One can be rather more definite about the site of the sugar-starch reactions. Invariably, at least in the author's experience, starch does not form in the grana, but only in the stroma between the intergrana lamellae. At least this appears to be an example of a division of function within an organelle. There is a small amount of evidence, obtained by the Sydney group, which suggests that the chloroplast membrane is relatively permeable towards salts, glucose and water, at least when stretched. Its function would appear to be, in part, that of a mechanical barrier assisting in the maintenance of the structural orientation of lamellae and stroma. On the basis of these meagre observations the schema Text-figure 4 is proposed for the structure-function relationships of the chloroplast. One can be certain that future research will show that this schema is at least 99 per cent. incorrect. That is unimportant—what is important is that the future research will be dependent upon the new techniques of electron microscopy and cell fractionation.

The Origin of Chloroplasts.

Before concluding I would like to discuss another basic problem in cytology which may be answered by the electron microscope, but which certainly will never be answered by the light microscope. That is the problem of the origin of the microscopic organelles of the plant cell (Text-figure 1). Since this Address has been concerned primarily with chloroplasts the point can be made by considering the problem of the origin of these bodies.

Meyer (1883) and Schimper (1885) established the theory of the continuity of the chloroplast. According to this theory chloroplasts never arise *de novo*, but always by the division of preexisting chloroplasts. In other words, they are self-duplicating systems. There is strong evidence for chloroplast division in the Algae and Bryophyta where a partition of the chloroplast between daughter cells can be followed as the cell divides. This type of division may not be a true division process, but rather a pinching apart resulting from the division of the cell.

After the discovery of chondriosomes in plant cells the "sui generis" theory was rejected. Guillermond and others (1941) believed the chondriosomes to be of two types: Those which give rise to chloroplasts and those which give rise to mitochondria. Assuming this to be so, there remains the problem of the origin of the chondriosomes. Do they arise by the division of preexisting chondriosomes or do they arise *de novo* from the cytoplasm?

Clear demonstration of the continuity of the chloroplasts has been described in both liverworts and mosses (Kaja, 1954). In *Anthoceros,* for example, the cells of the thallus contain a single chloroplast which can be observed to divide during cell division. Similarly the egg contains a single plastid but none are present in the sperm. After fertilization the zygote contains only a single chloroplast from which all the plastids of the organism are derived.

In the Pteridophyta, also, direct evidence for the continuity of the chloroplast is found. As shown by Stewart (1948) for *Isoetes*, chloroplast division precedes nuclear division during cell division. The plastid becomes elongated, divides, and the daughter plastids pass to the daughter cells.

Direct evidence for self-duplication and continuity of the chloroplast in the Gymnosperms and Angiosperms has not been obtained. No organelles identifiable as plastids have been observed in the meristematic cells. It is assumed that a precursor, to which the name proplastid is given, occurs. Although in more mature vegetative cells Reinhard (1933) observed chloroplasts dividing in *Fuchsia* and *Sedum.* Each division required from 1 to 2 days for completion. Also Dangeard (1947) describes chloroplast division in *Elodea canedensis.*

Apart from the direct evidence for the origin of chloroplasts in the Algae, Bryophyta and Pteridophyta, where they may be observed to divide, the continuity of theory is supported by genetical evidence. Transmission of the chloroplast is through the cytoplasm of one parent only, and the inheritance follows a non-Mendelian pattern. For example in *Mirabilis jalapa* var. *albomaculata* Correns (1908) described the maternal inheritance of plastids. Some plants have all green branches, others have white leaves and plastids devoid of chlorophyll and white flowers. If female green is crossed with male white all progeny are green plants, whereas if female white is crossed with male green the progeny are all white plants: a result which supports the view that the chloroplasts are self-duplicating units inherited via the cytoplasm of the egg. Another observation which supports the self-duplication theory is to be seen in the transmission of chloroplasts in *Euglena.* According to Lwoff and Dusi (1935) when *Euglena mesnili* is cultivated in the dark, the number of chloroplasts per individual decreases with each generation of cells. Gradually the number of chloroplasts per cell decreases until after about fifteen months many cells contain only one or two chloroplasts. Finally cells are obtained which contain no chloroplasts.

Thereafter such individuals are incapable of giving rise to chloroplast-containing individuals, even in the light. The most reasonable explanation is that self-duplication of the chloroplasts occurs more slowly than cell division, leading to a plastid-deficient organism.

Recent work with the light microscope (Heitz and Maly, 1933, and Strugger, 1954) strongly supports the idea of chloroplast duplication by division. The products of the binary fission of the chloroplast are believed to go to the daughter cells. Strugger extends the ideas of binary fission to the grana. He believes that during rapid cell division the proplastid is reduced to its simplest unit, consisting of one primary granum embedded in stroma. In other words, the granum as well as the chloroplast is a self-duplicating unit. From this elementary unit other chloroplasts are derived by division, and the grana within the chloroplast are assumed to arise also by division. Furthermore, Strugger believes that new grana arise by lamellae slipping from the primary granum, and then multiplying by surface division.

These views are not entirely accepted by Heitz and Maly (1953), who found the fluorescence of young chloroplasts to be homogeneous. They argued from this that the differentiation into stroma and grana occurs later, and there is no such unit as the primary granum. Although direct evidence for the self duplication of chloroplasts would appear to be established for the lower plants, the position is not clear for the higher plants. In these plants the important stages in the duplication process are apparently beyond the resolution of the light microscope.

As yet only a few electron microscope observations have been made, but these are sufficient to show that the problem can never be solved by the light microscope. Leyon (1953) has shown that Strugger's ideas do not apply to the development of grana in *Aspidistra.* In these chloroplasts a few isolated lamellae are the first ultra-structures to be seen in the proplastid. In a later paper (1954) he was able to show that the lamellae apparently arise from a "crystalline" body within the proplastid. Unpublished data of Hodge, McLean and Mercer show that grana differentiate at an early stage in the development of the chloroplast, and at a stage when the chloroplast could not be resolved by the light microscope. Also in chloroplasts of etiolated plants recovering in the light, grana differentiate independently of each other from the prolamellar body, and do not arise by the division of pre-existing grana. The greater part of chloroplasts from etiolated plants consists of a non-organized material, which has been termed the prolamellar body by Hodge, McLean and Mercer. Plate iii, figure 3, shows several grana initials in a chloroplast after exposure to light for ten hours, that is the grana can arise *de novo* from the prolamellar body.

Another interesting observation by Hodge, McLean and Mercer, unpublished, is that in meristematic cells of *Zea mays* it is not possible to distinguish between protoplastids, mitochondria and chondriosomes (Plate iv, figures 1 and 2). The only organelle present resembles a vesicle—a conspicuous membrane enclosing a more or less empty space. At a later stage both proplastids and mitochondria can be identified. Whether this vesicular unit represents an elementary self-duplicating unit is not known. Nor is it certain whether this unit is the precursor of all cell organelles. That is, are the mitochondria, microsomes and chloroplasts derived from the same elementary unit, as was postulated by Lewitzky (1910) and Guillermond (1932)?

Thus the problem of the origin of the chloroplast in the Angiosperms, which has puzzled Cytologists for a century, and which had apparently been resolved, is still partly an open question. Probably the most significant conclusion to be reached from the electron microscope work is that the important steps in the origin and development of the cell organelles in the Angiosperm cell occurs before these units are microscopically visible. Consequently, it is problematical whether arguments based on light microscope data have any real value. The answer will be found with the electron microscope.

Conclusions.

Many interesting parallels can be drawn between the electron microscope and the light microscope. Both came into being at a period when the advancement of knowledge was being prevented by the limits imposed by the sense of vision. In the sixteenth century the limit was that of the unaided eye, whereas today the limit is that imposed by the optics of the light microscope. The light microscope overcame the impasse imposed by the eye, and extended the sense of vision a thousandfold into the realms of cells and cell organelles; while the electron microscope removes the impasse imposed by the light microscope and extends the sense of vision by another thousandfold into the realms of molecules, which form the cell and cell organelles.

As with the early period in the development of the light microscope, the development of the electron microscope has followed a somewhat similar pattern. Neither instrument was of immediate and systematic use to the biologist, although the lag interval has been only a matter of years with the electron microscope, since we are living in an age where scientific value of an instrument is recognized almost immediately. Also initially both instruments were limited to those few gifted people with the skills needed to design and maintain them efficiently. Later, following the appearance of the commercial manufacturers, good light and electron microscopes gradually became freely available. As far as the electron microscope is concerned it is still a comparatively rare instrument. In Australia, for example, there are less than ten, and only one can be regarded as a really good instrument. This situation must be very similar to that in England when Robert Hooke had the only good compound microscope.

At the present time the electron microscopists' technique is far from perfect, but the development of better techniques is in progress. Many of the problems facing the electron microscopists are reminiscent of those met and solved by the light microscopist. One believes the problems will be solved, and gradually the resolution of the electron microscope will approach its theoretical limits, as did the resolution of the light microscope. Concurrently with these developments on the electron optics side, developments are proceeding on the biological side. The problems of fixation, mounting and artifact are yet to be solved. Existing techniques on the biological side are probably as crude as those used by the light microscopists before the cover slip and liquid mounts were introduced.

Several, and indeed the most interesting, comparisons between the two microscopes cannot be drawn since the basis for comparison lies in the future. Will the electron microscope become as essential to the biologist as the light microscope, and will it advance knowledge to as great an extent? My feeling is that the answer to both questions will be yes. I shall be very surprised if any really well-equipped research laboratory of the future is without one or two electron microscopes. For me to suggest that the electron microscope will influence biological thought to the same extent as did the light microscope may be rather surprising to you, for the light microscope has been the most powerful technique ever used by the biologist. Above all else, it provided the experimental data which made possible the concept of the cell as the fundamental unit of life, and the doctrine of the cellular organization of the organism. With the probable exception of the Theory of Evolution, the Cell Theory is the most significant and important concept in Biology. Since the electron microscope is theoretically capable of "seeing" at the molecular level, new concepts about the structure of living matter are likely to emerge.

The last few years have seen the development of the Cell Fractionation and Electron Microscope Techniques. Together, they provide a means far more penetrating than any yet used for studying the nature of living matter and the organization and function of the cell.

In a sketchy way I have attempted in this Address to show how the two techniques provide a means of investigating the origin, structure and function of the cell organelles. Possibly out of this type of approach a new theory of the cell will emerge: a theory in terms of the behaviour of molecules and submicroscopic structure, which will be as fundamental as the Cell Theory formulated by the light microscopists. Cytology, far from settling down to a sterile future, is about to emerge into a future with horizons as distant and exciting as those which were uncovered by the invention of the light microscope.

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EXPLANATION OF PLATES I-IV.

Plate i.

1. Portion of transverse section of mesophyll chloroplast isolated in 0·3 M glucose solution. Note disorganization of the intergrana lamellae, and the swelling and distortion of the grana.
2. Transverse section of chloroplast in mesophyll cell of four-week-old maize leaf, showing grana (G.), intergrana lamellae (I.L.), stroma (S.), and fat droplets (F.). Chloroplast membrane indistinct.

Plate ii.

1. Transverse section of chloroplast from starch sheath cell. Note absence of grana and presence of lamellae (L.), stroma (S.), and starch grains (S.G.).
2. Portion of starch sheath chloroplast isolated in 0·5 M glucose, shows disorganization of the lamellae.

Plate iii.

1. Portion of starch sheath chloroplast from four-week-old leaf, showing compound structure of lamellae. Central dense line (P zone) enclosed by two less dense layers (L zones). The latter are bordered by thin dense lines (C zones). × 260,000.
2. Granum from a mesophyll chloroplast, showing relationship between the grana and intergrana lamellae, and the compound nature of the grana lamellae.
3. Origin of grana (G.) in chloroplast of etiolated leaf 20 hours after exposure to light. × 210,000.

Plate iv.

1. Organelles in cells of leaf primordia of *Zea mays.*
2. Differentiation of organelles in cell of leaf primordia. Organelles of two types—chloroplast (C.) and mitochondria (M.). Nucleus (N.) and nucleolus (Nu.) also present.

The Honorary Treasurer, Dr. A. B. Walkom, presented the Balance Sheets for the year ended 29th February, 1956, duly signed by the Auditor, Mr. S. J. Rayment, F.C.A. (Aust.), and his motion that they be received and adopted was carried unanimously.

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

President: S. J. Copland, M.Sc.

Members of Council: R. H. Anderson, B.Sc.Agr.; A. J. Bearup, B.Sc.; A. N. Colefax, B.Sc.; J. W. Evans, M.A., D.Sc., Sc.D.; Dorothy A. Thorp, B.Sc.; T. G. Vallance, B.Sc., Ph.D.; and Professor J. M. Vincent, D.Sc.Agr., Dip.Bact.

Auditor: S. J. Rayment, F.C.A. (Aust.).

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

LINNEAN SOCIETY OF NEW SOUTH WALES.

GENERAL ACCOUNT. Balance Sheet at 29th February, 1956.

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				11,783	11	4
Accumulated Funds				31,783	11	4
Bookbinding Account	1,153	18	1			
Income Account	690	13	8			
Suspense	51	3	10			
Current Liabilities				1,895	15	7
				£33,679	6	11

ASSETS.

	£	s.	d.	£	s.	d.
Fixed Assets—						
Commonwealth Loans, at cost	15,048	10	0			
Debentures:						
Metropolitan Water, Sewerage and Drainage Board, at cost	3,194	7	6			
Science House (one-third share), at cost	14,835	4	4			
				33,078	1	10
Current Assets—						
Cash in hand	10	0	0			
Commercial Banking Company of Sydney, Ltd.	591	5	1			
				601	5	1
				£33,679	6	11

INCOME ACCOUNT. Year Ended 29th February, 1956.

	£	s.	d.	£	s.	d.
To Salary				629	3	4
,, Printing Proceedings	537	0	0			
,, Printing Reprints	337	14	0			
,, Blocks	155	5	0			
				1,029	19	0
,, Insurance				19	9	0
,, Postage	61	7	4			
,, Petty Cash	32	10	11			
				93	18	3
,, Audit	16	16	0			
,, Printing and Stationery	116	17	8			
,, Expenses	36	3	10			
,, Cleaning	40	7	6			
,, Bank Expenses	3	0	3			
,, Library	41	7	7			
,, Printing Colour Postcards	106	17	6			
				361	10	4
,, Transfer to Bookbinding Account ..				392	9	5
,, Transfer to Contingencies Reserve				1,000	0	0
,, Balance to 1956–57				690	13	8
				£4,217	3	0

	£	s.	d.	£	s.	d.
By Balance from 1954–55				875	7	2
,, Subscriptions: 1955–56	378	0	0			
Arrears	21	0	0			
In advance	21	0	0			
Associate		10	0			
				420	10	0
,, Entrance Fees				15	15	0
,, Interest				565	5	1
,, Science House				1,083	13	4
,, Sales				552	9	5
,, N.S.W. Government Grant				100	0	0
,, Fellowships Account (surplus income at 29th February, 1956, transferred)				343	15	2
,, Bank Expenses				5	13	0
,, Sale of Reprints				243	16	10
,, Postcard Sales				10	18	0
				£4,217	3	0

AUDITOR'S REPORT TO MEMBERS.

I have examined the books of account and vouchers of the Linnean Society of New South Wales for the year ended 29th February, 1956, and certify that the above Balance Sheet and accompanying Income Account are correct and in accordance therewith, and in my opinion present the true state of the Society's affairs at 29th February, 1956, as shown by the books. Certificates of the investments have been inspected.

S. J. Rayment, Chartered Accountant (Aust.),
Auditor.

Sydney, 12th March, 1956.

A. B. Walkom,
Hon. Treasurer.

1st March, 1956.

LINNEAN SOCIETY OF NEW SOUTH WALES.

LINNEAN MACLEAY FELLOWSHIPS ACCOUNT.

Balance Sheet at 29th February, 1956.

LIABILITIES.	£	s.	d.
Accumulated Funds			
Amount bequeathed by Sir William Macleay	35,000	0	0
Surplus Income Capitalized	20,126	17	10
	£55,126	17	10

ASSETS.	£	s.	d.	£	s.	d.
Fixed Assets						
Commonwealth Loans, at cost ..	30,450	0	0			
Debentures:						
Metropolitan Water, Sewerage and Drainage Board, at cost	16,306	14	9			
Rural Bank of N.S.W., at cost ..	2,172	15	0			
Loan on Mortgage	6,035	0	0			
				54,964	9	9
Current Assets.						
Commercial Banking Company of Sydney, Ltd.	157	19	8			
Commonwealth Savings Bank ..	4	8	5			
				162	8	1
				£55,126	17	10

INCOME ACCOUNT. Year Ended 29th February, 1956.

	£	s.	d.
To Salaries of Linnean Macleay Fellows	1,458	6	8
„ Research and Field Expenses ..	111	17	1
„ Balance, being Surplus Income transferred to General Account	343	15	2
„ Capital Account	29	16	3
	£1,943	15	2

	£	s.	d.
By Interest	1,943	15	2
	£1,943	15	2

AUDITOR'S REPORT TO MEMBERS.

I have examined the books of account and vouchers of the Linnean Society of New South Wales for the year ended 29th February, 1956, and certify that the above Balance Sheet and accompanying Income Account are correct and in accordance therewith, and in my opinion present the true state of the Society's affairs at 29th February, 1956, as shown by the books. Certificates of the investments have been inspected.

S. J. Rayment, Chartered Accountant (Aust.),
Auditor.

Sydney, 12th March, 1956.

A. B. Walkom,
Hon. Treasurer.

1st March, 1956.

LINNEAN SOCIETY OF NEW SOUTH WALES.

BACTERIOLOGY ACCOUNT.

Balance Sheet at 29th February, 1956.

LIABILITIES.	£	s.	d.	£	s.	d.
Accumulated Funds.						
Amount bequeathed by Sir William Macleay	12,000	0	0			
Accumulated Income Capitalized	6,120	0	0			
Research Fund	10	0	0			
				18,130	0	0
Income Account at 29th February, 1956	696	0	9			
Commercial Banking Company of Sydney, Ltd.	1,067	12	4			
Ramsgate Property Maintenance Account	80	0	0			
				1,843	13	1
				£19,973	13	1

ASSETS.	£	s.	d.	£	s.	d.
Fixed Assets.						
Commonwealth Loans, at cost	15,320	0	0			
Debentures:						
Metropolitan Water, Sewerage and Drainage Board, at cost	800	0	0			
				16,120	0	0
Freehold Property, at cost				3,850	0	0
Current Assets.						
Commonwealth Savings Bank				3	13	1
				£19,973	13	1

INCOME ACCOUNT. Year Ended 29th February, 1956.

	£	s.	d.	£	s.	d.
To Salary and Allowance				549	7	8
„ Insurance					16	11
„ Ramsgate Property:						
Insurance	5	12	6			
Rates	23	10	4			
Transfer to Maintenance Account	80	0	0			
				109	2	10
„ Balance to 1956–57				696	0	9
				£1,355	8	2

	£	s.	d.
By Balance from 1954–55	613	5	1
„ Interest	503	16	5
„ Rent	238	6	8
	£1,355	8	2

AUDITOR'S REPORT TO MEMBERS.

I have examined the books of account and vouchers of the Linnean Society of New South Wales for the year ended 29th February, 1956, and certify that the above Balance Sheet and accompanying Income Account are correct and in accordance therewith, and in my opinion present the true state of the Society's affairs at 29th February, 1956, as shown by the books. Certificates of the investments have been inspected.

S. J. Rayment, Chartered Accountant (Aust.),
Auditor.

Sydney, 12th March, 1956.

A. B. Walkom,
Hon. Treasurer.

1st March, 1956.

AUSTRALIAN FUNGI.

III. NEW SPECIES AND REVISIONS (CONTINUED).

By C. G. HANSFORD, M.A., Sc.D., F.L.S., Waite Institute, University of Adelaide.

[Read 28th March, 1956.]

Synopsis.

The present paper is a continuation of No. ii of this series, and includes revisions of many Australian Fungi found as type specimens in Herb. Kew. It includes 88 recognized species, of which 27 are described as new, and one new genus, *Brooksia*.

ASCOMYCETES.

(184) MELIOLA DORYPHORAE Hansf., n. sp. (2111.6332)

Plagulae epiphyllae, raro amphigenae, usque ad 3 mm. diam., densae, velutinae. Hyphae subrectae vel undulatae, cellulis 20–30μ × 7–8μ, opposite ramosae, dense reticulatae et subsolidae. Hyphopodia capitata alternata, antrorsa vel repentia, recta vel curvula, 30–44μ longa; cellula basali cylindracea vel cuneata, 7–17μ longa; cellula apicali irregulariter fortiterque lobata, recta vel curvata, versiformia, 20–30μ × 14–23μ. Hyphopodia mucronata illis capitatis commixta, ampullacea, alternata, pauca. Setae myceliales numerosae, dispersae, erectae, rectae, simplices, acutae, usque ad 400μ × 7–8μ. Perithecia in centro plagularum laxe aggregata, atra, globosa, verrucosa, usque ad 220μ diam. Sporae atrobrunneae, cylindraceae vel subellipsoideae, obtusae, 3-septatae, constrictae, 59–68μ × 22–24μ.

Hab. in foliis *Doryphorae sassafratis*, Mt. Mitchell, Queensland, Langdon 579, typus.

Colonies mostly epiphyllous, to 3 mm. diam., dense, velvety. Mycelium of substraight to undulate, dark brown hyphae, cells 20–30μ × 7–8μ, branching opposite at wide angles, densely reticulate and nearly solid. Capitate hyphopodia alternate, antrorse or spreading, straight or bent, 30–44μ long; stalk cell cylindric to cuneate, straight or antrorse-bent, 7–17μ long; head cell very irregularly and deeply lobate, straight or bent, versiform, 20–30μ × 14–23μ. Mucronate hyphopodia mixed with the capitate, alternate, ampulliform, few. Mycelial setae numerous, closely scattered, erect, straight, simple, acute, to 400μ × 7–8μ. Perithecia in loose central group, black, globose, verrucose, to 220μ diam. Spores cylindric to subellipsoid, obtuse, 3-septate, constricted, 59–68μ × 22–24μ.

(185) CHAETOTHYRIUM WOMERSLEYI Hansf., n. sp.

Plagulae epiphyllae, aegre perspicues, effusae. Mycelium ex hyphis hyalinis, cellulis 8–20μ × 2–4μ, irregulariter denseque ramosis, pelliculam hyalinam unistratosam efformantibus, omnino superficiale. Setae nullae. Perithecia dispersa, brunnea vel atro-brunnea, levia, subdiscoidea vel depresso-globosa, membranacea, usque ad 250μ diam. et 80μ–100μ alt.; paries 1–2-stratosus, hyalinus, tenuus. Asci suberecti, saccati, sursum late rotundati, haud incrassati, breviter nodoso-stipitati vel subsessili, 8-spori, aparaphysati, usque ad 80μ × 40μ. Sporae parallelae, cylindraceae utrinque rotundatae, hyalinae, plerumque curvulae, transverse 9–14-septatae, haud constrictae, 50–65μ × 6–7μ.

Hab. in foliis *Syzygii* spec., Lae, New Guinea, Womersley (typus WARI 4591 p.p.).

Colonies epiphyllous, scarcely visible save for the very loosely scattered perithecia, effuse, spreading. Mycelium of hyaline hyphae 2–4μ thick, the cells 8–20μ long, closely and irregularly branched and forming a thin transparent pellicle of one layer, easily removed from the leaf, entirely superficial. Around the perithecia the pellicle becomes pale brownish, deepening to dark brown as it covers the perithecia. Setae and conidia none. Perithecia scattered, dark brown to black-brown, smooth, subdiscoid to flattened globose, thin-walled, covered by the mycelial pellicle adherent to the upper part of the wall, to 250μ diam. and about 80–100μ high when fresh; wall of 1–2 layers of hyaline parenchyma, very delicate, enclosing at first a ground tissue of hyaline, branched, thin-walled hyphae, which are partly replaced by the developing asci. Asci fairly numerous, suberect from the flat base of the loculus, saccate, broadly rounded at the apex, not thickened, suddenly constricted below into a short wide stipe, or subsessile, 8-spored, aparaphysate, up to 80μ × 40μ. Spores parallel in ascus, cylindric with slightly attenuate, rounded ends, usually more or less bent, transversely 9–14-septate, not constricted, hyaline, refringent, 50–65μ × 6–7μ.

(186) ARNAUDIELLA BANCROFTII Hansf., n. sp.

Mycelium liberum nullum; thyriothecia dispersa, singula vel 2–3-aggregata, amphigenea, atra, orbiculata, depresso-conica, membranacea, usque ad 200μ diam., non fimbriata; paries superior ex hyphis atrobrunneis, irregulariter radiantibus, 4–5μ cr., ramosissimis compositus, radiato-dehiscens; paries inferior hyalinus, ex hyphis tenuibus, non radiantibus compositus. Asci aparaphysati, subglobosi, erecti, 8-spori, sessili, 30–40μ × 20–30μ, tenuiter tunicati, in maturitate elongati. Sporae parallelae, fusoideae utrinque rotundatae, curvatae, leves, 1-septatae, subinde leniter constrictae, brunnescentes, 18–20μ × 6–7μ.

Hab. in foliis *Eucalypti* spec. indet., Eidsvold, Queensland, T. L. Bancroft 3, Aug. 1913, in Herb. Kew, typus.

Free mycelium absent. Thyriothecia closely scattered, single or in small groups on indeterminate brownish areas of leaf, amphigenous, black, more or less rounded when single, depressed conical, membranous, to 200μ diam., not or very slightly fimbriate at margin; upper wall of irregularly radiating dark brown hyphae 4–5μ thick, much branched, dehiscent by irregular radiate fissures nearly to the margin. Lower wall hyaline, of fine hyphae, not radiate. The loculus of the young thyriothecium is at first filled with a loose hyaline tissue of more or less erect hyphae, similar to those of the lower wall, and connected with both upper and lower walls, septate, simulating paraphyses. The asci are scattered singly amongst this "ground tissue", which they gradually replace almost completely; at first clavate-ellipsoid, becoming subglobose as the spores develop, erect, sessile, 8-spored, 30–40μ × 20–30μ, thin-walled, again elongating at maturity. Spores more or less parallel in ascus, bent fusoid with rounded ends, becoming pale clear brown, smooth, thin-walled, 1-septate and sometimes slightly constricted in the middle, the cells equal, 18–20μ × 6–7μ. No true paraphyses.

The stomata of the host leaf are filled with dark mycelial plugs, which do not penetrate beyond the closed guard cells. Beneath the thyriothecia and extending radially from them there is a very thin plate of subcuticular hyaline mycelium, without haustoria in the epidermal cells.

(187) ASTERINA CORREICOLA Cooke & Mass., *Grevillea*, 16:5, 1886; Cooke, *Handb. Austr. Fungi*, p. 344, 1892.

Colonies epiphyllous, black, rounded, smooth, to 2 mm. diam., usually numerous and confluent, at first thin, becoming dense, and with development of thyriothecia almost solid in centre. Hyphae substraight, cells mostly 15–20μ × 5–7μ, closely and irregularly branched, reticulate. Hyphopodia alternate, rarely opposite, continuous, ellipsoid entire or slightly crenulate around margin, 10–14μ × 7–10μ. Thyriothecia closely crowded and often confluent, black, flattened-conical, radiate; margin not fimbriate; to 200μ diam., dehiscent by radiate fissures almost to the margin; lower wall hyaline, of indistinct structure, very thin. Asci numerous, aparaphysate, subglobose, sessile, 8-spored, to 50μ × 40μ. Spores conglobate, becoming dark brown, oblong with rounded obtuse ends, epispore smooth, 1-septate and rather deeply constricted in the middle, the cells equal and subglobose; 23–26μ × 10–13μ.

On *Correa laurenciana*, Upper Yarra, Victoria, J. G. Luehmann in Herb. Kew, type.

(188) ASTERINA EUPOMATIAE (P. Henn.) Theiss., *Abhandl. K.-K. Zool.-Bot. Ges., Wien*, 7:64, 1913.

On *Eupomatia laurina*, Cunningham's Gap, South Queensland, Langdon 1611.

Colonies amphigenous, to 5 mm. diam. or confluent, thin or becoming dense in centre. Mycelium of substraight, radiating, dark brown hyphae, cells 20–30μ × 4–5μ, branching opposite or irregular at acute angles, becoming rather closely reticulate in centre. Hyphopodia alternate or opposite, more or less antrorse, straight or bent, 2-celled, 9–15μ long; stalk cell cylindric, 3–6μ long; head cell subentire to sinuous or irregularly lobate, straight or variously curved, 5–11μ × 5–11μ. Thyriothecia rather closely scattered in centre of colony, black, rounded in outline, flattened-convex, radiate; upper wall of radiating dark brown hyphae 4–5μ wide, the cells 4–12μ long, fimbriate at the margin, the fringing hyphae tortuous-radiating, up to 30μ long; dehiscent by a few stellate fissures almost to the margin, into triangular segments; lower wall hyaline, very thin, composed of tortuous-radiating hyphae, very indistinct. Asci about 10, ripening in succession, globose to ovate, sessile, aparaphysate, 4–8-spored, 40–45μ diam. Spores long remaining hyaline, finally turning dark brown, oblong with rounded ends, smooth, 22–24μ × 10–12μ, 1-septate, constricted, the upper cell slightly wider than the lower. No conidial stage seen.

(189) ASTERINA PLATYSTOMA Cooke & Mass., *Grevillea*, 23:8, 1892; Cooke, *Handb. Austr. Fungi*, p. 314, 1892.

On leaves of *Castanospermum* sp., Brisbane, Queensland, Bailey 804, type in Herb. Kew.

Colonies epiphyllous, black, smooth, to 3 mm. diam. or numerous and confluent. Mycelium of substraight dark brown hyphae 4–5μ thick, the cells mostly 8–15μ long, irregularly and closely branched, becoming closely reticulate and almost solid in the centre with the development of the thyriothecia. Thyriothecia round, flattened-conic, black, up to 180μ diam., usually separate but closely contiguous in the older colonies, radiate, not fimbriate at the margin; lower wall indistinct; dehiscent by a few radial slits into wide segments. Asci numerous, maturing in succession, ovate, becoming elongate ellipsoid, widely rounded at apex, subsessile, 8-spored. Spores conglobate, or 2–3-seriate in elongated asci, becoming brown, smooth, 1-septate, oblong with rounded ends; constricted, 19–24μ × 9–11μ, the upper cell slightly wider than the lower.

Hyphopodia alternate, continuous, hemispheric, entire, 6–8μ diam., usually one to each cell of mycelial hyphae.

(190) ASTERINA SPONIAE Rac., *Paras. Algen u. Pilze Java's*, 3:34, 1900. = *Asteromella epitrema* Cooke, *Grevillea*, 20:6, 1892.

On *Trema aspera*, Queensland, Bailey 902 in Herb. Kew as type of *Asteromella epitrema* Cooke, which is the conidial stage.

Colonies epiphyllous, black, orbicular, dense, to 2 mm. diam., closely scattered and often confluent. Mycelium of crooked brown hyphae 3·5–5μ thick, the cells 25–30μ long, branching opposite or irregular, rather closely reticulate with wavy meshes. Hyphopodia alternate or unilateral, sessile, continuous, pulvinate, expanded above and rounded-angulose to sublobate, 8–10μ high by 5–12μ broad. Thyriothecia closely crowded in centre of colony, black, convex, rounded, to 100μ diam., often connate into irregular compound ascomata; lower wall hyaline, indistinct; upper wall of dark brown radiating hyphae 4μ thick with cells up to 7μ long, not fimbriate at margin, dehiscent by stellate fissures extending almost to the margin and the central parts falling away to expose the asci. Asci up to about 10, ripening in succession, aparaphysate, ovate to subglobose, sessile, 8-spored, about 45μ × 40μ. Spores conglobate, brown, oblong with rounded ends, 1-septate, constricted, smooth, 22–24μ × 10–12μ.

Pycnothecia similar to thyriothecia; lower wall radiate, subhyaline; pycnospores ovate to piriform, rounded at apex, slightly attenuate to truncate basal hilum, uniformly dark brown, smooth, continuous, 10–12μ × 6–9μ.

This species appears to occur throughout the range of its host plants, species of *Trema*, and has been recorded on *T. cannabina* in New South Wales.

(191) ENGLERULELLA HOMALANTHI Hansf., n. sp.

Plagulae amphigenae, tenues, leves, griseo-brunneae, usque ad 10 mm. diam., saepe confluentes. Mycelium ex hyphis sinuosis, dilute brunneis, opposite vel irregulariter ramosis, laxe sinuoso-reticulatis compositum, cellulis plerumque 25–30μ longis. Hyphopodia alternata vel unilateralia, hemiglobosa, integra, continua, 10–14μ diam., brunnea. Pycnidia in mycelio laxe dispersa, circa 60μ diam., subglobosa denum late aperta et sub-cupulata, brunnea, glabra, levia; paries unistratosus, parenchymaticus. Pycnosporae dilutissime brunneae, ellipsoideae utrinque obtusae, continuae, leves, plerumque 8μ × 4·5μ.

Perithecia inter pycnidiis dispersa, subglobosa, apice leniter papillata, atro-brunnea, levia, glabra, usque ad 80μ diam. et ad 120μ alt.; paries unistratosus, brunneus, parenchymaticus, cellulis angulosis, circa 10μ diam.; poro apicali dehiscentia. Asci 8–12, basali, haud fasciculati, ellipsoidei, tenuiter tunicati, subsessili, 8-spori, usque ad 65μ × 12–14μ, aparaphysati. Sporae brunnescentes, obclavatae utrinque obtusae, 1-septatae, leniter constrictae, leves, 13–14μ × 6–7μ, cellula superiore subglobosa, inferiore leniter longiore, deorsum attenuata.

Hab. in foliis *Homalanthi populifolii*, Queensland, Bailey 923 in Herb. Kew sub *Asteromella homalanthi* Cooke & Mass.

(192) MICROTHYRIUM AMYGDALINUM Cooke & Mass., *Grevillea*, 19:91, 1892; Cooke, *Handb. Austr. Fungi*, p. 312, 1892.

Type on *Eucalyptus amygdalinus* var. *linearis*, Spencer Gulf, South Australia, 1891, W. Gill, in Herb. Kew.

Thyriothecia loosely scattered, amphigenous, single or two to three confluent, rounded, black, smooth, flattened conical, when single 180–200μ diam., not fimbriate at margin; upper wall of subopaque dark brown radiating hyphae, dehiscent at first by an irregular central pore, extending outwards by a few radial fissures; lower wall hyaline, very thin, of indistinct structure. Asci numerous, aparaphysate, bent ellipsoid, centripetally arranged, thin-walled but definitely bitunicate; rounded at apex, sessile or subsessile, 8-spored, 50–60μ × 15–20μ when mature. Spores multiseriate and more or less parallel in the ascus, hyaline, fusoid with rounded ends, smooth, thin-walled, 1-septate and very slightly or not constricted in the middle, the cells equal; becoming pale brown after discharge and then measuring 16–18μ × 6–7μ, inside the ascus only about 5μ wide.

There is no trace of a superficial mycelium.

(193) VIZELLA GOMPHISPORA (B. & Br.) Hughes, Mycol. Paper, IMI, London 50:97, 1953.

On leaf of *Trochocarpon laurina*, McPherson Range, South Queensland, Langdon 407.

(194) CALYCULOSPHAERIA COLLAPSA (Romell) Fitzpatrick, *Mycologia*, 15:52, 1923.

On bark, Tasmania, Rodway 499 in Herb. Kew.

(195) CRYPTOVALSA ELEVATA (Berk.) Sacc., *Syll. Fung.*, 1:191, 1882.

On dead wood (? *Eucalyptus* sp.), Swan R., Western Australia, Drummond 225 in Herb. Kew.

The grooves of the wood, and to some extent the ridges also, are covered with a thin black, discontinuous stroma, in which the mouths of the perithecia occur closely scattered, scarcely elevated above the general level and marked only by the smooth round area pierced by a central pore, smooth, not sulcate. Perithecia completely immersed in the wood, closely scattered or in longitudinal close groups, ampulliform with rather short neck, the body up to 800μ diam., globose, thinly carbonous; the neck of rather thicker and harder black tissue, with hyaline lining to the central pore. Asci very numerous, produced over most of the inner surface of the locule, apparently not exuding intact but discharging their spores within the loculus, clavate with short pedicel, each containing 16 spores. Spores distinctly yellow-brown when fully mature, darker in mass, allantoid, continuous, smooth, 13–16μ × 4·5–5·5μ.

(196) DIDYMELLA ERUMPENS (Cooke) Hansf., n. comb.

= *Zignoella erumpens* Cooke, *Grevillea*, 21:36. = *Conisphaeria* (*Zignaria*) *erumpens* Cooke, *Handb. Austr. Fungi*, p. 307, 1892.

On twigs of unknown host, Victoria, Martin 948 in Herb. Kew, mixed with *Heptameria obesa* (Dur. & Mont.) Sacc., of which Cooke described the perithecia as belonging to *Z. erumpens*.

Perithecia immersed in bark, with only the slightly rounded, shining, black upper surface showing, scarcely projecting, smooth, glabrous, with central round pore, flattened-globose, to 280μ diam.; wall membranous, not carbonaceous nor brittle, parenchymatous, composed of dark brown angular cells 8–16μ × 6–7μ, sometimes in indefinite radiating series. Asci basal, numerous, erect, clavate-cylindric, rounded and very slightly thickened at the apex when young, short-stipitate, 8-spored, up to 90μ × 10–14μ. Paraphyses numerous, filiform, simple, hyaline, somewhat exceeding the asci. Spores obliquely 1–2-seriate, hyaline, ellipsoid with rounded ends, 1-septate and very slightly constricted in middle, smooth, 14–19μ × 5–6·5μ.

(197) EUDIMERIOLUM NEOLITSEAE Hansf., n. sp.

Plagulae hypophyllae, brunneae, usque ad 15 mm. diam. Mycelium superficialum ex hyphis tortuosis, ramosis, exhyphopodiatibus, 3–4μ crassis (cellulis circa 10μ longis), compositum, in stomatibus folii penetrans. Perithecia laxe gregaria, atrobrunnea, subglobosa, glabra, membranacea, 50–60μ diam., sessilia, sursum attenuato-rotundata et apice perforata; paries parenchymaticus, verisimiliter unistratosus. Asci 3–5, basali, ellipsoidei vel subsaccati, aparaphysati, 8-spori, apice rotundati, leniter incrassati, sessili, 35–45μ × 12–15μ. Sporae multi-seriatae, subparallelae, hyalinae, oblongae utrinque rotundatae, 1-septatae, haud constrictae, leves, 13–16μ × 3·5–4μ, cellulis aequalibus.

Hab. in foliis *Neolitseae dealbatae*, Cunningham's Gap, Queensland, Langdon 1622 (typus); in foliis *Cinnamomi oliveri*, loc. cit., Langdon 1610.

Colonies hypophyllous, dark brown, to 15 mm. diam., causing a brownish leafspot visible on the upper surface; consisting of many small groups of minute perithecia borne upon a dark brown external mycelium of crooked, closely branched, exhyphopodiate hyphae, the cells about 10μ × 3–4μ. These groups of perithecia with their superficial mycelium are 100–300μ diam., though often confluent and larger, each consisting of 2 to about 10 perithecia. The external mycelium is connected through the host stomata to a hyaline intercellular mycelium, without haustoria, in the mesophyll. Perithecia dark brown, subglobose, glabrous, membranous, 50–60μ diam. and 50–70μ high, sessile on the mycelium, the apex rounded-attenuate and with indistinct central pore; wall parenchymatous, apparently of a single layer of angular small cells, enclosing at first a hyaline loosely fibrous tissue, which disappears as the asci mature. Asci 3–5, basal, ellipsoid to subsaccate, aparaphysate, 8-spored, rounded and slightly thickened at apex, sessile, 35–45μ × 12–15μ, ripening in succession. Spores multiseriate and parallel in ascus, hyaline, oblong with rounded ends, 1-septate, not constricted, smooth, 13–16μ × 3·5–4μ, the cells equal. No conidial stage seen.

(198) MASSARIA AUSTRALIS Cooke, *Grevillea*, 13:65, 1885; Cooke, *Handb. Austr. Fungi*, p. 308, 1892.

Type on bark, Melbourne, 365 in Herb. Kew (? leg. Campbell).

Perithecia scattered loosely, immersed with erumpent black ostiole, which is often flattened laterally like *Lophiostoma*, but usually does not protrude, or only very slightly, from the bark; perithecial body entirely immersed in the rotten wood underlying, and there thinly membranous, black, up to 280μ diam., the wall closing in above through the bark and there hard and carbonous, brittle. Asci basal, numerous, clavate-cylindric, 8-spored; paraphyses narrow filiform, simple. Spores 1–3-seriate and overlapping, soon becoming dark brown, bent fusoid with obtuse ends, 1-septate and constricted in middle, the cells equal, smooth, 45–50μ × 15–18μ.

(199) PHYLLACHORA LANGDONII Hansf., n. sp.

Perithecia dispersa, singula vel 2-aggregata, amphigena, plerumque epiphylla, punctiformia, circa 400μ diam., atra, leniter elevata (usque ad 150μ), immersa; paries tenuis, subhyalinus, concentrice fibrosus, sursum clypeo epidermali adnatus. Asci basali, cylindracei vel clavulati, apice rotundati, breviter stipitati, 8-spori, usque ad 140μ × 17μ; paraphyses numerosae, ascos aequantes, filiformes, septatae, simplices. Sporae 1–2-seriatae, hyalinae, ellipsoideae, leves, continuae, 18–23μ × 7–8μ.

Hab. in foliis *Callistemonis* spec., Kilcoy Creek, Queensland, Langdon 1412.

Perithecia scattered singly, rarely in groups of 2, loosely or closely over the leaf, amphigenous but not opposite, mainly epiphyllous, appearing as black, round, shining dots about 400μ diam. In section they show as elevated (to 150μ above surface), depressed-globose loculi, about 400μ diam. and 250μ high, resting on a flat base and replacing the palisade tissue, opening by an apical pore lined with short periphyses; wall at sides and base very thin, and passing outwards into loose mycelial hyphae intercellular in the mesophyll. Epidermal clypeus only above the perithecium, up to 60μ thick, composed of opaque black-brown cells and covered by the host cuticle, adnate with the upper part of the perithecial wall. Asci mainly basal, cylindric to clavulate, rounded but not thickened at the apex, attenuate below into short narrow stipe, 8-spored, up to 140μ × 17μ. Spores 1–2-seriate, sometimes oblique, but usually parallel and overlapping, hyaline, continuous, narrow ellipsoid, smooth, 18–23μ × 7–8μ. Paraphyses numerous, equalling the asci, filiform, 1·5–2·5μ wide, definitely septate, simple, not swollen at apex. The perithecia are not on leafspots, nor surrounded by yellow zones.

(200) PHYLLACHORA QUEENSLANDICA Hansf., n. sp.

Stromata laxe dispersa, atra, nitida, epiphylla, usque ad 1·5 mm. diam., leniter convexa, crassitudinem totam folii occupantia, in utramque epidermidem clypeum efformantia. Perithecia usque ad 8 in stromate uno, depresso-globosa, usque ad 400μ diam. et ad 300μ alt.; paries subhyalinus, concentrice fibrosus. Asci numerosi, basali, clavulato-cylindracei, apice attenuato-rotundati, haud incrassati, subsessili vel breviter stipitati, 8-spori, usque ad 170μ × 30μ; paraphyses paucae, filiformes. Sporae oblique 2-seriatae, ellipsoideae, obtusae, hyalinae, continuae, leves, 28–32μ × 9–12μ, episporio circa 1μ cr., extus muco inclusae.

Hab. in foliis *Litseae dealbatae*, Mt. Budarin, Queensland, C. T. White, 1912, typus in Herb. Kew.

Stromata loosely scattered, at first on the unchanged leaf, but where loosely aggregated the leaf dying and turning brown over a wide area, after each stroma has become surrounded by a yellow-brown zone. Stromata black, shining, somewhat convex and rounded above the individual perithecia, up to 1·5 mm. diam., epiphyllous; on lower surface marked by grey-black, rather indefinite areas beneath the leaf tomentum, slightly convex; occupying the whole thickness of the leaf, and with a clypeus in both upper and lower epidermis, extending into the mesophyll as an opaque black-brown stroma about 60μ thick below and to 90μ thick on upper side, the intervening leaf tissue being more or less unchanged save immediately around the perithecia, but penetrated by subhyaline or hyaline intercellular hyphae, which are septate and extend much beyond the stromata.

Perithecia up to about 8 in single stromata, flattened-globose, the loculus up to 400μ diam. and to 300μ high, surrounded by a subhyaline wall of concentric fibrous tissue, passing internally into the subhymenial loose tissue below, and into a rather thick layer of parallel periphyses above, which extend to the round apical pore, from which in some cases they protrude in young stages. The perithecia are separated by stroma tissue, consisting of more or less parallel, brown, septate hyphae. Asci with a few hyaline filiform paraphyses, doubtfully septate, at first exceeding the asci, but at full maturity the asci almost aparaphysate; large, clavulate-cylindric, attenuate-rounded and not markedly thickened at the apex, at the base attenuate into a short wide stalk, or sometimes subsessile, thin-walled, 8-spored, to 170μ × 30μ. Spores obliquely 2-seriate and overlapping, ellipsoid, obtuse, hyaline, smooth, continuous, 28–32μ × 9–12μ, the spore wall about 1μ thick, and surrounded by a mucilaginous envelope up to 5–6μ thick.

(201) **Placostroma eucalypti** (Cooke & Mass.) Hansf., n. comb.

= *Phyllachora eucalypti* Cooke & Massee, *Grevillea*, 16:5, 1887.

Type on leaf of *Eucalyptus* sp., Bunyip, Victoria, March 1887 (? Martin).

Stromata epiphyllous, black, smooth, almost hemispheric, with some indication of the underlying perithecia as rounded swellings with minute central pores on the surface; up to 2 mm. diam., shining. In section the stromata are seen to develop between the palisade tissue, unaltered save for penetration by loose intercellular hyaline hyphae causing a little browning of some cells, and the epidermis, which is filled with the clypeus of black, opaque parenchyma; the mature stroma remains covered by the cuticle and the upper half of the epidermis, forming the shining exterior surface, penetrated only by the apical pores of the perithecia. Within the leaf, and between the perithecia, the stroma is up to 300μ thick, composed of brown-black parenchyma, often arranged in vertical series, but in other parts inordinate, passing above into the clypeus, which at the edge of the stroma is up to 60μ thick, but thickened above the perithecia to 140μ. Perithecia resting upon the palisade tissue, with only a thin brown stroma-line below them, each with a hyaline wall of concentrically fibrous, compressed tissue 10μ thick, which around the base of the ostiole becomes a mass of loose hyaline filiform periphyses. Asci basal, erect, wide clavate, narrowed below into a very short stipe, widely rounded above, mostly 4-spored, up to 60μ × 28μ. Spores parallel and overlapping, hyaline, ellipsoid with obtuse ends, slightly clavate, the upper half wider than the lower, smooth, 1-septate near the base, not constricted, 35–45μ × 8–10μ, the lower cell 9–18μ long. No paraphyses. Perithecia to 450μ diam. and 170μ high.

(202) **Rosellinia inspersa** Berk., *Hooker's Lond. Journ. Bot.* 1845, p. 299; Cooke, *Handb. Austr. Fungi*, p. 306, 1892.

Type on wood of *Eucalyptus* sp., Swan R., Western Australia, Drummond 215; also, loc. cit., Drummond 212 p.p., in Herb. Kew.

Perithecia closely scattered or subaggregate, erumpent-superficial, subglobose, black, mostly 300–350μ diam. and high, glabrous, with slightly truncate-conoid ostiole pierced by a minute round pore; surface appearing very slightly rough, not smooth and shining, due to rounded surface cells. Wall brittle, carbonaceous, parenchymatous, of several layers of dark brown angular cells. Asci basal, numerous, cylindric with rounded apex, usually straight, with slightly attenuate, rather short stipe, 8-spored, 100–150μ × 10–12μ. Paraphyses filiform, equalling the asci, doubtfully septate. Spores obliquely 1-seriate or straight, sometimes overlapping, soon turning dark brown, ellipsoid, somewhat flattened on one side, smooth, continuous, 14–16μ × 8–9μ × 6–7μ, with elongate germination slit on one face.

(203) **Sporormia megalospora** Auersw., *Hedwigia*, 7:68, 1868.

Perithecia scattered, sub-immersed to erumpent, globose to ovoid, 300–350μ diam., black, rather fleshy, glabrous, with short conoid ostiole. Asci widely clavate to elongate ellipsoid, rounded at apex, very shortly stipitate, 180–210μ × 30–40μ; paraphyses long, filiform, loosely branched, guttulate. Spores 8, sub-parallel, imbricate, 2–4-seriate, cylindric, straight or slightly bent, widely rounded at apex, slightly attenuate-rounded at base, fuscous-black, subopaque, 62–80μ × 16–18μ, 3-septate, strongly constricted and the cells easily falling apart; central cells sub-cylindric, 16–20μ long, the end cells slightly longer.

On Kangaroo dung, Keith, J. S. Hawker, WARI 4608, mixed with *Poronia punctata*.

(204) **Thaxteria archeri** (Berk.) Hansf., n. comb.

= *Sphaeria archeri* Berk., in Hooker, *Flora Tasmaniae*, 2:280, 1860. = *Zignoella archeri* (Berk.) Sacc., *Syll. Fung.*, 2:217. = *Gibberidea archeri* (Berk.) Cooke, *Handb. Austr. Fungi*, p. 304, 1892. = *Coelosphaeria leptosporoides* Wint., *Hedwigia*, 22:2, 1883. = *Leptospora spermoides* (Hoffm.) Fuckel, var. *rugulosa* Rick., *Ann. Mycol. Berl.*, 3:17, 1905. = *Nitschkia rugulosa* (Rick) Hoehnel, *Sitzb. K. Akad. Wien*, 123:59, 1914. = *Leptosporella leptosporoides* (Wint.) Hoehnel, *Ann. Mycol. Berl.*, 16:105, 1918. = *Thaxteria leptosporoides* (Wint.) Fitzpatrick, *Mycologia*, 15:60, 1923.

Type on bark, Tasmania, Archer in Herb. Kew.

Perithecia closely gregarious, superficial, arising singly from the extension upwards of a very thin, black stroma on and in the bark, the stroma often reduced to a few flexuous dark brown septate hyphae, without spines. Perithecia short-stalked, sometimes the stalks partly confluent below; 500–800μ diam., up to 1 mm. high, black, shining, coarsely tuberculate, the warts up to 50μ diam. and high, composed of cells of the stroma, becoming brownish when old; the perithecia at first subglobose, soon collapsing and becoming cupulate with a distinct papillate central ostiole. The stalk and outer (stroma) wall of the ascoma are composed of dark brown, rather thick-walled cells 8–25μ × 6–10μ, in the outer and lower parts often in longitudinal series, internally rather loosely arranged beneath the true perithecium, which is entirely embedded within the stroma; around the loculus the stroma-wall is 30–100μ thick. The true perithecial wall is hyaline, or faintly coloured on the outside, composed of compressed, concentrically fibrous, thin-walled tissue, 10–15μ thick at the base, up to 30μ thick above the loculus, pierced in the centre of the upper part by a minute round pore, lined with the ends of the wall fibres. Asci basal, erect, clavate, attenuate below into a narrow empty stipe, rounded and slightly thickened at the apex, 8-spored, 75–90μ × 14–20μ, aparaphysate. Spores parallel, 2–3-seriate and overlapping, slightly bent cylindric, ends obtuse rounded, long remaining hyaline and continuous, then 1-septate in middle, finally 3-septate and dark brown, smooth, not constricted at the septa, 20–30μ × 5·5–7μ.

(205) TREMATOSPHAERIA CONGESTA (Cooke) Berlese & Voglino, *Sacc. Syll. Fung.*, Addit. p. 150.

= *Psilosphaeria congesta* Cooke, *Grevillea*, 11:149, 1883; Cooke, *Handb. Austr. Fungi*, p. 307, 1892. = *Cucurbitaria* (*Melanomma*) *plagia* Cooke & Massee, *Grevillea*, 17:8, 1889; Cooke, *Handb. Austr. Fungi*, p. 304, 1892.

Type on wood, Twofold Bay, NSW, leg. Tyrone White, in Herb. Kew.

Perithecia densely crowded in linear groups emergent through the bark, finally laterally and longitudinally confluent over large areas, black, smooth, with slightly conoid ostiole pierced by a round pore; perithecia often stalked and are subglobose swellings at the end of each stalk, the latter arising from a common thin black stroma on the surface of the wood, or this stroma almost completely absent; other perithecia are sessile and then globose. Wall and stalk, where present, continuous, hard, brittle, carbonaceous, of several layers of subopaque parenchyma, enclosing a single globose loculus. Asci basal, cylindric with rounded and thickened (–5μ) apex, shortly stipitate or subsessile, 8-spored, up to 160μ × 20μ. Spores 2–3-seriate and overlapping, slightly bent fusoid, ends obtuse, uniformly clear brown, smooth, thin-walled, 1–3–(5)-septate, often very slightly constricted at middle septum, 32–39μ × 8–10μ. Paraphyses linear, simple, hyaline, equalling the asci, 1–2μ thick.

The host and the fungus are identical with the type specimen of *Cucurbitaria* (*Melanomma*) *plagia* Cooke & Massee, on stems of *Cassinia aculeata*, Port Philip, Victoria 1888; also Mt. Blackwood, Victoria, Mueller, 1891.

(206) GIBBERELLA PASSIFLORAE Cooke & Mass., *Grevillea*, 16:5, 1888; Cooke, *Handb. Austr. Fungi*, p. 283, 1892.

Type on dead twigs of *Passiflora edulis*, Brisbane, Bailey 535 in Herb. Kew.

Perithecia erumpent to superficial on a very thin stroma of hyphae forming *Fusarium* conidia, single or in close groups of about 6, appearing black, covering long lengths of the dead twigs of the host (mixed with *Diplodia* sp. and other fungi), globose to collapsing when dry, smooth, very slightly papillate at apex, 200–300μ diam. and high; wall dark blue-purple, composed of 2–3 layers of angular parenchyma, the cells compressed, 12–15μ diam. on the outside, the whole wall firmly membranous in texture; the round apical ostiole slightly paler and lined with short hyaline periphyses, the pore about 20μ diam. Asci basal, aparaphysate, numerous, cylindric to slightly clavulate, thin-walled, rounded at the apex, attenuate below into a short empty stipe, 4–6–8-spored, up to 80μ × 15μ. Spores 1–2-seriate and overlapping, broadly ovate with rounded ends, hyaline, smooth, 1-septate, not constricted, 10–14μ × 6–7·5μ. No 3-septate spores were found.

(207) Melanospora caprina (Fr.), Sacc., *Syll. Fung.*, 2:462, 1883.

On wood and chips, Tasmania, Archer, in Herb. Kew.

Perithecia scattered or aggregated in close groups, globose, brownish with white mealy surface, up to 1 mm. diam., with elongate ostiole to 2 mm. long by 150–180μ diam. in the middle, attenuate to rounded apex, dark brown, under the microscope golden-brown. Wall of perithecium thick, tough and hard, brittle when dry, 25–35μ thick around the body, composed of an outer layer of yellow, angular parenchyma, the cells 10–20μ diam., with rather thick side walls; the inner layers hyaline, compressed, of smaller cells. The ostiole is formed of agglutinate parallel hyphae, with a narrow central canal. The surface of the body is covered with loose hyphae, adpressed to the wall, and in the upper part in places loosely agglutinate as scattered, erect spicules. Asci basal, numerous, aparaphysate, clavate, 8-spored, thin-walled, narrowed below into a delicate stalk, up to 80μ × 18μ. Spores inordinate, ellipsoid to citriform, continuous, the ends slightly attenuate-rounded and with a small round pale spot on each, connected by a longitudinal pale slit on one side, the remainder of the spore wall uniformly dark brown, smooth; spores 12–20μ × 6–11μ.

(208) Ophionectria larvaespora (Cooke & Massee) Hansf., n. comb.

= *Lasiosphaeria larvaespora* Cooke & Massee, *Grevillea*, 19:83, 1891; Cooke, *Handb. Austr. Fungi*, p. 305, 1892; Berlese, *Icon. Fung.*, 1:119; Von Hoehnel, *Fragm. z. Mykol.*, 844.

Type on bark, socio scale insects and mosses, Mt. Macedon, Victoria, Martin 566 in Herb. Kew.

Perithecia scattered irregularly or sometimes in small groups, often seated on a bright yellow, loose mycelium, which extends up the perithecial wall almost to the apex as loose, flexuous, hyaline, interwoven, septate hyphae attached to the wall cells; perithecia without a stroma, globose, to 500μ diam., appearing bright lemon-yellow; the inner wall smooth and yellow-brown; ostiole almost flat, perforate by minute pore. Asci numerous, basal, cylindric, widely rounded and thickened at the apex when young, to 10μ, 8-spored, up to 250μ × 25μ. Paraphyses numerous, filiform, hyaline, 1μ thick, exceeding the asci, doubtfully septate and branched. Spores parallel and overlapping, hyaline, fusoid with obtuse ends, straight, up to 170μ × 9–11μ, transversely 15–17-septate, not constricted, the wall about 1μ thick, smooth, not breaking up into part-spores. Perithecial wall prosenchymatous, of several layers of angular, subhyaline thick-walled cells 8–10μ diam., lined with smaller and thin-walled parenchyma, the whole wall about 40μ thick.

(209) Pachysacca eucalypti Syd., *Ann. Myc. Berl.*, 28:435, 1930.

The type collection was made by G. Samuel on *Eucalyptus rostrata*, Noarlunga, South Australia, in Jan. 1924; additional specimens are WARI 3847 on the same host, Horsnall's Gully, South Australia, 8.1929, G. Samuel; on *E. odorata*, Kersbrook, S. Australia, Oct. 1933, WARI 3831; on *E. obliqua*, Millicent, S. Australia, WARI 3833; Balhannah, WARI 3836.

The collection on *E. odorata* appears macroscopically very different from the type, the leafspots being prominently dendritic and extending for 10 mm. or more, the branches about 0·5 mm wide. WARI 3847, however, is somewhat intermediate in appearance, as are the collections on *E. obliqua*.

Associated with this on *E. odorata* in WARI 3831 is a pycnidial fungus differing considerably from *Phomachora eucalypti* Syd., which is regarded as the true conidial stage of the *Pachysacca*.

SPILOMYCES DENDRITICA Hansf., n. sp.

Pycnidia immersa, in stromatibus *Pachysaccae eucalypti* dispersa, depresse globosa, usque ad 180μ diam. et 150μ alt., glabra, membranacea, nigra; paries pluristratosus, extus atrobrunneus, intus hyalinus, parenchymaticus. Sporophora stipata, vix distinguenda. Pycnosporae singulae, terminaliae in sterigmatibus elongatis (–10μ × 1μ), ovatae, primo hyalinae, brunnescentes, continuae, leves, 8–9μ × 3·5–4μ; sterigma persistens.

Hab. in foliis *Eucalypti odoratae*, Kersbrook, South Australia, 10.1933, WARI 3831.

The pycnidia occur scattered amongst the perithecia of *Pachysacca eucalypti* Syd., embedded within the stroma of the latter, and opening on its surface by a minute pore; black, globose to more or less flattened, up to 180μ diam. and to 150μ high; the wall of several outer layers of dark brown parenchyma, enclosing other hyaline, thin-walled layers, the innermost being sporiferous without differentiated sporophores. The conidia are borne singly at the ends of long sterigmata, which form a close palisade lining the loculus, and which remain attached to the shed spores as hyaline "tails" up to 10μ long by 1μ thick; the conidia themselves are ovate with rounded ends, at first hyaline, soon becoming dark brown, continuous, smooth, 8–9μ × 3·5–4μ, 1–3-guttulate within.

The other collections of *Pachysacca eucalypti* enumerated above have not been found to contain this pycnidial fungus, so that it is possible that it is a hyper-parasite.

(210) SYSTREMMA GLOBULOSA (Cooke & Massee) Hansf., n. comb.

= *Dothidea* (*Coccodea*) *globulosa* Cooke & Massee, *Grevillea*, 17:42, 1889; Cooke, *Handb. Austr. Fungi*, p. 299, 1892. = *Darwiniella globulosa* (Cooke & Mass.) Sacc., *Syll. Fung.*, 9:1049. = *Phragmodothella globulosa* (Cooke & Mass.) Theiss. & Syd., *Ann. Mycol. Berl.*, 13:343, 1915.

On *Drimys aromatica*, in Herb. Kew, type; without locality or collector.

Stromata hypophyllous, scattered, usually only one or two per leaf, hemispheric to subglobose, black, dull, finely tuberculate; developing beneath the epidermis, and then the leaf tissue growing out to form the inner stroma tissue like a gall, finally bursting the epidermis; 1–2 mm. diam. and high. In section the stromata consist of the rather small-celled outer layers, opaque black, parenchymatous, gradually passing inside into brown, subtranslucent tissue of large angular dark brown parenchyma; towards the base this stroma tissue breaks up into brown, to subhyaline or hyaline hyphae between the hypertrophied leaf tissue.

Loculi completely buried in the outer tissues of the stroma in a single layer (like *Hypoxylon*), elliptic, 150–170μ high, 100–150μ diam., opening to the surface by a small round pore lined with periphyses. Asci basal, somewhat fasciculate from a basal mass of hyaline parenchyma, at first replacing the delicate hyaline "ground parenchyma" of the loculus, of which traces often remain above the immature asci; erect, cylindric-clavate, rather thick-walled and thickened around the rounded apex, 8-spored, aparaphysate, 75–85μ × 12–15μ. Spores 2-seriate and often overlapping, long remaining hyaline, finally becoming dark brown, even before discharge, smooth, ellipsoid, the ends obtuse, 1-septate and often slightly constricted below the middle, usually straight, 19–22μ × 5–6μ, the upper cell 12–15μ long and slightly wider than the lower, which is 6–8μ long.

There is no separate perithecial wall; the loculus is at first filled with hyaline parenchyma, passing into the stroma tissue outside; the asci develop at the base of the loculus and grow upwards at the expense of the ground tissue; finally the apex opens lysigenously.

(211) BROOKSIA Hansf., n. gen. (*Pseudosphaeriales*).

Perithecia dispersa, stipitata, terminalia vel lateralia, singula, in hyphis mycelii evoluta, turbinata vel subglobosa, brunnea, glabra; paries perithecii unistratosus, parenchymaticus, apice late aperta. Asci aparaphysati, pauci, basali, saccati, 8-spori. Sporae cylindraceae vel fusoideae, subrectae, obtusae, dilute brunneae, leves, transverse 3-septatae. Fungi foliicoli, saprophytici; mycelium laxum, brunneum, superficialum, exhyphopodiatum.

Brooksia tropicalis Hansf., n. sp.

Mycelium hypophyllum, brunneum, irregulariter ramosum, laxe reticulatum, effusum; hyphis septatis, cellulis plerumque 20–30μ × 5–7μ, levibus vel indistincte minuteque hexagonaliter areolatis. Hyphae erectae laxe dispersae, brunneae, subrectae, septatae, usque ad 2 mm. alt., simplices, 8–10μ crassae, sursum attenuatae, obtusae, interdum conidiiferae. Conidia lateralia, pauca, singula vel subopposita, helicoidea, brunnea, simplicia, obtusa, multiseptata, usque ad 500μ × 7–10μ, cellulis circa 20μ longis, ad septa non constrictis, extus hexagonaliter areolatis, verruculosis. (*Helicosporium hendrickxii* Hansf.)

Perithecia laxe dispersa, stipitata, usque ad 250μ alt., turbinata vel subglobosa, atrobrunnea, levia, stipite 70–150μ × 7–10μ, transverse septata, hyphis erectis mycelii consimile; perithecia singula, terminalia vel raro lateralia, 80–110μ × 80μ, sursum truncata et in maturitate circa 50μ diam., basi attenuato-rotundata; paries parenchymaticus, unistratosus, ex cellulis 8–10μ diam., angulosis compositus. Asci 3–8, basali, aparaphysati, saccati, sessili, apice attenuato-rotundati et ad 3μ incrassati, 8-spori, usque ad 80μ × 40μ. Sporae parallelae vel inordinatae, fusoideae utrinque obtusae, rectae vel curvulae, transverse 3-septatae, medio non vel leniter constrictae, leves, 35–44μ × 9–11μ, in maturitate dilute brunneae.

Hab. in foliis *Syzygii* sp. indet., Lae, New Guinea, J. S. Womersley (WARI 4592, type)—in foliis *Dialii guineensis*, Gold Coast, Hughes (IMI 42152)—in foliis *Calophylli inophylli*, Sierra Leone, Deighton (IMI 45414-b)—in foliis *Sorindeiae juglandifoliae*, *loc. cit.*, Deighton (IMI 53375), (IMI 56453)—in foliis *Taraktogenodis kurzii*, *loc. cit.*, Deighton (IMI 51721)—in foliis *Parinarii excelsae*, *loc. cit.*, Deighton (IMI 8928)—in foliis *Cnestidis corniculatae*, *loc. cit.*, Deighton (IMI 57443)—in foliis *Wallichiae distichae*, *loc. cit.*, Deighton (IMI 6956-a)—in foliis *Homalii africani*, *loc. cit.*, Deighton (IMI 56748)—in foliis *Raphiae villosae*, *loc. cit.*, Deighton (IMI 51894)—in foliis *Uapacae guineensis*, *loc. cit.*, Deighton (IMI 8697-b).

The mycelium ramifies loosely over the lower surface of the host leaf and is completely superficial, bearing no relation to the stomata; there appears to be no penetration of the host and the fungus appears to be completely saprophytic; it is often mixed with *Grallomyces portoricensis* Stev. but is not connected with this. The hyphae are straight or sinuous, pale brown, smooth or indistinctly and minutely hexagonal-areolate, septate, loosely and irregularly branched, the cells 20–30μ × 5–7μ. From this repent mycelium arise at irregular intervals single, rarely in twos or threes in close proximity, erect straight, simple branches, up to 2 mm. long by 8–10μ thick, darker brown, and prominently marked on the surface with raised hexagonal areolae 1–3μ diam., the edges of these areolae dark brown, giving a rough appearance; these erect hyphae are septate, not normally constricted, at intervals of 20–30μ. In some colonies these erect hyphae bear lateral conidia about half-way up, either single or in a loose group of 2–5, each conidium on a short lateral sterigma about 10μ × 5μ, usually single but occasionally two opposite from the same parent cell of the "conidiophore". Conidia single and terminal on the sterigma, long cylindric, obtuse, pale to dark brown, simple, up to 500μ × 7–10μ, septate into cells about 20μ long, not constricted at the septa, having the same hexagonal areolae as the erect hyphae and conidiophores, spirally contorted with up to 9–10 turns, these about 30–35μ diam. These conidia were originally described as *Helicosporium hendrickxii* Hansf. (Recueil INEAC, 2:53, 1945).

The perithecia of *Brooksia tropicalis* arise from the same mycelium as the erect hyphae described above, though the conidia and perithecia are normally formed in separate colonies, which may be adjacent on the same leaf. Each perithecium arises usually at the end of a shorter erect hypha (70–150μ long) than the usual "setae" or "conidiophores", and which has the characteristic hexagonal areolae on the surface. Rarely the perithecia are lateral on the lower part of one of the long erect hyphae, and in the mature condition the upper part of the erect hypha appears to arise from the base of the perithecial wall in these cases. The young perithecium commences as a globose swelling of the apical cell of the stalk, which divides to give a mass of dark brown parenchyma, eventually enclosing a delicate tissue of hyaline parenchyma, at the base of which arise the ascogenous hyphae. These form a small mass and the asci develop as enlargements of the terminal cells of the branches of the hyphae, enlarging at the expense of, and eventually replacing the whole of the contents of the perithecium. The perithecial outer wall consists of a single layer of brown parenchyma, the cells angular, 8–10μ diam., smooth on the outer walls, which are slightly convex; towards the truncate apex of the perithecium the cells are somewhat smaller and form a ring around the widely open end of the ascoma. The asci are 3–8 in number, and develop in succession, the oldest discharging its spores and collapsing to make room for the next. There are no paraphyses; the asci enlarge to become saccate, attenuate-rounded and thickened at the apex to about 3μ, sessile at the base, 8-spored. Spores more or less parallel or inordinate in the ascus, long remaining hyaline and 1-septate, slightly constricted, in the middle, eventually becoming pale brown, somewhat fusoid, straight or slightly bent, the ends obtuse, transversely 3-septate, smooth. After discharge the spores germinate on the leaf surface to give a short hypha, which very soon sends up into the air the beginnings of the first "erect hypha" or "conidiophore", having the characteristic hexagonal areolae on its surface.

(212) HEPTAMERIA OBESA (Dur. & Mont.) Sacc., *Syll. Fung.*, 2:88, 1883.

On twigs, Victoria, Martin 948 p.p.; in Herb. Kew as type coll. of *Zignoella erumpens* Cooke.

Perithecia scattered or in groups of 2–3, separate, globose, black, smooth, papillate, up to 500μ diam., erumpent through bark of twig. Wall thick, brittle, carbonaceous, prosenchymatous. Asci basal, numerous, clavate-cylindric, 8-spored, rounded and thickened to 5μ at apex, very shortly stipitate. Paraphyses numerous, equalling asci, doubtfully septate, simple, hyaline, filiform. Spores 2–3-seriate and overlapping, fusoid, often bent, then ends attenuate-rounded, the central cell swollen and dark brown, later becoming muriform, smooth, the end cells pale clear brown, 4–5 on each side of central cell; 60–70μ × 12–15μ.

The perithecia of this fungus were included by Cooke in his diagnosis of *Zignoella erumpens.*

(213) LEPTOSPHAERIA VAGABUNDA Sacc., *Nuov. Giorn. Bot. Ital.*, 7:318, 1875.

Ascomata scattered individually or when growing on enlarged lenticels in groups of 2–4, almost wholly immersed, black, globose to ovate, 120–250μ diam., glabrous, the flat conoid ostiole scarcely protruding, pierced by a minute pore lined with short, ascending, hyaline periphyses. Wall of several layers of brown-black parenchyma with thick walls in the outer layers, progressively thinner and subhyaline inside, enclosing several layers of more or less compressed, hyaline, thin-walled cells, the whole wall about 20μ thick. Asci mostly basal, mixed with very numerous filiform, hyaline, simple or irregularly ramose, septate, paraphyses, 1μ thick, exceeding the asci and also enclosing them around the inner part of the wall. Asci cylindric-clavate, narrowed below into rather short stalk 2–3μ wide and 20–25μ long, the sporiferous part up to 110μ × 10–13μ, rounded at the apex but not noticeably thickened, 8-spored. Spores irregularly 1–2-seriate and overlapping, biconoid, inside the ascus always hyaline and 1-septate, constricted, the upper part of the spore slightly larger than the lower, the ends obtusely rounded, 4-guttulate, with distinct exospore about 1·5μ thick, apparently mucose. After discharge the spores become pale yellow-brown and lose the mucose exospore, becoming 3-septate with the central cells subglobose and larger than the terminal, obtusely conoid cells, constricted at the septa, the surface smooth but with indistinct darker granules, 20–26μ × 6–7μ; often the subapical cell is slightly the largest.

E. Muller in *Sydowia*, 4:284, 1950, gives an extensive synonymy for this species and considers the valid name to be *L. sepincola* (B. & Br.) Wint. in *Rabh. Kryptog.-Fl.*, 1887, p. 473.

On dead branches of *Corylus avellana*, Stirling West, South Australia, 7.1954, E. H. Ising, WARI 3881.

(214) MYCOSPHAERELLA BRUNNEA Hansf., n. sp.

Maculae amphigenae, rotundatae vel irregulares, dilute brunneae, linea rufo-brunnea leniter elevata circumdatae, 4–6 mm. diam. vel confluentes. Perithecia irregulariter dispersa, immersa, nigra, punctiformia, globosa, glabra, 100–150μ diam., poro apicali epidermidem folii leniter elevatam perforante; paries membranaceus, brunneus, unistratosus, parenchymaticus, sursum atro-brunneus. Asci basali, fasciculati, aparaphysati, late ellipsoidei vel saccati, recti vel incurvati, subsessili, 8-spori, 35–45μ × 15–20μ. Sporae pluriseriatae vel irregulariter dispositae, tenuiter ellipsoideae utrinque obtuse rotundatae, hyalinae, 1-septatae, haud constrictae, leves, 14–19μ × 4μ.

Hab. in foliis *Tristaniae* spec., Brisbane, Queensland, Bailey 506 in Herb. Kew.

This specimen is the type of "*Ascochyta brunnea*" Cooke & Mass. in *Grevillea*, 15:98, but I was unable to find any trace of their fungus on the material. It is possible that Cooke and Massee may have described the ascospores of this *Mycosphaerella* as conidia of their *Ascochyta* which were given as 12μ × 4μ.

(215) MYCOSPHAERELLA CRYPTICA (Cooke) Hansf., n. comb.

= *Sphaerella cryptica* Cooke, *Grevillea*, 20:5, 1892; Cooke, *Handb. Austr. Fungi*, p. 311, 1892.

Type on leaves of *Eucalyptus* sp., Victoria, Martin 753 in Herb. Kew.

Causing dark red-brown blotches on the leaf, amphigenous, not delimited by a line, becoming darker and almost black, often widely confluent and irregular. Perithecia amphigenous, closely crowded, black, globose, glabrous, up to 130μ diam., with only the apical pore penetrating the epidermis; wall thinly membranous, of dark brown parenchyma. Asci in basal fascicle, subsessile, obclavate to saccate, rounded and slightly thickened at the apex, 8-spored, to 40μ × 12–15μ, aparaphysate. Spores 2–3-seriate or irregularly arranged in ascus, hyaline, narrow ellipsoid with obtusely rounded ends, smooth, 1-septate, not constricted, thin-walled, 10–12μ × 2–3μ.

Also on *Eucalyptus* sp., Victoria, Martin 766 in Herb. Kew.

(216) MYCOSPHAERELLA IXODIAE Hansf., n. sp.

Maculae nullae; perithecia in foliis emortuis et alis caulis dispersa, immersa, atra, globosa, usque ad 150μ diam.; paries membranaceus, 1–2-stratosus, parenchymaticus, sursum obscurior et crassior, apice leniter papillosus, haud prominens, poro perforatus. Asci basales, fasciculati, incurvati, aparaphysati, erecti, ellipsoidei vel subsaccati, apice rotundati et usque ad 4μ incrassati, basi nodoso-stipitati, 8-spori, 60μ × 12–15μ. Sporae 2–3-seriatae, hyalinae, ellipsoideae, rectae vel curvulae, utrinque rotundatae, 1-septatae, haud constrictae, leves, 17–20μ × 4μ.

Conidia: SEPTORIA IXODIAE Hansf., n. sp.

Pycnidia in areolis folii etiam in alis caulis, dense dispersa, immersa, globosa, atra, punctiformia, usque ad 90μ diam.; paries membranaceus, parenchymaticus, brunneus, sursum obscurior, apice perforatus. Conidiophora hyalina, simplicia, continua, circa 15μ × 3μ. Conidia acrogenea, singula, hyalina, filiformia, arcuata vel sursum fortiter curvata, 3–4-septata, haud constricta, basi rotundata, levia, 60–105μ × 3μ, sursum attenuata, apice rotundata, 1·5–2μ cr.

Hab in foliis et caulibus *Ixodiae achilleoidis*, Mt. Lofty, South Australia, 5.1954, Hansford, WARI 3793.

Both stages are formed on indefinite brown areas of the older leaves and on the wings of the stems, the tissues soon dying and not demarcated by a definite border. Pycnidia closely scattered, mostly on upper surface of leaves, immersed, globose, black, punctiform, up to 90μ diam.; wall membranous, of one layer of pseudoparenchyma with some traces of formation from interwoven hyphae, brown, darker around the apex, which does not protrude from the tissues, and is pierced by a pore 15–20μ diam. Conidiophores hyaline, simple, continuous, about 15μ × 3μ. Conidia single, acrogenous, hyaline, filiform, usually arcuate or strongly bent above, 3–4-septate, rounded at the base, smooth, 60–105μ × 3μ, gradually attenuate to the rounded apex which is 1·5–2μ wide.

Perithecia formed amongst the pycnidia, especially on the older infected tissues, scattered, immersed, black, up to 150μ diam., glabrous; wall membranous, of 1–2 layers of dark brown polygonal cells, darker and somewhat thicker around the slightly papillate but not protruding apex, which is pierced by an irregular pore. Asci in a single basal rosette, incurved erect, aparaphysate, ellipsoid to subsaccate, rounded and thickened to 4μ at the apex, nodose-stipitate below, 8-spored, 60μ × 12–15μ. Spores 2–3-seriate, overlapping, hyaline, ellipsoid, straight or bent, both ends rounded, 1-septate, not constricted, thin-walled, smooth, 17–20μ × 4μ.

(217) MYCOSPHAERELLA MARTINAE Hansf., n. sp.

Maculae amphigenae, atrobrunneae, angulosae, venis folii delimitae, 1–3 mm. diam., subinde confluentes, haud zonatae. Perithecia plerumque epiphyllae, usque ad 10 in macula una, singulariter dispersa, immersa, nigra, punctiformia, globosa, glabra, circa 100μ diam.; paries brunneus, membranaceus, parenchymaticus, poro rotundato apicali epidermidem perforante. Asci aparaphysati, basali, fasciculati, recti vel incurvati, ellipsoidei vel saccati, apice rotundati incrassatique, 8-spori, subsessili, 40–50μ × 10–12μ. Sporae 2–3-seriatae, tenuiter ellipsoideae utrinque obtuse rotundatae, 1-septatae, haud constrictae, hyalinae, leves, 11–13μ × 2·5–3μ.

Hab. in foliis *Eucalypti* spec., Victoria, Martin 765 in Herb. Kew.

In microscopic morphology this is very close to *M. cryptica*, but the leafspots on the host are very different. They are amphigenous, 1–3 mm. diam., dark brown, darker on upper surface, angular, delimited by the leaf venation but sometimes coalescent, each containing about 10 scattered perithecia, mostly on upper surface.

(218) MYCOSPHAERELLA NUBILOSA (Cooke) Hansf., n. comb. (?).

= *Sphaerella nubilosa* Cooke, *Grevillea*, 19:61, 1892; Cooke, *Handb. Austr. Fungi*, p. 310, 1892.

Type on leaves of *Eucalyptus* sp., Melbourne, Victoria, Martin 584 in Herb. Kew.

Perithecia hypophyllous on rounded or irregular and confluent pale brown leafspots bounded by a thin brown line, soon drying and secedent, up to 10 mm. diam. Perithecia black, punctiform, closely scattered, globose, glabrous, immersed with only the apical pore penetrating the epidermis, 100–156μ diam.; wall membranous, of 2–3 layers of brown angular parenchyma, darker around the apical pore. Asci aparaphysate, in a basal rosette, ellipsoid to subsaccate, straight or incurved above, subsessile, 8-spored, rounded and slightly thickened at the apex, about 50μ × 18μ. Spores 2–3-seriate, oblique, overlapping, ellipsoid with rounded ends, usually straight, hyaline, smooth, 1-septate, not constricted, 12–14μ × 2·5–3μ.

Also on *Eucalyptus* spp., *loc. cit.*, Martin 589; Currumbin, Queensland, 1911, C. T. White 14, 15 (all in Herb. Kew).

(219) PHYSALOSPORA LATILANS Sacc., *Fl. Mycol. Lusit.*, p. 67, 1893.

On dead leaves of *Eucalyptus* sp., Meningie, South Australia, L. D. Williams, WARI 3874.

Perithecia epiphyllous, scattered or sometimes aggregated into irregular patches, not on leafspots, totally immersed, globose, about 250μ diam., black, the ostiole not projecting but merely penetrating to the surface; wall of several layers of dark brown parenchyma enclosing a centrum of hyaline hyphae connected above and below to the wall cells. This centrum is more or less completely replaced by the single basal rosette of asci, save for remains which enclose the latter and a few threads as "branched paraphyses" between the asci. Asci cylindric, subsessile, bent, rounded and thickened at the apex when immature, with a slight internal apical canal, 8-spored, 80–105μ × 9–13μ. Spores obliquely 1–2-seriate, hyaline, ellipsoid, sometimes slightly bent, obtuse at the ends, continuous, smooth, 18–21μ × 7–8·5μ.

This species has been recorded previously in Victoria on *Eucalyptus obliqua* and *E. diversicolor*.

(220) Wettsteinina coryli Hansf., n. sp.

Ascomata immersa, dispersa, atra, glabra, depresso-globosa, crasse membranacea vel scortea, in sicco dura, usque ad 400μ diam., ostiolo plano, perforato; paries pluristratosus, 20–30μ crassus, extus niger, intus subhyalinus. Asci numerosi, basales, cylindraceo-clavati, breviter stipitati, apice rotundati, incrassati (–10μ), 8-spori, 180–240μ × 30–45μ. Sporae oblique 1–2-seriatae, fusoideae utrinque rotundatae, saepe curvulae, 1-septatae, constrictae, cellula superiore longiore et lenissime latiore, hyalinae, leves 60–70μ × 19–22μ, exosporio usque ad 3·5μ cr., hyalino, gelatinoso. Post emissionem sporae brunnescentes et 3-septatae, cellulis terminalibus 6–10μ longis, endosporio brunneo, 1–2μ cr., exosporio hyalino, levi, 1–2μ cr. Paraphyses ascos superantes, filiformes, 1–2μ cr., septatae, laxe ramosae.

Hab. in ramis emortuos *Coryli avellanae*, Stirling West, South Australia, 8.1954, E. H. Ising, WARI 3896.

Perithecia immersed, scattered singly, black, glabrous, flattened globose, thickly membranous to leathery in texture when fresh, hard when dried, up to 400μ diam.; ostiole not differentiated and the apex of the perithecium opening through the uplifter and split bark by a small pore; wall of several layers of subopaque brown parenchyma, 20–30μ thick, becoming hyaline inside. Asci numerous, basal, cylindric-clavate with attenuate, short stipe and thickened (–10μ), rounded apex with a central wide internal canal, 8-spored, 180–240μ × 30–45μ, the wall about 2μ thick below. Spores obliquely 1–2-septate, fusoid with rounded ends, usually slightly bent, 1-septate and constricted, the upper half longer and slightly wider than the lower, remaining hyaline within the ascus, 60–70μ × 20–22μ, surrounded by a gelatinous exospore up to 3·5μ thick. Paraphyses exceeding the asci, filiform, 1–2μ thick, septate, loosely ramose and separating the individual asci, representing the remains of the original fibrous-mucose centrum. The spores after discharge turn brown, and a small cell, 6–10μ long, is cut off from each end, often slightly constricted at its septum; the brown colour is limited to the endospore layer, which is 1–2μ thick, while the exospore remains as a hyaline covering 1–2μ thick, smooth.

(221) Lophiostoma rhopaloides Sacc., Fung. ital. no. 237, and in *Syll. Fung.*, 2:689, 1883.

On dead wood, Stirling West, 7.1954, E. H. Ising, WARI 3883.

Perithecia closely scattered, innate with erumpent ostiole, sitting on the wood under the bark, the body up to 500μ diam., globose or slightly flattened, attenuate into a bluntly compressed-conoid ostiole which extends up to 200μ above the bark surface, black, carbonous, terminating in a narrow slit about 150μ long; body of perithecium less hard and brittle than the ostiole. Asci numerous, cylindric-clavate with narrow filiform stalk 30–40μ long by 2–3μ diam., the whole ascus to 140μ long and 10–13μ diam. in upper part, rounded but not noticeably thickened around the apex, 8-spored. Spores 1-seriate and oblique below, often 2-seriate and overlapping above, ellipsoid-obovate, becoming brown, smooth, transversely 3-septate, distinctly constricted at middle septum, less so at the others, the upper half slightly wider than the lower, the subapical cell often distinctly the largest, the ends rounded, 16–21μ × 6–7·5μ. Paraphyses filiform, hyaline, simple, continuous, 1μ thick, equalling the asci, numerous.

(222) Hysterographium depressum (Wint.) Hansf., n. comb.

= *H. hiascens* Rehm., subsp. *macrum* Sacc. & Berl., var. *depressum* Wint., *Rev. Mycol.*, 1886, p. 212.

Apothecia numerous, single or in small longitudinal groups, closely scattered on the exposed surface of the wood, emergent from longitudinal crevices, black, linear, straight or slightly bent, smooth, up to 1·5 mm. long by 0·3 mm. wide, slightly erumpent, with narrow, central, longitudinal cleft, the lips swollen and longitudinally striate. In section the lips are 50–60μ thick, composed of opaque black thick-walled cells, slightly thinner towards the base, and enclose a "loculus" up to 180μ wide and high. Asci basal, clavate with short stipe, 8-spored, widely rounded but not thickened at the apex, up to

130μ × 30μ. Spores obliquely 2-seriate, oblong to slightly clavulate-fusoid, the ends obtuse in surface view, somewhat acute in side view, becoming dark brown, 7–9-septate transversely and with 1–3 longitudinal septa, constricted at the middle septum, 30–38μ × 11–13μ = 6–8μ. Paraphyses fairly numerous, equalling or slightly exceeding the asci, simple or doubtfully ramose, 1–2μ thick, with very thin walls.

On dead wood of *Casuarina* sp., South Australia, Kanmantoo, July 1954, M. W. Carter, WARI 3892.

(223) **Sphaerosoma mucida** (Rodway) Hansf., n. comb.

= *Spragueola mucida* Rodway, *Proc. Roy. Soc. Tasm.*, 1919, p. 114.

Apothecia sessile, subglobose with coarsely nodulose surface, white, about 5 mm. diam. The hymenium covers the whole surface; asci cylindric, 8-spored, up to 220μ × 27μ, operculate. Spores 1-seriate, globose, hyaline, continuous, 18–22μ diam., closely spinulose all over, the spines up to 3μ long, acute from a rather broad base, somewhat flexible; inclusive of the spines the spores are up to 26μ diam. Paraphyses much exceeding the asci, filiform, about 3μ thick below, septate, the apices slightly swollen up to 6μ, straight when moist, becoming distorted and shrivelled when dry. The paraphyses form a thick epithecium over the asci, up to 100μ deep. When moist the fructifications are tough gelatinous, if very wet they are softer and viscid, becoming cartilaginous and hard when dried and then yellowish in colour.

The above description has been drawn up from re-examination of the type collection on rotting wood, Mt. Nelson, Tasmania, Rodway, in Herb. Tasmanian Museum.

(224) **Geoglossum glabrum** Pers. ex Fr., *Syst. Myc.*

Specimens examined: Tasmania: Cascades, Rodway, Aug. 1919, May 1924, July 1924; Victoria: Warrandyte, Clarke, Aug. 1904, in Herb. Dep. Agr. Vict. as no. 535/04; Cockatoo, McLennan, 1935; South Australia: National Park, Aug. 1952, Warcup, WARI 2437.

(225) **Geoglossum nigritum** (Pers.) Cooke, *Mycographia*, p. 205, 1878.

Specimens: Tasmania: Rodway, Cascades, July 1909, Aug. 1920, Sept. 1923; Marriott's Falls, June 1924; McRobies Gully, May 1917; Lindisfarne, Aug. 1924; National Park, June 1924; Victoria: Frankston, July 1903, McAlpine; Ringwood, Sept. 1903, C. French; Fern Tree Gully, Aug. 1918, Dickson; Colac, McLennan; New South Wales: J. B. Cleland, Neutral Bay, Sydney, June 1913; Sydney, 1917; Sedgwick, 1917; South Australia: Hospital, Adelaide, J. B. Cleland, June 1949, WARI 3746; Delamere, July 1952, Warcup, WARI 2113; Woodville, Cleland, 1918, WARI 2694.

(226) **Gloeoglossum glutinosum** (Pers.) Durand, *Ann. Myc.*, 6:419, 1908.

Specimens: Colac, Victoria, McLennan; Cockatoo, Vict., McLennan, 1935.

(227) **Leotia lubrica** Fr., *Syst. Myc.*, 2:29, 1823.

This appears to be the only species of this genus in Australia, where it is fairly common and has been recorded from all States except Western Australia. Amongst numerous specimens examined I have been unable to find any which could not be included in this species.

(228) **Microglossum olivaceum** (Fr.) Gill., *Champ. Fr. Discom.*, p. 25, 1879.

The only Australian specimens I have seen are Rodway 358 and 359, from Marriotts Falls, Tasmania, Sept. 1924.

(229) **Microglossum rufum** (Schw.) Underwood, *Minn. Bot. Studies*, 1:496, 1896.

Specimens: Tasmania, Rodway 362 from Lady Barron Falls, June 1924; Ulverstone, July 1924, Rodway.

(230) **Microglossum viride** (Pers. ex Fr.) Gill., *Champ. Fr. Discomyc.*, p. 25, 1879.

The only Australian specimen seen is Rodway 818, from Gordon, Tasmania, June 1913.

(231) **Mitrula cucullata** Fr., *Epicr. Myc.*, p. 584, 1838.

The only Australian record is based on a single collection, Rodway 433 on leaves of *Eucalyptus* on the ground, Falls Trail, Tasmania, Aug. 1896. I have examined this in the Rodway Herbarium and find that nothing now remains save the broken stalks of the ascomata. As far as I could gather, the record appears to be correct.

What are apparently two distinct species of *Mitrula* not previously recorded in Australia are represented in the Rodway Herbarium by collections made at Marriotts Falls, Tasmania, Sept. 1924; of these one is dark verdigris-green in colour of clava and stem, and the other pale flesh-coloured. Both have spores 12–15μ × 4·5–5·5μ. Further collections of these are needed for comparison with foreign species before they can be determined with certainty.

(232) **Trichoglossum hirsutum** (Pers. ex Fr.) Boud., *Hist. Class. Discom. Eur.*, p. 86, 1907.

Specimens examined: New South Wales: Sydney, May 1918, J. B. Cleland, WARI 2762. Tasmania: Rodway, National Park, June 1924, Oct. 1924; Cascades, May 1924. Victoria: Wallaby Creek, Sept. 1953, Ashton; Kallista, McLennan, 1935.

(233) **Trichoglossum walteri** (Berk.) Durand, *Ann. Myc.*, 6:440, 1908.

Specimens: Tasmania: Rodway, Mt. Wellington, Jan. 1909 and June 1911, on stems of *Dicksonia*; Cascades, Oct. 1919, on fern stem; Marriotts Falls, June 1924.

(234) **Vibrissea tasmanica** Rodway, *Proc. Roy. Soc. Tasm.*, 1924, p. 119.

The type collection, on leaf litter, Marriotts Falls, June 1924, Rodway, in Herb. Tasm. Museum, has been re-examined.

Ascomata when dry almost black, to 10 mm. high; stem filiform, even, about 500μ diam., smooth. Head when dry collapsed and rugulose, dark brown, becoming paler when soaked ("when fresh globose, 2–3 mm. diam., pale greenish, smooth"—Rodway) sharply delimited from the stem. Asci cylindric, somewhat narrowed to the base, rounded at the apex, up to 130μ × 5μ, 8-spored. Spores in a parallel bundle, at first in the apical part of the ascus, then extending downwards almost to fill it, filiform, hyaline, continuous, 80–120μ × 1μ. Paraphyses not numerous, simple, filiform, hyaline, slightly exceeding the asci and the somewhat clavate tips agglutinate to form a very thin greenish epithecium, the tips to 3μ wide, below 1μ.

(235) **Vibrissea mclennani** Hansf., n. sp.

Ascomata nigra, stipitata, usque ad 10 mm. alt.; caulis filiforme, circa 300μ diam., levis vel minute subtomentosus; caput usque ad 1 mm. diam., subglobosum vel hemisphaericum, acute delimitatum, nigrum, leve. Asci numerosi, filiformes, apice rotundati, deorsum leniter attenuati, usque ad 150μ × 5μ, 8-spori. Sporae parallelae, filiformes, hyalinae, usque ad 80μ × 1μ, haud septatae. Paraphyses numerosae, ascos aequantes, filiformes, apice subclavatae, simplices, deorsum 1μ cr., apice usque ad 2–3μ cr.

Hab. in ligno, Dandenongs, Victoria, E. McLennan, 1951 (typus in Herb. Univ. Melbourne).

Ascomata black, stipitate, to 10 mm. high; stem filiform even, about 300μ diam., smooth, or with short suberect ends of the parallel hyphae of the flesh forming very short hairs; bearing a terminal head up to 1 mm. diam., subglobose to hemispheric, sharply delimited from the stem and reflexed over it to form a rounded rim at the base, black, even when quite moist, smooth, sometimes with a central apical depression. Asci numerous, filiform, rounded at the apex, attenuate below into very narrow stem, up to 150μ × 5μ, 8-spored. Spores parallel, filiform, hyaline, not distinctly septate, up to 80μ × 1μ, the ends attenuate-rounded. Paraphyses numerous, equalling the asci, filiform and slightly clavate at apex, simple, 1μ thick below, enlarged to 2–3μ at apex.

(236) **Vibrissea queenslandica** Hansf., n. sp.

Ascomata stipitata, molle carnosa, pileata; stipes centralis, elongatus, tenuus, saepe curvatus vel leniter flexuosus, luteus, levis, mollis, usque ad 20 mm. × 1 mm., solidus, deorsum leniter attenuatus; caput pileiforme, luteum, aquosum, margine pallidior, subtranslucens, rotundatum, usque ad 10 mm. diam. et 1 mm. cr. Hymenium epipileum, convexum, rugulosum, minute granulosum. Asci cylindraceo-clavati, usque ad 180μ × 6–7μ, apice rotundati, deorsum in stipitem filiformem attenuati, 8-spori. Sporae parallelae, filiformes, hyalinae, 80–100μ × 1·5μ, intus granulosae, haud distincte septatae. Paraphyses filiformes, ascos aequantes, septatae, apice subglobosae vel clavatae, usque ad 5μ cr., deorsum 1μ cr.

Hab. in terra, Imersby Falls, Queensland, July 1915, Darnell-Smith, WARI 2705.

Ascomata stipitate, soft fleshy, pileate; the cap yellow-brown, watery, the surface darker than the rounded margin, which is subtranslucent and rugulose; the cap 800–1000μ thick and up to 10 mm. diam.; stem long, slender, often bent or flexuous, paler yellowish in colour, soft, subtranslucent, smooth, up to 20 mm. × 1 mm., solid, slightly attenuate downwards. Hymenium covering the upper surface of pileus, finely granulose on surface, convex, somewhat irregularly rugulose. Asci cylindric-clavate, up to 180μ × 6–7μ, the apex rounded, not thickened, attenuate into long filiform stipe which has a slightly bulbous base, 8-spored. Spores filiform, parallel in ascus, hyaline, 80–100μ × 1·5μ, the contents finely granulose, not distinctly septate. Paraphyses filiform, equalling the asci, the apex subglobose to clavate, enlarged to 5μ from 1μ thick below, septate.

(237) Coccomyces martinae Hansf., n. sp.

Ascomata epiphylla, dispersa vel 2–3-subaggregata, rotundata, circa 250μ diam., primo obtuse conoidea, demum subcupulata, dilute colorata, haud nigra, poro centrali irregulari dehiscentia. Asci erecti, cylindracei, apice rotundati, haud incrassati, nodoso-stipitati, 8-spori, 70–90μ × 7–9μ; paraphyses numerosae, filiformes, hyalinae, sursum irregulariter furcatae, circa 1μ cr., continuae (?). Sporae parallele positae, filiformes, hyalinae, leves, 60–70μ × 2μ, indistincte septatae.

Hab. in foliis *Eucalypti* spec., Victoria, Martin, s.n., typus in Herb. Kew (socio *Phoma eucalyptidea* Thuem.).

Ascomata epiphyllous, scattered singly or in groups of 2–3 on pale areas within the leafspots caused by the *Phoma*, but distinct from these by a definite margin and hence considered to be entirely independent. Ascomata round, about 250μ diam., at first squat conical, then the overlying epidermis opening by a central irregular pore, not as in other collections on *Eucalyptus*, by a cruciate wide slit; pale coloured, not black. Internally there is a very thin flat stroma, hyaline, beneath the hymenium, which is enclosed around the sides and above, by a thin layer of pale olivaceous parenchyma, adherent to the epidermis and filling the epidermal cells, 15–20μ thick, consisting of very small cells mixed with a crystalline deposit. Asci erect or incurved towards the apical pore, cylindric with thin, rounded apex, 8-spored, 70–90μ × 7–9μ, with very short nodose stipe. Paraphyses numerous, filiform, hyaline, irregularly furcate at the tips, which are not swollen. Spores parallel in the ascus, filiform, hyaline, smooth, indistinctly septate, 60–70μ × 2μ.

(238) Pseudopeziza eucalypti Hansf., n. sp.

Maculae amphigenae, plerumque epiphyllae, usque ad 1 mm. diam., interdum confluentes irregularesque. Apothecia plerumque epiphylla, atra, subcuticulares, rotundata vel irregulares, 0·5–0·75 mm. diam., erumpentia, discoidea, gelatinosa, sursum brunneo-nigra. Paraphyses erectae, ascos leniter superantes, simplices, deorsum hyalinae, apice brunneae, septatae, 100–120μ longae, deorsum 2–3μ cr., apice usque ad 5μ diam. Asci subcylindracei, clavati vel saccati, subsessiles vel breviter stipitati, apice late rotundati, 8-spori, 80–100μ × 20–30μ. Sporae oblique 2-seriatae vel inordinatae, hyalinae, fusoideae utrinque attenuato-rotundatae, rectae, leves, continuae, 25–32μ × 7–9μ.

Hab. in foliis *Eucalypti* spec. indet., Pinnaroo, South Australia, 9.1924, G. Samuel, WARI 3841.

Apothecia usually single, sometimes 2–3 in close group, on minute dark red-brown leafspots without definite border, about 1 mm. diam. or sometimes confluent and irregular. Apothecia amphigenous or mostly epiphyllous, black, subcuticular in origin, rounded to irregular, 0·5–0·75 mm. diam., at first covered by the cuticle, beneath which there is a very thin layer of black stroma, 5–10μ thick, extending around the hymenium as a thin border of dark parenchyma, the cells 5–10μ × 4–6μ, often erect and palisade-like. The cuticle is raised by the developing hymenium and finally breaks irregularly, falling away to expose the whole hymenium. Beneath the hymenium is a thin tissue of hyaline parenchyma arranged as a vertical palisade 2–4 cells thick, the uppermost cells being continued into the paraphyses, which are septate, simple, hyaline below, brown to dark brown at the apex, slightly exceeding the asci to form a thin epithecium, 100–120μ long, 2–3μ thick below, expanded to 5μ at the apex, the walls rather thick above and gelatinous. Asci vary from subcylindric to clavate or saccate, with short narrow stipe or subsessile below, widely rounded at the apex, 8-spored, when mature 80–100μ × 20–30μ. Spores obliquely 2-seriate or inordinate, hyaline, fusoid with attenuate-rounded ends, straight, smooth, continuous, 25–32μ × 7–9μ.

Beneath the apothecium the epidermis is filled with hyaline hyphae, which also penetrate some of the underlying cells of the mesophyll, killing them. There are no haustoria and the internal mycelium is rather scant, limited to individual cells of palisade tissue, or on the lower side of the leaf to cells of the mesophyll just below the epidermis. The whole texture of the hymenium is firm gelatinous when moist, becoming black and horny when dry, and then flattened down close to the leaf surface.

The conidial stage is described below as *Gloeosporiella eucalypti* Hansf.

(239) AGARICUS (PSALLIOTA) AUSTRALIENSIS Hansf., n. sp.

Pileus convexus vel patens, usque ad 10 cm. diam., ad discum leniter depressus, margine incurvatus et irregulariter laceratus; extus siccus, dilute puniceo-brunneus, interdum in areolas angulatus circa 8 mm. diam. profunde diffissus, aliter integer, fibrillosus vel marginem versus squamosulus. Stipes 10–15 cm. longus, medius 12 mm. diam., basi bulbosus usque ad 25 mm. diam., extus levis, sursum albus, deorsum cremeus et longitudinaliter fibrilloso-striatus, interdum dilute brunneus. Annulus superior, duplex, parte superiore membranacea, alba, 2–3 mm. lata, parte inferiore leniter crassiore, usque ad 10 mm. lata. Caro pilei niveum, molle, siccum; caro stipitis molle, niveum, solidum, ex hyphis parallelibus compositum. Lamellae maturae purpureo-nigrae, haud brunneae, stipatae, liberae, haud ventricosae, 5–9 mm. altae, margine fertiles. Basidia 4-spora; cystidia dispersa, ventricosa, 30–35μ × 7–9μ, sursum attenuata et in spinam unam, solidam, rectam vel curvatum, usque ad 7μ × 1μ producta. Sporae ellipsoideae, purpureae, leves, 10–15μ × 7–9μ, tunica 1μ crassa.

Hab. in horto, Sydney, New South Wales, Hutton, 1953 (typus); *l.c.*, R. J. Conroy, 1954, WARI 3803.

Pileus convex to spreading, up to 10 cm. diam., slightly depressed at the disc, the margin incurved and irregularly torn; surface dry, pinkish-brown in the external layer (cuticle), covering a creamy-white surface below; sometimes the surface splits into angular areas about 8 mm. diam. and up to 4 mm. deep, hence these stand out as warts, each having an angular top of the external brown cuticle and white below. Other specimens remain intact on the surface, which is very delicately fibrillose, becoming very slightly squamulose towards the margin. Stem 10–15 cm. long, by 12 mm. diam. in the middle, expanding below into a bulbous base about 25 mm. diam.; surface smooth and pure white above the ring, somewhat creamy below and longitudinally fibrillose-striate, some fibrils having a very pale brownish tinge; in some specimens the surface breaks up into indefinite rings of pale brownish scales pointing upwards. Ring superior, double, the upper part membranous, 2–3 mm. wide, white, the lower and outer ring thicker, tending to inroll and to break up into radial fragments, up to 10 mm. wide. Flesh of pileus pure white, soft, dry, not changing colour when cut, save immediately below the cuticle, where a very faint trace of cream is produced. Flesh of stem soft, pure white with a faint creamy watery tinge towards the surface, solid, soft, composed of longitudinal hyphae. Stem easily detached from pileus. Cuticle of pileus thin, peeling easily. Gills purple-black when mature, with no brown tinge, close, free, not ventricose, 5–9 mm. deep; the edge fertile. Basidia 4-spored; cystidia scattered, ventricose, 30–35μ × 7–9μ, attenuate upwards and ending in a solid, straight or curved spine 5–7μ × 1μ. Spores ellipsoid, purple, smooth, 10–15μ × 7–9μ, the wall 1μ thick, with minute apical germ-pore and slightly lateral basal hilum, which does not project.

(240) CAMAROSPORIUM EUCALYPTI Wint., *Rev. Mycol.*, 1888, p. 212.

On *Eucalyptus* sp., St. Armand, Victoria, H. Watts 8 in Herb. Kew, possibly part of the type collection (Reader 64, Melbourne, leg. Watts).

Leafspots elliptic, brown with dark marginal line, somewhat depressed below the leaf surface, 4–8 mm. × 2–4 mm., or confluent, especially along the leaf edge, smooth, not zonate. Pycnidia immersed in small groups below the upper epidermis, black, punctiform, globose, 100–200μ diam., with apical round pore penetrating the epidermis, not erumpent, glabrous, membranous; wall thinly parenchymatous, brown, darker around the apical pore. Spores at first hyaline and continuous, then turning brown and becoming 1-septate below the middle, some with a second transverse septum higher up and others with 1 longitudinal septum in the middle cell, or the upper and larger half with two oblique septa, smooth, more or less piriform, widely rounded at apex, attenuate to the subtruncate base, 12–16μ × 7–10μ, not constricted at the septa.

(241) CONIOTHYRIUM OLIVACEUM Bon. in Fuckel, *Symb. Myc.*, p. 377.

Cooke, *Handb. Austr. Fungi*, 1892, p. 352, records this species for Australia, his record being based upon Martin 701 on the bracts of *Leptospermum laevigatum*, Victoria, preserved in Herb. Kew. This specimen has been re-examined; the only fungus present is a species of *Hendersonia.*

Pycnidia rather closely scattered over the dead bracts, immersed with only the apical pore reaching through the epidermis, black, glabrous, thin-walled, globose, about 70μ diam.; wall of apparently only a single layer of brown parenchyma, paler around the base and darker to almost black around the apical pore. Conidiophores not seen. Conidia rounded-fusoid, straight or slightly bent, soon becoming rather dark brown, smooth, at first continuous, then with 1–3 cross septa, not constricted, 10–16μ × 7–8μ; the apex broadly rounded, the base slightly truncate.

It is obvious from this material that Cooke had only the very young, non-septate spores, and therefore the record of *C. olivaceum* must be deleted.

A second specimen, Martin, s.n., on *Eucalyptus* leaf, Victoria, in Herb. Kew, contains no *Coniothyrium*, but a pycnidial fungus with hyaline spores 8–10μ × 3μ, cylindric with rounded ends; accompanied by immature perithecia.

(242) DIPLODIA ACACIARUM Hansf., n. sp.

Pycnidia immersa, in maturitate lenissime erumpentia, dense dispersa, atra, globosa, usque ad 150μ diam., glabra, apice minute perforata; paries pluristratosus, firme carnosus, intus hyalinus. Sporophora hyalina, simplicia, recta, continua, usque ad 12μ × 2–3μ. Conidia terminalia, singula, obovata vel ellipsoidea, apice late rotundata, basi subtruncata, atrobrunnea, 1-septata, interdum subconstricta, 18–24μ × 11–15μ.

Hab. in ramulis emortuis *Acaciae decurrentis*, Stirling West, South Australia, 7.1954, E. H. Ising, WARI 3887.

Pycnidia immersed, becoming slightly erumpent at the apex when fully mature, closely scattered, black, globose, glabrous, up to 150μ diam., with minute round apical pore. Wall of several layers of dark brown-black parenchyma, firm but not carbonous, lined inside with layers of subhyaline parenchyma with thin walls, the innermost layer bearing the sporophores. These are more or less cylindric, simple, hyaline, straight, continuous, up to 12μ × 2–3μ, each forming a single apical conidium. Conidia obovate to ellipsoid, widely rounded at the apex, the base often distinctly truncate, dark brown, smooth, 1-septate in the middle and sometimes slightly constricted, 18–24μ × 11–15μ.

(243) DIPLODINA GAUBAE Petrak, *Sydowia*, 8:413, 1954.

Type on *Alyxia buxifolia*, Twofold Bay, New South Wales, Gauba 705; also in Herb. Kew on the same host, Brighton, Victoria, Campbell 375-a.

(244) DOTHIORELLA AMYGDALI Cooke & Mass., *Grevillea*, 19:91, 1891.

Type on *Prunus amygdalus*, Victoria, Martin 672 in Herb. Kew.

Pycnidia innate-erumpent, one or more on a stroma which bursts through transverse slits in the outer bark, black, smooth, with conical upper part and flat black ostiole, glabrous, 300μ or more diam.; wall hard and brittle, composed of several layers of dark brown angular parenchyma. Loculus single, and contents white, consisting of a rather gelatinous mass of conidia exuding through the apical pore as a mass, not a tendril. Conidia single and acrogenous on simple, hyaline, cylindrical conidiophores 10–20μ × 3–4μ, continuous, growing out from the cells of the innermost layer of the pycnidial wall. Conidia ellipsoid, smooth, bluntly rounded at both ends, continuous, hyaline, 22–30μ × 10–13μ, the wall about 1μ thick, contents granular and with a rather large central vacuole; finally after discharge turning brown and becoming 1-septate in the middle, not constricted.

These characters are those of the genus *Botryodiplodia*, and unless an earlier name can be found, the present fungus can be transferred as BOTRYODIPLODIA AMYGDALI (C. & M.) Hansf., n. comb.

(245) DOTHIORELLA BANKSIAE Hansf., n. sp.

Maculae epiphyllae, effusae, pallidae, indefinitae, arescentes, subinde zono dilute brunneo circumdatae. Pycnidia dispersa, immersa, atra, globosa, usque ad 250μ diam., glabra; paries firme membranaceus, pluri-stratosus, levis, glabrus, intus in stratas hyalinas transeuns. Conidiophora erecta, recta, simplicia, continua, hyalina, 20μ × 4–5μ, sursum attenuata, apice acuta. Conidia acrogenea, singula, hyalina, ellipsoidea vel elongato-ovoidea, continua, levia, 17–22μ × 6–8μ, intus granulosa.

Hab. in foliis *Banksiae integrifoliae*, Melbourne, Victoria, Campbell 403 in Herb. Kew.

The specimen is filed in Herb. Kew as the type of "*Sphaerella banksiae* Cooke & Mass.", of which not a sign could be detected on it.

Pycnidia scattered on indefinite pale areas of the leaf, usually towards the apex, completely immersed, but eventually the larger ones elevating the epidermis, which is pierced by the apical pore; sometimes the elevated epidermis is irregularly ruptured and secedent, leaving the naked pycnidia; black, globose, to 250μ diam. The pale areas dry out later and may be surrounded by an indefinite pale brown marginal zone around the whitish centre. Pycnidial wall tough and firm membranous, of several layers of polygonal brown parenchyma, smooth and glabrous outside, lined with inner layers of subhyaline or hyaline smaller cells; the innermost of these produces a palisade of conidiophores; these are erect, straight, simple, continuous, hyaline, 20μ × 4–5μ wide at the base, attenuate upwards to a narrow apical sterigma, which swells out at its end to form the single terminal conidium. Conidia ellipsoid to ovate, rounded at the apex, slightly attenuate to a minute basal hilum, hyaline, smooth, thin-walled, 17–22μ × 6–8μ, with granulose contents.

(246) HENDERSONIA EUCALYPTI Cooke & Harkn., *Grevillea*, 9:128, 1881.

The only Australian specimen under this name in Herb. Kew is on leaves of *Eucalyptus* sp., Gippsland, Victoria, 1886 "No. 3", collector unknown, and Cooke himself regarded his determination as doubtful.

Pycnidia buried in a warty leafspot, much like that produced by species of *Elsinoe*; black, not erumpent, opening through the stomata or sometimes above an oil gland, appearing as black dots, globose, 100–150μ diam.; wall rather thick, brittle, carbonaceous, especially around the apex. Conidia subfusoid with rounded ends, dark brown, rather thick-walled (1–2μ), becoming 1-, and then 3-septate, not constricted, smooth, 15–19μ × 7–9μ.

This was compared with the type of *H. eucalypti*, Harkness 2039, from California; in the latter the pycnidia are scattered loosely over the leaf, and are slightly erumpent, raising the epidermis but not actually breaking it; the conidia are thin-walled, with thick septa, and when old the outer walls collapse as in *Coryneopsis* (*Melanconiales*); they measure 10–17μ × 6–8μ.

It is thus evident that the Australian material does not correspond to that from California, but it would be best to await further collections before describing it as a new species.

(247) RHYTISMA HYPOXANTHUM B. & Br., PROC. LINN. SOC. N.S.W., 5:89, 1880.

Type in Herb. Kew, Bailey 701 on unknown leaves, Brisbane; also Bailey 850.

Brittlebank in his Ms. Catalogue of Australian Fungi records the host as *Cudrania javanensis*, but I have not been able to verify this determination.

Leafspots brown, rounded or irregular, to 25 mm. diam., thickened, smooth with scattered, slightly depressed, black fructifications on the upper surface. These originate in the epidermis, which is filled completely with a black clypeal stroma, extending below into the mesophyll of the much hypertrophied leaf as loose hyaline hyphae. The original black stroma splits horizontally, the upper part, still covered by the intact cuticle and about 10μ thick, lifts, while the lower half, 10–20μ thick, develops an internal thin layer of small cells, on which the close palisade of vertical conidiophores arises. Conidiophores 10–15μ long, simple, more or less straight, about 2μ wide at the base, gradually tapering to the apex, which abstricts single conidia, continuous, hyaline. Conidia when mature yellow-brown, darker brown in mass, ovate-ellipsoid, straight, continuous, smooth, 4–6μ × 2–2·5μ.

The fructifications are rounded, shining black, somewhat rugulose on the surface, 1–2 mm. × 1 mm., apparently opening by an irregular slit, as those most mature show an elevated irregular line down the middle; not hysteroid in appearance. No sign of any ascus stage was found.

In Herb. Kew the specimens are labelled "*Melasmia hypoxantha* Berk." and it would appear that this is the best name for this fungus, until its ascus stage becomes known.

(248) PELTOSOMA EUCALYPTI Hansf., n. sp.

Maculae saepe numerosae, dispersae, amphigenae, dilute brunneae, rotundatae, usque ad 10 mm. diam. vel confluentes. Mycelium externum ex hyphis dilute brunneis, flexuosis, saepe 2–6-connatis, exhyphopodiatis, 3μ cr., cellulis usque ad 15μ longis, dense rotundato-reticulatis compositum, per stomata in mesophyllum penetrans. Pycnidia in mycelio dispersa, superficialia, membranacea, olivacea, plano-convexa, demum discoidea, usque ad 150μ diam.; paries superior unistratosus, haud radiatus, ex hyphis flexuosis compositus, mox irregulariter disrumpens et evanescens; paries inferior dilute olivaceus, membranaceus, haud radiatus. Conidia atro-brunnescentes, in massa nigra, ovata vel ellipsoidea, apice rotundata, basi subtruncata, levia, transverse 3-septata, haud constricta, 15–22μ × 6–8μ, saepe curvula.

Hab. in foliis *Eucalypti oleosae*, Pinnaroo, 9.1924, G. Samuel, WARI 384.

Leafspots often numerous, scattered, amphigenous, pale brown without a dark marginal line, rounded, up to 10 mm. diam. or confluent. Mycelium superficial over the spot, of pale brown, septate, exhyphopodiate hyphae, 3μ thick, the cells up to 15μ long, irregularly branched, crooked, and often in strands of 2–6 hyphae following the depressions of the host cuticle, forming rounded meshes of a close reticulum. Branches from the external mycelium fill the stomatal openings with dark plugs of pseudoparenchyma, from which hyaline hyphae enter the stoma and penetrate the mesophyll, not forming haustoria in the host cells.

Pycnidia scattered on the external mycelium, completely superficial, up to 150μ diam., at first flattened-convex and with an upper membranous wall of one layer of crooked hyphae similar to those of the mycelium, not radiate, the wall soon splitting irregularly into fragments and disappearing almost completely, leaving the mass of conidia exposed, so that the mature fructification resembles a sporodochium. Lower pycnidial wall pale olivaceous to subhyaline, membranous, composed of agglutinate hyphae, not radiate in structure. The conidia are formed at the apices of short cells arising from the lower wall of the pycnidium, scarcely differentiated as conidiophores; the mature fructification consists almost entirely of a pulvinate to subglobose mass of conidia, appearing black in colour. Conidia at first hyaline, soon turning dark brown, formed singly on the parent cells, not catenulate, ovate to ellipsoid, rounded at the apex, slightly truncate at the base, smooth, transversely 3-septate, not constricted, 15–22μ × 6–8μ, often slightly bent.

(249) PHLEOSPORA MYOPORI (Cooke) Hansf., n. comb.

= *Septoria myopori* Cooke & Massee, *Grevillea*, 16:113, 1887.

Type in Herb. Kew: Campbell 414 on *Myoporum insularis*, Victoria.

The type material contains only two leafspots: rounded, sunken, 1–2 mm. diam., surrounded by a brown line, papery, whitish. Acervuli scattered on the upper surface, minute, appearing black, the colour due to the dark basal stroma, immersed, erumpent by irregular breaking of the overlying epidermis, 100–150μ diam. Basal stroma flat, forming a close palisade of erect, simple, continuous, subhyaline conidiophores, dark brown in mass, 30–35μ × 3–3·5μ, each forming a single apical conidium. Conidia hyaline, straight or usually bent to flexuous, continuous, the ends attenuate-rounded, smooth, 40–50μ × 3–3·5μ. There is no trace of a pycnidial wall or apical pore.

(250) SEPTORIA MARTINII Cooke, *Grevillea*, 19:5, 1891.

Type on *Senecio bedfordii*, Victoria, Martin 461 in Herb. Kew.

Leafspots epiphyllous, greyish-brown, more or less confluent, irregularly rounded and bordered by a black margin about 1 mm. wide, the spots varying from 2 to 15 mm. diam.; surface smooth and dotted with the black punctiform pycnidia. Pycnidia subepidermal, immersed with only the apical pore penetrating the epidermis, black, globose, smooth, membranous, 60–100μ diam.; finally the epidermis often secedent together with the apex of the pycnidium, which is then left widely open. Spores fusoid, curved or straight, hyaline, 20–40μ × 3μ, transversely 3–9-septate, not constricted, smooth, mostly 15–25μ long, the ends attenuate-rounded. Conidiophores not evident.

The second collection mentioned by Cooke, on *Senecio* sp., Bass River, C. Walter, May 1891, contains only a species of *Phyllosticta*, with ellipsoid spores 6–8μ × 3μ; the leafspots are also smaller and of different appearance.

(251) SPHAEROPSIS PHOMATOIDEA Cooke & Mass., *Grevillea*, 18:49, 1890.

Type on leaves of *Eucalyptus* sp., Victoria, Martin 473, in Herb. Kew.

The only recognizable fungus on this specimen agrees with *Readeriella mirabilis* Sacc.; the Kew folder also contains a sketch by Cooke of the tetrahedral spores of this species, together with the "pale amber" ovate spores of "*Sphaeropsis phomatoidea*", roughly half the size of those of *Readeriella*, and also of elongate cylindric hyaline spores. The last were present in my own mounts from the specimen, but their origin could not be traced; no sign was found of the spores Cooke attributed to *S. phomatoidea*. Consequently the most that can be said of Cooke & Massee's species is that it is very doubtful, and until further collections can be obtained to match his description, the name must be abandoned.

(252) STAGONOSPORA ORBICULARIS Cooke, *Grevillea*, 20:6, 1892.

Type on dead leaf *Eucalyptus* sp., Lilydale, Victoria, Campbell 740, in Herb. Kew.

Leafspots rounded, about 3 mm. diam., flat, smooth, grey-brown, surrounded by a darker brown border zone about ½ mm. wide, sometimes confluent, each with a loose group of black punctiform pycnidia around the centre. Pycnidia immersed, globose, glabrous, with only the apical pore piercing the epidermis, about 150μ diam.; wall membranous, pale brown, darker around the apex, thin, parenchymatous. Conidia elongate fusiform with subacute ends, bent to strongly arcuate, 3–5-septate, very slightly constricted, hyaline, smooth, thin-walled, 50–70μ × 3–4μ.

The same fungus has recently been collected on *E. macrorhynchus*, Clare, S. Australia, WARI 4583, leg. P. Birks.

(253) CORYNEOPSIS MICROSTICTA (B. & Br.) Grove, *Journ. of Bot.*, 1932, p. 34.

On dead bark of *Cydonia japonica* ("Japanese Flowering Quince"), Stirling West, 7.1954, E. H. Ising, WARI 3886.

Acervuli at first completely immersed in the outer layers of the bark, finally the latter splitting and then the conidial mass becoming erumpent and resembling a black pycnidium. There is no outer wall around the conidial mass and the conidia do not form cirrhi. Acervuli up to 200μ diam., loosely scattered over large areas. Conidiophores forming a rather loose palisade, erect, hyaline, simple, continuous, about 15μ long by 1·5μ thick, forming single apical conidia. Conidia at first hyaline enlargements of the apex of the sporophores, soon becoming yellowish and finally light brown; mature conidia subfusoid, rounded at the apex, slightly truncate at the lighter base, transversely 3-septate, smooth, 12–17μ × 5–7μ; the septa dark and thick, the outer conidial wall collapsing somewhat between them.

(254) CYLINDROSPORIUM SAMUELI Hansf., n. sp.

Maculae epiphyllae, brunneae, haud secedentes, usque ad 4 mm. diam., rotundatae vel irregulares, brunneo-marginatae. Acervuli subepidermales, pauci, epiphylli, irregulares, usque ad 0·5 mm. diam., epidermide rupto expositi. Conidiophora ex stromate hyalino plano oriunda, erecta, 10–15μ × 1·5–2μ, stipata, simplicia, continua. Conidia terminalia, singula, filiformia, plus minusve curvata, basi rotundata vel leniter pedicellata, sursum attenuata, apice rotundata, hyalina, levia, transverse 3–4-septata, haud constricta, 60–95μ × 4–5μ, in massa albida vel luteola.

Hab. in foliis *Eucalypti* sp. indet., Pinnaroo, South Australia, 9.1924, G. Samuel, WARI 3840.

Leafspots usually only epiphyllous, sometimes showing below as indefinite brown areas, brown, not secedent, up to 4 mm. diam., rounded or irregular, surrounded by a dark brown, thin line. Acervuli subepidermal, few on each spot, epiphyllous, becoming exposed by the lifting and laceration of the epidermis, which is stained brown but contains little sign of fungus tissue, irregular in outline, up to 0·5 mm. diam.; in section showing a flat, rather thin, hyaline, stromatic base, which forms a close palisade of erect conidiophores, 10–15μ × 1·5–2μ, simple, hyaline, continuous, each producing a single terminal conidium. Conidia filiform, more or less bent, 60–95μ long, the base rounded or slightly pedicellate, about 3μ wide, the middle of conidium about 4–5μ thick, attenuate upwards to 2–3μ at the rounded apex, transversely 3–4-septate, not constricted, hyaline, smooth, white to yellowish in mass. The acervuli first appear as slightly darkened spots below the upper epidermis of the leafspot.

(255) GLOEOSPORIELLA EUCALYPTI Hansf., n. sp.

Acervuli amphigeni, *Pseudopeziza eucalypti* commixti, primo cuticula folii texti, demum erumpenti, orbiculati vel irregulares, usque ad 600μ diam. Sporophora nulla. Conidia hyalina, subcylindracea vel fusoidea, apice attenuato-rotundata et 1-setosa, prope basim 1-septata constrictaque, basi attenuata, ad septum 3-setosa. Setae flexuosae, hyalinae, usque ad 50μ × 1–1·5μ; corpus conidii circa 45μ longus, cellula superiore 35–40μ × 7–9μ, inferiore 7–10μ × 3–4μ.

Hab. in foliis *Eucalypti* spec. indet., Pinnaroo, South Australia, 9.1924, G. Samuel, WARI 3844 p.p.

Acervuli mixed with the apothecia of *Pseudopeziza eucalypti*, which represents the ascus-stage, on the same leafspots, amphigenous, similar in appearance to the apothecia when dry, covered at first by the blackened upper half of the epidermis, which soon lifts, ruptures irregularly and is finally secedent, exposing the layer of conidia. Young acervuli in section are seen to develop in or below the epidermis, which is filled in the upper part by a thin layer of black pseudoparenchyma, covered by the unaltered cuticle. Beneath this layer a thin stromatic plate of smaller parenchyma is formed, resting on the palisade tissue of the host, the lower layers being pale olivaceous, the upper ones hyaline and thin-walled. The uppermost layer of this basal stroma is conidiiferous, the conidia developing as outgrowths from the parent cells; there are no specialized conidiophores. Each conidium consists of a large, narrowly ellipsoid terminal cell measuring 35–40μ × 7–9μ, with attenuate-rounded ends, thin-walled, smooth, hyaline, surmounted by an apical seta which appears to be quite solid and measures up to 40μ × 1μ, straight or flexuous. At the base of this large cell there is a much smaller basal cell, somewhat obconoid in shape, hyaline, 7–10μ × 3–4μ, bearing around its apex, just below the large terminal cell, three divergent setae, which are flexuous, 40–50μ × 1–1·5μ, and appear to be hollow, as there is a faint central canal staining with cotton blue. Thus these sub-basal setae would represent very narrow and elongate conidial cells, as distinct from the solid apical seta. The whole body of the conidium measures about 45μ long; in the acervulus the sub-basal setae are arranged vertically in close contact with the large terminal cell, but after the conidia have dispersed these three setae become widely divergent. The whole conidium is thin-walled, hyaline and smooth.

(256) GLOEOSPORIUM NIGRICANS Cooke & Mass., *Grevillea*, 19:91, 1891.

On dead leaf of *Eucalyptus pauciflora*, Australian Alps, 1891, leg. Walker, in Herb. Kew, type.

Acervuli amphigenous, not on leafspots, closely scattered, black, slightly convex, 0·25 to 0·5 mm. diam., rounded, usually separate. The upper surface is at first covered by a layer consisting of the epidermal cells of the host, filled with black parenchyma of the fungus, at length splitting irregularly, without a distinct pore. Lower wall consisting of an outer layer of brownish parenchyma, lined inside with 2–4 layers of hyaline parenchyma, forming a thin stroma, on which a close palisade of erect, straight, simple, hyaline, continuous conidiophores is formed, 10–14μ × 4μ. Conidia single and acrogenous, ovate, hyaline, continuous, smooth, thin-walled, 8–10μ × 5–6μ.

(257) HYALOCERAS DILOPHOSPORA Cooke, *Grevillea*, 19:5, 1891.

Type on *Leptospermum scoparium*, Port Philip, Victoria, C. French, June 1890, in Herb. Kew.

Leafspots minute, scattered, epiphyllous, consisting of single dark acervuli, at first covered by the epidermis, rounded to slightly elliptic or elongate, convex, finally irregularly dehiscent in the centre, about 0·5 mm. diam. Conidia formed on very short conidiophores, which are borne on a very thin hyaline, gelatinous, stromatic base; single, terminal, fusoid, more or less bent, mostly 4-septate, the ends attenuate, not or very slightly constricted at one or more septa, very pale brownish in mass, subhyaline individually, 25–30μ × 4·5–5μ, the apex with 2 divergent, solid, hyaline setae about 10μ × 1μ, and the base with a single seta, set rather to one side.

(258) MELANCONIUM EUCALYPTICOLA Hansf., n. sp.

Maculae amphigenae, rotundatae vel irregulares, usque ad 20 mm. diam. vel confluentes, griseae, brunneo-marginatae. Acervuli subepidermales, erumpenti et epidermide rupto circumdati, atro-olivacei, usque ad 120μ diam.; strato basali tenuiter stromatico, olivaceo, sursum in conidiophora erecta, stipata, dilute olivacea vel subhyalina, usque ad 60μ × 2·5–3μ, simplicia, septata transeuns. Conidia acro-pleurogenea, singula, ovata, atro-brunnescentia, levia, continua, apice rotundata, basi subapiculata vel truncata, 5–7μ × 3–4μ.

Hab. in foliis *Eucalypti fasciculosae*, South Australia, 1924, G. Samuel, WARI 3846.

Leafspots amphigenous, rounded or irregular, up to 20 mm. diam. or confluent and larger, grey with a narrow dark brown border on the upper surface, on the lower side of the leaf the spot showing as a smaller grey area with wider brown margin. Acervuli subepidermal, soon rupturing the epidermis, which remains surrounding the margin, black to dark olivaceous, up to 120μ diam., consisting of a thin stromatic layer surmounting the palisade layer of the leaf and extended above into an erect close palisade of pale olivaceous to subhyaline conidiophores, of which the outermost are the oldest and longest. Conidiophores up to 60μ × 2·5–3μ, simple, closely septate, straight or undulate, forming conidia singly on short sterigmata of which one grows out from each of the upper cells from its apex, and remains after the conidium has shed as a slightly prominent scar. The terminal cell of the conidiophore often bears an apical conidium on a similar sterigma, though there is no evidence that the conidiophore grows past this to form others in succession, as conidia lower down the conidiophore may be of the same age or even younger than the terminal one. Conidia single, one from each of the upper cells of the conidiophore, ovate, soon turning dark olivaceous-brown, smooth, continuous, rounded at the apex and slightly apiculate or truncate at the base, 5–7μ × 3–4μ, the wall 0·5–0·75μ thick.

(259) Myxosporium acerinum Peck, *Bull. Torrey Bot. Club*, 36:338, 1909.

Acervuli closely scattered on twig, hidden beneath the bark, up to 150μ diam., becoming slightly conical and finally the conidia exuding from the ruptured bark in the centre, as a white to pale yellowish small mass. In section the acervulus is flat below, with a thin conidiiferous basal stroma, hyaline inside, the outer wall next the wood or within the cortex pale olivaceous; upper wall not complete, very thin, with no sign of a pore; the covering bark of the host is ruptured irregularly in the centre. Conidiophores only on the flat base of the acervulus and hardly distinguished as such, being mere prolongations of the upper stroma cells, cylindric, up to 15μ × 4–5μ, obtusely conoid at the apex, where single conidia are formed, not separated from the basal cell. Conidia hyaline, ellipsoid to cylindric with rounded ends, the base very slightly truncate-apiculate, continuous, smooth, thin-walled, with finely granular contents, 25–35μ × 9–12μ.

On dead twigs of *Acer* (? *rubrum*), Stirling West, South Australia, E. H. Ising, WARI 3845.

(260) Myxosporium coryleum (Sacc.) Died., *Krypt.-Fl. Mark Brandenb.*, 9:794, 1914.

On dead branches of *Corylus avellana*, Stirling West, South Australia, 8.1954, E. H. Ising, WARI 3897.

Pustules scattered loosely, immersed, white, up to 500μ diam. or more, raising and splitting the epidermis longitudinally along the branch. Sporophores erect, forming a close palisade, at first about 4–5μ thick and 10–15μ long, elongating and becoming narrower as the terminal spore matures, simple or once furcate at the base, arising from a rather thin, whitish, basal stroma. Spores hyaline, oblong with widely rounded ends, the base slightly apiculate in immature spores, thick-walled (1–1·5μ), straight, cloudy-granulose within or sometimes with a single large guttula, 26–33μ × 10–14μ.

(261) Bactridium flavum Kunze & Schmidt, *Mykol.*, Hefte 1:5, 1817.

On wood, Queensland, Bailey 593 in Herb. Kew.

Sporodochia loosely scattered, pale yellow to white, more or less hemispherical, 1–1·5 mm. diam., consisting of a solid mass of hyaline pseudoparenchyma, from which arise divergent, dichotomously branched conidiophores forming an almost solid palisade over the surface. Conidiophores hyaline, thin-walled, septate, to 180μ × 6–7μ, often swollen at apices to 9μ, smooth, not constricted at septa. Conidia elongate fusoid with rounded apex and truncate base, single and terminal on branches of conidiophore, which do not grow past the first conidium to form others, but branch from below; 160–180μ × 30–35μ, straight, sometimes very slightly constricted at one or more septa, rather thick-walled (2–2·5μ), usually 6-septate, the middle cells largest, quite smooth and hyaline under microscope, yellow to pale honey-coloured in mass; separating from conidiophore by evagination of the terminal septum of the latter, that of the conidium remaining plane. There is no vestigial "ring" around the base of the conidium as in *Diploidium*.

(262) Cephalosporiopsis parasitica Hansf., *Proc. Linn. Soc. Lond.*, 155:42, 1943.

Forming a thin white, loose, mouldy growth over the colonies of *Englerulella homalanthi*, Queensland, Bailey in Herb. Kew.

Hyphae hyaline, 2μ thick, septate. Conidiophores erect lateral branches on mycelium, straight or finely torulose towards apex, continuous, gradually attenuate to the open apex, functioning as phialides, each producing an elliptical head of 2–10 parallel conidia. Conidia hyaline, narrow fusoid, slightly bent, smooth, indistinctly 1-septate in middle, not constricted, ends rounded-attenuate, 9–12μ × 2μ.

(263) MACROSPORIUM PEPONICOLUM Rabh., *Isis*, 1867, p. 101.

The only Australian record is that of Cooke, *Handb. Austr. Fungi*, 1892, p. 381, based on Bailey 625, on fruit of *Carica Papaya*, Brisbane, Queensland, in Herb. Kew.

The fruit shows rounded, sunken, whitish areas, with others brownish, up to 20 mm. diam., without definite margin. The edges of these areas are covered with a brown-olive mouldy growth, which is probably not the cause of the diseased appearance; this growth is entirely that of *Alternaria tenuis*, sensu Bolle; no other spores of any kind were found on the specimen. This Australian record should therefore be deleted.

(264) SPORIDESMIUM DENSUM (Sacc. & Roum.) Mason & Hughes, *Canad. Journ. Bot.*, 31:618, 1953.

On dead wood of *Rhus* sp., Stirling West, 8.1954, E. H. Ising, WARI 3899, pr. p.

The fungus forms a dark olive-brown mould on the surface of the substratum, consisting of tufts of short erect conidiophores, each bearing a single terminal conidium. Conidiophores scattered singly or 3–6-fasciculate, erect, dark brown, simple, up to 50μ × 5–6μ, 2–4-septate and constricted at one or more septa, truncate, at the apex after the conidium has fallen off, leaving a very thin, hyaline, central scar, through which the conidiophore continues growth; no definite ring remains on the older conidiophores. Conidia fusoid, dark brown, rather suddenly narrowed to the flat, truncate base which is 4–5μ diam., widest in the lower third (to 12μ) and gradually attenuate upwards to about 3·5–4μ at the paler, rounded apex, straight or bent, thick-walled and dark brown below, the wall thinner towards the apex, smooth, up to 115μ long, transversely 13–20-septate, not constricted at any septa.

(265) SPORIDESMIUM MELANOPUS B. & Br., *Ann. Nat. Hist.*, no 455; Cooke, *Handb. Austr. Fungi*, 1892, p. 378.

On wood, Victoria, without locality or collector's name, in Herb. Kew; the wood has the appearance of Eucalyptus wood from a paling fence.

Colonies effuse, thin to dense, forming a superficial mouldy growth on the wood, black; hyphae in irregular strands on and in the wood, olivaceous, septate, much branched. Conidia erect, closely scattered, each terminal on a short erect lateral branch of the vegetative mycelium not differentiated as a conidiophore. Conidia subopaque black-brown, irregularly obclavate and attenuate above into a narrower portion, the surface closely and irregularly dark-verruculose; often bent, the base rounded and sessile on the very short "stalk", the apex attenuate-rounded, but usually muriform in mature conidia, unlike that of *Alternaria* spp.; mature conidia 60–110μ × 20–30μ in widest part, attenuate upwards to 10–15μ wide at apex, transversely multi-septate and with one or more longitudinal septa, constricted at many of the transverse septa.

(266) STEMPHYLIUM PULCHRUM (Berk.) Sacc., *Syll. Fung.*, 4:521, 1886.

= *Mystrosporium pulchrum* Berk., *Hooker's Journ. Bot.*, 1845, p. 70.

On rotten wood, Swan R., Western Australia, Drummond 270 in Herb. Kew, type.

Colonies covering the wood with a thin black growth, consisting of a subhyaline to pale olivaceous septate mycelium, bearing numerous conidia, each on a short lateral peg; the pegs are in groups of 1–5 on slightly swollen, subhyaline, terminal or intercalary cells of the mycelium. Conidia single and terminal on the peg, which is continued upwards into a very short stalk of the conidium, the stalk being shed with the conidium and leaving the peg still attached to the mycelium; conidia commence as a swelling of a single cell at the end of the stalk, dividing in all directions to form the mature conidium. Conidia when mature consist of 3–5 irregular chains of cells, often hardly recognizable as chains owing to distortion, dark olive-brown, rather thick-walled, subglobose but quite firmly joined together, each cell about 10–14μ diam., smooth or indistinctly granulose on outer surface; the whole conidium elongate ellipsoid to cylindric or quite irregular, up to 70μ × 25μ; smaller conidia are almost subglobose.

(267) CERCOSPORELLA HALORAGIDIS Hansf., n. sp.

Maculae epiphyllae, plerumque apicales vel marginales, rufae, zono luteo circumdatae, usque ad 2 mm. diam., in hypophyllo atrobrunneae. Conidiophora ex stomatibus folii dense fasciculati, in massa punicea; simplicia, continua, recta vel curvata, usque ad 30μ × 4·5μ, apice conidiifera. Conidia singula, filiformia, hyalina, in massa punicea, basi truncata, sursum attenuata, apice rotundata, circa 1·5μ cr., plus minusve curvata, usque ad 200μ × 3·5–4μ, multiseptata, haud constricta, levia.

Hab. in foliis *Haloragidis* spec. indet., Mt. Lofty, South Australia, 4.1954, Hansford, WARI 3789.

Leafspots on upper surface rather indefinite, usually terminal or marginal, bright red and surrounded by a yellowish zone; on the lower surface dark brown. Conidiophores emerging through the stomata from a stromatic sub-stomatal mass up to 60μ diam., consisting of pale salmon-coloured parenchyma, and bearing on the free surface above the stoma a tight palisade of conidiophores, also salmon-pink in mass; conidiophores hyaline, simple, continuous, straight or bent, up to 30μ × 4·5μ, bearing single conidia at the apex. Conidia filiform, more or less bent to flexuous, pale salmon in mass, hyaline individually, truncate at the base, gradually attenuate upwards into a very narrow and elongate apex about 1·5μ wide, up to 200μ × 3·5–4μ near the base, multiseptate, not constricted, smooth.

(268) ISARIA RADIANS Berk., *Flora Tasmania*, 2:271, 1860.

The type specimen in Herb. Kew, ex Herb. Berkeley, on wood of unknown plant, Tasmania, has the following characters:

Tufts 18–22 mm. diam., consisting of radiating synnemata from a common centre, now all flattened, but possibly more or less erect in fresh state, not associated with any gall on host; fawn in colour, slightly paler towards the tips, irregularly branched above and often dichotomous, forming a loose colony-mass, penicillate-divergent above, composed of parallel brownish-yellow hyphae, the brown dye soluble in lacto-phenol. The individual hyphae of the synnema become loosely divergent above and 1–2-verticillate branched towards the apex, each verticil consisting of 2–6 branches, these sometimes again verticillate. The ultimate branches are not phialiform, parallel or slightly divergent, hyaline, continuous, 12–20μ × 3μ, with the protoplasm condensed at base and apex, leaving a large vacuole in the middle; the apex slightly roughened with very slightly prominent circular conidial scars, on each of which a single conidium is formed; conidia adherent in globose heads at the end of each verticil of conidia-forming cells. Conidia ovate to elliptic, hyaline, smooth, thin-walled, continuous, 4–5μ × 2·5–3μ.

(269) DIDYMOBOTRYOPSIS ISINGII Hansf., n. sp.

Synnemata per rimas irregulares corticis erumpentia, massam botryosam albidam efformantia, usque ad 2 mm × 1 mm., vix prominentia; clavae divergentes, 400–600μ × 100μ, cylindraceae, apice rotundatae, firme carnosae, haud gelatinosae, albae, intus ex hyphis hyalinis, parallelibus, septatis, 1·5–2μ crassis compositae. Sporophora erecta, cylindracea vel phialiformes, hyalina, continua, 20–30μ × 3–4μ, saepe curvula. Conidia acrogenea, obovata, apice late rotundata, deorsum leniter attenuata, basi subtruncata, 1-septata, haud constricta, hyalina, levia, 6–8μ × 3–3·5μ.

Hab. in ramulis emortuos *Viburni opuli*, Stirling West, South Australia, 8.1954, E. H. Ising, WARI 3898.

Forms small white botryose masses erumpent through small irregular cracks in the bark, sometimes with a central stalk portion penetrating the bark, scarcely projecting above the surface of the substratum, up to 2 mm. × 1 mm. The clavae are divergent from a common stromatic base, 400–600μ × about 100μ diam., cylindric with rounded apex, firmly fleshy, not gelatinous, white, slightly mealy on the surface with the conidia. The interior of each clava is made up of more or less parallel, hyaline, septate hyphae, without clamp connections, somewhat interwoven, 1·5–2μ wide, irregularly branched below the surface and forming terminal and lateral sporophores which are more or less erect to the surface and form a close palisade. Sporophores cylindric to phialiform, hyaline, continuous, 20–30μ × 3–4μ, attenuate upwards to about 1·5μ, often bent, forming a single terminal conidium, and after this has been shed, often growing past its slightly prominent scar to form others in succession, so that the apex of an old sporophore shows a close series of slightly projecting lateral scars. Conidia formed each on a very short and narrow sterigma, which eventually breaks in the middle to leave part on the sporophore as the conidial scar, and the remainder as the thickened, truncate base of the conidium; obovoid, widely rounded at the apex, slightly attenuate downwards, 1-septate, not constricted, hyaline, smooth, thin-walled, 6–8μ × 3–3·5μ.

(270) HARPOGRAPHIUM QUATERNARIUM Cke. & Mass., *Grevillea*, 16:3.

On twigs of *Passiflora* sp., Brisbane, Queensland, Bailey 512 in Herb. Kew, type.

Synnemata in scattered tufts, radiating from a common base, brown to dark brown, paler towards the clavate and loosely penicillate tips, up to 0·5 mm. long; composed of parallel yellow-brown hyphae, septate, dense below and covered with minute brown granules; hyphae divergent and irregularly or sub-verticillately branched above, somewhat looser and divergent. Ultimate conidiiferous cells in verticils of 2–4, slightly divergent, cylindric, straight or slightly bent, up to 20μ × 2·5–3μ, not phialiform. Conidia single on minute sterigmata around the apex of the parent cell, the sterigmata about 2–3μ × 1μ, apparently solid when the conidium is mature, from 1–4 on each parent cell, disappearing entirely after the conidium has been shed, and not noticeable on the base of the shed conidium. Conidia fusoid, hyaline, continuous, smooth, straight, up to 10μ × 2–3μ, the ends attenuate-rounded, or the base more acute than the apex; the conidia commence as globose swellings of the ends of the sterigmata.

(271) CRYPTOCORYNEUM NEOLITSEAE Hansf., n. sp.

Maculae minutae, atrobrunneae, amphigenae, haud secedentes. Sporodochia hypophylla, singula in centro macularum, usque ad 200μ diam. et ad 120μ alt., erumpentia, atrobrunnea, pulvinata, parenchymatica. Conidiophora erecta, simplicia, 1–3-septata, dense stipata, atrobrunnea. Conidia singula, terminalia, brunnea, recta vel curvula, cylindracea, transverse 5–10-septata, haud constricta, levia, apice rotundata, basi subtruncata, 40–60μ × 7–8μ.

Hab. in foliis *Neolitseae dealbatae*, Cunningham's Gap, Queensland, Langdon 1622.

Leafspots minute, dark brown, showing on both surfaces, not secedent. Sporodochia hypophyllous, single in centre of leafspot, developing from a hyaline parenchymatous stroma in the mesophyll occupying most of the leaf thickness and including the remains of host cells; near the lower surface the stroma cells become brownish and finally grow out through the broken epidermis to form an irregularly pulvinate mass above the leaf surface, of dark brown parenchyma, the whole mass up to 200μ diam. and to 120μ high, appearing black. The outer stroma cells develop into short cylindric conidiophores, each consisting of 2–4 cells. Conidia single and terminal, cylindric, brown with slightly paler ends, straight or slightly bent, the apex rounded and sometimes clavulate, the base subtruncate, transversely 5–10-septate, not constricted, smooth, 40–60μ × 7–8μ.

COASTAL SANDROCK FORMATION AT EVANS HEAD, N.S.W.

By J. W. McGarity, University of Sydney.

(Plate v; one Text-figure.)

[Read 28th March, 1956.]

Synopsis.

Two extensive deposits of coastal sandrock are described. Chemical and physical properties of this material are compared with similar properties of nearby sandy podzol soils and the conclusion reached that the sandrock was an A horizon of a peat bog soil which formed during the last great glacial recession.

Benching of the deposit at the sea front forms a valuable record of the degree and progression of the Recent emergence, mainly as a result of the unique physical properties of the sandrock.

The widespread occurrence of "sandrock" in the coastal regions of southern Queensland and northern New South Wales has been known for many years, but Coaldrake (1955) recently redirected attention to these deposits as possible sources of evidence in the determination of Pleistocene and Recent eustatic sea movements.

Two extensive deposits of coastal sandrock found on the north coast of New South Wales are here described, and some indication given of their probable genesis and significance in the interpretation of the Quaternary history of the area.

Nature and Distribution of the Deposits.

The sandrock deposits occur as two discrete areas to the north and south of Evans Head on the Evans River (Text-fig. 1) where they underlie, in part, sandy coastal plains of Pleistocene and Recent origin similar to those described by David (1950). They have been briefly described by Stonier (1895).

Both deposits outcrop at sea-level on the ocean front forming low cliffs or a series of platforms, the highest of which are 15 feet above high water mark (H.W.M.). While the exposures are nowhere more than one chain in width, they extend for two miles as nearly horizontal beds.

Loose dune sand 5–30 feet deep overlies the upper surface of the outcrops forming unstable cliffs at the sea edge. These sands frequently contain thin, unconsolidated horizons of organic deposition.

The Gap Deposit.

The southern deposit near "The Gap" outcrops at the edge of a coastal plain which is bounded to the west and north by resistant hills of Jurassic sandstone and shale (Text-fig. 1). The sandrock rises 15 feet above H.W.M. as a massive, consolidated, but rather soft deposit with indistinct horizontal banding (Plate v, fig. 1). Three well-defined horizontal platforms can be recognized, the highest forming the upper surface of the sandrock with two lower levels at 8 feet and 12 feet 6 inches above H.W.M. Where erosion has not cut into and removed one or both of the lower levels, they retain a constancy in height and frequency of occurrence which enables them to be traced over the full length of the exposure (Plate v, fig. 2).

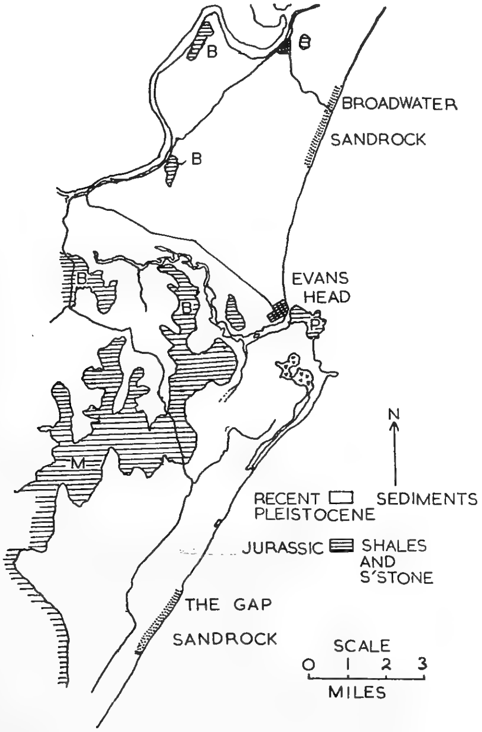
The deposit is overlain by dune sand of variable thickness.

The sequence listed below and shown in Plate v, figure 3 is typical of the Gap deposit passing through the unconsolidated deposits to sandrock at sea-level.

Bed	Thickness in feet. Minimum.	Maximum.
(1) Pale grey dune sand (A horizon)	½	1½
(2) White dune sand	4	30
(3) Shell bed (kitchen midden)	0	1
(4) White dune sand	2	4
(5) Grey humus dune sand (A horizon ?)	1	2
(6) White sand	0	1½
(7) Coastal sandrock	15*	15

* Extends a further 6 feet at least, below sea-level.

The grey humus dune sand (5) may directly overlie the sandrock. The shell bed (3) has only been found at one site.



Text-fig. 1.—Locality map showing sandrock deposits.

The Broadwater Deposit.

The northern deposit is associated with the large tract of stabilized sand running north of the Evans Head airstrip towards Broadwater. Although this deposit appears to be contemporaneous with that to the south, it is much dissected by wave action and the bench features observed in the Gap deposit are not seen. This is partly due to the presence of slightly compacted white sand, interposed between sandrock at 6 feet (this level is somewhat variable) and at 15 feet above H.W.M. (Plate v, fig. 4). The sand which attains a thickness of 8 feet shows darker bands of unconsolidated organic staining of varying width. It is apparent that a major time break in depositional conditions occurred and that large scale accumulation of organic matter when finally resumed, did not persist for any great length of time.

Variable depths of unconsolidated dune material similar to that overlying the southern sandrock deposit are found above the 15–16 foot level of the compacted organic layer.

Because the foregoing features indicate less uniformity in formation than the Gap deposit, further studies were not made on this deposit.

COMPOSITION OF SANDROCK AND RELATED DEPOSITS.

The coastal sandrock has been described by various workers under such names as painted sand, beach rock or black rock, the colour being attributed to either organic matter, or iron, or both.

At the Gap it is a medium-grained, soft and friable sandstone, the individual grains of which are cemented by organic matter. The mineralogical content is primarily quartz, but various resistant "heavy" minerals such as rutile, zircon, tourmaline, monazite, etc., are found in small amounts.

The colour is variable from dark brown (7·5 YR 3/1)* in the upper part of the bed to a very dark brown (10 YR 2/2) near sea-level. Bryan and Jones (1945) considered that colour was controlled by the intermixed organic matter. Both quantity and type would appear important.

TABLE 1.

Analytical Data for Sandrock and Associated Deposits.

Level. (Feet above H.W.M.)	Nature of Material.	Percentage Loss on Ignition.	Percentage Fe (HCl Extractable).
31	Grey humus dune sand (A horizon) ..	1·8	n.d.
30	Unconsolidated white dune sand ..	0·2	0·006
17½	Unconsolidated grey humus sand (A horizon ?)	2·3	n.d.
15	Brown peaty sandrock	68·0	0·009
12	Black sandrock*	19·0	0·015
12	Brown peaty sandrock	28·0	trace
0	Black sandrock	5·7	0·015
0	Black sandrock	5·0	n.d.

* Peaty material excluded from sample.

Under the microscope the individual grains of the darker sandrock are found to be coated with a continuous adherent "skin" of organic matter while the grains of the browner variety show a looser, patchy and somewhat flaky distribution of organic matter mainly concentrated at the points of contact.

Numerous small, highly humified roots up to half an inch in diameter are a common feature of the upper portion of the sandrock bed. Although some of the roots may have penetrated the sandrock after formation, the evidence of a vertically embedded tree trunk 7 feet below the upper surface proves the presence of large woody plants at the time of development.

These plant remains increase the variability of the organic matter content of the sandrock at the top of the deposit, so that the textural properties range from peat to peaty sand over distances of a few inches. The matrix of consolidated, sandy material contributes structural stability to the crumbly, humified material.

Below 8 feet from the upper surface, the sandrock becomes more homogeneous and the structure of plant material is no longer recognizable. A decrease in the organic matter content of bulk samples of sandrock collected from various positions down the deposit is shown in Table 1.

Many authors, e.g. Stonier (*op. cit.*), Ball (1924), have described iron staining of sandrock deposits, but in the samples from this locality the total iron is extremely low

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* Munsell Colour of air dry sample.

(Table 1). On ignition the sandrock burns to a loose white sand. Maze (1941) found somewhat similar results for thick organic hardpan deposits near Newcastle.

The exact nature of the sandrock in this locality is thus very much a function of the amount and kind of organic matter.

The analytical data for the unconsolidated material above the sandrock at the Gap are also tabulated. It is low in both iron and organic matter, but the values for the latter rise in the organic layers which are thought to represent soil A horizons. In the buried horizon immediately over the sandrock, small amounts of a white mineral adhere, as clay and silt sized particles, to individual unweathered quartz grains. These quartz grains are rounded and of smaller average diameter (·2 mm.) than in the sandrock (·4 mm.).

The dune sand has not been closely examined, but appears similar to that found elsewhere on the North Coast.

GENESIS OF THE GAP SANDROCK.

Coaldrake (*op. cit.*) lists three different types of coastal sandrock, viz. truncated "fossil" B horizons of former podsols, compressed peats and peaty sands, and compressed silty swamp deposits. The first problem, therefore, is whether the Gap deposits are A horizons or B horizons of former soils or perhaps a combination of both.

TABLE 2.

Analytical Data for Ground-water Podzols.

Profile Number.	Depth. (Inches.)	Colour.	Munsell Notation.	Percentage Loss on Ignition.	Percentage Fe (HCl Extract).
		Ground-water Podzol A1 Horizon.			
1149.1	0–6	Grey.	10YR 5·5/1	2·1	0·022
1148.1	0–6	Grey.	10YR 6/1	1·9	0·081
1147.1	0·6	Very dark greyish brown.	10YR 3·5/2	8·0	0·086
1146.A1	0–6	Grey.	10YR 4/1	7·8	0·027
1145.1	0–6	Dark grey.	10YR 4/1	11·6	0·059
		Ground-water Podzol B Horizon.			
1149.5	38–48	Very dark brown.	10YR 2/2	2·1	0·301
1148.4	24–48	Very dark brown.	10YR 2/2	1·7	0·521
1147.4	15–36	Very dark grey.	10YR 3/1	1·6	0·327
1145.3	11–26	Dark brown.	7·5YR 3/1	4·3	0·009
		Sandrock.			
Range	—	Dark brown. Very dark brown.	7·5YR 3/1 –10YR 2/2	68·0 –5·0	0·009 –0·015

The content and stage of decomposition of organic matter and the content and distribution of iron are the soil properties most likely to yield information on this subject. Accordingly, some comparisons of these particular properties of the sandrock with those of the organic surface and B horizons of ground water podzols forming at present in the area, have been made.

In Table 2 the iron contents of the B horizons of the podzols are shown to be generally higher than in the sandrock samples. However, the low value in the typical B horizon hardpan in sample 1145·5 from a heath swamp indicates that iron need not invariably be present in high amounts. Although Maze (*op. cit.*) found a sandy iron hardpan to be characteristic of freshwater swamps it appears that near Evans Head the iron content is not a good diagnostic property of soils formed under these conditions. The organic matter content (equivalent to loss on ingnition of the oven dry (105° C.) sample) appears to be a more useful indicator. Even though the organic matter is frequently quite high in the A horizons of these soils it is still far lower than the highest levels found in the sandrock. In the B horizons the amounts present are all lower, although in sample 1145, which is waterlogged for most of the year, the amount present does approach the lower values found in the sandrock.

These analytical results, though few in number, indicate that the upper sandrock at the Gap is unlikely to be either an A or B horizon of a groundwater podzol while closer to sea-level, on organic matter content alone, the possibility of either an A or B podzol horizon cannot be overruled.

The retention of cell structure of some of the original vegetation above the 8-foot level in the sandrock also indicates an A horizon of organic matter accumulation rather than colloidal movement and subsequent precipitation as expected in a B horizon. The gradual change in character and content of the organic matter with increasing depth, however, appears to be the result of greater decomposition and reprecipitation as indicated by the dispersed organic matter coating the grains of the sandrock at lower levels. This may have been due to either movement from the overlying horizon, in which case it would be classified as a B horizon, or possibly more favourable conditions of decomposition and precipitation *in situ* in the A horizon before or after burial.

The thin horizontal banding effects which extend through the full exposure are also suggestive of successive A horizon accumulation which could have scarcely survived the obliterating effects of organic matter decomposition, movement, and redeposition, associated with podzolization. The evidence therefore favours A horizon accumulations of Peat Bog soils ranging from a sandy peat in the upper part of the exposure to a peaty sand with increasing depth.

It follows that certain conclusions may be reached about the environment during the period of organic matter accumulation, and prior to the consolidation of the soil to sandrock.

There can be little doubt that a rising water-table was associated with this formation and that the rise must have continued for a long time—possibly thousands of years—for such a thick deposit to form. The lack of any well-defined breaks in the overall depositional pattern would indicate continued uniformity of conditions during this period.

Such conditions could result from two different physiographic situations, with peat formation in either (1) depressions or lakes at any height above sea-level where internal restriction of drainage by impervious layers favoured continued rise in the water-table, or (2) low-lying areas at sea-level where either positive eustatic sea movement or negative land movement gradually raised the water-table.

The field evidence points strongly to the second hypothesis. The uniformity of the depositional pattern of sand and organic matter in a horizontal distance of two miles implies a uniform rate of formation over the length of the deposit. It is less likely that such uniformity would prevail in depression situations above sea-level where wider water-table fluctuations might be expected. More significantly the constancy in level of the upper surface of the deposit reflects some sudden fall in the water-table level which arrested development and which could only be the result of large scale physiographic changes.

It is tempting, therefore, to suggest that the sandrock was built up during an eustatic sea rise and that the height of 15 feet above H.W.M. attained by this deposit correlates with the maximum sea height during the final stage of the last glacial recession.

Some additional information on the genesis of the deposit may be gleaned from the humified wood remains scattered through the sandrock above the 8-foot level. These have been identified mainly as *Agathis*, the evidence for this being included in a following paper (Bamber and McGarity, 1956).

The three living representatives of this genus in Australia are found in habitats where the water-table may be close to, but not immediately at the soil surface (L. S. Smith, priv. com.). It is thus suggested that *Agathis* forest communities may have fluctuated in development as the water-table fluctuated and that conditions suitable for the deposition of sand, and perhaps death of the trees, alternated with periods of forest re-establishment. Such a cycle of development could be the consequence of closely spaced but irregular rises in the water-table with intervening falls, and could explain the faint horizontal banding of the deposits.

If such were the case, then this deposit may have been formed in the interdune areas behind the littoral in situations similar to those in which *Agathis* forests are now found in south-eastern Queensland.

The Broadwater deposit, as indicated above, shows a break in the depositional pattern above the 6-foot level. The final layer of sandrock at approximately 15 feet, however, may be regarded as tentative evidence of the contemporary development of this deposit.

EROSION BENCHES.

Raised platforms are found at 15 feet, 12 feet 6 inches and 8 feet in the Gap deposit. While the upper platform is merely an effect of erosion on materials of differing hardness, the lower benches are the consequence of wave cutting.

It appears that the sandrock was sufficiently soft to record the Recent drop in sea-level and yet sufficiently hard to enable preservation of the platforms so formed, to the present day. Other dissected platforms may also be proved on more detailed investigation (e.g., at 4 feet above H.W.M.), but the evidence here is for sufficient check in the falling of the sea-level to produce only two major platforms.

This evidence would support the findings of other workers (*see* David, 1950) in Australia for Recent benching. It is inadvisable to attempt correlation of these levels with those found elsewhere until more precise methods of datum determination are available, but some relationship with the findings of Beasley (1947) for eustatic sea-levels in southern Queensland appears to exist.

UNCONSOLIDATED SAND DEPOSITS.

The deposits of dune sand immediately overlying the sandrock in both areas were apparently formed during the mid-Recent arid period and stabilized with the onset of wetter conditions. The dune sand is now being eroded, revealing organic matter horizons which suggests that temporary ameliorations of climate may have intervened during the period of accumulation.

The organic horizon (5) in the Gap deposit below the shell bed was an earlier deposit apparently close to the commencement of the arid period. The shell bed (an aboriginal kitchen midden) indicates the proximity to the sea, as well as the Recent age of the dune material. The sea front was evidently not very far to the east of its present position.

CONCLUSION.

Though the evidence and discussion in this paper is of a preliminary nature, it is hoped that attention will be drawn to the importance of palaeopedology as an aid in the elucidation of the Pleistocene and Recent chronology of the coastal sediments.

The study has indicated that the sandrock at the Gap is a former peat bog. A horizon formed under conditions of arrested decomposition associated with a rising water-table. This rising water-table is thought to be the consequence of a rising sea-level during the last glacial recession. If this is confirmed the overlying dune sands are of mid-Recent age and the past development of this part of the coast would appear very similar to the present.

Mainly through the unique physical properties of the sandrock, benching of the deposit at the sea front has occurred and this forms a valuable record of the degree and progression of the Recent emergence.

ACKNOWLEDGEMENTS.

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EXPLANATION OF PLATE V.

1.—The Gap. Sandrock (15 ft.) exposed at the sea edge. Note the horizontal banding.
2.—The Gap. Benching, showing levels at 12 ft. 6 in. (1) and 8 ft. (2) above H.W.M.
3.—The Gap. Sequence of unconsolidated and consolidated beds. The numerals (1-7) refer to beds as listed in text.
4.—Broadwater. Sandrock beds separated by unconsolidated sand.

A NOTE ON THE IDENTIFICATION OF PLANT REMAINS IN SANDROCK NEAR EVANS HEAD, N.S.W.

By K. Bamber, N.S.W. Forestry Commission, and J. W. McGarity,
The University of Sydney.

(Plate vi.)

[Read 28th March, 1956.]

Synopsis.

Specimens of wood from a coastal sandrock deposit near Evans Head, N.S.W., were identified as belonging to two genera, *Agathis* and *Eucalyptus*. The criteria of identification are described.

Since *Agathis* is not found naturally in New South Wales the significance of this occurrence is examined in relation to the distribution and habitat of present-day communities in Queensland.

Various workers (*see* David, 1950) have recorded the occurrence of plant fossils in the coastal sediments of Quaternary age in Eastern Australia. Usually these fossils are similar to plants now living in the area, a not unexpected finding in view of the wide range of growth conditions of many of these species.

At the Gap near Evans Head, N.S.W., coastal sandrock deposits contain an abundance of humified roots and aerial parts, particularly in the surface and subsurface of the beds. The identification of this fossil plant material was initially undertaken to provide indirect information on the environment at the time of sandrock formation.

Most of the material revealed structural properties of the Kauri pine genus, *Agathis*, which does not now occur naturally in N.S.W. The subject of this note, therefore, is a description of the specific characteristics of the material upon which the identification is based.

NATURE AND OCCURRENCE.

The sandrock at the Gap has already been described and the variability of the organic matter in content, and degree of decomposition, noted (McGarity, 1956). The less decomposed material in the upper portion of the sandrock frequently retains cell structure despite intense humification. This material comprises small roots up to 1 inch in diameter which can be removed by careful digging. Larger pieces of humified wood are occasionally found. These appear to be pieces of trunks and branches, and are more suitable for microscopic examination, particularly towards the interior of the specimens where decomposition is often less intense.

While it could be reasoned that much of the root and trunk material at the top of the sandrock may have been derived from vegetation growing above the deposit, the presence of roots and a large piece of vertically embedded wood, exposed on a wave-cut platform at a point 7 feet below the upper surface, leaves no doubt that this material at least was covered by the continued development of sandrock, either after or at the same time as growth. The large woody specimen, designated specimen A, is shown in Plate vi, figure 1.

This material was used for the description given below. Many other, more decomposed specimens above this level were examined microscopically, but these did not appear to differ appreciably, with one exception, from the described specimen.

The one exception, specimen B, from the upper surface of the sandrock is also described.

DESCRIPTION OF THE PLANT REMAINS.

Method of Examination.

As the samples were extremely fragile in the dry condition, they were soaked in glycerine and transverse, tangential longitudinal, and radial longitudinal sections prepared by hand with a safety-razor blade. These sections were mounted in glycerine and examined with microscope magnifications of 120 and 600.

Specimen A.

The large piece of wood from the 8 ft. platform (Plate vi, figure 1) had the field appearance of a tree stump. It was somewhat flattened with maximum dimensions of 14 in. in height × 12 in. × 5 in., with a tendency for division at the base (roots?). The wood was highly humified, dark brown to black in colour, very soft and fibrous, and fragments broken away with the fingernail left a woolly surface.

Under the microscope, the vertical wood elements were found to be tracheids. These were somewhat rounded in transverse section with thicker walled cells forming indistinct growth rings (Plate vi, figure 2).

In longitudinal section (Plate vi, figures 3, 4) the wavy walls of these tracheids were crowded with up to three rows of alternate, bordered pits and showed numerous resin plugs. In several sections all tracheids were blocked.

Uniseriate ray parenchyma up to 12 cells in height and numbering approximately 31 per sq. mm. showed distinct cross field pitting in radial section (Plate vi, figure 3). These pits, 2 to 9 per crossing, had oblique orifices. Ray tracheids were not observed. The ray cells contained abundant dark deposits which could have been resin, but the sections were extremely dirty, due to breaking away of fragments of cell walls, making positive identification difficult.

The major features of identification consist of the simple, basic wood structure of tracheids (Gymnosperm) with crowded, alternate pitting, the absence of resin canals and indistinct growth rings. This is typical of the Araucarineae. According to Dadswell and Eckersley (1935) it is possible to differentiate *Agathis* and *Araucaria*, members of this subfamily, by means of the wood structure. While species of *Agathis* can contain frequent or infrequent amounts of resin as plugs in tracheids, resin plugs are apparently always infrequent in *Araucaria*. The presence, therefore, of numerous resin plugs indicates that the humified material is *Agathis*.

The heavy deposits of resin in the specimen may in some way be related to a finding that conifers growing on peaty soils have increased accumulations of resin compared with those grown in normal situations (Anon., 1932).

It is impossible to identify to the species level with certainty, due to the decomposed nature of the material. However, the rays do not exceed 12 cells in height, which is a characteristic of *Agathis robusta* F.M.B. A microscopic comparison of sections of the humified material with authentic *A. robusta* showed almost identical features.

Root-like fragments from the 8-ft. level and above, although more decomposed, were structurally similar to the material described. The one exception already noted is described.

Specimen B.

This material from the upper surface of the sandrock was roughly rectangular, 3½ in. × ½ in. and barely ¼ in. thick, dark brownish-red in colour with distinct grain markings.

The vertical wood elements comprised parenchyma, vessels and wood fibres. The parenchyma cells were abundant and diffusely arranged with the moderately thick-walled resin-free wood-fibres. The vessels showed solitary arrangement with an average frequency of 9 per sq. mm. They were 150–300 microns in diameter and contained well developed tyloses.

Uniseriate, biseriate and triseriate arrangements of the squat ray cells were seen in radial section, the triseriate making up 15 per cent. of the rays. The frequency of the ray parenchyma was 33 per sq. mm., but many of these were collapsed and broken and the estimate is probably low. Cells of both xylem and ray parenchyma were filled with resin deposits.

The material showed the typical structure of *Eucalyptus* sp., the features of triseriate rays, paratracheal parenchyma, resin-free fibres and long rays would indicate, according to the classification of Dadswell and Burnell (1932), either *E. grandis* (W. Hill) Maid. or *E. saligna* Sm. Comparison with microscopic sections of these woods showed a close similarity.

PRESENT DISTRIBUTION OF AGATHIS.

Although it was impossible in both examinations to identify the exact species from the wood, the identification of the genus *Agathis* is itself of interest. No living representatives of this genus are known in New South Wales but three species are found to the north in Queensland. This indicates a southern extension of the genus during Quaternary times.

Of the three Queensland species, viz. *Agathis palmerstonii* F. v. M., *A. microstachya* and *A. robusta*, Mr. L. S. Smith, of the Botanic Gardens, Brisbane, has supplied the following information.

"*A. palmerstonii* and *A. microstachya* do not occur south of the Herbert River near Cardwell. Both of the above species grow in rain forest on the ranges and tablelands on well drained soils, usually associated with granites. Although occurring at altitudes of about 2,000 ft. or more, *A. palmerstonii* will occasionally follow the rivers down to about 250 ft.

"*A. robusta*, however, does occur in a type of rain forest on deep sandy soils between dunes only a few miles from the sea on the mainland just south of Fraser Island and probably in similar habitats on the island itself. These soils are porous and well drained, but presumably the roots are able to reach the water table. Free water does not occur at the surface."

It would appear, then, on the basis of habitat and distribution, that the tree stump and other remains are probably those of *A. robusta* communities which became established during periods when the peat swamps, from which the sandrock was formed (McGarity, *op. cit.*), were freely drained.

The absence of living *Agathis* from New South Wales suggests a retreat of the species possibly during the arid Recent period. Its failure to re-establish under the improved (?) present climatic conditions further suggests that in S.E. Queensland it may be a relic community surviving only in the most favourable situations.

The presence of *Eucalyptus* remains on the surface of sandrock could be the consequence of a change in the environment with invasion or replacement of the *Agathis* community, or merely material of more recent origin which may have penetrated the sand layers overlying the sandrock.

It is evident that the plant remains in this sandrock deposit are worthy of more intense investigation. The information obtained would no doubt shed more light on the environment of this period of Quaternary time, particularly if the age of the sandrock can be established with certainty by radiocarbon dating.

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EXPLANATION OF PLATE VI.

1.—Fossil wood (*Agathis*) on wave-cut platform, Evans Head, N.S.W.
2.—Transverse section of fossil *Agathis* showing growth ring of tracheids.
3.—Radial longitudinal section of fossil *Agathis*. Pitting of tracheids and ray parenchyma.
4.—Tangential longitudinal section of fossil *Agathis*. Resin plugs in tracheids.
Figs. 2, 3, 4, × 60 approx.

A REVISION OF *SAULOSTOMUS* WATERHOUSE AND DESCRIPTION OF A NEW RUTELINE GENUS (SCARABAEIDAE, COLEOPTERA).

By P. B. Carne, Division of Entomology, C.S.I.R.O., Canberra, A.C.T.

(Thirty-six Text-figures.)

[Read 28th March, 1956.]

Synopsis.

Saulostomus weiskei Ohaus, *collaris* (Blackburn) and *minicus* Lea are not considered by the author to be congeneric with *S. villosus* Waterh., the type species of the genus. These, and three newly described species (*excisus, norsemanae, halei*) form a distinct but closely related generic group for which the name *Eosaulostomus* is proposed. The female of *S. villosus* is described for the first time, a plesioallotype being designated.

Introduction.

Waterhouse (1878) proposed the genus *Saulostomus* for a single species (*villosus*). Ohaus (1904, 1935) subsequently described three additional species (*felschei, weiskei* and *striatus*), and Blackburn (1909) transferred to it his species *collaris* which he had earlier placed in the Dynastine genus *Aneurystypus*. Lea (1919, 1920) added the species *minicus* and *brunneoviridis*.

Although examples of neither *felschei* nor *striatus* have been examined, descriptions of these species and examination of material of the remaining species force the writer to the conclusion that only *brunneoviridis, felschei* and *striatus* can be considered as congeneric with the type species, *villosus*. The species *collaris, minicus* and *weiskei*, with the three new species herein described, form a distinct generic group for which the name *Eosaulostomus* is proposed. This generic division was foreshadowed by Blackburn, who wrote (1909): "I think it (*collaris*) must be regarded as representing an undescribed Rutelid genus, but it is so close to *Saulostomus* that it will be best to refer it to that genus provisionally. Its tarsi are evidently longer than those of *S. villosus* Waterh. (the type of the genus) but this appears to be the case also in some species which have been attributed to *Saulostomus* by Ohaus . . ."

The female of *villosus* has not been described, this sex being very rare in collections. One was obtained when the author reared field-collected larvae in the laboratory, and another was found among unidentified material in the Division of Entomology Museum, C.S.I.R.O., Canberra. The latter specimen has been designated as a plesioallotype.

The two genera may be distinguished as follows:

Dorsal surface bearing appreciable, sometimes conspicuous, vestiture; often with a metallic green lustre. Mandibles concealed beneath, or just level with margin of clypeus, the latter usually trapezoidal. Fore tibia with lateral teeth small and not deeply separated, confined to its distal half; tarsus short, stout, segments 1-4 together equal to or scarcely longer than segment 5. .... *Saulostomus* Waterh.

Dorsal surface glabrous or at most with sparse hairs near lateral margins of pronotum, without a metallic lustre except rarely on pygidium. Mandibles exposed or concealed beneath clypeus, the latter rounded. Fore tibia with sharp, deeply separated lateral teeth, extending on to its proximal half; tarsus slender, elongate, with segments 1-4 together much longer than segment 5. .... *Eosaulostomus*, gen nov.

Genus Saulostomus Waterhouse.

Saulostomus Waterh., 1878, *Trans. ent. Soc. Lond.*: 225. Ohaus, 1904, *Stett. ent. Ztg.* LXV: 68. 153. Carne, 1954, *Proc. R. ent. Soc.* (*B*) 23: 36.

Type species, *Saulostomus villosus* Waterh. (by monotypy).

Waterhouse's characterization of the genus reads as follows:

"Mentum narrowed at the insertion of the palpi, with the anterior margin truncate. Labium with the margin gently arcuate and not produced in the middle. Tarsi rather short and robust, the first four joints subequal, scarcely as long as broad, the first joint a little the longest. Claws simple. Antennae 10-jointed. Elytra with a membranous border."

Key to the species of the genus Saulostomus *Waterh.*[*]

1. Dorsal surface uniformly reddish-brown .... 2.
— Dorsal surface, especially of pronotum, with a metallic green lustre .... 3.
2(1). Elytral intervals smooth, impunctate, glossy. Distal fore tibial tooth conspicuously elongate. Length *c.* 11·5 mm. Qld. .... 1. *striatus* Ohaus
— Elytral intervals wrinkled, punctate, not glossy. Distal fore tibial tooth not notably elongate. Length 11-14 mm. N.S.W., Vic., Tas. .... 2. *villosus* Waterh..
3(1). Body clothed in yellow or reddish-yellow hairs; clypeus semicircular; basolateral pronotal angles rounded, disc closely punctate; pygidium with long erect hairs; 1st segment of hind tarsus almost twice length of 2nd. Length *c.* 12·5 mm. Aust. .... 3. *felschei* Ohaus
— Body clothed in white decumbent hairs, with some sparse erect pale yellow hairs on frons, sides of pronotum, elytra and pygidium. Clypeus trapezoidal; pronotum with basal angles well defined, disc rather sparsely punctate in middle; pygidium with both long erect and short decumbent hairs. Hind tarsus with 1st and 2nd segments subequal in length. Length 13-15·5 mm. N.S.W. .... 4. *brunneoviridis* Lea.

1. SAULOSTOMUS STRIATUS Ohaus.

Saulostomus striatus Ohaus, 1935, *Deutsch. ent. Ztg.*: 126.

The following is a free translation from the German description:

"Most closely related to *S. felschei* Ohs., a little smaller and more oval, both dorsal and ventral surfaces bright reddish-brown, shining, without metallic lustre; dorsally only the sides of the pronotum and the scutellum are covered with dense hairs, elsewhere the hair is sparse. Ventral surface and legs covered with long dense greyish-yellow hair. Clypeus with sides parallel, the edges black, emarginate; disc of clypeus and frons with large confluent punctures, vertex with smaller discrete punctures, these bearing short erect yellow hairs adjacent to the large eyes and behind the scarcely discernible clypeofrontal suture.

"Pronotum rather low convex, sides widened in the middle, anterolateral angles slightly produced, basolateral angles not rounded, with well defined basal ridge, without basolateral compressions. Surface with strongly impressed discrete punctures, mostly confluent at sides. Scutellum densely covered with close lying yellowish hair. Elytra with deeply impressed sutural striae, intervals impunctate, convex and hence brilliantly glossy, striae with small but deeply impressed punctures, many bearing short bristle-like hairs.

"Pygidium slightly convex, closely and finely scratched, slightly shining, covered with short decumbent greyish-yellow hairs, with long yellow bristle-like hairs at sides and apex. Abdomen with close lying hair, thorax and legs covered with longer and more erect grey hair. Legs strong, the three fore-tibial teeth evenly spaced, the apical tooth elongate and strong; claws simple.

"Antennae 10-jointed, club as long as shaft. Mouthparts poorly developed, labrum almost semicircular, apices of mandibles strongly narrowed, their basal teeth with only a few (4–5) furrows; maxilla with three movable bristles like those of *S. felschei*, the last segment of the palp a little thicker however; anterior edge of labrum equally as broad as base, projecting slightly forward in middle. Forceps quite similar to those of all other species of the genus, showing very few specific characters, as with most other species of the tribe.

"Length 11½, width 6 mm. Queensland, without precise locality."

2. SAULOSTOMUS VILLOSUS Waterhouse.

(Text-figs. 13, 21, 30.)

Saulostomus villosus Waterh., 1878, *Trans. ent. Soc. Lond.*: 225. Ohaus, 1898, *Stett. ent. Ztg.*, LIX: 39; 1904, *loc. cit.*, LXV: 154.

Waterhouse's description reads as follows:

"Clypeus pitchy-yellow, rather thickly and distinctly punctured, quadrangular, a little transverse, the margins reflexed, finely margined with brown. Thorax one-third

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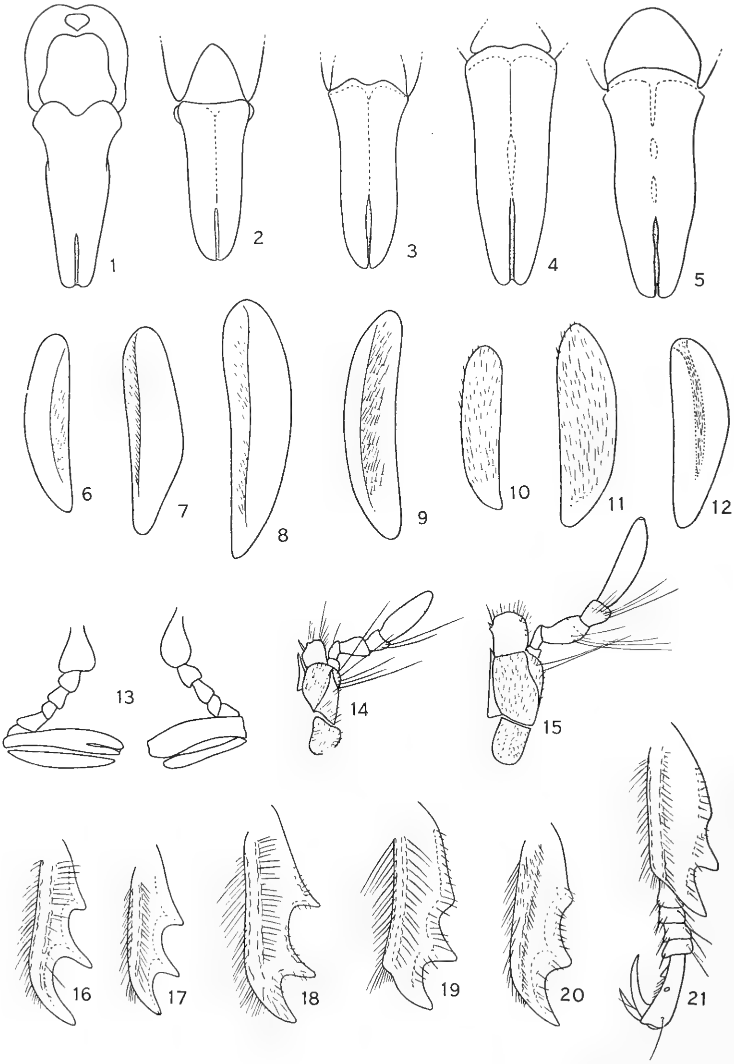
[*] Key characters for *striatus* and *felschei* drawn from original descriptions.

broader than long, convex, shining, clothed with long hair, not very thickly but rather strongly punctured, the sides gently rounded, the base sinuate on each side. Scutellum with a few punctures. Elytra with 4 pairs of striae, those at the sides rather obsolete, the surface of the interstices very uneven. The underside of the insect is clothed in



Text-figures 1-21.

1, *Eosaulostomus excisus*, sp. nov.: paratype ♂, genitalia, dorsal. 2, *E. collaris* (Blackb.): ♂ genitalia, dorsal. 3, *E. norsemanae*, sp. nov.: paratype ♂, genitalia, dorsal. 4, *E. weiskei* (Ohs.): paratype ♂, genitalia, dorsal. 5, *E. minicus* (Lea): paratype ♂, genitalia, dorsal. 6, *E. excisus*, sp. nov.: paratype ♂, left antennal club, inner face. 7, *E. collaris* (Blackb.): ♂, left antennal club, inner face. 8, *E. norsemanae*, sp. nov.: paratype ♂, left antennal club, inner face. 9, *E. halei*, sp. nov.: paratype ♂, right antennal club, inner face. 10, *E. weiskei* (Ohs.): cotype ♂, right antennal club, inner face. 11, *E. minicus* (Lea): cotype ♂, left antennal club, inner face. 12, *Saulostomus brunneoviridis* Lea: type ♂, left antennal club, inner face. 13, *S. villosus* Waterh.: ♀, antennae right and left (aberrant). 14, *Eosaulostomus excisus*, sp. nov.: paratype ♂, left maxilla, ventral. 15, *E. halei*, sp. nov.: paratype ♂, left maxilla, ventral. 16, *E. excisus*, sp. nov.: paratype ♂, left fore tibia. 17, *E. collaris* (Blackb.): ♂, left fore tibia. 18, *E. norsemanae*, sp. nov.: paratype ♂, left fore tibia. 19, *E. halei*, sp. nov.: paratype ♂, left fore tibia. 20, *E. weiskei* (Ohs.): cotype ♂, left fore tibia. 21, *Saulostomus brunneoviridis* Lea: type ♂, left fore tibia and tarsus.

long, thick pubescence. The points of the teeth on the anterior tibiae, and the spines on the legs are pitchy. Hab. Tasmania; Melbourne."

The following notes may be added to Waterhouse's description of the male: antennae with club longer than shaft, setose on inner face; ocular canthi exceptionally short and narrow; clypeofrontal suture transverse. Frons bearing setae on its anterior and lateral margins, with the disc almost glabrous in middle. Pronotum with anterolateral angles obtusely rounded, but with basolateral angles well defined, disc with a weak mediolongitudinal impression. Elytral intervals, as well as striae, with setiferous punctures. Pygidium clothed with both short decumbent, and much longer erect hairs. Fore tibia (Text-fig. 21) with lateral teeth evenly spaced, crowded into its distal half; tarsus short and stout, with segments 1–4 together scarcely longer than segment 5.

♀: compared with ♂, antennae much reduced, club much shorter than shaft (sometimes only 2-segmented, the 8th and 9th segments being partially or completely fused, as in Text-fig. 13). Pronotum more transverse, more convex, widest in anterior half, disc less abundantly clothed. Elytra dilated posteriorly; fore tibia with teeth more slender and acute: fore tarsus (Text-fig. 30) more slender, the larger claw distinctly toothed.

Plesioallotype ♀: 3 m. S.W. of Smithton, Tas., 7.1.48, K.H.L. Key and P. B. Carne. 3610. (Division of Entomology Museum, C.S.I.R.O., Canberra.)

Material examined: ♂♀, 12 m. N.W. of Adaminaby, N.S.W., coll. as larva, adult em. 15.11.48. P. B. Carne; ♂, Melbourne, G. F. Hill; ♂, Appollo Bay, Vic., Coghill 5.1.06; ♂, 16 m. SSW of Bonang, Vic., coll. as larva, adult em. 14.10.49. P. B. Carne; ♂, 13 m. S.E. of Nimmitabel, N.S.W., coll. as larva, adult em. 7.11.48, P. B. Carne; ♂, 4 m. ESE of Meeniyan, Vic., coll. as larva, adult em. 11.11.49, P. B. Carne; ♂, Yaouk, N.S.W., F.H.T. 1.31. (Division of Entomology Museum, C.S.I.R.O., Canberra.)

3. SAULOSTOMUS FELSCHEI Ohaus.

Saulostomus felschei Ohaus, 1904, *Stett. ent. Ztg.*, 65:156.

The following is a free translation from the German description:

"In appearance like a small metallic *Amblyterus cicatricosus* but differing in having simple claws on all legs, and in the structure of its mouthparts. Body cylindrical, slightly dilated posteriorly, considerably convex, dark reddish-brown ventrally, pronotum dark brassy green dorsally, less hairy than on ventral surface and legs, the hair long, reddish-yellow.

"Clypeus almost semicircular, evenly emarginate and with edge black, disc closely and coarsely wrinkled (also in frons), hair erect, head not glossy. Vertex more sparsely punctate and more shining. Mandibles more extended, the outer angles scarcely rounded, the distal tooth slightly so, basal tooth very small, only slightly pigmented. Last segment of maxillary palp long and spindle-shaped, apex truncate; chewing surface with sharp edges at sides and with 3 setae. Mentum more elongate, nearly square with rounded anterior angles, anterior margin slightly bent out.

"Pronotum strongly convex, slightly widened in middle, basolateral angles obtuse, anterolateral angles acute, slightly produced, surface closely punctate, the punctures bearing long yellow hairs. Scutellum with close fine punctures bearing long hairs at base, these becoming shorter posteriorly. Elytra glossy, slightly wrinkled, especially at sides, with long dense hair near apices.

"Pygidium finely wrinkled, glossy, with long dense hairs as on abdominal sternites; thorax and femora so densely clothed as to conceal their surfaces. Middle and hind tibiae bearing carinae with thorn-like ciliae, the surface posterior to these being strongly contracted. Fore tibiae with distal teeth very strongly developed, tarsi longer and more slender than in *villosus*, first segment almost twice as long as second. All claws simple.

"♂ length 12½, width 6 mm. New Holland."

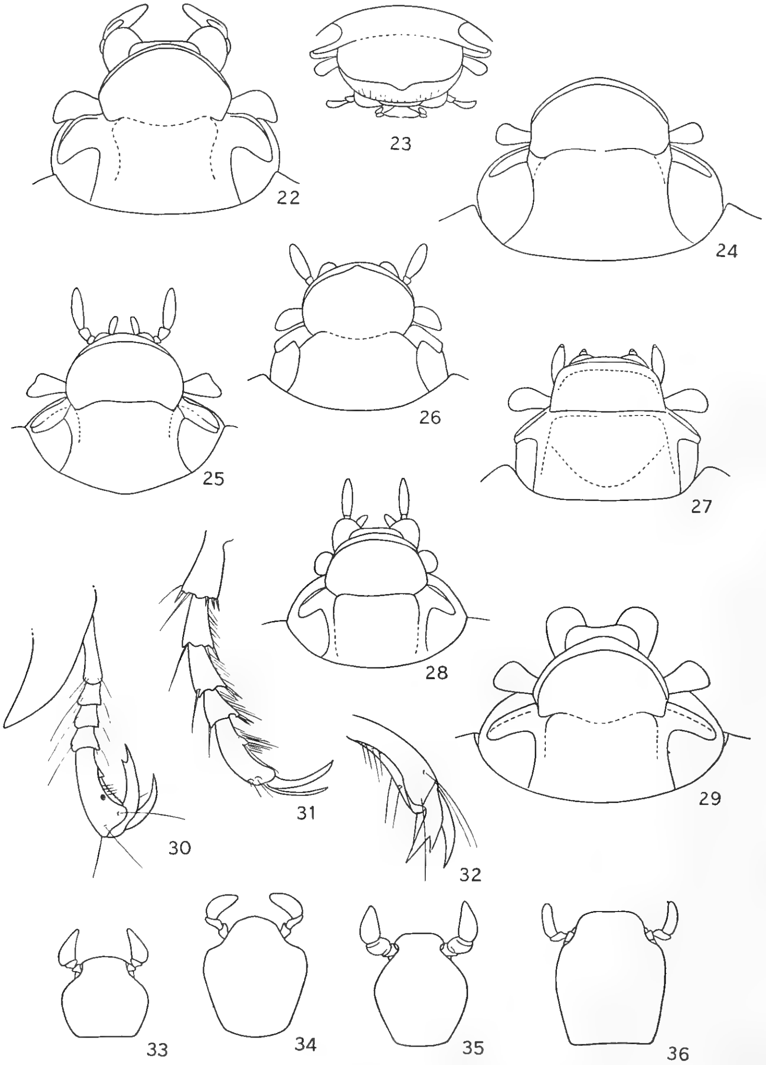
4. SAULOSTOMUS BRUNNEOVIRIDIS Lea.

(Text-figs. 12, 27.)

Saulostomus brunneoviridis Lea, 1920, Proc. Linn. Soc. N.S.W., 44:743.

Lea's description of this species is based on a single male. As the writer has examined additional specimens, a more comprehensive description is provided.

♂: Length 13–15·5 mm., body with conspicuous decumbent, almost adpressed, white setae. Head and pronotum metallic green, becoming brownish-green at sides of latter, or a uniform deep reddish-brown with a green lustre; elytra deep brown with a variable greenish lustre. Mandibles just visible in front of clypeus, the latter (Text-fig. 27) short, transverse, trapezoidal, with coarse confluent punctation, its anterior truncated face glabrous; clypeofrontal suture distinct, transverse. Frons with erect short pale yellow setae on disc and ocular margins. Antennae (Text-fig. 12) with club setose



Text-figures 22-36.

22, *Eosaulostomus halei*, sp. nov.: paratype ♂, head, dorsal. 23, *E. excisus*, sp. nov.: paratype ♂, head, anterior. 24, *E. weiskei* (Ohs.): ♂, head, dorsal. 25, *E. minicus* (Lea): ♂, head, dorsal. 26, *E. excisus*, sp. nov.: paratype ♂, head, dorsal. 27, *Saulostomus brunneoviridis* Lea: type ♂, head, dorsal. 28, *Eosaulostomus collaris* (Blackb.): ♂, head, dorsal. 29, *E. norsemanae*, sp. nov.: paratype ♂, head, dorsal. 30, *Saulostomus villosus* Waterh.: ♀, fore tarsus (right). 31, *Eosaulostomus halei*, sp. nov.: paratype ♂, hind tarsus (right). 32, *E. weiskei* (Ohs.): cotype ♂, claws of left fore tarsus of cotype. 33, *E. excisus*, sp. nov.: paratype ♂, mentum. 34, *E. norsemanae*, sp. nov.: paratype ♂, mentum. 35, *E. halei*, sp. nov.: ♂, paratype, mentum. 36, *E. weiskei* (Ohs.): ♂, mentum.

only on median zone of inner face, elsewhere smooth and shining, equal to or slightly shorter than shaft.

Pronotum widest on anterior half, basolateral angles well defined, basal ridge usually obsolete in middle, anterior ridge thickened; disc with strongly impressed but not very numerous punctures, these bearing decumbent white setae except on median longitudinal third which bears a weakly impressed line. Scutellum with white setae at base, disc smooth, with a variable submarginal garland of punctures. Elytra lacking distinct striae, surface irregular, with semidecumbent white setae borne in shallow punctures; epipleurae with fine membranous border and with pale yellowish-brown setae extending to apices of elytra. Fore tibiae stout, with segment 5 considerably shorter than segments 1–4 together; claws long, slender and unequal. Hind legs slender; tibiae bicarinate, bearing short sharp ciliae, spurs blunt and tapering; tarsus with segment 5 the longest and strongly notched on lower surface; claws, when retracted, extending to mid-point of segment 4.

Abdominal sternites with transverse rows of white setae. Pygidium flat, tapering, vertical, with setae patterned down mid-line, with sparse long pale yellowish-brown hairs on and behind apical ridge.

Material examined: Type ♂, Hunter R., N.S.W. (S. Aust. Mus.); 2 ♂♂, Upper Hunter (Aust. Mus.); 2 ♂♂, Hunter R.; 2 ♂♂, Murrurundi (Macleay Mus.).

Genus EOSAULOSTOMUS, gen. nov.

Type species, *Eosaulostomus excisus*, gen. et sp. nov.

Concolorous reddish-brown species of small to medium size (11–16 mm. in length), rarely with greenish tinge on pygidium. Mandibles simple, either exposed or concealed beneath rounded clypeus. Maxillae (Text-figs. 14, 15) with small untoothed galeae, palps slender and elongate; mentum variable (Text-figs. 33–36). Antennae 10-segmented, club at least as long as shaft, setose on inner face. Clypeus rounded, emarginate, with transverse clypeo-frontal suture. Pronotum low convex, glabrous. Elytra with poorly defined striae, intervals punctate; epipleurae with abundant lateral setae and membranous ventral border. Legs dynastoid; fore tibia with spurs reduced or lacking, lateral teeth strongly developed, not confined to its distal half; hind tibia bicarinate; tarsus with segments 3 and 4 armed with stout spines, 5 notched on middle of lower surface.

Eosaulostomus differs from *Saulostomus* in characters given in the key above; from *Clilopocha* Lea it differs in its quite characteristically Ruteline mouthparts, lack of elytral vestiture and much greater degree of claw asymmetry.

Key to the species of the genus Eosaulostomus, *gen. nov.*

1. Mandibles exposed beyond margin of clypeus; antennal club with inner face not wholly setose .... 2.

— Mandibles concealed beneath clypeus; antennal club with inner face wholly setose .... 5.

2(1). Clypeus smooth, shining, with shallow punctation; clypeofrontal suture obsolete in middle; mandibles and labrum only slightly exposed; pronotum with disc setose near anterolateral angles. Fore tibia (Text-fig. 16) not bearing small setae between teeth. Length 11-13 mm. S. Aust. .... 1. *excisus*, sp. nov.

— Clypeus rugulose, dull; clypeofrontal suture usually discernible or forming a distinct transverse ridge; mandibles and labrum strongly exposed. Fore tibiae bearing small setae between teeth. .... 3.

3(2). Antennal club with inner face setose only on extreme margin (Text-fig. 7). Pronotum evenly rounded at sides; fore tibia with teeth evenly spaced (Tex-fig. 17). Length *c.* 11 mm. W. Aust. .... 2. *collaris* (Blackb.), comb. nov.

— Antennal club with setose zone occupying ⅓ to more than ½ width of segment ...... 4.

4(3). Sides of pronotum not contracted behind anterolateral angles; setose area on inner face of antennal club confined to lateral third; fore tibial teeth unevenly spaced (Text-fig. 18); labrum concave (Text-fig. 29); scutellum coarsely punctate. Pygidium with sparse long hairs. Length 13-15 mm. W. Aust. .... 3. *norsemanae*, sp. nov.

— Sides of pronotum contracted behind anterolateral angles; setose area on inner face of antennal club occupying lateral ½ to ⅔; fore tibial teeth evenly spaced (Text-fig. 19); labrum transverse (Text-fig. 22); scutellum finely punctate. Pygidium with abundant long hairs. Length 11-14 mm. S. Aust. .... 4. *halei*, sp. nov.

5(1). Clypeus very flat, slightly emarginate anteriorly; clypeofrontal suture not impressed; antennal club exceptionally slender (Text-fig. 10); pronotum with basal ridge obsolete across middle. Length 14-16 mm. Qld. .... 5. *weiskei* (Ohaus), comb. nov.

— Clypeus moderately concave, strongly emarginate at sides and front; clypeofrontal suture impressed, antennal club broad (Text-fig. 11); pronotum with basal ridge continuous. Length 13-16 mm. Qld. .... 6. *minicus* (Lea), comb. nov.

1. EOSAULOSTOMUS EXCISUS, sp. nov.

(Text-figs. 1, 6, 16, 23, 26, 33.)

♂: Concolorous reddish-brown species, 11–13 mm. in length. Thorax, legs and abdominal sternites with very abundant long yellow hairs. Antennae setose on half of inner face of club (Text-fig. 6) and on segments 1–5. Apices of mandibles evenly rounded, labrum visible beyond clypeus, the latter rounded (Text-fig. 26), strongly emarginate and with a moderately deep truncated face; anterior margin of clypeus depressed or excised in middle (Text-fig. 23), disc with sparse, shallow punctation; clypeofrontal suture obsolete across middle. Ocular canthi well developed; frons coarsely and concentrically punctate. Maxillary palps slender, segments 3 and 4 conspicuously setose.

Pronotum low convex, widest in anterior half, anterolateral angles obtuse, basal angles rounded, basal ridge continuous or interrupted in middle; disc with shallow punctures and vague median impunctate stripe, the surface setose at sides, especially near anterolateral angles, rarely across anterior margin. Scutellum with exposed portion glabrous on posterior half. Elytra with discernible striae, surface shining. Fore tibia (Text-fig. 16) slender, acutely tridentate, lacking setae between the evenly spaced teeth. Tarsus slender, with segment 5 longer than segment 1. Hind tibia bicarinate, intercarinal regions glabrous. Ciliae short and closely set, spurs slender, tapering. Hind tarsus with segment 1 equal to or longer than segment 5, slightly dilated.

Pygidium moderately convex, abundantly setose. Genitalia as in Text-figure 1.

Types: Holotype ♂ and 11 paratype ♂♂, Reevesby Is., Sir Joseph Banks Group, S. Aust., coll. J. Clark (McCoy Soc. Expedition, Dec. 1936–Jan. 1937). (National Mus., Melbourne); 5 paratype ♂♂, Port Noarlunga, S. Aust., C. J. Hackett (S. Aust. Mus.). (7 Paratypes retained for Division of Entomology Museum, C.S.I.R.O., Canberra, and for distribution to British Museum, W. Australian Museum and Australian Museum, Sydney.)

2. EOSAULOSTOMUS COLLARIS (Blackburn), comb. nov.

(Text-figs. 2, 7, 17, 28.)

Aneurystypus collaris Blackb., 1892, PROC. LINN. SOC. N.S.W., (11) 7:286.—*Saulostomus collaris* (Blackb.), Blackb., 1909, *Trans. R. Soc. S. Aust.*, 33:80; Carne, 1954, *Proc. R. ent. Soc.* (B), 23: 36.

This species is closely related to *excisus*, differing in the following respects: antennae with setiferous zone much less extensive, rarely occupying more than quarter of inner face of club (Text-fig. 7); mandibles and labrum more exposed (Text-fig. 28), the latter rather truncated. Free margin of clypeus not depressed or excised in middle, disc finely wrinkled; clypeofrontal ridge distinct.

Pronotum with sides evenly rounded, quite glabrous dorsally; elytral punctures finer; fore tibial teeth (Text-fig. 17) less acute, the distal tooth less produced; tarsus more slender. ♂ genitalia as in Text-figure 2.

Type locality: Eyre's Sandy Patch, W.A. (on Bight near S. Aust. border).

Type in British Museum.

Material examined: ♂, Eyre's S.P. (in Blackburn's handwriting); 3 ♂♂, Eucla, 3 ♂♂, S. Aust. (S. Aust. Mus.).

3. EOSAULOSTOMUS NORSEMANAE, sp. nov.

(Text-figs. 3, 8, 18, 29, 34.)

♂: Concolorous reddish-brown species, 13–15 mm. in length. Closely related to *E. halei*, sp. nov., differing in the following respects: antennal club (Text-fig. 8) longer than shaft, with setose zone occupying lateral third of inner face of club; labrum markedly concave in outline; clypeus (Text-fig. 29) rounded from extreme base, disc rather depressed; clypeofrontal ridge distinct, transverse.

Pronotum with sides evenly rounded. Scutellum with distinct, strongly impressed punctures smaller than those of elytra; fore tibia (Text-fig. 18) with distal tooth more produced. Fore tarsus with segments 1 and 5 of equal length; hind tibia with intercarinal regions heavily punctate, spurs acute; pygidium with punctures more conspicuous, transversely distorted and arranged somewhat concentrically. ♂ genitalia as in Text-figure 3.

Types: Holotype ♂ and 8 paratype ♂♂, Norseman, 1.07; 2 paratype ♂♂, Norseman, 11.05, L. Vincent. (National Mus., Melbourne.) (6 Paratypes retained for Division of Entomology Museum, C.S.I.R.O., Canberra, and for distribution to British Museum, S. Aust. Museum, W. Aust. Museum, and Australian Museum, Sydney.)

Norseman is a small town situated approximately 110 m. S. of Kalgoorlie, W. Aust.

4. Eosaulostomus halei, sp. nov.

(Text-figs. 9, 15, 19, 22, 31, 35.)

♂: Concolorous reddish-brown species, with edges of tibiae, mandibles, clypeus etc. black, 11–14 mm. in length. Coxae, abdomen and pygidium clothed in long brownish-yellow hairs.

Antennal club (Text-fig. 9) longer than shaft, lateral half to two-thirds of inner face of club and segments 1–4 setose. Mandibles and labrum strongly exposed, the latter truncate or very slightly concave in outline. Clypeus (Text-fig. 22) with sides straight, parallel or more often diverging slightly at base, then rounded; disc flat, emarginate, finely wrinkled; anterior truncated face coarsely punctate. Ocular canthi angulate; clypeofrontal ridge elevated, trisinuate; frons concentrically rugose.

Pronotum glabrous, widest in anterior half, anterolateral angles not acute, basal ridge continuous; disc low convex, with large but shallow punctures becoming confluent at sides, with a weakly impressed median line impunctate on posterior two-thirds, and with slight depressions on either side behind anterior margin. Scutellum almost impunctate on exposed portion. Elytra with surface slightly microreticulate, punctures minute. Fore tibia (Text-fig. 19) moderately strongly tridentate, the teeth evenly spaced, spur lacking; tarsus with segment 1 much shorter than segment 5. Hind tibia with intercarinal regions punctate, slightly setose; ciliae sharp and closely set, spurs blunt. Tarsus (Text-fig. 31) with segments 1 and 5 equal in length.

Types: Holotype ♂ and 3 paratype ♂♂, Owiendana, N. Flinders Range, Hale and Tindale (S. Aust. Museum). (2 paratypes retained for British Museum and Division of Entomology Museum, C.S.I.R.O., Canberra.)

5. Eosaulostomus weiskei (Ohaus), comb. nov.

(Text-figs. 4, 10, 24, 35, 36.)

Saulostomus weiskei Ohaus, 1904, *Stett. ent. Ztg.*, 65: 157.

Concolorous reddish-brown species, 14–16 mm. in length. Coxae and abdomen with dense brownish-yellow hairs.

♂: Labrum concealed, apices of mandibles just visible in front of broad strongly rounded clypeus, the latter (Text-fig. 24) with short glabrous truncated face, sides weakly emarginate. Clypeofrontal suture subobsolete across middle, curved somewhat anteriorly; disc of clypeus confluently punctate, frons less heavily so. Ocular canthi slender; antennal club as in Text-figure 10.

Pronotum broadest in anterior half, low convex; shining; anterolateral angles blunt, anterior ridge thickened in middle, basal ridge obsolete across median third, disc sparsely and finely punctate, with a slightly depressed impunctate median stripe. Scutellum with patches of fine punctures at sides. Elytral disc with irregular striae of small lightly impressed punctures. Fore tibia (Text-fig. 20) rather strongly tridentate, spurs extremely small; tarsus elongate, segment 1 somewhat longer than segment 5. Hind legs slender: tibia with large setiferous intercarinal punctures, ciliae small, fine and closely set, spurs short and tapering; tarsus with segment 1 equal to or slightly shorter than segment 5.

Pygidium slightly convex, with fine somewhat concentrically arranged irregular punctures, and numerous small fine decumbent setae on disc and with longer yellowish-brown hairs behind apical ridge; the latter itself setose. ♂ genitalia as in Text-figure 4.

♀: Eyes smaller than those of ♂, antennae smaller although with club equal in length to shaft. Vestiture of abdomen, thorax and legs much reduced, pygidium bearing only sparse short setae. Middle and hind tibiae without intercarinal setae; tibial spurs very short and blunt.

Ohaus refers to sparse hairs being borne on the head, and to the pygidium sometimes having a weak coppery sheen. Neither of these characters is discernible on any of the 5 examples seen. He also states that the anterior claws of the ♂ are toothed, but in the 4 ♂♂ examined, only the right tarsus (Text-fig. 32) of a cotype has a claw showing such a structure, the left claw and those of the other ♂♂ examined being quite smooth and tapering.

Type locality: North Queensland.

Type: location unknown.

Material examined: ♂, Ravenshoe, N.Q., March 1921 (S.A. Mus.); cotype ♂, N. Qld., E. Weiske; N. Qld., comp. with type, K. M. Heller, 1914; Australia; Herberton, N.Q., F. P. Dodd. 1.11.1911 (Brit. Mus.).

6. EOSAULOSTOMUS MINICUS (Lea), comb. nov.

(Text-figs. 5, 11, 25.)

Saulostomus minicus Lea, 1919, *Trans. R. Soc. S. Aust.*, 43: 247.

♂: Concolorous reddish-brown species, 13–16 mm. in length. Thorax, legs and abdomen with abundant long yellowish hair. Mandibles almost quite concealed beneath clypeus, the latter (Text-fig. 25) strongly and evenly rounded, strongly emarginate, with the disc flat and coarsely, evenly punctate, clypeofrontal suture not impressed, transverse or somewhat anteriorly arcuate. Ocular canthi well developed. Antennae with club (Text-fig. 11) setose over entire inner face and longer than shaft.

Pronotum highly transverse, anterolateral angles acute, sides evenly rounded, basal ridge continuous, disc glabrous, abundantly punctate, confluently so at sides but sparsely so along median line. Scutellum punctate, glabrous on exposed portion; elytra with discernible striae, surface shining. Fore tibia strongly tridentate, spurs lacking, teeth evenly spaced; tarsus slender, with segments 1 and 5 equal in length. Hind tibia glabrous on intercarinal regions, but setose proximal of basal carina; ciliae slender and sharp, spurs short, slender and blunt; tarsus with segment 1 equal to or shorter than segment 5. ♂ genitalia as in Text-figure 5.

Type locality: Cunnamulla, Qld.

Type: in S. Aust. Museum.

Material examined: cotype ♂, Cunnamulla, Queensld., H. H. Hardcastle (Brit. Mus.); 2 ♂♂, Cunnamulla, H. Hardcastle (Division of Entomology Museum, C.S.I.R.O., Canberra); 2 ♂♂, Cunnamulla, H.H. (S. Aust. Mus.).

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RESISTANCE TO *PUCCINIA GRAMINIS TRITICI* IN KHAPSTEIN, A *VULGARE* DERIVATIVE of KHAPLI EMMER.

By D. S. Athwal and I. A. Watson, The University of Sydney.

[Read 18th April, 1956.]

Synopsis.

The results of studies with Khapstein, a stem rust resistant *vulgare* derivative of Khapli emmer, are reported. The mode of inheritance was studied and the relationship of this resistance to that of Marquillo, Thatcher, Hochzucht, Kenya 744 and Kenya 117A was found. Khapstein appears to be a useful source of resistance to the Australian stem rusts since it crosses readily with common wheats.

Introduction.

The availability of an effective source of resistance to *Puccinia graminis tritici* is basic to breeding programmes aimed at the development of rust resistant varieties. It is now well recognized that the extreme variability shown by this pathogen can be combated most effectively by varieties whose genes for resistance have come from diverse and unrelated sources. Khapli emmer provides genes which are unlike those used previously in breeding stem rust resistant bread wheats and, moreover, these genes appear to be effective against all but a few of the hundreds of races that occur throughout the world.

Although the resistance of Khapli has been known for many years, there have been difficulties in transferring this character to *vulgare* wheats. As a result of studies made over a period of twenty years at the University of Sydney, Steinwedel has been found useful for successful crosses with Khapli (Waterhouse, 1930, 1933, 1952). One selection from Waterhouse's crosses, a Steinwedel × Khapli cross, has been provisionally registered as Khapstein. The selection was made mainly on the basis of resistance to stem rust. Hence it is unlikely to be a commercial success, since it has several undesirable agronomic characters. In New South Wales, under severe rust epidemics involving all known local races and biotypes, Khapstein has shown a valuable resistance. From glasshouse tests seedlings and adult plants were found to be resistant to all stem rusts occurring in Australia. As it is used extensively in breeding, the present investigations were undertaken to determine the mode of inheritance of stem rust resistance. The crosses were planned so that a study could also be made of any relationship that might exist between the genes of Khapstein and those already identified by the writers (1954, 1955) in Kenya 744*, Kenya 117A 1347, Marquillo 724, Thatcher 1201, and Hochzucht 1227.

Review of Literature.

Hayes and Stakman (1922) obtained unsatisfactory results from their attempts to cross Khapli with Marquis. Hynes (1926) reported a successful cross between Federation and Khapli and he interpreted the results on the basis of multiple factors for stem rust resistance. Similar conclusions were drawn by Aamodt (1927) as a result of crosses between Khapli and a *durum* wheat. Waterhouse (1930) in Khapli × *durum* crosses obtained results which indicated that the resistance of Khapli was dependent on two dominant factors. In Khapli × *vulgare* crosses Waterhouse (1930, 1933, 1952) used more than 300 varieties and found that the compatibility with Khapli depended on the variety. Steinwedel was among a group of varieties that gave F_1 plants from which fertile lines could ultimately be selected. One of his lines having the stem rust resistance of Khapli and previously referred to as K.D. 1451 (Watson and Singh, 1952) has now been named Khapstein.

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* Varieties carry the Sydney University Accession Number.

Materials and Methods.

The present investigations with Khapstein are a continuation of the inheritance studies on Marquillo, Thatcher, Hochzucht, Kenya 744 and Kenya 117A reported earlier (Athwal and Watson, 1954, 1955). Various generations of material of the following crosses, all of which involve Khapstein as one of the parents, were used: Federation 107 × Khapstein 1451; Khapstein 1451 × Hofed 1200; Marquillo 724 × Khapstein 1451; Thatcher 1201 × Khapstein 1451; Hochzucht 1227 × Khapstein 1451; Kenya 744 × Khapstein 1451; Kenya 117A × Khapstein 1451.

The characters of seven of these parents have been previously described by the writers. The spike of Khapstein (Steinwedel × Khapli) is awnleted, clavate and compact; the glumes are glabrous and brown and the kernels white and long. It is resistant to all available biotypes of races 21, 126 and 222 occurring in Australia.

All results were obtained in the glasshouse at moderate temperatures (67–72°F.), using races 21, 126 and 222 of stem rust. Race 21 is from India and is quite unlike race 21Anz. 1 occurring locally in that Marquillo is susceptible to the latter (Watson, 1955). One biotype only of race 126 was used, viz. 126Anz. 1, but data were obtained from two biotypes of race 222, viz. 222AB (Anz. 2) and 222BB (Anz. 3). Seedlings of Hofed and Federation are susceptible to these races, and each was crossed with Khapstein to determine the mode of inheritance.

The initial tests were done with race 222AB. F_4 lines whose reaction to this race was known were then tested with races 21, 126 and 222BB and thus a comparison of the breeding behaviour of these lines to the different races was determined.

The crosses of Khapstein with the resistant varieties Marquillo, Thatcher, Hochzucht, Kenya 744 and Kenya 117A were tested with races 222AB and 21 to determine what relationship, if any, was shown in the resistances of the different varieties. It was found that there were gradations of reaction between resistance and susceptiblity in the F_2 generation of these crosses and difficulty was encountered in classifying the individual plants. Plants with an intermediate type of reaction occurred in the F_2 generation but F_3 breeding behaviour showed that these plants resembled closely other plants classified as semi-resistant. Definite indications on the mode of inheritance in such cases could therefore only be obtained from a study of the F_3 generation. In crosses between two resistant varieties the main emphasis was placed on the isolation of homozygous susceptible F_3 lines.

Random samples of F_2, F_3 and F_4 populations of crosses were employed in all cases. The following classes were used to record the seedling reactions:

Immune	(I)	0
Highly Resistant	(R+)	0;
Resistant	(R)	0,; and 1 or 0,; and $2^{=}$
Moderately Resistant	(R–)	0,; and 2, 2^{-}, $\times^{-}$ or $3^{=c}$
Semi-resistant	(SR)	2, 2^{+}, × or 3^{-c}
Intermediate	(Int.)	3^{c} or $\times^{+}$.
Susceptible	(S)	3, 4
Segregating	(Seg.)	F_3 and F_4 lines segregating for resistant and susceptible individuals.

If the hybrid lines showed a gradation of reactions they were defined by an appropriate range as, for example, R+ to SR, R– to SR, etc.

Experimental Results.

The reactions of the parents of the crosses studied here to races 126Anz. 1, 126Anz. 2, 222AB (Anz.2), 222BB (Anz. 3) and 21 are given in Table 1. These are average reactions at 67–72°F. In the table the reaction of Khapli is also given so that a ready comparison with Khapstein can be made. Their reactions to race 15 have been included to show certain differences between them.

Inheritance Studies with Race 222AB.—Six F_1 seedlings of a cross between Federation and Khapstein gave a semi-resistant reaction. Seedlings of Khapstein under the same conditions were moderately resistant. It was concluded that the reaction of

Khapstein was incompletely dominant. The reactions of F_2 plants of crosses of Khapstein with Federation and Hofed are given in Table 2.

The F_2 data of the cross Federation × Khapstein in Table 2 do not agree with a 3:1 ratio ($P < 0{\cdot}05$). If the classes showing the intermediate and the resistant types of reaction are grouped, the P value for agreement of those data with a 13:3 ratio lies between 0·05 and 0·10. When these same classes are combined in the Khapstein × Hofed cross the P value for the 13:3 ratio lies betwen 0·20 and 0·30.

TABLE 1.

Reactions of the Parental Varieties and Khapli to Several Races of Stem Rust.

Variety.	Race No.					
	126 Anz. 1	126 Anz. 2.	222AB (Anz. 2).	222BB (Anz. 3).	21	15
Federation ..	S	S	S	S	S	—
Hofed	S	S	S	S	S	—
Khapstein ..	R−	R−	R−	R−	R−	SR & Int.
Khapli ..	R	R	R	R	R	R
Marquillo ..	R+	R+	R+	R+	R & R−	—
Thatcher ..	R+	R+	R+	R+	I	—
Hochzucht ..	R+	R+	R+	R+	I	—
Kenya 744 ..	R−	R−	R−	R−	R−	—
Kenya 117A ..	R−	R−	R−	R−	R−	—

Some of the F_2 plants of the cross Federation × Khapstein classified for their reaction to race 222AB were transplanted in the field and the breeding behaviour of the F_3 seedling progeny was studied using the same race of rust. Table 3 summarizes the relationship between the reaction in F_2 and F_3.

Table 3 shows that 73 resistant F_2 plants gave either homozygous resistant or segregating F_3 progenies, except one which gave a susceptible progeny. In the F_2 generation it was difficult to separate semi-resistant and susceptible reactions from the intermediate ones, but most of the plants classified as intermediate gave either semi-resistant or segregating progenies and their breeding behaviour justifies their inclusion in the resistant class for the interpretation of F_2 data. The unexpected behaviour of one susceptible F_2 plant which gave resistant progeny and one semi-resistant plant which gave susceptible progeny is probably due to a mistake either during the F_2 classification or during transplanting.

TABLE 2.

Reactions of F_2 Plants of the Crosses Federation × Khapstein and Khapstein × Hofed to Race 222AB.

	Reactions.			
	Resistant R− and SR.	Intermediate.	Susceptible.	Total.
Federation × Khapstein ..	804	80	233	1117
Khapstein × Hofed	468	39	131	638

It may also be seen from Table 3 that approximately two-thirds of the susceptible F_2 plants gave segregating progenies; the remainder bred true for susceptibility. Among these latter families, however, an occasional plant was sometimes found having a degree of resistance. Lines showing such plants have been classified as homozygous susceptible when interpreting the data. It is not uncommon to find aberrations in the segregation of crosses involving *vulgare* parents whose resistance has been derived from 14-chromosome types.

The results on the inheritance of resistance can be explained by assuming that two factors differentiate the resistance of Khapstein from the susceptibility of

Federation. One of these factors is dominant, the other recessive, and when either is present singly partial resistance is shown. Of the 115 F_3 lines in Table 3, 42 possessed a certain amount of resistance but most of these did not equal the resistance of Khapstein. The numbers of resistant (42), segregating (62) and susceptible lines (11) agree with a 7:8:1 ratio with a P value of 0·10 to 0·20.

TABLE 3.

The Reactions to Race 222AB of the Progeny of 115 Tested F_2 Plants of the Cross Federation × Khapstein.

F_2 Reactions.	F_3 Reactions.					
	Resistant.		Segregating.		Susceptible.	Total.
	(R– to SR.)	(SR.)	(R–, SR and S.)	(SR and S.)		
Resistant :						
R– ..	13	10	8	—	—	31
SR ..	8	8	18	7	1	42
Intermediate ..	—	2	7	7	2	18
Susceptible ..	1	—	11	4	8	24
Total ..	22	20	44	18	11	115

More comprehensive data on a sample of 232 F_3 lines of the cross Federation × Khapstein is contained in Table 4. In the segregating lines, the numbers of R–, SR and S plants were counted and these lines can be classified as R– and SR > S (preponderance of moderately resistant and semi-resistant plants), SR > S (preponderance of semi-resistant plants) and S > SR (mostly susceptible plants). If

TABLE 4.

The Probable F_2 Genotypes and Their Breeding Behaviour in F_3 of Plants of the Cross Federation × Khapstein Tested with Race 222AB.

F_3 Breeding Behaviour.	Probable F_2 Genotype.	Numbers of Lines.	
		Observed.	Expected.
Resistant :			
R–	Kph_1 Kph_1 kph_2 kph_2	20 } 113	14·5 } 101·5
SR or R– to SR ..	Kph_1 Kph_1 Kph_2 kph_2 Kph_1 kph_1 kph_2 kph_2 Kph_1 Kph_1 Kph_2 Kph_2 kph_1 kph_1 kph_2 kph_2	93	87·0
Segregating :			
R– and SR>S SR>S ..	Kph_1 kph_1 Kph_2 kph_2 Kph_1 kph_1 Kph_2 Kph_2	77 } 105	87·0 } 116·0
S>SR	kph_1 kph_1 Kph_2 kph_2	28	29·0
Susceptible :			
S	kph_1 kph_1 Kph_2 Kph_2	14	14·5
Total	.. ..	232	232·0

Kph_1 and kph_2 are the dominant and recessive factors respectively in Khapstein the probable genotypes of the F_2 plants and their breeding behaviour in F_3 to race 222AB are given in Table 4.

The numbers of resistant, segregating and susceptible lines in Table 4 agree with a 7:8:1 ratio, the P value being approximately 0·30. While these reactions were being recorded a special note was taken of those lines as resistant as Khapstein and the results show that only 20 of the 113 lines in the resistant category equalled the moderate resistance (R–) of Khapstein. There was a preponderance of susceptible plants in 28 of the 105 segregating lines. It appears from this that the two factors for resistance on Khapstein are additive in effect and only when present together can they produce a reaction equal to that of the parent. As one of these factors behaves as a recessive and the other as a dominant, the observed frequencies of five categories of reaction in Table 4 are also expected to agree with a 1:6:6:2:1 ratio. The P value for agreement with this ratio lies between 0·30 and 0·50.

Relationship of the Resistance to Various Races.—A random sample of 127 F_4 lines of the cross Federation × Khapstein, whose reaction to race 222AB was known, were tested with races 21, 126Anz. 1 and 222BB. The reaction to these latter three races was identical and similar to that given to race 222AB. Of the 127 lines, 50 were moderately resistant or semi-resistant, 72 segregated for different grades of resistance and susceptibility, and five were homozygous susceptible. It was concluded, therefore, that the same two genes in Khapstein control resistance to all four races of rust.

TABLE 5.

Reactions of F_1 and F_2 Plants to Races 21 and 222AB of Crosses between Khapstein and Other Resistant Varieties.

	Gen.	Race.	Reactions.					
			Resistant.			Int.	Sus.	Total.
			I.	R+ & R.	R– & SR.			
Marquillo × Khapstein	F_1	222AB	—	—	4	—	—	4
Marquillo × Khapstein	F_1	21	—	—	4	—	—	4
Marquillo × Khapstein	F_2	222AB	—	777*	—	20	9	806
Thatcher × Khapstein	F_1	222AB	—	—	3	—	—	3
Thatcher × Khapstein	F_1	21	5	—	—	—	—	5
Thatcher × Khapstein	F_2	222AB	—	160	569	22	11	762
Thatcher × Khapstein	F_2	21	164	—	40	8	3	215
Hochzucht × Khapstein ..	F_1	222AB	—	—	4	—	—	4
Hochzucht × Khapstein ..	F_1	21	4	—	—	—	—	4
Hochzucht × Khapstein ..	F_2	222AB	—	259	829	26	16	1130
Hochzucht × Khapstein ..	F_2	21	513	—	161	6	10	690
Khapstein × Kenya 744	F_1	222AB	—	—	5	—	—	5
Khapstein × Kenya 744	F_2	222AB	—	—	801	18	24	843
Khapstein × Kenya 117A ..	F_1	222AB	—	—	9	—	—	9
Khapstein × Kenya 117A ..	F_2	222AB	—	—	1140	40	34	1214

* Plants showing different grades of resistance have been grouped together.

Relation of Khapstein to the Other Resistant Varieties.—In order to investigate this relationship the following crosses were studied: Marquillo × Khapstein; Thatcher × Khapstein; Hochzucht × Khapstein; Kenya 744 × Khapstein; and Kenya 117A × Khapstein.

Previous work by Athwal and Watson (1954, 1955) had shown that in Marquillo, Thatcher and Hochzucht there is a group of genes for resistance to race 222AB. Kenya 744 and Kenya 117A have a single factor for resistance to this same race. Thatcher and Hochzucht have as well a factor for immunity to race 21. The crosses were so planned that the relationship of Khapstein to each of these resistances could be studied. In view of the genetic similarity between some of the varieties all the crosses listed above are not necessary; nevertheless the results obtained are given in Tables 5 and 6.

It will be seen from Tables 5 and 6 that the three crosses of Khapstein with Marquillo, Thatcher and Hochzucht have behaved similarly in that susceptible segregates were obtained in the F_2 and F_3 generations. This similarity would be expected from the results obtained in previous studies (Athwal and Watson, 1955). In view of the complexity of inheritance in Marquillo, Thatcher and Hochzucht it is not possible to fit the data to any genetic ratio. However, it is evident that the genes for resistance present in these varieties are not allelic to those in Khapstein. Furthermore, the results with race 21 show that the immunity factor in Thatcher and Hochzucht is epistatic to, and non-allelic with, either of the two factors in Khapstein.

In the crosses of Khapstein with Kenya 744 and Kenya 117A three factors are segregating for reaction to race 222AB. Khapstein contributes two factors, one dominant and the other recessive, and a single factor comes from each of the Kenya varieties. The two crosses show the same type of F_2 and F_3 segregations, although there is a slight difference in the percentage of segregating lines (Table 6). No explanation can be given for this. The F_2 data on 843 plants of the cross involving Kenya 744 and 1214 plants of the Khapstein × Kenya 117A cross (Table 5) show that 24 and 34 plants respectively were susceptible. The results do not agree with the expected ratio of 61:3 ($P < 0{\cdot}05$) and the deficiency of susceptible plants suggests a loose linkage between one of the genes in Khapstein and the gene for resistance in the Kenya varieties. A deficiency of homozygous susceptible F_3 lines (Table 6) further strengthens this possibility.

TABLE 6.

Reactions of F_3 Lines to Races 21 and 222AB of Crosses between Khapstein and Other Resistant Varieties.

Cross.	Race.	Reactions.							
		Resistant.				Segreg.†		Sus.	Total.
			R+ to R.	R− to SR.	R to SR.	a.	b.		
Marquillo × Khapstein ..	222AB	—	17	23	51	20	14	1	126
Thatcher × Khapstein ..	222AB	—	16	83	133	25	18	—	275
Thatcher × Khapstein ..	21	49	—	45	101	— 27	‡ —	1	223
Hochzucht × Khapstein	222AB	—	22	90	164	38	23	2	339
Kenya 744 × Khapstein..	222AB	—	—	298	—	89	46	4	437
Kenya 117A × Khapstein	222AB	—	—	137	—	35	5	1	178

† Lines segregating as does an F_2 of the cross are recorded under " a "; those which segregate with approximately 25 per cent. or more susceptible are recorded under " b ".

‡ Lines under " a " and " b " have been grouped.

DISCUSSION.

The inheritance studies with Khapstein show that the resistance of this variety is governed by two independently inherited factors, one of which is dominant, the other recessive. Each of these two factors can produce a partially resistant reaction when present singly and their action appears to be additive. Previous work is conflicting in that Hynes (1926) and Aamodt (1927) attributed the resistance of Khapli to multiple factors, while Waterhouse (1930) concluded from results with race 43 that the resistance was due to two dominant factors.

It is possible that the inheritance of resistance in Khapli is much more complex than that in Khapstein. The latter is not as highly resistant to the Australian rusts as Khapli and it could be concluded that the full complement of genes conditioning rust resistance in the latter have not been transferred to Khapstein. Whereas the differences in the reaction to local rusts shown by those two varieties are not spectacular, a culture of race 15 from India makes evident clear-cut differences between them. Khapli is resistant to this race but Khapstein gives only intermediate and semi-resistant types of reaction. It will not be surprising, therefore, to find in future certain rusts to which Khapstein is susceptible but Khapli resistant. Similarly the mode of inheritance of Khapli resistance can be expected to vary with the race used on the segregating material.

The two factors for resistance present in Khapstein are not allelic with those in Marquillo, Thatcher and Hochzucht. It may be that they are independent of these factors and of the factor present in Kenya 744 and Kenya 117A. However, there appears to be a linkage between one of the factors in Khapstein and the factor which is effective against Australian rusts in the two above-mentioned Kenya varieties. The presence of ill-defined reactions in the F_2 generation and the size of the F_3 populations do not justify the calculation of linkage intensity. If such a linkage is present it will explain the deficiency of susceptible plants in crosses between Khapstein and Marquillo, Thatcher and Hochzucht (Table 1). The results obtained earlier (Athwal and Watson, 1955) have shown conclusively that the factor in Kenya 744 and Kenya 117A is strongly linked with one of the major factors in Marquillo, Thatcher and Hochzucht. Consequently a linkage would be expected between this major gene present in Marquillo and related varieties and one of the two factors in Khapstein.

As far as Australian races of stem rust are concerned, Khapstein appears to be one of the most valuable sources of resistance. It possesses resistance to all these rusts and the genes responsible are present in a genetic background that allows them to be transferred readily to any of the commonly cultivated varieties. So far no difficulties have been encountered using Khapstein as a donor parent in back-cross programmes that are under way with many varieties as recurrent parents. Moreover, the present studies indicate that it should be possible to combine the Khapstein resistance with that of Marquillo and of Kenya 117A. Such combinations would result in resistances with a broader genetic base than is possible with either component singly and this may lead to a more stabilized resistance (Watson and Singh, 1952).

SUMMARY.

Inheritance studies with Khapstein show that the resistance of this variety to Australian stem rust races and to race 21 is dependent upon two independently inherited factors. One of these factors is dominant, the other recessive, and while each is capable of giving partial resistance when present singly it appears that together their effect is additive. Crosses of Khapstein with certain resistant varieties show that the two factors are not allelic with a group of genes for resistance to race 222AB which are present in Marquillo, Thatcher and Hochzucht. Also they are not allelic with a factor for resistance to this same race in Kenya 744 and Kenya 117A nor with the factor for immunity to race 21 present in Thatcher and Hochzucht.

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THE WING VENATION OF LOMATIINAE (DIPTERA–BOMBYLIIDAE).

By G. H. Hardy.

(One Text-figure.)

[Read 18th April, 1956.]

Synopsis.

The forty-five points along veins of the wings in subfamily Lomatiinae, points where occasional cross-veins and spur-veins are found, are recorded and are explained on the theory that they are remnants of a former reticulate venation. One new synonym is given for *Comptosia maculosa* Newman.

Introduction.

Needham (1908) suggested that a more or less irregular meshwork of cross-veins once existed in the wings of Diptera, and this idea was treated as a theory in Hardy (1951), where it is noted that such a reticulation still exists in the wings of some Nemestrinidae. New facts since discovered support the view that those flies which exhibit veins taking wavy and recurrent courses in their vein pattern, and also spur-veins which are frequently found, have retained in these characters a remnant of an original reticulation.

The Lomatiinae developed a venation somewhat variable and distinctly differing from the normal dipterous types. This subfamily may be retaining, therefore, veins in a pattern that may yield data towards showing the original type from which various Brachycerous vein patterns had developed.

The present study is made possible through the courtesy of Mr. H. F. Lower, who supplied twelve specimens of *Comptosia maculosa* Newman which show a wide range of "supernumerary" veinlets occurring on the species. From these specimens come abundant new facts added to the data previously gathered.

The Venation Seen in Published Figures.

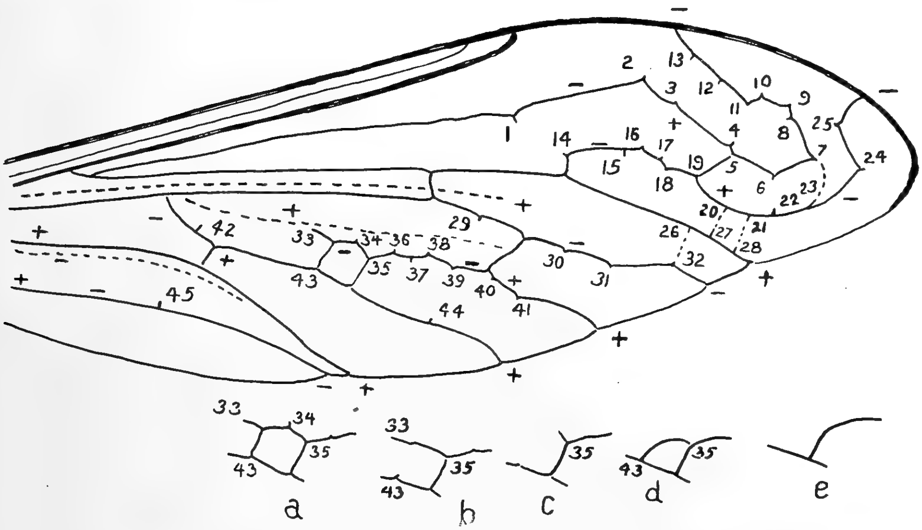
In the paper of Edwards (1934) on genus *Comptosia* and its allies, thirty-two photographs of wings yielded fifteen points where cross-veins and spur-veins commonly occur in the subfamily. These veinlets are incorporated in the composite diagram, each point being numbered for references as follows.

In Edwards' figure 1, *Comptosia brunnea* Edw., the venation is reduced to main-veins with simple curves, and no angulations mar the even flow of the pathway taken by any vein. This is a venation reduced to a basic type accepted in taxonomy for the genus. In figure 2, *C. maculosa* Newman, about which more data are given below, there is a vein crossing between points 5 and 19, which is a character found to be consistently present in the species. There are spur-veins just indicated at points 6, 7 and 14, and these spurs may become very pronounced on some specimens recorded below. In figure 3, *C. vittata* Edw., the same cross-vein occurs, and another one is crossing between points 21 and 28. Figure 4, *Oncodosia plana* Walker, has the veinlet crossing between 5 and 19, but figure 5, *O. patula* Walker, has only spurs at 35, 37 and indicated at 38. Figure 13, *Comptosia cognata* Walker, has two radial-median cross-veins, the second being between points 26 and 32; also a spur is at 35. Figure 20, *C. plana* Walker, shows veins crossing from 5 to 19 and from 6 to 22; a spur is indicated at 38. Interpreting positions in figure 21, *C. serpentiger* Walker, leaves some doubt. The vein crossing towards the apex of the radial field may not be homologous with that of figure 20, but concerned with points 7 and 23, and that apparent crossing vein just above the radial-median cross-vein is probably a mark, as no mention of it is made in the text. A spur is at 35. Figures 26 to 29 are wings of four South American species of *Macrocondyla*, having a vein crossing from 5 to 19, and another from 20 to 27 in three of the figures. In addition, figure 27 has yet another from 21 to 28, whilst figure 26 has a vein between points 26 and 32. In figure 29 there is a cell that probably does not conform with that within the loop in the median cell of *Comptosia*, but rather is formed by a vein crossing between points 37 and 41, but this will need confirmation.

COMPTOSIA MACULOSA Newman.

Neuria maculosa Newman, 1841, *Entomologist*, 1: 221. *Comptosia fulvipes* Bigot, 1892, *Ann. Soc. ent. France*, (7) 61: 359.

Synonymy.—The presence or absence of the median abdominal stripe was all that could be found to distinguish the two forms for which Edwards proposed the *maculosa*-group under subgenus *Aleucosia*. The stripe concerned grades to elimination point on the series now studied, and other markings are similarly variable. Apparently Edwards' group represents one valid species and the name given by Bigot becomes a synonym of it.



Text-figure 1.

Supernumerary veins, veinlets and spur-veins found in the genus *Comptosia* and its allies, are shown in the composite figure and their positions in the venational pattern are indicated by numerals 1 to 45.

Veins that are longitudinal in direction and marked by broken lines are vestigial: The two upper ones are convex, and the lowest is concave. Crossing veinlets indicated by a line of dots between spurs, are sometimes present.

An extra cell in the median field, below points 33, 34 and 35, is bordered by a crossing veinlet between points 33 and 43. The reduction of this leaves various forms shown in figures *a* to *e*.

Figure *a* shows the cell complete with its spur-veins radiating from it. Figure *b* shows the elimination of the crossing veinlet which may leave a spur at 43. Figure *c* shows further reduction leaving a spur at 35. Figure *d* shows elimination of spurs and the path taken between points 35 and 43 becomes shortened to a bow-form. Even the disappearance of this, as shown in Figure *e*, leaves the remaining vein taking a simple curved path.

In the text it is assumed that these variations in the wing pattern of Lomatiinae are vestiges of an original reticulation, which reticulation has become lost to Bombyliidae.

The various longitudinal veins are marked convex (+) and concave (−), and it will be noted that they do not consistently show one form, but may change in their course, showing such veins are complex, thus accounting for the curving paths taken in the radial field. This especially applies to sections of veins between points 2 and 6, and between 16 and 22.

Venation.—The veins on the wing of this species prove to be very variable, the main veins varying from wavy, even, rather angulated paths to gently curving lines.

The presence of cross- and spur-veins also varies. However, all specimens seen have the vein* crossing between points 5 and 19 shown on the accompanying diagram. This venation is basic for the species. The minimum venation in the present series has no extra cross-veins or spurs, and the specimen has been numbered 1. The specimen numbered 2 has, in addition, a spur-vein at point 14, and, on the left wing only, another at 35.

That numbered 3 has the same two spur-veins on both wings and another at 45 on the right one.

Number 4 is similar to Number 3, but misses the spur at 45 and has an additional one at 39 on the left wing.

Number 5 is similar to 4, with an extra spur-vein at points 39 and 41 on both wings.

Number 6 has the loop of the median cell on the right wing between points 35 and 43 without those associated spur veins, whereas the left wing has only a spur at 35. Another spur on both wings is at 14, and indications are strongly pronounced of another at 24 on the right wing.

Number 7 has the median loop interrupted on both wings, thus leaving spurs at points 35 and 43, and others are at 14 and 45. The right wing has spurs at 8, 38 and 42, yet another is faintly indicated by a curve occurring at 13. One on the left wing is at 39.

Number 8 has spurs at 10, 35 and 38, additional ones on the right at 6, 7 and 9, and on the left wing at 11 and 36. Some indications are at 24 on the right and at 1, 2 and 18 on the left wing.

Number 9 is interesting in having a very definite but short spur at point 24, which otherwise is indicated by an angulation there occasionally on other specimens. Other spurs are at 14 and 35, and in addition the left wing has one at 8.

Number 10 has the median loop complete with the spur-veins associated therewith, but limited to the right wing. Spurs are at 9, 10 and 36 on both wings, at 8, 33, 34 and 39 on the right, at 35 and 38 on the left, and indications are at 14, with additional ones at 3, 4, 12 and 16 on the right wing.

Number 11 has a spur at 10, 11, 14, 29, 35, 36 and 38. Extra ones are at 39 on the right, and at 30, 31, 33, 34 and 40 on the left. Indications are faint at 13 and 31 on the right and at 1, 2, 7, 9, 11 and 13 on the left.

Number 12 has the median loop between 35 and 43 without the spurs connected therewith on the left wing. Spur-veins are at 13, 31 and 36 on both wings, at 8, 10, 15, 16, 17, 30 and 38 on the right, and at 11, 37 and 44 on the left wing. Indications are at 1, 2 and 25 on both and faintly at 7, 10 and 13 on the left wing.

In addition to the above a strongly marked *vena-spuria* and a similar convex darkened remnant of a longitudinal vein passing through the median cell. These are marked by a broken line in the diagram and is a feature discussed in Hardy (1954).

Between points 2 and 6, and between 16 and 22 approximately, these radial branches are convex, thus indicating their complex nature in the part of the radial field that is normally concave in Diptera. The upper median branch is concave up to the wing border, the lower one is convex from point 40 to the apex. Markings on the wing correspond closely to those showing in Edwards' figure 2, only slight variations being noted in these.

Hab.—South Australia: six males and six females on *Melaleuca* flowers at Hartley, near Wellington, 16.10.1951 (H. F. Lower). This series is now deposited in the Australian Museum, Sydney. In distribution this species seems to be associated with the Mallee country of South and Western Australia.

Remarks.—In Edwards (1934) are shown fifteen points where veinlets are represented by spur- and cross-veins issue from the main-veins, and these are marked in the compounded diagram. Eight points so marked, namely 20, 21, 22, 23, 26, 27, 28 and 32, are not represented on the present series of twelve specimens. These latter include thirty-seven further points, of which twenty-one occur on a single specimen (No. 12

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* On another species (*C. hermeteles* Schin.), where this cross-vein also occurs, occasionally it is interrupted and even quite absent.

above), which is 46·7% of all forty-five known to occur in the Lomatiinae and 56·75% found in the series of specimens examined.

Theoretically *Comptosia* may be regarded as retaining in Asiloidea some characters of an original reticulation now largely lost. This is parallel to other cases, such as Tipulidae in Nematocera and Nemestrinidae in Tabanoidea, where so-called "supernumerary" veins are plentifully recorded in literature. Similar extra veinlets occur in Muscoidea, chiefly in the subcostal area and the median cell, whilst Syrphoidea have them widely distributed over the wing.

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SOME DENDROID GRAPTOLITES FROM NEW SOUTH WALES.

By Kathleen Sherrard.

(Plates vii-viii; two Text-figures.)

[Read 18th April, 1956.]

Dendroid graptolites have been found in New South Wales in the Ordovician and Silurian but have not yet been recorded from other geological systems. In most cases the exact geological horizon in which the dendroids occur can be determined from true graptolites which accompany them. The Dendroidea have received little attention in this State in comparison with their companion order, the Graptoloidea, which have been quite extensively recorded and described. In spite of this neglect their occurrence here is particularly noteworthy, since many of them are found in horizons where they are unusual in other parts of the world.

For instance, slate from the *Nemagraptus pertenuis* zone of the Ordovician at Tomingley contains the dendroids *Callograptus*, *Dendrograptus* and *Desmograptus* in association with the graptolites *Orthograptus calcaratus* var. *acutus*, *O. whitfieldi*, *Dicellograptus patulosus*, *Climacograptus antiquus*, *Amplexograptus perexcavatus* and *Retiograptus geinitzianus*, which accurately determine the zone. Dendroids have seldom been recorded from this horizon elsewhere, while further, an association of so many dendroids with so many graptolites seems rare.

The only closely, though not entirely, similar associations known to be recorded are from the Normanskill zone of the Ordovician in New York and Arkansas, U.S.A. (Ruedemann, 1947). In Britain, *Callograptus* has been found both lower and higher in the Ordovician, but is not recorded from the *Nemagraptus* zone (Bulman, 1934). Records from other places list only one of the genera of dendroids occurring at Tomingley in association with graptolites of the same zone. For example, the *Nemagraptus gracilis* zone of Sweden is recorded as containing *Desmograptus* ? *tullbergi*, but no other dendroid in association with an assemblage of graptolites somewhat similar to those at Tomingley (Hadding, 1913). Decker (1951) records from Oslo, Norway, *Callograptus compactus* with *Orthograptus calcaratus* var. *acutus*, *Climacograptus antiquus* and *Glyptograptus teretiusculus*. An interesting record is that of T. S. Hall (1904), of shale pebbles in a Jurassic conglomerate at San Remo, Victoria, which were found to contain *Callograptus*, *Ptilograptus* and *Dictyonema* with *Dicellograptus* and *Diplograptus*. However, the provenance of the graptolite-bearing inclusion, which must be Ordovician, is not recorded.

In addition to these associations in the Ordovician in New South Wales, in the Silurian here, the dendroid *Dictyonema* has been found on horizons different from those from which it is recorded in Britain and America. For example, its occurrences in the zones of *Monograptus nilssoni* and *M. scanicus* in the Yass district (Sherrard, 1954) are stratigraphically considerably higher than is usual for *Dictyonema* in the Silurian of Britain (Bulman, 1934) or North America (Ruedemann, 1947). However, dendroids have been obtained in high Silurian horizons of Czecho-Slovakia (Perner and Kodym, 1922) and of North Africa (Termier, 1948).

Dictyonema cf. *filiramus* from Heathcote, Victoria (Harris and Thomas, 1941), where it is associated with *Monograptus* cf. *nilssoni*, may come from about the same horizon as the New South Wales occurrences. *Dendrograptus* has been recorded from the Silurian of Yass (Shearsby, 1912). It is possible this is the specimen which is now in the Australian Museum and is figured here as a proximal end of ? *Dictyonema* sp. (Pl. viii, fig. 10).

Though some of the dendroids described in this paper are comparable in dimensions with species described from other parts of the world, since they occur here in different horizons, references to existing species have seemed unwise and new ones have been erected.

Possibly due to the chances of collecting, all the Ordovician dendroids found up to the present have been in the central west of the State. It may also be chance that no dendroid has been found in the zone of *Orthograptus quadrimucronatus*, though this zone has been quite extensively searched in the Goulburn, Yass, Queanbeyan and Snowy Mountains areas.

The dendroids from Tomingley are preserved as white impressions on blue-black slate. Unsuccessful efforts have been made to detach them by dissolving the matrix in hydrofluoric acid. Free carbon floated off but no dendroid was dislodged. Similarly an attempt to dissolve in acetic acid the calcareous slate of Licking Hole Creek from around ? *Thamnograptus* failed. Consequently the structure of the dendroids could not be studied. The term "theca" in this paper is used in the sense understood generally in descriptions of graptolites. The classification adopted in the Systematic Descriptions is that of Bulman (1938).

SYSTEMATIC DESCRIPTIONS.

Class GRAPTOLITHINA.

Order DENDROIDEA.

Family DENDROGRAPTIDAE.

In this family the stipes spring from some central process. They are arranged in either tree-like or reed-like fashion and branch in various ways. They may or may not be connected by dissepiments.

Genus DICTYONEMA.

This net-like genus, the longest and best known of all dendroid graptolites, has been found in both Ordovician and Silurian rocks of this State, though never entirely complete, but fragments recognizably conical in shape have been obtained.

ORDOVICIAN.

DICTYONEMA APERTUM, n. sp. (Pl. vii, fig. 1).

Holotype: Sydney University Reg. No. 7125.

Fragment 5 cm. by 2 cm., incomplete both distally and proximally, has undulating stipes, 8–9 in 10 mm., 0·25 mm. wide proximally and 0·1 mm. distally. They are connected by dissepiments of about 0·3 mm. width making a coarse irregular mesh up to 4·5 mm. long and 1·25 mm. broad, but which may be as small as 0·75 mm. square. Dissepiments sometimes 4–6 in 10 mm. Thecae very indistinct, may be denticulate or occasionally tubular, perhaps 16 in 10 mm. This species has dimensions similar to those of *D. irregulare* from the British Arenigian (Bulman, 1934) or *D. quebecense* from the Tetragraptus Beds of Canada (Ruedemann, 1947). Its precise horizon in New South Wales has not been determined, though it is almost certainly Ordovician.

Associate: None.

Locality: Kerr's Ck., Portion 57, Parish of Larras Lake, Orange district.

DICTYONEMA SALEBROSUM, n. sp. (Pl. vii, fig. 3).

Holotype: Sydney University Reg. No. 7126.

Rhabdosome preserved in slight relief in limestone, 4 cm. by 3 cm. revealed. Stipes 19 in 10 mm., each 0·3 mm. wide with 0·3 mm. between. Dissepiments indistinct, perhaps 7–8 in 10 mm., each about 0·25 mm. wide. Mesh regular. Denticulate thecae distinct, nearly 20 in 10 mm. The dimensions of this *Dictyonema* are comparable with *D. densum* Ruedemann from the Ottosee Shale of Tennessee.

Associates: *Glyptograptus teretiusculus*, *Leptograptus* cf. *validus*.

Locality: The Bluff, north bank, Belubula R., north-west of Cliefden Caves, Mandurama district.

Horizon: Zone of *Nemagraptus pertenuis* (Sherrard, 1954).

SILURIAN.

DICTYONEMA FAVOSUM, n. sp. (Pl. vii, fig. 2).

Holotype: Sydney University Reg. No. 7128.

Rhabdosome, incomplete cone, more than 7 cm. wide and 4 cm. long. Extreme proximal and distal ends covered. Stipes 13 to 18 in 10 mm., each 0·25 mm. wide and 0·5 mm. apart, bifurcating at about 1 cm. intervals. Stipes undulate slightly. Dissepiments irregular, sometimes at 1, sometimes at 2 mm. intervals apart, each 0·2 mm. wide, making a coarse, fairly regular mesh. Denticulate thecae, 10 in 10 mm., sometimes indistinct. This species has also been collected at Hatton's Corner, Yass, in association with *Monograptus bohemicus* (Brown and Sherrard, 1952, Pl. viii, fig. *e*, specimen No. F 44611, Australian Museum).

Associate: ? *Monograptus bohemicus.*

Locality: (g6), Quarry Ck., west of Orange (Packham and Stevens, 1955).

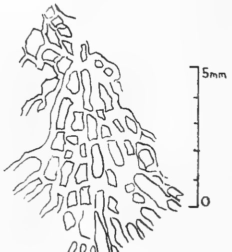
Horizon: Lower Ludlow.

DICTYONEMA VINCULOSUM, n. sp. (Text-fig. 2).

Holotype: Australian Museum No. F 46388.

Rhabdosome conical, incomplete, length 1·5 cm., breadth about 1 cm., proximal end not preserved. Stipes 16 per 1 cm. proximally, 22 per 1 cm. distally, each 0·12 mm. wide. Stipes bifurcate six times in 1 cm. Dissepiments about 12 per cm., each 0·1 mm. wide. Mesh fine and fairly regular. No thecae can be distinguished. A proximal end in the form of a short thickened stem is shown on a ? *Dictyonema*, No. F 46390 (Australian Museum) from the Bowning district, which probably belongs to this species (Pl. viii, fig. 10). The holotype, preserved as a delicate iron oxide net on brown sandstone, has proved impossible to photograph.

1



2

Text-figure 1.—*Reticulograptus undulosum,* n. sp., Paling Yards Public School Site, west of Orange. Lower Ludlow.

Text-figure 2.—*Dictyonema vinculosum,* n. sp., Portion 34, Par. Derrengullen. Zone of *Monograptus scanicus.*

Associate: *Monograptus salweyi.*

Locality: Portion 34, Par. Derrengullen (Siverdale), north-west of Yass.

Horizon: Zone of *M. scanicus.*

A *Dictyonema* which is too poorly preserved for specific description has been found in the Llandovery at Quarry Creek, west of Orange (Packham and Stevens, 1955). This *Dictyonema* is thus from a different horizon from any of those described. A key to the characters of those *Dictyonemas* described is given in Table 1.

Genus Reticulograptus.

Reticulograptus undulosum, n. sp. (Pl. vii, fig. 4, Text-fig. 1).

Holotype: Sydney University Reg. No. 7129.

Graceful, curving rhabdosome, 4 cm. wide by 2·5 cm. long, but not all uncovered. Most proximal part, a narrow stem, probably incomplete, is curved into a semi-circle. After 4 mm., bifurcates twice to four more or less strongly curved concentric stipes, which are packed into a width of 2 mm. Proximally each stipe is about 0·2 mm. wide with spaces of 0·4 mm. between each. Each stipe bifurcates about twice each centimetre, until in the most distal part there are 17 stipes, each 0·2 mm. wide and 0·5 mm. apart. Dissepiments 0·1 mm. wide and about 0·1 mm. apart. These are at right angles to the stipes proximally but distally are strongly inclined and anastomose among themselves, forming a net such as is seen in *Retiograptus*. Sharply denticulate thecae, some apparently spined, are arranged five in 3 mm. These can be seen in the proximal portions of some stipes.

TABLE 1.
Character of Forms Ascribed to Genus Dictyonema.

Species	*apertum.*	*salebrosum.*	*favosum.*	*vinculosum.*
Rhabdosome	Fragmentary.	Fragmentary.	Incomplete cone.	Incomplete cone.
Length (cm.)	5+	4+	7	1·5
Breadth (cm.)	2	3+	4	1·8
Mesh	Coarse, irregular.	Regular.	Fairly regular.	Fine regular.
Proximal end	—	—	—	? Thickened stem.
Bifurcation in 10 mm.	¾	1½	1	6
Stipes in 10 mm.	8–9	19	13–18	16–22
Spaces between stipes (mm.)	0·75 (prox.) 1·25 (dist.)	0·3	0·5	0·2
Dissepiments in 10 mm.	4–6	7–8	10–5	12
Width of stipes (mm.)	0·25–0·1	0·3	0·25	0·12
Width of dissepiments (mm.)	0·3	0·25	0·2	0·1
Shape of thecae	Denticulate.	Denticulate.	Denticulate.	—
Number in 10 mm.	? 14–16	20	? 10	—
Age	? Ordovician.	Ordovician Zone of *Nemagraptus pertenuis.*	Silurian Lower Ludlow.	Silurian Zone of *Monograptus scanicus.*

Associates: *Monograptus bohemicus tenuis*, *M. nilssoni*, *M. leintwardensis* var. *primus* (Packham and Stevens, 1955).

Locality: Paling Yards Public School Site, west of Orange.

Horizon: Lower Ludlow.

Genus Callograptus.

James Hall, in erecting the genus *Callograptus* (1865) wrote: "the aspect of these fronds is intermediate between *Dictyonema* and *Dendrograptus*". He indicated thus the variable character of species included in the genus. These fall into two groups, one with stipes which branch rather widely, recalling *Dendrograptus*, and a second with closely set parallel stipes suggesting a relationship to *Dictyonema*. In either group the stipes are sometimes connected by dissepiments. Miller (1889) chose *Callograptus elegans* as genolectotype. This is a branching or "shrub-like" genus, but can be separated from *Dendrograptus* by the presence of dissepiments. The other group is centred round *C. salteri*, which has numerous parallel stipes, occasionally connected by dissepiments, but is without the extreme regularity of *Dictyonema*. Representatives of both these groups can be recognized in the Ordovician of New South Wales, though so far none has been seen from rocks of any other age. The *C. elegans* group is represented by a small, shrubby rhabdosome from Cadia, *C. disjectus*, n. sp., while *C. arundinosus*, n. sp., is a representative of the other group.

CALLOGRAPTUS DISJECTUS, n. sp. (Pl. viii, fig. 4).

Holotype: No. F 39532, Australian Museum.

Small, complete, shrubby rhabdosome, 1·8 cm. wide by 1·5 cm. high, branching from a central stiff stem (0·5 mm. wide), which bifurcates at angles of 30 degrees once in about every 1·25 mm., making ultimately 36 stipes in a fan of 270 degrees, each stipe being about 0·25 mm. wide with spaces of 0·5 mm. between them. Proximally the stipes are stiff. Distally they bend gracefully back and are connected by a few thin dissepiments. Thecae (15 in 10 mm.) are indistinct, their apertures appearing to be introtorted, though occasionally prolonged to tubes.

Associates: *Nemagraptus pertenuis*, *Climacograptus antiquus*.

Locality: Cadia.

Horizon: Zone of *Nemagraptus pertenuis*.

CALLOGRAPTUS ARUNDINOSUS, n. sp. (Pl. viii, figs. 1, 2).

Holotype: Australian Museum No. F 46382.

The *Callograptus salteri* group is represented in New South Wales by handsome bamboo-like dendroids up to 4·0 cm. high by 2·0 cm. wide, *C. arundinosus*, n. sp. The stipes are arranged in two clumps, which separate near the base, the nature of which cannot be determined. The nearly parallel stipes are 0·6 mm. wide proximally decreasing to 0·3 mm. wide, distally, with spaces of 0·6–0·8 mm. between them. The stipes undulate very slightly and bifurcate about every 3 mm. until there are about 30 stipes in a width of 2 cm. distally. They terminate in trident-like points. Dissepiments are few and very thin. Inconspicuous thecae, sometimes tubular, are 15 in 10 mm.

Associates: *Orthograptus whitfieldi*, *O. calcaratus* var. *acutus*, *Dicellograptus patulosus*.

Locality: Tomingley village, mine spoil-heap.

Horizon: Zone of *Nemagraptus pertenuis*.

A key to the character of the species placed in this genus is shown in Table 2.

Genus DENDROGRAPTUS.

This genus contains dendroids with a strong central stem arising, when complete, from an expanded root-like extension and spreading distally into shrub-like branches which are never connected by dissepiments. None of the specimens from New South Wales is entirely complete, but the preservation is sufficiently good to establish two new species and possibly a third.

DENDROGRAPTUS RECTANGULOSUS, n. sp. (Pl. viii, figs. 3, 6).

Holotype: Australian Museum No. F 46383.

Rhabdosome incomplete, 2 cm. by 2 cm. This species has a shrubby character and shows no anastomosis. It springs from a horizontal stem which is 4·5 mm. long by 1·0 mm. wide. Its stipes are up to 2 cm. long and 0·7 mm. wide, decreasing distally to 0·3 mm. and bifurcating in zigzag fashion almost at right angles, 4 to 6 times in 1·3 cm. Distally there are 11 branches in 2 cm. Thecae, 14 in 10 mm., are generally denticulate, with occasionally short tubes or spines extending from the denticle for 0·5 mm. These tubes or spines are more strongly developed in some specimens, giving a feathery appearance to the rhabdosome (Pl. viii, fig. 3). In these cases the bifurcation of the branches takes place at less than a right angle. These dendroids suggest

Dendrograptus serpens Hopk. figured by Hopkinson and Lapworth (1875), which came from a slightly lower horizon than *D. rectangulosus*.

Associates, locality, horizon: as for *Callograptus arundinosus*.

DENDROGRAPTUS NUDUS, n. sp. (Pl. viii, fig. 5).

Holotype: Australian Museum No. F 46384.

This species is of the *Dendrograptus rigidus* type, having a straight, narrow rhabdosome, 3·0 cm. long by 1·5 cm. wide. The main stem is 0·5 mm. wide. The few branches leave the main stem at 35–50 degrees at intervals of 2 to 3 mm. and decrease in width to 0·3 mm. Thecae denticulate and indistinct, perhaps 15 in 10 mm. This species shows some resemblance to *Thallograptus succulentus* (Ruedemann, 1947) but the stipes of *T. succulentus* are composed of bundles of thecae, which are not observed in *D. nudus*.

Associates, locality, horizon: as for *Callograptus arundinosus*.

TABLE 2.

Character of Forms Ascribed to Genera Callograptus *and* Desmograptus.

Species	*disjectus.*	*arundinosus.*	*quinquelateralis.*	*spongiosus.*
Rhabdosome	Shrubby.	Bamboo-like.	Pentagonal.	Oval.
Length (cm.)	1·5	4	6	0·75
Breadth (cm.)	1·8	2	6	0·9
Proximal end	Stiff stem.	—	Stem.	Stem 0·7 mm. wide.
Bifurcations in 10 mm.	8	3	7	10–15
Mesh	—	—	Pointed, elliptical.	Oval.
Stipes in 10 mm.	20	15	8–12	16
Spaces between stipes (mm.)	0·5	0·8–0·6	1·2–0·3	0·8–0·6
Width of stipes (mm.)	0·25	0·6–0·3	0·7–0·25	0·4
Shape of thecae	? Tubular.	Tubular.	Denticulate or tubular.	? Denticulate.
Number in 10 mm.	15	15	13	—
Age	All from Ordovician, Zone of *Nemagraptus pertenuis.*			

? DENDROGRAPTUS, sp. (Pl. viii, fig. 8).

The strongly curved stipes of a small dendroid, 1·5 cm. by 1·5 cm., suggest the genus *Aspidograptus*, but other attributes exclude it from that genus. It has a central knot of attachment, 2 mm. long by 1 mm. wide. Stipes curve from either end of this, each 0·5 mm. wide. One stipe curves in a semi-circular sweep above the central knot and the other below it. Each stipe bifurcates after each millimetre, sending out a branch about 0·1 mm. wide at an angle of 40 degrees. Obscure traces of denticulate and tubular thecae occur at 0·5 mm. intervals. Circular apertures of ? thecae can also be seen on stipes and branches (eight in 6 mm.). The diagnosis of *Aspidograptus* requires first, branching from the convex side only of the main stipe, and second, stipes and branches to be of the same width. Consequently this specimen must be excluded from *Aspidograptus* and probably included in *Dendrograptus*.

Associates, locality, horizon: as for *Callograptus arundinosus*.

A key to the *Dendrograpti* described is given in Table 3.

Genus DESMOGRAPTUS.

This genus has a net-like form like *Dictyonema*, but it is distinguished from that genus by the frequent anastomosis of its undulating stipes.

Desmograptus quinquelateralis, n. sp. (Pl. vii, figs. 5, 6).

Holotype: Australian Museum No. F 46389.

Rhabdosomes almost pentagonal in shape with a horizontal base. Length up to 6 cm. Length:breadth ratio from 1:1 to 1·5:1. Proximal end, where preserved, consists of a vertical or curving stem (1·5 mm. wide, 5 mm. long) from which spring horizontal stipes which turn later through 135 degrees to a vertical direction, frequently branching (six times in 8 mm.). Bifurcation generally more frequent distally. Stipes undulate continuously and anastomose or are connected by dissepiments, making an elliptical mesh with pointed ends, 4–6 times as long as wide. Stipes 0·7 mm. wide proximally and 0·25–0·5 mm. distally; 8–12 stipes per cm. of width (distally), spaces between are the same width as the stipes proximally but open out to 2–3 times as wide to form the mesh. At their distal ends the stipes break into fork-like ends, as in *Desmograptus* ? *tullbergi* Hadding, which occurs on the same horizon in Sweden. Thecae 13 in 10 mm., tubular or denticulate, while circular breaks in the white chitin (eight in 6 mm.) may be apertures. The dimensions of *D. quinquelateralis* are not unlike those of *Desmograptus vermicularis* Ruedemann from the *Nemagraptus* horizon of Arkansas.

TABLE 3.
Character of Forms Ascribed to Genera Dendrograptus *and* Ptilograptus.

Species	*rectangulosus.*	*nudus.*	? Sp.	*scalaris.*	*discurrens.*
Rhabdosome	Shrubby.	Stiff, bare.	Cyclic.	Stiff, bare.	Zigzagged.
Length (cm.)	2	3	1·5	1	1·2
Breadth (cm.)	2	1·5	1·5	2·5	0·8
Proximal end	Horizontal stem.	Stem.	Knot.	—	—
Bifurcation in 10 mm. ..	3–5	3½	10	12	10
Width of stipes (mm.) ..	0·7–0·3	0·3	0·5–0·1	0·25	0·2
Shape of thecae..	Denticulate and tubular.	Denticulate.	Denticulate and tubular.	Denticulate, spined.	Denticulate.
Age	Ordovician, Zone of *Nemagraptus pertenuis.*			Ordovician, Zone of *Orthograptus calcaratus.*	Silurian, Upper Llandovery.

Associates, locality, horizon: as for *Callograptus arundinosus.*

Desmograptus spongiosus, n. sp. (Pl. viii, fig. 9).

Holotype: Australian Museum No. F 46386.

Small, complete and shrubby. Width 9 mm., height 7·5 mm. Stipes 0·3–0·5 mm. wide, which branch five times in 3–4 mm. and undulate and anastomose, making a mesh from once to twice as long as it is wide. The stipes leave a short central main stem 0·7 mm. wide and branches of about the same width as the stipes spring from the stipes. Distal stipes are 15 in 9 mm. with 0·7 mm. space between each stipe. Obscure thecae are denticulate and also seen as circular apertures on main stem. There are a few dissepiments, 0·01 mm. wide.

Associates, locality, horizon: as for *Callograptus arundinosus.*

A key to these *Desmograpti* is given in Table 2.

Family PTILOGRAPTIDAE.

Genus Ptilograptus.

This genus contains species with a central stem from which branches spring alternately on either side. One Ordovician species and one Silurian species have been recognized.

ORDOVICIAN.

PTILOGRAPTUS SCALARIS, n. sp. (Pl. viii, fig. 11).

Holotype: Australian Museum No. F 46385.

Rhabdosome 1 cm. long and 2·5 cm. wide. Central stem 0·5 mm. wide, increasing to 1 mm. at each point where branches are given off. Eight primary branches (0·25 mm. wide and convex upward) leave the main stem at irregular intervals on alternate sides at an angle of 30 degrees on one side and 80 degrees on the other, this inequality being perhaps due to preservation not being in true profile. The longest branch is 1·3 cm. The branches bifurcate several times at progressively lower angles (40 degrees, 30 degrees and 20 degrees) and at closer intervals (first after 4 or 5 mm., then after 1 mm.). The main stem seems to be made up of bunches of thecae and the main branches to arise from successive thecae. A thickening of the stem can be noticed prior to each branching. There are 13 thecae in 10 mm. on the branches. Thecae denticulate, with some spines. This species is of dimensions somewhat similar to *Ptilograptus acutus* Hopk. from the Lower Llandeilo of St. David's, Wales (Hopkinson and Lapworth, 1875), but comes from a higher horizon.

Associates: *Climacograptus bicornis, Orthograptus calcaratus, Dicellograptus elegans.*

Locality: Woodstock, quarry, one mile north of railway station.

Horizon: Zone of *Orthograptus calcaratus* and *Plegmatograptus nebula.*

Fragments possibly belonging to this genus have been collected at Tomingley.

SILURIAN.

PTILOGRAPTUS DISCURRENS, n. sp. (Pl. viii, fig. 12).

Holotype: Sydney University Reg. No. 7127.

Rhabdosome 1·2 cm. long and 0·8 cm. wide. Distinctly zigzagged main stem, with branches 10 in 10 mm., which leave the main stem at about 65 degrees. Proximal branches 4 mm. long and 0·2 mm. wide. Distal branches 2·5 mm. long. Branches show longitudinal cords, as are described for *P. glomeratus* by Pocta (1894). These cords are apparently internal sections of thecae. No secondary branching. Thecae distinct, denticulate, about 22 in 10 mm.

Associates: *Monograptus* cf. *pragensis pragensis, Dictyonema* sp.

Locality: (g2) Quarry Ck., west of Orange.

Horizon: Upper Llandovery (Packham and Stevens, 1955).

A key to these *Ptilograpti* is given in Table 3.

Family ACANTHOGRAPTIDAE.

In this family the branches are composed of bunches of very long thecae.

Genus ? ACANTHOGRAPTUS, sp. (Pl. viii, fig. 7).

A fragment, 1 cm. by 1 cm., which may be *Acanthograptus* sp., consists of a proximal stem, 1·5 mm. wide, which splits into three flexuous branches. These give off branchlets at 1·5 mm. intervals. Each branchlet widens distally from 0·3 to 0·8 mm. before opening, 10 times in 10 mm., to show bundles of tubular thecae up to 1 mm. long. Short thecal spines are given off between the branchlets. There are circular orifices in the centre of the branches at intervals of 1 mm.

Associates: Locality, horizon: as for *Callograptus arundinosus.*

UNCERTAIN RELATIONSHIP.

? THAMNOGRAPTUS.

Thin, black, linear fragments, giving off at right angles or smaller angles, other linear fragments may represent *Thamnograptus.* The main framework of about 3 mm. length is less than 0·1 mm. wide, with projecting branches about 1 mm. apart. It is possible that these fragments represent the broken off clathria of *Retiograptus geinitzianus*, which is associated with them.

Locality: Licking Hole Creek, Mandurama.

Horizon: *Nemagraptus pertenuis* zone, Ordovician.

Isograptus (Didymograptus) caduceus was also recorded in the assemblage at Licking Hole Creek, the type area for the zone of *Nemagraptus pertenuis* (Sherrard, 1954, Pl. x, fig. 5). While the thecae in this graptolite are typical of the Dichograptidae, being simple tubes with no traces of sigmoidal ventral curvature, its proximal end is like that of a *Dicellograptus*. The graptolite perhaps represents a transitional form not previously recorded.

Acknowledgements.

Dr. Ida A. Browne has kindly read this manuscript and advised upon it. I am also indebted to Mr. H. O. Fletcher, Palaeontologist to the Australian Museum, and to Mr. H. F. Whitworth, Curator of the Mining Museum, Sydney, who have both allowed me to study specimens in their charge. Mr. G. H. Packham has also kindly made available dendroids he has collected. Mr. J. Spencer Mann, of the University of Melbourne, was good enough to photograph some dendroids for me, and I am also grateful to my son, W. O. Sherrard, who accompanied me on collecting excursions and also helped me with photography.

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EXPLANATION OF PLATES VII–VIII.

Plate vii.

1, *Dictyonema apertum*, n. sp. Kerr's Ck., Port. 57, Par. Larras Lake. × 2. Syd. Univ. No. 7125.
2, *Dictyonema favosum*, n. sp. Quarry Ck., west of Orange. × 2. Syd. Univ. No. 7128.
3, *Dictyonema salebrosum*, n. sp. North-west of Cliefden Caves, Mandurama district. × 3. Syd. Univ. No. 7126.
4, *Reticulograptus undulosum*, n. sp. Paling Yards Public School Site. × 4. Syd. Univ. No. 7129.
5, *Desmograptus quinquelateralis*, n. sp. Tomingley. × 2. Aust. Mus. No. F 46389.
6, *Desmograptus quinquelateralis*, n. sp. Tomingley. × 2.
(Specimens in Figs. 1, 2 and 4 collected by Mr. G. H. Packham, in Fig. 3 by Mr. N. C. Stevens. Figs. 3 and 4 photographed by Mr. J. S. Mann, Melbourne University.)

Plate viii.

1, *Callograptus arundinosus*, n. sp. Tomingley. × 2. Aust. Mus. No. F 46382.
2, *Callograptus arundinosus*, n. sp. Tomingley. × 2.
3, *Dendrograptus rectangulosus*, n. sp. Tomingley. × 2.
4, *Callograptus disjectus*, n. sp. Cadia. × 2. Aust. Mus. No. F 39532.
5, *Dendrograptus nudus*, n. sp. Tomingley. × 2. Aust. Mus. No. F 46384.
6, *Dendrograptus rectangulosus*, n. sp. Tomingley. × 4. Aust. Mus. No. F 46383.
7, ? *Acanthograptus*, sp. Tomingley. × 2.
8, ? *Dendrograptus*, sp. Tomingley. × 2. Aust. Mus. No. F 46387.
9, *Desmograptus spongiosus*, n. sp. Tomingley. × 4. Aust. Mus. No. F 46386.
10, ? *Dictyonema*, sp. Bowning district. × 4. Aust. Mus. No. F 46390.
11, *Ptilograptus scalaris*, n. sp. Woodstock Municipal Quarry. × 2. Aust. Mus. No. F 46385.
12, *Ptilograptus discurrens*, n. sp. Quarry Ck., west of Orange. × 2. Syd. Univ. No. 7127. (Collected by Mr. G. H. Packham.)

CHLOROSIS AND LACK OF VIGOUR IN SEEDLINGS OF RENANTHEROUS SPECIES OF *EUCALYPTUS* CAUSED BY LACK OF MYCORRHIZA.

By L. D. Pryor.

(Plate ix; one Text-figure.)

[Read 18th April, 1956.]

Synopsis.

Poor growth and chlorosis in seedlings of some Renantherous species of *Eucalyptus* are corrected by the addition of *Scleroderma flavidum* spores, which leads to the formation of an ectotrophic mycorrhiza. Records of introduction in the northern hemisphere suggest that lack of suitable mycorrhiza may be responsible for the poor growth of the Renantherae as a whole. Obligate mycorrhiza in *Eucalyptus* seems to be limited to the systematic group Renantherae. It is suggested that a retrial, with the addition of fungal spores, of the important Renantherous species in areas where they have failed but might be expected to grow because of soil and climate, would be worth while.

It was noticed in 1953, when attempting to raise various species of *Eucalyptus* in the nursery at Eski Kellek, in Iraq, that some valuable species, all belonging to the systematic group, the Renantherae, grew weakly and in many cases became chlorotic and often died in the nursery soon after the second or third pair of leaves had been produced. This was found to apply to *Eucalyptus dives*, *E. pauciflora* and *E. Robertsonii*. The growth of *E. fastigata*, also in the same group, was a little better than that of the other three species but still was far from thrifty.

It was thought at the time, when looking for an explanation, that the highly calcareous soils characteristic of much of Iraq may have contributed to the trouble. The view that chlorosis and poor growth or even death might be caused, perhaps indirectly, by excess lime, had some support in the evidence from *E. camaldulensis*. This is the most commonly planted Eucalypt through the Mediterranean region and the Middle East. It thrives in many localities, but it is noticeable while tolerating some degree of lime that on highly calcareous soils in Iraq, Israel, Jordan and Morocco it becomes at times very chlorotic and fails. It has been suggested recently by work in Israel (Karschon, 1953), that chlorosis in this species can be corrected by suitable iron injection and that the effect is caused by lime-induced iron deficiency.

Some of the species which were raised successfully to the eighth leaf-pair stage in Iraq at the same time, in the nursery under the same conditions, included *E. microcarpa*, *E. sideroxylon*, *E. bicostata*, *E. viminalis* and *E. gomphocephala*, as well as *E. camaldulensis*. It could then be implied, if lime were the cause of the trouble, that the species concerned which failed must be distinctly more susceptible than *E. camaldulensis*.

Since nothing was known of the response of *Eucalyptus* to various major fertilizers, trials were made in Canberra with *E. macrorrhyncha* (Renantherae) and *E. bicostata* (Macrantherae) in pots of unsterilized washed sand to which ammonium sulphate, potash, superphosphate and lime were added singly at two ratings, and potash, superphosphate and ammonium sulphate together. A dressing in the form of ground calcium carbonate was used for the lime treatment. The response of both species to ammonium sulphate was marked, even when provided alone. The effect of lime was firstly to reduce germination to some degree, and of the plants which did become established the growth was comparable with the control, although there was a tendency for a purplish colour to develop at the margins and tips of the leaves. There was, however, no sign of chlorosis in the young plants and growth was reasonably healthy and not very different from that in which potash and superphosphate were supplied each alone. The results of these simple experiments, therefore, suggested that the chlorosis developed in Iraq was not induced by excess lime.

Trials were then made in Canberra growing *Eucalyptus* under bell jars in electrically heat-sterilized soil. A chlorotic condition similar to that found in Iraq developed in the Renantherous species, particularly in *E. pauciflora*, *E. macrorrhyncha*, *E. dives* and *E. fastigata*, while *E. bicostata* (Macrantherae) and *E. melliodora* (Terminales) did not show these symptoms. A further test was made by transplanting from sterilized soil eight highly chlorotic seedlings of *E. pauciflora* (in the second leaf-pair stage), four to non-sterilized soil and four to sterilized soil. In the space of three weeks the plants transferred to non-sterilized soil developed green leaves and regained vigour, while those transferred to sterilized soil lived for about five weeks and then died. On the roots of the plants in sterilized soil there was no trace of fungal hyphae, whereas in the unsterilized soil there was a thin, irregular investiture of hyphae.

Experiments were therefore extended to include non-sterilized soil. *E. pauciflora* and *E. macrorrhyncha* (Renantherae) were grown in comparison with *E. melliodora* (Terminales), *E. bicostata* (Macrantherae) and tomato. The growth of the latter three species (including tomato) was very substantially better in the sterilized than in the non-sterilized soil. On the other hand, the growth of *E. pauciflora* and *E. macrorrhyncha* was healthy and somewhat faster in the non-sterilized soil than in the sterilized soil, where it was chlorotic and weak. It is also noticeable with heat-sterilized soil in normal nursery practice that species of the Renantherous group are particularly prone to chlorosis and this frequently leads to death. When the species are grown in open-ended tubes in the nursery, however, they often grow well enough to root through to the soil below the tubes and then make a substantial recovery. It was concluded that heat sterilization of soil (taken from beneath a *Eucalyptus* stand) makes available nutrients of which only species of the Macrantherae and Terminales groups can immediately make use. It also seemed from the tests that the chlorotic condition which develops was probably due to lack of mycorrhiza due to the destruction by sterilization of the essential fungal symbiont.

Trials by Adding Fungal Spores.

Reports of mycorrhizal association in *Eucalyptus* are confined to morphological or anatomical descriptions, and no demonstration has been made hitherto to suggest that any such association is either obligatory or even beneficial. Samuel (1926) recorded an ectotrophic mycorrhiza on *E. rubida*. Material from *E. gigantea* from a natural stand examined by N. H. White (1954) appeared very characteristically mycorrhizal, showing the short, much-branched coralloid type of root formation with a distinct ectotrophic mycorrhiza exhibiting the characteristic "Hartig net". Smith and Pope (1934) record ectendotrophic mycorrhiza on species of *Eucalyptus* (unnamed) in South Africa, formed by a South African species of *Polysaccum* (syn. *Psilolithus*). The common occurrence of a range of Gasteromycetes in *Eucalyptus* forest has suggested mycorrhiza forming fungal species may be found in this group.

It was noticed in trial *Eucalyptus* plantations that there was a high degree of association between the fruiting bodies of *Scleroderma flavidum* and planted trees, and particularly with the species *E. pauciflora* and *E. Robertsonii* of the Renantherae. This was best seen after certain weather conditions following clean cultivation when the Gasteromycete disclosed its presence by cracking the surface of the soil. Fruiting bodies of this fungus were collected and an experiment was carried out in which spores were added to heat-sterilized soil in pots. It was realized, of course, that this method falls short of a pure culture technique, but it was thought that if the usual conditions of mycorrhiza formation with a Gasteromycete applied, an indication of the significance of the *Scleroderma* might be obtained. The pots with soil were heat-sterilized in an electric oven at about 400°F. for about five hours. The trial species were *E. bicostata* (Macrantherae), and *E. macrorrhyncha*, *E. pauciflora* and *E. dives* (Renantherae). Five pots of each were used. In the treated pots a liberal application of the spores of *Scleroderma* was made, sowing being carried out after an additional half an inch of sterilized soil had been added to cover the spores. Seed to produce about 100 seedlings was sown in each pot. The sowing was carried out in late winter and the pots placed in a heated frame to hasten growth. The conditions in the frame were more favourable for growth than in the earlier experiments under bell jars.

Differences appeared between the treated and untreated pots after about four months and at eight months this was marked. The untreated showed general discoloration and unthrifty growth in the Renantherous species, whereas the treated were much better in colour and growth (Pl. ix, fig. 1). There was no effect of inoculation on *E. bicostata* (see Table 1). Examination of the roots showed that in the pots to which the Scleroderma spores had been added distinct mycorrhizal clusters were visible both on the outside of the ball and within the ball itself. The clusters have the distinct morphological appearance of ectotrophic mycorrhiza with a short coralloid branching habit and a prominent whitish hyphal sheath (Pl. ix, figs. 2 and 3). There was no sign of this mycelium or mycorrhiza in the untreated pots. Microscopic examination of a mycorrhiza from one of the *E. macrorrhyncha* pots showed a thick hyphal mantle with distinct Hartig net penetrating to a depth of two or three cortical cells (Text-fig. 1). It is concluded, therefore, that *Scleroderma flavidum* can act as a mycorrhizal-forming fungus capable of promoting thrifty growth in the three Renantherous species of *Eucalyptus* tested, whereas, in the absence of this fungus, growth of these species in heat-sterilized soil is poor and unthrifty.

TABLE 1.

		A. Heat Sterilized Soil+Scleroderma Spores.			B. Heat Sterilized Soil.		
		Height Growth.* (6 mos.).	Colour.	Mycorrhiza.	Height Growth (6 mos.).	Colour.	Mycorrhiza.
		In.			In.		
Renantherae.	*E. dives*	5·3	Good.	Present.	3·2	Yellowish.	Nil.
	E. pauciflora	6·2	Good.	Present.	3·3	Yellowish.	Nil.
	E. macrorrhyncha	11·3	Good.	Present.	7·8	Yellowish.	Nil.
Macrantherae.	*E. bicostata*	9·5	Good.	Nil.	8·8	Good.	Nil.

* Average maximum growth. There were many seedlings per pot.

DISCUSSION.

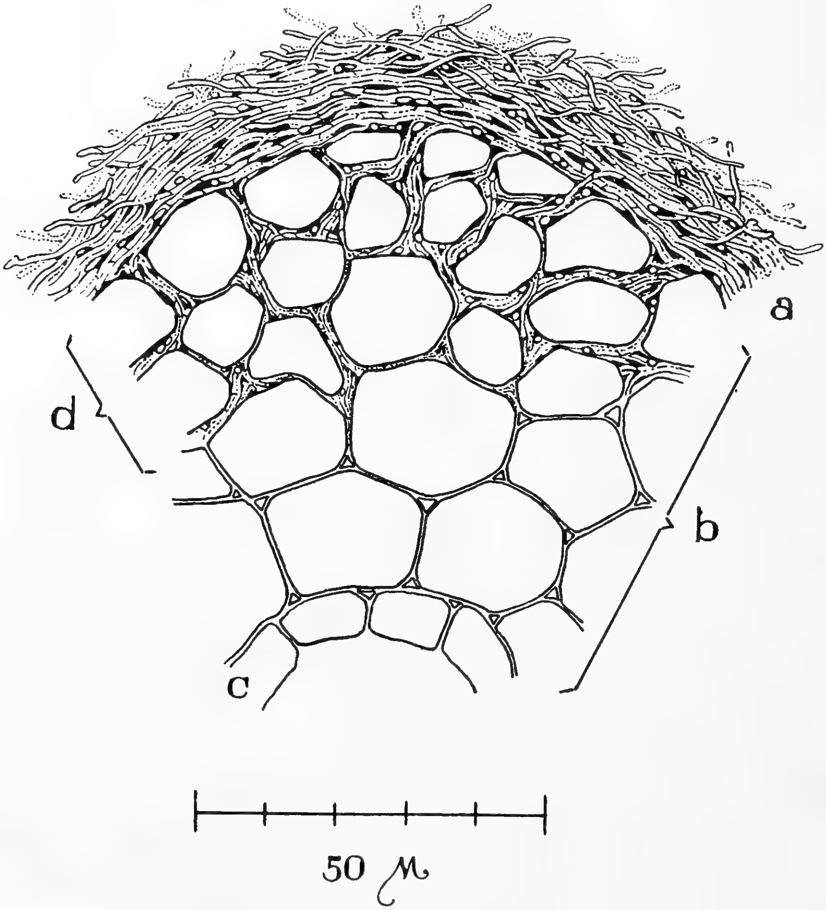
The precise role of mycorrhiza in *Eucalyptus* is likely to be as complex as in other tree species and doubtless is bound up with nutrition of the plant. It appears that with the Renantherous group of *Eucalyptus* species the presence of mycorrhiza is essential for healthy growth and that chlorosis in the Renantherae is generally due to lack of a suitable fungal symbiont. There is no reason to suppose that many other species or genera of fungi, besides *Scleroderma*, may not be similarly associated. According to Burges (1936), Peyronel lists 13 species of fungi which form mycorrhiza on *Fagus sylvatica*, and Melin (1948) mentions that about 30 species of fungus have so far been proved to be mycorrhiza forming with *Pinus sylvestris*.

Scleroderma as a genus is considered a mycorrhizal fungus of a good many genera in the northern hemisphere, particularly *Larix*, *Castanea*, *Fagus* and *Quercus* (Rayner, 1927). The one species used in this test has been determined as *Scleroderma flavidum*, which is found in Australia, New Zealand, Africa and America, the type having been described from America. The distribution in both northern and southern hemispheres is in conflict with the idea that suitable mycorrhizal fungi are lacking in the north, but it is likely that even if they are the one species (which is uncertain because of the difficulties in the taxonomy of the Gasteromycetes), the Australian form is physiologically distinct.

The most notable exception to the failure of the Renantherous species outside Australia is with *E. fastigata*, *E. regnans*, *E. obliqua* and *E. piperita* in New Zealand

and a few other species in South Africa. In view of the fact that on the one hand New Zealand is known to share with Australia one species of *Scleroderma* which is confined to the two countries, and the fact that there are strong vegetational links otherwise with South Africa and New Zealand which may well extend to the fungi, the explanation could be that adequate mycorrhizal symbionts are already available in those two countries, and Smith and Pope's (ibid.) observations lend support to this view.

In the northern hemisphere the position is different and a review of the record of introductions of *Eucalyptus* as an exotic shows that poor growth or failure is experienced with species of the Renantherae in many plantation projects outside Australia. Although it is known that many species of this group have been tried overseas, very few have made successful growth. An exception is *E. coccifera* and perhaps *E. gigantea* on the west coast of Scotland (Martin, 1948). Of course in some cases failure is simply due to the fact that the climate and soil are unsuitable, but this is by no means always so. Results from trials by M. Menager (1953), who has planted Eucalypts in Les Landes, France, are interesting in this connection. He notes as a result of his trials over four or five years that the best species are *E. Gunnii*, *E. Macarthuri*, *E. subcrenulata*, *E. rubida*, *E. Dalrympleana*, *E. viminalis*,



Text-figure 1.

Cross section of a mycorrhiza of *E. macrorrhyncha* and *Scleroderma flavidum* showing (*a*) hyphal mantle, (*b*) cortex, (*c*) endodermis, and (*d*) Hartig net.

E. stellulata, *E. parvifolia*, *E. bicostata* and *E. camaldulensis*, whereas perhaps the most valuable ones which have largely or entirely disappeared are *E. gigantea*, *E. obliqua*, *E. regnans*, *E. Andreana* (syn. *E. Lindleyana*), *E. Robertsonii* and *E. pauciflora*. It is striking that of these two groups the first belong to the Macrantherae with the one exception, *E. stellulata*, and the second entirely to the Renantherae.

In Cyprus there is a similar situation. Chapman (1953) records 21 species of the Renantherae and 19 species of the Macrantherae-Normales as having been introduced by seed between 1878 and 1934, as well as species from other groups, making a total of some 70 species. It is true that in the areas in which Eucalypts have been planted in Cyprus, the rainfall is rather low and species from groups other than the Renantherae and Macrantherae-Normales are likely to thrive better. Nevertheless, five species of the Macrantherae-Normales out of the 19 recorded as having been introduced are now found growing on the island, whereas not a single specimen of the group Renantherae has survived, although 11 of those introduced are considered likely to succeed from the general point of view of climate and soil available. This evidence also supports the view that failure is due to lack of mycorrhiza.

The Renantherae as a group on genetic grounds have the status of a sub-genus within *Eucalyptus*. They have many features which cut them off very distinctly from all other systematic groups within the genus and there is evidence of a strong barrier to interbreeding between them and other groups of the genus (Pryor, 1951). That the Renantherae have ectotrophic mycorrhiza obligatory for thrifty growth is yet another distinctive character of this group.

To understand the precise role of mycorrhiza throughout all the species, the fungi involved and the various aspects of the way in which each is related to the growth of the tree would require extensive investigation. The present study suggests that a retrial of all the Renantherous species of outstanding importance as timber producers is justified in areas where they have failed but where from general considerations of climate and soil they might otherwise have been expected to succeed. A simple way to start would be by the addition of spores of *Scleroderma flavidum* from Australia to potting soil overseas, but it must be anticipated that several other fungi will be necessary to suit all species.

The most important species of the Renantherae which come into this category are *E. Andreana*, *E. Andrewsii*, *E. Blaxlandi*, *E. coccifera*, *E. dives*, *E. fastigata*, *E. fraxinoides*, *E. gigantea*, *E. globoidea*, *E. laevopinea*, *E. macrorrhyncha*, *E. marginata*, *E. Muelleriana*, *E. obliqua*, *E. oreades*, *E. pauciflora*, *E. pilularis*, *E. radiata*, *E. regnans*, *E. Robertsonii*, *E. salicifolia*, *E. scabra*, *E. Sieberiana*, *E. stellulata*, *E. triantha*, and *E. urceolaris*.

A further point of interest follows from the recognition of ectotrophic mycorrhiza on *Eucalyptus*. This is in conflict with Asai's (1934) view that ectotrophism is a rather primitive state of symbiosis because he found it confined to supposedly primitive dicotyledonous orders such as Salicales and Fagales. The order Myrtiflorae, to which *Eucalyptus* belongs, is considerably advanced in the Engler and Prantl scheme. Even within the genus itself there is no reason to suppose that the Renantherae is a primitive group, and Garratt's (1950) idea that ectotrophic mycorrhiza results from highly evolved root-infecting fungi fits the case better than Harley's (1948) implication that it is a partial specialization preceding the development of full endotrophism. Obligate ectotrophism seems to be a highly specialized condition and therefore, in this respect at least, the Renantherae would be the most advanced group of the genus.

Acknowledgements.

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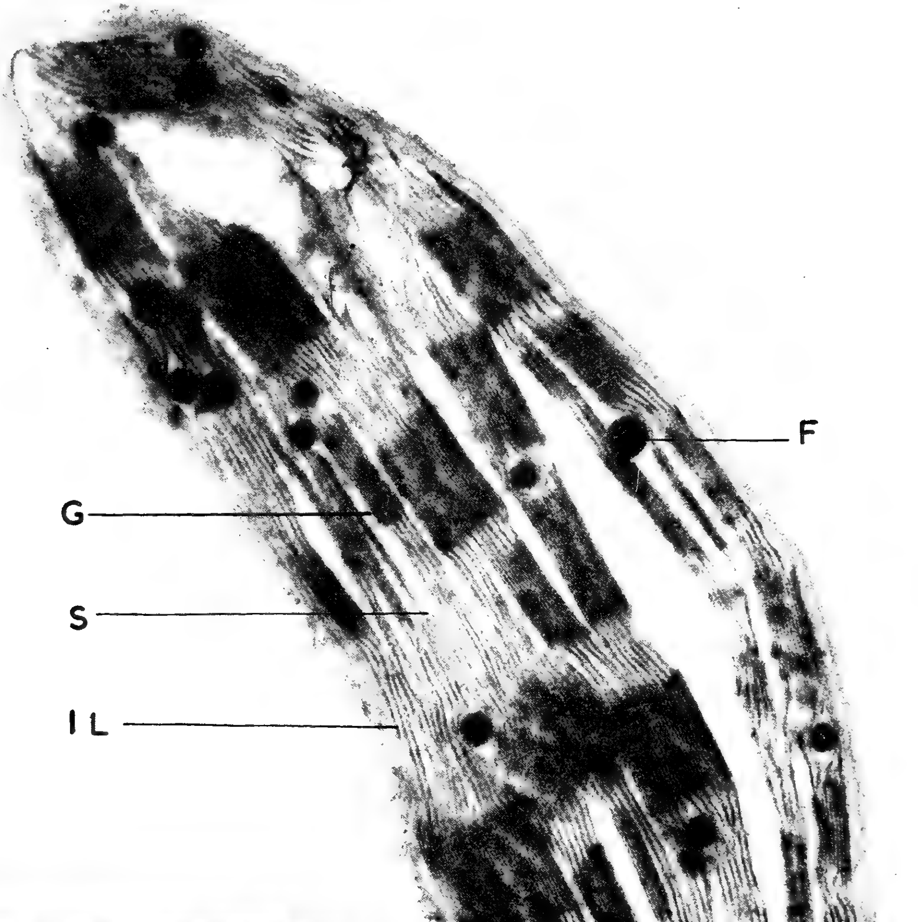
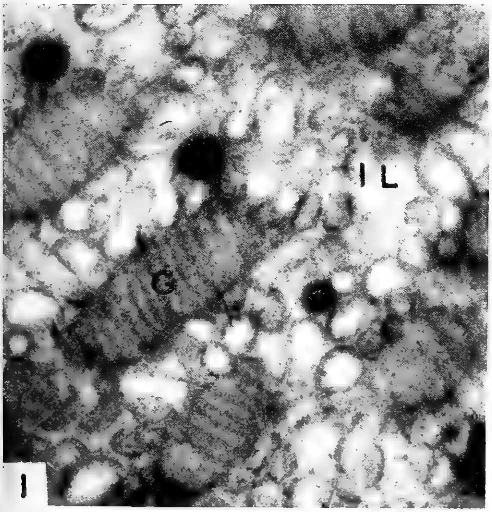
EXPLANATION OF PLATE IX.

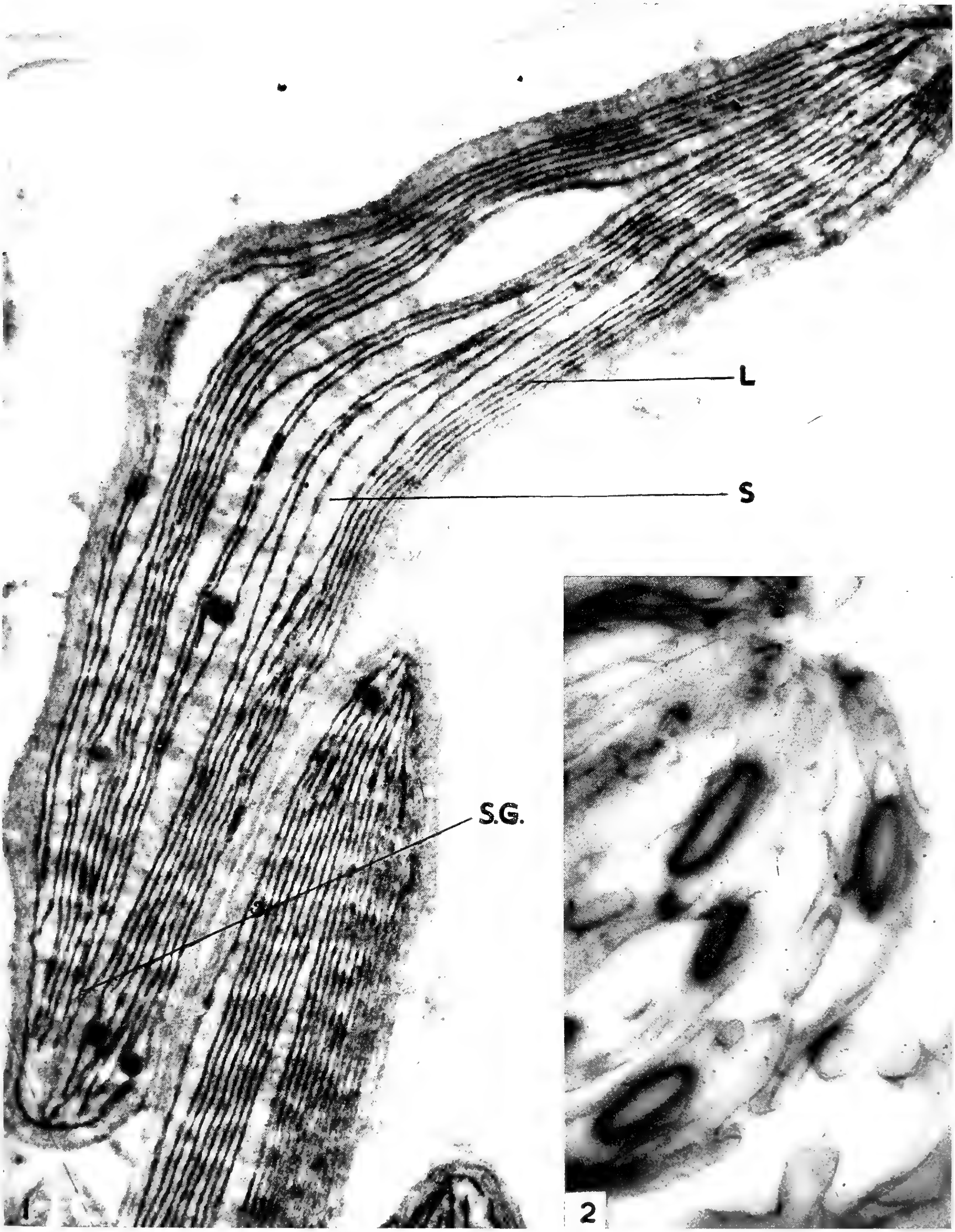
1. *E. dives.* Left, with spores of *Scleroderma*; right, in sterilized soil without spores.
2. Mycorrhizae of *Scleroderma* and *E. macrorrhyncha* on the outside of the root ball.
3. Mycorrhizae of *Scleroderma* and *E. macrorrhyncha* on the outside of the root ball.



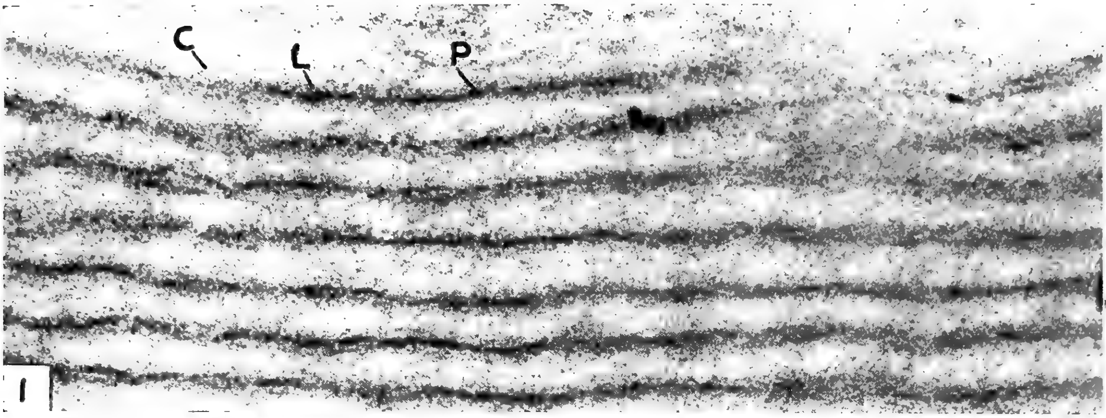


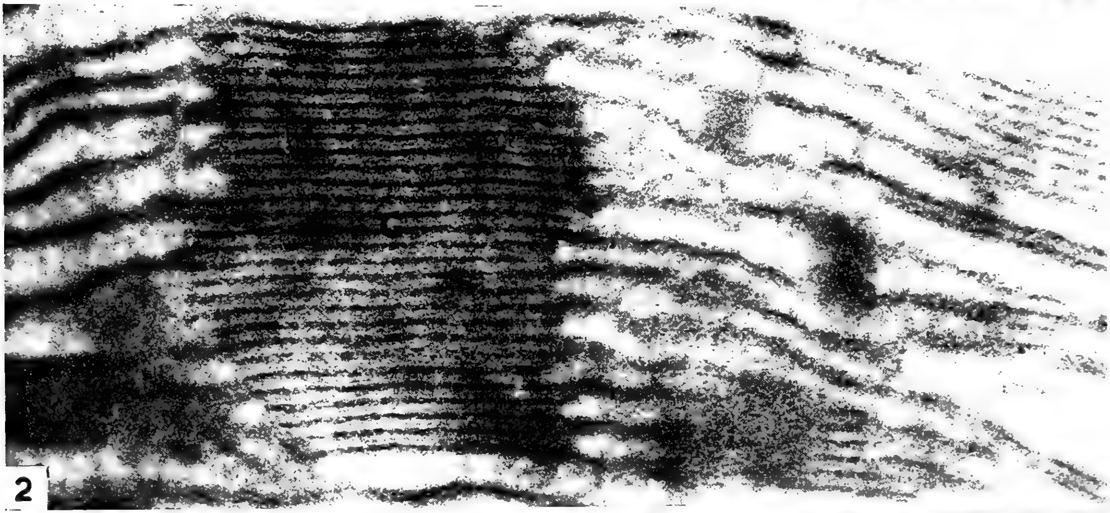
1. Transverse section of mesophyll chloroplast.

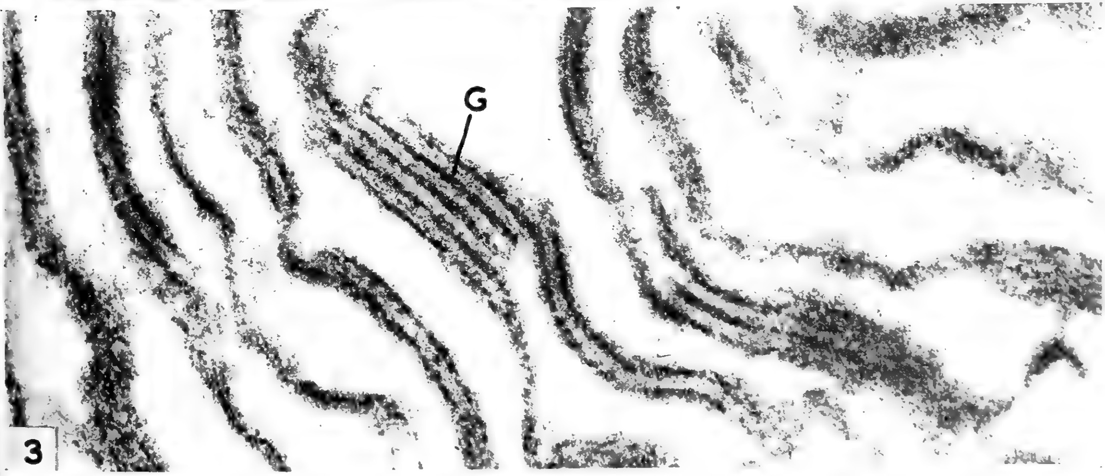
2. Transverse section of chloroplast in mesophyll cell.



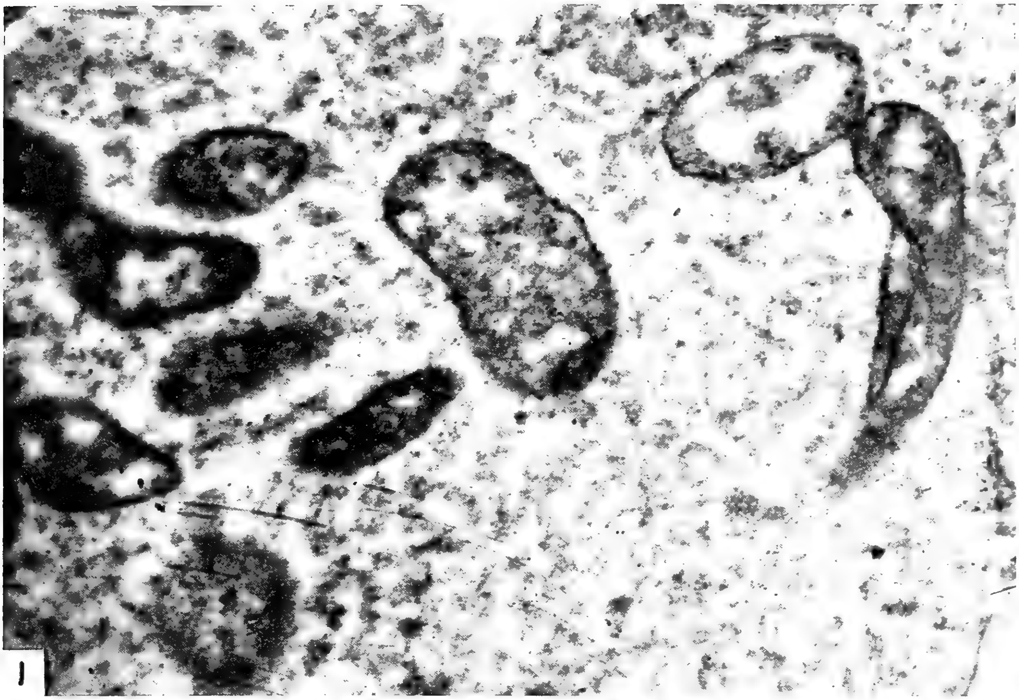
1. Transverse section of chloroplast from starch sheath cell. 2. Portion of starch sheath chloroplast.



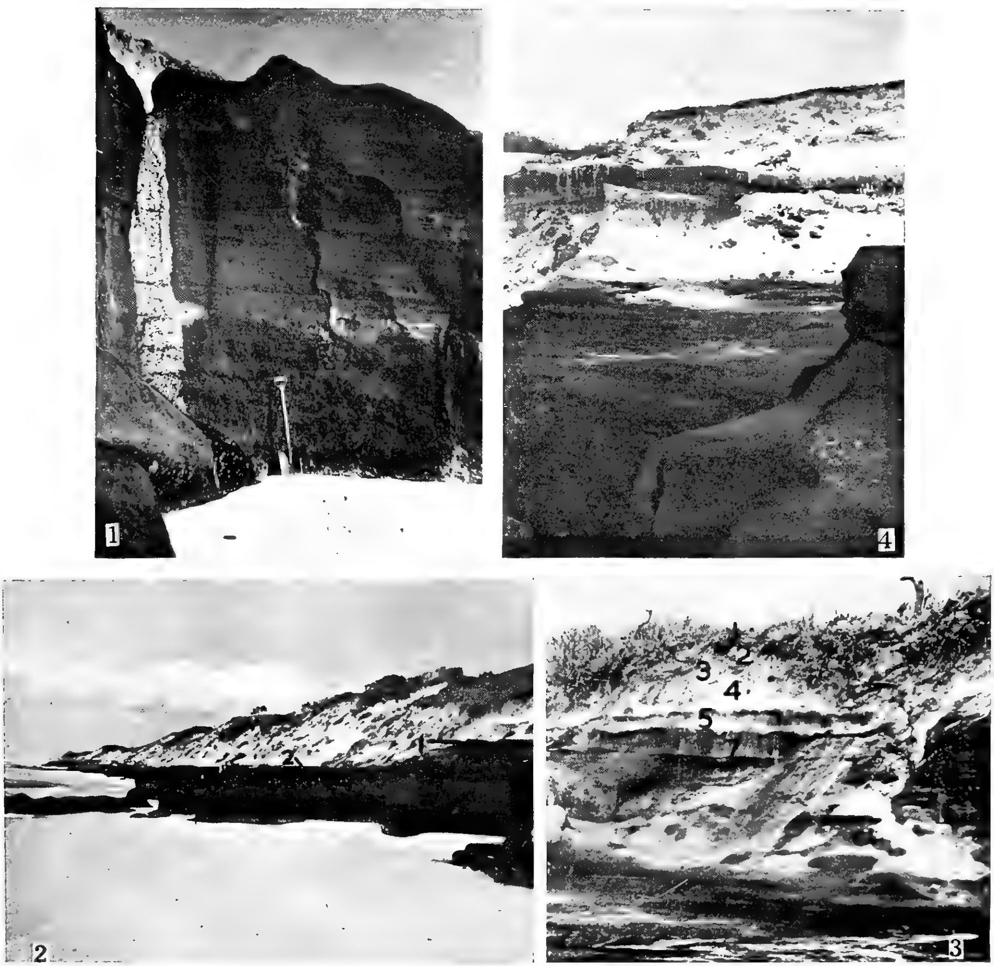




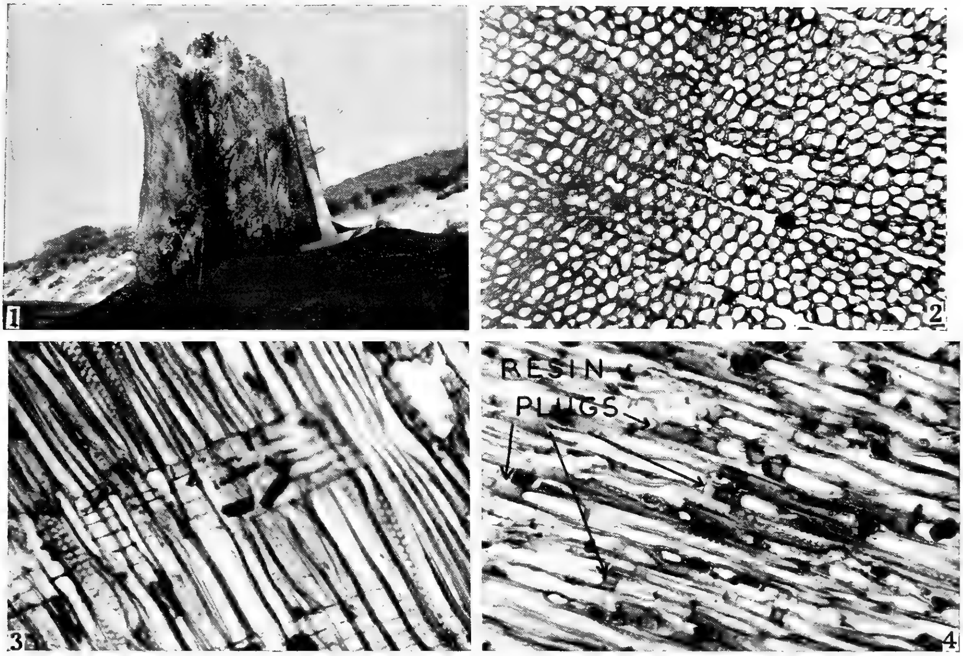
1. Portion of starch sheath chloroplast. 2. Granum from a mesophyll chloroplast. 3. Organ of grana in chloroplast.



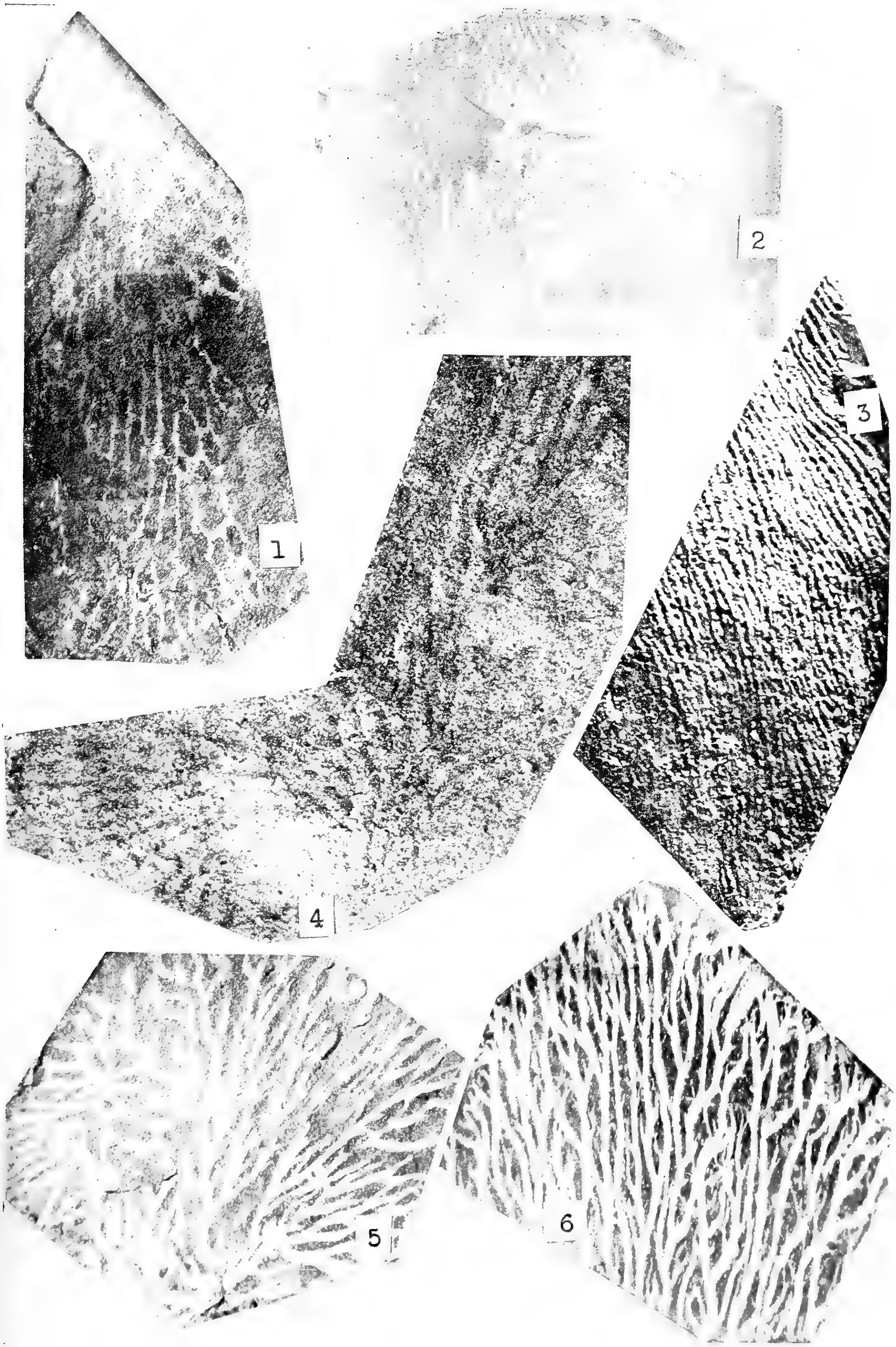
1. Organelles in cells of leaf primordia. 2. Differentiation of organelles in cell of leaf primordia.



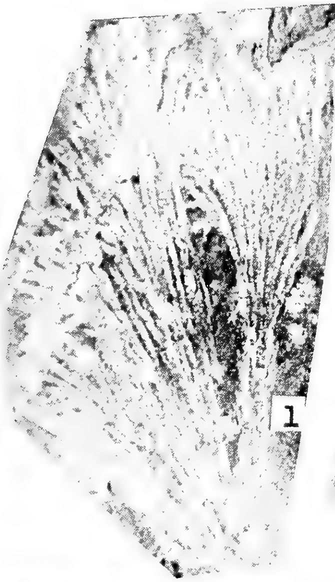
Coastal Sandrock Formation at Evans Head, N.S.W.



Fossil Wood (*Agathis*) from Evans Head, N.S.W.



Dendroid Graptolites from New South Wales.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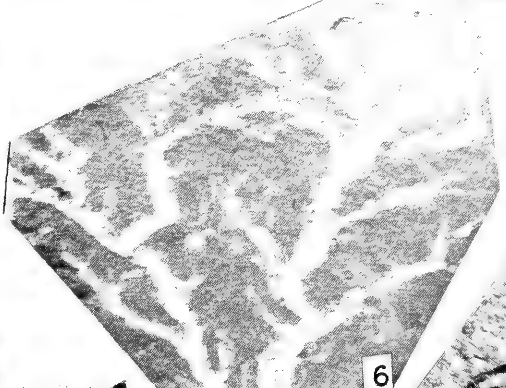
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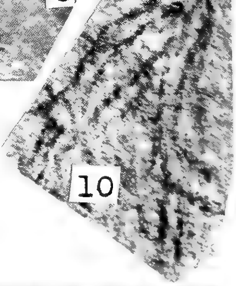
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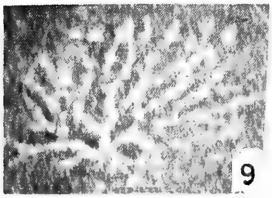
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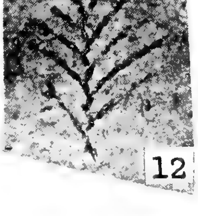
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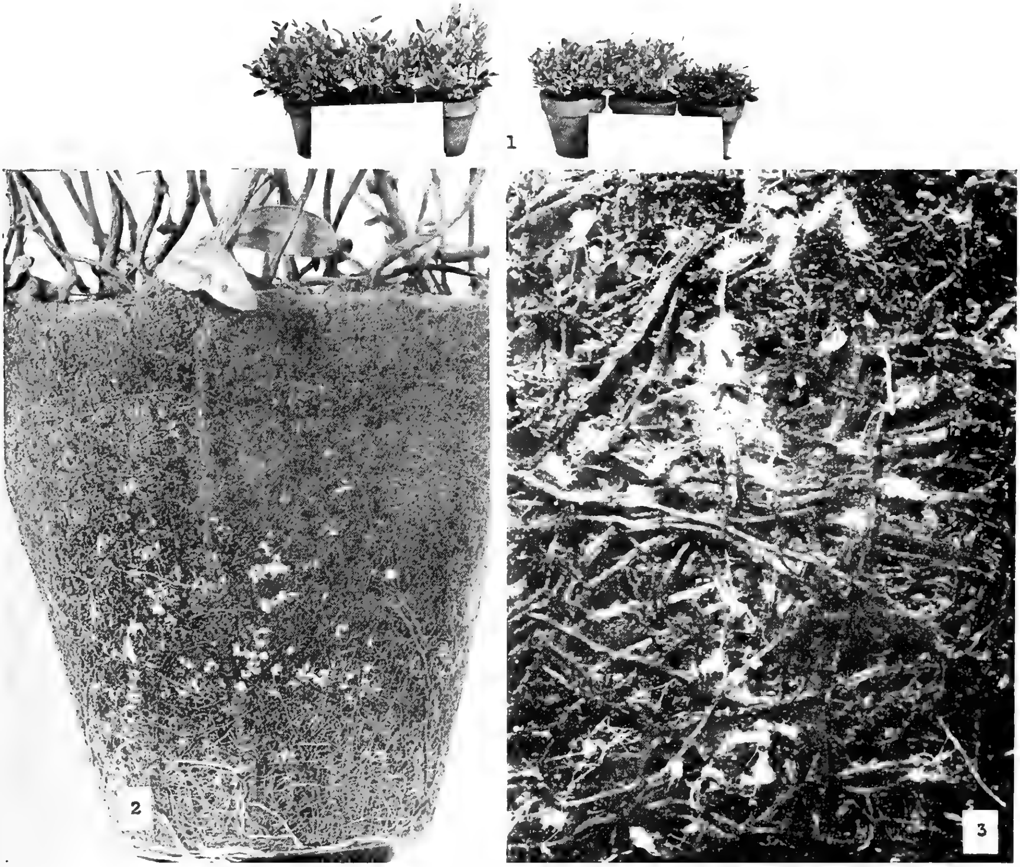
Dendroid Graptolites from New South Wales.



1. *Eucalyptus dives* with spores of *Scleroderma* (left) and without spores (right).
2, 3. Mycorrhiza of *Scleroderma*. and *Eucalyptus macrorrhyncha*.

AN F1 HYBRID BETWEEN *EUCALYPTUS PULVERULENTA* AND *E. CAESIA*.

By L. D. Pryor.

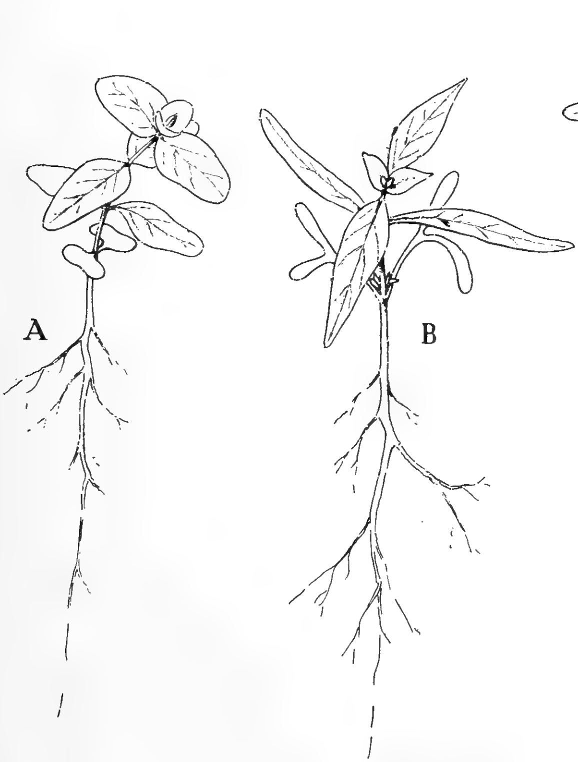
(Two Text-figures.)

[Read 30th May, 1956.]

Synopsis.

A viable F1 hybrid between *E. pulverulenta* and *E. caesia* has been produced by manipulated pollination. It is suggested that *E. caesia* belongs to a natural systematic group with bisected cotyledons and that successful hybridization between this group and many species of the Macrantherae-Normales may be possible.

Species which can cross often produce hybrids naturally when they grow near one another. Where they are always widely separated in the field it is necessary to make manipulated crossings to see whether they can hybridize. The capacity to cross is one index (though by no means the only one) of affinity between species (Duffield, 1952). Where each of the pair of species involved in successful crossing is derived from separate systematic groups an indication is given of the affinity of the groups and this in turn makes possible a reasonable forecast as to which species combinations may be successful in a breeding programme.



Text-fig. 1.—Seedlings of (*a*) *E. pulverulenta,* (*b*) *E. caesia* and (*c*) *E. caesia* × *E. pulverulenta* at about five months.

The combination, *E. pulverulenta* and *E. caesia*,* is of this kind. *E. pulverulenta* belongs to the group Macrantherae-Normales. It has a fairly wide overall distribution between Sydney and the Victorian border. It occurs nevertheless in very small separated stands on the mountain ranges. It retains opposite, orbicular, sessile, glaucous leaves to maturity and does not develop the lanceolate, petiolate, alternate leaves characteristic of most Eucalyptus species. *E. caesia* is a species of Western Australia which Blakely places in the series Obliquae. It has the common Eucalyptus type of mature foliage. The two species are separated in their natural occurrences by some 2,000 miles.

E. pulverulenta grows easily in Canberra, as it is fully frost-hardy and reasonably drought-resistant. *E. caesia*, however, usually fails because it is too frost-sensitive. Fortunately, as a result of more than usual care and attention, Mr. A. D. Helms was able to raise a tree of this latter species to the flowering stage in his garden in Canberra, and he made this available for experiment. *E. caesia* has a relatively short flowering period and *E. pulverulenta* a long flowering period, which usually commences at about the end of winter and goes on for about three months. *E. caesia* flowered during the middle of this period. Reciprocal pollinations were made, but with *E. caesia* as the female parent there was complete failure with *E. pulverulenta* (and with several other species), the only flowers which set seed being selfings. However, this indicated that the individual was fully self-compatible. On the other hand, with *E. pulverulenta* as the female parent a good setting was obtained on some 20 flowers and sufficient viable seed was produced to raise about 15 seedlings. The seedlings have now produced the eighth pair of leaves and the F1 hybrids are intermediate between the two parents (Text-fig. 1) in approximately the same way that the F1s, *E. cinerea* × *E. robusta*, are intermediate between the parents (Pryor, 1954). The juvenile leaves of *E. pulverulenta* are, like the adult leaves, glaucous, orbicular, sessile and opposite, whereas those of *E. caesia* are petiolate, alternate, ovate-lanceolate and non-glaucous. The F1s of this combination are intermediate in leaf shape and glaucousness and the leaves shortly petiolate and opposite. They are, at this seedling stage, as vigorous as the faster growing parent, *E. pulverulenta*.

Text-fig. 2.—Seedlings of (*a*) *E. pulverulenta*, (*b*) *E. caesia* and (*c*) *E. pulverulenta* × *E. caesia* at about 2 months, showing especially the cotyledon shape.

An interesting morphological feature is found in the cotyledons. Those of *E. pulverulenta* are of the shape characteristic of the Macrantherae-Normales, that is,

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* Nomenclature as in Blakely's "Key to the Eucalypts", 1934.

more or less transversely oblong and slightly emarginate. On the other hand, those of *E. caesia* are of a very distinct shape, being markedly bisected to form two slender lobes so that the whole cotyledon has the shape of the letter Y. This type of cotyledon is common in many Western Australian species but is confined to four or five only in eastern Australia. The F1 hybrid is intermediate between the two in this respect, as shown in Text-figure 2.

DISCUSSION.

The failure of the reciprocal cross is comparable with the experience of Brett (1949) in attempting to synthesize the hybrid *E. globulus* × *E. viminalis*, where there was failure with *E. globulus* as the female parent. The suggestion made to account for this was that, since the style length is so much greater in *E. globulus* than in *E. viminalis*, this made it impossible for the tube of germinating *E. viminalis* pollen to fertilize the *E. globulus*. In the present case *E. caesia* has a style very much longer (about two to three times) than *E. pulverulenta*. It may be that this difference is the cause of failure. There may, of course, be other explanations, but this is the simplest and could well be the reason for lack of seed setting.

The successful crossing of the two species is also of consequence for other reasons. The species with bisected cotyledons have special interest. In Blakely's system of classification, many of these species are grouped, but others are dispersed through different groups. This is partly a consequence of the exclusive use of anther shape in erecting the major subdivisions in the classification. The dispersal of some of the species with bisected cotyledons leads to a number of marked anomalies. For example, *E. Kruseana* is placed in the subseries Isophyllae with *E. cordata* and *E. pulverulenta*, but apart from the opposite, sessile, glaucous leaves, which are persistent to the mature state, it has little in common with the other two species. *E. Kruseana* has bisected cotyledons which are quite unlike those of its two companions in Blakely's scheme. The same is true of *E. decipiens*, which is placed by Blakely in the series Subbuxeales. This species has, however, little affinity with the other species in this group which are mostly eastern Australian, and it also differs distinctly from all of them in having bisected cotyledons. On the basis of anther shape also, the two species, *E. salubris* and *E. campaspe*, are widely separated in Blakely's scheme of classification, the former being placed in the Section Platyantherae and the latter in the Macrantherae. But these two species have much in common, including bisected cotyledons, and placing them closely together seems a more natural arrangement than the separation, as Blakely has done. The differences in anther shape are actually small in this case.

There are several other examples of anomalies if assessed on this basis and it seems that a natural major group would be erected by placing together all the species which have bisected cotyledons, and adding them to those series such as the Cornutae and Subcornutae which already have the bisected cotyledons as a common distinguishing feature. If this proposal is sound, then *E. caesia* is a representative of a natural group of about 60 species, most of which are confined to Western Australia, which might conveniently be called the "Bisectae". The successful production of an F1 hybrid with it and *E. pulverulenta* then suggests, on the grounds of "crossability", that it has about the same relationship to the Macrantherae-Normales as has the series Transversae and the series Exsertae.

If, then, the hybrid under discussion can be taken to indicate possibilities in crossing, there is a wide range of species available for hybridizing. These may give great practical benefits. For example, many of the species with bisected cotyledons are very drought-resistant or are tolerant to either salty, swampy or calcareous soils. Many of them also have highly decorative coloured flowers. There is then a chance of bringing them together in hybrid combination with several tall growing, good timber-producing trees of the Macrantherae-Normales group, most of which are, for *Eucalyptus*, extremely frost-resistant. Most of such combinations cannot occur naturally because the great majority of the species in the two groups are very widely separated geographically. More experiment will be necessary, of course, to determine how far this generalization is correct.

There is also one field occurrence of a natural hybrid which supports the idea that the "Bisectae" may cross with the series Exsertae. This is between *E. cladocalyx* and *E. camaldulensis* at Wirrabara in South Australia. Two suspected hybrids of this combination were seen in the field by Mr. C. D. Boomsma and during a subsequent inspection in company with him seed was collected from them. The progeny, though small, shows distinct segregation as would be expected from a hybrid of the supposed parentage. There is little doubt that *E. cladocalyx* belongs to the group with bisected cotyledons (although the form of the cotyledon is not so extremely bisected as in many of the species with this character), and that its affinity is with the Western Australian species. *E. camaldulensis* is distinctly one of the species of the Exsertae.

The hybrid *E. pulverulenta* × *E. caesia* could itself be a valuable ornamental plant, as *E. caesia* has very attractive, large, bright pink flowers and *E. pulverulenta* has decorative silvery foliage.

The prospect of combining species such as the very lime-tolerant *E. gomphocephala* with frost-resistant species such as *E. bicostata* or *E. Gunnii*, or the salt-resistant *E. occidentalis* with such species, or even drought-resistant mallee species such as *E. oleosa* with these, are examples of the situation which a programme of investigation could elucidate. These speculations must be put to experimental test if they are to be verified.

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BRETT, R. G., 1949.—Personal communication.

DUFFIELD, J. W., 1952.—Relationships and Species Hybridization in the Genus *Pinus*. *Zeitschrift für Forstgenetik u. Forstpflanzenzüchtung*, 1: 4, 93-97.

PRYOR, L. D., 1954.—PROC. LINN. SOC. N.S.W., 79: 196-198.

THE IDENTITY OF *EUCALYPTUS SUBVIRIDIS* MAIDEN AND BLAKELY.

By L. D. Pryor.

(One Text-figure.)

[Read 30th May, 1956.]

Synopsis.

*Eucalyptus subviridis** was first considered a hybrid between *E. cinerea and E. Blakelyi* because of its field occurrence and the segregation of juvenile characters in seedlings raised from it. It has also been synthesized by manipulation. The F1 is intermediate in many of its characters between the two parents and it grows as quickly as the slower growing parent, *E. Blakelyi*. Segregates which are near intermediate in morphology between the two parents in their characters are of lower viability than those which approach either parent. It follows that ecological sorting, if environmental conditions remain unchanged, would lead to the separate maintenance of the two species in the field even though they grow at times side by side and successfully hybridize.

Eucalyptus subviridis is one of a group of species described by Blakely which is hybrid. This species occurs always in the vicinity of stands of *E. cinerea*, where they are in contact with a stand of "red gum",† usually *E. Blakelyi*. At the line of junction *E. subviridis* is found occasionally. Several trees have been located near the type locality in the vicinity of Marulan, and others north of Yass. It is presumably of *E. cinerea* × *E. Blakelyi* parentage. The trees are moderately vigorous in the field, but several have been seen which, by the time they are about 35 feet tall and probably 20 to 30 years old, are unthrifty and one has died during the period of five years in which it has been under observation.

The tree is intermediate between the putative parents in most of its characters. The principal contrasting characters between *E. cinerea* and *E. Blakelyi* together with the comparable ones of *E. subviridis* are shown in Table 1.

Table 1.

	Bark.	Mature Leaves.	Buds.	Fruit.
E. cinerea ..	Rough.	Sessile, opposite and glaucous.	Threes.	Turbinate, valves level with rim.
E. Blakelyi	Smooth.	Alternate, petiolate and lanceolate.	Generally 7 or 11.	Hemispherical, valves strongly exserted.
E. subviridis	Rough half-way up trunk.	Sub-opposite, shortly petiolate, moderately glaucous, ovate-lanceolate.	Basal flower clusters usually 3, later ones mixed numbers.	Sub-hemispherical, valves moderately exserted.

Progeny raised from *E. subviridis* segregates very strongly in its juvenile characters, giving various combinations, from individuals resembling either presumed parent to various intermediates between them. The rate of growth of individuals in the progeny is very variable. This is a character many hybrid progenies share, the degree of variance in height growth often being much greater in hybrid combinations than in pure species.

Successful synthesis of this hybrid by manipulated pollination was achieved. The cross, *E. cinerea* × *E. Blakelyi*, and the reciprocal were both successful, giving a small

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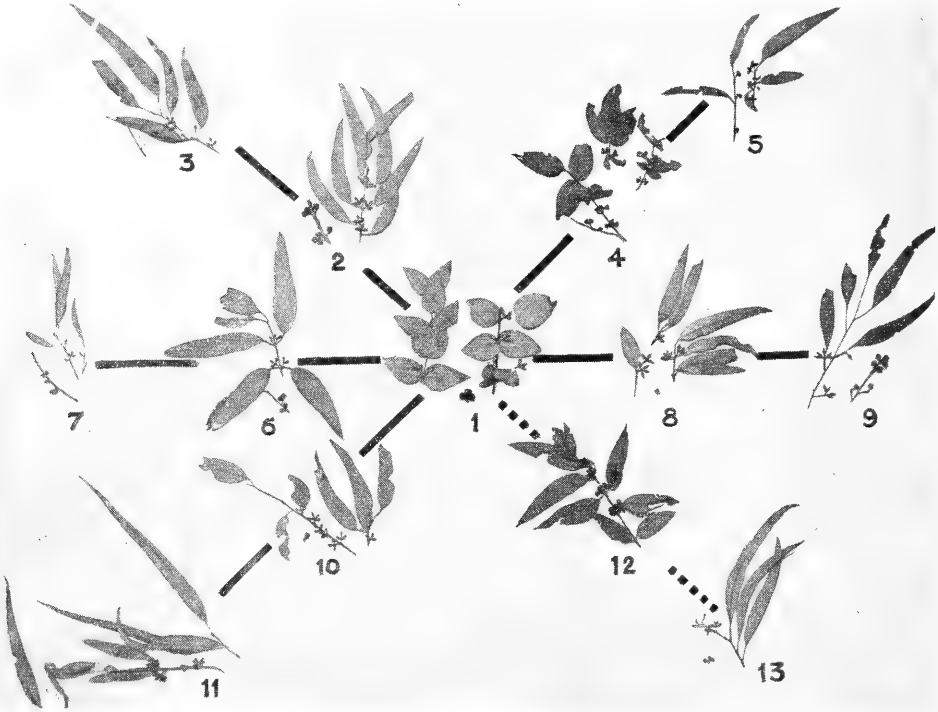
* Nomenclature as in Blakely's "Key to the Eucalypts", 1934.

† The term "red gum" is used here to denote a species of the series Exsertae.

number of F1s in both cases which are now six years old. In the juvenile stage the F1 hybrids are intermediate in most characters between the two parents as is the adult tree, but it shares apparent dominance in the same characters as does the F1 hybrid *E. cinerea* × *E. robusta* (Pryor, 1954). In particular, the leaves tend to remain opposite though shortly petiolate, and the square stem of *E. Blakelyi* persists. On the other hand glaucousness and leaf shape are approximately intermediate. The vigour of growth assessed by height at five years of age does not differ statistically from that of the slower growing parent, in this case and at this age, *E. Blakelyi.* So far the F1s have not flowered, except one precocious flower cluster which formed on one individual. The bud shape was intermediate between the two parents. The F1s are matched closely by some of the segregates in progeny from *E. subviridis.* There is little doubt, therefore, that *E. subviridis* is either the F1 between *E. Blakelyi* and *E. cinerea*, or some segregates from it.



1, *cinerea*; 2, *cinerea* × *viminalis*; 3, *viminalis*; 4, *cinerea* × *Macarthuri*; 5, *Macarthuri*; 6, *cinerea* × *rubida*; 7, *rubida*; 8, *cinerea* × *Blakelyi*; 9, *Blakelyi*; 10, *cinerea* × *Bridgesiana*; 11, *Bridgesiana*; 12, *cinerea* × *maculosa*; 13, *maculosa*.

Text-fig. 1.—Shows specimens of hybrids of *E. cinerea* with *E. viminalis, E. rubida, E. Bridgesiana, E. Blakelyi, E. maculosa* and *E. Macarthuri.* The dotted line to the *E. maculosa* was made because the progeny test had not at the time confirmed the supposition that the specimen was hybrid. It has since been confirmed. The persistence of opposite (though shortly petiolate) leaves in the hybrids is noticeable.

E. cinerea × *E. Blakelyi* is one only of a series of hybrids which *E. cinerea* forms in the field with species of the Macrantherae-Normales wherever it comes into contact with them. This may be seen on the Hume Highway between Collector and Moss Vale. Several of these have been examined and distinct segregation is obtained in progeny raised from individuals suspected of being hybrid between *E. cinerea* and, successively, *E. Bridgesiana, E. maculosa, E. viminalis, E. Macarthuri* and *E. rubida* (see Text-fig. 1).

It seems that *E. cinerea* is homozygous for opposite, sessile, glaucous, orbicular leaves in the mature state. It is also a fully rough-barked species. Individuals which occur fringing stands of *E. cinerea* which depart from this character by the development of petiolate and somewhat lanceolate leaves or with relatively smooth bark may in most cases be reckoned hybrid, and progeny raised from them segregates distinctly in all cases tested. This material is particularly suitable for the investigation of hybridism because of the ease of detecting hybrids in it. Combinations with *E. Macarthuri* are of special interest because of the characteristic oil present in *E. Macarthuri* and an analysis of the inheritance displayed by the progeny from this combination in relation especially to oil inheritance will be set out elsewhere.

The present study is one of the few recorded cases in which a "species" first located and examined in the field, progeny tested and determined as hybrid, has subsequently been confirmed in diagnosis by the synthesis of the hybrid by manipulated pollination. There remains only the raising of an F2 generation to complete a fully rigorous examination of the genetic status of *E. subviridis*. As a hybrid between *E. Blakelyi* and *E. cinerea* it should not be described as a species. The other five hybrids mentioned are about as common and can be found from time to time at stand junctions between *E. cinerea* and the other parent concerned, but they have never been formally described or named.

The material displays one other point which may be a common feature in *Eucalyptus.* The juvenile characters are so distinctly different in the two species that seedlings which are old enough to have produced 8 pairs of leaves can be assessed according to four contrasting characters, i.e., glaucous, orbicular, opposite, sessile leaves in *E. cinerea* and green, ovate, alternate, petiolate leaves in *E. Blakelyi.*

TABLE 2.

Progeny 50/702 E. cinerea × E. Blakelyi (*Six Months Old*).

		cinerea															*Blakelyi*	
No. of *cinerea* characters		4	3	3	3	3	2	2	2	2	2	2	1	1	1	1	0	
Combination		sessile	s	s	s	p	s	s	s	p	p	p	s	p	p	p	petiolate	
		glaucous	g	g	gr	g	g	gr	gr	g	g	gr	gr	g	gr	gr	green	
		opposite	op	alt	op	op	alt	op	alt	op	alt	op	alt	alt	op	alt	alternate	
		orbicular	lanc	orb	orb	orb	lanc	lanc	orb	lanc	orb	orb	lanc	lanc	lanc	orb	lanceolate	
	V=	11	1	–	–	–	–	–	–	–	–	–	–	3	–	–	1	V=vigorous
	M=	4	5	–	1	2	–	–	–	3	1	–	–	4	–	2	1	M=medium vigour
	R=	–	1	–	1	1	–	1	–	2	1	–	–	–	–	–	–	R=runt
		15	7	0	2	3	0	1	0	5	2	0	0	7	0	2	2	
		27					8						11					

Vigorous :	12=45%	0= 0%	4=36%
Medium :	12=45%	4=50%	7=64%
Runts :	3=11%	4=50%	0= 0%

Table 2 shows the classification of 46 individuals in a progeny from a tree of *E. subviridis* according to all the possible recombinations of the eight contrasting characters. The assessment is a little over-simplified as glaucousness and leaf shape are probably inherited "multiplefactorially" and not as Mendelian single-gene controlled characters. This means that the recombinants listed with non-glaucous leaves and with non-orbicular leaves are less in number than would be expected if there were simple Mendelian inheritance. Nevertheless the table gives a useful approximate assessment of the position of each segregate in the range between the parental extremes.

The individuals in each group are also assessed in three classes of vigour: Vigorous, Medium and Runts. The runts are obviously unthrifty and presumably are the result of gene combinations which are poorly viable. Many of these die as soon as they leave the nursery and are subjected to the more rigorous field conditions.

The implication from Table 2 is that recombinants in this hybrid progeny, which are near intermediate in their inheritance from either parent, are less viable than those which approach either parent. This condition indicates a substantial degree of genetic isolation of the two species which would aid the maintenance of each, even when they come in contact in the field and form hybrids. In short the gene combination of each species is of superior survival value to intermediates between them.

The facts suggest that F1 hybrids when they arise have a fair chance of survival because they are, in the early stages at least, as fast growing as the slower growing parent, *E. Blakelyi*. However, when an F2 generation is produced the individuals which survive will be those which resemble most closely either parent, the morphology presumably being closely tied to physiological characteristics too, so that the site factors which operate to keep the two stands separate will quickly lead to the sorting of the segregates. Thus, on the site carrying the *E. Blakelyi*, those approaching *E. Blakelyi* will tend to survive and the others will be eliminated, and vice versa. The possibility of gene flow from one population to the other exists, but it appears that the factors which have operated in the past to keep these two species separate will continue to operate and that the two populations will remain separate, as distinct species, unless some entirely new environmental situation arises which might lead to the emergence of a gene combination derived from both species which would be more successful than either of them in a habitat at present not available but which also might emerge in the future.

NOTES ON AUSTRALIAN MOSQUITOES (DIPTERA, CULICIDAE). I.

SOME SPECIES OF THE SUBGENUS NEOCULEX.*

By N. V. Dobrotworsky, Zoology Department, University of Melbourne.

(Four Text-figures.)

[Read 30th May, 1956.]

Synopsis.

The adults and larvae of *Culex fergusoni* Taylor are redescribed and descriptions of the pupa and eggs are given. A new species from Western Australia, *Culex latus,* is described. Adults, pupa, larva and eggs of *Culex douglasi,* n. sp., are described and an account is given of the biology and distribution of this species and of *Culex fergusoni* Taylor. Morphological notes on *Culex pseudomelanoconia* Theobald are given.

For an analysis of the relationships of the members of this subgenus adequate descriptions of all known species are necessary. The discovery of two new species provides an opportunity to present a redescription of *C. fergusoni* Taylor and some further data on *C. pseudomelanoconia* Theob.

While the four species dealt with in this paper are united by common features such as the presence of a transverse comb of rather long blunt spines on the paraproct, the smooth phallosome and the absence of lower mesepimeral bristles, they fall into two subgroups. *C. fergusoni* and *C. latus,* n. sp., have apical tergal bands, the same number of setae on the distal portion of the subapical lobe of the coxite, a patch of scales on the mesepimeron and, in the larval stage, a cuticle densely covered with minute spicules. All these characters link them to the Holarctic *C. territans* Walker and *C. apicalis* Adams. On the other hand, in *C. douglasi,* n. sp., and *C. pseudomelanoconia,* the tergites are either unbanded or have basal bands, and the patch of flat scales on the mesepimeron is reduced. These species are related to *C. chaetoventralis* Theob. and, more particularly, to the recently described *C. cheesmanae* Mattingly and Marks (1955).

Culex fergusoni Taylor.

Culicada fergusoni Taylor, Proc. Linn. Soc. N.S.W., 39:459, 1914.

Described by F. H. Taylor from one male and one female from Milson Island, Hawkesbury River, N.S.W. He did not describe the male terminalia.

Distinctive Characters: The goldish scaling of the scutum and the pale apical markings of the tergites are distinctive of this species.

The Male. Head: Vertex with pale narrow curved decumbent scales, and pale upright scales which become black laterally. Flat lateral scales restricted to a small area. Proboscis and palpi brown. Palpi exceeding length of proboscis (including labella) by the terminal segment and about a half of the penultimate; apical part of shaft and last two segments densely covered with long hairs. *Thorax*: Anterior pronotum with goldish bristles and a few narrow curved scales. Posterior pronotum with goldish narrow scales and 4–5 proepimeral bristles. Scutum with small goldish scales and a line of black scales along the acrostichal bristles; supra alar area covered with black scales. Scutellum with narrow pale scales and about five long strong bristles on each lateral lobe, and about seven on central one. Lower part of sternopleuron with row of white flat scales, one strong bristle and several weaker ones, all towards the posterior edge; another patch of scales and a row of bristles on postmedian area. Mesepimeron with patch of flat white scales near middle and patch of pale hairs on upper part. There are no prealar scales, postspiracular scales or lower mesepimeral bristles. *Wing*:

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* This work was supported in part by a grant from the Trustees of the Science and Industry Endowment Fund of Commonwealth Scientific and Industrial Research Organization.

Brown scaled. There are two clouds: a large one in the end of the upper basal cell, expanding towards the costa, and a small one in the base of the fork of the fifth vein. Upper fork cell less than twice as long as its stem; stems of upper and lower fork cells equal. Wing length: 4·0–5·0 mm. *Legs*: Brown, all femora and tibiae pale below. Front femur slightly shorter than proboscis. Hind femur and tibia each with distinct yellowish apical spot. Front and mid legs with toothed claws; hind legs with small equal, simple claws. *Abdomen*: Tergites black scaled; first with small median patch of pale scales; second to seventh with pale apical bands medially constricted on third to fifth, occasionally broken; eighth with yellowish scales and a few black ones. Venter black scaled basally, admixture of yellowish scales increasing distally. *Terminalia* (Text-fig. 1, *a*): Style stout, slightly curved, broadening slightly towards apex and narrowing abruptly before the tip; terminal appendage short. Coxite not swollen; subapical lobe well divided. Distal division with seven bristles, the first seta slightly flattened, the second, the longest, with hooked tip; the remainder hooked and barbed apically. Distal division accompanied by long seta. Proximal division with two long rods which have curved flaps apically. There is no leaf. Paraproct with an apical comb of 11–12 rather long blunt spines. Lateral plates of phallosome without teeth or tubercules, joined by a narrow bridge near the tip. Lobes of ninth tergite with 4–5 short setae.

The Female. Palps slightly less than one-quarter the length of the proboscis; third segment more than twice as long as the first two. Upper fork cell about three times as long as its stem. Stem of the lower fork cell about one and a quarter times the length of the stem of the upper one. Wing length: 3·3–4·0 mm. Tarsal claws of all legs small, simple. Apical bands on tergites, except sixth and seventh, widely broken. Venter paler than in males, usually with the last three sternites completely pale yellow. Terminalia (Text-fig. 1, *c*): Cerci broad and hairy; postgenital plate slightly concave distally. Insula with about ten setulae. Ninth tergite with 7–8 setae on either side. Pharynx (Text-fig. 1, *b*): Teeth short, thin and sharply pointed.

Variation: Some males have the abdominal bands broken on the fourth and fifth tergites. In some specimens the black scales on the venter are restricted to the first five sternites, with the sixth and seventh completely yellowish; in others black scales extend up to the seventh sternite.

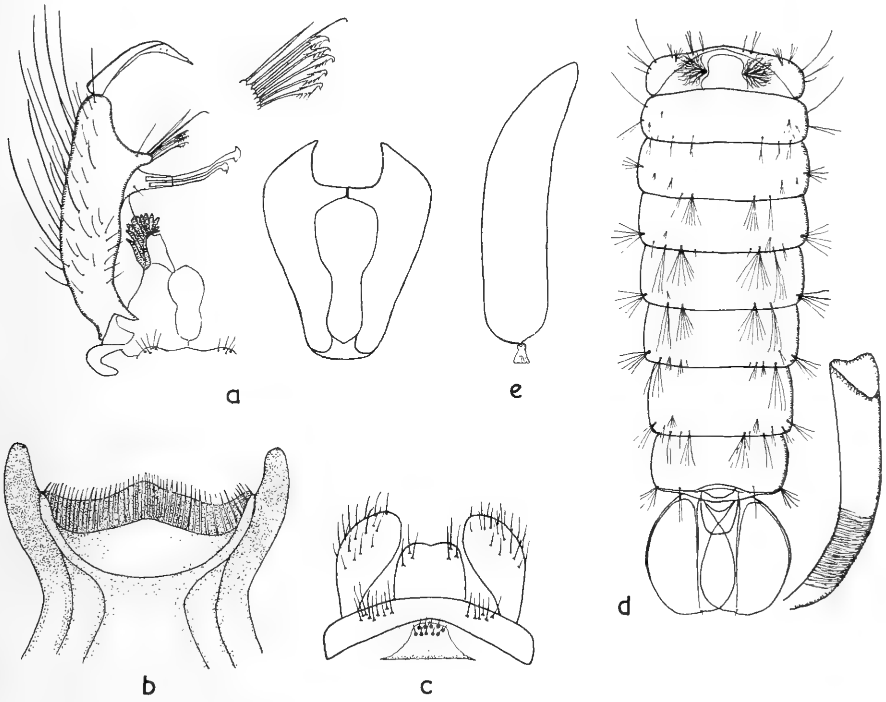
In females the upright scales on the vertex are occasionally blackish. The sixth and seventh tergites may have an admixture of yellowish scales. Usually only the sixth and seventh sternites are completely yellowish, but in some specimens the black scales are greatly reduced and the venter appears pale scaled.

Pupa: Cephalothorax: Trumpet long slender with oblique opening. Seta 1 long with 2 branches; 2 and 3 with 3 branches; 4 long, single; 5 with 3 branches; 6 delicate, with 2 branches; 7 long, with 2–3 branches; 8 and 9 moderately long, with 3–4 branches. *Metanotum*: Seta 10 with 3 branches; 11 long, single; 12 long, with 3–4 branches. The abdominal setae are shown in Text-figure 1, *d*. Paddle broadly oval; tip of midrib with single minute seta.

Larva: Head broad. Antenna long and curved, pale at middle, dark at base and beyond tuft. Subterminal setae strong and well removed from tip. Large antennal tuft with 30–35 branches. Head seta A with about 10 branches; B single or with 2 branches; C with 2 branches; *d* single; *e* with 3–4 branches; *f* minute, with 3–5 branches. Mentum with central tooth and 7–8 lateral teeth on each side. Larval skin densely covered with minute spicules. Prothoracic chaetotaxy: Seta 1 and 2 long, single; 3 single or with 2 branches, slightly more than half as long as 1; 4 with 2 branches and slightly longer than 3; 5 and 6 single, as long as 1; 7 as long as 4, with 3–4 branches; 8 as long as 7, with 2–3 branches. Pentad seta 1 with 5–6 plumose branches; 2 with 2 branches; 3 plumose, with 7–8 branches; 4 single; 5 with 3 strong branches. Comb of about 60 fringed teeth. Siphon long and slender with index of about 10. Pecten of 14–15 unidentate spines. There are 10–12 subventral siphonal setae which are single or have up to 5 branches, and 2 pairs of delicate single, or bifid dorsolateral ones. Saddle complete with bifid lateral hairs. Inner setae of dorsal brush with 4–5 branches; outer one single and long. Ventral brush has 12 tufts and one or two precratal ones. Anal papillae narrow, pointed; ventral pair about half the length of the saddle; dorsal pair shorter.

Eggs (Text-fig. 1, *e*) are deposited in elongate rafts. Those laid by gravid females collected in nature, contain from 84 to 150 eggs. The eggs are dark brown, about 0·8 mm. long and with an index of about 4·8. Anteriorly the egg is almost cylindrical but the posterior third is bent and sharply tapered. At the anterior pole there is a funnel-like corolla. The exochorion is granulate.

Biology: This is a homodynamous species. Males, females (often gravid) as well as the earlier stages can be collected at any time during the winter months. It is not a man-biting mosquito. It is numerous in the hill forests of Victoria where it breeds in clean water pools and swamps. At lower altitudes, and in more exposed situations, it is confined to rocky valleys where the larvae breed in back-water pools shaded by trees or overhanging rocks. They are sometimes found in swamps overgrown with bulrushes. The distribution of *C. fergusoni* is almost identical with that of *Theobaldia inconspicua* Lee and both species usually share the same breeding places.



1.—*Culex fergusoni,* Taylor. *a*, Male terminalia; *b*, female pharynx; *c*, female terminalia; *d*, pupal abdomen and trumpet; *e*, egg.

In the laboratory *C. fergusoni* deposited egg rafts on moist filter paper 2–5 inches above the water level. The rafts were not stuck to the paper for they floated away when the water level was raised. When the water level was kept low, the rafts, if on a vertical surface, dropped into the water as the larvae pushed off the egg caps. This was not possible when the rafts were placed on an inclined surface, and in such cases the newly hatched larvae crawled over the moist filter paper to the water. The egg cap is attached asymmetrically so that the egg spike is near its edge and the opening is oblique.

Distribution: *C. fergusoni* is distributed in Eastern Australia from South Australia to South Queensland (Marks). In Victoria it is recorded from: Kalimna, Franklin

River, Drouin, Jindivick, Woods Point, Healesville, Ringwood, Wattle Park, Springvale, Wattle Glen, Sherbrooke, Hurstbridge, Meredith, Lyonville, Violet Town, Otway, Grampians.

CULEX LATUS, n. sp.

Types: The holotype male from Kewdale, Western Australia, collected by F. N. Ratcliffe (15.10.53), allotype female collected by D. L. McIntosh in the same locality (10.11.52), paratype series of two males, one from the same locality, the second from Dardanch, W.A., collected by D. L. McIntosh (10.11.52) and four females from Donnybrook, W.A., collected by J. H. Calaby (27.1.53) are in the collection of the Division of Entomology, C.S.I.R.O., Canberra; one female from Drakes Brook Weir, W.A. (D. L. McIntosh), in British Museum (Natural History) and one male from Peel Estate, W.A. (D. L. McIntosh, 6.11.42) in School of Public Health and Tropical Medicine, Sydney.

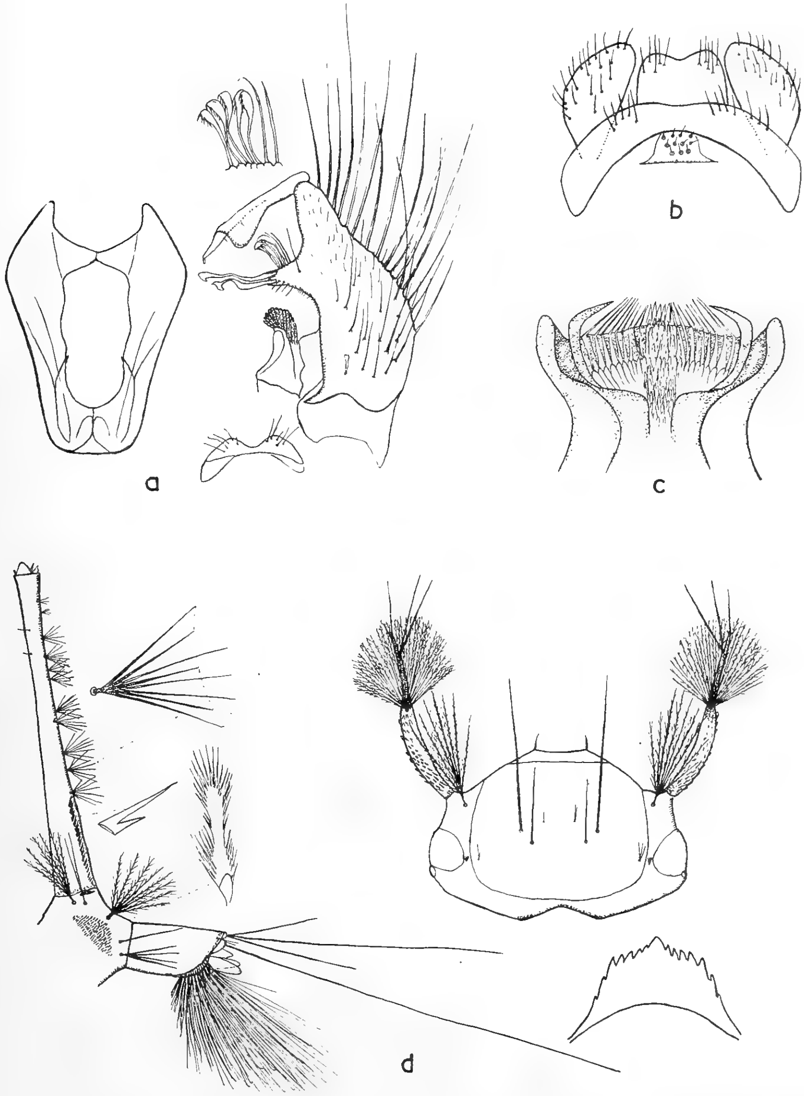
Distinctive Characters: The broad longitudinal stripe of pale scales on the scutum and the pale apical marks on the tergites distinguish this species.

Holotype ♂.—Head: Vertex with pale narrow curved decumbent scales; upright scales pale medially and black laterally. Pale flat lateral scales restricted to small area. Proboscis and palpi black; segments of palps pale at base. Palpi longer than proboscis by slightly more than the terminal segment; apex of shaft with only 1–2 long hairs; last two segments with scanty and relatively short hairs. *Thorax*: Anterior pronotum with dark bristles only. Posterior pronotum bare; there are eight black pro-epimeral bristles. Scutum with broad longitudinal stripe of pale scales between dorsocentral bristles; lateral scales small and black; bristles black. Scutellum with pale narrow curved scales and six strong black bristles on each lobe. Lower part of sternopleuron with patch of white scales, one strong bristle and a few weaker ones all towards the posterior edge; another larger patch of white scales and four bristles in post median area. Mesepimeron with large central patch of white scales and a patch of pale bristles on upper part. There are no pre-alar scales, postspiracular scales or lower mesepimeral bristles. *Wings*: Scales dark brown. Upper fork-cell only slightly longer than its stem. Stem of the lower fork-cell only slightly longer than stem of the upper fork-cell. Wing length: 3·3 mm. *Legs*: Dark brown, femora pale beneath. Front femur four-fifths of length of proboscis. Hind tibia with inconspicuous pale apical spot. Front and mid legs with toothed claws, the hind with equal, small and simple claws. *Abdomen*: Tergites black scaled; first with a patch of white scales near the middle and clothed with dense pale hairs laterally; second-sixth with apical lateral triangular white spots; seventh pale scaled apically. Venter brownish scaled, with a few scattered pale scales on basal part of segments, the number of these scales increasing on the distal segments. *Terminalia* (Text-fig. 2, *a*): Style stout, slightly curved, broadening into paddle before the middle, and narrowing abruptly before the tip; terminal appendage small. Coxite swollen basally and sharply contracted apically. Distal and proximal divisions of subapical lobe of the coxite close together. Distal portion with seven bristles: the first and second unmodified, the remaining five with blade-like apical expansion with serrated edges. Distal division accompanied by long seta. Proximal division with two rods flattened and curved at tip; the shorter one narrowed before terminal expansion. There is no leaf. Paraproct with an apical comb of ten rather broad, blunt spines. Lateral plates of phallosome without teeth or tubercles, joined by a narrow bridge near the pointed tips. Lobes of ninth tergite prominent, with 5–6 setae.

Allotype ♀.—This differs from the holotype male as follows: Palps about 0·4 the length of the proboscis; third segment of palp twice as long as first two. Posterior pronotum with a few black curved scales. Upper fork-cell about three times as long as its stem. Stem of lower fork-cell almost equal in length to the upper one. Wing length: 4·2 mm. Tarsal claws of all legs small and simple. Second tergite with narrow apical band. The white triangular apical patches on the third-sixth tergites are larger and extend towards mid line. *Terminalia* (Text-fig. 2, *b*): Cerci broad. Postgenital plate distinctly bilobed. Insula with distinct circular patch of ten setulae. Ninth tergite well developed, with 4–7 setae on either side. Pharynx (Tex-fig. 2, *c*): Side teeth thin and sharply pointed, central ones shorter and thicker with pointed tips.

Paratypes.—The paratype series of two males and four females does not show any significant variation.

Larva described from two pelts and one larva from Grangara, W.A. (7.9.55, D. L. McIntosh). Head broad. Antenna stout, clothed with spicules; dark at base and beyond the tuft. Subterminal setae strong and well removed from tip. Large antennal tuft of about 30 branches. Head seta A with 7–9 branches; B and C single; D small, single or with 2 branches; *e* with 3–4 branches; *f* small tuft with 9–10 branches. Mentum with central tooth and 6–7 lateral teeth on each side. Larval skin densely covered with minute spicules. Prothoracic chaetotaxy: seta 1 and 2 long, single, almost equal; 3 single or with 2 branches, about half as long as 1; 4 with 2 branches, longer than 3; 5 and 6 single, slightly shorter than 1 and 2; 7 with 3 branches; 8 with 2–3 branches, as long as 1. Pentad seta 1 long, with 6 plumose branches; 2 with 2 branches; 3 with



2.—*Culex latus,* n. sp. *a,* Male terminalia; *b,* female terminalia; *c,* female pharynx; *d,* head, terminal segments and mentum of larva.

8–9 plumose branches; 4 single; 5 with 4–5 branches. Comb of about 60–67 fringed teeth. Siphon long, slender, narrowing towards the middle and expanding apically with index of about 10. Pecten of 15–18 usually unidentate spines. There are about 9–11 subventral siphonal setae with 1–8 branches and 2 pairs of single dorso-lateral setae. Saddle complete with 2–3 branched lateral setae. Inner seta of dorsal brush with 1 long and 2 shorter branches; outer one single and long. Ventral brush has 13–14 tufts. Anal papillae less than half length of saddle.

Distribution: This species is recorded only from Western Australia.

CULEX DOUGLASI, n. sp.*

Types: Holotype male with associated larvae and pupa skins, and allotype female bred from larvae collected at Meredith, Victoria, 24.3.54, are in the collections of the National Museum, Melbourne. A paratype series of six males and six females from the same locality is divided between the above Museum and the Division of Entomology, Commonwealth Scientific and Industrial Research Organization, Canberra.

Distinctive Characters: This is a black species with white basal bands on the tergites as well as on the sternites.

Holotype ♂.—*Head*: Vertex with pale narrow curved decumbent and upright scales. Lateral scales broad flat and white. Proboscis and palpi blackish with violet reflections. Palpi longer than proboscis, including labella, by the terminal segment and about a half of the penultimate; last two segments clothed with long hairs, shaft with six long bristles at apex. *Thorax*: Anterior pronotum with bristles only. Posterior pronotum with a few pale narrow curved scales and long pale pro-epimeral bristles. Acrostichal and dorsocentral bristles black. Scutal scales goldish. Scutellum with similar scales, and seven border bristles on the central lobe, and five on each lateral lobe. Lower part of sternopleuron with fine hairs, a few narrow scales and three strong bristles all towards the posterior edge; small postmedian patch of broad pale scales and several strong bristles. Mesepimeron with patch of 10 pale hairs and a few scales on the upper part. No patch of scales near the middle of the mesepimeron, no pre-alar scales or lower mesepimeral bristles. *Wing*: Scales brown; plume scales very narrow. Upper fork-cell less than twice as long as its stem; lower fork-cell slightly shorter than upper one. Wing length: 3·0 mm. *Legs* brown scaled, femora pale below. Front femur four-fifths of the length of the proboscis. Front and mid legs with toothed claws; hind legs with small, equal simple claws. *Abdomen* black scaled with white basal bands on the second-seventh tergites and sternites. First tergite with a few median pale scales; eighth with a larger number of pale scales. The black scales on the venter have violet-pink reflections.

Paratypes ♂.—The series of 6 paratype males does not show much variation. In some specimens, the upright scales on the vertex become dark towards the neck. *Wing* length: 3·0–3·3 mm. *Terminalia* (Text-fig. 3, *a*): Style stout, slightly curved, broadening slightly distally and narrowing abruptly before the tip; there are two setulae; appendage short, finger-like. Coxite not swollen; subapical lobe well divided. Distal division with two long and three shorter bristles with recurved tips, the three shorter ones barbed apically. This division of lobe is accompanied by a long seta. Proximal division with two long sinuous rods curved and flattened apically. There is no leaf. Paraproct with an apical comb of 10–12 rather long, blunt spines. Lateral plates of the phallosome without teeth or tubercules joined by a narrow bridge near the tip. Lobes of the ninth tergite with 4–5 rather long setae.

Allotype ♀.—This differs from the holotype as follows: Palps about one-sixth the length of the proboscis; third segment longer than first two. Anterior pronotum with strong brown bristles, pale goldish hairs and, on dorsal side, pale narrow curved scales. Mid part of the mesepimeron with small patch of fine flat pale scales. Upper fork-cell about three times as long as its stem; stem of the lower fork-cell one and a quarter times as long as that of the upper. Wing length 4·0 mm. Tarsal claws of all legs are small and simple.

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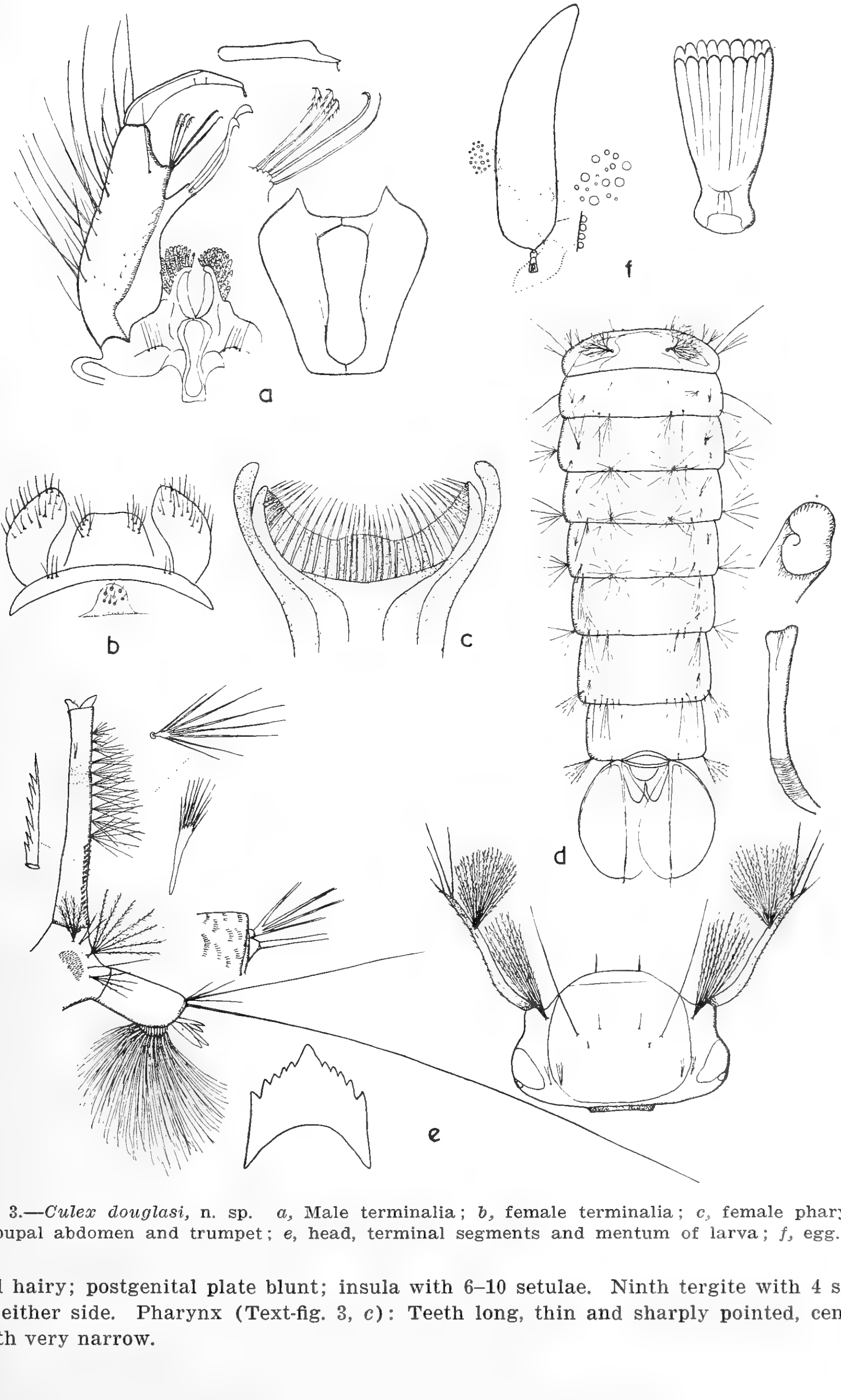
* This species is named in honour of Mr. G. W. Douglas who discovered it at Violet Town, Victoria.

Paratype ♀.—The series of six paratype females does not show much variation. The patch of scales on the mid part of the mesepimeron may be absent; evidently they are easily rubbed off. Wing length 3·2–4·0 mm. Terminalia (Text-fig. 3, *b*): Cerci broad and hairy; postgenital plate blunt; insula with 6–10 setulae. Ninth tergite with 4 setae on either side. Pharynx (Text-fig. 3, *c*): Teeth long, thin and sharply pointed, central teeth very narrow.



3.—*Culex douglasi,* n. sp. *a,* Male terminalia; *b,* female terminalia; *c,* female pharynx; *d,* pupal abdomen and trumpet; *e,* head, terminal segments and mentum of larva; *f,* egg.

Pupa: Cephalothorax: Seta 1 long, stout, usually single, sometimes with 2 branches; 2 short, with 3–5 branches; 3 with 3–4 branches; 4 with 2 branches; 5 with 3–4 branches; 6 short, with 2–4 branches; 7 long, with 2 branches; 8 long, with 4 branches; 9 with 2–3 branches. Metanotum: seta 10 with 2–3 branches, 11 with 2 branches, and 12 with 2–4 branches. Paddle oval; minute bifid seta at the tip of the midrib. The abdominal setae are shown on Text-figure 3, *d*.

Larva (Text-fig. 3, *e*): Larva pale, except the metathorax and the first, second, third and fifth segments of abdomen which are dark dorsally. There is a dark ring towards the middle of the siphon. Head broad. Antenna long, curved; white and strongly spiculated up to the tuft, dark apically; tuft well developed, with about thirty plumose branches and a three-pointed denticle at the base. Subterminal setae strong, well removed from tip. Head seta A of 9–10 branches; B single, long; C very small, with 4–5 branches; *d* single, tiny; *e* and *f* with 2–4 branches. Mental plate with central tooth and 5 lateral teeth, rarely 6 or 7. *Prothoracic chaetotaxy*: All setae, except the seventh, single; seventh with two branches. Setae 1 and 2 long; 3 delicate, about one-third the length of 2; 4 slightly longer than 3; 5 about as long as 2; 6 slightly shorter than 5; 7 about as long as 4; 8 slightly longer than 7. Pentad seta 1 with 3–5 plumose branches; 2 with 2 branches; 3 with 7–8 plumose branches; 4 single; 5 with 3–4 branches. Comb of about 40 scales fringed distally. Siphon slender, with index from 6·0 to 7·1, mean 6·5. Pecten of 16–21 spines, each with 5–7 denticles. There are 8–12 subventral setae each of 6–8 branches; setae twice the diameter of the siphon at the point of attachment, or slightly more. Dorso-lateral seta with 2–3 branches. Setae on the dorsal valves of the siphon are small. Saddle complete; its surface covered with short arched rows of very fine denticles. Saddle seta small, with 3–4 branches. Inner hair of dorsal brush with one long and 2–3 short branches; outer one long, single. Ventral brush with 14 tufts and single precratal tuft. Each tuft with 7–15 branches. Anal papillae narrow, pointed; dorsal pair about one-third of the length of the saddle; ventral pair longer than the dorsal.

Eggs (Text-fig. 3, *f*) are deposited in oval or rounded rafts. Rafts deposited after feeding on human blood in the laboratory contain up to 48 eggs. The egg is dark brown, thick anteriorly, bent and sharply tapering posteriorly. At the anterior pole there is a funnel-like corolla filled with a sticky substance. The exochorion is granulate. The egg is about 0·7 mm. long with an index of about 4·4.

Distribution: A total of 60♂♂ and 50♀♀ have been examined from the following localities: *Victoria*: Violet Town (G. W. Douglas), Euroa (N. V. Dobrotworsky), Delatite River (A. Neboiss), Meredith (A. Neboiss and N. V. Dobrotworsky); *New South Wales*: Blackfellow Gully, Dumaresq Creek, Commissioners Waters, Blue Hole—all in the Armidale area (E. J. Waterhouse); *Queensland*: Camp Mountain, Strathpine (E. N. Marks).

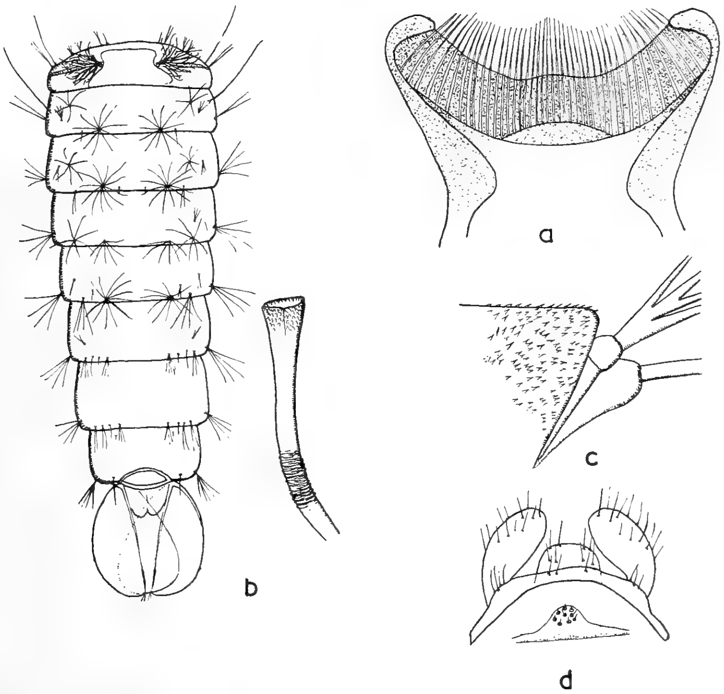
Biology: This species is not a common one and has a patchy distribution in Victoria, but in the vicinity of breeding places it is always numerous. The adults usually rest in dark recesses in the stream bank or in rocks. Beyond the fact that it does not attack man, nothing is known of the feeding habits of *C. douglasi* in nature. Adults collected from resting places late in April, or in May, had a well-developed fat body. They could be induced to feed upon human blood only after exposure to artificial lighting for several days at a temperature of 25°C. Oviposition commenced after the fourth blood-meal but each subsequent meal was followed by egg laying. In the laboratory, egg rafts were deposited on moist filter paper from one to three inches above the water surface. When development of the eggs is complete, the larvae hatch immediately the water level is raised up to the raft. Hatching can occur if the water level remains low. In this case the lifting of the egg cap causes the eggs to become detached from the corolla and the raft then drops into the water. If the eggs remain on the filter paper, the larvae cannot complete their emergence but die with the head stuck in the egg cap. Thus, in contrast to *C. fergusoni*, contact with water is necessary for emergence.

In Victoria the larvae breed in rocky valleys, in shallow, cool, clean back-water pools with a sandy bottom and shaded by rocks or trees; the larvae are most abundant under overhanging stones. In Queensland they breed together with *C. pseudomelanoconia* (E. N. Marks, 1954). In Victoria the larvae and pupae usually disappear from breeding places late in April.

CULEX PSEUDOMELANOCONIA Theobald.

Culex pseudomelanoconia Theobald, *Mon. Cul.*, IV:416, 1907.

This species is referred to here to permit a comparison of it with *Culex douglasi* and I will deal only with the morphological traits which are of importance for this purpose. The pupa has not been previously described.



4.—*Culex pseudomelanoconia* Theobald. *a*, female pharynx; *b*, pupal abdomen and trumpet; *c*, dorso distal part of saddle; *d*, female terminalia.

The adults of *C. pseudomelanoconia* can be easily distinguished from *C. douglasi* by the unbanded abdomen. The female palps of *C. pseudomelanoconia* are about one-fifth the length of the proboscis; the third segment equals the length of the first two. The pharynx (Text-fig. 4, *a*) has the same type of teeth as *C. douglasi*—long and sharply pointed. The male genitalia (Mattingly and Marks, 1955) is practically identical with that of *C. douglasi*. It is interesting to note that one male from New South Wales has four short barbed bristles on the distal portion of the subapical lobe instead of the usual three.

The early stages of *C. pseudomelanoconia* are also very similar to those of *C. douglasi*.

Pupa.—Cephalothorax: The trumpet is long and slender with a funnel-like opening. Seta 1 with 4–5 branches; 2, 4 and 7 with 2 branches; 3 with 3–4 branches; 5 with 4 branches; 6 small, with 3 branches; 8 with 3–4 branches; 9 single, or with two branches. Metanotum: seta 10 and 12 with 3 branches; 11 single. The abdominal setae and paddle are shown on Text-figure 4, *b*.

The larva of *C. pseudomelanoconia* can be distinguished from that of *C. douglasi* by a few morphological traits: The mentum usually has six lateral teeth, rarely seven. The pecten consists of 13–19 spines (mean 16); the distal ones have about 6 irregular denticles; the spines on the surface of the saddle are longer and irregularly arranged on the dorso-distal part (Text-fig. 4, *c*). The index of the siphon of Queensland specimens varies from 6·0 to 7·0, with mean 6·4; it is higher than given by Lee (1944).

C. pseudomelanoconia has been recorded from Queensland and New South Wales, but has not yet been found in Victoria.

Acknowledgements.

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A NOTE ON A UREDOSPORE COLOUR MUTANT IN BARLEY LEAF RUST, *PUCCINIA HORDEI* OTTH.

By N. H. Luig and E. P. Baker, Faculty of Agriculture, University of Sydney.

(Two Text-figures.)

[Read 30th May, 1956.]

Synopsis.

A colour mutant of *Puccinia hordei* Otth. is described. It differs from the original rust in certain morphological and physiological characteristics but behaves the same in pathogenicity on differential varieties used in race identification. This mutation will enable competition trends with other races on susceptible varieties to be more readily studied.

Introduction.

Pathogenic changes presumably due to mutation in the absence of sexual recombination are common in cereal rusts. Changes in visible morphological characters are less common, but colour mutations have been recorded in the case of wheat stem or leaf rust by Waterhouse (1952), Johnson, Newton and Brown (1934), and Johnston (1930).

Waterhouse reported that on seven occasions cadmium yellow or light cadmium uredopustules of *Puccinia graminis tritici* E. and H. had been noticed among normal coloured pustules. In six of these cases the race determinations showed that the light coloured culture was the same as the parent culture, but in the seventh instance the colour mutation proved to be a different race, namely r.56, which arose from a stock culture of r.34, and it is interesting that Waterhouse reported that when teleutospores of r.34 were used to infect the barberry, it proved to be heterozygous, one of the derived races being 56.

Johnson *et al.* studied the inheritance of spore colour and pathogenicity in crosses between physiologic forms of *Puccinia graminis tritici.* Although the cytoplasm was important in the inheritance of pathogenic differences there was every indication that spore colour was Mendelian in character. Red spore colour appeared to be due to the interaction of two dominant factors (one for orange pigment in the cytoplasm, and one for greyish-brown pigment in the spore wall). White colour was explained by the presence of the recessive allelomorphs of both factors.

Johnston collected an aberrant race, later described as race 27 of *P. triticina* Erikss., which differed from other known races in pustule size and colour, spore size and shape, a longer incubation period, thickness of spore wall and host reactions.

Description of Mutant.

Colour.

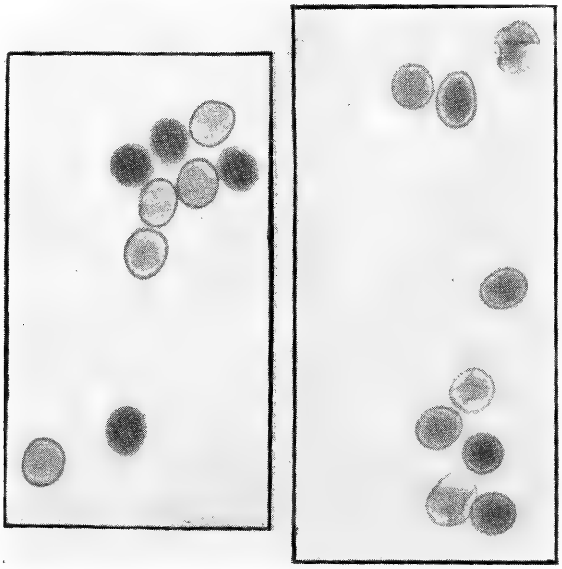
Whilst counting F_2 segregates for the inheritance of resistance to race UN14 of barley leaf rust the senior author observed a pustule which was of a bright yellow colour compared with the typical brown of this race. This pustule was separated and inoculated onto seedlings of a susceptible host. Although not free of contamination from this transfer, pure cultures of the yellow mutant were obtained in the succeeding transfer. Under the microscope and mounted in water, the cytoplasm of the mutant spores was paler yellow than that of the normal rust.

When compared with the colour charts in Ridgway's "Color Standards and Color Nomenclature" the mutant rust pustule approximated most closely "Cadmium Yellow" (Plate III) whilst the original was best described as "Sanford's Brown" (Plate II).

Morphology.

In morphology the two rusts were quite distinct. The uredospores of the original were globose, ellipsoid or oval, with few round, whilst those of the mutant were rounder, being mostly globose or round, with few oval. Differences in spore size were also shown. Measurements of mature spores shaken onto clear lacto-phenol on a slide were made, 100 spores being included in each sample. The spores of the original cultures were $25 \cdot 87\mu \pm 1 \cdot 94\mu$ long, and $23 \cdot 08\mu \pm 1 \cdot 37\mu$ wide, whilst the respective measurements for mutant spores were $24 \cdot 37\mu \pm 1 \cdot 64\mu$ and $22 \cdot 77\mu \pm 1 \cdot 28\mu$. At the $P = 0 \cdot 01$ level, differences in spore length were significant. However, differences in spore width were not significant at either the $P = 0 \cdot 05$ or $P = 0 \cdot 01$ levels.

Spores of both types were minutely echinulate. The original spores had 2–4 moderately large germ pores on each face, whilst those of the mutant were distinctly smaller and less visible. The spore walls of the former were considerably less hyaline. Certain features of the cytoplasm are later discussed.


1 2

Text-figures 1-2.

1.—Photomicrograph of uredospores of the original and mutant rusts of *Puccinia hordei* Otth., taken 5 minutes after staining with acid fuchsine in lacto-phenol. The mutant spores are intensely stained, whilst those of the original rust are unaffected. The distinctness and darker colour of the spore wall of the latter are exhibited in unstained preparations as well. (× 240. Orthochromatic plate.)

2.—Photomicrograph of uredospores of the original and mutant rusts of *Puccinia hordei* Otth., in clove oil after treatment for two minutes with acid fuchsine in lactic acid. Spores of the mutant type rust (with stained cytoplasm) are unaffected. Shrinkage of the cytoplasm and, to a lesser extent, the walls of the original rust spores has occurred giving an irregular outline. (× 300. Orthochromatic plate.)

Physiology.

When the mutant and original rusts were inoculated onto the same leaf of a susceptible barley variety, pustules of the original race appeared 1–2 days earlier than those of the mutant. Secondary smaller uredosori in a circle around the original pustule appeared to be more readily formed in the case of the mutant rust.

To ascertain whether possible physiological differences between the two rusts were reflected in differential staining reactions, certain tests of this nature were carried out. In general, little difference was observed when basic dyes were used. However, with acid dyes in solution with certain organic acids, markedly differential results were obtained. With acid fuchsine in lactic acid or lacto-phenol cotton blue the cytoplasm of the mutant spores was darkly stained after 5 minutes, whilst that of the original spores remained unaffected (see Text-fig. 1). After an interval of 15 minutes, however, the latter gradually became darker, and ultimately became as intensely stained as the mutant type.

A further physiological difference was that of apparent osmotic value in the two types of spores. This was measured by the relative plasmolysis in sucrose solutions of varying molarities. Where plasmolysis occurred, mature spores were plasmolysed within 5 minutes. With a sucrose solution of 0·52 mol. (or approx. 18 atm.) the spores of the original rust were plasmolysed, whilst those of the mutant type were unaffected. This differential behaviour ceased to exist at 0·60 mol. (approx. 20 atm.), when both types were plasmolysed.

A differential effect, apparently similar to plasmolysis, and similar in many respects to that shown by meristematic plant cells, was also observed upon treatment with clove oil. Mutant type uredospores were less affected by this treatment and when clove oil was added to spores, previously treated for two minutes with acid fuchsine in lactic acid, this difference became more noticeable. Shrinkage of both the unstained cytoplasm and, to a lesser extent, the walls of the original rust spores occurred rapidly, giving them ultimately an irregular shape. Mutant type spores remained stained but unaffected by this treatment (see Text-fig. 2).

Pathogenicity.

Another aspect investigated was that of possible pathogenic changes associated with the colour variation. Both rusts were tested side by side under comparable conditions in the seedling stage on the differential set devised by Levine and Cherewick (1952). The behaviour on varieties of the differential set was identical with both rusts, and is as under:

Variety.	Reaction Type.	Variety.	Reaction Type.
Reka I C.I.5051	3^{+c}	Club Mariout C.I.261	2^{+c}
Sudan C.I.6489	4	Samaria C.I.6493	4
Cruzat C.I.6482	; , 1^{-}	Berg C.I.6486	4
Chilean D C.I.1433	2	Gold C.I.1145	3^{c}
Bolivia C.I.1257	2^{+}	Lechtaler C.I.6488	3^{+}
Oderbrucker C.I.940	4	Austral C.I.6483	;
Quinn C.I.1024	;	Kinver C.I.2361	4
Egypt 4 C.I.6481	4	Speciale C.I.7536	4

From these reactions both rusts conform most closely to unified-numeration (UN) race number 14 on the key described by Levine and Cherewick. Minor reaction differences on varieties such as Bolivia (1^{++} compared with 2^{+} in the present investigation) are acknowledged, but on the broad basis of resistance and susceptibility the rusts are keyed out to this race.

DISCUSSION.

In the absence of genetic recombination associated with the sexual stage on the alternate hosts, *Ornithogalum* spp., which obviously could play no part in the present instance under glasshouse conditions, some other phenomenon must be sought to explain the origin of the colour variant. Nuclear recombination, associated with heterocaryosis, and mutation are other possible mechanisms to account for variability in rusts. The role of heterocaryosis at the present time awaits further confirmatory evidence, and the most logical explanation for the colour change is mutation used in the broadest sense to include both gene changes or chromosomal aberrations.

Apparent mutation for pathogenicity frequently occurs in many cereal rusts. These are physiological changes with usually no readily discernible morphological effects. This phenomenon is considered to account in the main for the many changes in both the wheat stem and leaf rust organism under Australian conditions. More specifically, in the case of the organism causing barley leaf rust, a major change in pathogenicity was detected in 1952 locally, when, in the field, formerly resistant varieties used in genetical studies became susceptible to a new variant. On the differential set a change from race UN16 to race UN14 was indicated. In this pathogenic change, also, no evidence is available to suggest that genetic recombination was responsible since the alternate hosts are confined entirely to a few locations in gardens, where they have never been observed carrying the aecidial stage.

In the present instance certain morphological and physiological changes were associated with that of colour. This might suggest that more than a point or single gene mutation was involved. However, pleiotropic effects of a single gene are widely known in higher organisms and, in addition, Johnston (1930) found other characteristics, many similar to those observed in the present study, which were associated with a change in uredospore colour. Although there was no direct proof that Johnston's variant arose through mutation, this was considered a likely probability in view of the complete absence of the sexual stage of *P. triticina* in nature in North America. Johnston observed an associated change in pathogenicity in addition. No such association was evident in the present study. However, varieties outside the differential set were not studied in any detail, and the evidence for absence of change in pathogenicity is not completely substantiated. In this connection it might be mentioned, however, that F_2 segregates, where tested, behaved identically with both the original and mutant rusts.

One obvious value of this mutant will be to enable competition trends between it and normal coloured rusts to be accurately assessed in successive transfers on apparently fully and uniformly susceptible barley hosts. There is nothing to suggest that such a mutation may not have occurred in nature before. It is logical to consider that the longer incubation period of the mutant would be an aspect placing it at a selective disadvantage in nature. The competitive behaviour in such cases can be readily studied under glasshouse conditions to gain knowledge of the possible evolutionary trends in nature. It was immediately observed that the newer UN race 14 was more virulent, and rapidly superseded the previous omnipresent UN race 16 under field conditions on commercial varieties susceptible to both rusts. Unpublished data from competition studies in the glasshouse have confirmed this observation, but in the absence of a readily contrasting morphological character such as uredosorus colour such studies are considerably more difficult technically.

Another obvious advantage given by the mutant rust is that in investigations on the mode of inheritance of resistance, identical plants in segregating populations can be studied simultaneously with more than a single race.

Acknowledgements.

The assistance of Dr. Y. T. Tchan is acknowledged for advice in connection with staining techniques and for taking the photomicrographs.

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THE STATUS OF NITROGEN IN THE HAWKESBURY SANDSTONE SOILS AND THEIR PLANT COMMUNITIES IN THE SYDNEY DISTRICT. I.

The Significance and Level of Nitrogen.

By Nola J. Hannon, Linnean Macleay Fellow of the Society in Botany.

(Plate x; one Text-figure.)

[Read 27th June, 1956.]

Synopsis.

The soils derived from Hawkesbury Sandstone in the Sydney district are of low fertility. Phosphorus and nitrogen are the chief limiting nutrients. The level of nitrogen in the parent rock, the soils and the plant material of these communities is described. Low concentrations prevail throughout, but increase from approximately 180 p.p.m. in the rock to the order of 600 p.p.m. in the surface soils. The soils are acid, pH 4·5-5·0, with high carbon-nitrogen ratios (18-49). Consequently, the level of available nitrogen is extremely low. The nitrogen content of much of the fresh leaf material is only about 7,000 p.p.m., but members of the Leguminosae and Casuarinaceae average 12,000 p.p.m. Similarly, seed of legumes and *Casuarina* L. contains at least four times the amount of nitrogen found in other species. Freshly fallen leaf litter contains a large percentage of the nitrogen content of mature leaves.

Introduction.

The natural plant communities of the Sydney district attract attention because of the mosaic of formations which occur and the distinctive and sclerophyllous character of many of their members. The majority of the species belong to the endemic Australian element, with Indo-Malayan representatives occurring only in restricted areas of improved environmental conditions. Trees and woody shrubs predominate, herbs and grasses being less conspicuous. There is a great diversity of floral type and leaf form.

Over a period of years several workers have been engaged in investigations of a number of aspects of the nature of these communities. These include floristic and structural descriptions, physiological studies, nutrient levels and requirements, anatomical, morphological and cytological investigations, and studies on the microflora and fauna involved in *Casuarina* litter decomposition. The present series of papers will make a further contribution to the knowledge already accumulated. Much detailed information, especially autecological studies, is still lacking; but when the communities have been characterized in sufficient detail, a synthesis of the various contributions should illustrate the basic chemical, physical and biological factors which are interacting to produce the resultant mechanism of the ecosystem. To date, reports of such syntheses are very few. Platt's (1951) ecological study of the Mid-Appalachian shale barrens forms a notable exception.

Since detailed descriptions of the associations and their habitat have been made by Pidgeon (1937, 1938, 1940, 1942), only a brief account will be included here.

There are three geological formations within the district, all of which are Triassic sediments. They are the Narrabeen Group (shales and sandstones), the Hawkesbury Sandstone and the Wianamatta Group (shales and sandstones), as described by Hanlon, Joplin and Noakes (1952).

Apart from several widely scattered outliers, the uppermost division of the Triassic, the Wianamatta Group, still remains in only the Sydney Plains, an area of approximately 35 by 50 square miles.

The Narrabeen Group outcrops cover a still smaller area near the coastal region to the north and south of Sydney.

A deeply dissected plateau region composed chiefly of Hawkesbury Sandstone extends to the north, south and west of Sydney. The horizontal bedding and resistant nature of the sandstone are responsible for the typical physiographic characters of the plateaux—the flat-topped divides and the steep gullies. This deposit consists predominantly of quartz grains, and the analyses given in the N.S.W. Mines Department's Annual Reports (1902, 1905, 1906, 1914, 1915, 1922) show very low levels of the elements required for plant nutrition. Lenticular beds of shale, generally only small, are scattered fairly frequently throughout the sandstone. The soils derived from it are highly siliceous with aluminous or ferriferous clay as the cementing agent and are light-coloured sandy loams. The youthful physiography of the plateaux and the comparative hardness of the rock strata have caused the development of shallow and immature soils. Outcrops of rock are very frequent in all types of communities. It is only on gentle slopes of gullies and in restricted sheltered areas of the plateaux that soil development proceeds to any depth. The soils are much lighter in texture, of a lower water-retaining capacity, and of less productivity than those derived from the Wianamatta and Narrabeen shales. They support the most sclerophyllous species which form a moderately dense cover.

There are two major habitats in which primary plant succession may occur on Hawkesbury Sandstone—the outcrops of the sandstone itself and the beach sand dunes which have been largely derived from it. These present very different media for plant growth.

The sandstone weathers slowly. Algae and lichens—crustose, foliose and fruticose forms in association with mosses—are often found on the rock surfaces. When the mosses are well established and the soil is a few inches deep, herbs and shrubs are found growing in the moss mats. The soil pH averages 4·5. The pioneer stages may be seen on rock outcrops scattered throughout the more advanced communities. From this stage a heath of sclerophyllous, evergreen shrubs is developed. Apart from changes in evaporation, temperature, light and soil in the early stages of the succession, changes providing increased shelter are all important for development from the heath stage. Progression beyond this point is determined by physical features of the environment, such as exposure, drainage, depth of soil and topography, which in turn influence the chemical factors as the supply of nutrients and water. Scrub and tree scrub merging into scrub forests* of various heights, or dry sclerophyll forest may be formed. Transitions from dry to wet sclerophyll forest are found in more favourable situations. The sclerophyll forests are dominated by various associations of *Eucalyptus* L'Hérit.† species. On Wianamatta Shale tall woodland and wet sclerophyll forests occur, and on the Narrabeen Series the wet sclerophyll or rainforest is developed. The different formations are characterized by different species. This distribution pattern is very marked and constant. Such great differences in vegetation type reflect equally great differences in environment.

Where drainage conditions are poor on Hawkesbury Sandstone, either a sedge or shrub swamp is developed, dependent on moisture conditions. The sedge swamps require the higher water level. The development of swamps is due, in some instances, to cupping of the sandstone, and in other cases to the presence of an impervious shale lens in the sandstone. The swamps are found on the uplands, and occur quite frequently. They are, however, usually of limited area.

The sand dunes have a high calcium carbonate and sodium chloride content and are of high pH value (8·0). The soil depth, moderate phosphate content and deficiency of organic matter also distinguish them from the soil formed in the lithosere. Behind the sand binding species as the grasses and mat plants, *Acacia sophorae* (Labill.) R. Br. forms a well defined zone and is the first of the shrubs to appear in the succession. It occurs at the back of the first dune, where organic matter is still very low. Other shrub species, such as *Leptospermum* Forst. & f. and *Banksia* L.f., form dense thickets where soil organic matter has increased and the pH fallen below neutrality, due to the removal of the calcium carbonate by leaching. This stage is followed by the mixed

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* In terms of the glossary of Beadle and Costin (1952), these subformations should more correctly be named shrub woodlands. However, to facilitate comparison with Pidgeon's descriptions of the sandstone communities, her nomenclature has been retained.

† The names and authorities of all species have been checked at the National Herbarium, Sydney.

Eucalyptus scrub forest, similar to that developed in the lithosere. Photographic records of all of these communities appear in Pidgeon's accounts.

A number of factors have been suggested as contributors to the development of xeromorphy in leaf tissue—such as lack of water, lack of nutrients and high light intensities (Shields, 1950).

Despite an average annual rainfall ranging from 35″ to 50″ throughout the area, it was thought originally that, owing to the very sandy nature of the sandstone soils, and consequently their low water retaining capacity, lack of water was the factor responsible for the development of the xeromorphic nature of the vegetation.

Hutton (1949) grew a typical xeromorphic representative, *Hakea teretifolia* (Salisb.) J. Britt., in natural soil, without the addition of any nutrients, under glasshouse conditions. The interaction effect of two light and two water levels was studied. Significant differences in the dry weight of the plants in each of the four treatments were noted. Differences in morphological and anatomical features of the leaves were also significant. Low water conditions also caused some marked changes in the chemical composition of the plants.

A lack of combined nitrogen or other mineral elements was also considered relevant. Work in this field has shown that the supply of nutrient elements is of great significance, both in the modification of leaf form and also in the distribution of the communities throughout the whole area (Beadle, 1953, 1954).

Pidgeon (1938, 1940, 1942) considered that the distribution of the various formations was dependent on the moisture content of the soils.

Beadle (1954) has criticized Pidgeon's views and has presented evidence to show the importance of phosphorus in determining the distribution of the formations. Beadle's analyses of parent material (unpublished data) and leaves (1954) show that phosphorus is at markedly different levels in the various formations.

As yet, however, a critical investigation of the effects produced by the interaction of phosphorus and water, both of which apparently play important roles in these communities, still awaits attention. Fertilizer trials carried out in the field where water will be at its normal level, in addition to further glasshouse investigations, should prove very enlightening.

Addition of phosphorus to Hawkesbury Sandstone soil strongly stimulates plant growth, but a nitrogen deficiency soon becomes evident. An investigation of the status of nitrogen in these communities was therefore begun.

Apart from the significance of nitrogen in this particular instance, it would be of interest to account for the development of nitrogen in a plant community. While the literature dealing with the various aspects of the nitrogen cycle is voluminous, the nitrogen sources, levels, and requirements of plant communities have received little attention, except in the case of crop plants.

The need for an investigation into the source of nitrogen for plant growth in White Sands, New Mexico, was pointed out by Emerson (1935). Total nitrate and nitrite in sand taken from the immediate vicinity of roots where vegetation was relatively luxuriant was reported to be 8 p.p.m. N. Shields (1953) indicated that she intended to undertake this project.

Beadle and Tchan (1955) have begun similar investigations in the semi-arid plant communities of western New South Wales.

Unlike other mineral nutrients whose supply in a community is primarily determined by the level found in the parent material, the possible pathways for the entry of nitrogen into a plant community are many.

While all mineral nutrients are of importance, nitrogen may be considered a "key" element in a plant community. Its nitrogen content is a fairly accurate index of productivity. This is so because, in order to accumulate nitrogen, it is necessary for soil conditions to be favourable for the growth of plants and microorganisms. This growth in turn involves at least a moderate supply of all essential plant food elements, a not unfavourable soil reaction and drainage conditions, and a reasonable amount of precipitation.

Nutrient Deficiencies of Hawkesbury Sandstone Soils.

The low productivity of the soils from an agricultural viewpoint has long been recognized (Jensen, 1914). The following glasshouse experiments illustrate the nature and extent of the nutrient deficiencies.

The soils were chosen from low scrub forest and from shrub swamp communities. The *Eucalyptus* forest is the typical and most widely spread community on the sandstone; but the swamp soil was included, despite the limited occurrence of swamps, because of its higher nitrogen and organic matter content.

Methods.

The procedure in the preparation of all glasshouse experiments was as follows:

Large soil samples were collected from typical community types to a depth of approximately one foot. On arrival at the laboratory, they were immediately spread out in a thin layer and air dried. Each sample was thoroughly mixed and passed through a quarter-inch sieve to remove the stones and larger roots.

Terra cotta pots of six-inch diameter, coated with a double layer of black bituminous paint and with small watch glasses as crocks, were filled with 1400 g. of air-dry soil. Nutrients are liberated from plastic pots, which are therefore unsuitable for this work.

Distilled water or nutrient solution was added to saturate the soil. Each pot was placed on a glass saucer so that any drainage water could be collected and recirculated through the soil to avoid loss of nutrients.

Well-developed seedlings of comparable vigour, which had been raised on wet filter paper, were planted and supplied with distilled water as required. The pots were placed at random in a long narrow strip against a north-west facing glasshouse wall, so that all would receive equal illumination and temperature.

The growth of the shoot systems of the individual plants within each pot was relatively even, particularly in the case of horticultural species, and in these instances each pot was treated as a single unit at harvesting, individual plants being bulked. The shoot systems were dried at 60°C. and weighed.

Details of Nutrient Treatments.

For "+ P" treatment, NaH_2PO_4 was added.

For "+ N" treatment, $NaNO_3$ was added.

For "+ Ca" treatment, $CaCl_2$ was added.

"Complete–N" solution. 2·5 ml. M KH_2PO_4, + 0·4 ml. M $CaCl_2$ + 100 ml. water were mixed with each 1400 g. soil which had been spread out on waterproofed paper. The soil was returned to the pot and 380 ml. of the following solution added.

Solution "A". 2 ml. M $MgSO_4$ + 1 ml. trace element solution + 1 ml. 0·5% ferric tartrate + 1900 ml. water.

"Complete–P" solution. 50 ml. M KNO_3 + 2 ml. M $CaCl_2$ were added into solution "A". 380 ml. of this solution per 1400 g. of soil were used.

"Complete" solution. 2·5 ml. M KH_2PO_4 + 100 ml. water were added to each 1400 g. soil. 2 ml. M $CaCl_2$ + 25 ml. M KNO_3 were added into solution "A". 380 ml. of this solution were added to each pot.

Trace Element solution. The trace element solution had the following composition and was used at the rate of 1 ml./litre of nutrient solution:

Element and Reagent.	Concentration of Reagent in Trace Element Solution. (g./l.)	Final Concentration of Element in Nutrient Solution. (p.p.m.)
Boron as H_3BO_3	2·86	0·5
Manganese as $MnSO_4.4H_2O$	2·04	0·5
Zinc as $ZnSO_4.7H_2O$	0·22	0·05
Copper as $CuSO_4.5H_2O$	0·08	0·02
Molybdenum as $H_2MoO_4.H_2O$ (assaying 85% MoO_3)	0·02	0·01

The selection of a species to serve as an indicator of the nutrient status of the soils was difficult. A rapidly growing upright type, tolerant of acid conditions and with a long period of vegetative growth, was required. Radish (*Raphanus sativus* L.), turnip (*Brassica rapa* L.), *Spinacia oleracea* L., *Eupatorium* L., *Portulaca grandiflora* Hook., lettuce (*Lactuca sativa* L.), snapdragon (*Antirrhinum majus* L.), and *Euphorbia* L. failed to develop satisfactorily in these soils. Tomato (*Lycopersicon esculentum* Mill.) and flax (*Linum usitatissimum* L.) grew only moderately well in the forest soils; however, tomato failed to survive in swamp soils and the flax developed a fasciated or bifurcated stem condition mentioned by Kerr (1953). However, barley (*Hordeum vulgare* L.), oats (*Avena sativa* L.) and particularly rice (*Oryza sativa* L.) were found to grow satisfactorily in these conditions.

Results and Discussion.

Table 1 shows values for the dry weight of the shoots of rice which were grown under various nutrient treatments. Only a single mean value for the growth in eucalypt forest and shrub swamp soils is given, since the locality-treatment interaction term is not significant ($F = 0{\cdot}99$). The treatment term is highly significant ($P < 1\%$).

TABLE 1.

Dry Weight of Rice (Oryza sativa *L.*) *Shoots under Various Nutrient Treatments.*

Plants grown in Hawkesbury Sandstone soils for eight weeks, water being maintained at field capacity.

Nutrient Treatment.*	Nutrient Concentration (p.p.m.).	Mean Weight per Pot of Four Plants in Eucalypt Forest or Shrub Swamp Soil (mg.).	Treatment Number.	Significance.	
				$P=0{\cdot}05$.	$P=0{\cdot}01$.
Complete ..	—	2753	1	>2–12	>2–12
$+P_2O_5+N$ ..	$+125+50$	2550	2	>3–12	>3–12
$+P_2O_5+N+Ca$	$+125+50+11$	1861	3	>4–12	>4–12
$+P_2O_5$ ..	75	1689	4	>5–12	>5–12
Complete – N ..	—	1339	5	>6–12	>6–12
$+P_2O_5$ ..	125	1080	6	>7–12	>7–12
$+P_2O_5$ ..	5	688	7	>8–12	>7–12
+N	30	556	8	—	—
+N	50	496	9	—	—
+N	2	472	10	—	—
Water	—	469	11	—	—
Complete – P ..	—	449	12	—	—

Weight of plants grown in washed river sand = 176 ± 24 mg. This represents growth due to seed reserves.
The difference necessary for significance: $P=0{\cdot}05$: 89 mg.; $P=0{\cdot}01$: 120 mg.
* Details of the nutrient treatments are given on page 122.

The increased growth of plant shoots in the presence of phosphate as compared with the controls and the close agreement between (i) "complete–P", "+N" and control treatments and (ii) "+P+N" and "complete" treatments, demonstrate very clearly the lack of phosphorus in the soils and the overriding significance of the deficiency of phosphorus and nitrogen as compared with other nutrients.

"Complete–N" compared with "complete" growth reflects the low level of nitrogen, and the poor growth in "+N" shows its place as secondary to that of phosphorus in the nutrient status of these soils.

Depression of growth with "+125 p.p.m. P_2O_5" as compared with 75 p.p.m. may be due to a lack of balance of nutrients, owing to the addition of a single salt. A depressing effect of high or moderately high levels of phosphorus on plant growth has been recorded by a number of workers (Rossiter, 1952). This effect is more marked in conditions of low nitrogen supply.

The less vigorous growth occurring in "+P+N+Ca" as compared with "+P+N" is surprising, since chemical analyses of the soils show very low levels of calcium (Storrier, 1951).

It is of interest to note that the only instance where the addition of nitrogen, in the presence of phosphorus, did not prove a stimulus to growth is in *Acacia suaveolens* (Sm.) Willd., a typical and commonly nodulated member of the dry sclerophyll scrub communities (Table 2). It is found only occasionally in swamps and then towards the edge of the communities. Growth was more vigorous where nutrients were added in the forest than in the swamp soil. The locality-treatment interaction term is highly significant ($F = 30{\cdot}58$; $F_{P = 0{\cdot}01} = 6{\cdot}93$); therefore the results have been presented for both the forest and swamp soils. The treatment and locality terms are both very significant ($P < 0{\cdot}01$). The root systems were nodulated in all treatments, but apparently not very effectively in the swamp soil and most effectively in the forest soil with added phosphate.

Casuarina littoralis Salisb. is a prominent member of the dry sclerophyll scrub and forests and is often nodulated in the field. Analysis of the experimental results shows that the locality-treatment interaction term is significant at the 5% level. A comparison of the growth made in the two soils shows that the only significant difference between soils occurs in "+P+N" treatment. *Casuarina* did not respond so markedly to the addition of nitrogen in the swamp soil. The explanation for this result is not clear. No nodules were found on the root systems in any of the treatments. It can only be said that *Casuarina* is not found growing in swamp communities under natural conditions, and apparently its development is hampered by some character of the swamp soils.

No interaction between treatment and locality is in evidence in either *Eucalyptus gummifera* (Gaertn.) Hochr. ($F = 1{\cdot}96$; $F_{P=0{\cdot}05} = 3{\cdot}88$) or *Hakea dactyloides* (Gaertn.) Cav. ($F = 1{\cdot}07$; $F_{P=0{\cdot}05} = 3{\cdot}88$). In both species the treatment term is highly significant ($P < 0{\cdot}01$). *E. gummifera* is a very widespread member of most communities and very often is found fringing swamp communities. *H. dactyloides* is one of the Proteaceae. This is one of the most common families of the native flora and its members dominate dry and swamp scrub.

Photographs of each of these species growing under the various treatments are shown in Plate x.

Level of Nitrogen in Hawkesbury Sandstone Communities.

Tables 3–18 are presented to show the range of nitrogen found in the parent material, soils and vegetation in Hawkesbury Sandstone communities.

Method.

There is a tremendous amount of literature on the use of the Kjeldahl method for nitrogen determinations. The position is perhaps best summarized by Kirk (1950): "The present status of the Kjeldahl method leaves much to be desired in spite of its wide use."

The choice of the catalyst appears to be the most important factor in the determination of nitrogen, especially with respect to the rate and efficiency of the conversion of the nitrogenous compounds to ammonium sulphate. Cupric sulphate, mercuric oxide and elemental selenium appear to be the most commonly used.

In the present investigation, total nitrogen analyses were made using the Kjeldahl method in main essentials as outlined by Jensen (1940). Nitrate is reduced with zinc powder and then potassium sulphate and copper sulphate are added. Selenium gave lower nitrogen values in soil analyses, and sometimes disagreement between replicates was noted where mercury was included in the digestion mixture, even though sodium thiosulphate was added at the time of distillation. Duplicate digestions were made of each sample and only figures showing no greater difference than 2% were accepted; most analyses differed by no more than 1%.

PARENT MATERIAL.

Results and Discussion.

The incidence of fossils in Hawkesbury Sandstone is very low, but apparently this series was laid down under water containing nitrogen (Table 3). The nitrogen level

TABLE 2.

Dry Weight of Shoots of Native Species under Various Nutrient Treatments.

Plants grown in Hawkesbury Sandstone soils for eight months, water being maintained at field capacity.

Acacia suaveolens (Sm.) Willd.

Soil.	Nutrient Treatment.	Mean Weight per Pot of Three Plants. (g.).	Treatment Number.	Significance.	
				P=0·02.	P=0·01.
Eucalypt forest soil.	+P+N*	15·07	1	—	>3
	+P	17·87	2	>1–3	>3
	+Water	3·33	3	—	—
Shrub swamp soil.	+P+N	11·13	1	—	>2–3
	+P	6·07	2	—	>3
	+Water	2·33	3	—	—

The difference necessary for significance: P=0·02 : 2·709 g.; P=0·01 : 3·092 g.

Casuarina littoralis Salisb.

Soil.	Nutrient Treatment.	Mean Weight per Pot of Three Plants (g.).	Treatment Number.	Significance.	
				P=0·02.	P=0·01.
Eucalypt forest soil.	+P+N	9·03	1	—	>2–3
	+P	4·40	2	—	>3
	+Water	1·90	3	—	—
Shrub swamp soil.	+P+N	6·33	1	>2–3	>3
	+P	4·20	2	>3	—
	+Water	2·23	3	—	—

The difference necessary for significance: P=0·02 : 1·930 g.; P=0·01 : 2·203 g.

Eucalyptus gummifera (Gaertn.) Hochr.

Nutrient Treatment.	Mean Weight per Pot of Three Plants in Eucalypt Forest or Shrub Swamp Soil (g.).	Treatment Number.	Significance P=0·01.
+P+N	9·87	1	>2–3
+P	5·19	2	>3
+Water	2·07	3	—

The difference necessary for significance: P=0·01 : 0·707 g.

Hakea dactyloides (Gaertn.) Cav.

Nutrient Treatment.	Mean Weight per Pot of Three Plants in Eucalypt Forest or Shrub Swamp Soil (g.).	Treatment Number.	Significance P=0·01.
+P+N	16·25	1	>2–3
+P	10·30	2	>3
+Water	5·40	3	—

The difference necessary for significance: P=0·01 : 1·415 g.

* The concentration of added nutrients throughout Table 2 is as follows: $+P_2O_5$: 125 p.p.m.; +N: 50 p.p.m.

of rocks is rarely reported. Hall and Miller (1908) give values ranging from 40 to 90 p.p.m. nitrogen for sandy rocks and 330 to 1070 p.p.m. for shales. Urey (1953) quotes Hutchinson's value of 510 p.p.m. nitrogen in sedimentary rocks, but notes that the shales and red clay of the sea bottom have been weighted most heavily in estimating an average value for sedimentary rocks.

The nitrogen content of the Hawkesbury Sandstone rock is a significant fraction of that found in the soils (Table 3), but in each instance it is obvious that nitrogen accretion has occurred with the development of soil and plant communities.

TABLE 3.

Total Nitrogen Content of Unweathered Hawkesbury Sandstone and Surface Soil (0–8 in.) Samples.

Site.	Total Nitrogen (on Oven Dry Basis)* (p.p.m.).	
	Rock.	Soil.
Darke's Forest Road	170	620
National Park..	210	290
Pearl Beach	160	640
French's Forest	150	330
Kuring-gai Chase	200	350

* In all subsequent tables, nitrogen values are expressed on an oven dry basis.

SOILS.

The soils are immature sandy iron podsols and, like European podsols, have a low base saturation and an acid reaction. They lack the high exchange capacity of the surface horizon of the European podsols (Storrier, 1951).

(i) Total Nitrogen.

Method.

At each site, aerial growth was removed and large samples (at least 10 kg.) of soil were collected. Except for the profiles, for which depths of sampling are indicated in Table 8, surface samples to a depth of approximately eight inches were taken. Prior to chemical analysis the soils were passed through a 2-mm. sieve and then thoroughly mixed. Subsamples were taken by coning and quartering until a sample of several hundred grammes remained. It was considered that any root pieces which passed through the sieve belonged, at least potentially, to the soil organic matter fraction. Special precautions were taken to ensure that root pieces were thoroughly mixed throughout the sample, as they separate readily from the coarser grained soil particles. Where necessary, the sample was ground more finely to pass a 0·5-mm. sieve; all samples for organic carbon analysis were ground to this state.

The nitrogen content of the soils has been expressed as a concentration, on a dry weight basis, since this is the usually accepted procedure. Expression on an absolute basis, taking an account of soil volume, probably has more meaning; but since the sandstone samples are similar throughout in structure and density, direct comparison of concentration values should be quite satisfactory.

Results.

The mean values of the nitrogen content of the soils in Table 4 are each based on the analysis of several samples collected within each of the formations at the given localities. For the present purpose the variability within the sites is considered to be of a sufficiently low order to justify the collection of single samples from each site.

Examination of Table 5 shows that, apart from the swamps, there is a general trend for higher formations to occur on soils with a higher nitrogen content. If the density and growth form of the vegetation be taken into consideration, the total nitrogen content expressed on an area basis for each community could be expected to show far greater differences.

TABLE 4.

Variability of Soil Nitrogen Content within Community Sites.

Formation.	Total Nitrogen (p.p.m.).
Low scrub forest at Jannali (8)	400±56
Wet sclerophyll forest at Pearl Beach (3)	920±70
Shrub swamp at Jannali (3)	1340±90
Shrub swamp at Loftus (3)	1530±72

The numbers in brackets refer to the number of samples analysed from each community.

In view of the results in Table 5, the figures of the valley sequence samples in Table 6 are much as would be expected, since plant growth in the valley at Warrah was much more luxuriant than that at Jannali.

TABLE 5.

Nitrogen Content of Soils from Typical Communities in Various Localities.

Formation.	Total Nitrogen (p.p.m.).
Scrub (2)	360± 90
Tree scrub (3)	410± 42
Low scrub forest (4)	300± 26
Tall scrub forest:	
Dry sclerophyll (4)	530±114
Dry-wet sclerophyll transition (3)	820±176
Wet sclerophyll (3)	1010±268
On shale lens (2)	1030± 85
Sedge swamp (5)	910±189
Shrub swamp (8)	1110±155

The numbers in brackets refer to the number of localities from which samples in each formation were taken.

In collecting the swamp samples mentioned in Table 5, central position in each swamp was chosen as sampling site (see Table 7).

The swamps are amongst the richest of the sandstone soils with regard to nitrogen content. Samples were collected along the slope of swamps, from near the outcropping rock ledge where water accumulation and algal growth are greatest, back through

TABLE 6.

Valley Sequence Samples.

Nitrogen Content of Soils at Various Depths.

Formation.	Total Nitrogen (p.p.m.).
Warrah Sanctuary:	
Wind swept scrub	700
Low scrub forest (immediately below scrub)	640
Low scrub forest	440
Tall scrub forest	830
In *Casuarina* stand	1030
Wet sclerophyll forest	980
Jannali:	
Open scrub	400
Low scrub forest	400
Tall scrub forest (dry sclerophyll)	470

increasing soil depth where surface soil water decreases. An average slope of swamps is approximately 1/12. It is seen that soil nitrogen is highest where water accumulation and algal growth are greatest (Table 7). The significance of this will be discussed in a later publication.

TABLE 7.

Shrub Swamp Transects.

Position of Sample in Swamp.	Total Nitrogen (p.p.m.).
Kuring-gai Chase :	
Close to rock edge : much algal growth	1960
Approximately 48 ft. above rock	1500
,, 96 ft. ,, ...	1300
,, 144 ft. ,, ...	1080
Close to fringing tree scrub	600
Waterfall :	
Close to rock edge	1120
Towards top edge of swamp	540
Jannali :	
At lower edge of swamp	1420
,, ,, ,, ,, ,, ...	1500
In middle of swamp	1060
At top edge of swamp	830
,, ,, ,, ,, ,, ...	660
,, ,, ,, ,, ,, ...	730
,, ,, ,, ,, ,, ...	660

While the nitrogen content of the soil decreases with depth throughout (Table 8), the sublayers of the swamp soils are relatively much richer than the dry sclerophyll communities.

TABLE 8.

Vertical Distribution of Soil Nitrogen.

Formation and Sample Depth.	Total Nitrogen (p.p.m.).
Jannali scrub :	
0″– 6″	550
10″–14″	300
27″–30″	250
Jannali tall scrub forest :	
0″– 8″	650
18″–24″	370
36″–40″	490
Kuring-gai tall scrub forest :	
0″– 4″	450
4″–14″	330
14″–26″	250
French's Forest tall scrub forest :	
0″– 4″	430
4″–10″	220
10″–18″	270
French's Forest shrub swamp :	
0″– 2″	1100
2″– 8″	1060
8″–20″	1000
Kuring-gai shrub swamp :	
0″– 2″	1170
2″– 8″	1040
8″–20″	880

Discussion.

According to Taylor (1950), "it may be said that all soil groups in Australia except the red loams and black earths respond strongly to phosphatic fertilizers, while nitrogen is either an essential or at least a limiting factor in virgin areas". Taylor quotes the typical range for podsols as 300–>2000 p.p.m. nitrogen, with the most frequent values being 400–600 p.p.m. and 1000–2000 p.p.m.

Under virgin conditions the organic matter and nitrogen content of a soil approach an equilibrium value, the magnitude of which depends primarily upon climate, vegetation, microflora, the topography and the parent material. The sclerophyllous vegetation, mineral-deficient parent material and low water-retaining capacity of the Hawkesbury Sandstone soils would not be expected to favour the development of high levels of nitrogen. The great importance of climatic factors in determining the soil-nitrogen level has been demonstrated by Jenny (1930) for grassland and timbered soils in U.S.A. For cultivated soils from originally timbered areas, Jenny found that temperature controlled the soil-nitrogen content, moisture having little influence over a range of 125–375 N.S. quotients (Niederschlag und Sättigungsdefizit—precipitation/saturation deficit values).

Prescott (1952) has stated that in Australia the effect of temperature is to reduce the efficiency of rainfall through its effect on evaporation and that no evidence of a direct effect on nitrogen content of the soil is to be observed, apart from its important effect on the rate of decomposition of organic matter as well as its production. However, for sake of comparison with Jenny's work on timbered soils, some of his figures are mentioned. In regions of annual temperature of 62°F., Jenny's value for soil nitrogen content is 570 ± 60 p.p.m., and for 64°F., 510 ± 30 p.p.m. Sydney's mean annual temperature is 63°F. and the N.S. quotient is 250.

Prescott suggests from the limited data available that in Australia the nitrogen content of soil is most closely related to the N.S. quotient. He also states that "A general examination of the records, together with a knowledge of general conditions in Australia, suggests a further important correlation between the nitrogen content of soil and the content of phosphoric acid". This certainly is of significance in Hawkesbury Sandstone soils in view of their great phosphate deficiency. Prescott reports that soils from Bundaberg, Queensland, of low phosphoric acid values show a high correlation with nitrogen content and those of high and very variable phosphoric acid values, no correlation, with a uniform nitrogen content independent of phosphate fluctuations.

In soils of the north-west wheatbelt of New South Wales, where total and available phosphorus is at a very high level, Hallsworth, Gibbons and Lemerle (1954) found no relationship between nitrogen and phosphorus in virgin soils.

It thus is obvious that the nitrogen content of these soils is low but comparable with similar types of soil in other areas. However, their high C/N ratios and low pH values tend to reduce the value of their nitrogen content as far as plant growth is concerned.

(ii) pH and Organic Carbon.

Apart from total nitrogen content of soils, other properties relevant to the availability of nitrogen for plant growth are pH values and the carbon-nitrogen ratio of the soils.

Method.

pH readings were made on a Jones Model B glass electrode potentiometer with sufficient water to give the equivalent of sticky point in the soil.

Table 9 shows that a distinctly acid reaction is common to all samples.

Organic carbon was determined by the Walkley-Black method, as outlined by Piper (1947). The results given in Table 10 are as carbon, and no correction has been made to account for incomplete recovery of the organic matter.

According to Walkley (1935), the Walkley-Black (1934) rapid method gives a mean recovery for most agricultural surface soils between 75 and 80%, taking dry combustion values as the standard of comparison. This method has the advantage of speed and

TABLE 9

pH Values of Surface (0–8 in.) Soil Samples.

Formation.	Location.	pH.
Scrub	Waterfall	4·8
Tree scrub	Loftus	5·0
	Jannali	4·6
Low scrub forest	Linden	3·8
	Helensburgh	4·7
	Waterfall	4·8
Tall scrub forest:		
Dry sclerophyll	East of Darke's Forest	4·4
	North of Bulli	4·7
	Waterfall	4·5
Dry-wet sclerophyll	Berowra	4·5
Sedge swamp	Waterfall	4·6
	Bulli	4·4
	South of Waterfall	4·7
Shrub swamp	Warrah Sanctuary	4·5
	Kuring-gai	4·8
	Waterfall	4·6
	Waterfall	4·7
	Jannali	4·7

TABLE 10.

Organic Carbon Content of Soils.

Formation and Location.	Total Nitrogen (p.p.m.).	Organic Carbon (p.p.m.).	C/N.
Scrub:			
South of Waterfall	450	12,000	26·7
Ocean Beach Dunes—*Leptospermum*	470	15,700	33·4
Tree scrub:			
Waterfall	410	10,500	25·6
Low scrub forest:			
Helensburgh	330	8,000	24·2
Ocean Beach Dunes—*Banksia—E. botryoides*	230	10,600	46·1
Ocean Beach Dunes—*Eucalyptus pilularis*	300	13,600	45·3
East of Darke's Forest	—	14,000	—
Tall scrub forest:			
Dry sclerophyll forest:			
East of Darke's Forest	620	22,400	36·1
Appin Road	400	15,500	38·7
National Park	290	7,000	24·1
Dry-wet transition:			
Berowra	470	13,000	27·7
Warrah Sanctuary	980	22,400	22·9
Warrah Sanctuary	1,000	22,900	22·9
Wet sclerophyll:			
Warrah Sanctuary	700	18,500	26·4
Berowra	1,540	28,000	18·2
Pennant Hills	780	17,200	22·1
On shale lens:			
Bulli	1,110	27,500	24·8
Pennant Hills	940	21,000	22·3
Sedge swamp:			
Madden's Plains	1,630	37,500	23·0
Loftus	670	10,600	15·8
Waterfall	900	24,200	26·9
Appin Road	750	18,600	24·8
Shrub swamp:			
Bulli	770	20,700	27·0
Waterfall	530	25,400	47·9
Jannali	1,050	52,100	49·6
Warrah Sanctuary	1,830	35,200	19·3

even relative figures are of considerable value for this purpose. Even though the carbon contents of the soils as given in Table 10 are high, it is seen that they are underestimated by the use of this method.

Results and Discussion.

As organic residues decompose, there is a narrowing of the C/N ratio until an equilibrium value of about 12 is reached. Russell (1950) has stated that "A C/N ratio of around 10 is very common for English arable soils". The wide ratios, as exist in the Hawkesbury Sandstone soils (Table 10), indicate that much of the organic matter is in only very early stages of decomposition, apparently blocked at this point by a limiting factor, resulting in the accumulation of an organic complex. The nature of this supposed limiting factor has not been investigated, but the character of the organic matter of soils is determined largely by the character of the vegetation. The low level of nitrogen in the highly lignified plant material (see Table 14) and in the soil probably is the cause of lack of formation of typical "humus". The general low level of other mineral elements, especially phosphorus, and the low pH values would militate against rapid decomposition of litter and hence lead to slow humus formation.

Experimental work on the nature of the organic matter in Hawkesbury Sandstone soils would be of considerable interest. Respiration studies by means of the Warburg technique (Rovira, 1953) to measure the carbon dioxide evolved and hence the microbial activity would give valuable data. Attempts to increase the rate of narrowing of the C/N ratio by addition of nitrogen and phosphorus should prove especially interesting.

Parberry and Swaby (1942) studied the release of nitrogen from different organic materials added to soils and found that sufficient nitrogen for crop needs was liberated in one season only from materials containing an initial nitrogen content of greater than 25,000 p.p.m. No nitrogen was liberated in this period from materials having less than 15,000 p.p.m. nitrogen. Waksman and Tenney (1927) state that 17,000 p.p.m. nitrogen in plant material is adequate for microbial needs. Bledsoe (1937) concluded that if the water-soluble nitrogen content is 5,000 p.p.m. or above, favourable nitrate accumulation occurs, even though the total nitrogen content is less than 17,000 p.p.m. The native vegetation shows no level of soluble nitrogen comparable with this figure or even total nitrogen exceeding 15,000 p.p.m. (Table 14).

Hosking (1935) has made an extensive investigation of the C/N ratio of Australian soils in nine zonal groups. His records show great variation in organic matter content, not only between different soil types, but also within each type. Using a dry combustion method, he found that C/N of podsol surface samples ranged from 10 to 33. Of 50 samples, 68% fell between 10 and 20, and of these, 54% between 14 and 20. Hosking's figures for surface podsol samples (0–9″) are shown in Table 11. For comparable soils in North America, Hosking quotes a mean value of 21·8 for C/N of Quebec Province and 16·3 for United States soils.

TABLE 11. (Taken from Hosking, 1935.)

Carbon and Nitrogen Contents of Australian Podsol Surface Samples.

Factor.	Minimum.	Maximum.	Mean.
C/N	10·0	32·9	19·1±0·8
P.p.m. Carbon ..	2,200	95,600	32,500
P.p.m. Nitrogen ..	190	5,400	1,730

Due to the much higher mean value of 1,730 p.p.m. nitrogen of Hoskings' samples in comparison with those of Hawkesbury Sandstone, the latter's C/N ratios are the higher, but even so they are likely to have been underestimated in comparison with Hoskings', since they have been determined by a wet combustion method.

(iii) Available Nitrogen.

The level of available nutrients in any soil at any particular time depends on the balance existing between the rate of their formation from the soil reserve and the rate of their removal by growing plants, the soil population and leaching. In any ecosystem, available nutrients present in the soil represent at least a temporary excess over the requirements of the various members. Such an excess of nitrogen is unlikely to occur in a mineral-deficient soil of such a high carbon-nitrogen ratio as that derived from Hawkesbury Sandstone, since the phosphorus level would probably limit the activity of the microbial population just as it does plant growth.

Therefore, only few chemical analyses of available nitrogen in soil have been made. It is felt that a measure of the rate of production of available nitrogen from the soil organic reserve is a better indication of the nitrogen-supplying power of a soil than the absolute amount of available nitrogen present in the soil at any given time. This is especially pertinent in soil where the rate of decomposition of organic matter is low and the naturally occurring plants are slow-growing perennials.

Method.

(a) Chemical Analysis.

Soil extracts were prepared following Piper's method (1951, unpublished data), in which a solution of pH 1·8 of sodium sulphate and copper sulphate in concentrated sulphuric acid is used for the extraction. Ammonia was estimated colorimetrically with Nessler reagent and the nitrate nitrogen by the xylenol method (Piper and Lewis, 1951, unpublished data).

Results.

Nitrate nitrogen was detected in several soil samples on one occasion, and the highest value was 2 p.p.m. in the surface layer of a swamp (0–4″). During a period of hot weather following good rains, no nitrate was found in any of 18 samples. The soils are very light in texture and their nitrate content would be markedly affected by leaching.

Ammoniacal nitrogen was consistently present and values of 1–2 p.p.m. nitrogen were usual.

These values are much lower than those given by Beadle and Tchan (1955*a*) for soils in western New South Wales where nitrogen is limiting plant growth. Total available nitrogen in these soils averages 12 p.p.m.

Russell (1950) gives the following figures for the mineral nitrogen content of the surface layers of cultivated soils. Grassland: approx. 5 p.p.m. as ammonium and 1·2 p.p.m. as nitrate. Arable soils of moderate pH: "a constant but low content of ammonium nitrogen but a very variable nitrate content ranging from 2–20 p.p.m.". A rich garden soil may contain up to 60 p.p.m. nitrate nitrogen.

Süchting (1949) has recorded that of the total nitrogen present in forest soils, 90–95% is unavailable as heterocyclic polyoxy compounds of high molecular weight, the lignin-protein complexes.

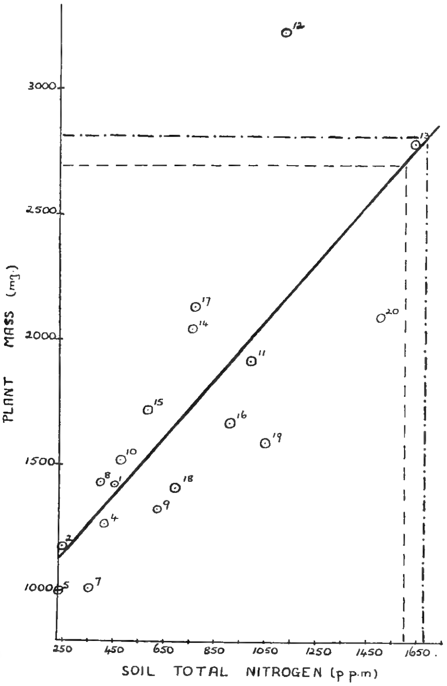
(b) Bioassay.

Incubation of soil with chemical analysis of samples taken at frequent intervals would allow a thorough study of the mineralization of soil organic matter. However, a bioassay experiment has provided some information. A bioassay lacks the precision of the more thorough study in that only a single final value is obtained and a greater number of sources of error is involved.

Details of the preparation of soils and pots were the same as described for the other glasshouse experiments. Since phosphorus is the prime limiting factor in the soils and plant growth would be hindered in its absence, a mineral solution complete but for nitrogen was added to the soils. Thus the soil's reserve of nitrogen would be the only source available for plant growth. The addition of nutrients would probably cause increased nitrification of the organic matter, but it appears that this disadvantage cannot be avoided. The results are given in Table 12 and Text-figure 1.

Results and Discussion.

Analysis of the plant yields listed in Table 12 shows that the locality term is highly significant ($F = 18{\cdot}33$; $F_{P=0{\cdot}01} = 2{\cdot}97$). The regression line to the points in Text-figure 1 has been fitted. Analysis of this straight line equation shows that there are significant deviations of some points from this line, but it is obvious that the fitting of a quadratic equation would be no improvement. Nevertheless the regression coefficient is very significant ($F = 7{\cdot}26$; $F_{P=0{\cdot}05} = 4{\cdot}49$; $F_{P=0{\cdot}01} = 8{\cdot}53$).



Text-fig. 1.—Relationship between the growth of rice and soil total nitrogen. ⊙: mean weight per pot of four plants in each of the soils. Numbers refer to the yield numbers in Table 12. ————: regression line fitted to points ⊙. $Y = 862{\cdot}4 + 1{\cdot}16x$. - - - -: Waterfall tree scrub soil + 50 p.p.m. nitrate-nitrogen. -·-·-·: Kuring-gai shrub swamp soil + 50 p.p.m. nitrate-nitrogen

With the exception of numbers 3 (a tree scrub occurring on a shale lens) and 18 (a swamp with a lower than average nitrogen content) it is seen from Table 12 that the plant yields fall into two classes which correspond with the following grouping of formations:

a. Scrub, tree scrub, low scrub forest and dry sclerophyll forest.

b. Dry-wet sclerophyll transition, shale lens samples and swamps.

Thus more vigorous plant growth developed where soil total nitrogen is high. More nitrogen is available for plant growth in the higher formations and swamps, i.e., the available nitrogen is proportional to the total nitrogen in these soils. This is as expected, since the nature and nitrogen content of the readily oxidizable fraction of the organic matter would be much the same throughout all communities—the chief difference between formations would be in the amount of organic matter present (Table 10).

Nitrate nitrogen was added to two of the soils as an additional treatment, so that an indication of the absolute level of available nitrogen liberated from the organic matter might be given. These results are shown in Table 13.

TABLE 12.

Dry Weight of Rice Shoots in Various Soils.

Plants were supplied with " Complete-N " mineral solution and water to field capacity for eight weeks.

Formation.	Locality.*	Soil Total Nitrogen (p.p.m.).	Plant Yield.† (mg.).	Yield Number.	Significance.‡
Scrub	S. of W.	450	1419	1	2, 4, 5, 7, (9).
	O.B.D.	240	1177	2	5, 7.
Tree scrub	D.F.R.§	—	1992	3	1, 2, 4, 5, 6, 7, 8, 9, 10, 15, 16, 18, 19.
	W.	410	1267	4	(2), 5, 7.
Low scrub forest . .	O.B.D.	230	1002	5	
	D.F.R.	—	1533	6	(1)¶, 2, 4, 5, 7, (8), 9, 18.
	L.	350	1006	7	
Tall scrub forest :					
Dry sclerophyll . .	A.R.	400	1432	8	2, 4, 5, 7, (9).
	E.D.F.	620	1320	9	2, 5, 7.
Dry-wet sclerophyll transition . .	B.	470	1519	10	(1), 2, 4, 5, 6, 7, (8), 9, (18).
	W.S.	980	1909	11	1, 2, 4, 5, 6, 7, 8, 9, 10, 15, 16, 18, 19.
	Bl.§	1110	3231	12	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20.
Sedge swamp	M.P.	1630	2780	13	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 18, 19, 20.
	A.R.	750	2046	14	1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 15, 16, 18, 19.
	Bl.	580	1715	15	1, 2, 4, 5, 6, 7, 8, 9, 10, 18, 19.
	W.	900	1663	16	1, 2, 4, 5, 6, 7, 8, 9, 10, 18.
Shrub swamp . .	Bl.	770	2127	17	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 15, 16, 18, 19.
	K.	690	1410	18	2, 4, 5, 7, (9).
	J.	1050	1589	19	1, 2, 4, 5, 7, 8, 9, 18.
	W.	1500	2091	20	1, 2, (3), 4, 5, 6, 7, 8, 9, 10, 11, 15, 16, 18, 19.

Growth due to seed reserves in washed river sand = 176 ± 24 mg.

The differences necessary for significance : P = 0·05 : 86 mg. ; P = 0·02 : 105 mg. ; P = 0·01 : 118 mg.

* Locality abbreviations : S. of W. = South of Waterfall ; O.B.D. = Ocean Beach Dunes ; D.F.R. = Darke's Forest Road ; W. = Waterfall ; L. = Linden ; A.R. = Appin Road ; E.D.F. = East of Darke's Forest ; B. = Berowra ; W.S. = Warrah Sanctuary ; Bl. = Bulli ; M.P. = Madden's Plains ; K. = Kuring-gai ; J. = Jannali.

† " Yield " represents the mean weight per pot of four plants.

‡ This column gives the numbers of the yields which are significantly less than the yield in question. (P = 0·01, except those marked ( ) ¶, when P = 0·02 and ( ) when P = 0·05).

§ Soil sample collected from a shale lens in the sandstone.

TABLE 13.

Dry Weight of Rice Shoots under Various Nutrient Treatments.

Plants were grown in soil for eight weeks, water being maintained at field capacity.

Nutrient Treatment.	Yield (mg.).	
	Waterfall Tree Scrub.	Kuring-gai Shrub Swamp.
Complete	2701	2805
Complete −N	1267	1410
+ Water	470	467

The difference necessary for significance : P = 0·01 : 186 mg.

* The concentration of the added nutrients is as follows : $+P_2O_5$: 125 p.p.m. ; +N : 50 p.p.m.

From Text-figure 1 it is seen that where 50 p.p.m. of available nitrogen was added to the Waterfall tree scrub soil, plant growth equivalent to a 1600 p.p.m. level of total nitrogen was produced. Thus 50 p.p.m. of available nitrogen is equivalent to 1190 p.p.m. total nitrogen, since the total nitrogen value for this soil is only 410 p.p.m. (Table 12). It follows that over a period of eight weeks only $\frac{50}{1190} \times 410 = 17{\cdot}2$ p.p.m. nitrogen became available from the soil organic matter. This is under conditions of water and all nutrients other than nitrogen being in full supply; under field conditions this value would be markedly reduced. Glasshouse temperature ranged from 17°C. to 33°C. during this period. Even this value of 17 p.p.m. would be an over-estimate, since micro-organisms are better able to compete for the added nutrients than the growing plant (Russell, 1950). It is therefore to be expected that only part of the added 50 p.p.m. nitrogen would have been taken up by the plant.

In the Kuring-gai shrub swamp soil, which has a higher total nitrogen content than the Waterfall sample, 34·8 p.p.m. nitrogen became available under the same conditions. From the data in Table 12 it appears that in the selection of a swamp sample the choice of the Kuring-gai swamp was somewhat unfortunate. Chemical analyses which were made later showed that it had a nitrogen content which is below average for swamps. Nevertheless, even in this sample twice the amount of nitrogen became available as did in the tree scrub soil. Under field conditions nitrate production may be hampered in swamps due to restricted aeration.

Harmsen and Lindenbergh (1949) describe a soil, which in successive weeks produced 7, 9, 10, 10, 10, 9 p.p.m. available nitrogen, as one with a very poor nitrogen nutrition for plants. A rich nitrogen nutrition for plants is ensured in a soil producing 27, 46, 60, 65, 68, 69, 68 p.p.m. available nitrogen in successive weeks. In both instances these soils were incubated in darkness in a saturated atmosphere at 29°C. with a moisture content of 60–70% of the total moisture-holding capacity.

PLANT MATERIAL.

(i) Leaf Analyses.

Method.

Only healthy mature leaves were collected for chemical analysis. The samples were taken from several positions on each plant, bulked, and subsamples were chosen for analysis. As far as possible, sampling from the various localities for each species was done in the same month to avoid any seasonal variation. However, from the results of Mitchell (1936) and Tamm (1951), who studied the nutrient composition of leaves of different ages in deciduous species, it would appear unlikely that the leaf nitrogen content would vary with season in the mature samples that were selected, since the species occurring in Hawkesbury Sandstone communities have long-lived evergreen foliage.

Results and Discussion.

The consistently higher value of legume leaf tissue as compared with non-leguminous material (Table 14) is of interest, and probably is linked with the presence of nodules capable of nitrogen fixation on their root systems. The few legume species that have been tested are capable of nitrogen fixation when inoculated with appropriate rhizobia (Hannon, 1949). The Casuarinaceae also approach the value of the legumes, and nodules from which bacteria were isolated have been found on *Casuarina littoralis* and *C. torulosa* in the field. Their ability to fix nitrogen has not yet been tested, but Mowry (1933) has reported nitrogen fixation for nine other species of *Casuarina*. In the glasshouse experiment (Table 3) it was apparent that *C. littoralis*, unlike *Acacia suaveolens*, responded to the addition of nitrate. However, careful examination of the root systems of *Casuarina* showed that no nodules had developed, whereas they were very obvious in *Acacia*. Further investigations on this aspect of *Casuarina* in Hawkesbury Sandstone communities will be reported later.

Only few organic carbon values for leaf material are available; of these, all fall within the range of 35–40% on a dry-weight basis. Fraser (1948) records 45% organic carbon in *Casuarina* cladodes. The amount of lignification in the tissue will obviously influence the percentage nitrogen values. The aerial tissue of *Bossiaea scolopendria* is of cladode form and is very lignified. Cladodes are also present in *Casuarina*; *C. distyla* is a much more lignified species than either *C. littoralis* or *C. torulosa*. This accounts

TABLE 14.

The Concentration of Nitrogen in Mature Leaf Tissue.*

Species.	P.p.m. Total Nitrogen (on Dry Weight Basis).				
	Scrub.	Swamp.	Low Scrub Forest.	Tall Scrub Forest.	
				Dry-wet.	Wet.
Proteaceae :					
Banksia serrata L.f.	—	—	[1] 4,300	—	—
Banksia serrata	—	—	[2] 5,100	[3] 4,800	—
Banksia robur Cav.	—	[1] 4,300	[2] 4,400	—	—
Grevillea punicea R.Br.	—	[1] 5,100	[2] 7,500	—	—
Isopogon anethifolius (Salisb.) Knight	—	[1] 4,000	[2] 5,800	—	—
Persoonia lanceolata Andr.	—	[1] 6,700	[2] 5,000	—	—
Persoonia levis (Cav.) Domin ..	—	—	[1] 6,900	[2] 7,700	[3] 5,300
Persoonia levis	—	—	[4] 8,500	—	—
Persoonia levis	—	—	[5] 8,000	—	—
Petrophile fucifolia (Salisb.) Knight ..	—	[1] 5,500	[2] 5,800	—	—
Rutaceae :					
Eriostemon lanceolatus Gaertn. f. ..	—	—	[1] 8,000	—	—
Eriostemon crowei F. Muell.	—	—	[1] 7,600	[2] 8,700	—
Myrtaceae :					
Angophora costata (Gaertn.) J. Britt.	—	—	—	[1] 6,300	—
Angophora costata	—	—	—	[2] 7,500	—
Baeckea diosmifolia Rudge	—	[1] 7,200	—	—	—
Calytrix tetragona Labill.	—	[1] 6,700	—	—	—
Darwinia fascicularis Rudge	—	[1] 6,800	—	—	—
Eucalyptus gummifera (Gaertn.) Hochr.	—	[1] 9,000	[2] 6,200	[3] 9,000	—
Eucalyptus haemastoma Sm.	—	[1] 6,700	[2] 5,700	—	—
Eucalyptus pilularis Sm.	—	—	[1] 9,200	[2] 8,700	[3] 8,900
Eucalyptus pilularis	—	—	—	[4] 9,600	—
Leptospermum squarrosum Gaertn. ..	—	[1] 7,400	—	—	—
Leptospermum attenuatum Sm. ..	[1] 7,400	—	—	—	—
Leguminosae :					
Acacia discolor (Andr.) Willd. ..	—	—	[1] 12,600	[2] 16,500	—
Acacia suaveolens (Sm.) Willd.† ..	—	[1] 20,700	[2] 15,300	[3] 19,200	[4] 18,400
Acacia suaveolens	—	—	[5] 18,600	—	—
Bossiaea scolopendria Sm.†	—	—	[1] 8,800	—	—
Dillwynia ericifolia Sm.	—	—	[1] 11,000	—	—
Dillwynia floribunda Sm.	—	[1] 8,900	—	—	—
Gompholobium grandiflorum Sm. ..	—	—	[1] 10,900	—	—
Gompholobium latifolium Sm. ..	—	—	[1] 20,500	[2] 22,500	—
Pultenaea elliptica Sm.	—	[1] 12,300	[2] 10,000	—	—
Casuarinaceae* :					
Casuarina distyla Vent...	—	—	[1] 7,200	—	—
Casuarina littoralis Salisb.	[1] 13,100	—	[2] 10,000	—	—
Casuarina littoralis	—	—	[3] 12,900	—	—
Casuarina torulosa Ait.	—	—	—	[1] 11,700	[2] 11,500
Epacridaceae :					
Epacris microphylla R.Br.	—	[1] 5,700	—	—	—
Epacris pulchella Cav.	—	—	[1] 5,100	—	—
Monotoca elliptica (Sm.) R.Br. ..	[1] 9,300	—	[2] 9,500	[3] 7,500	—

* In species marked †, phyllodes or cladodes replace leaves.

For explanation of the small figures prefixing the nitrogen concentrations, refer to the footnote to Table 14.

Footnote to Table 14.

Details of Leaf Samples.

Species.	Number in Table 14.	Locality ‡	Dominant Species in Community.	Month of Sampling.
Banksia serrata	1	N.P.	*Eucalyptus haemastoma-E. gummifera.*	July.
	2	O.B.D.	*Eucalyptus botryoides* Sm.-*Banksia serrata.*	March.
	3	W.S.	*Eucalyptus piperita* Sm. - *Angophora costata-Syncarpia glomulifera* (Sm.) Niedenzu.	March.
Banksia robur	1	W.S.	*Hakea teretifolia.*	January.
	2	W.S.	*Eucalyptus punctata* D.C.-*E. haemastoma.*	July.
Grevillea punicea	1	W.S.	*Hakea teretifolia.*	July.
	2	W.S.	*Eucalyptus punctata-E. haemastoma-E. gummifera.*	July.
Isopogon anethifolius	1	W.S.	*Hakea teretifolia.*	July.
	2	W.S.	*Eucalyptus punctata-E. haemastoma-E. gummifera.*	July.
Persoonia lanceolata	1	W.S.	*Hakea teretifolia.*	January.
	2	W.S.	*Eucalyptus punctata-E. haemastoma-E. gummifera.*	July.
Persoonia levis	1	N.P.	*Eucalyptus haemastoma-E. gummifera.*	July.
	2	W.S.	*Eucalyptus piperita-Angophora costata-Syncarpia glomulifera.*	March.
	3	W.S.	*Eucalyptus piperita-Angophora costata-Ceratopetalum apetalum* D. Don.	March.
	4	O.B.D.	*Eucalyptus botryoides-Banksia serrata.*	March.
	5	O.B.D.	*Eucalyptus pilularis.*	March
Petrophile fucifolia	1	W.S.	*Hakea teretifolia.*	January.
	2	W.S.	*Eucalyptus punctata-E. haemastoma-E. gummifera.*	January.
Eriostemon lanceolatus	1	N.P.	*Eucalyptus haemastoma-E. gummifera.*	July.
Eriostemon crowei	1	W.S.	*Eucalyptus punctata-E. haemastoma-E. gummifera.*	March.
	2	W.S.	*Eucalyptus piperita-Angophora costata.*	March.
Angophora costata	1	N.P.	*Eucalyptus piperita-Angophora costata.*	July.
	2	Bl.	*Eucalyptus piperita-Angophora costata.*	November.
Baeckea diosmifolia	1	W.S.	*Hakea teretifolia.*	March.
Calytrix tetragona	1	W.S.	*Hakea teretifolia.*	January.
Darwinia fascicularis	1	W.S.	*Hakea teretifolia.*	July.
Eucalyptus gummifera	1	W.S.	*Hakea teretifolia.*	January.
	2	W.S.	*Eucalyptus punctata-E. haemastoma-E. gummifera.*	January.
	3	W.S.	*Eucalyptus piperita-Angophora costata.*	March.
Eucalyptus haemastoma	1	W.S.	*Hakea teretifolia.*	March.
	2	W.S.	*Eucalyptus punctata-E. haemastoma-E. gummifera.*	January.
Eucalyptus pilularis	1	O.B.D.	*Eucalyptus pilularis.*	March.
	2	K.C.	*Eucalyptus pilularis-Angophora costata.*	March.
	3	P.H.	*Eucalyptus pilularis-Angophora costata.*	May.
	4	W.S.	*Eucalyptus piperita-Angophora costata.*	March.

FOOTNOTE TO TABLE. 14—*Continued.*

Details of Leaf Samples.—Continued.

Species.	Number in Table 14.	Locality.‡	Dominant Species in Community.	Month of Sampling.
Leptospermum squarrosum	1	W.S.	*Hakea teretifolia.*	July.
Leptospermum attenuatum	1	O.B.D.	*Leptospermum attenuatum.*	January.
Acacia discolor ..	1	N.P.	*Eucalyptus haemastoma-E. gummifera.*	July.
	2	W.S.	*Eucalyptus piperita-Angophora costata.*	March.
Acacia suaveolens ..	1	W.S.	*Hakea teretifolia.*	January.
	2	N.P.	*Eucalyptus haemastoma-E. gummifera.*	July.
	3	K.C.	*Eucalyptus pilularis-Angophora costata.*	March.
	4	W.S.	*Eucalyptus piperita-Angophora costata-Ceratopetalum apetalum.*	March.
	5	O.B.D.	*Eucalyptus botryoides-Banksia serrata.*	March.
Bossiaea scolopendria ..	1	W.S.	*Eucalyptus punctata-E. haemastoma-E. gummifera.*	January.
Dillwynia ericifolia ..	1	W.S.	*Eucalyptus punctata-E. haemastoma-E. gummifera.*	January.
Dillwynia floribunda ..	1	W.S.	*Hakea teretifolia.*	January.
Gompholobium grandiflorum.	1	W.S.	*Eucalyptus punctata-E. haemastoma-E. gummifera.*	January.
Gompholobium latifolium	1	O.B.D.	*Eucalyptus botryoides-Banksia serrata.*	March.
	2	W.S.	*Eucalyptus piperita-Angophora costata-Syncarpia glomulifera.*	March.
Pultenaea elliptica ..	1	W.S.	*Hakea teretifolia.*	January.
	2	W.S.	*Eucalyptus punctata-E. haemastoma-E. gummifera.*	January.
Casuarina distyla ..	1	W.S.	*Eucalyptus punctata-E. haemastoma-E. gummifera.*	January.
Casuarina littoralis ..	1	J.	Proteaceae spp.	March.
	2	O.B.D.	*Eucalyptus pilularis.*	March.
	3	O.B.D.	*Eucalyptus botryoides.*	March
Casuarina torulosa ..	1	W.S.	*Eucalyptus piperita-Angophora costata.*	March.
	2	P.H.	*Eucalyptus pilularis-Angophora costata.*	May.
Epacris microphylla ..	1	W.S.	*Hakea teretifolia.*	March.
Epacris pulchella ..	1	W.S.	*Eucalyptus punctata-E. haemastoma-E. gummifera.*	March.
Monotoca elliptica ..	1	O.B.D.	*Leptospermum attenuatum.*	March.
	2	O.B.D.	*Eucalyptus pilularis.*	March.
	3	W.S.	*Eucalyptus piperita-Angophora costata-Syncarpia glomulifera.*	March.

‡ Locality abbreviations: N.P. = National Park; O.B.D. = Ocean Beach Dune Series; W.S. = Warrah Sanctuary, Pearl Beach District; B. = Berowra; K.C. = Kuring-gai Chase; P.H. = Pennant Hills; J. = Jannali.

for the lower nitrogen content of these species as compared with the other representatives of their families. With the exception of *A. suaveolens*, which bears phyllodes, the other species mentioned in Table 14 have true leaves and all of these exhibit much the same degree of lignification.

Shields (1953) reports that the total nitrogen content of mature leaves from dicotyledons growing in gypsum sand having a maximum concentration of nitrite and nitrate of 8 p.p.m. ranges from 12,500 to 40,000 p.p.m. of the dry leaf weight.

For comparison it is of interest to note the analyses given by Parberry and Swaby (1942). The average total nitrogen content of mesomorphic species was as follows: grasses, approx. 20,000 p.p.m.; legumes, 20,000–40,000 p.p.m. Mitchell's (1936) and Tamm's (1951) figures for leaf material of deciduous tree species mostly exceed 20,000 p.p.m. nitrogen.

(ii) Wood.

Details of the nitrogen content of the wood of some of the species listed in Table 14 will be reported in a later publication.

(iii) Litter.

To complete the description of the communities, the litter phase is briefly mentioned here. Additional investigations of litter returns will be reported later.

Method.

In the forest communities it was found that the greatest percentage of leaf litter was made up of the relatively large leaves from the tree stratum. Usually two or more species of *Eucalyptus* grow in association, and identification of individual fallen leaves to the various species, so that comparison of fresh and fallen material can be made, is frequently difficult. However, it was found that wherever *Angophora costata* was growing, a very considerable percentage of the leaf litter was composed of this species whose leaves can be recognized. Therefore separate nitrogen analyses were made on *Angophora* litter.

The samples were collected on fine wire frames raised two inches above ground level to allow evaporation of moisture from condensation and rain.

Results and Discussion.

To enable direct comparison of litter with fresh leaf material, results were expressed on an area as well as a dry weight basis (Table 15). This would eliminate errors due to loss of dry matter at the time of leaf fall or later. However, a comparison of litter and fresh leaf figures in Table 16 indicates that no loss of dry matter does occur; in fact, a shrinkage in surface area of the litter might be suggested, but it is necessary to account for up to 27% of the original area if the variation between extreme values of g./sq. cm. in leaf and litter is due to shrinkage alone. Leaf thickness would need consideration also.

TABLE 15.
Concentration of Total Nitrogen in Angophora costata *Leaves.*

Month of Sampling.	Period Since Previous Sample.	Total Nitrogen (on Oven Dry Weight) (p.p.m.).	Total Nitrogen (Per sq. cm. of Leaf) (µg.)
Litter:			
November	4·0 months	3600	64
April	2·5 ,,	4300	78
September	1·0 ,,	6700	105
Fresh mature leaf:			
July (site: National Park)	—	6300	103
November (site: Kuring-gai)	—	7500	106

The litter analyses indicate that, at least for *Angophora* which forms the greatest percentage of litter in forest communities, nitrogen is not withdrawn into the plant before leaf fall.

TABLE 16.

Dry Weight of Angophora costata *Leaves.*

Details of Sample.	Oven Dry Weight of Leaves (g./sq. cm.).
Leaf litter. Site: Warrah Sanctuary.	
Month of Sampling:	
July–November	0·016
November–January	0·022
January–April	0·020
April–August	0·021
August–September	0·018
September–October	0·021
March–May	0·020
May–July	0·017
July–November	0·020
Mature fresh leaves:	
National Park—July	0·017
Kuring-gai—November	0·014

Fraser (1948) found that the nitrogen content of the undecomposed layer of *Casuarina* litter also was very similar to that of the fresh material, both when expressed on a dry weight and on a corrected ash basis.

TABLE 17.

Concentration of Nitrogen in General Litter Samples from Dry Sclerophyll Forest.

Samples collected at fortnightly intervals from May to December and bulked for final analysis.

Litter Sample.	Total Nitrogen (p.p.m.).
Leaf	4300
Twig	2900

All species may not be similar in this respect, however. This is suggested by the lower figure of 4300 p.p.m. for the bulked leaf sample composed of several species in Table 17. It would seem unlikely that loss by leaching before the samples were collected would account for this lower value, in view of the *Angophora* data.

TABLE 18.

Total Nitrogen Content of Mature Fruit and Seed.

Species.	Total Nitrogen (p.p.m.).		Nature of Seed.
	Fruit.	Seed.	
Proteaceae:			
Isopogon anemonifolius (Salisb.) Knight	1,100	2,700	Furry, small.
Myrtaceae:			
Eucalyptus piperita	2,200	3,300	Minute.
Leptospermum squarrosum	2,200	7,000	Minute.
Leguminosae:			
Acacia linifolia (Vent.) Willd.	4,700	28,700	Very large; 29/g.
Dillwynia ericifolia	—	33,100	Large; 200/g.
Casuarinaceae:			
Casuarina distyla	3,100	33,000	Winged, small.

Epacridaceae:

Seed of *Epacris pulchella* is extremely fine. The sample was a mixture of fruit pods and seed and contained 8,200 p.p.m. total nitrogen. With the exception of the Leguminosae and Epacridaceae species listed, whose fruit are leathery, the other species have woody fruit.

Unless the differences in nitrogen content of the litter given in Table 15 are influenced by seasonal variation, it would appear that at least part of the nitrogen is leached fairly rapidly, since only approximately 60% remained after four months under conditions where natural decomposition would have been retarded.

In addition to leaf and twig litter (Table 17), flower, fruit and seed litter also require consideration. As in leaf material, the Leguminosae and Casuarinaceae show a much higher nitrogen content in their seed than the other species analysed (Table 18).

GENERAL DISCUSSION.

In view of the illustration given above, of the deficiencies of phosphorus and nitrogen in these plant communities, the following points are worthy of comment.

The native vegetation forms a moderately dense cover represented by heath, scrub and forest. With the low initial mineral content of the parent material, such development is remarkable.

It would appear that considerable economy has been exercised to prevent the loss of nutrients from the communties and maintain the original "working capital" (Beadle and Burges, 1949) of bases and nitrogen. In this regard, analyses of drainage waters and a tracing of root systems, especially of tree species and denitrification studies, should prove particularly illuminating. From observations of Beadle (private communication) and Hannon (Table 3 and unpublished data), the loss of phosphorus and net loss of nitrogen in the fire-free communities is not detectable. From her studies of *Casuarina* litter, Fraser (1948) has suggested the occurrence of a calcium cycle in these communities. Turner (1954), in preliminary work on the composition of eucalypt forest litter, has also noted that the calcium and potassium content of the leaf litter in dry sclerophyll forest communities exceeds that in wet sclerophyll. The phosphorus value is much lower. The ecosystem may well be regarded as a closed cycle, apparently with a comparatively low metabolic rate, yet with an efficiency approaching 100%.

In addition, the species have been selected for, or adapted to, the conditions of low water and nutrient supply. Analytical data (Table 14) show their nitrogen content to be extremely low. Beadle's (1954) figures for phosphorus are correspondingly low.

Further physiological investigations of representatives of the flora would be of great value. As mentioned before, studies on the *Eucalyptus* litter decomposition and the nature of the soil organic matter and microflora would be of interest also.

The means by which nitrogen has reached its present level calls for attention. It has been shown that the total nitrogen content of these soils is low, but quite comparable with similar soils; but the carbon-nitrogen ratio is higher and available nitrogen lower than in other parts of the world. This suggests that the rate of nitrification of organic matter will be low.

As previously mentioned, the sources of nitrogen for natural plant communities have not received careful investigation. The major contributing factors as symbiotic and non-symbiotic nitrogen fixation are well known and it has been usual to deduce, by inspection of the occurrence of legumes, nitrogen-fixing algae or bacteria, which agent was responsible for nitrogen accessions. The analyses of leguminous and *Casuarina* tissue (Tables 14 and 18) suggest that they have an independent supply of nitrogen. The role that they have played in building up the nitrogen content of these communities to their present level might well be of importance. Studies on the development and circulation of nitrogen in the Hawkesbury Sandstone communities will be reported later.

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EXPLANATION OF PLATE X.

Native species growing in Hawkesbury Sandstone soil under various nutrient treatments.

A: *Acacia suaveolens* (Sm.) Willd.
Left to right: 1–3 Eucalypt forest soil
1: + Water; 2: + P; 3: + P + N
4–6 Shrub swamp soil
4: + Water; 5: + P; 6: + P + N

B: *Casuarina littoralis* (Salisb.) (*C. suberosa* Ott. & Dietr.).
Left to right: 1–3 Shrub swamp soil
1: + P + N; 2: + P; 3: + Water
4–6 Eucalypt forest soil
4: + Water; 5: + P; 6: + P + N

C: *Eucalyptus gummifera* (Gaertn.) Hochr.
Left to right: 1–3 Eucalypt forest soil
1: + Water; 2: + P; 3: + P + N
4–6 Shrub swamp soil
4: + Water; 5: + P; 6: + P + N

D: *Hakea dactyloides* (Gaertn.) Cav.
Left to right: 1–3 Shrub swamp soil
1: + P + N; 2: + P; 3: + Water
4–6 Eucalypt forest soil
4: + Water; 5: + P; 6: + P + N

Reduction: × 0·05 approx.

Photographs by Mr. J. D. McLean.

THREE NEW AUSTRALIAN CHIGGER NYMPHS (ACARINA, TROMBICULIDAE).

By ROBERT DOMROW, Queensland Institute of Medical Research, Brisbane.

(Forty-four Text-figures.)

[Read 27th June, 1956.]

Synopsis.

The nymphs of *Euschöngastia cairnsensis*, *Trombicula antechinus* and *Acomatacarus australiensis* are described.

Since the publication of my first two descriptions of Australian nymphal *Euschöngastia* (These PROCEEDINGS, 80, 1955, pp. 57 and 130), material of a third species reared many years ago has come to hand, and nymphs of two species of other genera have been reared. These three nymphs, *Euschöngastia cairnsensis*, *Trombicula antechinus* and *Acomatacarus australiensis*, are described below, and a note on the larval tracheal system of the last named is added.

EUSCHÖNGASTIA CAIRNSENSIS (Womersley & Heaslip, 1943).

Types: Three morphotype nymphs in Queensland Institute of Medical Research, Brisbane, reared from engorged larvae from *Isoodon obesulus* Shaw and Nodder, Cowan Cowan, Moreton Is., Q., April-May, 1941, by D. J. W. Smith. Associated larval pelts accompany the specimens.

Description of Nymph.

Body: Mean idiosomal length 575μ (544μ to 590μ), breadth across propodosoma 342μ, across hysterosoma 303μ. Fairly well marked constriction at level of posterior pair of coxae; colour in life unknown, although mounted specimens are quite yellow. Genital area oval (Text-fig. 5), 74μ long; anterior sucker 17·5μ to 19·3μ, posterior sucker 15·7μ to 17·5μ long. Genital plates with about five or six ciliated setae each; inner genital setae 3·3 and simple. Anal plates (Text-fig. 9) stout, 48μ long, well sclerotized anteriorly, with three or four pairs of ciliated setae. Genitalia just behind level of coxae IV, and anal plates separated by about half their own length from genitalia.

Palpi (Text-figs. 7 and 8) five-segmented; femur with three or four and genu with six or seven dorso-lateral ciliated setae. Tibia with simple claw 28μ long, two inner spathulate accessory combs, and an external forwardly directed nude seta set near base of claw, in addition to about four dorso-external and a single internal ciliated setae near insertion of tarsus. Tarsus with about eight ciliated setae, three apical nude setae, and a single external sub-basal sensory rod.

Gnathosoma: Hypostome (Text-fig. 2) similar to other described species, with fourteen to sixteen nude apical setae and about twenty-two ciliated setae on ventral surface. Chelicerae (Text-fig. 3) normal, with finely serrated concave dorsal edge, blade 48μ long.

Legs: Leg I largest, leg IV longer than legs II and III, which are sub-equal; all seven-segmented. Coxae in two groups, with numerous ciliated setae; only coxae I fused medially. All tarsi with two distinct claws. Precoxal plates (Text-fig. 6) with three to five ciliated setae each. Tarsus I (Text-fig. 4) without preapical dorsal process, stout, 199μ long, 62μ high, tibia I 83μ long, tarsus II 64μ long, tibia II 41μ long.

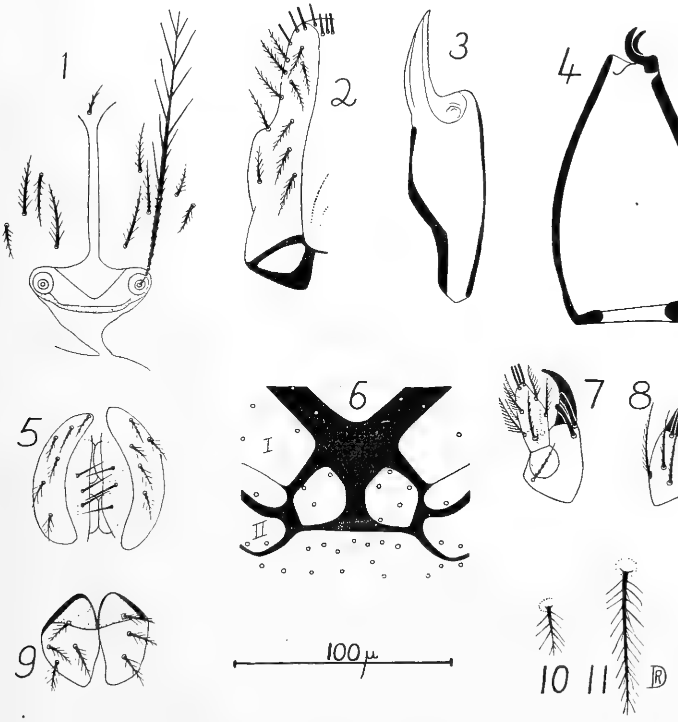
Scutum (Text-fig. 1): Sensillary area almost triangular, constricting rapidly in front of sensillary bases. Anterior margin of tectum invisible. Single ciliated tectal seta present. Sensillary area without median carina, but with saddle bridging sensillary bases. Posterior apodeme with irregular sides, with two diverging lines at apex. Sensillae filiform, of normal type, with apical ciliations to 26μ long. Eyes absent, parascutal setae one on each side, with variable number of ciliated setae near by. The scutal standard data are given in Table 1.

Setation: Body setation very similar to that of *E. smithi*. Length of setae behind scutum (Text-fig. 10) to 24·6μ, length of terminal setae (Text-fig. 11) to 63μ. The types of leg setae are as in *E. perameles*, but the sensory setae on tarsus I are not quite as numerous. Blunt finger-like setae to 21·1μ long, ciliated setae to 24·6μ long. Fine tapering setae shorter and more numerous ventrally, as in other two species below.

TABLE 1.

Standard Data (in Micra) of Scutum of E. cairnsensis.

CTL.	ASL.	SB.	ASL./SB	PSL.	PAD.	TS.	SS.	SENS.
67	81	49	1·65	17·6	28·1	—	28·0	130
60	74	44	1·68	14·0	31·6	19·3	26·3	123
67	77	44	1·75	14·0	24·6	19·3	28·0	118
Means : 64·7	77·3	45·7	1·69	15·2	28·1	19·3	27·4	124



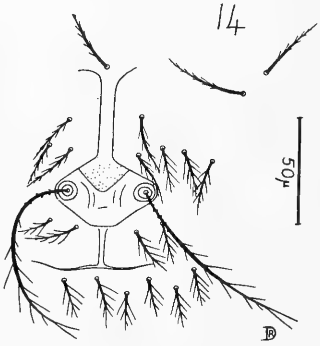
Text-figs. 1-11.—*Euschöngastia cairnsensis*. Nymph. 1, scutum; 2, hypostome in ventral view; 3, chelicera; 4, tarsus I in lateral view; 5, genitalia; 6, precoxal area; 7 and 8, palpal tibia and tarsus in internal and external view; 9, anal plates; 10 and 11, body setae from near scutum and from end of hysterosoma.

EUSCHÖNGASTIA PERAMELES (Womersley, 1939).

A larger series of new nymphal material has been reared, and shows that the genitalia illustrated previously (These PROCEEDINGS, 80, 1955, p. 59) are an extreme form. No distinction was then made between the inner genital setae and the setae on the genital plates, as all were ciliated. Nearly all the new specimens show 3·3 inner genital setae, with several ciliations, but the range is from 2·2 and 2·3 through to 4·5. Two rather more typical specimens are illustrated below (Text-figs. 12 and 13). The number of ciliated setae on the genital plates is very variable, ranging from about eight to fifteen.

The data given for the palpal tibia and tarsus are correct in essentials, and may now be said to conform completely to the pattern given below.

The new material is as follows: Five nymphs from *Isoodon obesulus*, Rockhampton, May, 1955; eight nymphs from same host, Paddington, Brisbane, August to September, 1955; four nymphs from *Perameles nasuta* Geoffroy, Mt. Glorious, September, 1955. The latter is the first record of *E. perameles* on this genus. Another series of larvae was taken on this host, same locality, 22.xi.55, but no nymphs were obtained. *P. nasuta* is not nearly as common as the other local bandicoot, *I. obesulus*; only six of more than two hundred bandicoots examined have been this species.



Text-figs. 12-13.—*Euschöngastia perameles*. Nymph. Genitalia, amended.
Text-fig. 14.—*Trombicula antechinus*. Nymph. Scutum.

EUSCHÖNGASTIA SMITHI (Womersley, 1939).

There is nothing to add to the description of the nymph of this species (These PROCEEDINGS, 80, 1955, p. 130), except to note that the illustration of the inner surface of the palpal tibia and tarsus does not show the position of the external setae.

DISCUSSION.

Three Australian species of *Euschöngastia* Ewing are now known to me as nymphs, and all are of remarkably similar facies. The majority of morphological characters are almost identical, including the hypostome, the sensory setae of the legs, the precoxal area, the genital and anal areas, and the setation of the palpi.

Since Womersley's figures (1952) indicate that the setation of the palpal tibia and tarsus is possibly not constant for all trombiculine genera or subgenera, e.g. *globularis* group and *Leptotrombidium*, a detailed account of the constant pattern of the three *Euschöngastia* species is given.

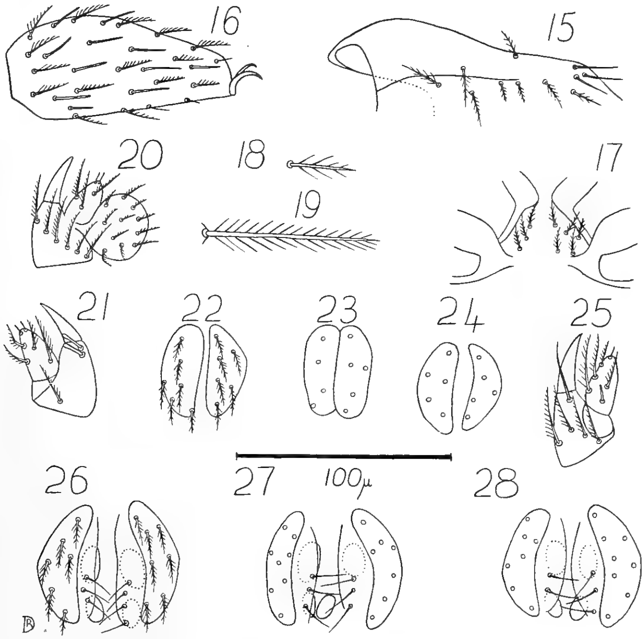
Tibia: 1. A single terminal claw. 2. Two dorso-internal accessory combs set in tandem at base of claw. 3. A single nude external seta set near base of claw, and running forward parallel to claw. 4. A single (very occasionally two) internal ciliated seta set near insertion of tarsus. 5. Several dorso-external ciliated setae.

Tarsus: 6. A single external sub-basal sensory rod. 7. About three or four apical nude setae rather similar to those at tip of hypostome. 8. Eight or nine ciliated setae.

E. cairnsensis, like *E. smithi* and *E. perameles*, runs to couplet 10 of Womersley's key (1952, p. 376), but none of the three is related to the two species included in this couplet. *E. perameles* is readily separated by its relatively uniform body setation, and consistently more setae on the precoxal, genital and anal plates. The larva of *E. perameles* is also a distinct form. However, *E. cairnsensis* and *E. smithi* are almost identical, and can only be separated by the nature of the inner genital setae, and possibly by the sensillae. The inner genital setae are ciliated in *E. perameles*, simple or bifurcate in *E. smithi*, and simple in *E. cairnsensis*. The larvae of *E. smithi* and *E. cairnsensis* are readily separated.

TROMBICULA ANTECHINUS Womersley, 1954.

Types: Three morphotype nymphs in Queensland Institute of Medical Research, Brisbane, and one each at Institute for Medical Research, Kuala Lumpur, and South Australian Museum, Adelaide. All specimens are accompanied by correlated larval pelts, and were reared from engorged larvae from inside the ears of *Rattus assimilis* Gould, Mt. Glorious, Q., September, 1955.



Text-figs. 15-28.—*Trombicula antechinus*. Nymph. 15, hypostome in ventral view; 16, tarsus I in lateral view; 17, sternum; 18 and 19, body setae from near scutum and from end of hysterosoma; 20, palp with abnormal growth; 21, internal view of palpal tibia and tarsus; 22, 23 and 24, anal plates; 25, external view of palpal tibia and tarsus; 26, 27 and 28, genitalia.

Description of Nymph.

Body: Mean idiosomal length 638μ (620μ to 652μ); breadth across propodosoma 264μ, across hysterosoma 310μ; well marked constriction at level of posterior pair of coxae; pale straw colour in life. Genital area oval (Text-figs. 26 to 28), 60μ long, with two pairs of genital suckers; anterior sucker 14·6μ to 16·7μ, posterior sucker 10·5μ to 13·9μ long. Genital plates with about seven or eight ciliated setae each; inner genitalia generally with 3·3 simple setae, but ranging from 2·3 to 3·4. Anal plates (Text-figs. 22 to 24) 48μ long, slightly sclerotized, with four to six ciliated setae each. Genitalia placed just behind coxae IV, and anal plates separated by about their own length from genitalia.

Gnathosoma: Chelicerae typical, with concave dorsal edge of blade slightly serrate; blade 58μ long. Hypostome (Text-fig. 15) of typical shape, but with only seven or eight rather long simple setae apically. About sixteen ciliated setae on base of gnathosoma.

Palpi (Text-figs. 21 and 25) five-segmented, of typical structure. Femur with two or three and genu with six to eight (ten on one side of one specimen) ciliated dorsolateral setae. Tibia with simple claw 30μ long, two internal accessory spathulate combs, and an external forwardly directed nude seta set near base of claw, in addition to about four dorso-external and a single (two on one side of one specimen) internal ciliated seta near insertion of tarsus. Tarsus with nine ciliated setae, about three or four nude apical setae, and a single external sub-basal sensory rod. Near the insertion of the tarsus of one specimen there is attached by a short stem a spherical growth which has several ciliated setae (see Text-fig. 20).

Legs: Leg I largest, leg IV longer than legs II and III, which are sub-equal; all seven-segmented; with distinct sternum present between coxae I and II (Text-fig. 17) with about six to eight ciliated setae. All tarsi with two strong claws (Text-fig. 16). Coxae I and II and III and IV in two distinct groups, with numerous ciliated setae. Tarsus I 109μ long, 37μ high, tibia I 81μ long, tarsus II 63μ long, tibia II 37μ long. Tarsus I without preapical dorsal process (Text-fig. 16).

Scutum (Text-fig. 14). Sensillary area clearly diamond-shaped, with anterior corner punctate. Tectum with anterior margin indistinct, and with single ciliated tectal seta. Saddle poorly defined, but posterior apodeme distinct. Sensillae filiform, of fairly uniform thickness, with basal barbules merging into ciliations to 28μ long apically. Eyes absent. Parascutal setae one on each side with varying number of setae near by. The scutal standard data are given in Table 2.

TABLE 2.

Standard Data (in Micra) of Scutum of T. antechinus.

CTL.	ASL.	SB.	ASL./SB	PSL.	PAD.	TS.	SS.	SENS.
46	58	36	1·61	17·6	39	35	32	—
49	61	39	1·56	17·6	42	42	37	116
47	65	40	1·62	19·3	44	42	35	116
44	63	39	1·61	15·8	39	35	33	109
—	—	39	—	21·1	42	—	35	109
Means: 46·5	61·7	38·6	1·60	18·3	41·2	38·5	34·4	112·5

Setation: Dorsal and ventral body setae (Text-figs. 18 and 19) strongly ciliated and increasing in length posteriorly from 28μ just behind scutum to 84μ at posterior margin of hysterosoma. The setation of the legs is as in *E. cairnsensis* (see Text-fig. 16).

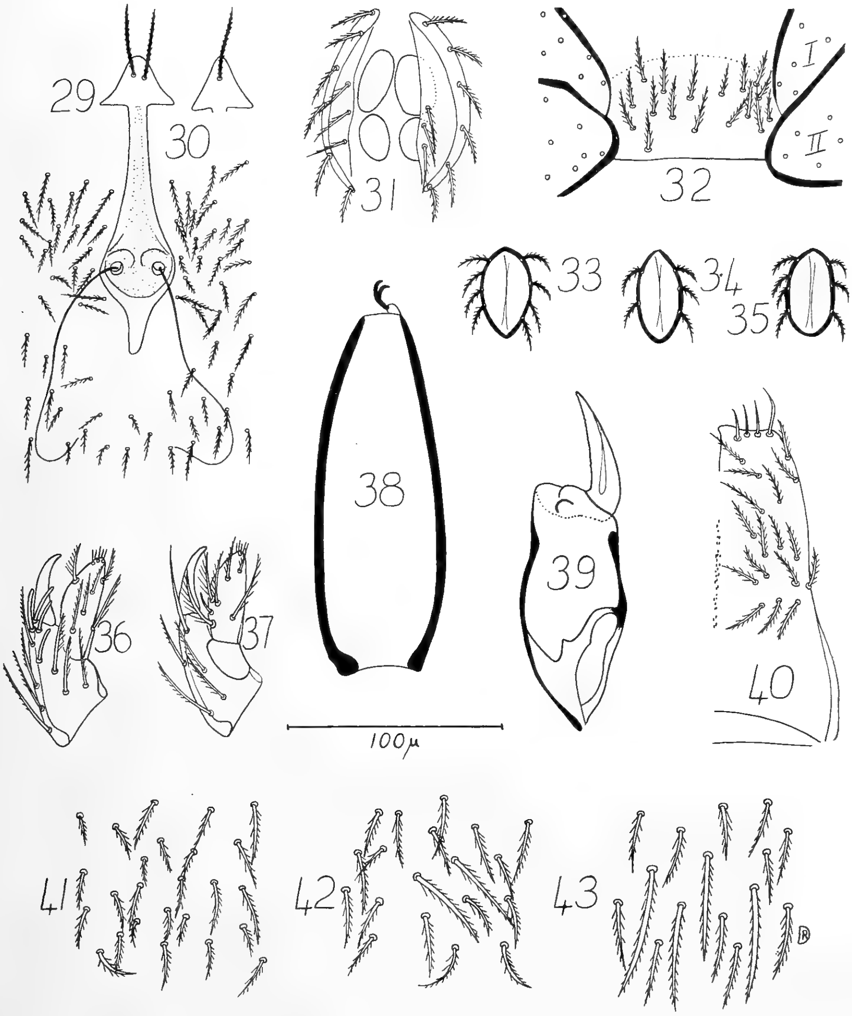
Development: The developing nymphal legs were distinct inside the larval cuticle by the fourteenth day, and a distinct dorsal spine was present, as figured by Jones (1951). The nymphs emerged 25 to 27 days after detachment.

DISCUSSION.

From both the larval and nymphal structures this species seems to be a member of the subgenus *Neotrombicula.* In nymphal characters it is almost identical with the description of the subgenotype *T.* (*N.*) *autumnalis* (Shaw, 1790), given by Richards (1950), yet the larvae are quite distinct. In Womersley's key (1952, p. 349) the specimens run to near *T. autumnalis,* but may be separated by the length of the terminal body setae, the number of ciliations on the sensillae, and the number of setae surrounding the crista. However, none of these are at all precise characters.

The nymphs may be separated from the three species of *Euschöngastia* discussed above by the presence of a complete sternum, the diamond-shaped sensillary area, and the reduced number of apical setae on the hypostome. The standard data of the scuta are also very different—CTL and ASL are much smaller due to the short crista, while TS and SS are quite noticeably larger. Otherwise the external morphology is identical, including the palpal formula.

A large series of larvae of this species is now available, and the contour of the posterior margin of the scutum shows wide variation, ranging from slightly concave, through flat, to evenly convex. Womersley (1954) described the posterior scutal margins of the two closely related species *T. novae-hollandiae* Hirst, 1929, and *T. antechinus* as "deep behind PL and rather flattened medially" and "not so deep behind PL and medially very slightly concave" respectively. Some of his specimens of the former are quite flat and even slightly concave, and the probability that these two species are the same is very strong. There is also great variation in the length of the dorsal setae, ranging from 56μ to 80μ in *T. novae-hollandiae*, and from 45μ to 58μ in *T. antechinus*. Otherwise the specimens are all identical. If the nymph of Hirst's species proves as devoid of recognizable specific characters as the present species, the problem will not be any simpler.



Text-figs. 29-43.—*Acomatacarus australiensis*. Nymph. 29, scutum and surrounding setae; 30, abnormal tectum with single seta; 31, genitalia; 32, sternum; 33, 34 and 35, anus; 36 and 37, internal and external view of palpal tibia and tarsus; 38, tarsus I in lateral view; 39, chelicera; 40, hypostome; 41, 42 and 43, anterior, mid-dorsal, and posterior body setae. (All to same scale, except 29, 30 and 38, which are drawn to three-quarters the indicated scale.)

ACOMATACARUS AUSTRALIENSIS (Hirst, 1925).

Types: Four morphotype nymphs in Queensland Institute of Medical Research, Brisbane, and one each at South Australian Museum, Adelaide, and Institute for Medical Research, Kuala Lumpur. All reared from engorged larvae from the perineum of *Isoodon obesulus*, Paddington, Brisbane, 9.xii.55. Associated larval pelts accompany the specimens, and a large series of larval whole mounts was made.

Description of Nymph.

Body without marked medial constriction, but with anterior half much wider than posterior half, forming distinct shoulders, length 670μ to 778μ, breadth across propodosoma 342μ to 373μ, across hysterosoma 264μ to 326μ. Colour in life dull white. Genital area oval (Text-fig. 31), 89μ long; anterior suckers 22·8μ to 31·6μ, posterior suckers 21·1μ to 24·6μ long. Genital plates very narrow and weakly sclerotized, with about six ciliated setae each. Inner genital setae 3·3, slender, with very fine ciliations on anterior edge. Anus (Text-figs. 33 to 35) 41·2μ long, surrounded by sclerotized ring with from two to four ciliated setae on each side; no discrete anal plates present. Genitalia just behind level of coxae IV, and anal plates separated by slightly less than their own length from the genitalia.

TABLE 3.

Standard Data (in Micra) of Scutum of A. australiensis.

ASL.	SB.	ASL./SB	PSL.	PAD.	TS.	SENS.
119	—	—	17·6	56	45	—
116	—	—	17·6	45	49	114
118	24·6	4·80	17·6	53	45	158
123	28·1	4·38	19·3	45	45	165
116	28·1	4·13	19·3	53	45	—
116	24·6	4·72	17·6	53	39	—
Means :						
118	26·4	4·51	18·2	51	45	156

Palpi (Text-figs. 36 and 37) five-segmented; femur with about sixteen slender ciliated setae; genu with about eighteen stronger ciliated setae. Tibia with simple claw 31·6μ long, four inner spathulate combs arranged 3.1 and one nude external seta near base of claw, in addition to two to four ciliated setae on inner face and two on the outer surface, and several strong shortly ciliated setae on the dorsal edge. Tarsus with about twelve ciliated setae, about four short nude apical setae, and a single external sensory rod, which is set rather high.

Gnathosoma: Hypostome (Text-fig. 40) with four pairs of inwardly curved simple apical setae, and numerous ciliated setae further back; with a short row of granulations medially. Chelicerae (Text-fig. 39) standard, blade 61μ long.

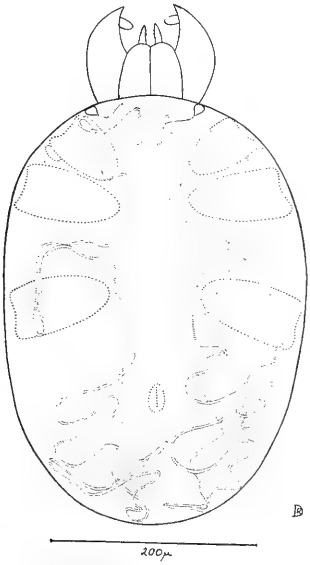
Legs I and IV longer than body and legs II and III; all seven-segmented. Coxae in two groups. All tarsi with two distinct claws. Sternum (Text-fig. 32) entire, with posterior margin straight; with numerous ciliated setae. Tarsus I (Text-fig. 38) slender, without preapical dorsal process, 210μ to 228μ long, 74μ to 81μ high, tibia I 130μ to 154μ long, tarsus II 98μ to 122μ long, tibia II 81μ to 88μ long.

Scutum (Text-figs. 29 and 30): Sensillary area subcircular, merging into stout posterior apodeme, and into broad crista anteriorly. Tectum distinct, arrow-shaped, with two tectal setae (only one in one specimen) set fairly well back from apex. Sensillae extremely fine and without any ciliations whatever. Eyes absent. Setae around scutum arranged as shown. The scutal standard data are given in Table 3.

Setation: Dorsal body setae (Text-figs. 41 to 43) increasing in length from 17·6μ just behind scutum to 56μ at posterior margin of body, with more ciliations on one side than the other. The increase in length is not regular, setae of rather different lengths being mixed. The sensory setation of the legs is as in *E. perameles*.

DISCUSSION.

The colony of pale yellow, lightly pink-tinted larvae from which these nymphs were bred was found in large patches around the perineum and scrotal stalk of the host, and comprised several hundred individuals in varying degrees of engorgement. This area of skin was removed and placed in a refrigerator overnight, but few larvae disengaged. After another two full days in the refrigerator, scores of larvae had detached, and quickly became very active when placed in water. The largest were chosen to breed out nymphs. Some were placed on moist filter paper in closed containers, but these failed to moult. Others were kept in water with a little merthiolate, and nymphochrysalises were seen after fourteen to nineteen days. The nymphs emerged after 25 to 28 days. Other specimens from *Perameles nasuta*, Mt. Glorious, 22.xi.55, failed to moult.



Text-fig. 44.—*Acomatacarus australiensis*. Larva. Dorsal view of tracheal system.

The mounted larval material is without doubt *Acomatacarus australiensis* (Hirst) and has been compared closely with his excellent figures and further material from the Sydney (type) area. The holotype of *A. hirsti* (Womersley, 1944) is considered to be a typical specimen of Hirst's species. The standard data, specialized setation, and even the scutal punctae of all these specimens are identical, and the dorsal setae conform to the pattern given by Hirst, namely, a pair of humerals and two pairs of posthumerals enclosing a band of about eighteen and a short row of eight, followed by two rows of ten to twelve, and then with irregular rows arranged roughly 8.8.4.4. In engorged specimens this setal pattern is disrupted. The galeal seta is always nude. Womersley (1945) briefly described a single nymph from New Guinea as *A. australiensis*, but now (in ms.) considers this doubtful. Actually the whole genus needs revision.

Tracheal System.

Several workers (summarized by Brennan, 1949, and Wharton, 1950) have reported taenidial ducts in some larval leeuwenhoekiine genera. Those opening ventrally between the gnathosoma and coxae I were believed to be tracheae. In the present species these tubes are moulted with the larval pelt and are left trailing, still attached to the spiracles. The above belief, then, seems justified. In whole mounts the larval tracheal system (Text-fig. 44) is as follows. The two spiracles are in the normal position, 8·75μ wide anteriorly, and fairly well sclerotized. Each atrium tapers quickly, giving rise to the narrowest part of the trachea. This narrow section is quite within the limits of resolution, being about 2·3μ in diameter. From this narrow section the trachea becomes gradually thicker, up to 3·5μ in diameter, and runs upward in a loop near the cheliceral apodemes, and then passes ventrally again, out to the level of coxa I. It then passes medially, between coxae II, and then outward again just before the level of coxae III, where a large loop is made. It then returns medially, passes between coxae III, and, still just beneath the ventral cuticle, continues to the posterior margin of the hysterosoma. Here it follows the upward curve of the body and continues on to the dorsum, just below the cuticle, in a very tortuous path. The tracheae are thinner dorsally, up to 2·8μ in diameter, and finish in a distinct, elongate swelling. These swellings are on an average 28μ long and 4·55μ in maximum diameter. Some of the folds in the tracheae are very close. A similar system is present in *A. athertonensis* Wom.

Acknowledgements.

I am indebted to Messrs. H. Womersley and H. M. Hale, of the South Australian Museum, for much kind advice and the loan of type and other specimens.

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NOTES ON AUSTRALIAN BUPRESTIDAE, WITH DESCRIPTIONS OF THREE NEW SPECIES AND TWO SUBSPECIES OF THE GENUS *STIGMODERA*, SUBGENUS *CASTIARINA*.

By C. M. Deuquet, B.Com.

(Three Text-figures.)

[Read 27th June, 1956.]

Synopsis.

The following are described as new: *Stigmodera (Castiarina) acuta*, *S. (C.) parvula*, and *S. (C.) violatra*. *Stigmodera (Themognatha) caerulans* is described as a variant of *S. mniszechi* Saund. and *S. (C.) roseipes* as a variant of *S. octospilota* L. & G. *S. (C.) rufipes* Macl. is reinstated as a distinct species.

Stigmodera mniszechi was described by Edw. Saunders in 1867 from specimens taken in coastal Western Australia (Perth to Geraldton), where it is found in October-November on the flowers of *Melaleuca*, in which it breeds. Forty years later another form of this insect was taken on the inland sand-plains of W.A. on the flowers of Mallee (*Eucalyptus stricta*), in which it breeds. The latter shows such clear and constant differences from the former, not only of colour and size, which are of minor importance in this amazingly variable genus, but of form and structure, that it deserves, I think, a subspecific name. Owing to its distinctive colour, *caerulans* seems to be an appropriate name. In proposing this I am expressing the opinion of two most competent entomologists, Horace Brown and the late John Clark.

The differences between the two forms are:

	Stigmodera mniszechi Saund.	*Stigmodera caerulans* Deuq. (subsp.).
Colour of pronotum ..	Nitid bronze (" thorace nitidissimo " (Snd.)).	Disc and anterior sides dark blue, posterior sides and margins brilliant metallic blue.
Elytra and scutellum	" Dark greenish black " (Snd.).	Shiny dark blue, with scutellum, basal margin and sutural anterior half bright metallic blue.
Form	Slightly flatter, much more rugose and more deeply sulcate over the whole surface of elytra, especially on shoulders.	More oval, more elongate, smoother on elytra and lower side of pronotum.
Underside	Black " subtus nitida " (Snd.).	Blue, epipleura with shiny cyaneous reflections.
Average dimensions ..	30×15½ mm.	35×16 mm.

When nearing the transverse sanguineous band near the apex, the blue area is produced in *S. caerulans* along the suture into an enlarged oval generally connected narrowly with the apical patch. I have not seen this ovate spot occurring in any of the *S. mniszechi* Saund. examined.

STIGMODERA (CASTIARINA) RUFIPES Macl.

Stigmodera rufipes was described by Macleay (*Ent. Soc. of N.S.W.*) in 1862. Although its morphological characteristics entitle this insect to a distinct species rank, it was unaccountably listed by Carter as a variety of *Stig. octospilota* L. & G.

Its shape and the markings of its pronotum alone make it easily distinguishable, and Dr. Obenberger appropriately but belatedly named it *S. stigmaticollis* in 1928.

Here are the most striking differences between the two insects:

	Stigmodera octospilota L. and G.	*Stigmodera rufipes* Macl.
Form	Broad, robust, ovate.	Narrower, more rectangular, moderately convex.
Head	Large yellow spot on centre.	Long narrow yellow vitta on centre.
Pronotum	Dark bronze with wide yellow margins.	Yellow margin extending thinly across the anterior part, a small medial yellow spot close to the front margin and a yellow vitta narrowly covering the medial sulcus on basal third.
Legs	Blue.	Blue except femora and lower part of tibiae, which are brick red.
Dimensions	14 × 6 mm.	14 × 5 mm.

STIGMODERA (CASTIARINA) OCTOSPILOTA L. & G., var. ROSEIPES Deuq.

In the New England district of New South Wales is to be found fairly commonly a variety of *octospilota* which shows constant differences from the species described in 1838 by Laporte (Comte de Castelnau) and Gory. These differences are: (1) Femora almost entirely brick-red. (2) The vermiculation between the three hindmost visible abdominal segments blue in both *octospilota* and *rufipes* is red in *roseipes*. (3) The elytral pattern is different: the dark blue antemedian fascia of *S. octospilota* L. & G. is reduced in *roseipes* to an arcuate longitudinal vitta extending from the base to the middle of the sides where it connects with the postmedian fascia. These differences are, I think, sufficiently important to justify the varietal name as above.

STIGMODERA (CASTIARINA) ACUTA, n. sp. (Text-fig. 1).

Elongata, acuminata. Capite thoraceque bronzeo-cyaneis; antennis et pedibus concoloribus. Elytra bronzeo-nitida. Sex maculae: prima et secunda basale, tertia et quarta post medium, flavae; quinqua et sexta prope apicem laete sanguineae. Apex bidentatus. Subtus nitido-cyanea, albo pubescens.

Elongate, acuminate. *Head and pronotum* bronzy with brilliant greenish reflections on basal area of pronotum and scutellum; *legs and antennae* dark blue. *Elytra* greenish-black with markings as follows: two subbasal oval spots not quite reaching the base; two narrower but slightly longer medial spots behind the former; two small oval anteapical maculae connected with a sanguineous lateral mark extending to the sides and slightly produced downwards along the margin nearly as far as the apex. All maculae unconnected with the suture. Epipleural red spots brightly sanguineous.

Head deeply and widely excavated between the eyes, irregularly punctate, more densely so near base. *Prothorax* widest behind middle, apex subtruncate, base strongly bisinuate, posterior angles acutely produced, no trace of medial sulcus nor of basal fovea. The ♀ has near the posterior angle, on each side, a large almost round fovea above the scutellum. Disc minutely punctate, the punctures slightly deeper on the sides. *Scutellum* almost triangular, smooth. *Elytra* rather flat, sides subparallel, slightly sinuate behind middle, greatly and sharply attenuated to the shortly bispinose apex. With the ♀ the apices are more widely bilunate and the spines slightly longer, the external ones the more prominent. Striate-punctate, the striae outlined by neat regular costae, intervals flat and smooth.

Underside punctate, with a short silvery pubescence.

Dimensions: ♂, 13½ × 4 mm.; ♀, 15 × 5 mm.

Habitat: Acacia Plateau (northern N.S.W.) (Harold Davidson).

Type in Australian Museum, Sydney. Three examples (2 ♂, 1♀) of this fine species, which belongs to the beautiful *producta* Saund.–*spectabilis* Kerr. group, the latter being its nearest ally and from which it differs as follows:

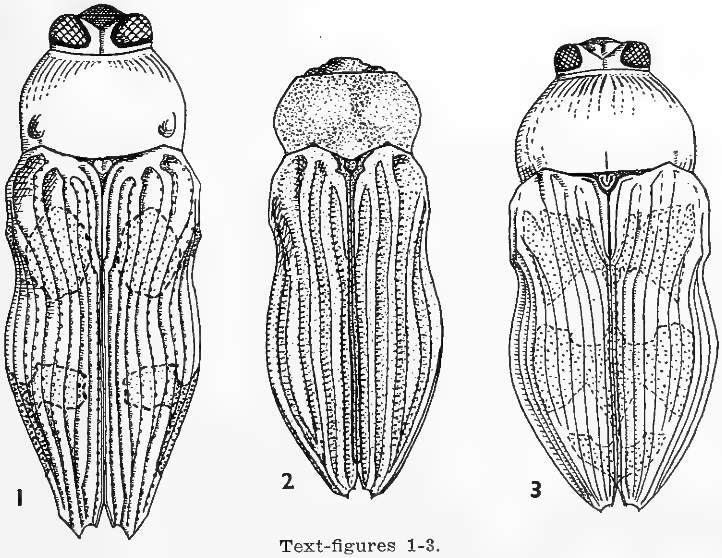
	Stigmodera spectabilis Kerr.	*Stigmodera acuta* Deuq.
Form	Convex, much broader.	Elongate, flatter, narrower.
Colour of head and pronotum.	Uniform very shiny blue.	Coppery with brilliant iridescence on apex and sides.
Scutellum	Brilliant blue.	Brassy.
Apices	Widely bidentate with sutural tooth shorter.	♂ very acuminate, minutely lunate, very short narrowly separated spines. ♀ wider lunula than ♂.

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

Elongata, capite et thorace bronzeo-cyaneis, longitudinaliter profonde in medio concavis; elytris rufis, interstitiis fortiter elevatis; sutura nigro-cyanea, pedibus ejusdem coloris. Apice bispinoso. Corpus subtus nigro-aenea, breviter albo pubescens.

Elongate, rectangular. *Head*, *pronotum* and *scutellum* dark blue with bronze reflections on disc. Suture bronzy black. *Elytra* brick-red. Legs and underside dark blue.

Head deeply furrowed longitudinally, closely punctate. *Prothorax* short, convex, almost straight at apex, arcuate at base, closely punctate, more thickly so at sides. Disc with deep medial sulcus and large depression on basal half; a small oblong fovea near the posterior angle on each side. Sides strongly rounded, posterior angles acutely produced. *Elytra* wider than prothorax at base, shoulders prominent, shortly narrowed sinuately, behind these, interstices conspicuously raised, apex slightly open at suture, bispinose, finely lunate with exterior spines more produced, striate-punctate.



Text-figures 1-3.

1. *Stigmodera* (*Castiarina*) *acuta* (× 4·5). 2. *S.* (*C.*) *parvula* (× 8). 3. *S.* (*C.*) *violatra* (× 3·5).

Underside punctate, sparsely clothed with minute whitish hair.

Habitat: Armidale, N.S.W. (C. Deuquet).

Dimensions: 6½ × 2½ mm.

Stig. nanula Kerr. (1890), *S. canaliculata* Blkb. (1892) and *S. parvula* are undoubtedly very closely related, although differences between them are plain and constant. Nevertheless *canaliculata* and *parvula* could quite plausibly be regarded as variants of *nanula*, which is the oldest name. All three are much smaller than *Stig. erythroptera* Bois. I should also mention that a much smaller example of *erythroptera* than the N.S.W. prototype is found in various parts of Queensland.

Parvula differs from *nanula* Kerr. by the colour of its head, legs, antennae, the ground colour of elytra, less globose form and absence of large rounded apical macula, while *canaliculata* Blk. is a good deal smaller, has a bluish iridescence near each hind angle of pronotum, and is less attenuated at apex; it has besides, at the tip of each elytron, a definite black marking extending part way along the suture and gradually disappearing half way to scutellum, not found in *parvula*.

Type in Australian Museum, Sydney.

STIGMODERA (CASTIARINA) VIOLATRA, n. sp. (Text-fig. 3).

Convexa, navicularis. Rubra-sanguinea; capite, thorace, scutelloque splendide violaceis; elytris rubeis-sanguineis, tribus fasciis cyaneo-nigris, punctato-striatis, pedibus obscure purpureis. Subtus caerulea, modice punctata, dense pubescens.

Elongate, ovate, slightly attenuated towards apex. *Head*, pronotum and scutellum of brilliant bluish-purple colour. *Elytra* blood-red with two dark blue fasciae not extending to sides, the first, premedial, wide, narrowly reaching the suture, widening obliquely upwards and downwards and resembling in form two unfurled flags attached to the same pole; the second, postmedial, almost straight in front, slightly bifurcating at sides, produced laterally and expanding at suture into a small rounded mark; and a preapical lunulate mark unconnected with apex or lateral margins. (The elytral pattern of the ♂ example differs much from the ♀, its only markings being a small oblong postmedial spot on each elytron and a minute subtriangular preapical mark at lower end of suture.)

Head deeply channelled, densely punctate. *Prothorax* strongly convex with finely drawn medial line from apex to basal fovea, nearly straight at apex, more sinuate at base, anterior angles moderately produced, posterior with a shallow impression above each, two minute but clearly outlined calli on basal half, the disc closely punctate, more deeply so at sides, base with a shallow median lobe. *Elytra* slightly widened at shoulders and much so postmedially, then obliquely narrowed to apex; striae and intervals covered with small punctures, the latter unevenly; posterior margins finely serrated, apex with moderately wide oblique lunation, each elytron shortly bispinose, exterior spine slightly more protrusive.

Underside rather densely clothed with whitish hair.

Dimensions: ♀, 18 × 8 mm.; ♂, 16 × 6½ mm.

Habitat: The granite belt of Stanthorpe, south Queensland (Ed. Sutton).

This strikingly handsome buprest was first captured by Mr. Sutton and shortly afterwards by Mr. A. Gemmell, both enthusiastic and experienced entomologists of the Stanthorpe district. Three examples, one ♂ and two ♀, examined. The closest ally of this species is *Stig. indistincta* Saund., from which it clearly differs as follows: (1) larger and broader, more convex and ovate; (2) pronotum of entirely different colour; (3) pattern of elytral markings different, especially by the absence of elongated diamond-shaped spot below the scutellum.

Several species of *Stigmodera* show the same difference in sexual coloration (generally in the markings of the elytra) as that occurring in *Stig. violatra*. *Stigmodera maculiventris* Macl., *elegans* Geh., *discoidea* Cart., *punctatissima* Saund. are among the best known. This disparity of pattern has been the cause of many mistakes in past descriptions by unwary authors.

Type ♀ in the Australian Museum, Sydney. Type ♂ and one paratype ♀ in Coll. Gemmell.

To Miss P. Goodwin, of the Australian Museum, Sydney, I wish to express my cordial thanks for her excellent drawings.

A LIST OF CORALS COLLECTED IN THE VICINITY OF SINGAPORE.

By R. D. Purchon, Ph.D., F.L.S., Raffles Professor of Zoology, University of Malaya,
Singapore.

(*Communicated by Mr. K. E. W. Salter.*)

[Read 25th July, 1956.]

Since the creation of this Department of Zoology in 1950, collections of coral have been made from time to time in the vicinity of Singapore. The most extensive collections have been made from Raffles Light, a small island some 12 miles from Singapore, while smaller collections have been made from islands closer to Singapore, such as Pulau Sudong and Pulau Hantu; collections have also been made on the west coast of Singapore, at Tanjong Gul and Tanjong Berlayar.

The corals so collected were identified as far as possible at the British Museum (Natural History) with the kind help of Captain A. K. Totton and Mr. White, to whom the writer wishes to express his thanks. Further additions were made to the collection, and the identification of the entire collection was finally undertaken by Professor J. W. Wells, Department of Geology, Cornell University, Ithaca, New York, who visited the University of Malaya in 1954. The writer is deeply grateful to Professor Wells for his great help and continued interest. Thanks are also due to Dr. A. G. Searle, of this Department, for his long-continued participation in this work.

The collection now amounts to 47 genera and, in addition to these, nine other genera are recorded from Singapore in literature, namely, *Caulastrea*, *Leptoseris*, *Lithophyllon*, *Oulophyllia*, *Plesiastrea*, *Stylocoeniella*, *Culicia*, *Monomyces* and *Rhizopsammia* (personal communication from Professor J. W. Wells). Thus 56 genera of corals are known from this region in all.

The present collection includes several genera not previously known from Singapore, and amounts to 76 species in all. This is considered to be sufficiently representative to merit publication.

LIST OF SPECIES.

Family SERIATOPORIDAE: *Stylophora mordax* (Dana), *Seriatopora hystrix* (Dana), *Pocillopora damicornis* (Linn.), *P. verrucosa* (Ellis and Solander).

Family ACROPORIDAE: *Acropora variabilis* (Klunzinger), *A. tubicinaria* (Dana), **A. concinna* (Brook), **A. brueggemanni* (Brook), *A.* cf. *corymbosa* (Lamarck), *Astraeopora myriophthalma* (Lamarck), *Montipora informis* Bernard, *M. fruticosa* Bernard, *M. laevis* Quelch, *M. solanderi* Bernard, *M. efflorescens* Bernard, *M. striata* Bernard, *M. prolifera* Bernard.

Family AGARICIIDAE: *Pavona frondifera* Lamarck, *P. crassa* (Dana), *Pachyseris speciosa* (Dana).

Family SIDERASTREIDAE: *Pseudosiderastrea tayamai* Yabe and Sugiyama.

Family THAMNASTERIIDAE: *Psammocora* (*Stephanaria*) *togianensis* (Umbgrove), *Psammocora contigua* (Esper).

Family FUNGIIDAE: *Fungia actiniformis* Quoy and Gaimard, *F. fungites* (Linn.), **F. repanda* (Dana), *F. echinata* (Pallas), *Herpolitha limax* (Esper), *Polyphyllia talpina* (Lam.), *Podabacia crustacea* (Pallas).

Family PORITIDAE: *Goniopora malaccensis* Brueggemann, *G. lobata* M.E. & H., *G. stutchburyi* Wells, *G. fruticosa* Saville Kent, *G.* cf. *columna* Dana, *Porites* (*Synaraea*) *convexa* Verrill, *P. nigrescens* Dana, *P. lutea* M.E. & H., *Alveopora excelsa* Verrill.

Family FAVIIDAE: *Favia speciosa* (Dana), *Favites abdita* (Ellis and Solander), *Goniastrea pectinata* (Ehrenberg), *G. benhami* Vaughan, *Platygyra lamellina* (Ehrenberg), *Leptoria phrygia* Ellis and Solander, *Hydnophora exesa* (Pallas), *H. rigida* (Dana), *Trachyphyllia geoffroyi* (Audouin), *Scapophyllia cylindrica* M.E. & H., *Cyphastrea chalcidicum* (Forskaal), *Echinopora lamellosa* (Esper), *Diploastrea heliopora* (Lamarck), *Oulastrea crispata* (Lamarck).

Family MERULINIDAE: *Merulina ampliata* (E. & S.).

Family OCULINIDAE: *Galaxea fascicularis* (Linn.).

Family MUSSIDAE: *Lobophyllia hemprichii* (Ehr.), *Symphyllia nobilis* (Dana).

Family PECTINIDAE: *Oxypora lacera* (Verrill), *Mycedium tubifex* (Dana).

Family CARYOPHYLLIIDAE: *Euphyllia glabrescens* (Chamisso and Eysenhardt), **E. fimbriata* (Spengler), *Pectinia lactuca* (Pallas), *Plerogyra sinuosa* (Dana), *Paracyathus stokesi* M.E. & H.

Family DENDROPHYLLIIDAE: *Turbinaria peltata* (Esper), *T. crater* (Pallas), *T. mollis* Bernard, *Tubastrea diaphana* (Dana), *T. aurea* (Quoy and Gaimard), *Dendrophyllia nigrescens* Dana, *Balanophyllia malaccensis* Moseley, *B. stokesiana* (M.E. & H.).

Family FLABELLIDAE: *Flabellum stokesi* M.E. & H.

Family HELIOPORIDAE: *Heliopora coerulea* (Pallas).

Family MILLEPORIDAE: *Millepora platyphylla* Hemprich and Ehrenberg.

Family STYLASTERIDAE: *Distichopora violacea* (Pallas).

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* Specimens of these species are in the collection of the Raffles Museum, Singapore, while specimens of the remainder are in the collection of the Department of Zoology, University of Malaya, Singapore.

THE AUSTRALIAN ALEYRODIDAE (HEMIPTERA–HOMOPTERA).

By L. J. Dumbleton, Canterbury Agricultural College,
Christchurch, New Zealand.*

(*Communicated by Dr. J. W. Evans.*)

(Eighty-eight Text-figures.)

[Read 25th July, 1956.]

Synopsis.

Descriptions and figures of 22 Australian species, and keys to the subfamilies, genera and species are given. Maskell's eight species and one of the two described by Froggatt are redescribed from cotype material. Three species are cosmopolitan or tropicopolitan and five species are described as new.

The Aleyrodidae so far described from Australia comprise eight species described by Maskell (1896), two species (one of which falls into synonymy) by Froggatt (1911, 1918), two species by Solomon (1935), and three species by Takahashi (1940, 1950). Three cosmopolitan species, presumably introduced, are also known from Australia. The five species described here as new bring the total to 22 species. Solomon remarks on the number of undescribed species present in Western Australia and there is little doubt that the aleyrodid fauna is much larger than this collection indicates, and much larger and more varied than that of New Zealand.

Solomon and Takahashi gave full descriptions of their species, but those of Maskell and Froggatt are inadequate.

Maskell's type material was studied by Quaintance and Baker (1917) who gave extended descriptions of *hirsutus*, *T-signatus* and *banksiae*, but owing to the condition of the type of *banksiae* the figures of that species are not good.

The Maskell type material has now been returned from the U.S. Bureau of Entomology and is in the collections of the Entomological Research Station, Nelson, N.Z., together with the Maskell Collection of Coccidae. Maskell's unmounted duplicate material of some of the species has been located. Some of this has been bleached before mounting, in order to permit the study of detail which it is impossible to make out in the type mounts of some of the black or densely pigmented species. Four undescribed species found amongst Maskell's unmounted material are described here.

The adult stage is known for only seven of the species.

FAMILY ALEYRODIDAE WESTWOOD.

Keys to the Subfamilies of the Aleyrodidae.

Pupal Cases (Australian species only).

With compound or agglomerate pores .... Udamoscelinae Enderlein.
Without compound or agglomerate pores .... Aleyrodinae Enderlein.

Adults.

Paronychium spine-like; fore-wing may have, in addition to vein R_s, veins C, S_c, R_1, Cu, M and A .... Udamoscelinae.
Paronychium blade-like; fore-wing may have, in addition to vein R_s, veins R_1 and Cu .... Aleyrodinae.

Subfamily Udamoscelinae.

Key to Genera of Udamoscelinae (Pupal Cases).

8 pairs of compound pores .... *Synaleurodicus* Solomon.
5-7 pairs of compound pores .... *Aleurodicus* Douglas.

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* Work carried out, in part, while on the staff of the Entomological Research Station, Department of Scientific and Industrial Research, New Zealand.

Key to adults of Australian species of subfamily Udamoscelinae.

Anal vein present in fore wing (*Synaleurodicus*).

Antennae 7-segmented; genital segment in male concealed by sub-triangular lateral flaps; claspers sigmoid; operculum subrectangular; lingula parallel-sided, acutely pointed .... *Synaleurodicus hakeae* Solomon.

Anal vein absent in fore wing (*Aleurodicus*).

Antennae 8-segmented; no lateral flaps concealing genital segment in male; claspers long, slender, curved; operculum semicircular; lingula subconical, apex not acutely pointed .... *Aleurodicus destructor* Mackie.

Genus ALEURODICUS Douglas.

ALEURODICUS DESTRUCTOR Mackie (Text-figs. 1–3).

Aleurodicus destructor Mackie, 1912, *Phillip. agr. Rev.*, 5:142.—Quaintance and Baker, 1913, *Bull. U.S. Bur. Ent.*, 27 (tech. ser.), Pt. 1:56–7, Pl. 13, Figs. 1–7.

Aleurodes albofloccosa Froggatt, 1918, *Agric. Gaz. N.S.W.*, 29:434–6, Figs. 1–4.

Pupal Case (Text-fig. 1).—"Length 1·33–1·5 mm., width 0·83–1·0 mm. Shape subelliptical to ovate, some examples narrowed cephalad. Colour yellowish to brownish, empty case colourless. There is a narrow marginal rim composed of the short squarish wax tubes, the incisions being shallow and acute. On the dorsum there are 7 pairs of very conspicuous compound wax pores, six pairs on the abdomen about equally developed and a pair on the cephalic region of about half the size of the former. From the marginal area all around arise a series of spines, 10–12 on a side, and there is a pair cephalad of the vasiform orifice. Vasiform orifice (Fig. 2) subcordate, about as wide as long. Operculum subrectangular, about twice as wide as long. Lingula spatulate, rather short and broad, bearing a pair of spines." (Quaintance & Baker, 1913.)

Female.—Antenna 8-segmented; third segment slightly longer than 4 plus 5, not as long as 4 plus 5 plus 6; 4, 5 and 6 subequal, longer than 7 and 8 which are subequal. Wing immaculate, veins Sc, R_1, Rs and M present.

Male (Text-fig. 3).—Terminal segment longer than wide. Claspers long slender tapering curved, nearly twice as long as terminal segment, and with a small blunt triangular tooth distad of membranous bulge on inner face. Penis long slender tapering curved, more than half as long as claspers. Vasiform orifice subcircular. Operculum subcircular nearly filling orifice. Lingula conical with wide base and two apical setae. Antepenultimate segment has a backwardly-directed process in the mid dorsal line.

Type.—In U.S. National Museum.

Localities.—Dungay, Tweed R., N.S.W., coll. H. Brooks (Froggatt); Hawkesbury R., and Paterson R., N.S.W. (Froggatt); Gippsland, Vict. (Froggatt).

Food Plants.—*Banksia* and several undetermined scrub trees (Froggatt).

Material.—Cotype material of *albofloccosa* in the collection of the Entomological Branch, N.S.W. Department of Agriculture, Sydney.

Froggatt later recognized that his species was a synonym of *Aleurodicus destructor* Mackie and some of his cotype material is so labelled. Examination of this material has confirmed the synonymy.

Genus SYNALEURODICUS Solomon.

SYNALEURODICUS HAKEAE Solomon (Text-figs. 4–8).

Synaleurodicus hakeae Solomon, 1935, *Jour. Roy. Soc. W. Aust.*, 21:79–83, Pl. 9 & 10.

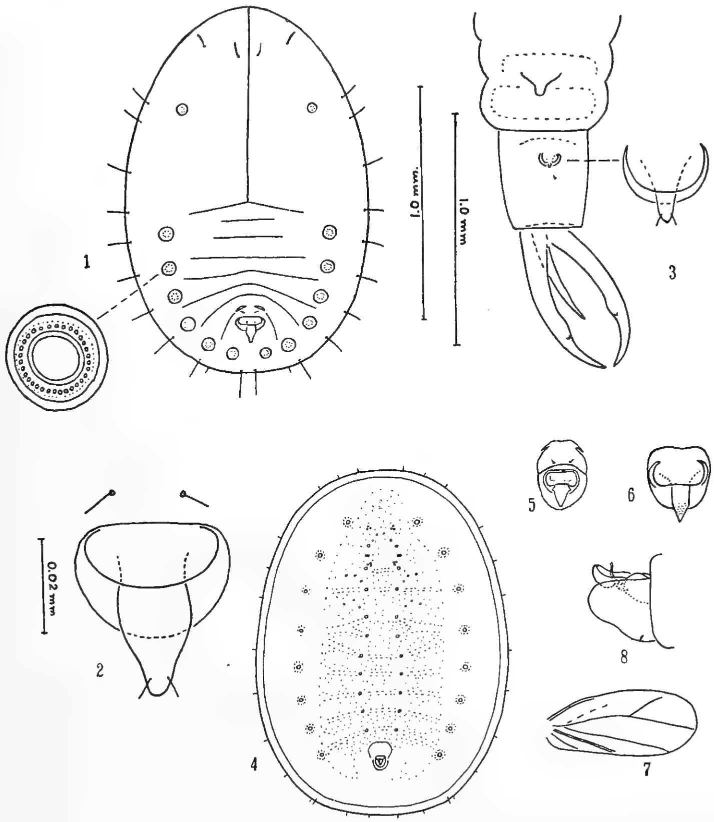
Egg.—Length 0·275 mm., pedicel 0·03–0·10 mm. Shape ellipsoid. Chorion white with rounded, flattened, fissured tubercles.

Larva.—First instar. Length 0·39 mm., width 0·22 mm. Ovoid, slightly convex. Pale yellow. Red ocelli present. There are 26 small supra-marginal setae. The posterior marginal setae are long, anterior marginal setae short. Vasiform orifice stoutly pyriform, operculum twice as wide as long.

Larva.—Second instar. Length 0·64 mm., width 0·41 mm. Similar to third instar.

Larva.—Third instar. Length 0·86 mm., width 0·52 mm. Ovoid, slightly convex. Colour pale yellow. Distinct narrow marginal area with minute supra-marginal setae at intervals. Red ocelli present. Two indistinct longitudinal rows of dorsal pores.

Pupal Case (Text-fig. 4).—"Length 1·45 mm., width 1·05 mm., dorsum minutely punctate; slightly convex; outline ovoid, wider posteriorly. Colour: very light yellow peripherally, with a large central brown area; a pale sutural band occurs behind each of the three thoracic and first seven abdominal segmental areas. Simple wax pores appear as small clear spaces in the brown central area of cephalothorax; some collected into groups; two lateral compressed groups of two or three simple pores in each sutural band of thorax and abdomen, the groups aligned in two longitudinal rows. Eight compound wax pores in a longitudinal row on each side of dorsum; each compound pore appearing as a raised dark brown circlet enclosing a clear depressed area in which appear several circular or oval pores, varying in number from 3 to 7 in the type specimen; each of these central pores is continuous with a transparent downwardly-projecting tube, the tubes being enclosed in a cylindrical sheath; on the crest of the brown rim is a circlet of small pores. Tracheal folds not evident. Narrow marginal band marked by fine radial striations, and bearing 26 small supra-marginal setae, with a posterior pair of longer infra-marginal setae; small bilobed supra-marginal processes occur between the setae. Vasiform orifice (Fig. 5) with upraised bright yellow rim of which the outer margin is obtuse anteriorly, but otherwise sub-circular; adjoining this anteriorly is an elevated area, rounded in front and bearing a posterior pair of small spines; the rim passes obliquely downward into the orifice where it has a subcordate inner margin and is raised into several intermediate ridges; operculum just over twice as wide as long, anterior and posterior borders slightly concave, lateral



1-3. *Aleurodicus destructor* Mackie. 1, Pupal case, dorsal; 2, Pupal case, vasiform orifice; 3, Male, terminal segments of abdomen, dorsal, to show median dorsal process, vasiform orifice and genitalia.

4-8. *Synaleurodicus hakeae* Solomon. (Figures after Solomon.) 4, Pupal case, dorsal; 5, Pupal case, vasiform orifice; 6, Female, vasiform orifice; 7, Male, forewing; 8, Male, genitalia, lateral.

borders convex; projecting part of lingula widens a little, then tapers with minute crenulations to posterior end, which reaches almost to the outer margin of the orifice rim; lingula and posterior part of operculum finely setose dorsally." (Solomon.)

Female (Text-fig. 6).—Length 2·33 mm. Colour yellow with brown markings on frons, clypeus, and part of epicranium; antennae, sides of thorax, pronotum, coxae, and basal sclerites of abdomen dark brown. Antennae 0·78 mm. long. Segment 3 as long as 4 plus 5, 5 is two-thirds length of 4, 6 two-thirds length of 5, 7 two-thirds length of 6. No sensoria on antenna. Forewing 2·33 mm. long. R_1, R_s, M, and A distinct. Operculum (Text-fig. 6) twice as wide as long, posterior margin slightly concave. Lingula projecting, sides sub-parallel, apex pointed.

Male.—Length 1·93 mm. Antennae 0·59 mm. long. Forewing (Text-fig. 7) 1·75 mm. long. A pair of large lateral subtriangular flaps (Text-fig. 8) on the abdomen conceal most of the terminal segment and genital apparatus. Claspers somewhat sigmoid, basal part narrower than the rest. Penis sub-sigmoid.

Type.—Not designated.

Type Locality.—Cottesloe, Perth, W.A.

Food Plant.—*Hakea prostrata.*

Subfamily ALEYRODINAE.

Key to adults of Australian species of the Subfamily Aleyrodinae.

1. Wings maculated ... (2)
   Wings not maculated ... (3)
2. Wings with dark brown maculation; operculum subrectangular concave posteriorly ... *Neomaskellia bergii* Signoret.
   Wings with reddish maculation; operculum subtrapezoidal, wider posteriorly ... *Aleurocanthus T-signatus* Maskell.
3. Lingula truncate apically ... *Trialeurodes vaporariorum* Westwood.
   Lingula rounded apically ... (4)
4. Antennal segment 3 equal to 5 plus 6 plus 7; operculum trapezoidal ... *Aleurotrachelus dryandrae* Solomon.
   Antennal segment 3 longer than 5 plus 6 plus 7; operculum transverse, concave posteriorly ... *Aleyrodes atriplex* Froggatt.

Key to Genera of Aleyrodinae (Pupal cases).
(Australian species only.)

1. Lingula very short, or knobbed and lobed ... (2)
   Lingula of normal length, subparallel-sided or constricted at base, rounded or pointed apically ... (3)
2. Sides of pupa case deflexed underneath; no papillae on dorsal disc or submargin; lingula short ... *Neomaskellia* Q. & B.
   Sides not deflexed; papillae present, lingula long; knobbed and lobed ... *Trialeurodes* Cockerell.
3. Submarginal area defined ... (4)
   Submarginal area not defined ... (8)
4. Submargin defined by presence of papillae ... (5)
   Submargin defined by line or fold, or by presence of submarginal striations ... (6)
5. Papillae rounded; thoracic folds, pores and combs absent; anal furrow present ... *Aleuroclava* Singh.
   Papillae sub-cylindrical; thoracic tracheal folds, pores and combs present; anal furrow absent ... *Orchamus* Q. & B.
6. Thoracic and abdominal tracheal pores invaginated, thoracic folds present ... *Dialeurodes* Cockerell.
   Not as above ... (7)
7. Margin with two rows of teeth; body rather pointed anteriorly; median abdominal ridge present ... *Aleurotrachelus* Q. & B.
   Not as above. One row of teeth; body elliptical; no abdominal ridge present ... *Tetraleurodes* Q. & B.
8. Vasiform orifice and lingula long and pointed; anal furrow present ... (9)
   Not as above ... (10)
9. Adult shape outlined by two longitudinal tuberculate lines ... *Asterobemisia* Trehan.
   Not as above ... *Bemisia* Quaintance & Baker.
10. Pale species, shape elliptical, submarginal setae present, but few on disc ... *Aleyrodes* Latreille.
    Dark species, often pointed anteriorly, and with numerous discal setae in addition to submarginal setae and with abdominal segments limited laterally and with rays extending towards submargin ... *Aleurocanthus* Q. & B.

Genus ALEUROCANTHUS Quaintance & Baker.

Key to pupal cases of Australian species.

1\. With somewhat flattened anterior margin; apparent margin not toothed; margin vertical, toothed, apices of teeth truncate, apparent 2nd row of teeth mesad; 4 pairs of modified pores on disc laterad, 2 on cephalothorax and 2 on anterior half of abdomen .... *banksiae* Maskell.

Rather pointed anteriorly; margin with single row of rounded teeth; with numerous long fine setae or stout spines .... (2)

2\. Thoracic tracheal folds present; body constricted across thoracic pores, abdominal tracheal pore invaginated, all pores with 5-6 smaller teeth; about 22 long thin setae on each side on submargin; eye spots absent .... *hirsutus* Maskell.

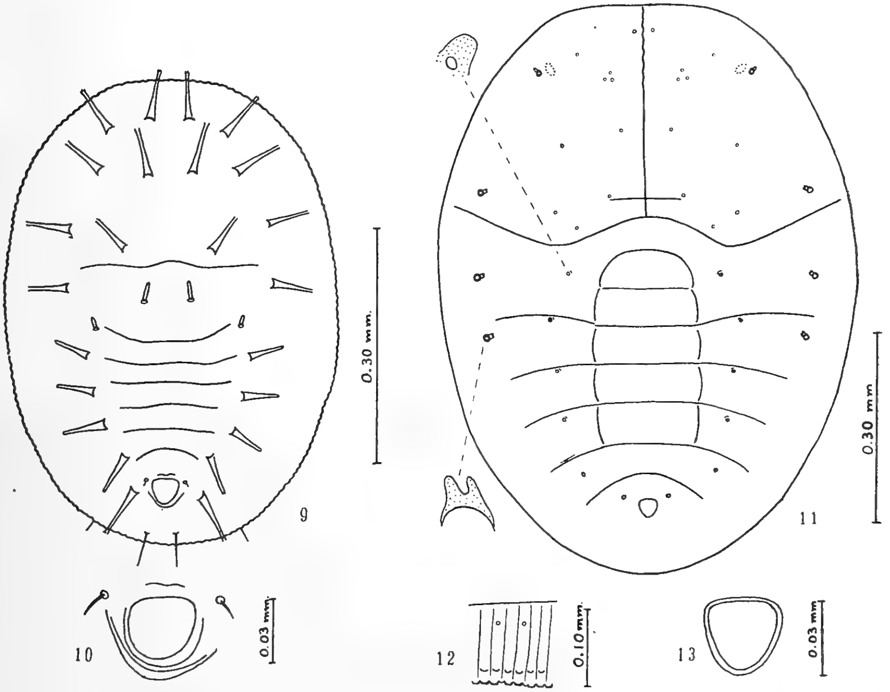
Folds and pores absent; body not constricted; 12 stout spines laterad on disc on each side; eye spots present .... *T-signatus* Maskell.

ALEUROCANTHUS BANKSIAE Maskell (Text-figs. 9-13).

Aleurodes banksiae Maskell, 1896, *Trans. Proc. N.Z. Inst.*, 28:423–4, Pl. 25, Fig. 1 *a–f*.

Aleyrodes banksiae Mask. Cockerell, 1902, *Proc. Acad. nat. Sci. Philad.*, 54:281.—Kirkaldy, 1907, Bull. 2, *Div. Ent. Hawaii*, p. 47.—Quaintance, 1908, *Genera Insect.*, fasc. 87, p. 5.

Aleurocanthus banksiae (Mask.), Quaintance & Baker, 1914, *Bull. U.S. Bur. Ent.*, 27 (tech. ser.), Pt. 2:102.—Quaintance & Baker, 1917, *Proc. U.S. nat. Mus.*, 51:339–40, and footnote p. 335, Pl. 33, figs. 1–5.



9-13. *Aleurocanthus banksiae* Maskell. 9, Larva, dorsal; 10, Larva, vasiform orifice; 11, Pupal case, dorsal; 12, Pupal case, margin; 13, Pupal case, vasiform orifice.

Larva (Text-fig. 9).—Length 0·60 mm., width 0·42 mm. Colour brown. Shape elliptical, flat. Margin crenulated, about 12 teeth in 0·1 mm. Segmentation as in figure. Four rows, each of four strong setae on thorax, setae bifid or trifid apically. Abdomen with six pairs of similar setae. Those on 1st segment are smaller and more slender and those on 2nd segment are smaller, short and stumpy. Setae on 8th segment small, caudal setae larger. Posterior marginal setae present. Vasiform orifice (Text-fig. 10) subcircular, 0·03 mm. long. Operculum filling orifice. Lingula not discernible.

Pupal Case (Text-fig. 11).—Length 0·98 mm., width 0·70 mm. Colour black. Shape elliptical, somewhat flattened anteriorly. Dorsum flat with vertical sides 0·10 mm. high. Apparent margin straight but vertical margin (Text-fig. 12) ribbed or striate, about 7 ribs in 0·1 mm. There is a row of minute pores near the top of the vertical margin, the marginal teeth are square-ended and sometimes notched and irregular. Mesad of the marginal teeth is a row of teeth or tubercles. Abdominal segments distinct, limited laterally. Sutures, pores, and segmentation as in figure. Transparent eye spots present with pore or short process just laterad of each. A similar process just cephalad of transverse moulting suture laterally and two on each side on the anterior lateral abdominal area. Mesad of these latter are five pairs of pores or processes on abdominal segments 3–7. Vasiform orifice (Text-fig. 13) sub-triangular, 0·035 mm. long and same width. Operculum filling orifice. Lingula not discernible.

Adult.—Unknown.

Lectotype.—Pupal case on slide mount in Maskell Collection. This has been bleached and remounted.

Type Locality.—Melbourne, Vict., coll. C. French.

Food Plants.—*Banksia integrifolia* and *Callistemon linearis.*

Material.—Slide mount of larva in Maskell Collection. No unmounted duplicate material.

This species was placed in *Aleurocanthus* by Quaintance and Baker with some hesitation and mainly on larval characters. The two rows or marginal teeth suggest *Aleurotrachelus* but there is no median ridge.

ALEUROCANTHUS HIRSUTUS Maskell (Text-figs. 14–20).

Aleurodes hirsuta Maskell, 1896, *Trans. Proc. N.Z. Inst.*, 28:434, Pl. 31, fig. 1.

Aleyrodes hirsuta Mask., Cockerell, 1902, *Proc. Acad. nat. Sci. Philad.*, 54:281.—Kirkaldy, 1907, Bull. 2, *Div. Ent. Hawaii*, p. 57.—Quaintance, 1908, *Genera Insect.*, fasc. 87, p. 6.

Aleurocanthus hirsutus (Mask.), Quaintance & Baker, 1914, *Bull. U.S. Bur. Ent.*, 27 (tech. ser.), Pt. 2:102.—Quaintance & Baker, 1917, *Proc. U.S. nat. Mus.*: 343–4, Pl. 34, fig. 10–15.

Larva (Text-fig. 14).—Length 0·60 mm., width 0·45 mm. Colour yellowish. Shape elliptical, slightly constricted across thoracic folds, flat. About 6 narrower modified teeth (Text-fig. 15) in thoracic tracheal pore area. Slight invagination in abdominal pore area but no modified teeth. About 7 minute setae mesad of margin on each side. One pair cephalic, one pair 1st abdominal and one pair 8th abdominal setae short. Caudal setae longer. Twenty-eight longer setae on each side as in figure, trifid at tips. Vasiform orifice (Text-fig. 16) subtriangular, 0·04 mm. long, 0·028 mm. wide. Operculum nearly filling orifice, 0·023 mm. long, 0·020 mm. wide. Lingula obscured.

Pupal Case (Text-fig. 17).—Length 1·02 mm., width 0·76 mm. Colour yellowish-brown. Shape elliptical, constricted across thoracic folds, slightly invaginated caudally, flat. Margin toothed, about 13 teeth in 0·1 mm. Thoracic tracheal folds present, pore area (Text-fig. 18) with about 6 smaller teeth. Abdominal pore area (Text-fig. 19) similar. About 22 sub-marginal and 14 discal setae on each side, long, tips trifid. About 4 pairs of minute setae on anterior sub-margin. One pair of short cephalic setae. Caudal setae and 8th abdominal setae short. Vasiform orifice (Text-fig. 20) somewhat egg-shaped, length 0·05 mm., width 0·045 mm., floor of orifice reticulate. Operculum not wholly filling orifice, length 0·03 mm., as wide as long, trapezoidal, slightly emarginate laterally. Lingula obscure, (?) broadly triangular.

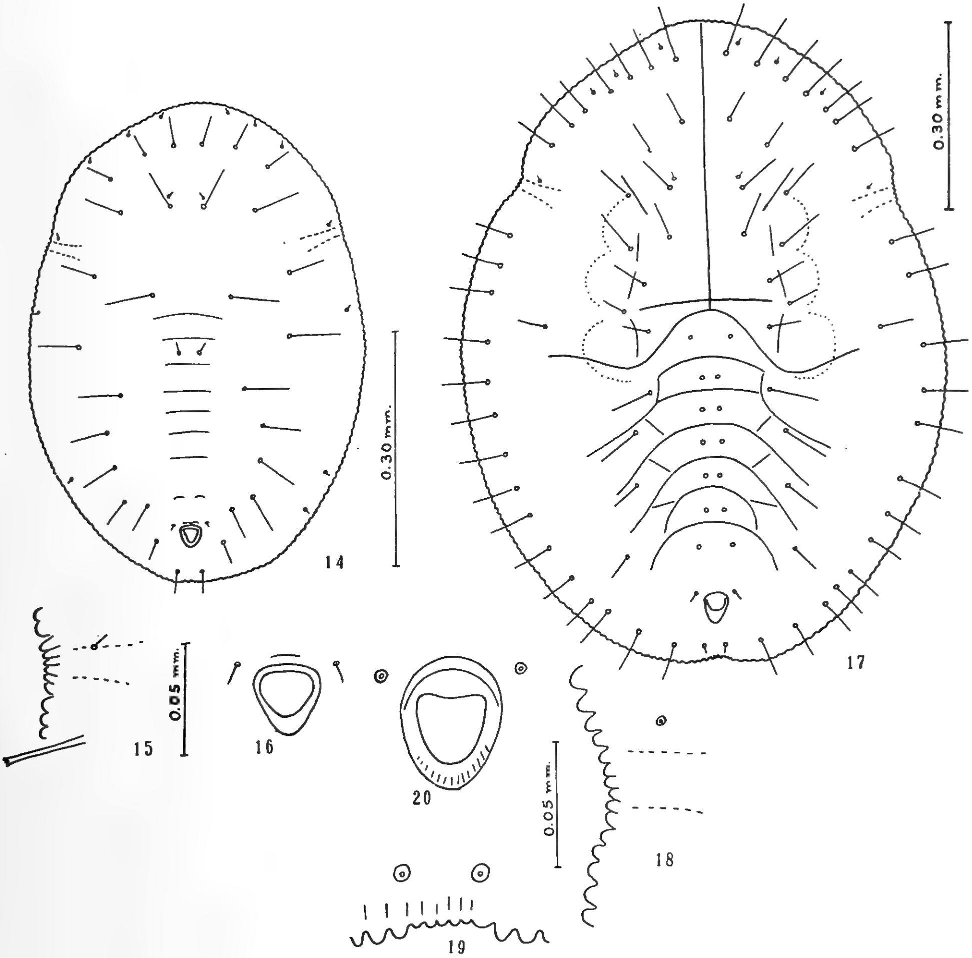
Adult.—Unknown.

Lectotype.—Pupal case on slide mount in Maskell Collection.

Type Locality.—Sydney, coll. Froggatt.

Food Plant.—*Acacia longifolia.*

The type may be a parasitized specimen. The sutures, segmentation and other details are difficult to discern. The species is figured here from Maskell duplicate material. Quaintance and Baker (1917) appear to be inaccurate in their measurements of body length and size of teeth.



14-20. *Aleurocanthus hirsutus* Maskell. 14, Larva, dorsal; 15, Larva, thoracic tracheal fold and comb; 16, Larva, vasiform orifice; 17, Pupal case, dorsal; 18, Pupal case, thoracic tracheal fold and comb; 19, Pupal case, caudal margin; 20, Pupal case, vasiform orifice.

ALEUROCANTHUS T-SIGNATUS Maskell (Text-fig. 21–25).

Aleurodes T-signata Maskell, 1896, *Trans. Proc. N.Z. Inst.*, 28:433–4, Pl. 35, fig. 2.

Aleyrodes T-signata Mask., Cockerell, 1902, *Proc. Acad. nat. Sci. Philad.*, 54:281. —Kirkaldy, 1907, Bull. 2, *Div. Ent. Hawaii*, p. 72.—Quaintance, 1908, *Genera Insect.*, fasc. 87, p. 8.

Aleurocanthus signatus (Mask.), Quaintance and Baker, 1914, *Bull. U.S. Bur. Ent.*, 27 (tech. ser.), Pt. 2:102.

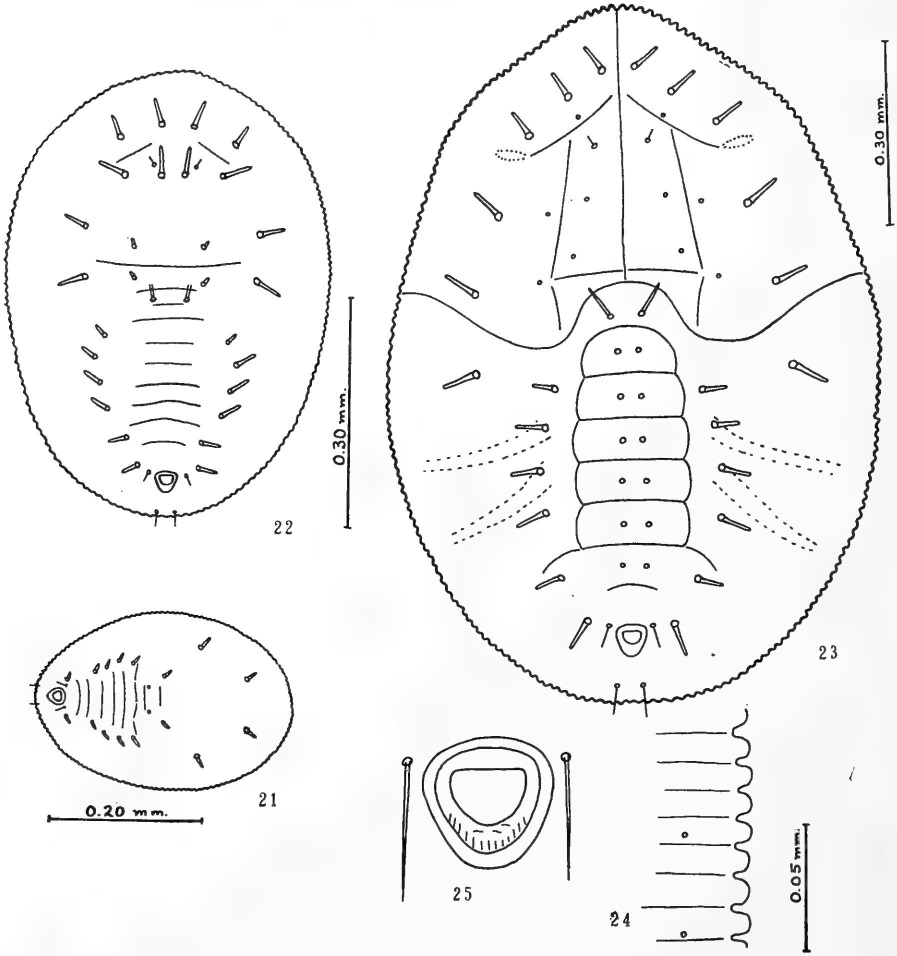
Aleurocanthus T-signatus (Mask.), Quaintance and Baker, 1917, *Proc. U.S. nat. Mus.*, 51:353–5, Pl. 39, fig. 1–9.

Egg.—(Ovarian, Q. & B., 1917), 0·23 mm. long, 0·12 mm. wide, oval, somewhat crescentic, colour light brown.

Larva (early instar) (Text-fig. 21).—Length 0·35 mm., width 0·24 mm. Colour light brown. Shape elliptical. Margin toothed, about 24 teeth in 0·1 mm. Segmentation, pores and setae as in figure. Cephalothorax with 3 pairs of short stout spines (the setae described by Quaintance and Baker (1917) are not evident), abdomen with one pair of para-median pores on 1st segment and 5 pairs of short stout spines on segments

3–6 and 8. One pair of setae on 8th segment and one pair caudal setae. Orifice subcircular. Operculum subtriangular, occupying most of orifice.

Larva (later instar) (Text-fig. 22).—Length 0·60 mm., width 0·45 mm. Shape elliptical. Colour brown. Margin toothed, about 14 teeth in 0·10 mm. Segmentation, pores and setae as in figure. Six stout spines on each side of cephalothorax, one pair short cephalic paramedian setae, two pairs of short spines posteriorly on thorax. One pair of paramedian processes on 1st abdominal segment, six pairs of stout spines laterad between segments 2 and 8. One pair of setae on 8th segment and one pair of caudal setae.



21-25. *Aleurocanthus T-signatus* Maskell. 21, Larva, early instar, dorsal; 22, Larva, late instar, dorsal; 23, Pupal case, dorsal; 24, Pupal case, margin; 25, Pupal case, vasiform orifice.

Pupal Case (Text-fig. 23).—Length 1·08 mm., width 0·77 mm. Colour dark brown to black. Shape elliptical, rather straight-sided and pointed anteriorly. Flat, with a median ridge on thorax and abdomen. Margin toothed, about 9 teeth in 0·1 mm. Margin (Text-fig. 24) radially striate with minute pores about 0·03 mm. mesad of teeth. Five pairs of stout spines on cephalothorax and one pair of paramedian cephalic setae. Eye spots present, transparent. Abdomen with one pair of paramedian spines on 1st segment, 6 pairs of para-median pores on succeeding segments and 7 pairs of spines laterad of these. One pair of 8th abdominal and one pair of caudal setae present. Tracheal folds, pores and combs absent. Abdominal segments distinct, limited laterally.

Two prominent rays or curved troughs of lighter pigmentation extending toward margin from third and fourth segments. Vasiform orifice (Text-fig. 25) sub-circular, length 0·05 mm. Operculum semicircular, width 0·03 mm., length 0·22 mm., not completely filling orifice. Floor of orifice coarsely reticulate, posterior margin ribbed.

Female (specimen in poor condition).—Forewing 1·24 mm. long, width 0·5 mm., vein R_1 absent. Forewing with four red patches, two on each side of radial vein, posterior proximal spot asymmetrical T-shape, base standing on posterior margin, long arm directed to base of wing. Hind tibia with about 20 setae in comb. Operculum transverse, concave posteriorly. Lingula not discernible.

Lectotype.—Slide mount of pupal case in Maskell Collection.

Type locality.—Botany, near Sydney, coll. Froggatt.

Material.—Four slide mounts in Maskell Collection: 1 early larva, 1 late larva, 1 pupa and 1 adult female.

Food plant.—*Acacia longifolia.*

Aleurotrachelus limbatus and *Aleurocanthus hirsutus* are recorded from the same food plant and the same general locality.

ALEUROCLAVA ELLIPTICAE, n. sp. (Text-fig. 26–28).

Aleurodes decipiens Maskell, 1896 (in part—pupa), *Trans. Proc. N.Z. Inst.*, 28:428–9, Pl. 28, fig. 1*e* and 1*f*.

Bemisia decipiens (Mask.), Quaintance & Baker, 1914, *Bull. U.S. Bur. Ent.*, 27 (tech. ser.), Pt. 2: p. 100. (In part—pupa.)

In Maskell's description of *decipiens* the description of the larva has page precedence and Maskell noted that the pupa was smaller in size and had a different vasiform orifice. The presumed larva is in fact a pupa and must stand as the type of *decipiens*. The pupa is described below as a new species.

Larva.—Unknown.

Pupal Case (Text-fig. 26).—Length 1·24 mm., width 0·8 mm. Colour yellowish. Shape elliptical, flattish. Tracheal folds, pores and combs absent. Margin (Text-fig. 27) crenulate, about 16 crenulations in 0·1 mm. About 33 sub-marginal rounded papillae on each side. Sub-marginal area with slight radial striations. Mesad of the papillae are two rows of minute pores. Disc with small sub-circular pustules. One pair of cephalic, one pair of 1st abdominal, one pair of 8th abdominal and one pair of caudal setae. Vasiform orifice (Text-fig. 28) subcordate, length 0·04 mm., width 0·04 mm., anterior margin straight. Operculum sub-triangular, 0·022 mm. long, 0·03 mm. wide, occupying most of orifice. Lingula not clearly discernible. Anal furrow present, contouring orifice laterally and extending to caudal margin, expanded at mid-length, narrowed at margin.

Adult.—Unknown.

Lectotype.—Slide mount of pupal case (labelled as pupa of *decipiens*) in Maskell Collection.

Type locality.—Botany, near Sydney, coll. Froggatt.

Food plant.—*Styphelia* (*Monotoca*) *elliptica.*

This species is apparently congeneric with another species described as new from *Eucalyptus globulus* in New Zealand, but probably of Australian origin. It is not a typical *Bemisia* or *Asterobemisia* and, while it differs from *Aleuroclava* in the presence of a sub-margin, it appears to come nearest to that genus.

Genus ALEUROTRACHELUS Quaintance & Baker.

Key to pupal cases of Australian species.

Teeth of inner marginal row truncate apically; lateral abdominal areas with traces only of ridges near 7th and 8th segments; pores on dorsum sparse and small; operculum sub-triangular .... *A. limbatus* Maskell.

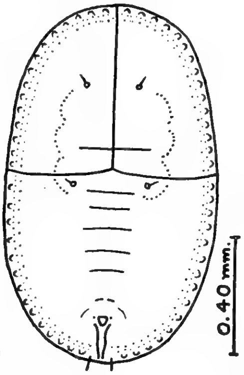
Teeth of inner marginal row with rounded apices; lateral abdominal area with 4 or 5 prominent ridges opposite segments 3 to 6; pores larger and more numerous especially on cephalic and lateral thoracic areas and between lateral, abdominal ridges; operculum sub-cordate .... *A. dryandrae* Solomon.

ALEUROTRACHELUS DRYANDRAE Solomon (Text-fig. 29–33).

Aleurotrachelus dryandrae Solomon, 1935, *Jour. Roy. Soc. W. Aust*,, 21:83–86, Pl. 11 and 12.

Egg.—Length 0·22 mm., pedicel 0·13 mm. long. Shape subreniform. Chorion dark brown, reticulated.

Larva.—First Instar. Length 0·29 mm., width 0·19 mm. Colourless when newly hatched, becoming black. Nine marginal setae on each side. One pair cephalic setae very large, the pair on first abdominal segment slightly shorter. Two pairs of small setae near vasiform orifice. Vasiform orifice occupies the posterior part of a clearly demarcated area of the integument. Orifice subcordate, operculum filling orifice.



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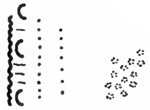

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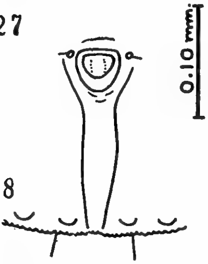

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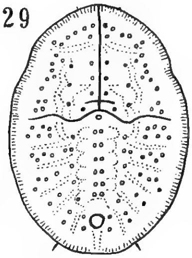

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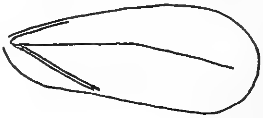

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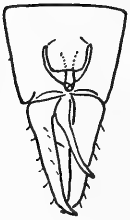

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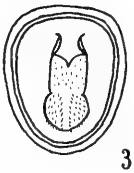

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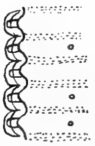

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26-28. *Aleuroclava ellipticae*, n. sp. 26, Pupal case, dorsal; 27, Pupal case, margin; 28, Pupal case, vasiform orifice, anal furrow and caudal margin.

29-33. *Aleurotrachelus dryandrae* Solomon. (Figures after Solomon.) 29, Pupal case, dorsal; 30, Pupal case, margin; 31, Pupal case, vasiform orifice; 32, Female, forewing; 33, Male, vasiform orifice and genitalia.

Larva.—Second Instar. Length 0·46 mm., width 0·33 mm. Sub-margin with 18 small erect setae.

Larva.—Third Instar. Length 0·74 mm., width 0·58 mm.

Pupal Case (Text-fig. 29).—"Length 1·24 mm., width 0·92 mm. The older larvae or pupal cases appear black, usually metallic, with a marginal fringe of wax. Dorsum pitted, with raised median part; outline subovate. A well-defined sinuous line follows a ridge of similar form between thoracic and abdominal regions; from midpoint of this a median line runs to the anterior margin, thus marking the position of the T-shaped rupture by which the imago emerges; thoracic region with prominent median ridge sagittiform anteriorly, and two prominent lateral ridges; prominent median ridge of abdominal area marked by seven transverse ridges; on surrounding flat area of dorsum is a radiating series of five prominent ridges on each side directed laterally and posteriorly. Numerous raised circular pores on dorsum, each with a central column. Thoracic and caudal tracheal folds very faintly indicated. Margin (Text-fig. 30) crenulated, with two series of teeth, the outer much paler than the inner; wax tubes well developed; a series of small spines a little within the margin, and a row of minute pores internal to these; dorsum just internal to margin bears ridges corresponding to the crenulations; an anterior and a posterior pair of marginal setae. Vasiform orifice (Text-fig. 31) subcordate, situated between two ridges on a palmate area on posterior part of the median dorsal ridge where it slopes down toward the posterior margin; operculum filling the orifice; lingula included, setose; a pair of small setae on each side of orifice, another pair anterior to it." (Solomon.)

Female.—Length 1·28 mm. Colour yellow, legs, front of head, second segment of antenna, mesosternal region, some dorsal areas on thorax, operculum and a large median area anterior to it grey. Antennae 0·35 mm. long; segment 3 with 3 sensoria apically, longer than segments 4–6 combined; 4 about two-thirds the length of 5; 5 with single apical sensorium, shorter than 6; 6 slightly longer than 7; 7 with sensorium very near tip. Forewing (Text-fig. 32) 1·22 mm. long, R strongly bent just beyond middle, R_s distinct, Cu a clear line in wing. Operculum broader than long but narrowing posteriorly, posterior margin slightly concave. Lingula narrow cylindrical, slightly enlarged distally, apex with several obtuse lobes.

Male.—Length 0·97 mm. Antenna 0·29 mm. long. Claspers 0·12 mm. long. Forewing 0·94 mm. long. Colour as in female, except for transverse brown markings on abdomen and the brown colour of the genital segment. Claspers as in Text-fig. 33. Penis enlarged basally, curved strongly upwards.

Type.—Not designated.

Type locality.—Crawley, Perth, W.A.

Type food plant.—*Dryandra floribunda.*

Other food plants.—*Hakea* spp., *Banksia* sp., *Grevillea* sp., *Dryandra* sp.

ALEUROTRACHELUS LIMBATUS Maskell (Text-fig. 34-39).

Aleurodes limbata Maskell, 1896, *Trans. Proc. N.Z. Inst.*, 28:436, Pl. 38, fig. 1.

Aleyrodes limbata Mask., Cockerell, 1902, *Proc. Acad. nat. Sci. Philad.*, 54:281. —Kirkaldy, 1907, Bull. 2, *Div. Ent. Hawaii*, p. 60.—Quaintance, 1908, *Genera Insect.*, fasc. 87, p. 6.

Aleurotrachelus limbatus (Mask.), Quaintance & Baker, 1914, *Bull. U.S. Bur. Ent.*, 27 (tech. ser.), Pt. 2:103.

Larva (Text-fig. 34).—Larval exuviae usually or often attached to pupal case. Length 0·60 mm., width 0·40 mm. Colour brown. Shape elliptical, anterior part of case usually crumpled or folded back. Margin (Text-fig. 35) with two rows of teeth, outer rounded, inner truncate apically, about 12 or 13 teeth in 0·1 mm. Tracheal folds, pores and combs absent. Minute pores mesad of inner row of teeth, one mesad of each fourth or fifth tooth. Segmentation and pores as in figure. A pair of paramedian pores with long processes on first abdominal segment. One pair of caudal setae and one pair on eighth abdominal segment. Vasiform orifice (Text-fig. 36) length 0·03 mm., width 0·035 mm., subcircular, with a fold contouring it laterally and posteriorly. Operculum subtriangular, sides concave, length 0·018 mm., width 0·022 mm. Lingula obscured, (?) finger-like.

Pupal Case (Text-fig. 37).—Length 0·95 mm., width 0·65 mm. Colour dark brown. Shape elliptical, somewhat pointed anteriorly, very slightly constricted across thoracic tracheal folds. Margin (Text-fig. 38) with two rows of teeth, outer rounded, about 10 teeth to 0·1 mm., inner truncate, dark. A minute pore mesad of each second tooth. Thoracic tracheal folds visible, two teeth in pore area sometimes slightly smaller. No abdominal tracheal fold, little or no marginal invagination, two teeth in pore area sometimes slightly smaller. Median ridge narrow in cephalic area, wide on abdomen. Segmentation, pores and setae as in figure. One pair of caudal setae and one pair on eighth segment. First abdominal segment with two nearly contiguous paramedian pores producing long processes. Vasiform orifice (Text-fig. 39) subcircular, 0·04 mm. long.

Operculum subtriangular, 0·03 mm. long, as wide as long, laterally concave. Lingula obscured.

Adult.—Unknown.

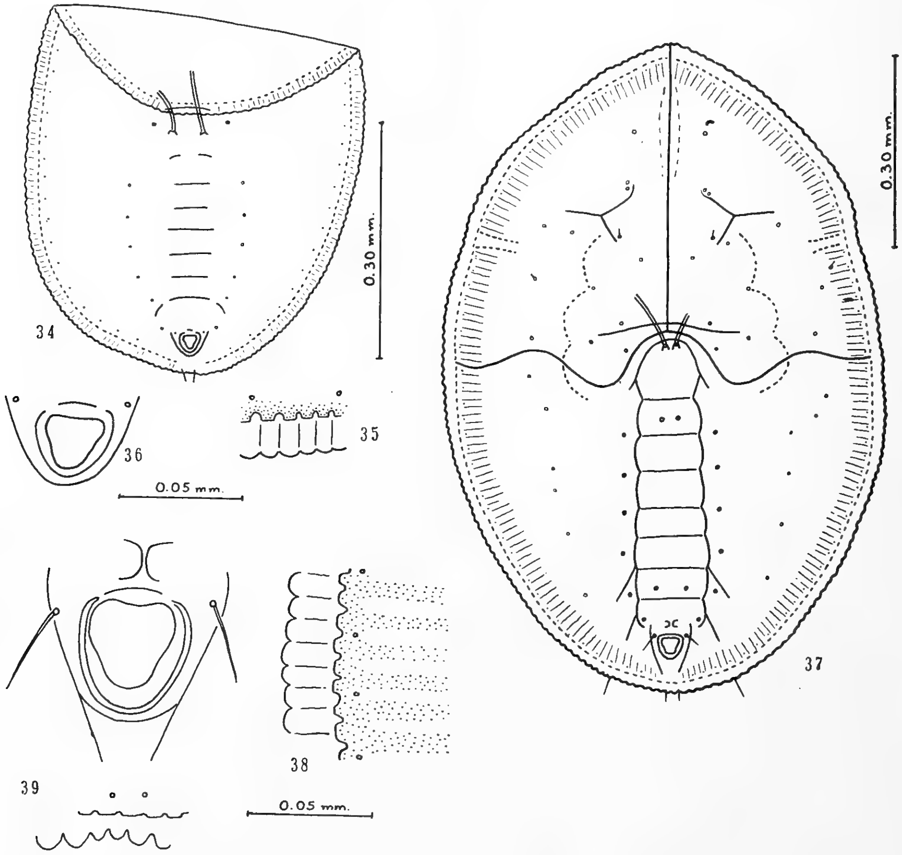
Lectotype.—Slide mount of pupal case (labelled *limbata*) in Maskell Collection.

Type locality.—Sydney, coll. Froggatt. (Also from Kurrajong Heights, coll. Musson.)

Food plants.—*Acacia longifolia* (Sydney). *Leucopogon juniperinus* (Kurrajong Heights).

Material.—Slide mount of larva and slide mount of pupal case (labelled *croceata*) and duplicate unmounted material in Maskell Collection.

This species was also present in Maskell duplicate material of *croceata* from *Styphelia* (*Monotoca*) *elliptica* from Botany, near Sydney.



34-39. *Aleurotrachelus limbatus* Maskell. 34, Larva, dorsal; 35, Larva, margin; 36, Larva, vasiform orifice and caudal margin; 37, Pupal case, dorsal; 38, Pupal case, margin; 39, Pupal case, vasiform orifice.

Genus Aleyrodes Latreille.

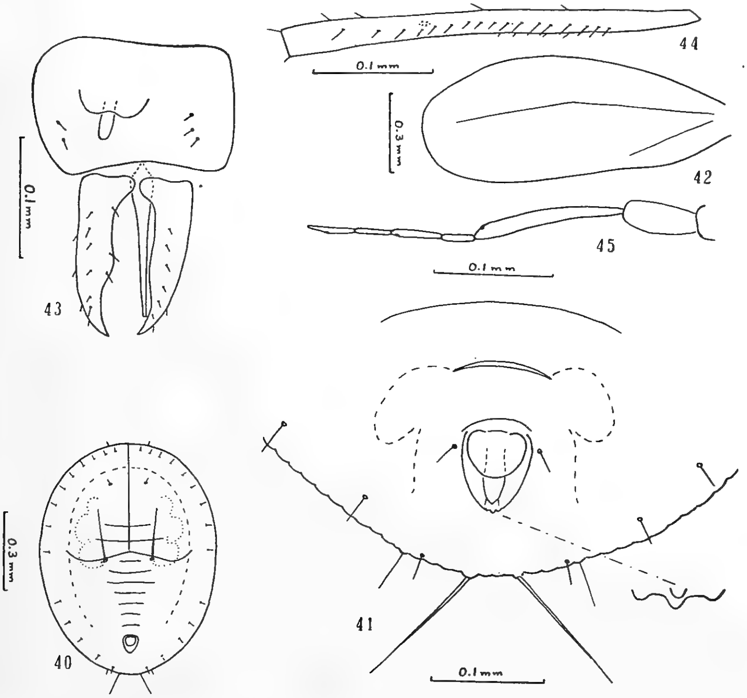
Aleyrodes atriplex Froggatt (Text-fig. 40-45).

Aleyrodes atriplex Froggatt, 1911, *Agric. Gaz. N.S.W.*, 22:757.

Froggatt's description and figure do not permit identification of this species. Froggatt's presumed cotype material was kindly made available to me by the Entomological Branch of the N.S.W. Department of Agriculture for the preparation of the following description.

Larva.—Length 0·55 mm., width 0·40 mm. Very similar to the pupal case except for the two cephalic setae which are 0·12 mm. long. The two setae on the first abdominal segment are 0·15 mm. long. The lateral margins of abdominal segments 6–8 are more distinctly lobed than in the pupal case.

Pupal Case (Text-fig. 40).—Length 0·85 mm., width 0·66 mm. Colour white, transparent. Shape elliptical, widest slightly anterior to mid-length. Thoracic and abdominal tracheal folds, pores and combs absent. No constriction of body across position of thoracic folds and no caudal invagination. Margin crenulate. Anterior marginal setae 0·01 mm. long, posterior marginal setae 0·04 mm. long. Submargin separated from disc by a rather faint line, bearing on each side 8 or 9 setae on the cephalothorax and 5 on each side of abdomen. Two short paramedian setae 0·02 mm. long. Two long paramedian setae on first abdominal segment, 0·2 mm. long. Sutures and segmentation as in figure. Vasiform orifice (Text-fig. 41) subcordate, 0·07 mm. long, 0·06 mm. wide, caudally with small blunt median tooth and two less well defined paramedian teeth. Operculum semicircular, 0·04 mm. long, 0·05 mm. wide, occupying half or slightly more than half of the orifice. Lingula 0·045 mm. long, 0·02 mm. wide, widest about mid-length, about half its length exposed caudad of operculum, bluntly pointed, with two subapical setae.



40-45. *Aleyrodes atriplex* Froggatt. 40, Pupal case, dorsal; 41, Pupal case, vasiform orifice and caudal margin; 42, Female, forewing; 43, Male, vasiform orifice and genitalia; 44, Male, hind tibia; 45, Male, antenna.

Female.—Forewing (Text-fig. 42) length 1·16 mm., width 0·44 mm., white, immaculate, veins R_s and Cu present, R_s with single flexure at mid-length.

Male.—Clasper (Text-fig. 43) 0·125 mm. long, penis 0·125 mm. long. Operculum 0·03 mm. long, 0·05 mm. wide, posterior margin with median concavity. Lingula finger-like, sides sub-parallel, apex rounded. Hind tibia (Text-fig. 44) 0·35 mm. long with 16–17 setae in comb. Antenna (Text-fig. 45) 0·35 mm. long, segment 3 slightly shorter than segments 4–7 inclusive, 4 shortest, 6 slightly longer than 4; 5 and 7 sub-equal, sensillae distal on segments 3 and 5, slightly past mid-length on segment 7.

Lectotype.—Slide mount of pupal case from cotype material, in collection of Entomology Branch, N.S.W. Department of Agriculture, Sydney.

Type locality.—Broken Hill, N.S.W.

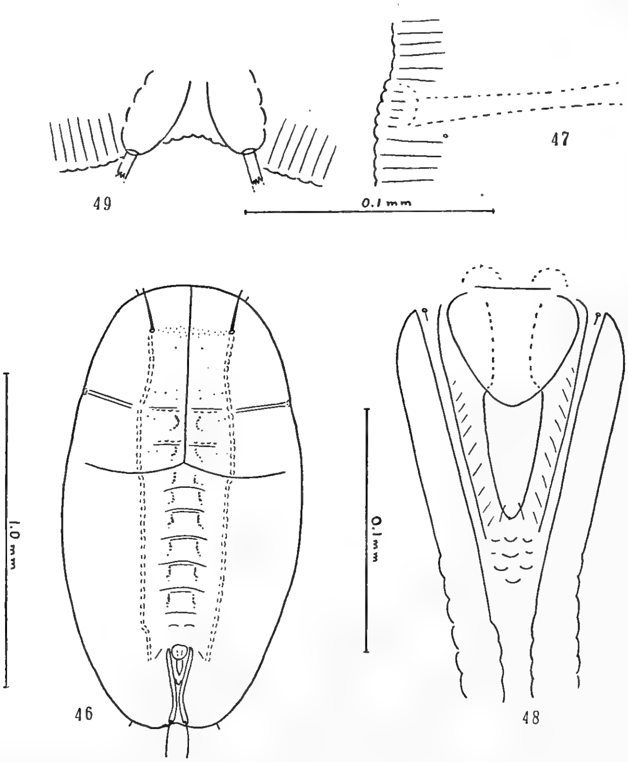
Food plant.—Saltbush (*Atriplex* sp.).

Material.—Cotype material: 1 card mount of adults, 1 card mount of leaf bearing larvae and pupal cases, from the type locality, 25/11/1911. A third card bearing adults is labelled as from Saltbush, Gosford, W.W.F., 20/3/1911.

Genus Asterobemisia Trehan.

Asterobemisia helyi, n. sp. (Text-fig. 46–49).

Pupal Case (Text-fig. 46).—Length 1·40 mm., width 0·75 mm. Shape flat, elongate ovoid, widest about mid-length, little or not at all narrowed across thoracic folds, concave caudally. Colourless. Margin faintly crenulated or toothed. About 30 minute pores on submargin on each side. Submargin radially striate, bounded internally by a faint submarginal line. Dorsal area defined by a narrow tuberculate line running from cephalic area to a point level with the apex of the operculum; narrowed and concave between cephalic setae and the pro-thoracic mesothoracic suture, narrowed slightly immediately caudad of the transverse moulting suture and again opposite the anterior margin of the eighth abdominal segment. Area between submargin and tuberculate line with minute rounded sculpturing. Mesothorax with transverse tuberculate and toothed line anteriorly and a pair of paramedian lobed figures caudad of this. Similar lobed figures on metanotum and on abdominal segments 1–6. A long stout cephalic seta, extending beyond the body margin, is present at the anterior end of the tuberculate line on each side. The transverse line between the cephalic seta bases is raised and beset with small circular tubercles. The anterior and posterior marginal setae are present. Thoracic tracheal folds (Text-fig. 47) present, ending in 4 or 5 short rounded teeth on the margin. Anal furrow present. Vasiform orifice (Text-fig. 48) 0·06 mm. wide, 0·12 mm. long, elongate triangular, caudally imbricated. Operculum subtriangular,



46–49. *Asterobemisia helyi*, n. sp. 46, Pupal case, dorsal; 47, Pupal case, thoracic tracheal fold and comb; 48, Pupal case, vasiform orifice and anal furrow; 49, Pupal case, caudal margin.

0·05 mm. wide, 0·05 mm. long. Lingula 0·09 mm. long, slender, pointed apically, slightly constricted subapically, distinctly constricted and shouldered about 0·04 mm. from base and with two subapical setae. Setae on eighth abdominal segment minute, situated between the vasiform orifice and the anterior end of the fold or ridge which contours the orifice. The ridges narrow behind the orifice but diverge again towards the caudal margin. They are somewhat tuberculate between orifice and margin. The caudal setae (Text-fig. 49) are situated on the caudal ends of the ridges. Anal furrow present, contained by the ridges.

Adult.—Unknown.

Holotype.—Slide mount of pupal case. Deposited in the collection of the Entomological Branch, N.S.W. Department of Agriculture, Sydney.

Paratypes.—In the collection of the author.

Type locality.—Botanic Gardens, Sydney, coll. P. C. Hely, 14/4/55.

Food plant.—Valencia orange.

Genus BEMISIA Quaintance & Baker.

BEMISIA DECIPIENS Maskell (Text-fig. 50–52).

Aleurodes decipiens Maskell, 1896 (in part—larva), *Trans. Proc. N.Z. Inst.*, 28:428–9, Pl. 28, fig. 1*a*–1*d*.

Aleyrodes decipiens Mask., Cockerell, 1902, *Proc. Acad. nat. Sci. Philad.*, 54:281.—Kirkaldy, 1907, Bull. 2, *Div. Ent. Hawaii*, p. 51.—Quaintance, 1908, *Genera Insect.*, fasc. 87, p. 5.

Bemisia decipiens (Mask.), Quaintance & Baker, 1914, *Bull. U.S. Bur. Ent.*, 27 (tech. ser.), Pt. 2:100.

Maskell, in describing this species, noted that what he supposed was the larva was larger than the pupa, showed faint indications of pupal structures and had a markedly different vasiform orifice. The "larva" is without doubt a pupa and must constitute the type of Maskell's species *decipiens*. The pupa is described elsewhere in this paper as a new species.

Larva.—Unknown.

Pupal Case (Text-fig. 50).—Length 1·6 mm., width 0·9 mm. Colour yellowish. Shape elongate elliptical, flat. Maskell shows 8 or 9 marginal wax processes on each side. Faint thoracic tracheal folds, no abdominal tracheal fold. Margin (Text-fig. 51) crenulate, about 13 crenulations in 0·1 mm., slight radial striation. Anterior and posterior marginal setae present. Caudal setae and eight abdominal setae present. Sutures and segmentation indistinct. Dorsal disc covered with subcircular pustules. Vasiform orifice (Text-fig. 52) elongate, pointed posteriorly, 0·13 mm. long, twice as wide as long. Floor sculptured. Operculum subsemicircular, length 0·04 mm., width 0·063 mm., occupying only one-third to one-quarter of orifice. Lingula very long, pointed, constricted at one-third length, swollen at two-thirds length, two setae apically. Caudal furrow narrow, extending from caudal margin to apex of orifice and contouring the orifice laterally.

Adult.—Unknown.

Type.—Slide mount (labelled "larva") of pupal case in Maskell Collection.

Type locality.—Botany, near Sydney, coll. Froggatt.

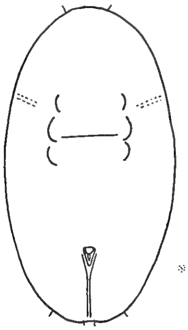
Food plant.—*Styphelia* (*Monotoca*) *elliptica.*

Genus DIALEURODES Cockerell.

DIALEURODES DRYANDRAE Takahashi (Text-fig. 53).

Dialeurodes dryandrae Takahashi, 1950, *Annot. zool. Jap.*, 23, No. 2:85–88, fig. 1.

Pupal Case (Text-fig. 53).—"Pale in colour, broad, broadest at the metathorax, narrower anteriorly, broadly rounded at the front margin, much indented at the hind end, scarcely constricted across the thoracic tracheal pores, flattened. Submarginal area defined by a wide line from the dorsal disk, exclusive of the hind part, broad; the line not reaching posteriorly beyond the level of vasiform orifice. Mid-thoracic suture reaching the submarginal area; suture between the thorax and abdomen not so; the seventh and eighth abdominal segments not well defined; pockets narrow. Dorsum with many rather large, rounded, short papillae or corrugations, which are absent on the seventh and eighth tergites. Margin thin, a little crenate, but devoid of distinct teeth. Thoracic tracheal folds distinct. Thoracic tracheal pores large, widely thickened at the margin, within and slightly separated from the margin of pupa case, not closed, with 6 or 7 minute teeth, which are rounded apically. Vasiform orifice large, much wider than long, a little narrowed posteriorly, rounded at the hind margin, with many minute pointed teeth. Operculum occupying most of vasiform orifice, subcordate. Caudal furrow very narrow, broadened just at the base, without sculptures, much longer and narrower than the vasiform orifice. Caudal ridges broad, sclerotized. Pupa case about 0·93 mm. long, about 0·75 mm. wide." (Takahashi.)



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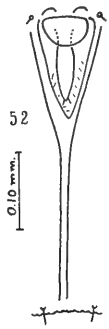

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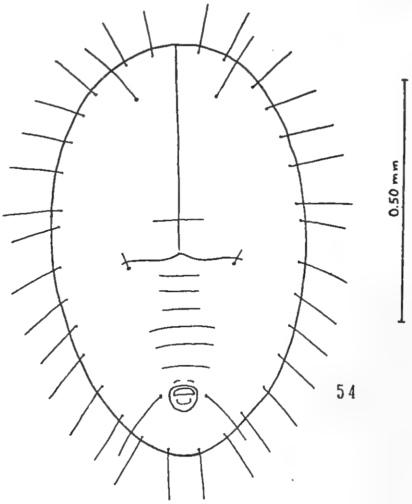

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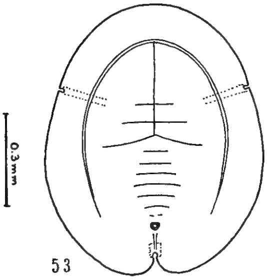

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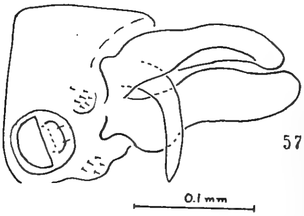

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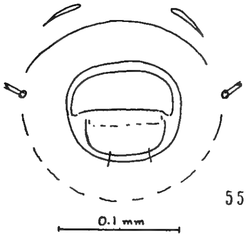

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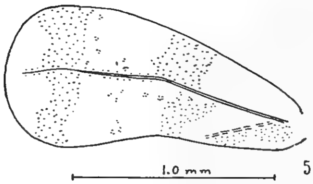

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50-52. *Bemisia decipiens* Maskell. 50, Pupal case, dorsal; 51, Pupal case, margin and discal ornamentation; 52, Pupal case, vasiform orifice and anal furrow.

53. *Dialeurodes dryandrae* Takahashi. (Figure after Takahashi.) 53, Pupal case, dorsal.

54-57. *Neomaskellia bergii* Signoret. 54, Pupal case, dorsal; 55, Pupal case, vasiform orifice; 56, Female, forewing; 57, Male, genitalia and vasiform orifice.

Adult.—Unknown.

Type.—Pupal case deposited in Selangor Museum, Kuala Lumpur, Malaya.

Type locality.—Nedlands, W.A., coll. K. R. Norris, 20/5/1940.

Food plant.—*Dryandra floribunda.*

Genus NEOMASKELLIA Quaintance and Baker.

Key to Australian species (pupal cases).

Pupal case with 15-16 pairs of spines arising from submargin; 8th abdominal setae long	*bergii* Signoret.
Pupal case with 12 pairs of spines on submargin; 8th abdominal setae short	*eucalypti*, n. sp.

NEOMASKELLIA BERGII Signoret (Text-fig. 54–57).

Aleurodes bergii Signoret, 1867, *Ann. Soc. ent. Fr.* (4), 8:426.

Aleurodes sacchari Maskell, 1890, *Trans. Proc. N.Z. Inst.*, 22:171.

Neomaskellia bergii (Mask.), Quaintance & Baker, 1917, *Proc. U.S. nat. Mus.*, 21:437–9.

Egg.—Length 0·272 mm., oval, stalk half as long as egg.

Pupal Case (Text-fig. 54).—Length 0·72–0·80 mm., width 0·432–0·552 mm. Shape elliptical, rather strongly arched. Colour dark to pale brownish. Submargin with row of about 32 prominent curved spines situated on tubercles. Margin deflexed under case, minutely and irregularly serrate. The cephalic setae and the eighth abdominal setae are very long; those on the first abdominal segment are short. Vasiform orifice (Text-fig. 55) elevated on tubercle-like structure, transverse, subcircular to elliptic. Operculum semicircular, caudal margin straight or irregularly curved. Lingula very broad with only apex showing beneath operculum.

Female.—Length 1·84 mm., colour brown. Antennae short thick, segment 2 globose; 3, 0·1 mm. long; 4, 0·03 mm.; 5, 0·055 mm.; 6, 0·033 mm.; 7, 0·033 mm. Head with vertex depressed mesad and lateral margins elevated. Forewing (Text-fig. 56) 1·36 mm. long, R_s and Cu present, with two transverse dark brown mottled areas. Vasiform orifice elliptic, transverse. Operculum semicircular, half filling orifice. Lingula very broad, exserted.

Male.—0·84 mm. long. Forewing 0·64 mm. long, R_s present, Cu absent. Claspers (Text-fig. 57) 0·144 mm. long, dark brown, not acutely pointed distally, thick.

Food plant.—Sugar cane (*Saccharum officinarum*).

A tropicopolitan species.

NEOMASKELLIA EUCALYPTI, n. sp. (Text-fig. 58–61).

Larva.—Unknown.

Pupal Case (Text-fig. 58).—Length 1·0 mm., width 0·65 mm. Colour black. Shape elliptical, convex, sides much deflexed under body especially in thoracic tracheal fold region. Margin (Text-fig. 59) toothed, about 16 teeth to 0·1 mm., teeth obsolete posteriorly but showing an apparent margin between posterior marginal setae. By reason of the deflexed sides the teeth point mesally, but 7 or 8 teeth point outward at the position of the thoracic tracheal fold. Twelve setae (Text-fig. 60) on each side, curved downward, hollow, with an aperture apically, embedded in a column of wax twice as long as the seta. Tracheal folds not evident. Eye spots present. One pair of paramedian cephalic pores, a pair of stronger pores on first abdominal segment, slightly smaller pores on segments 2–6. A pair of setae on eighth abdominal segment. Caudal setae present. Vasiform orifice (Text-fig. 61) raised, 0·065 mm. long, 0·070 mm. wide, subcircular, posterior margin toothed internally. Operculum subtrapezoidal, 0·025 mm. long, 0·04 mm. wide, concave apically. Lingula short, transverse.

Adult.—Unknown.

Holotype.—Slide mount of pupal case deposited in Maskell Collection.

Type locality.—Botanic Gardens, Sydney, coll. Froggatt, 1897.

Food plant.—*Eucalyptus* sp.

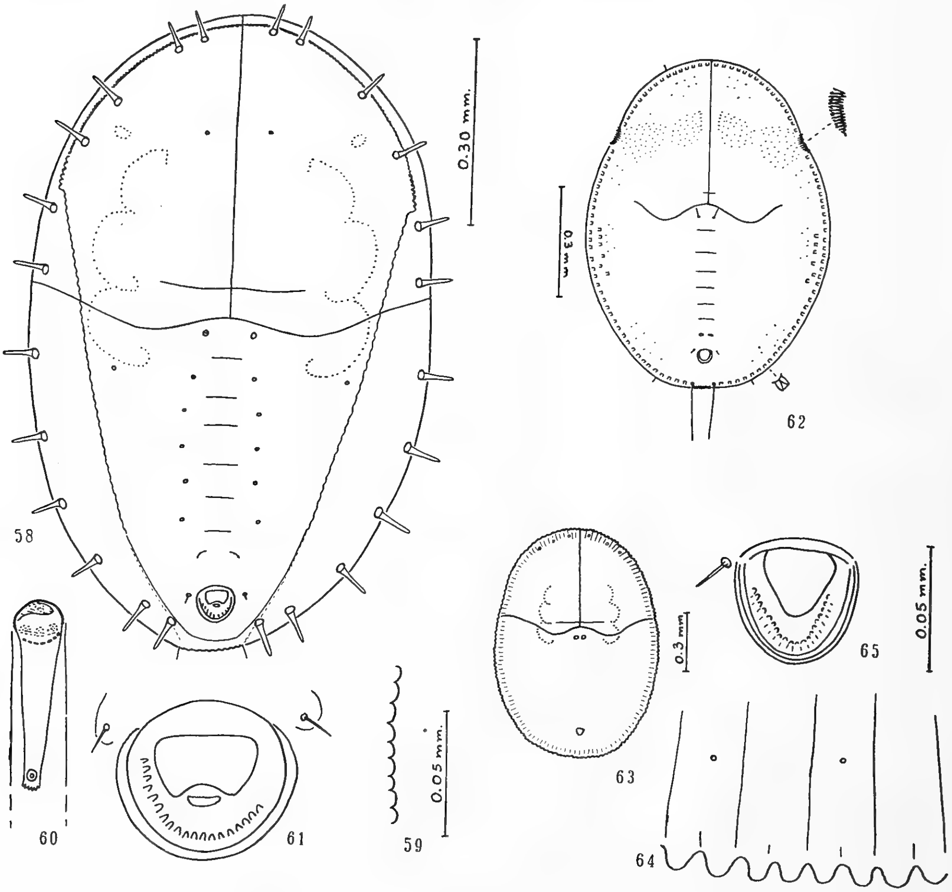
Described from unmounted material found in the Maskell Collection.

Genus ORCHAMUS Quaintance and Baker.

ORCHAMUS CITRI Takahashi (Text-fig. 62).

Aleuroplatus citri Takahashi, 1940, *Trans. nat. Hist. Soc. Formosa*, 30, 205:381–2, 1 fig.

Pupal Case (Text-fig. 62).—"Pale brownish yellow, covered with a brittle glassy secretion in dried specimens. Elliptic, about 1·4 times as long as wide, broadest at the basal part of abdomen, a little narrower anteriorly, constricted across the thoracic tracheal combs, flattened, thin; cephalothorax a little shorter than the abdomen. Midthoracic suture reaching the margin, as long as the space between the vasiform orifice and the base of abdomen; thoracic segments not defined; suture between the thorax and abdomen, rather short, abruptly extending latero-anteriorly on the lateral part, reaching beyond the hind leg; abdominal segments distinct on the median narrow area, the basal segment the longest, pointed at the anterior end; rhachis absent. Dorsum with many distinct papillae arranged in a single row along the whole margin excepting the combs; about 6 or 7 similar papillae scattered on the lateral part of the abdomen; the papillae truncate apically, constricted near the base, nearly as long as wide, broadest at the base, equal in size, much shorter than the teeth of combs, 5 of them occupying a space of about 0·092 mm.; some small indistinct pores scattered on the submarginal area, which are not translucent and not discernible in some specimens; a pair of rather short stout setae present on the middle of the basal abdominal segment, a pair of shorter setae near the vasiform orifice as usual, a pair of long setae near the hind end. Eye spots absent. Margin scarcely crenate; many short thin dorsal lines running mesad from the margin; two pairs of usual marginal setae short. Thoracic tracheal folds very wide, not well defined, with numerous dots or very short spines; about 10 much larger



58-61. *Neomaskellia eucalypti,* n. sp. 58, Pupal case, dorsal; 59, Pupal case, margin; 60, Pupal case, marginal seta; 61, Pupal case, vasiform orifice.

62. *Orchamus citri* Takahashi. (Figure after Takahashi.) 62, Pupal case, dorsal.

63-65. *Tetraleurodes croceata* Maskell. 63, Pupal case, dorsal; 64, Pupal case, margin; 65, Pupal case, vasiform orifice.

slender spines present in a group at the end of the fold; the spines directed mesally. Caudal ventral fold not defined, with some very small dots. Thoracic tracheal combs sunken, prominent, with about 12–14 long slender teeth, which are arranged regularly, obtusely-pointed apically, and the middle ones are longer than those on the sides. Caudal comb similar to the thoracic ones, with 8 or 9 similar teeth. Vasiform orifice nearly as long as wide, nearly as wide as the caudal comb, rounded, not notched, nearly as long as the space between the vasiform orifice and the caudal comb, with no teeth discernible; the anterior marginal area not defined. Operculum occupying about two-thirds of the orifice. Lingula concealed. Pupa case 0·92 mm. long, 0·66 mm. wide, 0·484 mm. wide across thoracic combs; vasiform orifice about 0·046 mm. wide; dorsal papilla 0·014 mm. long; thoracic comb 0·07 mm. wide; longest tooth of thoracic comb 0·018 mm." (Takahashi.)

Adult.—Unknown.

Cotypes.—In the collection of R. Takahashi.

Type locality.—Raymond Terrace, Sydney, N.S.W., coll. N. S. Noble, 25/5/1932 and Jan., 1940.

Food plant.—*Citrus* (Lemon).

The raising of *Orchamus*, previously a subgenus of *Aleuroplatus*, to generic rank has been proposed in another paper.

Genus TETRALEURODES Cockerell.

Key to Australian species (pupal cases).

1. Submargin distinctly separated by line or fold .... (3)
   Submargin marked by radial striations only .... (2)
2. Submarginal striated area narrow; marginal teeth as long as wide; vasiform orifice toothed posteriorly .... *croceata* Maskell.
   Submarginal striated area wide; marginal teeth much wider than long; orifice not toothed .... *niger* Maskell.
3. Marginal teeth truncate or square tipped .... *elaeocarpi* Takahashi.
   Marginal teeth rounded .... (4)
4. Abdominal segments wide, limited laterally by tuberculate ridge; tuberculate figure enclosing orifice .... *pluto*, n. sp.
   Not as above .... (5)
5. Vasiform orifice toothed posteriorly; tracheal folds present; eye spots present .. *litzeae*, n. sp.
   Not as above .... *stypheliae* Maskell.

TETRALEURODES CROCEATA Maskell (Text-fig. 63–65).

Aleurodes croceata Maskell, 1896, *Trans. Proc. N.Z. Inst.*, 28:428, Pl. 27, fig. 2.

Aleyrodes croceata (Mask.), Cockerell, 1902, *Proc. Acad. nat. Sci. Philad.*, 54:281.—Kirkaldy, 1907, Bull. 2, *Div. Ent. Hawaii*, p. 51.—Quaintance, 1908, *Genera Insect.*, fasc. 87, p. 5.

Aleurotrachelus croceatus (Mask.), Quaintance & Baker, 1914, *Bull. U.S. Bur. Ent.*, 27 (tech. ser.), Pt. 2:103.

Larva.—Length 0·18 mm., width 0·12 mm. Colour pale yellow. Shape elliptical, flat. Margin toothed, about 20 teeth to 0·1 mm. Two paramedian processes at mid-length on thorax, two rather long caudal setae. Vasiform orifice subtriangular, 0·03 mm. long, as wide as long. Operculum subtriangular, 0·025 mm. long, as wide as long.

Pupal Case (Text-fig. 63).—Length 1·15 mm., width 0·80 mm. Colour dark brown or black. Shape elliptical, convex. Thoracic and abdominal tracheal folds, pores and combs absent. Margin (Text-fig. 64) with well separated rounded teeth, 8 teeth to 0·1 mm. Submargin with radial striae at alternate interspaces giving the teeth the appearance of being paired. Minute pores on submargin mesad of teeth. Sutures distinct, abdominal segmentation indistinct. One pair of paramedian pores or processes on first abdominal segment, one pair of setae on eighth abdominal segment, one pair of caudal setae. Vasiform orifice (Text-fig. 65) subcircular, 0·045 mm. wide, posterior internal margin ribbed and toothed. Operculum subtriangular, 0·025 mm. long, as wide as long, occupying about half the orifice. Lingula obscured.

Adult.—Unknown.

Lectotype.—Pupal case on slide mount deposited in Maskell Collection. Prepared from duplicate unmounted cotype material, labelled "*croceata* ex *Styphelia elliptica*, coll. Froggatt".

Type locality.—Botany, near Sydney, coll. Froggatt.

Food plant.—*Styphelia* (*Monotoca*) *elliptica.*

Material.—Unmounted duplicate material in the Maskell Collection.

The single slide mount of a pupal case in the Maskell Collection labelled *croceata*, and therefore the presumed type, is a specimen of *Aleurotrachelus limbatus*. The species was placed in *Aleurotrachelus* by Quaintance and Baker presumably after examination of this slide, since the *croceata* of Maskell's duplicate material has only a single row of marginal teeth and would not fall in that genus. Of existing genera it most nearly fits *Tetraleurodes*. *Aleurotrachelus limbatus* was found to be present with *croceata* in the duplicate material and it is presumed that Maskell recognized the distinctness of the two species, but, not realizing that *limbatus* was present in the material, mounted a specimen of *limbatus* as the type of *croceata*. There is little in the rather general description of Maskell's species that can be used to identify it with his duplicate material.

While *croceata* has a glassy wax ring it is not now of a yellow colour, though it may have bleached with time. Most of the pupae in the duplicate material have been parasitized.

TETRALEURODES ELAEOCARPI Takahashi (Text-fig. 66).

Tetraleurodes elaeocarpi Takahashi, 1950, *Annot. Zool. Jap.*, 23, No. 2:85–88, fig. 3.

Pupal Case (Text-fig. 66.)—"Black, strongly sclerotized, elliptic, not constricted. Submarginal area not separated from the dorsal disc, rather narrow, much darker in colour than the median area, without linear sculptures. Mid-thoracic suture reaching the submarginal area; cephalothorax without median ridge; pronotum not defined from the mesonotum; suture between the meso- and metanota prominent, long, straight, but not reaching the submarginal area; suture between the thorax and abdomen extending cephalo-laterally on the lateral part, nearly reaching the margin and the hind end of mesothorax; abdominal segments distinct in the median rather narrow area; the first abdominal segment much longer than the second; the seventh as long as the sixth, the eighth longer than the seventh and the vasiform orifice; the second-seventh each with a pair of small circular markings along the anterior margin; pockets distinct. Dorsum without granules and sculptures, with a pair of setae between the eyes, at the median part of the first abdominal segment, and also near the hind end. Eyes rather small separated from the submarginal area. Marginal teeth large, stout, wider than long, widened toward the base, truncated apically, 53 in number on the cephalothorax; a small indistinct semilunar paler part present near the base of each tooth. Thoracic tracheal folds and combs, and caudal furrow wanting. Vasiform orifice small, subcordate, protruding, slightly longer than wide, rounded, not notched, without teeth, nearly as long as the space between the orifice and submarginal area; the anterior marginal area defined. Operculum occupying the orifice. Venter densely marked with many subcircular sculptures on the lateral part. Pupa case about 1·0 mm. long." (Takahashi.)

Adult.—Unknown.

Type.—Pupa case deposited in Selangor Museum, Kuala Lumpur, Malaya.

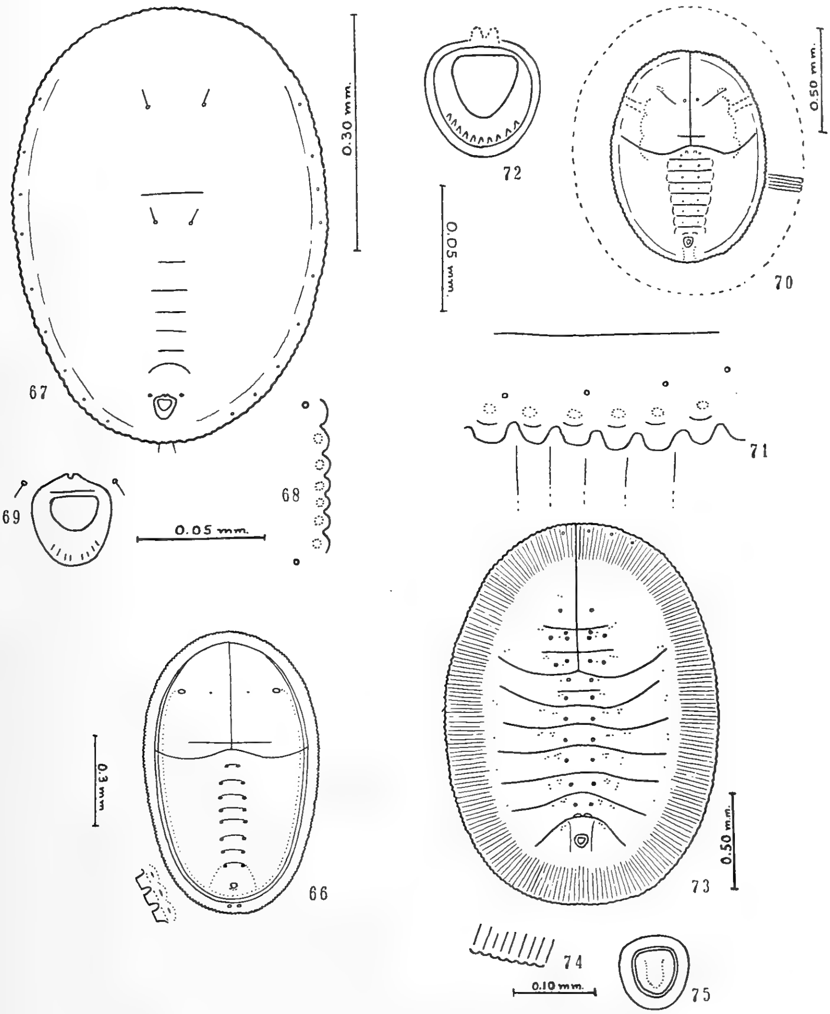
Type locality.—Sydney.

Food plant.—*Elaeocarpus reticulatus.*

TETRALEURODES LITZEAE, n. sp. (Text-fig. 67–72).

Larva (Text-fig. 67).—Length 0·55 mm., width 0·41 mm. Colour black. Shape elliptical, flat. Margin (Text-fig. 68) toothed, about 12 teeth to 0·1 mm. with a paler refractile spot behind each tooth. A submarginal line is present. About 12 small circular pores on each half of the submargin. One pair of caudal setae and one pair on the eighth abdominal segment. Two setigerous paramedian pores at mid-length on thorax and two on first abdominal segment. Segmentation faint. Vasiform orifice (Text-fig. 69) 0·035 mm. long, 0·03 mm. wide, wider anteriorly and with two paramedian lobes anteriorly, posterior internal margin toothed or ribbed. Operculum transverse, 0·015 mm. long, 0·02 mm. wide.

Pupal Case (Text-fig. 70).—Length 1·0 mm., width 0·75 mm. Colour black. Shape elliptical, flat. Wax fringe 0·2 mm. wide. Margin (Text-fig. 71) toothed, teeth rounded, well separated, 6 or 7 teeth in 0·1 mm. Mesad of each tooth is a submarginal tooth or tubercle and a paler subcircular spot. Behind each alternate tooth is a small pore. Submarginal line 0·045 mm. from margin. Thoracic and abdominal tracheal folds present, wide. Teeth not modified in tracheal pore areas. Eye spots present. Two paramedian pores caudad of eye spots. First abdominal segment with two paramedian pores and two smaller pores, the following six segments each with two paramedian pores. Scattered minute paired pores present especially in the cephalic area. Vasiform orifice (Text-fig. 72) 0·05 mm. long, 0·045 mm. wide, with two paramedian anterior processes, posterior internal margin toothed. Operculum not filling orifice, subtriangular, 0·025 mm. long, 0·028 mm. wide.



66. *Tetraleurodes elaeocarpi* Takahashi. (Figure after Takahashi.) 66, Pupal case, dorsal.

67-72. *Tetraleurodes litzeae*, n. sp. 67, Larva, dorsal; 68, Larva, margin; 69, Larva, vasiform orifice; 70, Pupal case, dorsal; 71, Pupal case, margin; 72, Pupal case, vasiform orifice.

73-75. *Tetraleurodes niger* Maskell. 73, Pupal case, dorsal; 74, Pupal case, margin; 75, Pupal case, vasiform orifice.

Adult.—Unknown.

Holotype.—Pupal case on slide mount deposited in Maskell Collection.

Type locality.—Richmond, N.S.W.

Food plant.—*Litzea dealbata.*

Material.—Described from unmounted material in Maskell Collection.

The species has been allocated to *Tetraleurodes* although it does not fit it entirely.

TETRALEURODES NIGER Maskell (Text-fig. 73–75).

Aleurodes niger Maskell, 1896, *Trans. Proc. N.Z. Inst.*, 28:437, Pl. 33, fig. 1.

Aleyrodes nigra, Cockerell, 1902, *Proc. Acad. nat. Sci. Philad.*, 54:281.

Aleyrodes niger Mask., Kirkaldy, 1907, Bull. 2, *Div. Ent. Hawaii*, p. 62.—Quaintance, 1908, *Genera Insect.*, fasc. 87, p. 7.

Aleurolobus niger (Mask.), Quaintance & Baker, 1914, *Bull. U.S. Bur. Ent.*, 27 (tech. ser.), Pt. 2:100.

Larva.—Unknown.

Pupal Case (Text-fig. 73).—Length 1·90 mm., width 1·35 mm. Colour black. Shape elliptical, moderately convex. Margin (Text-fig. 74) weakly crenulated, about 8 crenulations in 0·1 mm. Submarginal area radially striate, striae extending inwards 0·2 mm. There are a number of small pores near the margin. The marginal striations become less regular mesally and there is no distinct line between the submargin and the disc. The abdominal sutures end at the inner margin of the submargin. Dorsal pores as in figure. In addition to the circular pores there are a number of minute sensillae on the dorsal disc as well as at the lateral margins of the abdominal segments. Thoracic and abdominal tracheal folds pores and combs absent. No specialized teeth in the pore areas. Vasiform orifice (Text-fig. 75) subcircular, internal diameter 0·05 mm. Operculum appears to fill the orifice. Lingula subparallel sided, bluntly pointed.

Adult.—Unknown.

Lectotype.—Pupal case on slide mount in Maskell Collection.

Type locality.—Melbourne, Vict., coll. French.

Food plant.—*Acacia pycnantha.*

The type specimen is very black, but the location of the pores, sutures, etc., can be seen by strong transmitted light. The species was placed in *Aleurolobus* by Quaintance and Baker (1914) who had Maskell's material available for study, but it lacks the trilobed figure surrounding the orifice which is characteristic of the genus. The species was not keyed or mentioned by Quaintance and Baker (1917) in dealing with the genus *Aleurolobus.*

TETRALEURODES PLUTO, n. sp. (Text-fig. 75–78).

Larva.—Unknown.

Pupal Case (Text-fig. 76).—Length 1·18 mm., width 0·80 mm. Colour black. Shape elliptical, convex, with a depression between the sloping submarginal area and the convex dorsum. The abdominal region bears a forwardly-directed block of wax, the posterior portion of which is separated and directed posteriorly. The thoracic and abdominal tracheal folds are visible ventrally as white areas in unmounted specimens. Thoracic folds faintly visible in mounts, with two marginal teeth in the pore area usually smaller. Margin (Text-fig. 77), toothed, about 7 teeth to 0·1 mm. Faint indications of a second row of teeth or crenulations just mesad of the marginal teeth. Submarginal area striate, with a number of simple pores near inner margin and midway a series of minute paired pores, of which one is larger than the other. The pores on the dorsum are similarly paired. Sutures, segmentation and pores as in figure. Abdominal segments well marked, wide, lateral boundaries sculptured or tuberculate. One pair of minute setae on eighth abdominal segment. Vasiform orifice (Text-fig. 78) semicircular, 0·03 mm. long, 0·04 mm. wide, enclosed by a lobed figure whose posterior and lateral margins are tuberculate. Operculum occupying most of orifice, semicircular, 0·023 mm. long, 0·03 mm. wide. Lingula not visible.

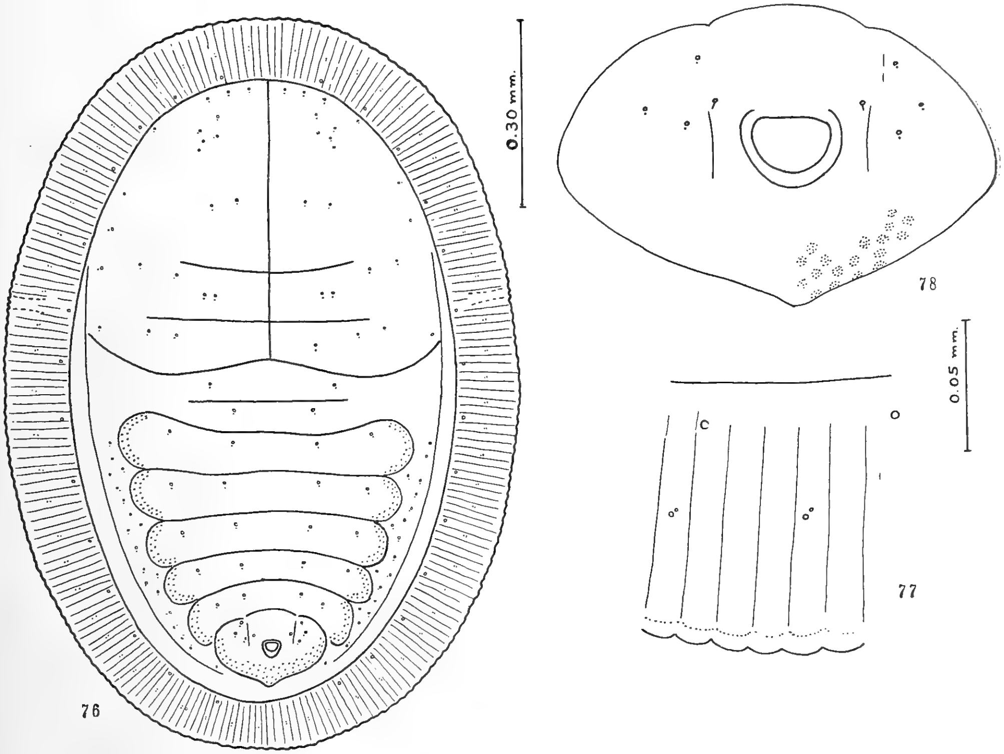
Adult.—Unknown.

Holotype.—Pupal case on slide mount deposited in Maskell Collection.

Type locality.—Western Australia.

Food plant.—"Common on a number of yellow flowering plants."

This species is described from material in the Maskell Collection, labelled "*Aleurodes* from Lea, his 206, West Australia, 1896".



76-78. *Tetraleurodes pluto,* n. sp. 76, Pupal case, dorsal; 77, Pupal case, margin; 78, Pupal case, vasiform orifice.

TETRALEURODES STYPHELIAE Maskell (Text-fig. 79–82).

Aleurodes stypheliae Maskell, 1896, *Trans. Proc. N.Z. Inst.*, 28:442, Pl. 25, fig. 1.

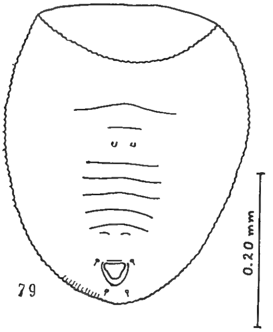
Aleyrodes stypheliae Mask., Cockerell, 1902, *Proc. Acad. nat. Sci. Philad.*, 54:281.—Kirkaldy, 1907, Bull. 2, *Div. Ent. Hawaii*, p. 71.—Quaintance, 1908, *Genera Insect.*, fasc. 87, p. 8.

Tetraleurodes stypheliae (Mask.), Quaintance & Baker, 1914, *Bull. U.S. Bur. Ent.*, 27 (tech. ser.), Pt. 2:108.

Egg.—Oval, yellow.

Larva (Text-fig. 79).—Exuviae often attached to pupal case. Length 0·46 mm., width 0·31 mm. Colour dark brown. Shape elliptical, flat. Margin crenulated, about 16 crenulations to 0·1 mm. Margin radially striated. Segmentation as in figure. A pair of long processes arise from two paramedian pores on the first abdominal segment. Four pairs of small pores on the lateral margins of abdominal segments 3–6. One pair of setae on eighth abdominal segment and one pair of caudal setae. Vasiform orifice subtriangular, 0·035 mm. long, as wide as long. Operculum subtriangular, 0·03 mm. wide, 0·027 mm. long, sides somewhat concave, nearly filling orifice. Lingula not discernible.

Pupal Case (Text-fig. 80).—Length 0·71 mm., width 0·48 mm. Colour dark brown. Shape elliptical, slightly more rounded anteriorly, flat. Margin (Text-fig. 81) crenulated, about 11 crenulations in 0·1 mm., mesad of each crenulation is a lighter spot. Submarginal area extends mesad about 0·04 mm. and has darker striae, and among them about 16 small pores on each side. Submargin separated from disc by a narrow less-pigmented area. No thoracic or abdominal tracheal folds, pores or combs. Sutures and segmentation as in figure. Two long processes arise from paramedian pores on the first abdominal segment. Abdominal segments 3–6 more strongly limited laterally. A pair of lateral pores on segments 3–7. Posterior marginal, caudal and eighth abdominal setae present. Vasiform orifice (Text-fig. 82) subsemicircular, 0·05 mm. long, as wide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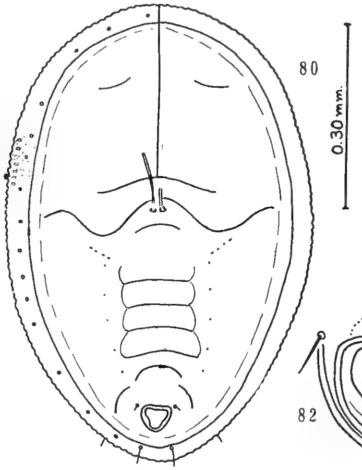
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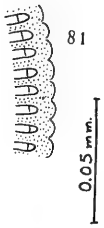
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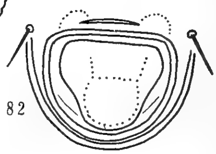
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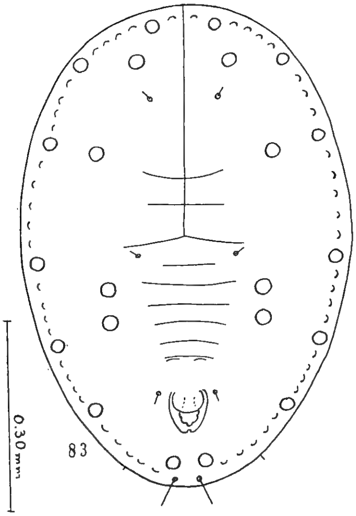
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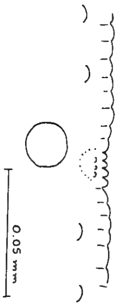
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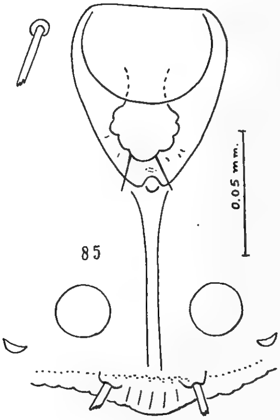
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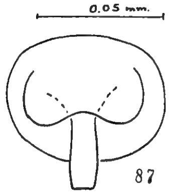
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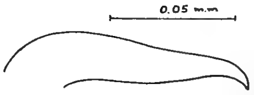
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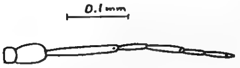
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79-82. *Tetraleurodes stypheliae* Maskell. 79, Larva, dorsal; 80, Pupal case, dorsal; 81, Pupal case, margin; 82, Pupal case, vasiform orifice.

83-88. *Trialeurodes vaporariorum* Westwood. 83, Pupal case, dorsal; 84, Pupal case, thoracic tracheal pore area; 85, Pupal case, vasiform orifice and caudal margin; 86, Female, antenna; 87, Female, vasiform orifice; 88, Male, penis lateral.

as long. Operculum nearly filling orifice, 0·03 mm. long, 0·04 mm. wide, subtrapezoidal, lateral margins concave, broadly rounded apically. Lingula obscured.

Adult.—Unknown.

Lectotype.—Pupal case on slide mount in Maskell Collection.

Type locality.—Melbourne, Vict., coll. French. (Also from Sydney, coll. Froggatt.)

Food plant.—*Styphelia* (*Monotoca*) *richei.*

Material.—Slide of larva and unmounted duplicate material in Maskell Collection.

Genus TRIALEURODES Cockerell.

TRIALEURODES VAPORARIORUM Westwood (Text-fig. 83–88).

Aleyrodes vaporariorum Westw., 1856, *Gardener's Chronicle*, p. 852.

For synonymy and full description see Russell, 1948, *Misc. Publ. U.S. Dep. Agric.*, 635:43–49.

Pupal Case (Text-fig. 83).—Length 0·75–1·10 mm., width 0·5–0·75 mm. Derm thin and colourless except for the papillae. Shape elliptical. Case raised off leaf on vertical palisade of white wax. Margin crenulated, about 12 crenulations in 0·1 mm. Thoracic tracheal pore area (Text-fig. 84) marked by narrowing and depth of 3–10 crenulations. Commonly 75–110 submarginal papillae in a single row; 1–9 pairs may be larger than the others but these may be absent. Usually four pairs of subdorsal papillae but these may be absent. When present one pair is cephalic, one pair mesothoracic, and one pair on each of the third and fourth abdominal segments. Setae: one pair cephalic, one pair first abdominal, one pair eighth abdominal often very long, and one pair caudal usually long. Vasiform orifice (Text-fig. 85) 0·056–0·076 mm. long, 0·056–0·070 mm. wide, cordate, notched at posterior tip and with prominent tooth in notch. Operculum 0·036–0·048 mm. long and 0·044–0·060 mm. wide, cordate. Lingula 0·040–0·060 mm. long, 0·024–0·032 mm. wide, with two long setae and three pairs of lateral lobes and one median unpaired lobe. Caudal furrow present, narrow.

Female.—Antennae (Text-fig. 86) with segment 3 shorter than segments 4–6 combined, 5 nearly twice as long as 6, flagellum of 7 short. Wings white, unspotted, forewing 1·0 mm. long, R_1 absent. Hind tibia with 13–16 setae in comb. Operculum (Text-fig. 87) 0·02 mm. long, 0·045 mm. wide. Lingula truncate and excavate apically, length 0·03 mm., width 0·01 mm.

Male.—Penis (Text-fig. 88) length 0·1 mm., tapering and slightly falcate at apex in lateral view.

A cosmopolitan species with numerous food plants.

THE PELAGIC NUDIBRANCH, *CEPHALOPYGE TREMATOIDES* (CHUN, 1889), IN NEW SOUTH WALES WITH A NOTE ON OTHER SPECIES IN THIS GENUS.

By JOAN E. STEINBERG, Fulbright Scholar, Department of Zoology,
University of Sydney.

(Plate xi; eight Text-figures.)

[Read 29th August, 1956.]

Synopsis.

The Phyllirhoid nudibranch, *Cephalopyge trematoides* (Chun, 1889), is recorded from Port Jackson, N.S.W. On the basis of variations observed in Australian specimens, the validity of the six species in *Cephalopyge* is discussed and it is concluded that they all should be synonymized with *C. trematoides.* The specimens from New South Wales are described.

In 1936 Dakin and Colefax published a description of a pelagic nudibranch belonging to the family Phyllirhoidae from five specimens taken off the coast of New South Wales which they referred to the genus *Ctilopsis* André, 1906. A year later, on the basis of further investigation of the literature, they reassigned their specimens to the genus *Cephalopyge* Hanel, 1905, with which *Ctilopsis* had been synonymized (Thiele, 1931) and stated, moreover, that they appeared to be a southern variety of *C. orientalis* Baba, 1933.

On the morning of October 27, 1955, many *Cephalopyge* were observed swimming near the end of a small wharf in Camp Cove just inside Inner South Head, Port Jackson, N.S.W. Also present were large numbers of small salps. Approximately one hundred *Cephalopyge* were collected on this and the following day. They appeared to be less abundant on the 28th. The animals were observed and photographed alive and motion pictures were taken of their swimming movements. Some were relaxed with menthol and others were killed without relaxation with dilute glacial acetic acid. All were preserved in alcohol. They were identified as *Cephalopyge trematoides* (Chun, 1889).

One specimen of *Cephalopyge* collected by Dakin and Colefax and two specimens of *Cephalopyge trematoides* collected off the coasts of Southern and Lower California (see Dales, 1953) have been examined by me and compared with my specimens.

In all there have been six species included in the genus *Cephalopyge.* These are based on eleven collections, totalling few more than thirty specimens, with no collection containing more than about five. To my knowledge only one has ever been seen alive (Pierantoni, 1923). Odhner, in his revision of the Dendronotacea (1936), lists five of the species: *C. trematoides* (Chun, 1889), *C. mediterranea* (Pierantoni, 1923), *C. orientalis* Baba, 1933, *C. picteti* (André, 1906) and *C. michaelsarsi* (Bonnevie, 1921). The sixth, *C. arabica* Stubbings, was described in 1937. The genus had been divided into two subgenera by Thiele (1931) on the basis of the development of the foot, but Dakin and Colefax (1937) questioned the validity of this division and the variation in my specimens shows that this character is, as they suggested, dependent on the amount of contraction or expansion at the time of preservation.

The use of the number of hermaphrodite glands in separating species was also thought by these authors and by Stubbings (1937) to be unsatisfactory. Dakin and Colefax found it necessary to make a careful examination of serial sections in order to determine the number of glands and so questioned the findings of previous authors in regard to the number they had recorded. Stubbings felt that the actual number was apparent only in young animals. He synonymized *C. trematoides* and *C. mediterranea* as the only feature really separating them was a difference in the number of these glands. In my specimens the number of glands varies considerably, thus supporting these authors' contentions.

The differences in the length and shape of internal and external organs which have been used to separate the species in *Cephalopyge* can all be shown to be merely artifacts of preservation if a large enough series of animals is available. On this basis, when I found a radula present in my specimens, I assigned them to *C. trematoides.* However, *C. picteti* had also been found to possess a radula. It has been retained in the genus *Ctilopsis* by Pruvot-Fol (1946) because the teeth in the radula are denticulate and the radular formula is 1.1.1. Under ordinary magnification, the radula in my specimens is identical with that figured by Pruvot-Fol (1929) for *C. mediterranea* (= *C. trematoides*). However, under very high magnification the teeth were seen to be denticulated in the same manner as those figured by André for *C. picteti.* Similarly, the median tooth differs in structure from the laterals, thus giving a formula of 1.1.1. The only difference is in the size of the teeth, André's being larger in smaller specimens. Dakin and Colefax have pointed out the great similarity of their material to André's. The only differences they noted were the length of the anterior and posterior hepatic caeca and the absence of a radula. I have been able to locate a radula in the single specimen of Dakin and Colefax's material available to me and it has been stated above that the differences in the length of internal organs are due to preservation. Despite discrepancy in the size of the radular teeth, I have concluded that there is no reason to maintain *C. picteti* in a separate genus or even as a distinct species and so synonymize it with *C. trematoides.*

There are no valid characters distinguishing *C. orientalis* from *C. trematoides* other than the absence of a radula. I think it is safe to assume that Baba overlooked this very small structure, as had Dakin and Colefax. Therefore, *C. orientalis* must be considered synonymous with *C. trematoides.*

C. arabica, in which Stubbings was unable to locate a radula, differs from *C. orientalis* in having: (*a*) a long tail, more rounded than that of the latter and bearing a terminal tuft of setae; (*b*) three hermaphrodite glands as opposed to four in *C. orientalis*; and (*c*) an intestine narrow at the base which differs from *C. orientalis* in which it is a broad tube narrowing toward the anus. The question of the hermaphrodite glands has already been discussed and the shape of the tail and of the intestine varies in preserved specimens. If, again, we assume that Stubbings missed the radula (which is quite possible as he apparently did not dissect any of his specimens for the mouthparts and I have never been able to identify the radula in serial sections) the caudal setae, although they have not been noted by any other author, do not seem to be of sufficient importance to separate this species from *C. orientalis* which has now been synonymized with *C. trematoides.*

C. michaelsarsi is known from a single rather mutilated specimen. It was described as lacking a dorsal anterior hepatic caecum but possessing what has been interpreted as a ventral one. One of the specimens from the North-eastern Pacific which I have examined appeared to lack a dorsal anterior hepatic caecum, but it was found to have only an extremely short one. It is quite possible that this may have been the case in Bonnevie's specimen. The ventral anterior hepatic caecum is poorly defined, as, indeed, is the ventral posterior one. No radula was found. I feel that these differences are not of sufficient strength to warrant the retention of this as a separate species. It appears to me to be nothing more than a badly preserved specimen of *C. trematoides.* However, none of my specimens showed any variation in the structure of the hepatic caeca which could be likened to the condition illustrated by Bonnevie. If subsequent investigation reveals specimens possessing a ventral anterior caecum, then the question of the validity of *C. michaelsarsi* would again be open. Until such a time, however, I prefer to place it in synonymy with *C. trematoides.*

Cephalopyge Hanel, 1905.

Cephalopyge Hanel, 1905, *Zool. Jb.*, 21:460. Type, by monotypy, *Phyllirhoe trematoides* Chun, 1889.

Ctilopsis André, 1906, *Rev. suisse Zool.*, xiv:72. Type, by monotypy, *Ctilopsis picteti* André, 1906.

Dactylopus Bonnevie, 1921 (not Gill, 1859; not Claus, 1862), *Zool. Anz.*, 53:146. Type, by original designation and monotypy, *Dactylopus michaelsarsii* Bonnevie, 1921.

Nectophyllirhoe Hoffman, 1922, *Zool. Anz.*, 54:304. Type, by monotypy, *Dactylopus michaelsarsii* Bonnevie, 1921.

Boopsis Pierantoni, 1923, *Pubbl. Staz. zool. Napoli*, v:84. Type, by original designation, *Boopsis mediterranea* Pierantoni, 1923.

Bonneviia Pruvot-Fol, 1929, *Bull. Soc. zool. Fr.*, liv:570. Type, by monotypy, *Dactylopus michaelsarsii* Bonnevie, 1921.

Cephalopyge trematoides (Chun, 1889).

Phyllirhoë trematoides Chun, 1889, *S.B. preuss. Akad. Wiss.*, 1889:547. (Type locality: Canary Islands.)

Cephalopyge trematoides Hanel, 1905, *Zool. Jb.*, 21:460; Thiele, 1931, *Handb. Syst. Weichtierkunde*, 2:446; Odhner, 1932, *Ark. zool.*, 23:46; Baba, 1933, *Annot. zool. jap.*, xiv:159; Odhner, 1936, *Mem. Mus. Roy. Hist. nat. Belg.*, 3:1125; Stubbings, 1937, *Sci. Rep. Murray Exped.*, 5:12; Pruvot-Fol, 1946, *Bull. Mus. Hist. nat. Paris*, (2) 18:175; Dales, 1953, *Ann. Mag. nat. Hist.*, (12) 6:193.

Ctilopsis picteti André, 1906, *Rev. suisse Zool.*, xiv:72; Vessichelli, 1906, *Mitt. zool. Sta. Neapel*, xviii:131; Pierantoni, 1923, *Pubbl. Staz. zool. Napoli*, v:93; Odhner, 1932, *Ark. Zool.*, 23:47; Bertolini, 1935, *Pubbl. Staz. zool. Napoli*, xv:69; Dakin and Colefax, 1936, *Proc. zool. Soc. Lond.*, 1936:457; Stubbings, 1937, *Sci. Rep. Murray Exped.*, 5:9; Pruvot-Fol, 1946, *Bull. Mus. Hist. nat. Paris*, (2) 18:175.

Ctilopsis trematoides, Vessichelli, 1906, *Mitt. zool. Sta. Neapel*, xviii:131.

Dactylopus michaelsarsii Bonnevie, 1921, *Zool. Anz.*, 53:152.

Nectophyllirhoe michaelsarsi, Hoffman, 1922, *Zool. Anz.*, 54:304; Thiele, 1931, *Handb. Syst. Weichtierkunde*, 2:447; Pruvot-Fol, 1946, *Bull. Mus. Hist. nat. Paris*, (2) 18:175.

Boopsis mediterranea Pierantoni, 1923, *Pubbl. Staz. zool. Napoli*, v:84; Pruvot-Fol, 1929, *Bull. Soc. zool. Fr.*, liv:467; Bertolini, 1935, *Pubbl. Staz. zool. Napoli*, xv:67.

Boopsis trematoides, Pierantoni, 1923, *Pubbl. Staz. zool. Napoli*, v:94; Bertolini, 1935, *Pubbl. Staz. zool. Napoli*, xv:68.

Bonneviia michaelsarsi, Pruvot-Fol, 1929, *Bull. Soc. zool. Fr.*, liv:570.

Cephalopyge picteti, Thiele, 1931, *Handb. Syst. Weichtierkunde*, 2:446; Baba, 1933, *Annot. zool. jap.*, xlv:159; Odhner, 1936, *Mem. Mus. Roy. Hist. nat. Belg.*, 1:1125; Dakin and Colefax, 1937, *Ann. Mag. nat. Hist.*, (10) 19:267; Stubbings, 1937, *Sci. Rep. Murray Exped.*, 5:11.

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New localities: Camp Cove, Port Jackson, N.S.W., Australia, 27th and 28th October, 1955 (33° 50′ S, 151° 17′ E); North-eastern Pacific, 11th March, 1951, 0–140 metres in net tow (28° 38·1′ N, 115° 15·9′ W); North-eastern Pacific, 22nd January, 1952, 0–132 metres in net tow (33° 24′ N, 117° 55′ W). *Other localities*: Canary Islands (Chun, 1889); Amboina (André, 1906); North Atlantic (47° 34′ N, 43° 11′ W) (Bonnevie, 1921); Gulf of Naples (Pierantoni, 1923; Bertolini, 1935); Villefranche sur Mer, France (Pruvot-Fol, 1929); South-west of Canary Islands (20° 35′ N, 23° 29′ W) (Odhner, 1932); Shimizu Bay, Japan (Baba, 1933); off coast of New South Wales (Dakin and Colefax, 1936); John Murray Expedition Sta. 96, Central part of Arabian Sea; Sta. 131d, Southern part of Arabian Sea (Stubbings, 1937); North-eastern Pacific, 28° 30′ N, 117° 58′ W (Dales, 1953).

Specimens from New South Wales have been deposited in the National Museum of Victoria, the British Museum and the United States National Museum.

External Features.

The body is elongate and laterally compressed. Viewed from the side it is seen as a very elongated ellipse. The tail is slightly truncate in life, but may become rounded during fixation. The largest animal collected measured 25 mm. in length and 3½ mm. in height and the smallest measured 10 mm. in length and 2 mm. in height.

In life the body wall was transparent and colourless. It has become less so in preservation, but the internal organs can still be distinguished easily. There are many glandular epithelial cells distributed throughout the body wall. They are especially concentrated along the dorsal and ventral margins of the body and show up as bands of opaque spots (Text-fig. 1, UG). The longitudinal bundles of muscle fibres which run nearly the entire length of the body are seen more clearly in preserved specimens. They are quite conspicuous in cross serial sections.

With the exception of the intestine which is pinkish and a reddish-brown organ in the reproductive system (the ampulla), the internal organs of the living animal are nearly colourless, differing only in opacity. The main masses of the hermaphrodite glands are the most opaque, the rest of the reproductive organs being less so. The hepatic caeca and stomach are quite translucent as are the finger-like processes of the hermaphrodite glands, the renal organs and the buccal mass.

The rhinophores (Text-fig. 1, R) are long, smooth and usually held erect or directed slightly anteriorly (Plate xi, fig. B). They may sometimes be directed laterally (Plate xi, fig. A). They are almost completely contractile into pockets below and laterad to the cephalic disc (Text-fig. 1, CD) which is situated above the mouth. There are no other external appendages. The mouth is a longitudinal slit surrounded by somewhat fleshy lips containing many unicellular glands. A longitudinal groove (Text-fig. 1, LG) runs from the base of the mouth ventrally and posteriorly to the foot. The walls of this groove contain many glandular cells, but no ciliated cells could be distinguished.

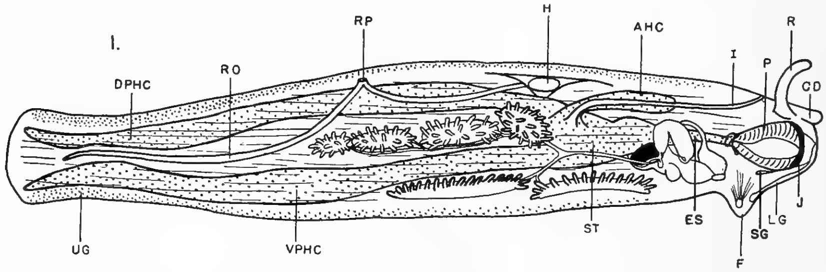
The foot (Text-fig. 1, F) is located below the posterior region of the pharynx and is capable of considerable contraction and expansion. Variations in the appearance of this structure may be seen in Plate xi. The large muscles controlling the foot can be seen running down to the small pedal gland. This gland is rounded and consists of cells staining similarly to those found in the longitudinal groove. Stubbings (1937) says that no such groove was visible in his specimens but he indicates darkly-staining cells in the region where it is found in mine.

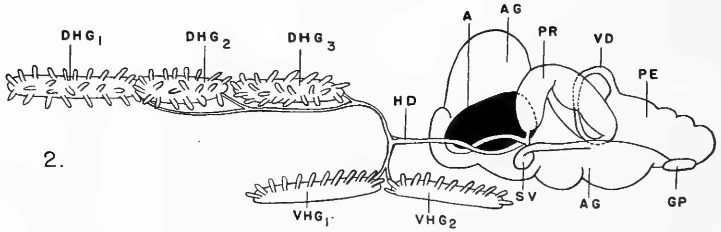
Alimentary Canal.

The pharynx (Text-fig. 1, P) is very muscular and is roughly oval in outline, the broadly rounded end being anterior and covered by the jaws (Text-fig. 1, J; Text-fig. 3). These are chitinous and well developed but lack a process masticatorius. The edges where they are joined dorsally are smooth except for a large triangular projection on the inner side. The cutting edge bears a membranous strip which is loose at its ventral end and which contains many small spicules arranged vertically in irregular rows (Text-fig. 4). The ventral edge of each jaw may be seen in cross section to bear about 7–9 small inwardly-directed teeth, which may be interlocking.

The radula is located at the tip of a very small laterally compressed papilla, the odontophore (Text-fig. 5), which lies just inside the base of the jaws. The odontophore rests on a platform of muscular tissue which lies below the jaws. In cross section there may be seen a shallow groove at the tip of the odontophore in which the radula probably lies. The teeth could not be seen in sections and it was only with great difficulty that I eventually demonstrated their presence. The radula consists of about twelve rows of three hooked teeth each (Text-fig. 6). There is no radular sac. The laterals in the third row of teeth appear to be denticulate on the inner side of the large spine only with four to eight denticles. The median tooth is denticulated on both sides of the central spine with six denticles. The radular formula is 12 × 1.1.1.

The salivary glands (Text-fig. 1, SG) lie beneath the pharynx and enter that organ just below and behind the odontophore. They appear to be flattened ellipses in cross section. The pharynx opens into a short muscular oesophagus (Text-fig. 1, ES) which leads into the stomach (Text-fig. 1, ST). This is a rather large sac-like structure into which three hepatic caeca (digestive diverticula) and the intestine open. The anterior hepatic caecum (Text-fig. 1, AHC) arises from the stomach dorsally and slightly to the left of the median line. It consists of a finger-like projection running anteriorly above the stomach and the oesophagus. It is quite variable in both length and breadth in preserved specimens (Plate xi, figs. C, D, E), and in life was seen to contract and expand to some degree. In most of my specimens it is a little more than half the length of the intestine but may be nearly as long as that organ or very short. The other two hepatic caeca (Text-fig. 1, DPHC, VPHC) arise posteriorly from the stomach and run, one dorsally and one ventrally, down the length of the body. They reach nearly to the end of the tail in living and in most preserved specimens but may be contracted to varying degrees in the latter. Peristaltic waves were seen to be almost continually passing down these diverticula in the living animals.





Text-fig. 1.—*Cephalopyge trematoides* (Chun, 1889). ×5. UG, unicellular gland; R, rhinophore; CD, cephalic disc; LG, longitudinal groove; F, foot; P, pharynx; J, jaw; SG, salivary gland; ES, oesophagus; ST, stomach; AHC, anterior hepatic caecum; DPHC, dorsal posterior hepatic caecum; VPHC, ventral posterior hepatic caecum; I, intestine; RO, renal organ; RP, renal pore; H, heart.

Text-fig. 2.—Diagram of reproductive system. ×14. VHG 1-2, ventral hermaphrodite glands; DHG 1-3, dorsal hermaphrodite glands; HD, common hermaphroditic duct; A, ampulla; SV, seminal vesicle; PR, prostate gland; VD, vas deferens; PE, penis; AG, accessory glands; GP, genital pore.

The intestine (Text-fig. 1, I) originates from the stomach to the right of the anterior hepatic caecum. It parallels the course of this organ, passes it, and eventually terminates dorsally just behind the rhinophores. None of my specimens had the anus raised on a papilla. The intestine is usually broad at its base, tapering to a narrow tube, but may be narrow at the base too.

Reproductive System.

There are two groups of hermaphrodite glands, one lying between the body wall and the ventral parts of the alimentary canal (Text-fig. 2, VHG 1–2) and the other lying between the dorsal and ventral posterior hepatic caeca (Text-fig. 2, DHG 1–3). A membrane of connective tissue lies horizontally over the lower group of glands, separating them from the rest of the body cavity. The dorsal group of glands are also separated from the rest of the perivisceral cavity by membranes of connective tissue. Each gland in the upper group consists of a solid centre mass which bears numerous finger-like projections. Sperm are formed in the central core and eggs develop in the projections. The number of glands varies considerably as, apparently, they increase in number as the animal grows older. As few as two and as many as six have been observed, but it is difficult to determine the number by observation in a whole specimen or by serial sections. If the glands are dissected out they can be separated and each will be seen to have a small duct leading out from it anteriorly. The duct of each gland passes under the gland anterior to it and then joins a common duct. The glands, if there are more than two, do not usually lie singly in a straight line but overlap somewhat, giving the impression in the whole animal of there being just one gland or, as is more often the case, the appearance of only two glands.

The ventral group usually consists of two rather elongate glands each bearing two longitudinal rows of finger-like processes. There may be a very small, nearly spherical gland lying between the two larger ones whose duct joins that of the anterior gland. Figure D in Plate xi shows a specimen with a ventral mass consisting solely of a single spherical gland displaced dorsally.

The ducts from both groups of glands unite to form a common tube (Text-fig. 2, HD) which runs forward into the large reddish ampulla (Text-fig. 2, A). It enters this organ anteriorly and ventrally. The larger ovo-sperm duct emerges from the ampulla posteriorly and ventrally. It runs anteriorly the length of the ampulla where it bifurcates into a short oviduct which enters the seminal vesicle (Text-fig. 2, SV) and an even shorter sperm duct which enters a thickened prostate region (Text-fig. 2, PR). A comparatively short vas deferens (Text-fig. 2, VD) leaves the prostate ventrally and curves up behind it. It enters the penis (Text-fig. 2, PE) which is muscular and unarmed. When everted this organ bears a fleshy wing-shaped structure proximally.

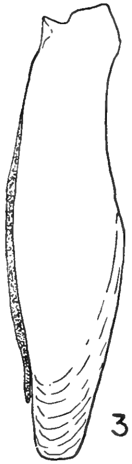
The oviduct becomes closely associated with the accessory glands (Text-fig. 2, AG) a short distance after it leaves the seminal vesicle. The accessory glands appear to be two in number and lie below the main genital mass as well as on the left side of it and the stomach. The oviduct can be traced through serial cross sections but cannot be followed in a dissection. It runs straight forward in direct contact with the lower accessory glands and toward the end of its course the inner wall of the oviduct becomes glandular. It eventually opens to the exterior through a genital pore (Text-fig. 2, GP) in common with the penis.

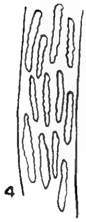
Renal Organ and Heart.

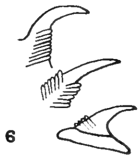
The renal organ (Text-fig. 1, RO) lies between the two posterior hepatic caeca in the posterior region of the body. Anteriorly it curves dorsally and opens to the outside by a small pore (Text-fig. 1, RP) located to the right of the median line. A branch continues forward to the region of the heart (Text-fig. 1, H). This structure is located above the stomach.

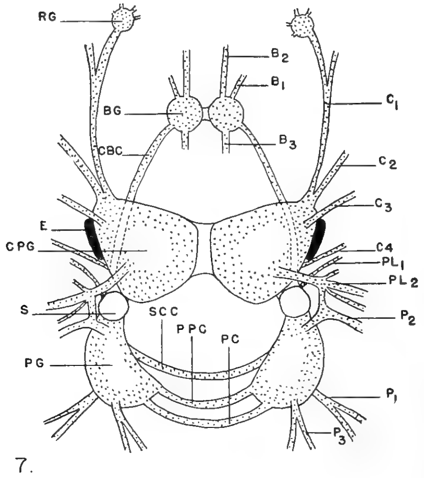
Nervous System.

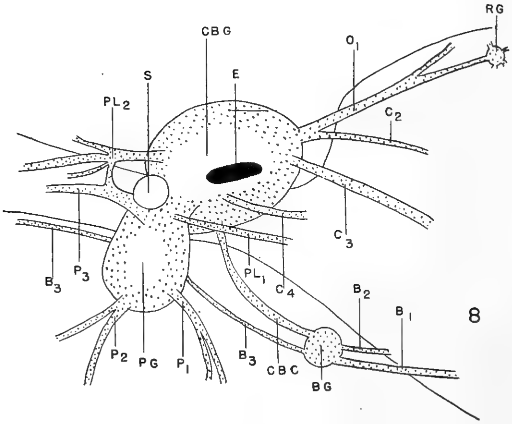
The nervous system of *Cephalopyge trematoides* is very similar to that of *Phyllirhoe bucephala* Peron and Lesueur, 1810, as described by Vessichelli (1906), but shows a number of small differences. The central ganglia are situated at the posterior end of the pharynx in a circumoesophageal ring (Text-figs. 7 and 8). This consists dorsally of a large pair of cerebro-pleural ganglia (CPG) connected by a short commissure and postero-laterally of a slightly smaller pair of pedal ganglia (PG). The cerebro-pleural ganglia are rounded and the limitations of the two regions of which they are composed are obscured. The pedal ganglia are also somewhat rounded. A small pair of buccal ganglia (BG) located below and slightly anterior to the cerebro-pleural ganglia are











Text-fig. 3.—Right jaw seen from inside. × 25.

Text-fig. 4.—Portion of membrane along inner edge of jaw. × 450.

Text-fig. 5.—Odontophore and radula. × 50.

Text-fig. 6.—Teeth of third row of radula. × 750.

Text-fig. 7.—Diagram of central nervous system seen from above. CPG, cerebro-pleural ganglion; PG, pedal ganglion; BG, buccal ganglion; CBC, cerebro-buccal commissure; E, eye; S, statocyst; PC, pedal commissure; PPC, parapedal commissure; SCC, subcerebral commissure; RG, rhinophore ganglion; C_{1-4}, cerebral nerves; PL_{1-2}, pleural nerves; P_{1-3}, pedal nerves; B_{1-3}, buccal nerves.

Text-fig. 8.—Diagram of central nervous system seen from right side (see Text-fig. 7 for explanation).

joined by a short commissure and are connected to the upper ganglia by a long slender cerebro-buccal commissure (CBC). In *Phyllirhoe bucephala* the buccal commissure is no longer distinguishable. A pair of eyes (E) are located laterally on the surface of the cerebro-pleural ganglia and a pair of statocysts (S) lie at the cerebro-pleuro-pedal connective.

The pedal commissure (PC) and the parapedal commissure (PPC) connect the two pedal ganglia under the oesophagus. While these ganglia are somewhat widely separated, the commissures are nearly straight and so cannot be seen in a lateral view. They are much longer in *P. bucephala.* The subcerebral commissure (SCC) connecting the cerebro-pleural ganglia runs below the anterior part of the pedal ganglia and anterior to the parapedal commissure. As is the case in *P. bucephala*, no nerves arise from this commissure.

The nerves originating from the circumoesophageal ganglia on the right side are as follows: a large rhinophore nerve (C1) runs forward from the antero-dorsal region of the cerebro-pleural ganglion. A small branch of this nerve leads to the body wall at the base of the rhinophore. The main branch ends in a rhinophore ganglion (RG) at the base of the rhinophore. This appendage is innervated from this ganglion as is the cephalic disc. The next nerve, C2, is thinner than C1 and appears to originate from the base of this nerve. It innervates the dorsal mouth parts. The bases of nerves C1 and C2 are further apart in *P. bucephala.* C3 leaves the cerebral region of the ganglion anterior to the eye and runs antero-ventrally to the lower mouthparts. It was not seen to anastomose with PL1 as it occasionally does in *P. bucephala.*

Nerve C4 is a slender nerve originating just below the posterior end of the eye. It runs anteriorly to the mouth. The cerebro-buccal commissure arises just below this nerve. Neither an optic nor a statocyst nerve can be observed. In *P. bucephala* the statocyst is raised on a short nerve. The first pleural nerve (PL1) comes from the cerebro-pleuro-pedal commissure and runs below and parallel to nerve C4. It innervates the body wall in the region of the posterior part of the pharynx. PL2 arises from the extreme posterior region of the cerebro-pleural ganglion just above the statocyst. It is connected to the nerve P3 by a vertical branch a short distance out from its base. PL2 also gives off a small branch ventrally just past this connection which parallels the course of the main nerve and probably innervates the anterior region of the stomach. It occasionally was seen to arise from the connection between PL2 and P3 rather than from PL2 itself. PL2 runs posteriorly through the body, sending branches to the body wall. The first branch is given off just past the connection to P3 and runs vertically up to the body wall.

Of the nerves originating from the pedal ganglion, P1 arises antero-ventrally and runs down to the foot. P2 comes off postero-ventrally and sends one branch to the foot and another back to the ventral body wall. The nerve P3 arises dorsally just below the statocyst and, as has been mentioned, is connected to nerve PL2. It sends one main branch ventrally to the anterior region of the genital organs. The main stem continues back into the body. I was unable to follow its several branches to their termination.

The buccal ganglion gives off two nerves anteriorly, the outer one (B1) innervating part of the pharynx and the inner one (B2) running to the salivary gland. The single nerve arising from the posterior part of the ganglion (B3) runs backward toward the oesophagus. There is no indication of a gastro-oesophageal ganglion.

The nerves on the left side of the circumoesophageal ring are identical with those on the right side in so far as their origin from the ganglia is concerned. There may be differences in the paths of the branches, however, especially in the case of nerves PL2 and P3.

Acknowledgements.

I am deeply indebted to Miss Isobel Bennett of the Department of Zoology, Sydney University, for her help in many ways while this work was in progress and to Dr. Doreen Maxwell for her assistance in collecting and her helpful criticism. I am also grateful to Mr. John McGowan of Scripps Institution of Oceanography for the two specimens of *Cephalopyge trematoides* from the North-eastern Pacific, the records of which are listed under new localities for the species. I should like to thank Mr. Leslie Congdon who photographed specimens C, D and E, in Plate xi.

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EXPLANATION OF PLATE XI.

A. Photograph of living *Cephalopyge trematoides* (Chun, 1889). × 7.

B. Photograph of anterior portion of a preserved specimen showing extended rhinophores and foot. × 9.

C. Photograph of anterior portion of a preserved specimen showing a short anterior hepatic caecum: 1-2. × 8.

D. Photograph of anterior portion of a preserved specimen showing an anterior hepatic caecum of medium length: 1—2; 3, displaced spherical ventral hermaphrodite gland, × 8.

E. Photograph of anterior portion of a preserved specimen showing a long anterior hepatic caecum: 1—2, × 8.

THE FAMILY DISCOZERCONIDAE (ACARINA, MESOSTIGMATA) IN AUSTRALIA.

By Robert Domrow, Queensland Institute of Medical Research, Brisbane.

(Plate xii; five Text-figures.)

[Read 29th August, 1956.]

Synopsis.

Discozercon derricki, n. sp., is described from a centipede, *Scolopendra* sp., in south Queensland, being the first record of the family Discozerconidae from Australia.

The bizarre mite family Discozerconidae Berlese, 1910 comprises two species. *Discozercon mirabilis* Berlese, 1910 was taken from the centipede *Scolopendra subspinipes* in Java, and *Discomegistus pectinatus* Trägårdh, 1911 from the millipede *Rhombocephalus giganteus* in Trinidad. A second species of *Discozercon* from an Australian scolopendrine centipede, which I am pleased to name for its collector, is described below.

DISCOZERCON DERRICKI, n. sp.

Types: Holotype male in the Queensland Museum, allotype female in the Queensland Institute of Medical Research, one paratype male in the United States National Museum, and one in the British Museum (Natural History); all collected from *Scolopendra* sp., Mount Tamborine, South-East Queensland, 24.ii.54, E. H. Derrick.

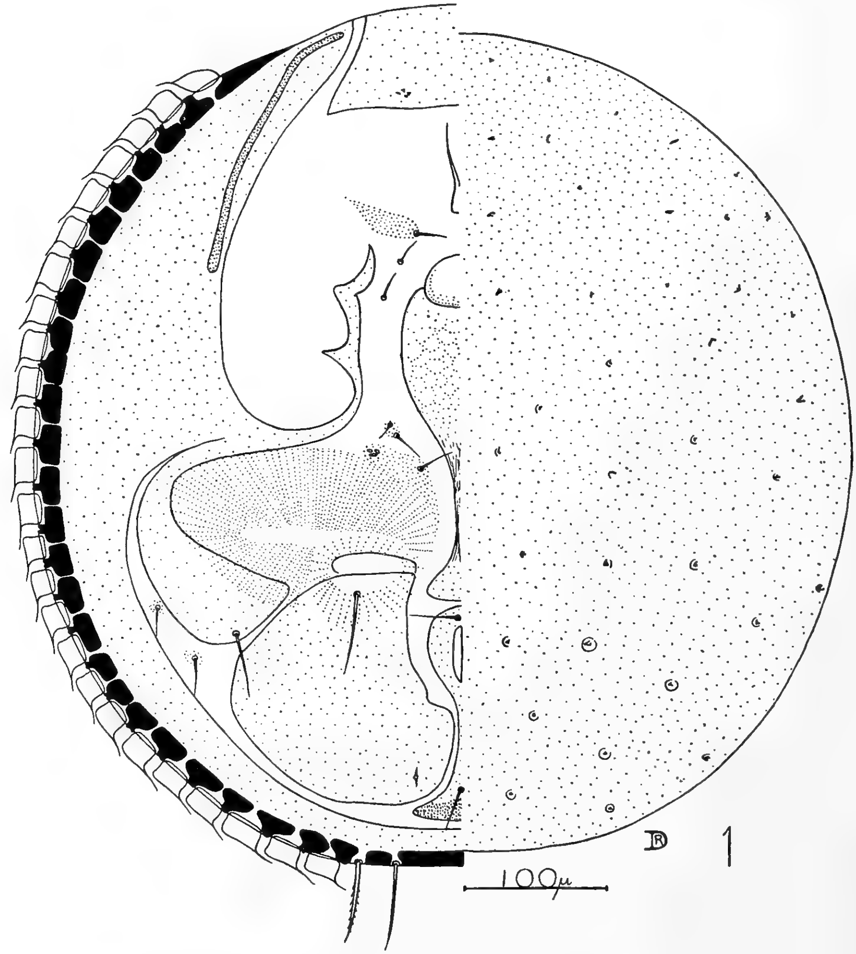
Male (Text-fig. 1 and Plate xii, above).

A brown, well-sclerotized species, with venter flat, and dorsum slightly arched; idiosoma sub-circular, length (excluding setae) 630μ, breadth 608μ. Dorsum almost entirely covered by single sub-circular shield, without setae, but with numerous conspicuous pores; surface covered by faint and finely reticulated markings. Margin with 23 to 26 pairs of greatly flattened setae, with flagellum arising from outer posterior corner. These setae are set in strongly sclerotized outer edge of ventral peripheral shield, which carries simple peritremes, and extends inwardly to form endopodal plates. Extreme posterior of body with two pairs of normal setae, of which the outer pair are finely ciliated. Infra-vertical shield trapezoidal, with posterior margin longest; with two small groups of pores posteriorly.

Tritosternum normal, with two slender and finely ciliated laciniae. Sternal setae I placed on weakly sclerotized jugular shields; sternal setae II and III free in sternal cuticle. Genital aperture covered by transversely oval operculum very similar to that of *Discomegistus*. Genito-ventral shield "figure of eight" shaped, with anterior half larger than posterior, and with reticulate markings; median strip striate. No setae are present on genito-ventral shield. Anal shield similar in shape to ventral shield, with anus longitudinally placed in anterior half of shield. Two adanal setae very close together in front of anus; postanal seta in posterior half of shield, set in front of zone of fine barbules.

With large transversely oval sucker (Plate xii, below) on either side of ventral shield, flanked laterally by crescentic shield and three setae, and posteriorly by larger shield fitting between posterior margin of crescentic shield and anal shield. These larger shields have a single seta anteriorly, and a small pore in inner posterior corner. Between the suckers and the genito-ventral shield is a slightly sclerotized area with three setae and a small group of pores, which possibly represent the metasternal-genital complex.

Gnathosoma deeply set behind infra-vertical shield, so that only terminal segments of palpi project beyond outline of idiosoma; with tendency to fold inwards over sternal area. Palpi normal, with tarsus set on inner distal corner of tibia, and only half as thick as tibia. Sensory seta on palpal tarsus as long as tarsus, and two-tined (Text-fig. 5). Ventral surface of gnathosoma spinose; hypostomal setae as follows—I of medium length, II shorter, III very long, IV minute (Text-fig. 3). Chelicerae (Text-fig. 4) with two-segmented shaft. Fixed finger small and simple. Movable finger with line of small hairs on inner margin of blade as in *Discomegistus*; with spermatophore carrier comprising two flagelliform processes. At least two very frail and non-sclerotized processes are present near the fingers, but are not illustrated to avoid obscuring the main structure. Similar processes are described by Trägårdh (1911) for *Discomegistus*.

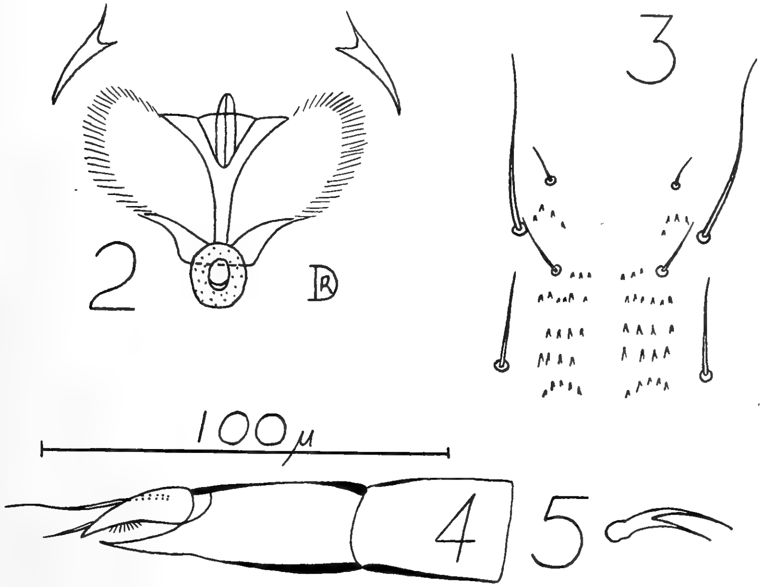


Text-fig. 1.—*Discozercon derricki*, n. sp. Male. Venter on left, dorsum on right.

Legs directed forward; I largest, with strong setation, especially on femur; II to IV smaller, with weak setation. All tarsi with well-developed ambulacra, but without distinct claws; tarsi I with slender, articulated telotarsus as in *Discomegistus*.

Female.

As in male, except that no shield covers genital aperture, which contains a strongly sclerotized structure (Text-fig. 2). Ovum single and broadly oval. The chelicerae are lacking.



Text-figs. 2 to 5.—*Discozercon derricki,* n. sp. 2, Sclerotized structure in female genitalia; 3, Hypostomal setae; 4, Male chelicera; 5, Sensory seta on palpal tarsus.

Distribution.

Known only from the type host and locality in South-East Queensland.

Remarks.

The new species has been described in detail, partly to supplement Berlese's rather meagre description of the genotype, and partly to show the close relationship between *Discozercon* and *Discomegistus*. *D. derricki*, n. sp., may be readily separated from the genotype by the following characters—the number and shape of the marginal setae, the number of terminal idiosomal setae, and the shape of the genito-ventral and anal shields.

There has been some confusion over the familial classification of certain 'related' genera of myriapodophilous mites. The two groups in question are as follows:

I. *Heterozercon* Berlese, 1888; *Atacoseius* Berlese, 1905; *Allozercon* Vitzthum, 1926.
II. *Discozercon* Berlese, 1910; *Discomegistus* Trägårdh, 1911.

Berlese (1892) erected the family Heterozerconidae for *Heterozercon*, and later (1910) also referred *Discozercon* Berlese, 1910 to this family, but chose to rename it Discozerconidae. Not having seen Berlese's original papers, Baker and Wharton (1952) regarded the above five genera as comprising a single family—for which they used Berlese's Discozerconidae—because all have ventral suckers. However, as the suckers (the only real similarity) are basically different in structure in the two groups, and appear to have arisen independently, I prefer to use the familial classification of Vitzthum (1942) and Radford (1950), namely, Heterozerconidae Berlese, 1892 for Group I, and Discozerconidae Berlese, 1910 for Group II. Trägårdh (1911) gives the most satisfactory account of the relationships of these two families.

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EXPLANATION OF PLATE XII.

Discozercon derricki, n. sp.

Above—Venter of male, × 118. Below—Ventral sucker, × 240.

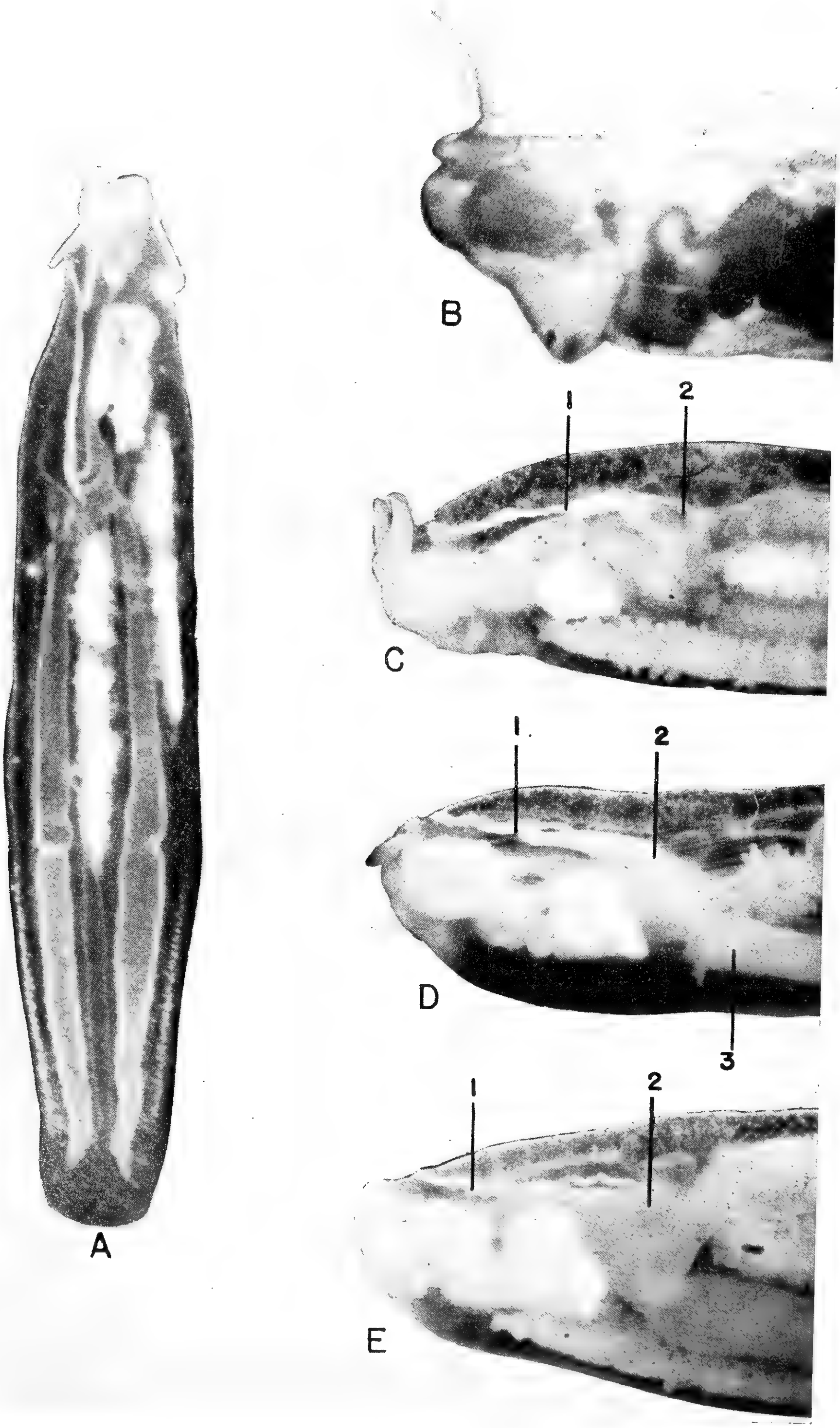
Acacia suaveolens
Eucalypt forest soil Shrub swamp soil
+Water; +P; +P+N; +Water;+P;+P+N;

Casuarina littoralis
Shrub swamp soil Eucalypt forest soil
+P+N; +P; +Water; +Water;+P;+P+N;

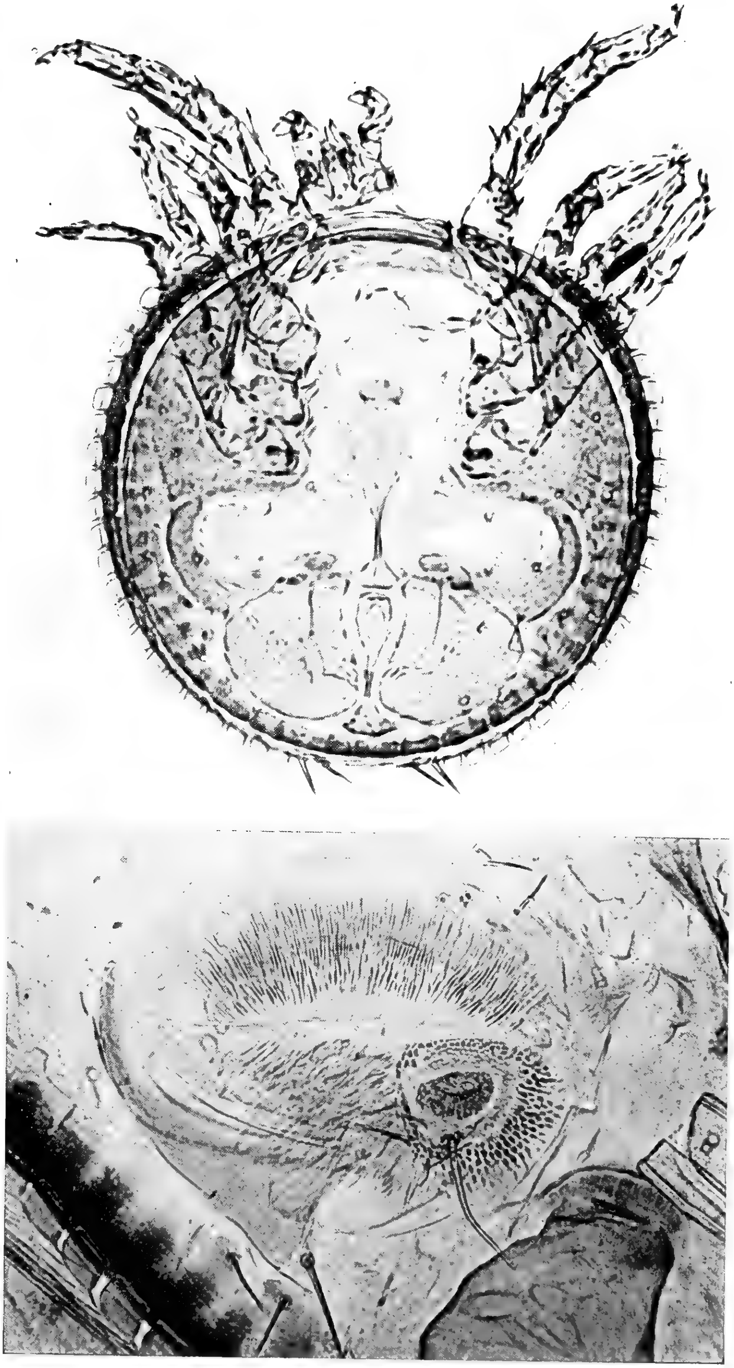
Eucalyptus gummifera
Eucalypt forest soil Shrub swamp soil
+Water; +P; +P+N; +Water;+P;+P+N;

Hakea dactyloides
Shrub swamp soil Eucalypt forest soil
+P+N; +P; +Water; +Water; +P; +P+N;

Native species growing in Hawkesbury Sandstone soil under various nutrient treatments.



Cephalopyge trematoides (Chun).



Discozercon derricki, n. sp. Above, venter of male; below, ventral sucker.

SOME ACARINA MESOSTIGMATA FROM THE GREAT BARRIER REEF.

By Robert Domrow, Queensland Institute of Medical Research, Brisbane.

(Twenty-seven Text-figures.)

[Read 26th September, 1956.]

Synopsis.

A collection of sixteen species of monogynaspid mesostigmatic mites from nine families is described from Low Isles on the Great Barrier Reef. Ten species and one neoparasitid genus are described as new; the families Liroaspidae, Rhodacaridae, Eutrachytidae and Urodinychidae, and a pseudoparasitid genus are recorded from Australia for the first time. Illustrations of all sixteen species are given.

The following are described as new: *Epicroseius porosus*, n. sp. (Liroaspidae); *Rhodacarus marksae*, n. sp. (Rhodacaridae); *Gamasiphis* (*Laelaptiella*) *mackerrasae*, n. sp. *Austrogamasellus camini*, n. g., n. sp. (Neoparasitidae); *Hypoaspis womersleyi*, n. sp., *Haemolaelaps machaeratus*, n. sp., *Cosmolaelaps multisetosus*, n. sp. (Laelaptidae); *Eutrachytes simplicior*, n. sp. (Eutrachytidae); *Trigonuropoda terrae-reginae*, n. sp., *Urodiaspis novae-hollandiae*, n. sp. (Urodinychidae).

In August, 1954, a party of scientists sponsored by the Great Barrier Reef Committee went to Low Isles (145° 34′ E., 16° 23′ S.) to investigate the condition of the reef and to collect on the island. Drs. E. N. Marks and M. J. Mackerras forwarded their collections of mites to me for preliminary sorting, and the Mesostigmata are described below, comprising sixteen species from nine families, belonging to all three cohorts of the super-cohort Monogynaspida. No Trigynaspida were taken. More than twenty species from other suborders were also taken, and will be described by other workers.

Two areas were collected—a sandy cay with plentiful low vegetation and trees, and a mangrove flat ("Green Ant Is."), parts of which are now permanently above high-water mark. A detailed description of these areas may be found in Stephenson *et al.* (1931). All specimens were taken from organic debris, e.g. under rotting pieces of wood, or in leaf mould, particularly from under the native cabbage, *Scaevola Koenigii* Vahl. (Goodenovieae). The material was placed directly into plastic bags, and the mouths firmly tied. On return to the field laboratory, the contents were extracted in a Salmon-type portable funnel for some hours, the mites and other small arthropods dropping down into a tube of spirit placed under the funnel.

The types and half the paratypes of the new species, and half the specimens of already described species, are deposited in the Queensland Museum, Brisbane. The remainder of the material has been distributed between the following: University of Queensland, Brisbane; Queensland Institute of Medical Research, Brisbane; South Australian Museum, Adelaide; British Museum (Natural History), London; United States National Museum, Washington; and the Chicago Academy of Sciences, Chicago. Detailed collection data are given with each species.

The lengths and breadths given are those of the idiosoma, including any projections, but excluding setae.

Cohors LIROASPINA.

Family LIROASPIDAE.

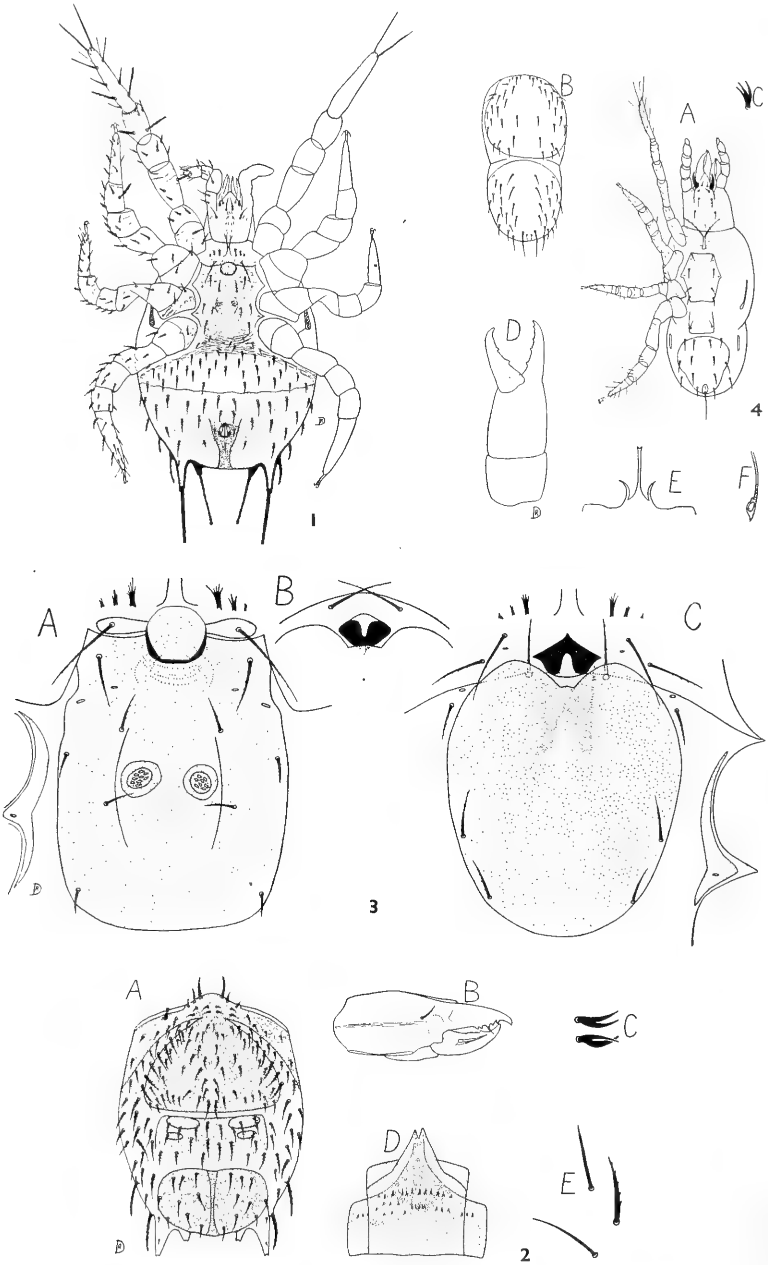
Genus Epicroseius Berlese.

Epicroseius porosus, n. sp.

Types: Holotype male and allotype female from under rotting log, Green Ant Is., 14.viii.54, E.N.M. and M.J.M. coll.

Male.

A large, brown, heavily sclerotized species, 685μ long, 482μ wide. Dorsum (Text-fig. 2, A) flat, with three shields. Anteromedian shield strongly convex anteriorly, and almost straight posteriorly, with about twenty pairs of setae; fused anteriorly to narrow peritremal shield with about twelve pairs of setae. Small bridge of sclerotized cuticle between peritremal shield and posterolateral corners of anteromedian shield, forming a cleft with numerous strong setae. Mid-dorsal shield transverse and rectangular, entirely covered by striated cuticle, except for four small transverse exposed



Text-figures 1-4.

1.—*Epicroseius porosus.* Venter of male. 2.—*Epicroseius porosus.* Adult. A, Dorsum; B, Chelicera; C, Tined seta on palpal tarsus; D, Tectum; E, Hypostomal setae. 3.—*Epicroseius porosus.* A, Male sternogenital complex; B and C, Female sternogenital complex. 4.—***Rhodacarus marksae.*** Female. A, Venter; B, Dorsum; C, Tined seta on palpal tarsus; D, Chelicera; E, Tectum; F, Peritreme.

areas; with about twenty setae. Posterior dorsal shield slightly convex anteriorly, oval, with sclerotized median longitudinal strip without setae, which is continuous with similar ventral strip behind anus; lateral margins well sclerotized, with about two setae on each side; remainder reticulated, with about seven pairs of setae. Posterior angles of body each with two projections, of which the exterior pair are the larger; each with very strong seta (to 184μ long). Dorsal cuticle with about 30 setae, of which two posterolateral pairs are large, to 140μ long, and placed on small tubercles. All dorsal setae heavily ciliated on each edge, with ciliations becoming shorter apically, except for most of setae on third dorsal shield, which are almost smooth and spiniform.

Venter (Text-fig. 1): Tritosternum with stout base (flanked by six spiny processes) which divides into two laciniae, each with three ciliated branches. Sternal setae I on transverse sclerotized zone, while II and III are on single shield which extends back to level of coxae IV, having four pairs (five in one specimen) of extra setae. On this shield (Text-fig. 3, A) are two sub-circular areas with small elongate pores. Sternal pores between sternal setae II and III, metasternal pores normal. Spiracle between coxae III and IV, with peritreme running forward and turning onto dorsum. Genital aperture between sternal setae I and II, covered by nude circular plate. Wrinkled, weakly sclerotized zone behind coxae IV, followed by normal striated cuticle, and then a broad ventri-anal shield, with setae similar to those on dorsum. Anal area normal in shape, with usual three setae, extending back to meet median strip of third dorsal shield.

Gnathosoma: Palpi with tarsus and tibia not distinctly separated; sensory seta on tarsus 2-tined (Text-fig. 2, C). Labial cornicles weak. Only three pairs of sub-equal hypostomal setae present (Text-fig. 2, E), as in *E. zimmermani*. Chelicerae (Text-fig. 2, B) with fixed digit slightly longer than movable digit, with four fairly strong teeth and simple pilus dentarius. Movable digit with one strong tooth, flanked by fine serrations. With simple seta externally near base of fixed digit. Tectum (Text-fig. 2, D) triangular, with apex deeply notched; with numerous small spiniform processes basally.

Legs with setation similar to body setae, except on distal halves of tarsi, and most segments with narrow, roughened strips on the cuticle. Tarsus I slender, with strong setae, and without any ambulacral apparatus; apex with two long setae ventrally, and several very small, fine setae dorsally. Other tarsi with normal ambulacrum and two claws.

Female.

Of similar facies dorsally to male, length 730μ, breadth 530μ.

Venter as in male except for sterno-genital area. All three pairs of sternal setae free, without obvious sternal sclerotization. Genital setae placed behind fold in body wall. Epigynial shield heart-shaped, broadly rounded posteriorly, sclerotized more heavily near anterior indentation, and with two pairs of setae. Genital aperture with movable, strongly sclerotized structure, which varies in position as shown (Text-fig. 3, B and C). Ovum single and broadly oval.

Nymph.

Similar to adult, except that posterior longitudinal strip is not well developed, and mid-dorsal shield is absent. Setae of terminal process much longer relatively, to 225μ long, while one seta in front of these processes is also very long, to 212μ. Only three pairs of hypostomal setae present.

Remarks.

The status of the four species of *Epicroseius* described by Berlese (summarized by Vitzthum, 1939, and Trägårdh, 1953) is still uncertain, and I am not prepared to identify my specimens with any of them. The only fully described species is *E. zimmermani* Trägårdh, 1953, which may readily be separated from the present species by the number of setae on the male sterno-genital shield, and the nature of the hypostomal setae and tectum. The species name indicates the porose areas on the male sterno-genital shield, which are not present in *E. zimmermani*. This is the first record of the family from Australia.

Material examined: The types, six paratype males, four paratype females, and thirteen morphotype nymphs, from leaf mould on cay, 19.viii.54, and Green Ant Is., 24.viii.54, E.N.M. coll., and from under rotting log, Green Ant Is., 14.viii.54, E.N.M. and M.J.M. coll.

Cohors GAMASINA.

Family RHODACARIDAE.

Genus RHODACARUS Oudemans.

RHODACARUS MARKSAE, n. sp.

Type: Holotype female from leaf mould, Green Ant Is., 24.viii.54, E.N.M. coll.

Female.

A minute, very weakly sclerotized species, 302μ long, 144μ wide, with well-marked constriction just behind level of coxae IV. Dorsum (Text-fig. 4, B) with two sub-circular shields, the anterior with distinct shoulders and 23 pairs of simple setae, the posterior with nineteen pairs, of which inner posterior pair are weak, and adjacent pair much stronger.

Venter (Text-fig. 4, A): Tritosternum with narrow base and two ciliated laciniae. Sternal and metasternal shields completely fused, with four pairs of setae. Only sternal pores evident. Area between anterior margin of sternal area and base of tritosternum weakly sclerotized. Genital shield quadrate with a pair of setae near posterior corners. Ventri-anal shield well developed, broader anteriorly, and with four pairs of setae in addition to three anal setae, of which post-anal is longer than adanals. Ventral cuticle with four setae, of which two are very close to anterior margin of ventri-anal shield. Metapodal plates simple and elongate. Peritreme (Text-fig. 4, F) short, lying above coxae III; stigmata comma-shaped.

Legs slender, with very weak setation; coxal formula 2, 2, 2, 1. Tarsi I without ambulacra or claws, but with rather long apical hairs. All other tarsi with ambulacra and claws.

Gnathosoma: Chelicerae (Text-fig. 4, D) very large and heavily sclerotized; both digits with strong teeth and serrations. Sensory seta on palpal tarsus three-tined (Text-fig. 4, C). Tectum (Text-fig. 4, E) with three elements, laterals crescentic and curved outwards, and mucro longer, and shortly bifurcate apically; shoulders very slightly serrate.

Remarks.

The new species may be readily separated from the genotype, *Rhodacarus roseus* Oudemans, 1902, by the shape of the tectum and ventral shields. *R. pallidus* Hull, 1918, is stated by Halbert (1920) to have claws on tarsus I; if this is correct, it should be placed in either *Rhodacaropsis* or *Rhodacarellus* as defined by Willmann (1935). This is the first record of the family from Australia. I have pleasure in naming this species for one of the collectors of this interesting material.

Material examined: The holotype is unique.

Family ASCAIDAE.

Genus ASCA von Heyden.

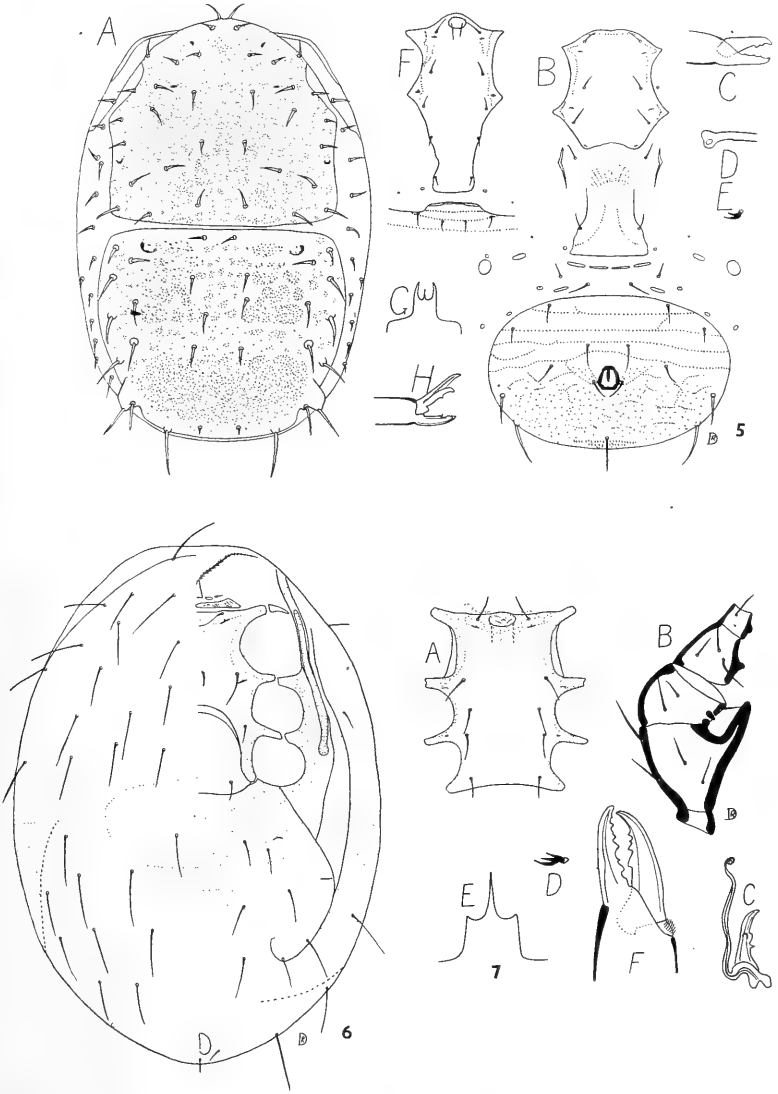
ASCA MAJOR Womersley, 1956.

Male.

As this sex was not known to Womersley, it is described here. Of similar facies to female dorsally and posteroventrally, but smaller, 396μ long. Sternal, metasternal and genital shields fused to form holoventral shield (Text-fig. 5, F), which is strongly convex anteriorly, and narrow and weakly defined posteriorly; with usual five pairs of setae and three pairs of pores; with two pairs of pores in ventral cuticle opposite posterior corners. Ventri-anal shield (Text-fig. 5, F) with small flat anterior projection bounded by four small setae; four transverse lenticular shields fused to anterior edge of this projection. Fixed finger of chelicerae (Text-fig. 5, H) with two teeth and small pilus dentarius; movable finger with single tooth; spermatophore carrier straight and slightly longer than movable finger.

Remarks.

The specimens have been compared with the holotype. Apparently the species is widespread in the State, as the previous record was from S.E. Queensland. The specimens labelled as paratypes of this species in this Institute comprise two species, but fortunately the holotype conforms to the published description.



Text-figures 5-7.

5.—*Asca major*. Female. A, Dorsum; B, Venter; C, Chelicera; D, Basal portion of peritreme; E, Tined seta on palpal tarsus. Male. F, Venter; G, Tectum; H, Chelicera. 6.—*Gamasiphis* (*Heteroiphis*) *australicus*. Female. Dorsum on left, venter on right. 7.—*Gamasiphis* (*Heteroiphis*) *australicus*. Male. A, Sternogenital complex; B, Femur, genu, tibia and basitarsus II; C, Spermatophore carrier; D, Tined seta on palpal tarsus. Female. E, Tectum; F, Chelicera.

Material examined: Twenty females, one male and one nymph from leaf mould on cay, 14 and 19.viii.54, and Green Ant Is., 24.viii.54, E.N.M. coll., and from leaf mould, Low Is., viii.54, M.J.M. coll.

Family NEOPARASITIDAE.

Genus GAMASIPHIS Berlese.

Subgenus HETEROIPHIS Trägårdh.

GAMASIPHIS (HETEROIPHIS) AUSTRALICUS Womersley, 1956.

Male.

As this sex was unknown to Womersley, it is described here. Of similar facies to female dorsally and posteroventrally, 388μ to 402μ long. Holoventral shield (Text-fig. 7, A) with usual five pairs of setae and three pairs of pores; both anterior and posterior margins slightly concave. Leg II (Text-fig. 7, B) with small rounded process on metatarsus and tibia, a small pointed process on genu, and a very large process on femur. Spermatophore carrier (Text-fig. 7, C) elongate, sinuous, and delicately coiled apically.

Remarks.

The specimens have been compared with the holotype. The only other record is from South Australia. Attention is drawn to the two pairs of pores and the disposition of the striations on the ventri-anal shield, and the transverse oval marking on the dorsum which gives rise to the oblique sutures characteristic of the subgenus (Text-fig. 6).

Material examined: Seven females and three males from leaf mould on cay, 14 and 19.viii.54, E.N.M. coll., and from leaf mould, Low Is., viii.54, M.J.M. coll.

Subgenus LAELAPTIELLA Womersley.

GAMASIPHIS (LAELAPTIELLA) MACKERRASAE, n. sp.

Types: Holotype female and allotype male from leaf mould on cay, 19.viii.54, E.N.M. coll., and Green Ant Is., 24.viii.54, E.N.M. coll. respectively.

Female.

A small, brown, well-sclerotized species, 366μ long, 235μ wide. Dorsum (Text-fig. 8, B) completely covered by single dorsal shield, which encroaches slightly ventrally, and fuses posteriorly with the ventri-anal shield; evenly sclerotized except for numerous circular plain areas; with about 33 pairs of simple setae, and pair of distinct marginal pores just behind level of peritreme.

Venter (Text-fig. 8, A): Prae-endopodal plates present. Sternal shield about as long as broad, with sternal setae I and II and pores in normal position. Sternal setae III close together medially. Metasternal complex fused completely to posterolateral corners of sternal shield. Endopodal shield IV free, and well developed. Exopodal shields fused and extended behind coxae IV. Genital shield convex anteriorly, and noticeably broadened basally behind coxae IV; with a single pair of genital setae. Metapodal shield simple and placed in between genital, exopodal and ventral shields. Ventri-anal shield broad, extending from just behind genital shield to end of body, where it fuses with dorsal shield; with transverse lines and seven pairs of setae in addition to three anal setae. Peritreme as illustrated, Text-fig. 9, F.

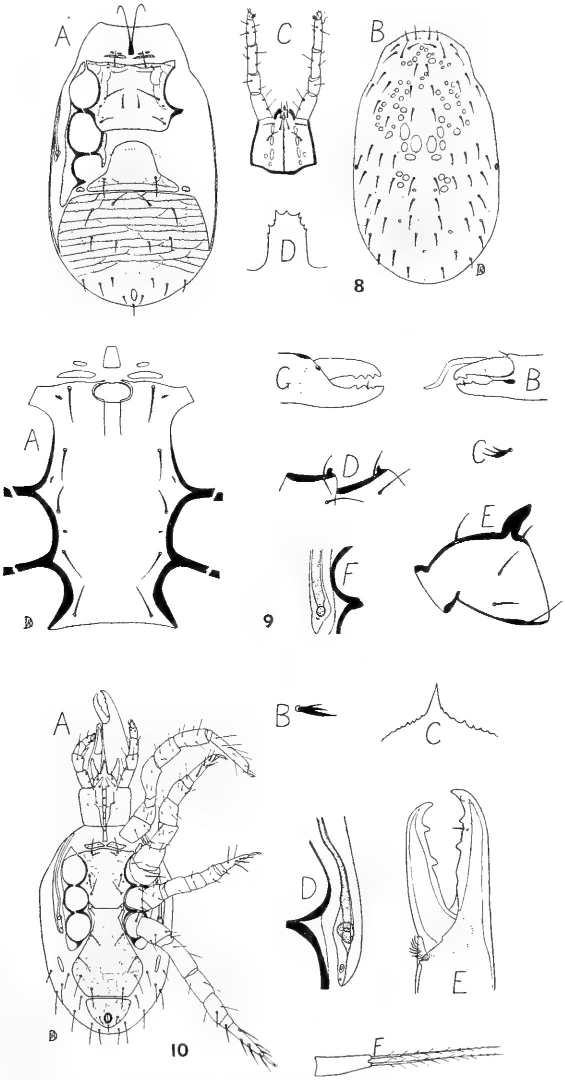
Gnathosoma (Text-fig. 8, C) short and broad basally, with palpi relatively long and slender. Sensory seta on palpal tarsus 3-tined (Text-fig. 9, C). Chelicerae (Text-fig. 9, G) simple; movable finger with three teeth, fixed finger with three larger teeth and simple pilus dentarius.

Male.

Essentially as in female, length 347μ breadth 212μ. Sternal, metasternal, endopodal and genital areas all fused (Text-fig. 9, A). Ventri-anal shield free. Leg II (Text-fig. 9, D and E) with large process on femur and smaller process on genu and tibia. Chelicerae (Text-fig. 9, B) with slender, curved spermatophore carrier. Tectum (Text-fig. 8, D) with three anterior and three pairs of lateral points.

Remarks.

Womersley (1956) placed this subgenus as a genus of the family Ascaidae. However, both the holotype and paratype show a three-tined sensory seta on the palpal tarsus, and this, together with many other characters, places it as a *Gamasiphis*. *Laelaptiella* is closest to the subgenus *Gamasiphoides* Womersley, 1956, but may be separated on the nature of the peritremal and exopodal shields. The new species may be recognized by the shape of the tectum, and the relatively wider genital shield. I have pleasure in naming this species for one of the collectors of this varied material.



Text-figures 8-10.

8.—*Gamasiphis* (*Laelaptiella*) *mackerrasae*. Female. A, Venter; B, Dorsum; C, Gnathosoma, ventral view. Male. D, Tectum. 9.—*Gamasiphis* (*Laelaptiella*) *mackerrasae*. Male. A, Sternogenital complex; B, Chelicera; C, Tined seta on palpal tarsus; D and E, tibia, genu and femur II. Female. F, Basal portion of peritreme; G, Chelicera. 10.—*Austrogamasellus camini*. Female. A, Venter; B, Tined seta on palpal tarsus; C, Tectum; D, Basal portion of peritreme; E, Chelicera; F, Tritosternum.

Material examined: The types, eleven paratype females and ten paratype males, all with same collection data as types.

Genus Austrogamasellus. n. g.

Genotype: *Mysolaelaps stigmatus* Fox, 1946, Puerto Rico, by present designation.

Diagnosis: As in *Austrogamasus* Womersley, 1942, except that four pairs of genito-ventral setae are present instead of a single pair of genital setae.

By the courtesy of Dr. Irving Fox, I have been able to examine a specimen of *Mysolaelaps stigmatus*; it is not a *Mysolaelaps*, nor even a laelaptid, but a true neoparasitid, having a three-tined sensory seta on the palpal tarsus.

Austrogamasellus camini, n. sp.

Type: Holotype female from leaf mould on cay, 14.viii.54, E.N.M. coll.

Female.

A light brown, fairly well-sclerotized species, 545μ long, 326μ wide. Dorsal shield covering entire dorsum, but not encroaching onto venter; with numerous slender setae and transverse reticulations.

Venter (Text-fig. 10, A): Tritosternum normal, as illustrated (Text-fig. 10, F). Two prae-endopodal plates present. Sternal shield longer than broad, with anterior margin convex and posterior margin flat; with usual three pairs of setae and two pairs of pores. Metasternal complex represented only by seta and pore. Genito-ventral plate expanded behind coxae IV and reaching to anterior edge of anal plate, with four pairs of setae and markings as shown; with a pair of small pores just behind genital setae. Anal plate flat anteriorly and deeply rounded behind, with anus and three small anal setae in posterior half. Metapodal plate elongate. Exopodal plate IV expanded posteriorly. Peritremal shield narrow, extending well forward; with two small pores in posterior corner (Text-fig. 10, D). Striated cuticle with about eight pairs of simple setae.

Legs fairly slender, with weak setation, except on tarsus IV.

Gnathosoma typical. Sensory seta on palpal tarsus distinctly three-tined (Text-fig. 10, B). Tectum rounded, with numerous short teeth and rather larger central spine (Text-fig. 10, C). Chelicerae (Text-fig. 10, E) well developed, with clump of setules at base of movable finger, which has two strong teeth; fixed finger with two teeth flanking small serrations and pilus dentarius; pitted to receive apical tooth of movable finger.

Remarks.

The following details of the genotype should be noted: the genito-ventral shield is without linear markings except marginally; the tectum is evenly rounded, with numerous equal small points; and the sternal shield rather more pointed posteriorly than illustrated by Fox. The new species may be separated on all three characters. I have pleasure in naming this species for Dr. J. H. Camin for much kind advice during the preparation of this paper.

Material examined: The holotype and one paratype female, both with same collection data.

Family PSEUDOPARASITIDAE.

Genus Sessiluncus Canestrini.

Sessiluncus heterotarsus (Canestrini, 1897).

Remarks.

See Text-figs. 11 and 12. Although the present specimens are slightly different (in the armature of leg II and in pretarsus I) from the illustrations given by Vitzthum (1926), I have no hesitation in placing them as this species.

The following characters are considered to be important in assigning specimens to this genus: the characteristic excavation of the anterior margin of the sternal shield to accept the base of the tritosternum; the disposition of the dorsal and ventral shields; the characteristic markings of the sternogenital shield; the unusual outgrowths of the peritremal tube; perhaps pretarsus I is retractile to some extent.

It might be worth adding a translation of Vitzthum's (1926) remarks: "There are now four *Sessiluncus* species known. Only the Italian *Gamasellus* (*Sessiluncus*) *eremita* Berlese, 1918 (*Redia*, 13: 137) is known from Europe. The two other previously known species, *G.* (*S.*) *latus* and *solitarius* Berlese, 1904 (*Redia*, 2: 168-169) are from Java. Of these, the first named has a rather strongly reduced pretarsus I. In *S. latus* and *solitarius*, pretarsus I is not only long and slender, but also two-clawed. Berlese has justly mentioned (*Redia*, 2: 168) that one must not be deceived by the name *Sessiluncus*, and consider the reduction of the pretarsus present in the type species to be a character peculiarly diagnostic for the subgenus." Vitzthum later (1935) described a further species which is closely related to *S. heterotarsus*. This is the first record of the genus from Australia.

Material examined: Two males and one female from leaf mould, Green Ant Is., 24.viii.54, E.N.M. coll.

Family PHYTOSEIIDAE.

Genus PLATYSEIUS Berlese.

PLATYSEIUS QUEENSLANDICUS, Womersley, 1956.

Remarks.

The specimen before me fits the illustrations of Womersley very closely indeed, the setation of the dorsal and ventral shields being identical. The chelicerae (not illustrated, as placed vertically) can be seen to have numerous small teeth on the fixed finger and two or three larger teeth on the movable finger. The tectum is slightly different, but still basically three-pointed. (See Text-fig. 13.)

Material examined: One female from leaf mould on cay, 19.viii.54, E.N.M. coll.

Genus HYPOASPIS Canestrini.

HYPOASPIS WOMERSLEYI, n. sp.

Types: Holotype female and allotype male from leaf mould on cay, 14.viii.54, E.N.M. and M.J.M. coll.

Female.

A small, pale, weakly sclerotized species, length 450μ, width 233μ. Dorsum with single shield with numerous slender setae; with a pair of large pores in posterior half, as illustrated, Text-fig. 14, F.

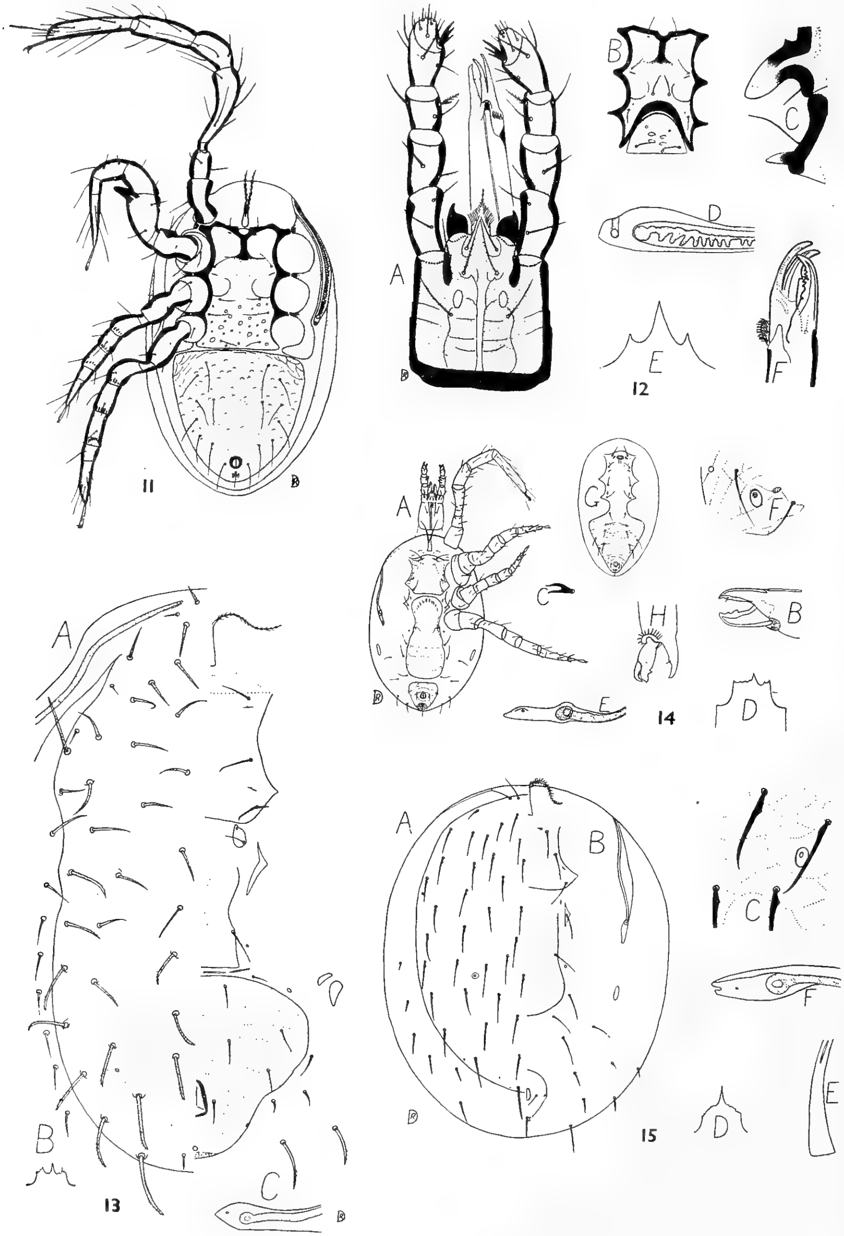
Venter (Text-fig. 14, A): Tritosternum typical. Cuticle between tritosternum and sternal shield slightly sclerotized. Sternal shield convex anteriorly, and almost flat posteriorly, with usual three pairs of setae, two pairs of pores, and anterior and lateral reticulations. Metasternal complex represented by seta and pore. Genital plate slightly expanded behind coxae IV, and extending almost to anal plate, with genital setae placed on small marginal prominences. Three further pairs of setae flank the plate, the anterior of which are placed opposite slight marginal edentations of the plate. Three transverse and two lateral lines are present on the posterior half of the plate, while another pair of lines enclose the bases of the genital setae. Anterior flap of genital plate almost reaching sternal shield. Anal plate triangular, with sides slightly rounded; with a pair of pores opposite the central anus. Unpaired anal seta longer than paired. Metapodal plates elongate. Ventral cuticle with about four pairs of simple setae in addition to the three pairs flanking the genital shield. Peritreme typical, as figured, Text-fig. 14, E.

Legs normal, with few slightly stronger setae on tarsi II to IV.

Gnathosoma typical. Sensory seta on palpal tarsus with two distinct tines (Text-fig. 14, C). Tectum (Text-fig. 14, D) with anterior edge irregularly dentate. Chelicerae (Text-fig. 14, B) with clump of setules at base of movable finger, which has two teeth. Fixed finger without distinct teeth, but with small pilus dentarius.

Male.

Of similar facies to female. Length 373μ, width 218μ. Holoventral shield typical, with five pairs of ventral setae, and transverse reticulations on ventral area (see Text-fig. 14, G). Femur II without spur, but with small spinose seta. Chelicerae (Text-fig. 14, H) with spermatophore carrier sharply bent apically; movable digit with single tooth; fixed finger with pilus dentarius on small elevation.



Text-figures 11-15.

11.—*Sessiluncus heterotarsus.* Male. Venter. 12.—*Sessiluncus heterotarsus.* Male. A, Gnathosoma in ventral view; C, Femur and genu II; D, Basal portion of peritreme; E, Tectum; F, Chelicera. Female. B, Sternogenital complex. 13.—*Platyseius queenslandicus.* Female. A, Dorsum on left, venter on right; B, Tectum; C, Basal portion of peritreme. 14.—*Hypoaspis womersleyi.* Female. A, Venter; B, Chelicera; C, Tined seta on palpal tarsus; D, Tectum; E, Basal portion of peritreme; F, Pore on posterior half of dorsal shield. Male. G, Venter; H, Chelicera. 15.—*Haemolaelaps machaeratus.* Female. A, Dorsum; B, Venter; C, Pore on posterior part of dorsal shield; D, Tectum; E, Basal portion of tritosternum; F, Basal portion of peritreme.

Remarks.

This species is named for Mr. H. Womersley, Acarologist, South Australian Museum, for his teaching and his many kindnesses while I was in Adelaide.

Material examined: The types and one paratype female, all with same collection data.

Family LAELAPTIDAE.

Genus HAEMOLAELAPS Berlese.

HAEMOLAELAPS MACHAERATUS, n. sp.

Type: Holotype female from leaf mould on Green Ant Is., 24.viii.54, E.N.M. coll.

Female.

A pale brown, medium-sized species, 638μ long, 498μ wide. Dorsum (Text-fig. 15, A) with single, oval, reticulated shield, with about 36 pairs of setae, all of which are bladed except those at the extreme anterior and posterior. Posterior half of shield with pair of large, pore-like structures (Text-fig. 15, C). Striated marginal cuticle with about six pairs of setae, which increase in length posteriorly.

Venter (Text-fig. 15, B): Tritosternum with elongate base and two ciliated laciniae (Text-fig. 15, E). Area between tritosternum and sternal shield weakly sclerotized. Sternal shield with concave, indistinct anterior margin, and posterior margin weakly concave; with usual three pairs of setae, two pairs of pores, and anterior and lateral reticulatory lines. Metasternal pore free, and metasternal seta placed on small shield nearby. Genital shield with single pair of setae, with four transverse lines behind them, and forwardly directed lines in front. With small platelet just behind genital setae, and larger elongate-oval metapodal plates further out. Anal shield broadly rounded anteriorly and pointed posteriorly, with fine lines around the edge, and posterior barbules. Anus central, with unpaired anal seta stronger than the paired, which have a small pore opposite them on the margin of the shield. Striated cuticle with about ten pairs of setae. Peritreme (Text-fig. 15, F) with small notch and pore posteriorly on peritremal shield; extending forward onto dorsum almost to extreme anterior.

Legs without outstanding characters.

Gnathosoma typical. Chelicerae not clearly visible in unique specimen, but apparently normal. Tectum (Text-fig. 15, D) with single, sharply pointed mucro, flanked by small serrations. The nature of the sensory seta on the palpal tarsus is unknown, as the tarsi are missing.

Remarks.

The present specimen agrees with all the characters given by Strandtmann (1949) for the genus *Haemolaelaps* (including the characteristic pattern of lines on the genital plate) except that the dorsal setae are modified. It has the same general facies as the genotype, *H. marsupialis* Berlese, which is common in S.E. Queensland, and which has recently been illustrated in detail by Womersley (1955). The new species may readily be recognized by the nature of the dorsal setae. At first glance the bladed dorsal setae suggest *Cosmolaelaps* Berlese, but the two Pacific species, *C. serratus* Trägårdh, 1953, and *C. scimitus* Womersley, 1956, have a very different pattern of lines on the genital plate.

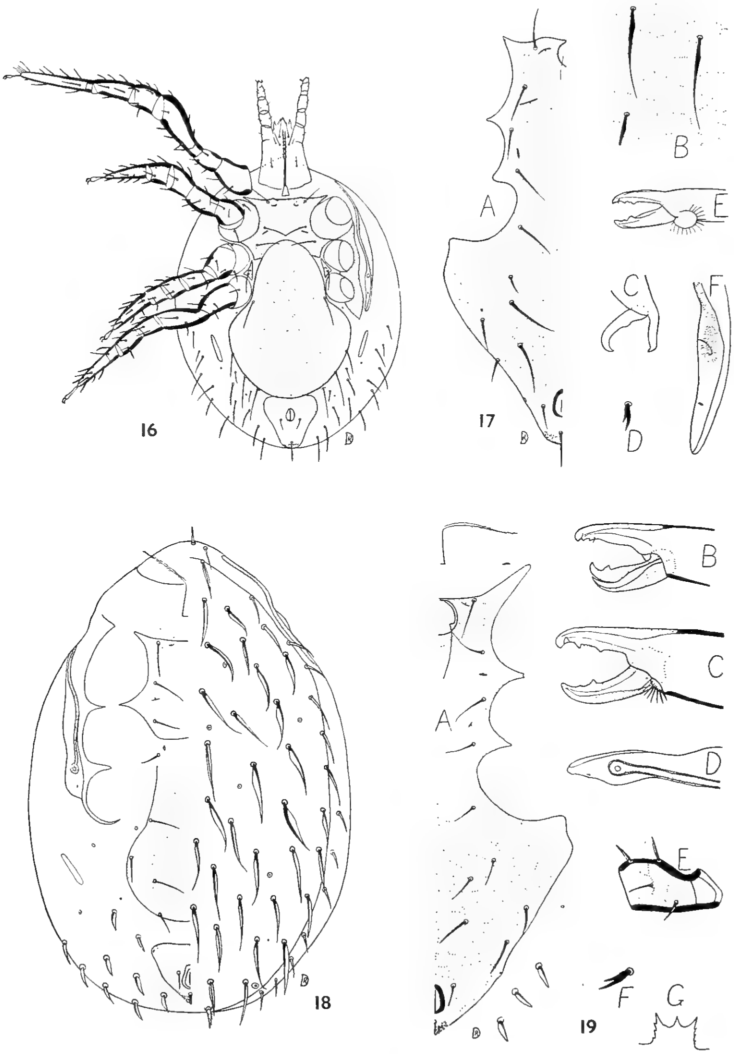
Material examined: The holotype is unique.

Genus LAELASPIS Berlese.

LAELASPIS VITZTHUMI (Womersley, 1956), n. comb.

Male.

As this sex was unknown to Womersley, it is described here. Of similar facies dorsally to female. Leg II not modified. Sternal, metasternal, genital, ventral and anal plates all fused to form holoventral shield (Text-fig. 17, A), which is broadly expanded behind acetabula IV, and then tapers to posterior. With usual five pairs of sternal, metasternal and genital setae and three pairs of pores; also with usual three anal setae, of which smaller paired adanal setae are set near level of middle of anus; with five pairs of ventral setae, of which the two inner pairs are much stronger than the others. With pattern of linear reticulations as shown, including two forwardly-directed concentric loops on discal portion of ventral area. Dorsal setae bladed (Text-fig. 17, B), as in female.



Text-figures 16-19.

16.—*Laelaspis vitzthumi.* Female. Venter. 17.—*Laelaspis vitzthumi.* Male. A, Holoventral shield; B, Portion of dorsal shield; C, Chelicera. Female. D, Tined seta on palpal tarsus; E, Chelicera; F, Basal portion of peritreme. 18.—*Cosmolaelaps multisetosus.* Female. Venter on left, dorsum on right. 19.—*Cosmolaelaps multisetosus.* Male. A, Holoventral shield; B, Chelicera. Female. C, Chelicera; D, Basal portion of peritreme; E, Femur IV; F, Tined seta on palpal tarsus; G, Tectum.

Remarks.

Womersley (1956) described three species as *Gymnolaelaps* Berlese (*G. vitzthumi, G. planus,* and *G. australicus*), but now (*in litt.*) agrees that they should be placed in *Laelaspis.* Berlese (1903) gives a comprehensive diagnosis and excellent figures of

Laelaspis, and also a good figure of the genotype of *Gymnolaelaps*. The status of *G. annectans* Womersley, 1955, is uncertain. (See Text-fig. 16.)

Material examined: Four males and two females from leaf mould on cay, 14 and 19.viii.54, E.N.M. coll.

Genus COSMOLAELAPS Berlese.

COSMOLAELAPS MULTISETOSUS, n. sp.

Types: Holotype female and allotype male from leaf mould on cay, 14.viii.54, E.N.M. coll.

Female.

A medium-sized, well-sclerotized species, 590μ long, 358μ wide. Dorsal shield single, coarse textured, with reticulatory markings and numerous large pores arranged as shown; with about 40 pairs of large setae, all of which (except a few on anterior margin) have a heavily sclerotized central rib and transparent bladed edges (Text-fig. 18).

Venter (Text-fig. 18): Tritosternum typical; area between its base and sternal shield slightly sclerotized. Sternal shield about as wide as long, with both anterior and posterior margins slightly concave; with usual three pairs of sternal setae, two pairs of pores, and reticulate markings anteriorly and laterally. Metasternal complex represented by seta and pore only. Genito-ventral shield widened behind coxae IV, and broadly rounded posteriorly, with four pairs of setae and reticulate markings; with a pore just behind the genital setae. Anal plate triangular, with small pore in anterior corners. Anus slightly eccentric, flanked by three small anal setae. Metapodal plates elongate; with small platelet between them and exopodal shields IV, and a pore behind them. Striated cuticle with about nine pairs of short, broadly bladed setae. Peritremal shield narrow, fused to exopodal plate; with small pore in posterior corner (Text-fig. 19, D); peritreme extending forward to level of coxae II, where it passes on to dorsum, and extends almost to extreme anterior.

Legs stout, with short setae. Femur IV (Text-fig. 19, E) with two erect setae on anterior edge as described by Berlese (1903).

Gnathosoma typical. Sensory seta on palpal tarsus two-tined (Text-fig. 19, F). Tectum (Text-fig. 19, G) with three sub-equal anterior points and barbed lateral margins. Chelicerae (Text-fig. 19, C) also typical, with clump of setules at base of movable digit, which has one strong tooth. Fixed digit with two teeth and fine serrations; pitted to receive apex of other finger.

Male.

Of similar facies to female. Holoventral plate typical, with five pairs of ventral setae (Text-fig. 19, A). Chelicerae (Text-fig. 19, B) with fairly well-developed spermatophore carrier following curve of movable digit, which has one strong tooth; fixed digit with three smaller teeth apically.

Remarks.

The present species agrees very well with Berlese's (1903) rather detailed diagnosis for *Cosmolaelaps*, which makes no mention of the number of genito-ventral setae. All the species known to me have a single pair, whereas the new species has four. The pattern of reticulations on the genital plate should be compared with that typical for *Haemolaelaps* (Text-fig. 15, B).

Material examined: The types and six paratype females, all with same collection data.

Cohors UROPODINA.

Family EUTRACHYTIDAE.

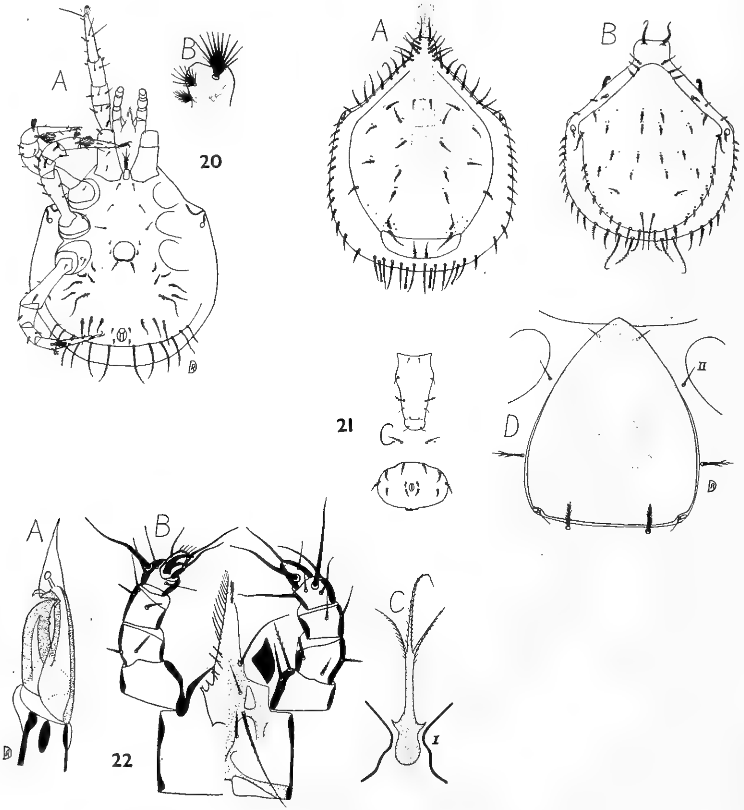
Genus EUTRACHYTES Berlese.

EUTRACHYTES SIMPLICIOR, n. sp.

Types: Holotype male and allotype female from under rotting log, Green Ant Is., 14.viii.54, E.N.M. and M.J.M. coll.

Male.

A brown, heavily sclerotized species. Dorsum (Text-fig. 21, A) with complete marginal shield, with shoulders bearing loops of peritremes; with blunt anterior process over gnathosoma. Marginal shield with single row of ciliated setae laterally and anteriorly; posterior edge with ten longer ciliated setae interspersed with four spathulate setae. Dorsal shield fused anteriorly with marginal shield; with about eleven pairs of setae and numerous pores, especially in posterior corners. Post-dorsal shield transverse, in close contact with surrounding shields; with a single pair of setae on posterior margin.



Text-figures 20-22.

20.—*Eutrachytes simplicior.* Male. A, Venter; B, Fan-shaped setae on tibiae. 21.—*Eutrachytes simplicior.* A, Male dorsum; B and C, Dorsum and ventral shields of nymph; D, Genital shield of female. 22.—*Eutrachytes simplicior.* Adult. A, Chelicera; B, Gnathosoma, dorsal view on left, ventral view on right; C, Tritosternum.

Venter (Text-fig. 20, A): Tritosternum (Text-fig. 22, C) with base between coxae I, and with three normal laciniae. All ventral shields fused, with sternal setae well developed. Genital operculum sub-circular and surrounded by six setae. About six pairs of ciliated setae behind coxae IV, and anus flanked by four small and six longer ciliated setae. A transverse row of twelve stout setae behind anus. Stigmata opposite coxae III, with peritremes looping over onto dorsal surface and then descending again to level of coxae II. Foveolae pedales absent.

Legs long and slender, without special setation, except for fan-like setae near the apices of tibiae II to IV (Text-fig. 20, B). Tarsus I with normal ambulacrum and claws.

Gnathosoma (Text-fig. 22, B): Camerostome not well developed. Hypostomal setae as follows: I short and barbed, II long and barbed, III short and simple, IV long and simple. Labial cornicles stout. Palpal trochanter with one simple and one barbed internal seta. Palpal tibia and tarsus with strong setation; sensory seta on tarsus two-tined. Tectum with several long points basally; mucro heavily ciliated. Chelicerae (Text-fig. 22, A) very long; fixed digit with pointed hyaline process apically, with large pore; pitted to receive point of movable digit.

Female.

Similar to male, length 622μ, breadth 544μ. Genital shield (Text-fig. 21, D) large, extending forward to anterior margin of sternal area. Sternal setae I and II simple, III barbed. Metasternal complex fairly reduced. With pair of setae behind articulatory edge of genital shield.

Nymph.

Of similar facies to adult. Marginal cuticle from behind shoulders to posterior margin with single row of setae, of which the posterior four are longer. Marginal shield only represented by two pairs of platelets at shoulders and along antero-lateral margins, which have a single upwardly directed, strongly sclerotized hook. Anterior process with two setae. Dorsal shield with about 22 pairs of setae, of which the posterior four pairs are longer and stouter; most of these setae have a pore near their base. Post-dorsal shield absent. (See Text-fig. 21, B.)

Venter (Text-fig. 21, C) with elongate median shield bearing normal sternal, metasternal and genital setae; with transverse suture and two pores between metasternal and genital setae. Anal shield a broad transverse oval, with six pairs of setae, and row of barbules at posterior margin.

Remarks.

Only two species of *Eutrachytes* are known, *E. truncata* (Berlese, 1888) and *E. lata* Trägårdh, 1953. In the key given by Trägårdh, the new species is very close to *E. lata*, in not having a triangular outline, and being without projecting posterior angles, but may be separated by the simpler setal pattern on the anterolateral and posterior regions of the body, and by the pattern of the longer dorsal setae and pores. This is the first record of the family from Australia.

Material examined: The types and two morphotype nymphs, all with same collection data.

Genus Deraiophorus Canestrini.

Deraiophorus biroi Canestrini, 1897.

Male.

A brown, heavily sclerotized species, 778μ long, 642μ wide. Dorsum (Text-fig. 23, A) with complete marginal shield, with well-developed shoulders (Text-fig. 24, A) bearing loops of peritremes, a pair of smaller 3-setose processes further back (Text-fig. 24, B), and a bifurcate anterior process with eight sinuous ciliated setae (Text-fig. 23, E). Marginal shield with scattered simple setae; posteriorly with transverse row of twenty setae of increasing length medially. Dorsal shield fused anteriorly with marginal shield, with about twenty pairs of simple setae and numerous pores (Text-fig. 24, E); with fairly distinct median furrow. The cast nymphal skins and debris are carried about on top of the animal as in *Eutrachytes*. Post-dorsal shield narrow and transverse, well separated from surrounding shields; with four setae and pores.

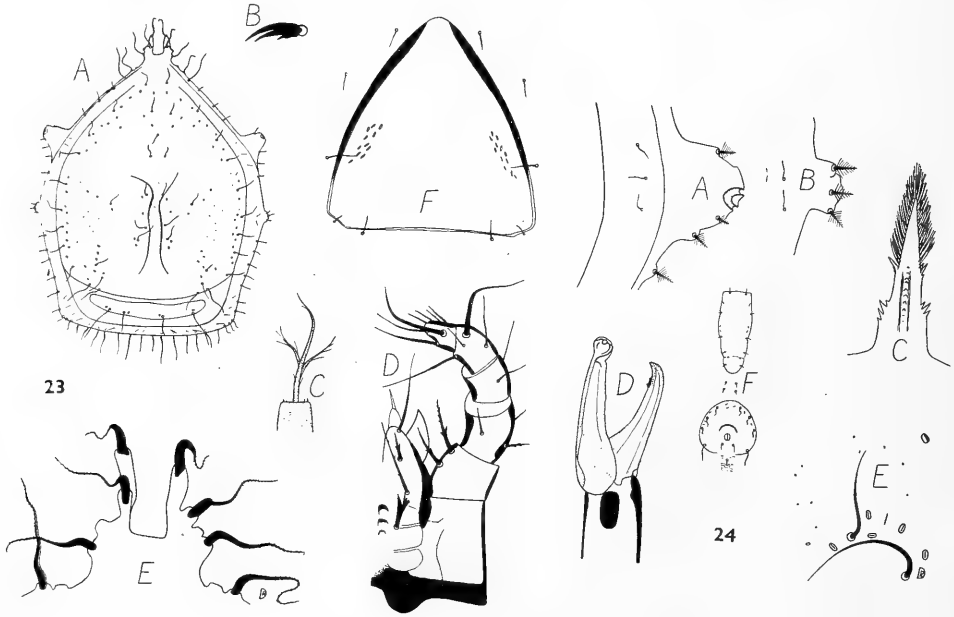
Venter: Tritosternum (Text-fig. 23, C) with its broad base placed between coxae I; with three normal laciniae. All ventral shields coalesced, and of typical facies. Genital aperture opposite coxae III. Foveolae pedales absent.

Legs long and slender as in *Eutrachytes*, except that tarsus I has no ambulacrum or claws, but only an apical sensory hair much longer than the tarsus itself.

Gnathosoma (Text-fig. 23, D): Camerostome not well developed. Hypostomal setae as follows: I stout, expanded and barbed apically, II long and slightly barbed, III short and slightly barbed, IV long and slender. Labial cornicles stout. Palpal trochanter with both internal setae barbed, otherwise palpi similar to *Eutrachytes*. Sensory seta on palpal tarsus three-tined, but internal tine weak (Text-fig. 23, B). Tectum (Text-fig. 24, C) also similar to *Eutrachytes*, but with two groups of basal points and median row of barbules. Chelicerae (Text-fig. 24, D) very long; fixed digit with only blunt apical process with pore; pitted to receive point of movable digit.

Female.

Of similar facies and size to male. Genital shield (Text-fig. 23, F) similar in shape and position to that of *Eutrachytes*, surrounded by same five pairs of setae, and with several slit-like pores laterally. Metasternal seta present.



Text-figures 23-24.

23.—*Deraiophorus biroi*. Male. A, Dorsum; B, Tined seta on palpal tarsus; C, Tritosternum; D, Ventral view of gnathosoma; E, Anterior dorsal projection. Female. F, Genital shield. 24.—*Deraiophorus biroi*. Adult. A, Humeral projection; B, Lateral projection; C, Tectum; D, Chelicera; E, Dorsal setae and pores. Nymph. F, Ventral shields.

Nymph.

Of similar facies to adult, but without marginal and post-dorsal shields.

Venter (Text-fig. 24, F) with elongate median shield bearing short sternal, metasternal and genital setae and pores; with transverse suture and two pores between metasternal and genital setae. Anal shield as long as wide, with anterior and lateral margins broadly arched; with about five pairs of setae, and patch of small barbules posteriorly. The resemblance of this nymph ventrally to that of *Eutrachytes simplicior* is striking.

Remarks.

Only four species of this genus were listed by Trägårdh (1953). Three of these were very briefly described without illustrations by Canestrini (1897), and Berlese (1904) added a fourth. I have been unable to ascertain the status of *D. tuberculatus* Kramer listed by Canestrini (1898). The present specimens could be *D. biroi* Can., and as they agree with the recorded data they are placed here. This is the first record of the genus from Australia.

Trägårdh erected a new family, Deraiophoridae, for this genus, but it is here placed in the Eutrachytidae, together with *Eutrachytes*. Indeed, according to Camin (*in litt.*) both these genera may eventually be returned to the Prodinychidae.

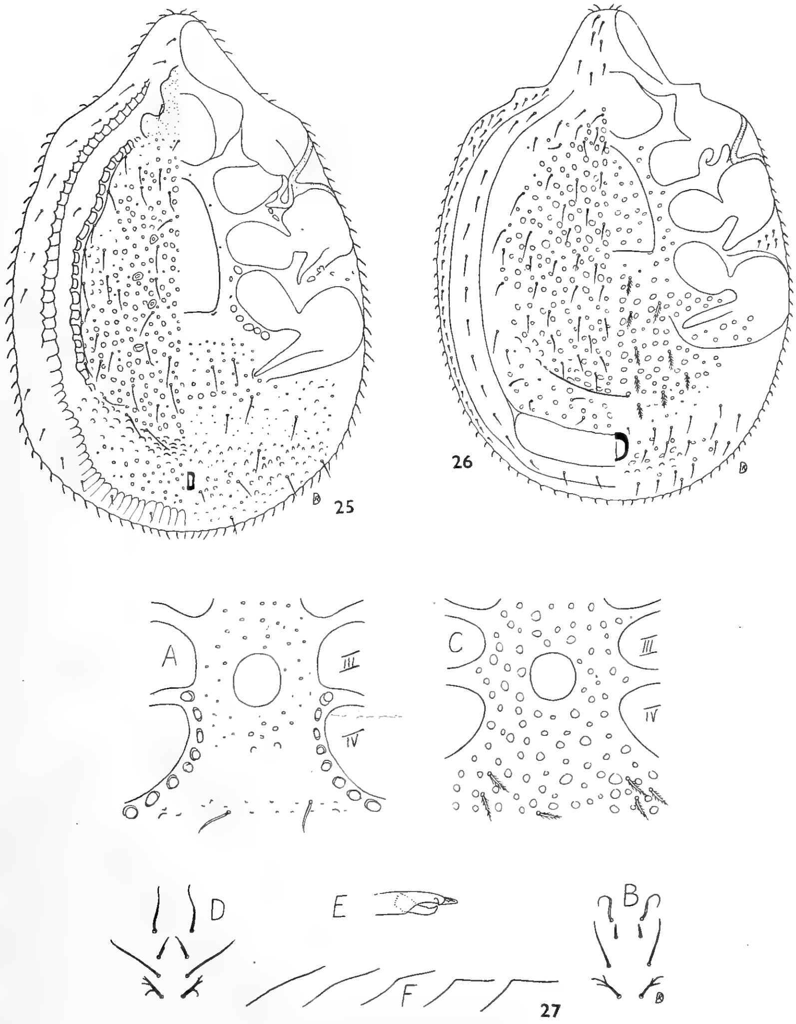
Material examined: Twenty-three males, eight females and five nymphs from leaf mould on cay, 14 and 15.viii.54, and Green Ant Is., 24.viii.54, E.N.M. coll., and from under rotting log, Green Ant Is., 14.viii.54, E.N.M. and M.J.M. coll.

Family URODINYCHIDAE.

Genus TRIGONUROPODA Trägårdh.

TRIGONUROPODA TERRAE-REGINAE, n. sp.

Types: Holotype female and allotype male from leaf mould on cay, 19.viii.54, E.N.M. and M.J.M. coll.



Text-figures 25-27.

25.—*Trigonuropoda terrae-reginae*. Female. Dorsum on left, venter on right. 26.—*Urodiaspis novae-hollandiae*. Female. Dorsum on left, venter on right. 27.—*Trigonuropoda terrae-reginae*. A, Male inter-coxal area; B, Hypostomal setae. *Urodiaspis novae-hollandiae*. C, Male inter-coxal area; D, Hypostomal setae; E, Chelicera; F, Antero-lateral prominences.

Female.

A dark brown, very heavily sclerotized species, 600μ long, 420μ wide, with body encircled by small spinules. Marginal shield with inner edge strongly scalloped, and with about sixteen pairs of short setae. Dorsal shield entire, in close contact with marginal shield, and fused with it anteriorly; covered with small circular depressions except laterally, and with several larger irregular markings centrally. The posterior part of the dorsal shield is at a much lower level than the rest, while at the front there is a distinct depression flanked by a pair of setae. Post-dorsal shield absent. (See Text-fig. 25.)

Venter (Text-fig. 25): Genital plate reaching from level of coxae IV to near anterior margin of sternal area. Metasternal complex very reduced. Ventri-anal area covered with depressions and with several nude setae like those on dorsum. With circlet of about eight strongly marked depressions around inner margin of acetabula IV. One of these depressions is small, due to the broad genital shield near by. Peritreme between coxae II and III.

Legs typically uropodoid, retractable into distinct foveolae pedales. Without spine on femur II.

Gnathosoma enclosed in well-developed camerostome. Hypostomal setae (Text-fig. 27, B) as follows: I three-branched, II long and slender, III short and spinose, IV weakly sclerotized and possibly slightly flattened.

Male.

Very similar to female, length 617μ, breadth 414μ. Genital operculum circular, placed just behind mid-line of coxae III (Text-fig. 27, A). With circlet of eight distinct sub-equal depressions around acetabula IV, cf. female. Without spine on femur II.

Nymph.

With elongate shield between coxae, wider anteriorly, and truncate posteriorly, with circular depressions and five pairs of setae; with pair of elongate longitudinal pores in front of fifth pair of setae. Anal shield large, broadly oval, with about four pairs of marginal setae and pores; anus posteriorly placed. With three pairs of setae on posteroventral corners of body. Without circlet of depressions around acetabula IV.

Dorsal marginal shield with single row of setae, and two large setae on inner posterior edge. Dorsal shield with honeycombed pattern, and with large irregular pores on disc as in adult; without anterior depression. This nymph is very similar to that of *Urodiaspis* described below.

Remarks.

Trägårdh (1953) erected the genus *Trigonuropoda* for *Urodinychus polyphemus* Vitzthum, 1935, on the presence of a deep antero-dorsal depression. The present species may be readily recognized by the distinct circlet of pits around acetabula IV, especially in the male, and by the smooth genital shield and inconspicuous sternal setae in the female.

Material examined: The types, sixty-three paratype males, thirty-seven paratype females and three morphotype nymphs; all with same collection data.

Genus URODIASPIS Berlese.

URODIASPIS NOVAE-HOLLANDIAE. n. sp.

Types: Holotype female and allotype male from leaf mould on cay, 19.viii.54, E.N.M. coll.

Female.

A dark brown, heavily sclerotized species, 600μ long, 428μ wide, sometimes with a pair of small, blunt, angular projections (Text-fig. 27, F) near base of large anterior process. Dorsum encircled by narrow shield bearing two rows of spinulose setae. Marginal shield with about fifteen pairs of longer setae, fused with dorsal shield anteriorly, and excavated posteriorly to accept the post-dorsal shield. Dorsal shield as in *Trigonuropoda*, but without anterior depression and central markings. Post-dorsal shield transverse, in close contact with dorsal and marginal shields, and without setae. (See Text-fig. 26.)

Venter (Text-fig. 26): Genital plate with articulation just in front of mid-line of coxae IV, and extending forward to just behind level of sternal margin; covered with circular depressions, a few of which are also present between the shield and the acetabula. Ventri-anal area with similar depressions, and ciliated setae in front of level of anus, and nude setae behind these. Circular depressions also present on fovealae pedales IV.

Legs typically uropodoid, retractable into definite foveolae pedales. Without spine on femur II. Without circlet of pits around acetabula IV.

Gnathosoma enclosed in definite camerostome. Hypostomal setae (Text-fig. 27, D) as follows: I four-branched, II long and slender, III stout, with single barb, IV long and simple. Fixed digit of chelicerae with apical process, and pitted to receive apical tooth of movable finger (Text-fig. 27, E).

Male.

Very similar to female, length 606μ, breadth 436μ. Genital operculum circular, between coxae III and IV, and surrounded by circular depressions (Text-fig. 27, C). Without circlet of pits around acetabula IV. With stout spine, similar to those on coxae of *Laelaps*, on posterior margin of femur II.

Nymph.

Dorsal shield as in adult, fused anteriorly with marginal shield, which has about sixteen pairs of small setae and one pair of stronger setae posteriorly. Post-dorsal shield absent. With narrow peripheral shield as in adult, with a single row of setules.

Venter with elongate sternal shield with five pairs of small setae, two pairs of pores, and a pair of strong setae at posterior angles. With a small platelet near these strong setae, and a smaller one behind posterior margins of foveolae pedales IV, which have circular depressions as in adult. Anal shield transverse-oval, with about ten setae.

Remarks.

Trägårdh (1944) erected a new family, Urodiaspidae, for the genus *Urodiaspis*, characterized, among other features, by the presence of a posterior dorsal shield and the absence of a scalloped marginal shield. However, in 1953, he returned the genus to the Urodinychidae, characterized, among other features, by the absence of a posterior dorsal shield and the presence of a definitely scalloped marginal shield. In this family he also included *Diurodinychus* Berlese, 1916 (placed by Baker and Wharton, 1952, in the Urodiaspidae), which was originally described as having both a posterior dorsal shield and a scalloped marginal shield. The family Urodiaspidae, then, appears unnecessary. The present species is described as a *Urodiaspis*, even though the metasternal complex is much more reduced than that illustrated by Trägårdh (1944) for the genotype, *U. tecta* (Kramer, 1876). However, neither Kramer's nor Berlese's (reproduced by Baker and Wharton, 1952) original illustrations show a well-developed metasternal complex.

Material examined: The types, three pairs of paratype adults, and two morphotype nymphs, all with same collection data.

Acknowledgements.

I am particularly indebted to the Great Barrier Reef Committee, and Drs. E. N. Marks and M. J. Mackerras for the opportunity of describing this very interesting material. In addition to those mentioned in the text, I am also grateful to Mr. H. M. Hale for the loan of many specimens, to Mrs. P. N. Macgregor for obtaining many old references, and to Mrs. J. W. Phillips for typing this manuscript.

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CYCLOCEPHALA SIGNATICOLLIS BURMEISTER, AN INTRODUCED PASTURE SCARAB (COLEOPTERA).

By P. B. CARNE.

(Five Text-figures.)

[Read 25th September, 1956.]

Synopsis.

The Argentinian scarab *Cyclocephala signaticollis* Burm. has become established in a number of Sydney suburbs. The first specimens were obtained in 1947.

This paper describes both the adult and larval stages, particular emphasis being placed on characters which enable them to be distinguished from those of native species of Dynastinae. The distribution of the species in South America and its life cycle under Australian conditions are briefly described.

The introduction is a cause for some concern, as the species is closely related to a number of turf and pasture pests in the Americas. Although only minor damage has been caused by the local Sydney population, the species may spread into areas more favourable to its survival and multiplication.

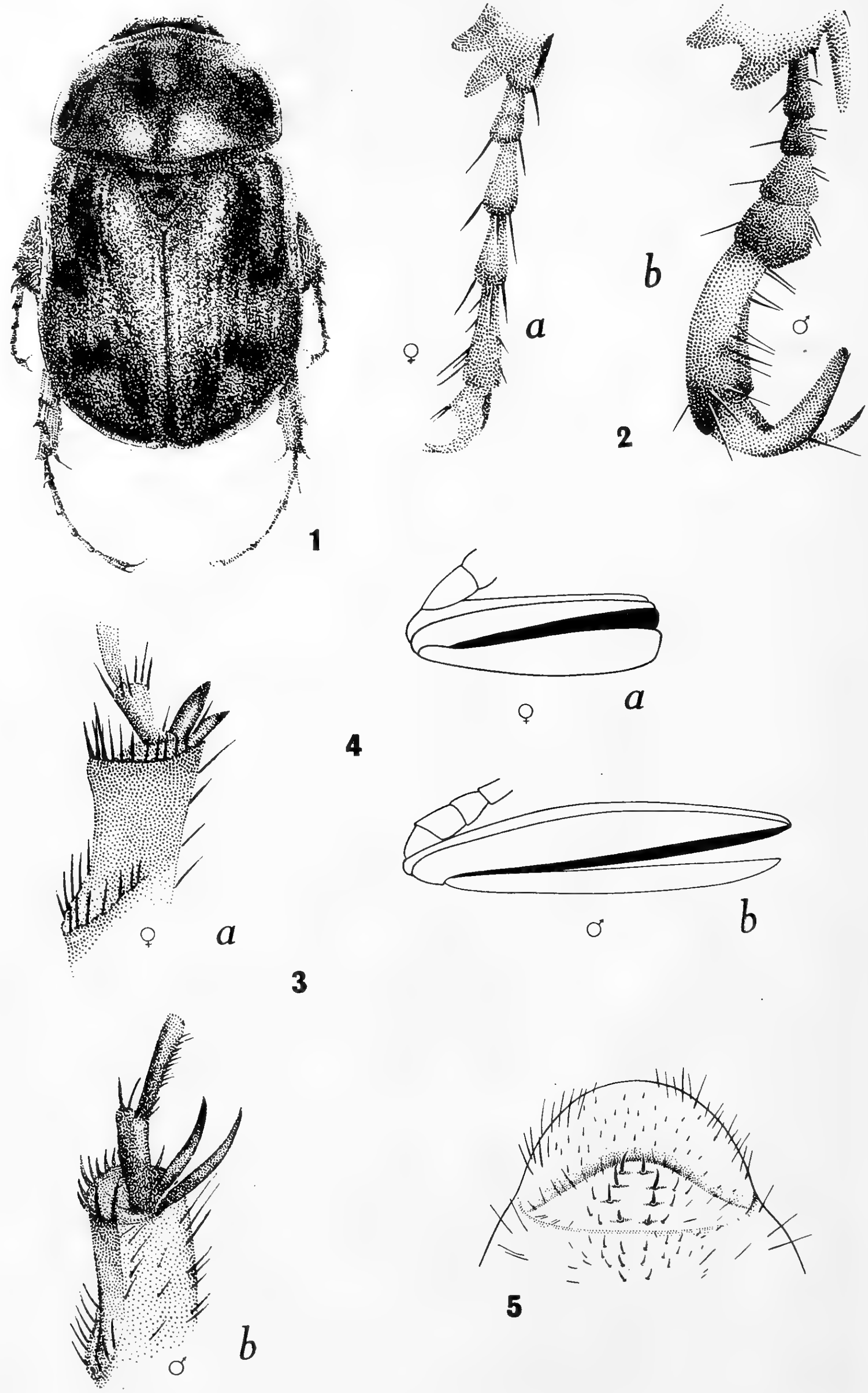
Introduction.

Cyclocephala signaticollis Burmeister, a dynastine native to Argentina and Uruguay, was introduced to Australia at some time prior to 1947 and has become established in a number of Sydney suburbs. The first specimens were obtained by Mr. C. E. Chadwick, of the N.S.W. Department of Agriculture, who collected larvae from turf in the suburb of Bardwell Park in November, 1947, and reared them to obtain adults in December of that year. Other adults were taken in large numbers at lights at both Bardwell Park and Ashfield in early to mid-December. Over the years 1948 to 1951 the beetles were reported from an increasingly wide area, including the suburbs of Lane Cove, Burwood and Concord. In 1951 the writer carried out a brief survey of pastures and lawns in the area and found *Cyclocephala* larvae to be the predominant scarab species in these situations, and the cause of moderate damage to the vegetation. By 1955 the distribution of the species extended over the whole of the suburban area between the Parramatta and George's Rivers, and the north shore suburbs as far as Chatswood.

Neither the name nor the origin of the insect was known until late in 1950, when specimens were identified by Mr. E. B. Britton, of the British Museum. The species is closely related to a number of serious pests in South America and the United States. The literature on these indicates that although they may exist harmlessly in compost or in rough pastures, they occasionally cause severe damage to improved pastures, lawns or vegetable crops. One cannot overlook the possibility that, in Australia, *C. signaticollis* may not yet have encountered environments most favourable for its survival and multiplication.

The species is formally described in a forthcoming revision of the Australian Dynastinae (Carne, in press), but it is felt that the introduction might be of interest to a wider audience than will be reached by a specialist taxonomic paper. Should it become necessary to attempt the control of this species, the first requirements will be a means of identifying both the adult and the larva, and basic information on its life cycle. It is in anticipation of this possible need that the present paper has been prepared.

The only other known instance of an exotic Dynastine becoming established in Australia had disastrous consequences for the rural community of the New South Wales coast (Wallace, 1945, 1946). Reference is of course made to the Black Beetle (*Heteronychus sanctae-helenae* Blanchard) which was introduced from South Africa



Figures 1-5.

Cyclocephala signaticollis Burm. Fig. 1: Dorsal view of male showing full development of colour pattern. Fig. 2: Anterior tarsus (*a*) of female, (*b*) of male. Fig. 3: Spurs of posterior tibia (*a*) of female, (*b*) of male. Fig. 4: Antennal club (*a*) of female, (*b*) of male. Fig. 5: Raster of third instar larva.

possibly during the period of the first World War. Neither the first appearance of this insect nor its subsequent spread was recorded, nor can it now be traced, as for ten years or more its identity was confused with that of a widely distributed native dynastine, *Metanastes vulgivagus* (Olliff). Early experiments on the control of the pest were almost certainly carried out with mixed populations of the two species, which differ considerably in their fundamental ecology.

DESCRIPTION OF THE SPECIES.

(*a*) *Adult.*

The adult beetle (Fig. 1) is rather delicate, dorsally glabrous, and ranges in length from 1·34 to 1·50 cm. It is light brown to brownish-beige in colour, the pronotum somewhat darker than the elytra, but both with a surface gloss. The elytra and pronotum bear complex, bilaterally symmetrical, dark brown markings and shallow irregular punctation. In some specimens the elytral markings are obsolete, but a trace of the pattern always remains on the pronotum. The head is dark brownish-black, the clypeus a dull reddish-brown; the abdomen, legs and coxae are light brown, the latter with erect golden hairs. The pygidium is lightly and irregularly punctate, glabrous except for a central tuft of yellowish hairs on its posterior margin. The anterior claws of the female (Fig. 2, *a*) are equal and simple, and the tarsal segments equal in length. In the male (Fig. 2, *b*) the claws are much larger, strongly asymmetrical, the larger claw being finely toothed at its apex; the last tarsal segment is greatly enlarged to support the claws, and the preceding segments are correspondingly shorter and broader. Sexual dimorphism is also shown in the form of the hind tibial spurs (Fig. 3, *a* and *b*) and the antennal club (Fig. 4, *a* and *b*).

The insect is at once distinguishable from all endemic Dynastinae, none of which have dorsal colour patterns of the type here described and figured. The only endemic scarabaeids with which *C. signaticollis* could conceivably be confused are certain species of *Anoplognathus* (especially *abnormis* Macl.), but these are restricted in distribution to northern Queensland.

(*b*) *Larva.*

The larva is a typical "curlgrub". Whereas most native dynastine larvae have heavily punctured reddish-brown heads, and antennae with the ultimate segments each bearing four or more conspicuous sensory areas, the larva of *C. signaticollis* has a smooth yellow head, and the ultimate antennal segment bears a single dorsal and two ventral sensory areas. In this respect it is similar to certain ruteline larvae but, whereas the latter have finely and evenly ridged stridulating areas on the lower surfaces of their mandibles, those of the present species are coarsely and unevenly ridged, as in all other dynastines.

The third instar larva has a head capsule ranging in width from 4·4 to 5·2 mm. The following characters will enable it to be positively identified:

The head capsule is yellowish-brown and slightly rugulose; a weakly pigmented ocellus is present at the base of each antenna. All tarsal claws are long and slender. The two posterior pairs of abdominal spiracles are larger than the first six pairs, being approximately equal in size to those of prothorax.

The raster and lower anal lip bear numerous small hamate setae; in addition, on the lower anal lip there are some seven to nine exceptionally large and deeply pigmented hamate setae, with their sockets arranged in a roughly circular or oval pattern (Fig. 5).

The second instar larva is similar, but has a head capsule width of *c.* 2·9 mm. The first instar larva has a raster completely devoid of hamate setae; its lower anal lip and raster are uniformly covered with fine slender setae. The head capsule width is *c.* 2·1 mm.

The central group of large hamate setae on the lower anal lip of second and third instar larvae enables them to be distinguished immediately from all other scarabaeid larvae known to the writer. Certain melolonthine larvae have rather similar hair patterns, but in this subfamily the anal slit is longitudinal, not transverse.

The Ecology and Distribution of Cyclocephala spp. in the Americas.

Although nothing has been published concerning *C. signaticollis* other than its formal description (Burmeister, 1847), several other species have been studied intensively. Johnson (1941) gives an interesting account of the behaviour of *C.* (*Ochrosidia*). *borealis* Arrow in Connecticut, and confirms similar observations by Neiswander (1938) on the same species in Ohio. Adult flights of this species occur in late June and in July (corresponding to late December and January in Australia), and larval damage to turf is noticeable in both spring and autumn. Ritcher (1944) refers to *C. abrupta* Casey and *immaculata* Oliv. in Oregon and Kentucky respectively, and it is clear from his remarks that the life cycles of these two species are closely similar to that of *borealis*.

In a letter dated 19th June, 1951, the Director of the Instituto de Sanidad Vegetal, Buenos Aires, quotes Senor Antonio Martinez, a field entomologist, as follows: "*Cyclocephala signaticollis* Burm. is found in the provinces of Buenos Aires, the eastern part of Córdoba, southern Santa Fé, in Entre Rios and the north-east of the Pampa territory. It is also known from the neighbouring country of Uruguay . . . . The roots of native grasses are the natural food of the larvae, while they also attack lucerne, wheat, maize, linseed, sunflower and barley. This information is based on unpublished personal observations" (author's translation).

This information indicates that the species occurs over an approximately circular area, of radius 2½ degrees of latitude, having Buenos Aires as its centre. As might be expected from their comparable situations and latitudes, the temperature régime of Buenos Aires (34° 36′ S.) is very similar to that of Sydney (33° 52′ S.), while both have a fairly evenly distributed average annual rainfall, although that of Sydney (48 in.) is appreciably greater than that of Buenos Aires (37 in.).

In its native country the species appears to be restricted to an area on the extensive coastal plain (0–600 ft. above sea level), having an average annual rainfall of from 30 to 50 inches. To the north and north-east the rainfall increases steeply to more than 80 inches; to the south and south-west there is a rapid decline to less than 10 inches. A narrow belt of 30–40 inch rainfall country extends across the continent in a north-westerly direction: the north-westerly limit of the species approximates to a point within this belt where rain ceases to be evenly distributed and falls mainly in the summer months. The probabilities are, therefore, that in Australia the species is unlikely to extend its range inland from the coastal plain or into areas outside the 30–50 inch average annual rainfall zone.

Observations on the Species in Australia.

Field observations in the Sydney area in 1951 showed that larval feeding and damage to vegetation was confined to the autumn and early winter months, there being no resumption of activity in the spring. Larval development is very rapid and most of the larvae have completed feeding by the end of May.

In Table 1 are summarized the percentages of the population in each growth stage at different times of the year.

TABLE 1.

The Development of C. signaticollis *in Relation to the Time of Year, Sydney, 1951.*
Percentage of Population in Each Stage.

Time of Sampling.	First Instar Larvae.	Second Instar Larvae.	Third Instar Larvae.	Prepupae.	Pupae.	Adults, Immature in Soil.	Adults, on Wing and Mature in Soil.
Mid-March	10	10	80	—	—	—	—
Late May	—	—	30	70	—	—	—
Early November ..	—	—	—	20	80	—	—
Early December ..	—	—	—	—	—	100	—
Late December ..	—	—	—	—	—	—	100

The adult is very short-lived and does not appear to feed. Examination of the mouth parts showed them to be poorly developed and probably non-functional; the mandibles are anteriorly excurvate, as are those of *C. borealis* Arrow (Johnson, 1941).

The flight period is from late November to early January, peak flights occurring in all years in late December. The adults first appear in flight at dusk, becoming strongly attracted to lights after dark; males outnumber females. Copulation occurs on the ground and the females burrow into the soil immediately after.

The species was found in greatest numbers in deep friable loams carrying couch grass (*Cynodon dactylon*) and *Paspalum dilatatum*. These grasses, together with a variety of weeds, form the main cover of uncultivated garden beds and disused allotments in the Sydney area. The species was also abundant in grazed *Paspalum*-subterranean clover pastures. In all situations its presence was indicated by an impoverishment of the *Paspalum*. The larvae seem to have high soil moisture requirements, for although their distribution was fairly uniform in March, 1951, by the end of May the greatest numbers were found in shaded or otherwise naturally damp situations.

C. signaticollis is able to complete its life cycle on a diet consisting solely of decomposing organic matter. Dense populations were found in old compost heaps, and larvae were successfully reared in the insectary in such material. On the other hand, the larvae were quite abundant (up to 15 per sq. link in May, 1951) in pastures, and here they probably derived at least part of their nutriment from the roots of grasses.

DISCUSSION.

It seems very probable that the species was introduced by a ship having previously berthed at or near Buenos Aires. As the adult stage is short-lived and delicate, it is most likely that the insect was transported as larvae in soil, the adults emerging on arrival.

It is of particular interest to record that prior to 1947 not a single specimen of this beetle was taken in Sydney, despite the presence there of a number of amateur and professional entomologists who collect regularly in the vicinity of their homes. When the species was first observed it was extremely abundant over quite a large area. The maximum reproductive capacity of dynastid beetles is the order of 15–30×, and even had mortality factors been negligible in their operation during the period of population increase following introduction, there must have been a very large absolute number of the insects present in the area for at least several seasons prior to 1947. That they were not collected then suggests that the behaviour of the species may be influenced by its population density.

Acknowledgements.

For specimens of both adults and larvae the writer is indebted to Mr. C. E. Chadwick (N.S.W. Dept. of Agriculture) and Mr. A. L. Dyce (Wildlife Survey Section, C.S.I.R.O.); for information concerning early records of the species in Sydney, to the late Mr. K. McKeown (Australian Museum).

The figures were drawn by Mr. L. A. Marshall and photographed by Mr. D. H. Wilson (Division of Entomology, C.S.I.R.O.).

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A REVIEW OF THE FOSSIL FRESHWATER MUSSELS (MOLLUSCA, PELECYPODA) OF AUSTRALASIA.

By DONALD F. MCMICHAEL, The Australian Museum, Sydney.*

(Plates xiii-xiv; one Text-figure.)

[Read 26th September, 1956.]

Synopsis.

The named and described fossil freshwater mussels are reviewed as a preliminary to a study of the evolution of the recent Australasian forms of this group. Of the twenty-two names found in literature which have been applied to fossils believed to be freshwater mussels, five have never been described, while two names based on figures without descriptions probably do not apply to freshwater mussels at all. Of the remaining fifteen names, two belong to recent species and a third is considered to be a synonym of a recent species. Of the twelve described forms known only as fossils, five are attributed to recent genera, three belong in the fossil genus *Unionella* Etheridge, and three new generic names are provided for the remainder. A new species is described from New Zealand, and a new name provided for the New Zealand species, *Unio inflata* Hutton, which is preoccupied. It is suggested that further work on this group will reveal a number of new species, and with more knowledge these forms will be of greater value in stratigraphical correlation.

Fossil freshwater mussels have been recorded from Australia and New Zealand during the past century, but no palaeontologist to date has attempted to monograph or even list all the recorded forms. This is not surprising, for an examination of the literature reveals a state of complete confusion. In the following pages an attempt is made to collate the available information and to indicate as precisely as possible the status and relationships of the described and named forms, based on a study of the fossil material available and a knowledge of the recent fauna.

Further knowledge of this group will have to await a comprehensive review for which a great deal of material must be examined, type specimens must be located and studied, and a thorough search of the literature made. It must be pointed out, however, that no such review will be of any value unless due reference to recent species is made. Nearly all the named forms from this region have been placed in the genera *Unio* Philipsson and *Anodonta* Lamarck, the former if hinge teeth were visible, the latter if they were not visible. As Modell (1942) has pointed out, these genera are today precisely defined groups of species, definitely not Australian, and are not "dumping grounds" for miscellaneous fossil forms.

Knowledge of the fossil species is of great importance in order that a thorough understanding of the past history and phylogeny of the recent forms can be obtained, and if the fossil species were better known they might prove more important in stratigraphical correlation. At the moment, the presence of freshwater mussels indicates only that the beds in question are freshwater, and post-palaeozoic.

In the present review the species or specific names are treated more or less in chronological order. This order is based on their first usage in literature as far as could be determined from the references which I have located. It is interesting to note that Etheridge, Jr. (1879), in connection with the description of *Unio aucklandicus wilkinsoni* gave the first list of recent species described from or attributed to Australia.

For the convenience of those who have not access to this scattered literature, the species descriptions are, for the most part, reprinted from the original. Where possible, I have examined specimens and attached further notes if necessary. In some cases,

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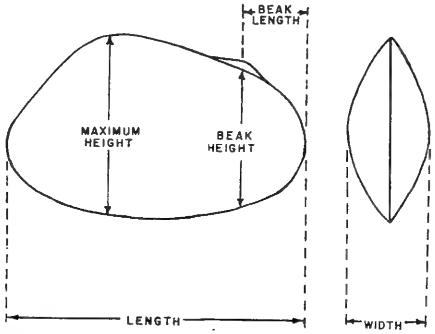
where the original description was inadequate or entirely lacking, additional information based on the figures has been given. The dimensions here given are based, wherever possible, on the type specimens, but in some cases are obtained from the figures and should be regarded as approximate only. The measurements used have been found the most satisfactory for expressing the important features of form in this group and are illustrated in Text-figure 1.



Text-fig. 1.—Dimensions of Freshwater Mussel Shells. Beak height is measured from the hinge line to the ventral margin, and does not include the height of the beaks above the hinge line. In the tables of dimensions, the abbreviations T.L., B.L., and M.H. are used for Total Length, Beak Length, and Maximum Height respectively.

I would like to thank especially Mr. H. O. Fletcher for help and advice on several points; Mr. E. D. Gill for the loan of the several specimens in the collection of the National Museum of Victoria and for valuable information on *Unio dacombii;* and Dr. C. A. Fleming and the Director of the New Zealand Geological Survey for the loan of material from that collection, especially the holotype of *Unio inflatus* Hutton.

UNIO DACOMBII Selwyn (*nomen nudum*).

Unio dacombii "McCoy" Selwyn, 1861, *Geology of the Colony of Victoria*; *Catalogue of the Victorian Exhibition, 1861*, p. 186. *Type Locality*: Middle Jurassic Coal, Valley of the Wannon River, Victoria.

Remarks.

Before giving the long list of references to this name, some comments as to the discovery of the fossil and the status of the name are necessary. During the year 1859 Mr. E. Dacomb, of Portland, Victoria, apparently discovered a fossil freshwater mussel while sinking a shaft near Coleraine and forwarded the specimen to A. R. C. Selwyn, who in turn gave it to Professor F. McCoy. The latter informed Selwyn that he proposed to name it *Unio dacombii* and it was intended for publication in McCoy's *Prodromus of the Palaeontology of Victoria.*

Mr. E. D. Gill, Palaeontologist at the National Museum of Victoria, kindly investigated at my request to see if McCoy had ever described this shell. After a thorough search of the literature he concluded that the species had not been described in print, although a letter in the McCoy papers at the National Museum revealed that the manuscript description was prepared in 1879 and was to have been published in a forthcoming Decade of the *Prodromus.* No type specimen could be located in the National Museum collection, and it probably does not exist today.

Tenison Woods (1883) noted that the fossils discovered during the borings were recorded in the local papers, the *Geelong Advertiser* and the *Portland Guardian,* of various dates in 1859. At Mr. Gill's request, the research section of the Melbourne Public Library searched the newspapers mentioned, but found no description of *Unio dacombii.*

As a consequence of the absence of type material or description, nothing can be said about the nature of the species, the name remaining a *nomen nudum*. The following list of references to the name *Unio dacombii* was compiled in the main by Mr. Gill.

Selwyn, 1862, *Reports Relative to the Geological Survey of Victoria*, 1861, No. 2: 13.

Selwyn and Ulrich, 1867, Notes on the Physical Geography, Geology and Mineralogy of Victoria. *Official Record, Intercolonial Exhibition of Australasia 1866-1867, Intercolonial Exhibition Essays*, No. 3: 145-236.

Brough Smyth, 1874, *Reports of Progress, Geol. Surv. Victoria*, p. 35.

Ulrich, 1875, *A Descriptive Catalogue of the Specimens in the Industrial and Technological Museum (Melbourne), illustrating the Rock System of Victoria.* Melbourne. p. 82.

Etheridge, 1878, *A Catalogue of Australian Fossils.* London. p. 113.

Etheridge, 1881, *Papers Proc. Roy. Soc. Tasmania* for 1880: 19.

Tenison Woods, 1883, PROC. LINN. SOC. N.S.W., (1), 8: 44.

Murray, 1887, *Victoria, Geology and Physical Geography.* Melbourne. p. 96.

Johnston, 1888, *Systematic Account of the Geology of Tasmania.* Hobart. p. 156. (Erroneously listed from Western Australia.)

UNIO DAINTREEI Clarke (*nomen nudum*).

Unio daintreei "McCoy" Clarke, 1867, *Quart. Journ. Geol. Soc. London*, 23: 10.

Remarks.

This name is apparently an error for *Unio dacombii* "McCoy" Selwyn and may have been published through confusion with the fossil plant *Taeniopteris daintreei* McCoy, 1860, which was found at the Wannon River with *Unio dacombii* and was validly described in McCoy's *Prodromus. Unio daintreei* has apparently not been used again.

(?) VELESUNIO HUTTONI, nom. nov. (Plate xiii, figs. 1-3.)

Unio inflata Hutton, 1873, *Catalogue of the Tertiary Mollusca and Echinodermata of New Zealand in the collection of the Colonial Museum*, p. 25, sp. no. 66. *Type Locality*: Morley Creek, Southland, New Zealand. (Not *Unio inflatus* Studer, 1820; not *Unio inflatus* D. H. Barnes, 1823; not *Unio inflata* Cristofori and Jan, 1832; not *Unio inflata* Hecart, 1833, *fide* Sherborn.)

Unio inflata Hutton, 1887, PROC. LINN. SOC. N.S.W., (2), 1: 229.

Diplodon inflatus (Hutton), Suter, 1915, *New Zealand Geol. Surv. Palaeont. Bull.* No. 3, Pt. 2: 56, Pl. 1, figs. 1, *a* and *b*.

Diplodon sp. Suter, 1921, *New Zealand Geol. Surv. Palaeont. Bull.* No. 8: 94.

Description. (After Suter.)

"Shell rather small, oval, ventricose, inequilateral, concentrically striated, the umbones much corroded. Beaks at about the anterior third of length, directed forwards, and incurved, inflated. Anterior end short narrowly rounded, the dorsal margin slightly convex. Posterior end about twice as long as the anterior, and more broadly convex, the dorsal margin straight, slowly descending, basal margin broadly rounded. Sculpture consisting of fine and close, somewhat unequal concentric striae, interrupted by more conspicuous periods of rest; the umbones corroded, smooth, with a few diverging ridges produced by pressure upon the thin pliable layer. Hinge unknown."

Remarks.

Through the courtesy of Dr. Charles Fleming, Senior Palaeontologist, Geological Survey Branch, D.S.I.R., New Zealand, I have been able to examine the holotype of this species, which was thought to have been lost (Suter, 1921), but is still in the collection of the Geological Survey.

It is well described by Suter, as reprinted above, and little more can be said about the holotype. Additional material referable to this species has been loaned by Dr. Fleming, from two localities in the Ohai Valley, Southland. None of the specimens examined has perfect beaks, but even in the best of them there is no trace of beak sculpture. Suter wrote "umbones . . . smooth", but this cannot be positively stated. None the less the shells recall in shape and variability the recent species of *Velesunio* from Australia, and on this basis, coupled with the apparent absence of sculptured beaks, the species is tentatively referred to the genus *Velesunio* Iredale.

The variation in shape is mostly due to elongation of the posterior end of the shell, as well as some variation in the slope of the dorsal margin, but the latter is probably due to distortion and breakage in some cases. One of the series from the Ohai Valley is the lot recorded by Suter (1921) as *Diplodon* sp. and for which he had proposed a manuscript name. Suter was unable to compare his specimens with the holotype of *Unio inflata* at the time, and so the name was not published.

If this species does in fact belong to the genus *Velesunio*, it is of considerable interest, as no species of velesunionine mussels occur in New Zealand today. The subfamily is probably the most primitive in this region, however, and appears to have existed in Australia since the Triassic. It is therefore not unlikely that a species of *Velesunio* could have developed in New Zealand during the Tertiary and since have become extinct.

Geological Age.—Hutton and Suter referred to the beds as Miocene, but Fleming informs me that all are Basal Oligocene (Whaingaroan) in age.

Dimensions.

Specimen(s).	Total Length.	Beak Length.	$\frac{\text{B.L.}}{\text{T.L.}}$	Maximum Height.	$\frac{\text{M.H.}}{\text{T.L.}}$	Beak Height.	Width.
	mm.	mm.	%	mm.	%	mm.	mm.
Holotype	49	16	32	31	64	27	27
New Birchwood Mine, Ohai Valley. Mean of 9 specimens	50	11	22	32	64	25	21
Above Smith's No. 6 Coal Seam, Ohai Valley. Mean of 2 ..	58	13	23	33	57	27	28

HYRIDELLA AUCKLANDICA (Gray).

Unio aucklandica Gray, Hutton, 1873, *Catalogue of the Tertiary Mollusca and Echinodermata of New Zealand in the collection of the Colonial Museum*, p. 25, sp. no. 65.

Diplodon menziesi aucklandicus (Gray), Suter, 1913, *Manual of the New Zealand Mollusca*, p. 941.

Remarks.

Hutton (1873) recorded the recent species *Hyridella aucklandica* (Gray) from a coal formation at Dunstan, Otago, but was doubtful as to the exact identity, as the specimen was poorly preserved. His brief description, without figures, is totally inadequate to determine the nature of the species which he had. Suter (1913), when describing the recent freshwater mussels of New Zealand, stated that this species (which he referred to the genus *Diplodon* Spix) occurred fossil "in the lignite beds of Dunstan, Otago, probably older Pliocene". Suter (1915) does not list the species in his Catalogue of the Tertiary Mollusca, so the age of the beds appears to be uncertain.

The location of Hutton's specimen is unknown. However, included in the material loaned by the New Zealand Geological Survey is a series of impressions in a fine indurated shale from quartzose coal measures on the Kawaran River, near Cromwell, Otago, belonging to the Taranaki Series of Miocene age. Two freshwater mussel species appear to be represented, including forms very similar to *H. aucklandica* and *H. menziesi*, two of the recent New Zealand species. One of the impressions is rather like the Australian species, *Hyridella depressa*, but could be a form of *H. menziesi.*

The form described by Etheridge as a variety of *U. aucklandicus* is treated next as a full species of the genus *Hyridella.*

HYRIDELLA WILKINSONI (Etheridge Jr.). (Plate xiii, fig. 4.)

Unio aucklandicus var. *wilkinsoni* Etheridge Jr., 1879, *Annual Report Dept. Mines*, New South Wales, for 1878, p. 169, Pl. 3, fig. 5. *Type Locality*: Home Rule Lead, Gulgong Goldfield, New South Wales, at a depth of 126 feet from the surface.

Unio aucklandicus var. *wilkinsoni* Etheridge Jr., Wilkinson, 1887, *Notes on the Geology of New South Wales*, 2nd ed., p. 76.

Description. (After Etheridge.)

"Shell oblongovate, very inequilateral, expanding a little posteriorly; anterior side very short and rounded; posterior side obliquely truncated and obscurely bi-angled; umbones quite anterior, decorticated and depressed; epidermis yellowish olive, delicately thread-striated on the posterior side, but almost quite smooth and shining on the anterior side and body of the shell; anterior muscle scars deep and well defined; pallial line well marked in the anterior portion.

"*Observations*: The state of preservation of the specimen does not permit of a more detailed description than the above, and as we have merely the exterior exhibited to us, the dental formula cannot be given. The characters of the anterior muscular impression and the pallial line are revealed by the accidental removal of the shelly matter, more especially in the left valve. During fossilization a slight amount of crushing has taken place. Otherwise the original form of the shell is perfectly well preserved."

To this can be added the following, based on a fine example of this species from the Victorian Pliocene or Pleistocene at Langi Logan Goldmine. The specimen is from the National Museum collection, No. P.16766.

Dorsal margin slightly elevated behind the beaks, then curving ventrally; posterior margin evenly rounded; ventral margin slightly sinuate in the middle; beaks situated at about one-sixth of the total length from the anterior end.

Remarks.

Etheridge, in describing this species, listed all the known recent species of freshwater mussels from Australia and concluded that it was most nearly related to *Unio aucklandicus* (Gray). Although the latter is a New Zealand species, it does resemble *wilkinsoni* in form, and is a member of the genus *Hyridella* Swainson. The form of the fossil shell leaves no doubt that it is a species of *Hyridella*, closely related to present-day forms, even though the key criterion for that genus, the beak sculpture, is not discernible. In fact it is very similar to the present-day species *Hyridella drapeta* (Iredale), to which *wilkinsoni* may well be ancestral. *H. aucklandica* could also have been derived from this source, as it seems likely that the New Zealand mussel fauna arose by a series of introductions from the Australian mainland.

Dimensions.

Specimen.	Total Length.	Beak Length.	B.L./T.L.	Maximum Height.	M.H./T.L.	Beak Height.	Width.
	mm.	mm.	%	mm.	%	mm.	mm.
Holotype (from figure), left valve	50	15	30	22	44	18	?
Right valve	53	15	27	26	49	24	?
Langi Logan Goldmine. N.M.V. P.16766	60	10	17	27	45	23	?
H. drapeta I. Manning R., N.S.W. (A.M.). Mean of 5..	66	15	23	37	56	32	21

Hyridella wilkinsoni is a little more elongate than typical specimens of *H. drapeta* from New South Wales and Victoria, though it is approached by some northern populations. The name *wilkinsoni* has many years' priority over *drapeta*, and partly for this reason the fossil is here admitted as a full species rather than a phyletic subspecies, because of the nomenclatural confusion which would result if the latter rank were given it.

Apparently only one specimen, the holotype, was found, and Etheridge was at the British Museum at the time of its description, but the type is apparently not in that collection. It cannot be located in the collection of the N.S.W. Geological Survey, so its whereabouts remain unknown.

Geological Age.—Etheridge gave the age of the Home Rule deep lead as Pliocene, though it may be older than this, possibly Oligocene. The Victorian specimen is of either Pliocene or Pleistocene age.

PROHYRIA, gen. nov.

Type species, Unio johnstoni Etheridge Jr., 1881.

Description.

Medium-sized to large freshwater mussels of the subfamily Velesunioninae, the anterior end moderately to markedly swollen, the posterior end drawn out into a bluntly rounded rostration, which is of maximum length at a position in the middle of the height of the shell; hinge well developed, with large cardinal teeth.

Remarks.

This genus is erected for two species of Australian fossil freshwater mussels, the type species *Unio johnstoni* from the Tertiary of the Launceston Basin, Tasmania, and *Unio eyrensis* Etheridge from the Triassic at Leigh's Creek, South Australia. Although there is an enormous time gap between these two occurrences, this is of little importance in freshwater mussels, which from all evidence evolve very slowly. The genus does not occur today, although there is a vague resemblance in form to the New Guinea species, *Microdontia anodontaeformis* Tapparone Canefri, and it is possibly genetically related. It must be remembered that taxonomic characters in the freshwater mussels are few and far between, and that fossilization renders particularly obscure those which are of most value, the hinge characters, muscle scars, and beak sculpture. Thus fossil genera will always be rather insecurely based, and must depend on similarities of form, which could be quite misleading.

PROHYRIA JOHNSTONI (Etheridge Jr.). (Plate xiii, figs. 6, 7.)

Unio johnstoni Etheridge Jr., 1881, *Papers & Proc. Roy. Soc. Tasmania* for 1880, pp. 20-21, figs. "1 & 2" (two figs. at top of first plate, unnumbered). *Type Locality*: Tamar River, between Whirlpool Reach and Georgetown, Tasmania.

Unio sp. Johnston, 1874, *Papers & Proc. Roy. Soc. Tasmania* for 1873, p. 47, Pl. 2, fig. 11.

Unio johnstoni Etheridge, Johnston, 1887, *Papers & Proc. Roy. Soc. Tasmania* for 1886, p. 134.

Unio johnstoni Etheridge, Johnston, 1888, *Systematic Account of the Geology of Tasmania,* Hobart, p. 274, Pl. 34, figs. 1 and 1*a*.

Description. (After Etheridge.)

"Shell transversely elongated, acuminated towards the posterior; anterior end convex and very gibbous; posterior end bluntly pointed, and gradually acuminated from the anterior end; anterior margin obliquely rounded downwards; posterior margin narrow and rounded; hinge line straight, gradually descending from the umbones towards the posterior end; ventral margin gently rounded or convex, entire, no sinuation; flanks of the shell most convex at a point on the anterior end midway between the beaks and the ventral margin, whence the sides rapidly decline to the latter, gradually flattening towards the pointed posterior end; diagonal ridge inconspicuous, rounded; posterior slope small; umbones large, broad, becoming somewhat flattened by decortication; shell substance moderately thick; surface coarse and rough on the anterior end, with strong, prominent, concentric lines of growth, which gradually flatten out into laminae on the posterior end; bent upwards at the rounded diagonal ridge; no sign of radiatory lines; dental and muscular characters unknown."

Five specimens of this well-characterized species are available in the collection of the Australian Museum, Nos. F.117, F.1653, and F. 17462-64, all from the Launceston Basin. They contribute little in the way of descriptive material, apart from the important fact that the beaks appear to be unsculptured. This indicates an affinity with the subfamily Velesunioninae, and agrees with the condition found in *Unio eyrensis* Etheridge.

Remarks.

Etheridge based this species on material found in the Milligan collection of fossils in the British Museum and considered Johnston's earlier record of *Unio* sp. from the Tertiary Muddy Creek beds on the West Tamar River to be the same form.

One of the Australian Museum specimens shows that the posterior end of the shell becomes very acuminated and this suggests that this species lived in a muddy environment. The present species differs from the other species in the genus, *Prohyria eyrensis*, in being more swollen anteriorly and more finely acuminate posteriorly.

The holotype of *P. johnstoni* is in the Milligan collection, British Museum No. 96928. Etheridge wrote "9628" in error.

Geological Age.—According to David (1950) the age of the beds is Oligocene.

Dimensions.

Specimen(s).	Total Length.	Beak Length.	$\frac{B.L.}{T.L.}$	Maximum Height.	$\frac{M.H.}{T.L.}$	Beak Height.	Width.
	mm.	mm.	%	mm.	%	mm.	mm.
Holotype (from Etheridge, and figure)	97	22	23	51	52	43	45
A.M. F.117	126	25	20	64	52	58	55
A.M. F.1653	60	12	20	29	50	24	24
A.M. F.17462–64. Mean of 3	84	20	24	44	55	39	34

* PROHYRIA EYRENSIS (Etheridge Jr.). (Plate xiii, figs. 8–12.)

Unio eyrensis "Tate" Etheridge Jr., 1892, (in) H. Y. L. Brown, Reports on the Coal-Bearing Area in the Neighborhood of Leigh's Creek, *South Australian Parliamentary Papers*, 1891, No. 158: 11, Pl. 3, figs. 1-3. *Type Locality*: Black Hills, near Leigh's Creek Railway Station, S.A.

Unio gregorianus "Etheridge m.s." Clarke, 1886, *Catalogue of Exhibits of the Queensland Court; Colonial and Indian Exhibition, London*, 1886, p. 165 (*nomen nudum*).

Unio gregorianus "Etheridge m.s." Etheridge Jr., 1892, (in) H. Y. L. Brown, Reports on the Coal-Bearing Area in the Neighborhood of Leigh's Creek, *South Australian Parliamentary Papers*, 1891, No. 158: 11 (*nomen nudum*).

Unio eyrensis "Tate" Etheridge Jr., 1892 (in) Jack and Etheridge, *Geology and Palaeontology of Queensland and New Guinea*, Brisbane, p. 389.

Unio eyrensis Etheridge, David, 1950, *Geology of the Commonwealth of Australia*, Vol. 1: 422 and 429.

Remarks.

This species was first described in 1892 from specimens received from Tate and H. Y. L. Brown, obtained at Leigh's Creek, South Australia. Etheridge adopted Tate's manuscript name "*eyrensis*". Previously, however, Etheridge had given a manuscript name (*Unio gregorianus*) to a specimen from the Bundanba Mine on the Ipswich Coalfield, Queensland. Clarke used this name in 1886 as a *nomen nudum*. When describing *U. eyrensis* for the first time, Etheridge commented on the occurrence of *U. gregorianus*, noting that it was close to *U. eyrensis*. He did not describe the Bundanba specimen as *gregorianus* at that place, and the name remained a *nomen nudum*. Etheridge later (1892, in Jack and Etheridge) described in detail a second occurrence

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* Out of chronological order.

of *U. eyrensis*, the locality being the Bundanba Mine, Queensland, but made no reference to the name *Unio gregorianus* there. It seems certain, however, that this Queensland specimen was the same shell as that which had been previously referred to as *U. gregorianus*, and that name is here listed as a synonym. Apparently Etheridge had decided in the intervening period that the two forms were after all referable to the same species, and either overlooked, or deliberately omitted, any reference to his earlier manuscript name.

No figure was given of the Bundanba specimen, but the description suggests that it was in fact the same as *U. eyrensis*.

Description. (After Etheridge.)

"Shell elongately or transversely nasute, or triangularly wedge-shaped, decreasing rapidly in convexity towards the posterior end; umbonal region fairly gibbous and convex, but the flanks decreasing rapidly towards the ventral margin, within the cast a more or less pronounced sulcus extending from behind the umbones to near the centre of the ventral margin. Hinge line straight, ventral margin rounded, passing rather sharply upwards into the anterior and posterior margins. Anterior end small, somewhat acutely curved, posterior end narrow, obtusely pointed. Umbones eroded; ligament long, large, and strong; cardinal teeth large; lateral teeth strong, diverging downwards from the hinge line or dorsal margin. Anterior adductor impressions obliquely conical, but not superficially large, vertically striated, and bounded posteriorly by a strong, subdentate ridge; supplementary anterior scars not visible; posterior adductor impressions feeble. Sculpture of coarse irregularly concentric lines.

". . . In all the specimens there is evidence that the umbones were very much eroded, and the surface in one or two was covered by a coarsely lined 'epitheca'. The hinge teeth appear to have been of the usual characters, a large cardinal in each valve interlocking, and now represented by casts; and long lateral teeth indicated by slits along the impression of the hinge line possessing a slight oblique downward trend."

The description of the Bundanba specimen differed slightly; the length was more than twice the height, and the anterior end was slightly produced.

I have been able to examine a specimen of this species from the National Museum collection, No. P.16767, which possesses the characteristic shape of the genus *Prohyria*, to which this species is referred. An internal cast in the Australian Museum, No. F.9081, from the Tate collection, is possibly a paratype and, although the posterior end is fractured off, shows the characters of the hinge and anterior muscle scars well, and again is similar to *Prohyria johnstoni* in form. A further specimen from the National Museum may belong to this species. It is No. P.16764, from Lake Eyre, and appears at first sight to be more regular in shape than the other specimens, with the beaks more medially situated. However, this may be due to breakage, as the growth lines indicate that the shape of the young shell was more like the *Prohyria* form. This specimen has perfect beaks, which are quite smooth, confirming the Velesunionine nature of the species, if indeed the specimen belongs here.

Types.

The species was described while Etheridge was Palaeontologist at the Australian Museum and the New South Wales Geological Survey, but was based on specimens received from South Australia. Thus the types are probably in South Australia, but do not appear to be in the Museum collection. As mentioned above, the specimen in the Australian Museum is possibly a paratype, while the National Museum specimen No. P.16767 is also probably from the type series. The Bundanba specimen should be in the collection of the Queensland Geological Survey (see below under *U. ipsviciensis*).

Geological Age.—According to David (1950), the age of the Leigh's Creek series is Triassic. The Queensland specimen was from ironstone in brick-clay overlying coal at the Bundanba Mine. The coal belongs to the Ipswich Series (Triassic), but the beds overlying these, the Bundanba Series, are of Lower Jurassic age. David (1950) notes that *U. eyrensis* occurs in the Denmark Hill shales at the top of the Ipswich Series and also records *Unio* from the Bundanba series. Presumably the former is the Bundanba Mine *U. eyrensis*.

Dimensions.

Specimen(s).	Total Length.	Beak Length.	B.L./T.L.	Maximum Height.	Beak Height.	M.H./T.L.	Width.
	mm.	mm.	%	mm.	mm.	%	mm.
Holotype (from Etheridge, and figure)	85	20	24	45	33	53	39
A.M. F.9081	68+ (=85 est.)	16	19	45	35	53	37
N.M.V. P.16767	102	24	24	59	49	58	50

ALATHYRIA TAMARENSIS (Etheridge Jr.).

Anodonta tamarensis Etheridge Jr., 1881, *Papers & Proc. Roy. Soc. Tasmania* for 1880, pp. 22-23, figs. "3 & 4" (two figs. at bottom of first plate unnumbered). *Type Locality*: Tamar River between Whirlpool Reach and Georgetown, Tasmania.

Anodonta tasmanica [sic] Johnston, 1887 (err. pro *A. tamarensis*), *Papers & Proc. Roy. Soc. Tasmania* for 1886, p. 131.

Anodonta "tasmanica Etheridge" Johnston, 1888, *Systematic Account of the Geology of Tasmania*, Hobart, p. 274, Pl. 34, figs. 2 and 2*a*.

Unio tamarensis (Etheridge), Dennant and Kitson, 1905, *Rec. Geol. Surv. Victoria*, 1: 123.

Description. (After Etheridge.)

"Shell transversely-obliquely-oval, generally compressed, in marginal outline obliquely hatchet-shaped; anterior and posterior ends compressed, sharp at the margins; anterior outline (margin) rounded; posterior outline obliquely truncated in the upper portion, rounded in the lower; hinge line horizontal, straight; ventral margin rounded obliquely from the anterior end; beaks near the centre of the hinge, but, as regards the whole shell, more anterior, not inflated, but much decorticated; diagonal ridge and posterior slope to all appearances not defined; convexity of the shell not great, the most convex point being below the beaks, at about the middle of each valve; angle formed by the hinge line and truncated posterior margin = 143°. Shell substance much eaten; surface decorticated, but apparently covered with numerous concentric superimposed layers of epidermal matter, following the marginal outline of the shell. . . . With the hinge characters I am quite unacquainted, the reference to *Anodonta* being made purely on external resemblance."

Remarks.

I have seen no specimens of this species, but the shape of the shell, the size and general appearance leave little doubt that it is related to the present-day genus *Alathyria* Iredale, and it is consequently listed as such. It has nothing to do with *Anodonta*, which is a holarctic genus, of comparatively recent origin, which has never occurred in this region. Etheridge found the holotype of this species in the Milligan collection in the British Museum, along with *Prohyria johnstoni*, and it is apparently known only from the unique holotype. The occurrence in Tasmania of a species of *Alathyria* in Tertiary time is of interest, as that genus is at present confined to the mainland of Australia and occurs for the most part in the warmer parts of the continent. It is possible that the genus has become extinct in Tasmania owing to the progressive cooling of the southern regions of the continent since the beginning of the Tertiary.

The holotype is in the Milligan collection, British Museum No. 96929.

Geological Age.—According to David (1950), the age of the beds of the Launceston Basin is Oligocene. Mr. Gill informs me that there is evidence that these beds are older, probably of Eocene age.

Dimensions.

Specimen.	Total Length.	Beak Length.	$\frac{\text{B.L.}}{\text{T.L.}}$	Maximum Height.	$\frac{\text{M.H.}}{\text{T.L.}}$	Beak Height.	Width.
	mm.	mm.	%	mm.	%	mm.	mm.
Holotype (from Etheridge, and figure)	91	30	33	57	63	49	32

UNIO MURRAYI Murray (*nomen nudum*).

Unio murrayi "McCoy" Murray, 1887, *Victoria, Geology and Physical Geography,* Melbourne, p. 96.

Remarks.

Murray writes as follows (p. 96): "Only two species of fossil fauna have been discovered in the Victorian Mesozoic rocks, viz. *Unio dacombi* (McCoy), found in the rocks of the Wannon, and *Unio murrayi* (McCoy), discovered in a piece of sandstone from near Loutit Bay." No record of such a species having been described can be found in the literature available to me. In the letter from McCoy in the National Museum (see above under *Unio dacombii*) the following is written: "The fossil specimen No. 3839 obtained by Mr. R. A. F. Murray and handed to me is an example of *Unio murrayi* (McCoy). This specimen is of great interest as the second example of a fossil of the animal kingdom from the Mesozoic coal-bearing formations of Victoria . . . . This . . . (with *Unio dacombii*) . . . will be figured and described in a forthcoming Decade of the Palaeontology of Victoria."

Mr. Gill has been able to locate the "type" specimen in the collection of the National Museum, No. P.16772-73, and it is identifiable by the No. 3839 on the specimen. Rather than validate the name by describing the specimen here, I prefer simply to state that it is a smallish species, rather similar to present-day forms of the genus *Velesunio.* It is, however, not very well preserved and it seems better to leave the name as a *nomen nudum* until better material is available. The relationship with *Velesunio* is doubtful, as the time gap between the age of the Victorian Coal Measures (Jurassic) and the present day is so great, and the taxonomic characters of *Velesunio* so negative that the resemblance could be due to convergence as much as genetic affinity.

Locality and Geological Age.—The specimen was found between Loutit Bay and Airey's Inlet in the Otway District, in a piece of sandstone. These rocks are of Lower Jurassic age according to Gill (personal communication).

PROTOVIRGUS, gen. nov.

Type species, Unio dunstani Etheridge Jr., 1888.

Description.

Mesozoic freshwater mussels of uncertain affinity, with very elongate shells, tapering posteriorly to a bluntly rounded posterior end; small to medium sized, the maximum height less than 48% of the total length; beaks apparently unsculptured, situated very much towards the anterior end, at between one-fifth and one-sixth of the total length; the maximum height of the shells at the position of the beaks, or just posterior thereto.

Remarks.

The shells described by Etheridge as *Unio dunstani* are very elongate freshwater mussels which differ from all other species, both recent and fossil, described from Australia. The occurrence, in New Zealand, of an undescribed Cretaceous species which is very similar in form to *U. dunstani* prompts me to erect the above new genus to include them. The name is based on the external resemblance in form to the present-day New Guinea genus *Virgus* Simpson, but is not intended to imply any direct genetic relationship.

Protovirgus dunstani (Etheridge Jr.). (Plate xiv, fig. 8.)

Unio dunstani Etheridge Jr., 1888, *Mem. Geol. Surv. New South Wales*, Palaeontology, No. 1: 11-12, Pl. 1, figs. 11-19. *Type Locality*: Ironstone bands in the Wianamatta Shale, Gibraltar Tunnel, Bowral.

Description. (After Etheridge.)

"Shell narrow, very transversely elongated, thin and compressed throughout its length, approaching to linguliform. Cardinal margin very long and slightly arched, ventral margin comparatively straight, sharp and knife-edge like. Anterior end very much compressed, the margin rounded, posterior end thin, attenuated, and very much compressed towards the margins, which are obliquely rounded, the posterior-ventral angle being almost pointed. Umbones placed close to the anterior end, small, and laterally flattened; flanks of the shell almost flat, diagonal ridges and posterior slopes but very faintly developed, the latter very faintly concave, and lost in the compressed posterior end. Anterior adductor impression fan-shaped, situated very high up under the anterior cardinal margin; umbonal scars very strongly marked, two immediately behind the adductor scars in a line, and close under the cardinal margin, the others clustered on the flank; posterior adductors faint and shallow. Pallial line well marked, with the impression of fibre scars at the anterior end. Ornament of very closely set concentric lines, with irregular glossy growth laminae.

"Observations . . . . It possesses the unmistakable outline of one section of the genus *Unio*, represented by such forms as *Unio grayanus* Lea . . . ."

The types are in the Australian Museum, but little can be added to the description from them. The beaks appear to be unsculptured, but are not perfect in any of the specimens. Etheridge erred in one important fact; the size of the figures on Plate 1, figs. 13-16, is given as half magnification when it should have been two times. This reduces the size of the shells from about 120 mm. in length (according to Etheridge's plate) to about 30 mm.

Remarks.

This species is readily separable from the other forms found in the Wianamatta Series by its elongate shape. As Etheridge indicated, it resembles the recent species *Lanceolaria grayanus* (Lea) in shape as much as it does *Virgus* Simpson, but once again the resemblance is undoubtedly superficial. It is probable that all three forms are the products of similar, but independent sets of selective factors, possibly associated with life in muddy streams.

Etheridge failed to make a holotype, the specimens in the Australian Museum, Nos. F. 35780, 35765, 35776, 35777, 35779 and 35693, being syntypes. The largest and most perfect specimen (Etheridge's figure No. 13) is here selected as lectotype (No. F.35776).

Geological Age.—The species occurs in the transition beds between the Hawkesbury Sandstone and the Wianamatta Group, which are considered to be Upper Triassic in age.

Dimensions.

Specimen(s).	Total Length.	Beak Length.	B.L./T.L.	Maximum Height.	M.H./T.L.	Beak Height.	Width.
	mm.	mm.	%	mm.	%	mm.	mm.
Lectotype	37	7	19	12	32	11	5
Lectoparatypes. Mean of 4 . .	28+	6	21	12	43	10	5

Protovirgus flemingi, sp. nov. (Plate xiv, figs. 1-3.)

Description.

Shell elongate, length from 2½ to 3 times the maximum height; beaks very anterior, situated about 20% of the total length from the anterior end. Anterior margin regularly rounded, ventral margin almost straight or slightly convex; dorsal margin behind the beaks falling away gradually towards the ventral margin; posterior margin sharply rounded; the shell rather wedge-shaped in lateral aspect. Surface of the shell smooth; beaks apparently unsculptured; shell surface marked with fine lines of growth. Shell apparently thin, compressed; hinge ligament prominent. Hinge teeth and muscle scars unknown.

Dimensions.

Specimen.	Total Length.	Beak Length.	B.L./T.L.	Maximum Height.	M.H./T.L.	Beak Height.	Width.
	mm.	mm.	%	mm.	%	mm.	mm
Holotype	58	11	19	20	35	18	?
Paratype N.Z.G.S. 5264 ..	53	11	21	20	38	17	?
Paratype N.Z.G.S. 5394 ..	52+	12	24	25	<48	20	?

The width of the shells cannot be measured, as the types are all embedded in a hard, slaty matrix (with the valves spread open in the holotype), but the shells seem to have been fairly compressed, probably not more than 10 or 15 mm. in total width of adjoined valves.

Types.

The holotype consists of counterparts of both valves, the outer surface only being visible. It is portion of lot No. 5364 in the collection of the New Zealand Geological Survey. A paratype is also present in the same lot, and consists of a perfect left valve. The specimens are in a fine slate and come from the Morgan Mine, Rewanui, Mawheranui Survey District. Additional paratypes are from lot No. 5394, New Zealand Geological Survey, from the Paparoa Coal Measures, Morgan East Dip, Liverpool Colliery.

Geological Age.—Dr. Fleming, to whom this fine species is dedicated, informs me that these beds are part of the Paparoa Group, of Upper Cretaceous age (approximately Lower Senonian).

Remarks.

Only a few well-preserved specimens are available, but they are so vastly different from all other New Zealand species that they demand description. The age of the fossils (Upper Cretaceous) is not too different from that of the Wianamatta species *P. dunstani*, which is Upper Triassic. The New Zealand species is considerably larger than the best available specimen of *P. dunstani*, but the latter probably grows to a larger size than the isolated specimens suggest. *P. flemingi* is more tapering in form than *P. dunstani*, which shows relatively little taper.

The Cretaceous *P. flemingi* is possibly a derivative of *P. dunstani*. The latter species may well have persisted through into Jurassic time in Australia. Unfortunately the Jurassic forms known from Victoria are undescribed and only *Unio murrayi* has been examined. It is possible that one of these *nomina nuda* was based on a species of *Protovirgus*.

It should be noted that one specimen associated with the Liverpool Colliery paratypes of *P. flemingi* (NZGS 5394) appears quite different, recalling some of the recent hyridelline species. It is not described here, however, for lack of sufficient material.

Genus UNIONELLA Etheridge Jr.

Unionella Etheridge Jr., 1888, *Mem. Geol. Surv. N.S.W.*, Palaeontology, No. 1: 12.
Type species by original designation, *U. bowralensis* Etheridge Jr., 1888.

Remarks.

Etheridge (1888) described four species of small freshwater bivalves from the Wianamatta "Shales" of the Sydney district. Of these, one species is very different and has been treated above under the name *Protovirgus dunstani*. The other three are all fairly similar, small species, but Etheridge placed one of them tentatively in *Unio*, though he was doubtful of its precise affinities, and the other two in a new genus, *Unionella.* Re-examination of all the type material of these three species has convinced me that they all belong to the one genus, and for this *Unionella* is available. It should be noted that the name has been missed by Neave and other recorders, and anticipates Haas' *Unionella* for recent forms. However, I am not sure that there are in fact three distinct species, especially in view of the fact that all three forms occur together in the one horizon. The forms differ slightly in shape and degree of obesity, but basically are rather similar. In fact, it is probable that Etheridge himself confused at least one of the shells (one of his types of *U. bowralensis* being closer to *U. wianamattensis*). It seems likely, on the basis of a knowledge of the variability of present-day freshwater bivalves, that all three are polymorphs or perhaps different ecophenotypes of one biological species. Furthermore, I am not at all sure that the shells have anything to do with the freshwater mussels. Etheridge was in some doubt as to their affinities, suggesting either Unionidae or Cyrenidae (= Corbiculidae), but he did state that they apparently did not possess the distinguishing features of the palaeozoic genera *Carbonicola* McCoy and *Anthracosia* King (Anthracosiidae). Study of some of the literature on this family has led me to the belief that they are in fact members of the same lineage. The Wianamatta shells bear a striking resemblance to some of the species figured in Trueman and Weir's (1946-54) monograph of this group, and the hinge characters seem to agree fairly well. Unfortunately the family Anthracosiidae in England and Europe is essentially Carboniferous. However, allied genera assigned to the family are recorded from Russia and also from the Karoo System of South Africa. The age of these beds appears to be late Permian, and the South African forms figured by Amalitsky (1895) are remarkably similar in form to the Wianamatta species, though they appear to differ in hinge characters. I cannot, at the present time, take this study any further, but wish to put forward the suggestion that *Unionella* is in fact a relict group of Anthracosiidae, which apparently flourished in Eurasia during late Palaeozoic time, but also became established in the southern continents towards the close of the Permian. Although it is not recorded from the Australian Permian, it may have only reached this portion of Gondwanaland at the beginning of the Triassic, by which time the group had become extinct in Europe.

It is also of interest to note that the variation observed in communities of Carboniferous Anthracosiidae is frequently as great as that which separates the three species named from the Wianamatta Group, and this lends strength to the hypothesis that *Unionella* includes but one variable species. However, the forms are described separately here for the sake of completeness, and it must be left to someone else to determine their true nature.

Description.

In describing the genus Etheridge commented as follows: "The undoubtedly eroded condition of the umbones indicates either Unionidae or Cyrenidae as their natural resting place; but with no genus in either family do they otherwise agree. The single condition of the adductor muscular impression and the faintly marked state of the posterior clearly separate the present shells from *Unio*, to which they are, however, related through the umbonal muscular scars and the exterior ligament. The absence of lateral teeth, which I believe do not exist in the present genus, shows a transition towards *Anodonta*, but there are no other characters in common . . . . The hinge structure, although not wholly known, is still sufficiently apparent to separate *Unionella* from any of the Cyrenidae. I have not been able to actually isolate a hinge line, but in numerous cases where the umbones have been dissolved and the anterior end of the shell decorticated, we are presented with the following features: Posterior to the umbones the hinge is perfectly straight; but in front of them there is a constant flexure, or double flexure, which seems to indicate the presence of cardinal teeth. I cannot, however, account for this appearance in any other way . . . . In some instances there is probably little difference between the dental formula of . . . *Unio* . . . and the structure observed in the Bowral shells. The eroded state of the umbones is so very marked in both the typical species, so much so in some individuals as to almost expose the interior cavity of the shell and render the umbonal muscular scars outwardly perceptible."

The following brief generic diagnosis is based on all three species:

Shells small, somewhat swollen, slightly or not at all winged posteriorly; the posterior ridge more or less prominent; beaks situated towards the anterior end, swollen, unsculptured; hinge with one cardinal tooth in each valve, fitting into a socket in the opposite valve. The maximum height about 50% of the total length. Shell surface not sculptured, marked only with fine growth lines, sometimes with prominent rest marks.

UNIONELLA WIANAMATTENSIS (Etheridge Jr.). (Plate xiv, figs. 4-5.)

Unio wianamattensis "Etheridge" Wilkinson, 1887 (*nomen nudum*), *Notes on the Geology of New South Wales*, 2nd ed., p. 76.

Unio wianamattensis Etheridge Jr., 1888, *Mem. Geol. Surv. New South Wales*, Palaeontology, No. 1: 10, Pl. 2, figs. 1-4.

Type Locality: Messrs. Goodlet and Smith's Brick Quarry at Crown Street, Waterloo, and Surry Hills.

Description. (After Etheridge.)

"Shell ovate-obliquely oblong, laterally compressed, thin. Dorsal margin or hinge line straight posteriorly, angulated at the anterior end, but in its entire length not as long as the shell; ligament small, and projecting but little above the dorsal margin. Ventral margin nearly straight, with a slight sinus at the middle. Anterior end small, very much compressed, and with the margin rounded; posterior end compressed, the margin obliquely truncated. Umbones small, obtuse, and ill defined, sometimes eroded; diagonal ridge well marked, although not strong; the flanks of the valves decrease rapidly in convexity from this ridge to the ventral margin, but an almost imperceptible sinus traverses them upwards from the ventral marginal inflection. Posterior slopes small, steep, and not concave. Internal characters of the cardinal margin unknown. Pallial line not deeply impressed. Small, deep, muscular pits, more or less arranged in a semicircle, occupy the umbonal cavity; anterior and posterior adductor impressions unknown. Surface with fine concentric ridges, subdivided by distant subimbricating growth laminae, the whole covered with a very regular and beautiful microscopically and longitudinally wrinkled epidermis."

Dimensions.

Specimen.	Total Length.	Beak Length.	B.L. / T.L.	Maximum Height.	M.H. / T.L.	Beak Height.	Width.
	mm.	mm.	%	mm.	%	mm.	mm.
Lectotype F.35775	16	4	25	8	50	7	5
Lectoparatype F.35773 ..	15	4	27	8	53	7	4
U. bowralensis, syntype F.35767	16	4	25	9	56	8	5

Remarks.

As indicated above under the remarks on the genus, this species, though classified tentatively by Etheridge in *Unio*, seems to belong with the other small species in *Unionella*. The type series of this form came from Waterloo, but included among the separated specimens are some which are closer to *U. bowralensis*. Also, as mentioned above, one of the syntypes of *U. bowralensis* is much closer to the *wianamattensis* form and is included below in the table of dimensions.

Little further can be added to Etheridge's description; the hinge characters are still unknown.

No holotype was selected for this species, the syntypes being numbers F.35773, F.35775, F.35781 in the collection of the Australian Museum. Of these, No. F.35775 is the most perfect isolated specimen, and is here selected as lectotype, and is the specimen figured on Plate 2, figs. 1, 2 and 3. Other specimens are available from Croydon, but the specimens from Surry Hills recorded by Etheridge are not present.

Geological Age.—The beds from which this species was taken are among the transition beds between the Hawkesbury Sandstone and the Wianamatta Group, and are of Upper Triassic age.

UNIONELLA BOWRALENSIS Etheridge Jr. (Plate xiv, fig. 6.)

Unionella bowralensis Etheridge Jr., 1888, *Mem. Geol. Surv. New South Wales*, Palaeontology, No. 1: 13, Pl. 1, figs. 21-23, Pl. 2, figs. 8-14.

Type Locality: Ironstone bands in the Wianamatta Shale, Railway Cutting near Gibraltar Tunnel, Bowral, New South Wales.

Description. (After Etheridge.)

"Shell short, somewhat nasute, moderately convex, compressed and rather sharply produced posteriorly. Cardinal margin to some extent arched, ligament small, short; ventral margin slightly convex. Anterior end shorter and much more gibbous than the posterior; margin rounded. Posterior end small, obtusely pointed; margin rounded, obliquely so above. Umbonal region and body of the shell gibbous, and rapidly declining to the ventral margin. Umbones depressed and inconspicuous; at times much eroded; diagonal ridge rounded, inconspicuous; posterior slope hardly differentiated from the general body of the shell. Anterior adductor impressions deep; umbonal scars extending in a line from the anterior adductor into the umbonal cavity, and there clustered. Ornament of fine concentric lines, with distant laminae of growth.

"Obs. . . . This, the most abundant form at Bowral, is distinguished from (*U. carnei*) by its much shorter and nasute outline. The cardinal margin is shorter and the upper part of the posterior margin more obliquely directed. The flanks of the shell also appear to be more evenly rounded."

Remarks.

This form, the type species of *Unionella*, is the most distinct of the three and is characteristically swollen anteriorly, with the posterior-ventral portion of the shell produced to an almost sharp point. As mentioned above, it is included among the syntypes of *U. wianamattensis*. Little further can be added to Etheridge's description from the material available in the Australian Museum. This includes the syntypes, Nos. F.35763, F.35767 (= *U. wianamattensis*), F.35768, F.35769, F.35770, F.35771, F.35772, F.35774, and a block of specimens of this species and *Protovirgus dunstani*, F.35693. No holotype was selected, and I therefore select specimen No. F.35770 as lectotype. This is the specimen figured on Plate 2, figure 12, and is perhaps the most typical of this form; beside this, it also shows the hinge characters of the species well. The latter, which are mentioned in the genus description, consist of a large cardinal tooth in each valve, fitting into an opposing socket in the opposite valve.

Geological Age.—This species occurs at the same horizon and locality as *Protovirgus dunstani*, and the beds are of Upper Triassic age.

Dimensions.

Specimen(s).	Total Length.	Beak Length.	$\frac{\text{B.L.}}{\text{T.L.}}$	Maximum Height.	Beak Height.	$\frac{\text{M.H.}}{\text{T.L.}}$	Width.
	mm.	mm.	%	mm.	mm.	%	mm.
Lectotype	13	4	31	7	6	54	5
Lectoparatypes. Mean of 4, F.35771, 768, 769 and 765 ..	10	4	40	7	5	70	5

UNIONELLA CARNEI Etheridge Jr. (Plate xiv, fig. 7.)

Unionella carnei Etheridge Jr., 1888, *Mem. Geol. Surv. New South Wales*, Palaeontology, No. 1, 14, Pl. 1, fig. 20, Pl. 2, figs. 5-7.

Type Locality: Ironstone bands in the Wianamatta Shale, Railway Cutting near Gibraltar Tunnel, Bowral, New South Wales.

Description. (After Etheridge.)

"Shell quadrangular-oblong, longer than high, thick, produced posteriorly. Cardinal margin long, erect, and straight, but not as long as the shell; ligament small, short. Ventral margin straight. Anterior end small, the margin rounded; posterior end produced, somewhat obliquely truncated, and slightly produced ventrally. Umbonal region and body of the shell towards the posterior broad and gibbous; umbones depressed and rather incurved, usually very much eroded, placed at about one-fourth from the anterior end; diagonal ridge very prominent and strongly marked; sharp towards the umbones; posterior slope wide and flattened, or inclined to the concave, becoming straight-walled under the erect cardinal margin. Anterior adductor impression elongately triangular, strongly marked; posterior impression on the diagonal ridge; umbonal scars similar to those of the last species (*U. bowralensis*), and very strongly marked. Ornament consisting of very fine regular lines, with distant laminae of growth, but the former sharply sinuous or deflected in the region of the anterior adductor.

"Obs.—The quadrangular outline, erect and straight hinge line, and very marked diagonal ridge are characters not met with in the preceding species.

"A peculiar inflection of the fine ornamenting lines of the surface is observable in *U. carnei.* In front of the pronounced anterior cardinal muscular scars the strong ridge separating the latter from the body of the shell is represented outwardly by a slight depression of the surface or sinus. In passing over this, the fine linear ornament is waved or inflected, and becomes a very important feature of this species. Sometimes it is very marked, at others faint, but invariably present in one form or the other."

Remarks.

This form, which is larger and relatively longer than either *bowralensis* or *wianamattensis*, is represented by only three specimens in the material available, Nos. F.35764, F.35766 and F.35778 in the Australian Museum collection. One of these specimens (F.35778) is rather similar to *wianamattensis* in form, but the other two are characterized by the marked posterior ridge, the swollen form of the shell, and the elevation of the posterior dorsal margin.

All three specimens are syntypes, and of these, No. F.35766 is here chosen as lectotype, being the specimen figured on Plate 1, fig. 20, and the better preserved of the typical *carnei.*

Geological Age.—As in the last species, with which this form is apparently sympatric, the beds are of Upper Triassic age.

Dimensions.

Specimen.	Total Length.	Beak Length.	$\frac{B.L.}{T.L.}$	Maximum Height.	$\frac{M.H.}{T.L.}$	Beak Height.	Width.
	mm.	mm.	%	mm.	%	mm.	mm.
Lectotype	18	5	28	9	50	7	8
Lectoparatype F.35764 ..	18	6	33	9	50	8	8
Lectoparatype F.35778 . ..	17	3	18	8	47	7	7

"ANODONTA" GOULDII Johnston.

Anodonta gouldii Johnston, 1888, *Systematic Account of the Geology of Tasmania*, Hobart, p. 84, Pl. 34, fig. 5.

Remarks.

This species is mentioned by Johnston (p. 84) as coming from clay or sandy slate beds at Fingal, Tasmania, and is called *Anodonta gouldii* on that page. No description is offered, but on Plate 34, along with other freshwater mussel species, *A. gouldii* is figured and the specific name is therefore valid. According to David (1950), the age of the Fingal Slates is either Upper Silurian or Lower Devonian, and they are therefore very much older than the earliest known fossil freshwater mussel.

The figure shows a shell which does resemble a freshwater mussel, but it is so poor that it could represent almost any bivalve. Many important details are not shown and little further can be said about the species until the type is located and examined. I feel sure that it will prove to belong to some other group of pelecypods, unless some error in locality or horizon has occurred.

The type is probably in the Tasmanian Museum, Hobart.*

"UNIO" ETHERIDGEI Johnston.

Unio etheridgei Johnston, 1888, *Systematic Account of the Geology of Tasmania*, Hobart, Pl. 34, figs. 4 and 4*a*, plate caption.

Remarks.

Once again Johnston has failed to describe a species which is figured and named in the plates of his Geology of Tasmania. This form does not receive even as much as a mention in the text, but the plate caption bears the species name and the locality—Launceston Tertiary Basin.

The shell does not look like a freshwater mussel at all, but is probably one of the large brackish water shells of the family Geloinidae, a tropical group which occurs today in the waters of northern Australia and elsewhere. Although this group does not occur in Tasmania today, it could well have done so under the warmer climatic conditions which existed during the Tertiary. Once again, examination of the type material, possibly preserved in the Tasmanian Museum,* is the only way that the nature of this form can be determined. In either case, the specific name is validly introduced, the figure theoretically constituting sufficient description.

MESOHYRIDELLA, gen. nov.

Type species, Unio ipsviciensis Etheridge Jr., 1892.

Description.

Small freshwater mussels of uncertain affinity, but possibly belonging to the subfamily Hyridellinae. Shells elongate-oval, not winged, moderately swollen. Dorsal margin behind the beaks more or less straight, then curving rather sharply downwards, and descending obliquely to form a rather blunt posterior end with the ventral margin. Beaks not elevated or swollen, heavily corroded, sculptural characters unknown. Shell surface marked with fairly strong growth lines. Hinge characters and muscle scars unknown.

Remarks.

This genus is erected on rather negative taxonomic characters, but is considered necessary as the resting place for the mesozoic species, *U. ipsviciensis* Etheridge, which does not seem to belong with any of the other described recent or fossil forms. The name is based on the vague resemblance which the species bears to some of the recent species of *Hyridella*, but should not be taken to imply any definite genetic affinity.

MESOHYRIDELLA IPSVICIENSIS (Etheridge Jr.). (Plate xiii, fig. 5.)

Unio ipsviciensis Etheridge Jr., 1892, (in) Jack and Etheridge, *Geology and Palaeontology of Queensland and New Guinea*, Brisbane, p. 388, Pl. 42, figs. 2 and 3. *Type Locality*: Shaft of the Bremer Basin Colliery at a depth of 200 feet.

Unio sp. Etheridge, 1891, (in) H. Y. L. Brown, Reports on the Coal-Bearing Area in the Neighborhood of Leigh's Creek, *South Australian Parliamentary Papers*, No. 158: 11.

Unio sp. David, 1950, *Geology of the Commonwealth of Australia*, Vol. 1: 429.

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* The Director of the Tasmanian Museum has subsequently informed me that the types of these two species cannot be located in the collections of that Museum.

Description. (After Etheridge.)

"Transversely elongated, narrow, wedge-like, sub-acute posteriorly. Dorsal or cardinal margin short, much less than the length of the shell; ventral margin generally rounded, but straight towards the centre. Anterior end short and rounded; posterior end produced and obtusely pointed. Umbones small, quite anterior, and much eroded. No true posterior slope, but the flanks insensibly graduating into the posterior end. Surface roughened with corrugations."

I have been able to examine a specimen from the lower Jurassic siltstone of Korrumburra, Gippsland, Victoria, from the National Museum collection, No. P.16768–69, which seems to agree fairly well with the rather meagre description and poor figure of this species. The shell is not perfect and the corrosion of the beaks is too great to give any further information on the generic affinity of the species.

The other references cited in the synonymy include a specimen mentioned by Etheridge as *Unio* sp. in connection with the description of *Prohyria eyrensis* from Lake Eyre. This specimen, which was compared favourably with the "undescribed species from the Bremer Basin Coal Shaft at a depth of 200 feet" (i.e. *ipsviciensis*), was a somewhat distorted example taken from a bore core at Leigh's Creek, at a depth of 622 feet. It was about two inches in length, but crushed and firmly attached to the matrix, and Etheridge was unable to give any other characters. He did say, however, that it differed from *U. gregorianus* (= *Prohyria eyrensis*) and also from two other species (at that time, and still, undescribed) from the Rolling Downs formation. It seems likely that the specimen was an example of *M. ipsviciensis*, especially in view of the fact that another species, *P. eyrensis*, also occurs at Leigh's Creek and the Ipswich coalfield.

The type of *Mesohyridella ipsviciensis* has not been located. Etheridge makes no mention of the location of his specimen, but states in the introduction of the volume (p. xv) "the absence of such references will, in the great majority of instances, infer that the fossils are in the collection of the Queensland Geological Survey". Unfortunately that collection is packed away and is not available for study at the present time.

Geological Age.—The beds from which the type specimen came are at the top of the Ipswich Series, and are of Upper Triassic age. According to Gill, the Victorian specimen from Korrumburra is of Lower Jurassic age.

Dimensions.

Specimen.	Total Length.	Beak Length.	B.L./T.L.	Maximum Height.	M.H./T.L.	Beak Height.	Width.
	mm.	mm.	%	mm.	%	mm.	mm.
Holotype (from figure) ..	36	8	22	19	53	18	14
Korrumburra P.16768–69 ..	35	8	23	17	49	15	11

UNIO STIRLINGI Ferguson (*nomen nudum*).

Unio stirlingi Ferguson, 1909, *Mem. Geol. Surv. Victoria*, 8: 3.

Unio stirlingi David, 1950, *Geology of the Commonwealth of Australia*, Vol. 1: 467.

Remarks.

This name has been most elusive and after much searching the earliest reference I have found is Ferguson (1909), who simply mentions the species as coming from the Jurassic rocks of Victoria.

David (1950) repeats the usage by stating that "*Unio stirlingi* is not uncommon in the South Gippsland beds . . . ."

In neither place is any description or figure offered. The South Gippsland beds are of Middle Jurassic age.

A specimen from the National Museum collection, No. P.16774, is labelled *Unio stirlingi* and comes from Burnes or Burries Creek, the label being rather illegible. Neither Gill nor I have been able to find this locality on available maps. The specimen is in poor condition and may or may not have anything to do with the original shell which was to be named *Unio stirlingi.* The fossil vaguely resembles some of the recent species of *Hyridella.*

VELESUNIO JAQUETI (Newton).

Unio jaqueti Newton, 1915, *Proc. Malac. Soc. London*, 11: 230-231, Pl. 6, figs. 2-6. *Type Locality*: Lightning Ridge, New South Wales.

Unio sp., Newton, 1915, *Proc. Malac. Soc. London*, 11: 232, Pl. 6, fig. 1.

Unio sp., David, 1950, *Geology of the Commonwealth of Australia*, Vol. 1: 487.

Description. (After Newton.)

"Shell elongately oval, narrow; dorsal margin slightly sloping to posterior extremity; dorsal and ventral borders subparallel; umbones anterior, eroded; valves compresso-convex; posterior region produced and slightly narrowing at the end, anterior and ventral borders rounded; sculpture exhibiting concentric growth lines, crossed by numerous closely set fine radial striations."

Remarks.

Two opalized specimens of *Unio jaqueti* were described, both somewhat imperfect. A third specimen listed as *Unio* sp. appears from the shape to belong to this species also, and is so listed in the synonymy.

I examined Newton's types superficially at the British Museum and, apart from confirming the fact that the species could belong with the recent genus *Velesunio*, I can add little to the description. The shell is rather featureless, but recalls very much in outline the recent species *V. wilsonii*, which lives today throughout the arid regions of central and northern Australia.

This species extends the range of *Velesunio* back into the Mesozoic. However, I have no hesitation in so doing, for the genus today exhibits many features which mark it as a very primitive group. It is rather unspecialized in anatomical characters, and the lack of any trace of beak sculpture, as well as the simple hinge construction, suggests that it could be an ancient group which has survived in Australia through its long isolation. Furthermore, there is some resemblance between the recent species of *Velesunio* and the undescribed Jurassic species *U. murrayi* Murray.

The types came from both Lightning Ridge and White Cliffs, but the holotype, which is specimen No. L.21833 in the British Museum collection, is from Lightning Ridge, which should be regarded as the restricted type locality. The paratype was in the F. St. J. Thackeray collection, which is now in the British Museum.

Geological Age.—The age of the opal-bearing beds at Lightning Ridge and White Cliffs is Cretaceous, but, according to David (1950), their exact position in the Cretaceous sequence is doubtful.

Dimensions.

Specimen.	Total Length.	Beak Length.	$\frac{\text{B.L.}}{\text{T.L.}}$	Maximum Height.	Beak Height.	$\frac{\text{M.H.}}{\text{T.L.}}$	Width.
	mm.	mm.	%	mm.	mm.	%	mm.
Holotype	42	11	26	20	17	48	12
Paratype	37+ (=52 est)	17	33	22	20	42	15

HYRIDELLA WHITECLIFFSENSIS (Newton).

Unio whitecliffsensis Newton, 1915, *Proc. Malac. Soc. London*, 11: 231, Pl. 6, figs. 7 and 8. *Type Locality*: White Cliffs, New South Wales.

Unio sp., David, 1950, *Geology of the Commonwealth of Australia*, Vol. 1: 487.

Description. (After Newton.)

"Shell of small size, with moderately inflated valves, length about 1½ times the height; umbonal regions anterior, coarsely rugose or marked with strong widely V-shaped costae; anterior margin rounded, posterior side with an elongate, abrupt, oblique, and narrow angulate ridged area, in front of which the valve is slightly excavated. Sculpture beyond the V-shaped costal rugosities of the umbonal area consists of periodic growth-divisions, and numerous closely set, microscopical concentric striations, which at the posterior ridge become angulate, and take an upwardly oblique direction on the surface of the posterior area . . . . Umbones themselves . . . not present."

Remarks.

This species, like the last, was found in an opalized state but in this case is quite well preserved. The figure shows well the strong V-shaped sculpture on the beaks of this young specimen, which proves it to be closely related to the members of the subfamily Hyridellinae. There are two genera of recent Hyridelline mussels in Australia today, *Hyridella* and *Protohyridella.* The latter genus has the V-shaped sculpture extending well down the sides of the shell, while the former has the sculpture confined to the beaks. Considering the young age of the holotype of this species (as indicated by its size) it is not possible to say exactly to which genus the species belongs, but a brief examination of the type in the British Museum suggests the former as its correct resting place. Once again this takes the range of a recent genus back to the Cretaceous, and *Hyridella* is probably a more advanced group than *Velesunio.*

Whatever its correct generic affinity, there can be no doubt that the fossil species belongs with the Hyridellinae, which therefore must also be regarded as an ancient group. This suggests the possibility that the Triassic-Jurassic form described above as a new genus, *Mesohyridella*, may be ancestral to the true Hyridellinae of Cretaceous, Tertiary and Recent times.

The holotype is in the British Museum, in the F. St. J. Thackeray collection, No. L.26362.

Geological Age.—As in the last species, this form is of Cretaceous age.

Dimensions.

Specimen.	Total Length.	Beak Length.	B.L./T.L.	Maximum Height.	Beak Height.	M.H./T.L.	Width.
	mm.	mm.	%	mm.	mm.	%	mm.
Holotype	22	4	18	15	10	68	10

HYRIDELLA DEPRESSA (Lamarck).

Unio depressa Lamarck, Dennant and Kitson, 1903, *Rec. Geol. Surv. Victoria*, 1: 146.

Remarks.

In their table of Pliocene and Pleistocene fossils recorded from South Australia, Victoria and Tasmania, Dennant and Kitson record Lamarck's recent species *Hyridella depressa* from Coleraine. The two specimens on which this record is based are in the collection of the South Australian Museum, unregistered, from the Tate collection, *ex* Dr. J. C. Verco. They are labelled "*Rugoshyria cultelliformis*" (a subjective synonym of *H. depressa*) "from Victoria, Coleraine, Fossil, Dennant". They are quite well-preserved specimens, and can almost certainly, from their form, be assigned to the genus *Hyridella.* It is quite possible that they are in fact specimens of *H. depressa*, especially as that species occurs in Victoria today, and was undoubtedly living there during Pliocene and Pleistocene times.

A specimen in the National Museum collection, No. P.16765, supposedly from the Tertiary rocks at the Hopkins River, near Warrnambool, is rather poorly preserved, but appears to belong here also. Mr. Gill is in some doubt as to the correctness of the locality of this specimen.

Dimensions.

Specimen.	Total Length.	Beak Length.	B.L./T.L.	Maximum Height.	Beak Height.	M.H./T.L.	Width.
	mm.	mm.	%	mm.	mm.	%	mm.
Coleraine (S.A. Museum)—							
Specimen 1	45	11	24	27	21	60	14
Specimen 2	48	11	23	25	23	52	19
H. depressa. Recent (A.M.). Mitchell R., Vict.	65	15	23	33	28	53	20

VELESUNIO AMBIGUUS (Philippi).

Unio ambiguus Philippi, 1847, *Abbildung. neuer Conchyl.*, 3, *Unio*, Pl. 3, fig. 2, p. 7 (47) (Recent. *Type Locality*: Australia.)

Unio (Hyridella) protovittatus Hale and Tindale, 1930, *Rec. South Australian Mus.*, 4: 134, figs. 8 and 9. *Type Locality*: "Layer C" at Tartanga, Murray River Valley, South Australia.

Remarks.

The well-known species *Velesunio ambiguus* is undoubtedly the most common, most widespread, and most variable of the recent Australian freshwater mussels. Hale and Tindale (1930) described some shells from sub-recent Aboriginal deposits at Tartanga and nearby localities as a new species, *U. protovittatus*, on the grounds that the sub-recent shells were consistently thicker in shell substance than the recent *U. vittatus*. The latter name applies to one of the several variations of *V. ambiguus* and is characterized by a thin, relatively high shell (normal *V. ambiguus* possessing a moderately thick shell). The contrast between the thick-shelled sub-fossil mussels and the thin recent form is thus somewhat misleading. Furthermore, it is well known that shells of both land and freshwater molluscs which are buried in soil for many years become thickened by secondary deposition of calcium salts, and it seems likely that this accounts for some of the difference observed in the Tartanga shells.

Carbon 14 dating of the beds indicates an age of about 6,000 years (Tindale, personal communication). Dr. I. D. Hiscock, of the University of Queensland, has examined Hale and Tindale's type material and does not consider the form to be of taxonomic value. I therefore place it in the synonymy of *Velesunio ambiguus*.

The type specimens are in the South Australian Museum, registered No. P.178 (*fide* Hale and Tindale, 1930).

Dimensions.

Specimen.	Total Length.	Beak Length.	B.L./T.L.	Maximum Height.	Beak Height.	M.H./T.L.	Width.
	mm.	mm.	%	mm.	mm.	%	mm.
Holotype, *U. protovittatus* (from figure)	70	20	29	52	49	74	28
Recent *V. ambiguus* " vittatus " form. Murray R., S.A. Mean of 5 specimens ..	55	14	25	38	34	69	20

CONCLUSIONS.

It will be seen from the foregoing review that a great deal more material must be collected and studied before the fossil freshwater mussels of Australia and New Zealand are properly known. No fossils are known to date from the New Guinea region, though the recent fauna is apparently rich and is directly related to that of Australia.

In addition to the named forms listed here, a number of additional references to the finding of freshwater mussel fossils can be found in literature, but in these cases no scientific name has been used other than *Unio*, and they have not been dealt with here. Many such references can be found in David (1950). Some additional material is to be found in the several collections, and these may represent further new species. Thus there is a small *Unionella*-like form occurring in the Hawkesbury Sandstone at Brookvale, N.S.W., and a poorly preserved shell from Pleistocene rocks at Inverell, N.S.W., which appears quite different from any known species. The New Zealand Geological Survey collection contains some impressions of Tertiary forms which may or may not be the same as the recent New Zealand species. There is also the shell associated with the paratypes of *Protovirgus flemingi* from the Liverpool Colliery, which is quite unlike any other Cretaceous species.

However, it should be remembered that this essay is only a preliminary attempt to bring together the named forms, and it is quite likely that many references have been overlooked. It is to be hoped that a comprehensive study of the group will soon be made, as the resulting knowledge should prove of value to palaeontologist and neontologist alike.

It is hoped that an account of the evolutionary history and relationships of the freshwater mussels of the Australasian region, both fossil and recent, will soon be published.

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EXPLANATION OF PLATES XIII-XIV.

(Photographs by Howard Hughes, Australian Museum.)

Plate xiii.

All figures approximately two-thirds natural size.

Fig. 1. *Unio inflata* Hutton (= *Velesunio huttoni* McMichael.) Holotype. New Zealand Geological Survey.

Fig. 2. *Velesunio huttoni* McM. New Birchwood Mine, Ohai, New Zealand. New Zealand Geological Survey.

Fig. 3. *Velesunio huttoni* McM. New Birchwood Mine, Ohai, New Zealand. Specimen crushed dorso-ventrally, showing beaks, ligament. New Zealand Geological Survey.

Fig. 4. *Hyridella wilkinsoni* (Etheridge). Langi Logan Gold Mine, Victoria. N.M.V. P. 16766.

Fig. 5. *Mesohyridella ipsviciensis* (Etheridge). Korrumburra, Gippsland, Victoria. N.M.V. P. 16768-69.

Figs. 6, 7. *Prohyria johnstoni* (Etheridge). Tamar River, Tasmania. A.M. F.117.

Fig. 8. *Prohyria eyrensis* (Etheridge). Leigh's Creek, South Australia. Possible paratype. A.M. F.9081.

Figs. 9, 10. *Prohyria eyrensis* (?) (Etheridge). Lake Eyre, South Australia. N.M.V. P.16764.

Figs. 11, 12. *Prohyria eyrensis* (Etheridge). Leigh's Creek. South Australia. Possible paratype. N.M.V. P.16767.

Plate xiv.

Figures 1 to 3 approximately natural size; figures 4 to 8 approximately 1½ times.

Figs. 1, 2. *Protovirgus flemingi* McM. Holotype, counterparts. Morgan Mine, Rewanui, Mawheranui Survey District, New Zealand. New Zealand Geological Survey No. 5264.

Fig. 3. *Protovirgus flemingi* McM. Paratype. New Zealand Geological Survey No. 5264.

Fig. 4. *Unionella wianamattensis* (Etheridge). One of the syntypes of *Unionella bowralensis* Etheridge. A.M. F.35767.

Fig. 5. *Unionella wianamattensis* (Etheridge). Lectotype. Brick quarry at Crown Street, Waterloo. A.M. F.35775.

Fig. 6. *Unionella bowralensis* Etheridge. Lectotype. Gibraltar Tunnel, Bowral, N.S.W. A.M. F.35770.

Fig. 7. *Unionella carnei* Etheridge. Lectotype. Gibraltar Tunnel, Bowral, N.S.W. A.M. F.35766.

Fig. 8. *Protovirgus dunstani* (Etheridge). Lectotype. Gibraltar Tunnel, Bowral, N.S.W. A.M. F.35776.

REVISION OF THE GENUS *PODOLEPIS* LABILL.

By Gwenda L. Davis, Department of Botany, University of New England,
Armidale, N.S.W.

(One hundred and fifty-three Text-figures.)

[Read 31st October, 1956.]

Synopsis.

All described species have been critically examined and sixteen found to be valid. These, with two new species and one new variety, have been redescribed with text-figures of habit, chief diagnostic characters and distribution maps.

An introductory section includes a brief historical account of the genus and explanations of the taxonomic procedure adopted.

The taxonomic section is followed by a discussion of the origins and affinities of the species and suggestions are made as to the speciation processes at work within the genus.

INTRODUCTION.

Historical.

The genus *Podolepis* Labill. is widely spread throughout Australia where it is represented by eighteen species, only one of which extends to Tasmania.

The type-species, *P. rugata*, was described and figured by Labillardière (1806) from material he collected in Western Australia "in terrâ Van-Leuwin". In the same year, Sims erected the monotypic genus *Scalia* (*S. jaceoides*) to accommodate a plant grown in England from seeds collected in New South Wales.

Between 1806 and 1852 five other generic names were added to the literature: *Stylolepis* (*S. gracilis* Lehm., 1828), *Siemssenia* (*S. capillaris* Steetz, 1828), *Panaetia* (*P. Lessoni* Cass., 1829), *Scaliopsis* (*S. Lucaeana* Walp., 1840) and *Rutidochlamys* (*R. Mitchellii* Sond., 1852).

De Candolle (1838) recognized eight species of *Podolepis* and relegated the genera *Scalia* Sims and *Stylolepis* Lehm. to synonymy under *P. acuminata* R. Br. and *P. gracilis* Grah., respectively, and at the same time he transferred both *P. ferruginea* (Labill.) DC. and *P. rosmarinifolia* (Labill.) DC. to the genus *Ozothamnus*.

Bentham (1866) extended the generic concept still further by incorporating in it the genera *Scaliopsis* Walp., *Rutidochlamys* Sond., and *Siemssenia* Steetz, and recognizing twelve species of *Podolepis*.

Subsequent taxonomic history was concerned only with nomenclature and descriptions of new species.

The table (p. 246) sets out, in chronological order, the history of the genus and the taxonomic fate of all described species and varieties.

Distribution.

Podolepis Labill. is confined to Australia, and of the eighteen species described in this Revision only three are recorded in four or more of the States, and the remainder are confined to the eastern, southern or western portions of the Continent. New South Wales and Western Australia have the largest number of species, nine and eleven respectively, while only a single one represents this genus in Tasmania.

It is probable that further collecting in the northern regions of Australia will extend considerably the known range of many species, as well as producing others which are undescribed. This applies particularly to the large area of country north and east of the Fortescue River (W.A.), from which no species of *Podolepis* is recorded.

Date.	Name.	Current Name.
1806	*Podolepis rugata* Labill.	*Podolepis rugata* Labill.
	Scalia jaceoides Sims.	*P. jaceoides* (Sims) Voss.
1813	*P. acuminata* R.Br.	*P. jaceoides* (Sims) Voss.
1828	*Stylolepis gracilis* Lehm.	*P. gracilis* (Lehm.) R. Grah.
	S. gracilis Lehm. var. *glabra* Lehm.	*P. gracilis* (Lehm.) R. Grah.
	S. gracilis Lehm. var. *arachnoidea* Lehm.	*P. gracilis* (Lehm.) R. Grah.
1829	*Panaetia Lessoni* Cass.	*P. Lessoni* (Cass.) Benth.
1837	*Podolepis canescens* A. Cunn. ex DC.	*P. canescens* A. Cunn. ex DC.
	P. aristata Benth.	*P. canescens* A. Cunn. ex DC.
	P. auriculata DC.	*P. auriculata* DC.
	P. divaricata A. Cunn. ex DC.	*Gnephosis tenuissima* Cass.
	P. ferruginea (Labill.) DC.	*Helichrysum ferrugineum* (Labill.) Less.
	P. inundata A. Cunn. ex DC.	*P. canescens* A. Cunn. ex DC.
	P. longipedata A. Cunn. ex DC.	*P. longipedata* A. Cunn. ex DC.
	P. rosmarinifolia (Labill.) DC.	*Helichrysum diosmaefolium* Sweet.
1838	*P. contorta* Lindl.	(See Nomina dubia.)
	Panaetia fulva Lindl.	(See Nomina dubia).
1840	*Scaliopsis lucaeana* Walp.	*P. longipedata* A. Cunn. ex DC.
1843	*Podolepis chrysantha* Endl.	*P. canescens* A. Cunn. ex DC.
1845	*Siemssenia capillaris* Steetz.	*P. capillaris* (Steetz) Diels.
	P. filiformis Steetz.	*P. gracilis* (Lehm.) R. Grah.
	P. nutans Steetz.	*P. nutans* Steetz.
	P. rosea Steetz.	*P. gracilis* (Lehm.) R. Grah.
	P. rosea Steetz. var. *molissima* Walp.	*P. gracilis* (Lehm.) R. Grah.
	P. subulata Steetz.	*P. canescens* A. Cunn. ex DC.
	P. aristata Benth. var. *chrysantha* (Endl.) Steetz.	*P. canescens* A. Cunn. ex DC.
1847	*P. Lucaeana* (Walp.) Walp.	*P. longipedata* A. Cunn. ex DC.
1848	*Rutidosis arachnoidea* Hook.	*P. arachnoidea* (Hook.) Druce.
1849	*P. tetrachaeta* (Schldt.) Walp.	*Leptorrhynchus tetrachaetus* (Schlechtd.) J. M. Black.
1851	*P. Gilberti* Turcz.	*P. Lessoni* (Cass.) Benth.
	P. pallida Turcz.	*P. auriculata* DC.
	Rutidochlamys Mitchelii Sond.	*P. arachnoidea* (Hook.) Druce.
	P. affinis Sond.	*P. canescens* A. Cunn. ex DC.
1852	*Panaetia Muelleri* Sond.	*P. Muelleri* (Sond.) G. L. Davis.
1859	*Podolepis hieracioides* F. Muell.	*P. hieracioides* F. Muell.
1864	*P. rhytidochlamys* F. Muell.	*P. arachnoidea* (Hook.) Druce.
1866	*P. Lessoni* (Cass.) Benth. (in part).	*P. Lessoni* (Cass.) Benth.
	P. Lessoni (Cass.) Benth. (in part).	*P. Muelleri* (Sond.) G. L. Davis.
	P. microcephala Benth.	*P. microcephala* Benth.
	P. Rutidochlamys Benth.	*P. arachnoidea* (Hook.) Druce.
	P. Siemssenia F. Muell. ex Benth.	*P. capillaris* (Steetz.) Diels.
	P. aristata Benth. var. *minor* Benth.	*P. canescens* A. Cunn. ex DC.
1874	*Helipterum Kendallii* F. Muell.	*P. Kendallii* (F. Muell.) F. Muell.
1883	*P. Kendallii* (F. Muell.) F. Muell.	*P. Kendallii* (F. Muell.) F. Muell.
1894	*P. jaceoides* (Sims) Voss.	*P. jaceoides* (Sims) Voss.
1895	*P. rubida* Maid. and Baker.	*P. canescens* A. Cunn. ex DC.
1898	*P. longipedata* A. Cunn. ex DC. var. *robusta* Maid. and Betche.	*P. robusta* (Maid. and Betche) J. H. Willis.
1905	*P. capillaris* (Steetz.) Diels.	*P. capillaris* (Steetz.) Diels.
	P. Georgii Diels.	*P. Georgii* Diels.
1907	*P. Kendallii* (F. Muell.) F. Muell. var. *nanus* Ewart.	*P. Kendallii* (F. Muell.) F. Muell.
	P. Spenceri Ewart.	*P. gracilis* (Lehm.) R. Grah.
1913	*P. cupulata* Maid. and Betche.	*P. Muelleri* (Sond.) G. L. Davis.
1917	*P. arachnoidea* (Hook.) Druce.	*P. arachnoidea* (Hook.) Druce.
	P. jaceoides (Sims) Druce.	*P. jaceoides* (Sims) Voss.
1918	*P. laevigata* Gdgr.	(See Nomina dubia.)
	P. papillosa Gdgr.	(See Nomina dubia.)
1929	*P. gnaphalioides* Domin.	(See Nomina dubia.)
	P. angustifolia Hort.	*P. gracilis* (Lehm.) R. Grah.
	P. jaceoides (Sims) Domin.	*P. jaceoides* (Sims) Voss.
1942	*P. acuminata* R. Br. var. *robusta* (Maid. and Betche) J. H. Willis.	*P. robusta* (Maid. and Betche) J. H. Willis.
1954	*P. robusta* (Maid. and Betche) J. H. Willis.	*P. robusta* (Maid. and Betche) J. H. Willis.
1956	*P. neglecta* G. L. Davis.	*P. neglecta* G. L. Davis.
	P. Gardneri G. L. Davis.	*P. Gardneri* G. L. Davis.
	P. rugata Labill. var. *littoralis* G. L. Davis.	*P. rugata* Labill. var. *littoralis* G. L. Davis.
	P. Muelleri (Sond.) G. L. Davis.	*P. Muelleri* (Sond.) G. L. Davis.

Economic Importance.

Podolepis spp. are never sufficiently numerous to assume weed proportions and there is no record of any poisonous properties. In the Armidale district it has been noticed that young buds of *P. jaceoides* (Sims) Voss are selectively eaten by rabbits but, apparently, only accidentally by stock.

Nomenclature.

Type selection has been made wherever possible and in the absence of co-type material the meaning of the name has been established by some other method, which is discussed, in each case, under the appropriate species.

In a few instances, however, the original descriptions are inadequate and it has not been possible for the present writer to examine the type specimens. The original descriptions are therefore quoted in full and the species listed as *nomina dubia.*

The nomenclature of types recommended by Furtardo (1937) and Davis and Lee (1944) has been followed throughout.

Text-fig. 1. Total distribution of *Podolepis* spp.

Categories.

In general, the principles formulated in an earlier paper (Davis, 1948) have been followed, but in this genus the taxonomic characters are not as definite as those of other genera revised by the present writer (*Brachycome* Cass., *Calotis* R.Br., *Lagenophora* Cass. and *Solenogyne* Cass.).

Variation within each species is continuous and usually proportional to the range. Since the erection of a separate category to accommodate each peak of variation would serve no useful purpose, certain species are merely stated to be polytypic, and these, usually, have a long synonymy. In the single instance of discontinuous variation within a species, varietal status was conferred.

The similarity of certain species and the fact that they replace each other geographically suggests Rassenkreiss formation in the past. Geographic subspeciation does not appear to be operative at the present time, since analysis of variation in each species has failed to reveal a geographic basis.

Specific Descriptions.

All species have been critically examined and redescribed on considerably more material than was available to the original authors and limits of natural variation are indicated in each case. Text-figures of habit and the chief diagnostic characters are provided for each species as well as distribution maps based on the specimens examined.

In each instance the locality data as cited in the original description are quoted in full under the heading "Type Data", and in the case of synonyms this information is supplied in parentheses in the text immediately following the first reference to the specific name.

More than seven hundred specimens are cited in the text, the location of each being indicated as follows: Department of Botany, Adelaide University (AD); State Herbarium of South Australia (AD); Waite Agricultural Research Institute, Adelaide (ADW); Botanical Museum and Herbarium, Brisbane (BRI); Herbarium of the Commonwealth Scientific and Industrial Research Organization, Canberra (CAN); Department of Botany, University of Tasmania (HO); National Herbarium, Melbourne (MEL); National Herbarium of New South Wales (NSW); Department of Botany, University of New England (NE); Herbarium of the late Mr. J. M. Black, Adelaide, now incorporated in the State Herbarium of South Australia (JMB); Herbarium of Professor J. B. Cleland, Adelaide (JBC); Herbarium of Mr. E. H. Ising, Stirling West, S.A. (I).

Evaluation of Taxonomic Characters.

Taxonomic treatment of this genus is made difficult by the fact that there are no *primary* taxonomic characters. The various species are, in fact, composed of certain combinations of *secondary* taxonomic characters, which are concerned with degree of development rather than of nature. These constitute what is referred to as the "*look*" of each species, which the present writer finds difficult to convey in words. It is hoped that the text-figures illustrating each species will supply this deficiency.

Specific characters, though consistent throughout each genus, do not necessarily apply to others, even related ones, and in revising a genus all parts of the plant must be considered afresh from this point of view.

Under their respective headings the various parts of *Podolepis* are now discussed in relation to their value in this taxonomic treatment.

Habit: This is essentially a genus of branching herbs whose habit depends on the degree of branching, which, in turn, is influenced by edaphic factors and length of growing period. A definite type of habit is not irrevocably associated with any species, although in certain of them a particular form tends to predominate, and so is of limited taxonomic value.

Indumentum: The presence of septate hairs on vegetative parts is a generic character, and since their density varies within most species, the degree of development of the indumentum has been found of no value in intra-generic classification.

Leaves: Leaf arrangement and, to a lesser extent, leaf shape, are to be regarded as secondary taxonomic characters, since a number of species can be identified on this basis alone. In certain species a cluster of radical leaves is a conspicuous feature of the mature plant, but in others this represents merely a juvenile stage. Variation in leaf shape is small and continuous, and this character, by itself, is of very limited value.

Inflorescences: In *P. arachnoidea* the inflorescences are almost sessile and form clusters at the ends of the branches, but in most other species the number of capitula is controlled by the degree of branching of the main axis, and this varies within species.

Involucre: The general shape is of some importance in identifying living material, but on pressing, the individual involucral bracts tend to separate and so alter or modify the characteristic involucral shape.

Involucral bracts: These, although commonly referred to as being whorled, are arranged as a compressed spiral of several rows, their shape varying according to their relative position. A gradual transition is noted from the normal green scale-leaves of the peduncle, to those with scarious tips and finally to the sessile outer involucral bracts of the capitulum. The shape and structure of the intermediate involucral bracts are characters of considerable importance in the classification of *Podolepis* and it is in these that the characteristic form is attained. The inner involucral bracts have reduced laminae and are not distinctive in any way except in *P. Muelleri*, where they become stiff at maturity and are united laterally to form a "cup". Certain characters may be more conspicuous when the bracts are massed in the involucre than when examined individually. For example, the almost honeycombed involucres characteristic of *P. rugata* and *P. auriculata* are due to the mass-effect of the closely overlapping transversely rugose laminae, which conceal the herbaceous claws of adjacent bracts.

Ray florets: In most species, some at least of the peripheral florets are ligulate and female, but in *P. Lessoni*, *P. Muelleri*, and *P. Kendallii* they are tubular and can only be distinguished from the bisexual florets by the corolla being 3–4-toothed and bearing a single pappus bristle or none. In *P. Georgii* there are no female florets. Apart from the presence or absence of ligules, details of the ray florets are of very minor importance in classification, and their colour is usually yellow.

Disc florets: These are invariably yellow and the tubular corolla is usually 5-toothed, though occasional florets are 4-toothed. In *P. Georgii* only 16–20 of the outermost florets are bisexual, the remainder being male, with aborted styles, but in all other species these florets contain apparently functional stamens and pistils.

Pappus: Little variation is seen in the pappus of most species, but it is absent from the female florets in *P. Muelleri* and *P. Kendallii*, while in *P. Lessoni* it is represented only by a single bristle. The disc florets of each of these species bear a pappus of characteristic form. In *P. Georgii* it is unique in that the bristles are united towards the base into about eight bundles.

Fruits: In only two species, *P. Kendallii* and *P. Georgii*, are the fruits distinctive and diagnostic. In all others their similarity is almost an occasion for comment.

TAXONOMY.

COMPOSITAE, tribe GNAPHALIEAE, sub-tribe HELICHRYSEAE.

PODOLEPIS Labill., *Nov. Holl. Pl.*, ii, 56, t.208 (1806).

Synonymy: *Scalia* Sims, *Bot. Mag.*, t.956 (1806); *Stylolepis* Lehm., *Sem. Hort. Hamb.*, (1828): 17; *Panaetia* Cass. in *Ann. Sc. Nat.*, Sér. 1, 17 (1829): 417; *Scaliopsis* Walp. in *Linnaea*, 14 (1840): 318; *Siemssenia* Steetz in *Lehm. Pl. Preiss*, 1 (1845): 467; *Rutidochlamys* Sond. in *Linnaea*, 25 (1852): 497.

Annual or perennial herbs with a variable amount of septate-hairy indumentum which is commonly deciduous, and occasionally hispid. *Leaves* entire, the cauline ones alternate, linear to lanceolate, commonly sessile and decurrent; radical leaves lanceolate, petiolate, forming a conspicuous basal cluster or only present on young plants. *Inflorescence* a capitulum, solitary and terminal on the main stem or axillary and numerous, occasionally clustered with very short peduncles. *Involucral bracts* in several rows with scarious, entire, smooth or wrinkled, erect laminae; the outer bracts sessile, the intermediate ones with herbaceous claws which sometimes have scarious margins and appear sessile. *Receptacle* flat, naked. *Ray florets* female (except in *P. Georgii* Diels), ligulate or tubular with fewer corolla-teeth than the 5-toothed disc florets. *Anthers* with fine tails and pointed terminal appendages. *Style branches* filiform in female florets, truncate in bisexual ones. *Pappus* of capillary bristles, finely barbellate or subplumose, often united at the base, rarely in bundles. *Fruits* usually terete and microscopically papillose, rarely thick and tuberculate.

Type species: *Podolepis rugata* Labill.

Key to the Species.

1. Peripheral florets with long conspicuous ligules, much exceeding the disc florets.

2. Intermediate involucral bracts with conspicuous claws.

3. Laminae more or less smooth, not transversely rugose, entirely scarious.

4. Ligulate florets yellow.

5. Laminae pale, chaffy, transparent, longer than broad; perennials with a cluster of radical leaves.

6. Laminae of intermediate bracts the same length or longer than their claws.

7. Sparsely woolly or hispid plants. Radical leaves linear to oblanceolate with flat margins. Widely distributed in the eastern States and Tasmania .... 1. *P. jaceoides*.

7.* Plants with a large amount of loose wool distally. Radical leaves spathulate with crinkled margins. Southern highlands of eastern Australia .... 2. *P. robusta*.

6.* Laminae of intermediate bracts shorter than their claws.

8. Bracts appressed, with triangular closely overlapping laminae concealing their claws. Queensland and northern New South Wales .... 3. *P. longipedata.*
8.* Bracts not closely appressed, with ovate laminae; claws partly exposed. Blue Mountains to Southern Alps; elevated districts in Victoria .... 4. *P. hieracioides.*
5.* Laminae reddish-brown, stiff, not transparent, broader than long; annuals; radical leaves present only on young plants. Swan River district (W.A.) ...... 11. *P. nutans.*
4.* Ligulate florets pink. Widely distributed in Western Australia .... 10. *P. gracilis.*
3.* Laminae transversely rugose.
9. Laminae slightly rugose, their apices acute to acuminate; involucre shining.
10. Claws of outer and intermediate bracts truncate distally at the base of the entirely scarious laminae. Widely distributed throughout Australia .... 6. *P. canescens.*
10.* Claws of outer and intermediate bracts extending half-way or more along the median portion of the laminae. Meekatharra district (W.A.) .... 7. *P. Gardneri.*
9.* Laminae very deeply rugose; involucre not shining, with honeycombed appearance.
11. Bracts obtuse. Widely distributed in South and Western Australia ...... 9. *P. rugata.*
11.* Bracts acuminate. Northern districts of Western Australia .... 8. *P. auriculata.*
2.* Intermediate involucral bracts sessile, with a hard thick central portion and scarious margins rather stiff. Queensland and northern New South Wales .... 5. *P. neglecta.*
1.* Peripheral florets hardly exceeding those of the disc.
12. Intermediate bracts with slender claws and sharply demarcated scarious laminae. Florets all tubular, female ones with 3-4-lobed corolla.
13. Bracts smooth, shining, with shortly ciliate margins, the innermost basally united to form a "cup". Female florets 3-10, with no pappus. Bisexual florets with up to 13 shortly plumose bristles. South-western New South Wales; South Australia .... 13. *P. Muelleri.*
13.* Bracts slightly rugose, dull, with fringed margins. Female florets 8-16, with a single distally plumose pappus bristle. Bisexual florets with 3-4 distally plumose pappus bristles. Widely distributed in Western Australia .... 12. *P. Lessoni.*
12.* All bracts sessile, with a herbaceous central region.
14. Bracts acute, their scarious margins transversely rugose.
15. Capitula solitary and terminal on leafy branches. Florets all tubular. Female florets 4-6, with no pappus. Bisexual florets with 7-10 plumose pappus bristles. Fruits covered with long finger-like papillae. Western Australia .... 17. *P. Kendallii.*
15.* Capitula clustered and almost sessile. Female florets 5-7, with a short ligule. Pappus of 25-30 bristles. Fruits microscopically tuberculate. Queensland and western New South Wales .... 16. *P. arachnoidea.*
14.* Scarious margins of bracts not rugose.
16. Bracts rhomboidal with broad scarious margins. Florets all tubular, the outermost row bisexual with 150-200 pappus bristles united into about 8 bundles; remainder of florets male, with 1-10 distally plumose pappus bristles. Fruits heavily tuberculate with a smooth distal collar. Western Australia .... 18. *P. Georgii.*
16.* Intermediate and inner bracts with a median or submedian constriction. Female florets shortly ligulate, with no pappus; bisexual florets with 14-18 barbellate pappus bristles.
17. Bracts glabrous, shining. Female florets 9-12. Capitula longer than broad. Western districts of eastern States; widely distributed in South and Western Australia .... 14. *P. capillaris.*
17.* Bracts glandular on outer surface, not shining. Female florets 6. Capitula broader than long. Shark Bay district (W.A.) .... 15. *P. microcephala.*

1. PODOLEPIS JACEOIDES (Sims) Voss, in *Vilmorin's Blumeng.*, 1 (1894):537.

(Text-figs. 2–8.)

Synonymy: *Scalia jaceoides* Sims, *Bot. Mag.*, t.956 (1806); *Podolepis acuminata* R.Br. in *Ait. Hort. Kew*, ed. 5, (1813):82; *P. jaceoides* (Sims) Druce in *Rep. Bot. Exch. Cl. Brit. Isles* (1917):640; *P. jaceoides* (Sims) Domin in *Bibliothec. Bot.*, 89, (1929):676.

Type data: "Native of New South Wales—introduced by Mr. Loddices of Hackney." Cultivated in England.

Plants with a perennial stock from which one or more erect scape-like stems arise each year, reaching a height of 7–80 cm. A variable amount of loose white wool is usually present on the stem and undersides of leaves, which are frequently hispid above. *Radical* and lowest *cauline leaves* up to 20 cm. long, 2 cm. broad, linear to oblanceolate, acute, tapering proximally; remainder of leaves linear to lanceolate, sessile, stem-clasping or shortly decurrent, passing gradually into the bracts of the peduncle. *Inflorescences* usually solitary, terminating the scape-like stem, but occasionally plants are polycephalous with 2–8 capitula. *Involucres* up to 3 cm. diameter, 2 cm. long. *Involucral bracts* with glandular linear claws and smooth scarious laminae; intermediate bracts up to 2 cm. long, the ovate laminae 5 mm. broad, obtuse to acute; innermost bracts shorter, the laminae hardly broader than the claws. *Florets* yellow, with 20–40 finely barbellate pappus bristles united at the base. *Ray florets* 30–40, female, the ligule up to 2·5 cm. long, 2·5 mm. broad, deeply 3–5-toothed. *Fruits* about 3 mm. long, 1 mm. broad, terete, shortly papillate, dark reddish-brown.

Habitat: Amongst grasses in open situations and forest land.

Range: Widely spread throughout eastern States and Tasmania, south-east of South Australia.

Text-figs. 2-16.

2-8. *P. jaceoides.*—2, Habit × 0·3; 3-5, outer, intermediate and inner Involucral Bracts × 3; 6, Ray floret × 3; 7, Disc floret × 3; 8, Distribution. 9-16, *P. robusta.*—9, Habit × 0·3; 10-13, outer, intermediate and inner Involucral Bracts × 3; 14, Ray floret × 3; 15, Disc floret × 3; 16, Distribution.

Specimens examined:

Queensland: Longreach, 10.1913, E. Jarvis (BRI); Copperfield, 1869, Slatter (MEL); Peak Downs, F. Mueller (MEL); Anakie Downs, P. O'Shanesy (MEL); Maryborough, 1874, F. Mueller (MEL); Toowoomba, 9.1921, R. J. Holdsworth (BRI); Stanthorpe, 11.1916, H. Wright (BRI); Southern border, 11.1884, E. Hickey (MEL).

New South Wales: Brunswick and Tweed Rivers (MEL); Tenterfield, C. Stuart (MEL); Glen Innes, 15.12.1914, E. Breakwell (NSW.25393), Stonehenge, 12.1899, J. H. Maiden (NSW.25405, 25418); Chandler's Peak, Guyra, pasture land, 3.1917, J. L. Boorman (NSW.25394); Ebor Falls, 4,200 ft., Basalt, grassy slopes, 1.1.1941, C. Davis (NE); Point Lookout, 5,500 ft., 3.1949, M. Slade (NE); Armidale, cleared woodland among grasses, 28.10.1955, G. L. Davis (NE); Walcha district, 11.1897, J. H. Maiden (NSW.25440); Moona R., Walcha, 12.1884, A. R. Crawford (MEL); Walcha Road, 12.1912, J. L. Boorman (NSW.25392); Tamworth, 1885, D. A. Porter (MEL); Tia Falls, 10.1900, W. Forsyth (MEL; NSW.25485); Moonan Brook, Scone, 1883, H. Carter (MEL); Upper William's River, 11.1.1934, L. Fraser and J. Vickery (NSW.25388); Dungog, 4.10.1911, W. F. Blakely (NSW.25385); Mt. Lindesay, 11.1909, R. H. Cambage (NSW. 25403); Warrumbungle Ranges, 10.1899, W. Forsyth (NSW.25486); Namoi R., Woolls (MEL); Castlereagh R., Woolls (MEL); Brewarrina, 11.1903, J. L. Boorman (NSW. 25483); between Warrego and Darling Rivers, 9.1885, E. Betche (MEL); Warrego R., 9.1885, E. Betche (NSW.25485); Bourke, 8.1948, R. McCall (NSW.25420); Paroo R. district (NSW.25412); between Nyngan and Nevertire, 23.9.1924, A. Morris (NSW. 25422; ADW.); Nevertire, 20.9.1886, E. Betche (NSW. 25484); Wallerawang, 12.1886, Deane (MEL); Mt. Victoria, 1889, J. J. Fletcher (NSW.25408); Mt. Werong, 4.12.1911, R. H. Cambage (NSW.25391); Mt. Werong-Ruby Creek, 3,500 ft., Granite hillside, 23.10.1951, L. A. S. Johnson and E. Constable (NSW.17996); Jenolan Caves, 10.1899, W. F. Blakely (NSW. 25389); Port Jackson, 1838, Siemssen (MEL); Otford, 10.1897, A. H. Camfield (NSW. 11961); Campbelltown, T. Aikin (BRI); Nepean Dam-Bargo Road, 1,000 ft., clay soil, E. Constable (NSW.26611); Cordeaux-Appin Road, 950 ft., shale, 9.11.1950, H. K. Mair and E. Constable (NSW. 16090); Mt. Kembla, 8.1900, A. G. Hamilton (NSW. 25384); Bowral, 20.11.1945, H. M. Rupp (NSW.858); Cambewarra, 1884, Bauerlen (MEL); Badgery's Crossing to Nowra, 9.1899, W. Forsyth and A. A. Hamilton (NSW. 25383); Huskisson, 50 ft., loam, 19.8.1939, F. A. Rodway (NE); Lake George, 1870, W. Woolls (MEL); Lachlan R., 1878, F. Mueller (MEL); Wentworth, Fone (MEL); Darling R., sandy soil with clay, saltbush, Vict. Exp. (MEL); Lower Edward's R., Mein (MEL); Wagga, 1886, R. Thom (MEL); Mulwala, 10.1890, J. J. Fletcher (MEL; NSW.25407); Gerogery, 11.10.1949, E. J. McBarron (NSW.25396); Albury, 11.1905, J. E. R. Fellowes (NSW. 25395); Mt. Bimberi, 6,000 ft., granite, 12.1931, A. Burges (NSW. 25413); Adaminaby-Talbingo Road, 3,000 ft., 4.12.1943, S. Copland (NE); near Kiandra, 12.1901, W. Forsyth (NSW.25382); Nimmitabel, 12.1916, J. L. Boorman (NSW. 11960; BRI); Barber's Creek, 10.1898, H. J. Rumsey (NSW.25390).

Victoria: Hume R., 1883, Jephcott (MEL); Upper Murray R., 1883, Findlay (MEL); Beechworth, 1871, Falck (MEL); Mt. Stanley, 3,300 ft., 3.1.1949, E. J. McBarron (NSW.25376); Myrtleford, 1883, Lucas (MEL); Snowy Crk., 1881, M. Cann (MEL); Snowy R., 11.1886, C. H. Grove (MEL); Omeo, undulating ranges, mica schist formation, 1.11.1882, (MEL); Swan Hill, Gummov (MEL); near the Avoca, mallee scrub, 4.12.1853, F. Mueller (MEL); Wycheproof, 9.1918, W. W. Watts (NSW.25361); Charlton, 1.10.1917 (NSW.25360); Walmar, Wimmera, plains, 18.9.1860, Dallachy (MEL); Nhill, St. E. D'Alton (MEL); Dimboola, 1903, St. E. D'Alton (NSW.25378); N.W. Horsham (MEL); Horsham, 11.1904, Thurmann (BRI); Donald, Curdie (MEL); Grampians, 10.1904, Combe (MEL); Moyston, 10.1881, D. Sullivan (MEL); Wandovale, pasture land, 2.10.1842, J. G. Robertson (NSW.25375); Rennick, 11.1950, G. C. Shepherd (MEL); Beaufort, 27.9.1932, (AD); Creswick Diggings, 1860, J. W. Whan (MEL); Daylesford, 1878, R. Wallace (MEL); Geelong, 1881, I. B. Wilson (MEL); St. Albans, basalt plains, 22.11.1941, J. H. Willis (MEL); fields around Melbourne, 9.1852, F. Mueller (MEL); Melbourne (AD); Frankston Bay, 10.1896, C. Walter (NSW.25359); Dromana, 10.1903, C. Walter (MEL).

Tasmania: Hellier R., 23.1.1928, E. Cheel (NSW.25373); Penguin, forest ridge, 11.11.1843, Gunn (MEL); hilly ground by the Cataract, Launceston, 12.1863 (MEL); Launceston, 11.1865, S. G. Hannaford (NSW.25371); near Perth, W. H. Archer (NSW.25370); Pieman Heads, 23.2.1930, H. F. Comber (HO); Cradle Valley, dry heath flora, 3,000 ft., 1.1915, G. Weinderfer (NSW.11964); Detention Corner, Frenchman's Cap, 4.1842 (MEL); Miena, 11.1.1949, J. Garden (NSW.25368); New Norfolk, 15.11.1840, R. Gunn (NSW.25366); between Derwent Bridge and Bronte, on slope above swampy ground, 27.1.1947, N. T. Burbidge (HO); Glenorchy, open hillside, 900 ft., 15.11.1931, F. H. Long (HO); Knocklofty, amongst grass in stony soil, 27.10.1937, H. D. Gordon (HO); Domain, Hobart, 3.11.1934, V. V. Hickman (HO); near Hobart, A. Simpson (BRI); Sandy Bay, 1.1924, A. H. S. Lucas (NSW.25369); Mt. Wellington, Summit, 4,000 ft., 18.2.1843, R. Gunn (NSW.25372); Mt. Nelson, 11.1913, L. Rodway (HO).

South Australia: Moolooloo Station, between Beltana and Blinman, 10.1915, R. S. Rogers (NSW.25362); Appila Yarrowie, 1882, L. Wehl (MEL); near Jamestown, 2.11.1920, J. M. Black (JMB); Kadina, 15.10.1939, J. B. Cleland (JBC); Yorke Penin., 1879, Tepper (MEL); Snowtown, 10.10.1923, J. M. Black (JMB); Hallett's Cove, 9.10.1920, J. B. Cleland (JBC); Port Willunga, 24.9.1914, J. M. Black (JMB); Sandergrove, 2.10.1926, J. B. Cleland (JBC); Pinnaroo, 10.1920, J. M. Black (JMB); Bordertown, 14.10.1916, E. H. Ising (I.3855); Hynum and Robertson, on rendzina soil, natural untopdressed pasture, 3.11.1945, N. S. Tiver (ADW); between Narracoorte and Kingston, 12.1929, Richardson (JMB); Lake Bonney, 1874, C. Wehl (MEL); near Mt. Gambier, 1880, C. Wehl (MEL).

Kangaroo Is.: Rocky R., 9.1908, R. S. Rogers (NSW.25364); Rocky R., 4.12.1934, 24.11.1945, J. B. Cleland (JBC).

Curtis' Botanical Magazine contains descriptions of a number of plants grown in England last century from seeds sent from the New World, many of which were hitherto undescribed. Sims erected the monotypic genus *Scalia* (*S. jaceoides* Sims or "Knap-weed Scalia") to accommodate one such plant, "a native of New South Wales—introduced by Mr. Loddices of Hackney". The generic name, according to Sims, was "the name given by Theophrastus to a certain plant of this order", and the excellent coloured plate accompanying the description leaves no doubt as to the identity of the species, although no type material is available in Australia.

No other species were described in this genus, which Robert Brown (1813) reduced to synonymy under *Podolepis acuminata* ("Sharp-scaled Podolepis"), which he described from material collected personally in New South Wales and "introduced in 1803 by Colonel William Paterson".

Subsequent taxonomic history is concerned with the application of the Law of Priority, and no less than three authors independently reinstated the original specific epithet.

In its typical condition, *P. jaceoides* is a conspicuous plant with brilliant yellow capitula measuring 4 to 6 cm. across the expanded ray florets, and commonly overtopping the grasses among which it grows. In the New England district it grows in patches and throughout October and November is a common feature of the landscape. The plants are typically robust with a conspicuous cluster of radical leaves and a single leafy and unbranched stem with a terminal capitulum. The foliage is often harsh to the touch, due to the presence of short stiff hairs, but many specimens have been examined which bear only a small amount of white wool and others are almost glabrous. No geographic basis was found for these variations in indumentum.

Although it is usual for each plant to bear only a single capitulum, the perennial stock may give rise to more than one stem and sometimes buds develop in the axils of the upper leaves and the polycephalous condition results.

As well as this vigorous habit, which occurs throughout the entire range, a number of specimens have been examined which are slender in all vegetative parts and whose capitula are correspondingly reduced in size. The smallest specimen handled in the course of this work was from Frenchman's Cap (Tasmania) and, although only 7 cm. in height, bore a solitary capitulum of normal size.

Willis (1954*b*), referring to the variation of this species, expressed the opinion that "several forms of it exist in Victoria, some with very large solitary golden-yellow heads, others with much paler heads flowering at a different time. It is possible that more than one species is involved, and that the whole group needs a competent systematic revision". Attempts by the present writer to discover discontinuities in this very widespread species have failed, and the variation in every character investigated has been found to be continuous and not associated in any way with geographic position. In view of this, the only practical taxonomic procedure is to treat *P. jaceoides* as a large polymorphic species.

2. PODOLEPIS ROBUSTA (Maid. and Betche) J. H. Willis, *Vict. Nat.*, 70 (1954): 227. (Text-figs. 9–16.)

Synonyms: *P. longipedata* A. Cunn. ex DC. var. *robusta* Maid. and Betche, PROC. LINN. SOC. N.S.W., 23 (1898): 12; *P. acuminata* R.Br. in Ait., var. *robusta* (Maid. and Betche) J. H. Willis, *Vict. Nat.*, 59 (1942): 120.

Type data: Mt. Kosciusko, 5,500–6,000 ft., 1.1898, J. H. Maiden; Kiandra district, 2.1897, E. Betche; Walcha district, 11.1897, J. H. Maiden.

Lectotype (Willis, 1954*a*): Kiandra district, 2.1897, E. Betche (MEL).

Lectoparatypes (Willis, 1954*a*): Kiandra district, 2.1897, E. Betche (NSW.25440); Mt. Kosciusko, up to 5,500 ft., 1.1898, J. H. Maiden (NSW.25441).

Robust perennials with a single woolly-white scape-like stem up to 60 cm. high. *Radical leaves* up to 20·5 cm. long, 4·5 cm. broad, spathulate, obtuse to sub-acute, glabrous, often with crinkled margins, and tapering to a broad stem-clasping base. *Cauline leaves* up to 14·5 cm. long, 1·7 cm. broad, broad-linear, acute, stem-clasping, shortly decurrent; the lowest almost glabrous, the upper with a dense woolly-white indumentum. *Inflorescences* 6–11, forming a more or less dense terminal cluster on the stem. *Involucres* about 2·5 cm. diameter, 1·5 cm. long. *Involucral bracts* with broad-ovate, smooth, scarious, obtuse laminae; intermediate bracts up to 1·3 cm. long, the laminae and claw of equal length. *Florets* yellow, with 27–34 finely barbellate pappus bristles united at the base. *Ray florets* 30–40, the ligule up to 1·7 mm. long, 2·5 mm. broad, usually deeply 4-lobed. *Fruits* 2·5–4 mm. long, terete, smooth, contracted at summit.

Habitat: Amongst grasses in alpine pastures.

Range: Southern Alps at high altitudes.

Specimens examined:

New South Wales: Bimberi Peak, Upper Cotter R., 6,200 ft., granite, 15.1.1912, R. H. Cambage (NSW.25330, 25481); Kiandra district, 2.1897, E. Betche (NSW.25442, Lectoparatype; MEL, Lectotype; BRI); Mt. Kosciusko Range, 1.1880, Findlay (MEL); Mt. Kosciusko, up to 5,500 ft., 1.1898, J. H. Maiden (NSW.25441, Lectoparatype); near Kosciusko Hotel, 2.1920, R. H. Cambage (NSW.25332); Pretty Point, Mt. Kosciusko, 5,500 ft., 2.1901, R. Helms (NSW.25334; BRI); near Perisher Gap, 12.3.1949, C. Skottsberg (NSW.25335); Bett's Camp to Mt. Kosciusko, 16.2.1914, J. H. Maiden (NSW.25482); Snowy R., below Charlotte Pass, 5,700 ft., granite, 20.1.1951 (NSW.18834).

Victoria: Cobboras, 6,000 ft., 1.1854, F. Mueller (MEL); near Mt. Cobberas, upland flats between 2,000 and 6,000 ft., on Limestone R., Upper Silurian formation, quartz-porphyry, Stirling (MEL); Bogong High Plains, *ca.* 5,700 ft., grassy slopes of Mt. Cope, at the head of Pretty Valley, 15.1.1946, J. H. Willis (MEL); Bogong High Plains, Pretty Valley, *ca.* 2 miles E. of Mt. Jim, 5,500 ft., 27.1.1952, C. I. Skewes (MEL); Mt. Feathertop to Mt. Hotham, 6,000 ft., A. J. Tadgell (MEL); Mt. Buffalo, summit, 1.1899, C. Walter (MEL; NSW.25338); Mt. Buffalo, 4,500 ft., common on alpine meadows, 21.1.1950, H. C. E. Stewart (BRI); Mt. Buffalo, 3.1930, P. R. H. St. John (MEL); 4,300 ft., granite, 19.1.1913, R. H. Cambage (NSW.25339); Mt. Hotham, 1.1900, J. H. Maiden (NSW.25340); 6,100 ft., 13.2.1952, E. L. Robertson (ADW.7346); Dargo High Plains, 1883, Howitt (MEL); Mt. Buller (MEL).

Willis (1954*a*), in raising this population to specific status, gave an admirable summary of its previous taxonomic history, which is now quoted in full: "the first specimens, presumably, were collected by F. von Mueller near the summit of the Cobboras in January 1854. He labelled them '*Podolepis acuminata* var. *enervis* ferd.

Mueller' in allusion to the very indistinct nervation of the hyaline involucral bracts; but he never published any description of his plant. Bentham (1866) merely listed the Cobboras collection under *P. acuminata*, but, in citing Mueller's later gathering (1861) of comparable material from Haidinger Range, he remarked: 'the lamina of the involucral bracts almost obtuse'. It remained for Maiden and Betche to publish this alpine *Podolepis*—as a variety *robusta* of the east coast species *P. longipedata* A. Cunn. in DC. Why the authors should have allied *P. robusta* with *P. longipedata* is inexplicable, since the two entities have few features in common, either in habit, foliage, inflorescence, shape and areolation of involucral bracts or achenes."

Willis nominated a lectotype and lectoparatypes from specimens of two out of the three localities of Maiden and Betche's type series. Their third locality, Walcha district, is not mentioned by Willis and, in the opinion of the present writer, this material is not conspecific with that from the other localities and is, in fact, a vigorous plant of *P. jaceoides* (Sims) Voss.

In its basal cluster of large glabrous leaves, loosely woolly stems and polycephalous condition, this species is very distinctive, and the frequently crinkled margins of the lower leaves are doubtless the source of the local name "Mountain Lettuce" (Willis, 1954*a*). The cauline leaves bear varying amounts of wool according to their position on the stem, the lowest being almost or quite glabrous. Woolly hairs are to be seen first along the lower midrib and scattered generally over the upper surface. In the upper leaves, which are woolly on both sides, the upper surfaces are the most densely clothed.

With such a restricted range it is not surprising that vegetative variation is small, but some was seen in the arrangement of capitula. These were either closely grouped on short peduncles at the apex of the stem or more loosely arranged on long peduncles arising from the axils of the cauline leaves at various levels.

The closest relative of *P. robusta* is *P. jaceoides*, with which there is a strong similarity in the shape and size of the involucral bracts. This resemblance is most marked in polycephalous specimens of *P. jaceoides*, but the two species are easily distinguishable on vegetative characters. It is probable that *P. robusta* originated as a geographic sub-species of the widespread *P. jaceoides* (Sims) Voss.

3. PODOLEPIS LONGIPEDATA A. Cunn. ex DC., *Prod.*, 6 (1838): 163.

(Text-figs. 17–24.)

Synonymy: *Scaliopsis Lucaeana* Walp. in *Linnaea*, 14 (1840): 318; *Podolepis Mitchellii* Sond. in *Linnaea*, 25 (1852): 508.

Type data: "New South Wales. Sandy seashores of Moreton Bay. Cunningham."

Lectotype: Moreton Bay, Cunningham (MEL).

Lectoparatype: Moreton Bay, 10,1824, A. Cunningham (BRI).

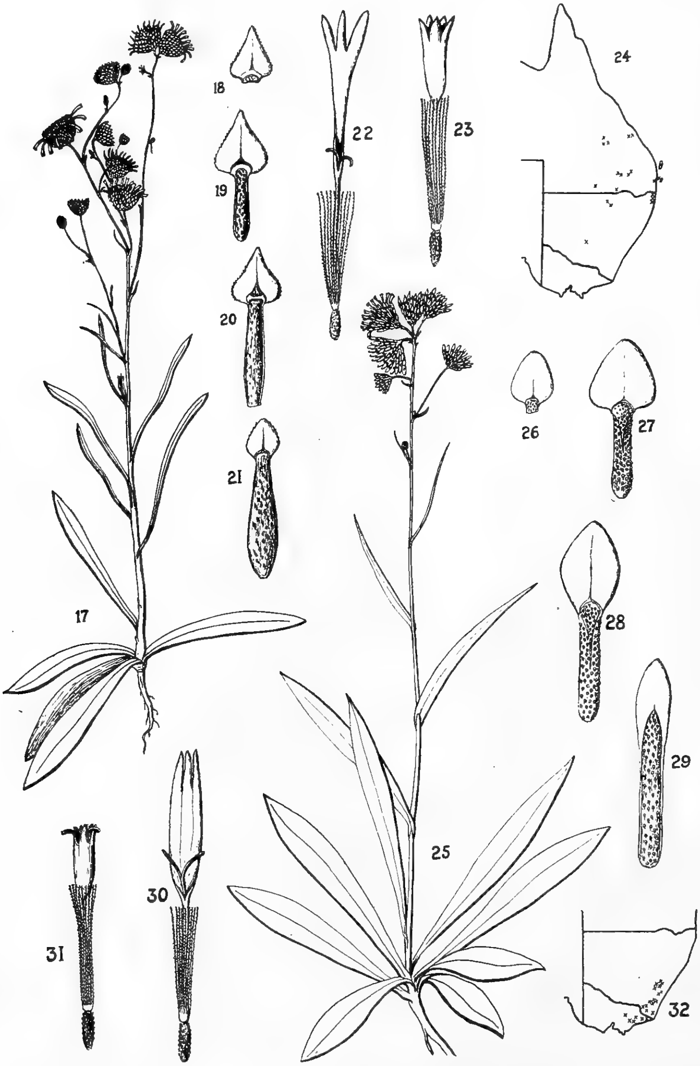
Perennial(?) plants 25–94 cm. high with a loose woolly indumentum and a cluster of radical leaves. The main stem is commonly exceeded by the uppermost lateral branches. *Leaves* broad-linear to oblanceolate, acute, stem-clasping, glabrous, or with scattered septate hairs. *Radical leaves* 5–20 cm. long, 0·5–2·5 cm. broad; *Cauline leaves* slightly smaller, decurrent, becoming linear distally. *Inflorescences* 3–27. *Involucres* 1·5–2 cm. diameter, 1–1·5 cm. long. *Involucral bracts* commonly reddish-brown, with triangular, smooth, finely torn-ciliate, acute and closely overlapping laminae; the claws shortly glandular; intermediate bracts 8·5 mm. long. *Florets* yellow, with a pappus of 20–30 finely barbellate bristles, united at the base. *Ray florets* about 40, the ligules 1·6–2 cm. long, 2–3 mm. broad, 3-lobed. *Fruits* 1·8 mm. long, 0·6 mm. broad, terete, minutely papillose, contracted distally.

Habitat: Sandy soil.

Range: Widely spread in Queensland extending into the north-west and far North Coast of New South Wales, with a single record from the Lachlan R.

Specimens examined:

Queensland: Mackenzie R., F. Mueller (MEL); Rockhampton, found only in loose sandy situations, 8.1912, J. L. Boorman (NSW.25348); Jericho, 4.1946, M. S. Clemens (BRI); the Virgin, Springsure, 6.1913, J. L. Boorman (NSW.25347); Mt. Playfair Sta., sandy country, 1934, A. M. McLaughlin (BRI); Fraser Is., 10.1921, F. C. Epps (BRI); Moreton Is., 9.1901, Field Nat. Excursion (BRI); Moreton Bay, 10,1824, Cunningham (MEL, Lectotype; BRI, Lectoparatype); Caloundra, on sand, 1.1912 (BRI); Chinchilla, amongst grasses on brown sandy soil, 992 ft., 7.1.1931, C. E. Hubbard and C. W. Winders n.6436 (BRI); Miles, in paddock amongst grasses, 993 ft., 19.10.1930, C. E. Hubbard n.5184 (BRI); Bungeworgorai, near Roma, very common in sandy soil, 25.10.1933.



Text-figs. 17-32.

17-24, *P. longipedata.*—17, Habit × 0·3; 18-21, outer, intermediate and inner Involucral Bracts × 3; 22, Ray floret × 3; 23, Disc floret × 3; 24, Distribution. 25-32. *P. hieracioides.*—25, Habit × 0·3; 26-29, outer, intermediate and inner Involucral Bracts × 3; 30, Ray floret × 3; 31, Disc floret × 3; 32, Distribution.

C. T. White n.9529 (BRI); Wallumbilla, 12.1916, E. W. Bick (NSW. 11968); Curragh Sta., near Cunnamulla, around bore in paddock, in brown loam, 620 ft., 6.1.1931, C. E. Hubbard and C. W. Winders n.6218 (BRI); Bumble Sta., 70 miles N. of Mungindi, 21.9.1922 (NSW.25349); Tropical Australia, 1846, Mitchell (MEL, Lectotype of *P. Mitchellii* Sond.).

New South Wales: Terranora, Tweed R., on sandy ridges (NSW.25350); Cape Byron to Tweed R., low sandy ridges (MEL); East Coast, 1802-5, R. Brown (MEL); 25-mile peg, Walgett-Lightning Ridge Road, 400 ft., red sandy loam, 27.5.1951, E. Constable (NSW.29288); Collarenebri, 1.1948, J. Waterhouse (NE); Lachlan R., 1879, Tucker (MEL).

Bentham (1866) listed as synonymous with *P. longipedata* the following species: *Scaliopsis Lucaeana* Walp., *P. Mitchellii* Sond. and *P. hieracioides* F. Muell. He stated "the northern specimens generally have an annual appearance, with smaller flower-heads than the southern ones, which have sometimes several stems from a hard stock, but Brown's specimens quite connect the two forms." After examining a considerable number of specimens, the present writer is in agreement with Willis (1954*b*), that Bentham's northern and southern forms are taxonomically distinct and that they correspond to the species *P. longipedata* A. Cunn. ex DC. and *P. hieracioides* F. Muell. respectively. *P. longipedata* is therefore treated here in its original restricted sense and corresponds only in part to that species in *Flora Australiensis*.

Two specimens collected by Cunningham in 1824 were examined, one of which, bearing a field label, was nominated lectotype, and the second, accompanied by a label written by Mueller was designated lectoparatype, since it is probably part of the original material examined by Mueller.

Type material of *Scaliopsis Lucaeana* Walp. ("New Holland, Lhotsky") has not been examined and the problem arose as to whether it was synonymous with *P. longipedata* or *P. hieracioides*. However, according to the original description, "the outer bracts are sessile, scarious-transparent; the inner ones with linear stalked leaf-like claws", and as this suggested *P. longipedata* rather than *P. hieracioides*, *S. Lucaeana* is listed as a synonym of the former species.

With regard to *P. Mitchellii* Sond. ("Sub-tropical Australia. Mitchell"), two specimens have been examined which were collected in 1846 by Mitchell. One of these is identified and extensively annotated by Sonder, so has been nominated lectotype, while the species itself is sunk in synonymy. Both specimens are complete plants and, although more slender than those collected by Cunningham, fall within the limits of *P. longipedata*.

Morphologically, this species resembles most closely *P. jaceoides* (Sims) Voss, from which it probably originated as a geographic sub-species.

4. PODOLEPIS HIERACIOIDES F. Muell., *Fragm.*, I (1859): 112.

(Text-figs. 25–32.)

Type data: "In grassy valleys beside the banks of the rivers Delatite, McAllister, Mitta Mitta, Omeo Creek and elsewhere. 2–4,000 ft."

Lectotype (Willis, 1954*b*): Macallister River, 1.1859, F. Mueller (MEL).

Lectoparatype: Grassy banks of Delatite River, 26.3.1853, F. Mueller (MEL).

Homoeotype (Willis, 1954*b*): Between the Upper Cann and Genoa Rivers, open Eucalypt forest, on gentle slope, 2½ miles N.E. of Cooponcambra Mt., 13.1.1953, R. Melville and N. A. Wakefield (MEL).

Robust polycephalous perennials with a leafy stem up to 70 cm. high arising from a cluster of radical leaves. A woolly indumentum of septate hairs is present on the stem and at the leaf-axils. *Radical leaves* up to 16·5 cm. long, 2·8 cm. broad, elliptical, acute, with a broad stem-clasping base, glabrous or with scattered short septate hairs. Lower *cauline leaves* up to 13 cm. long, 1 cm. broad, linear, acute, becoming narrower and shorter as they ascend the stem. *Inflorescences* 3–20, clustered. *Involucres* 1·5–2 cm. diameter, 1·5 cm. long. *Involucral bracts* with ovate, smooth, entire, obtuse to subacute laminae and densely glandular claws which are not entirely covered by laminae of adjacent bracts; intermediate bracts about 8·5 mm. long, 3·5 mm. broad. *Florets* yellow, with a pappus of 20–25 slender barbellate bristles, shortly united at the base. *Ray florets* 15–20, the laminae about 1·8 cm. long, 2 mm. broad, usually 3-lobed. *Fruits* about 3 mm. long, terete, microscopically papillose, contracted at summit.

Range: Highlands, from Blue Mountains to Gippsland.

Specimens examined:

New South Wales: Rydal, W. Woolls (MEL); near Little Hartley, 15.1.1892, J. J. Fletcher (NSW.25409); Widgidee Creek, Duckmaloi, dry hillside, 7.3.1935, V. May (NSW.25344); Edith, slaty shale, 4,250 ft., 9.3.1950, E. F. Constable (NSW.11435); Bargo R., 12.1902, J. L. Boorman (NSW.25342); Bowral, 1.1894, A. H. S. Lucas (NSW.11965); Moss Vale, 1.1928, K. Thorpe (ADW.8759); Queanbeyan, 3,700 ft., 16.1.1912, R. H. Cambage (NSW.11966); Braidwood district, 3,600 ft., 1.1885, W. Bauerlen (MEL); Michelago, 1.1909, J. L. Boorman (NSW.25343); Yarrangobilly Caves, 2.1897, E. Betche (NSW.25345); Island Bend, Snowy R., 4,000 ft., forests, 6.2.1953, M. Mueller (MEL); Snowy R., valley, above Island Bend, 4,500 ft., occasional in forest, granite, 23.1.1951, L. A. S. Johnson (NSW.15595); Mt. Kosciusko, Sawpit Creek, 1.1899, J. H. Maiden and W. Forsyth (NSW.25346); Mt. Kosciusko, up to 5,500 ft., 1.1898, J. H. Maiden (NSW.25341); Mt. Franklin road, 18 miles below Chalet, shallow soil on sedimentary rock, grey-brown podsolic soil, 17.2.1953, C. W. E. Moore (NSW.25598); Tantawanglo Mt. (MEL).

Victoria: Between Upper Cann and Genoa Rivers, open Eucalypt forest on gentle slope, 2½ miles N.E. of Cooponcambra Mt., with bracken, grasses, *Cynoglossum suaveolens*, *Wahlenbergia* spp., etc., 13.1.1953, R. Melville and N. A. Wakefield (MEL. Homoeotype); Tambo R., 1883, Howitt (MEL); Macallister R., 1.1859, F. Mueller (MEL. Lectotype); Ranges on the western branch of the Macallister, 1.1863, F. Mueller (MEL); Delatite R., 26.3.1853, F. Mueller (MEL. Lectoparatype).

As already pointed out in connection with the previous species, *P. hieracioides* F. Muell. was united by Bentham (1866) with *P. longipedata* A. Cunn. ex DC. With a much larger series of specimens than was available to Bentham, the present writer is in agreement with Willis (1954*b*) that the two species have little in common except the polycephalous condition. The shape of the involucral bracts is quite distinct, but the most conspicuous difference lies in their arrangement. Whereas in *P. longipedata* the triangular laminae are closely appressed and overlapping, so that their claws are concealed, in *P. hieracioides* the bracts are much fewer in number and are loosely arranged, with their long glandular claws partly or entirely exposed.

P. longipedata constitutes Bentham's "southern form", but his statement that these plants "have sometimes several stems from a hard stock" was only supported by one specimen (Michelago, Murrumbidgee River) in which four stems arose separately from the base.

Variation was seen in the development of the indumentum on the radical leaves, and even those which were apparently glabrous had a minute marginal fringe of hairs. Some specimens were sparsely septate-hairy on the upper surfaces of their radical leaves and in extreme instances hairs were sufficiently numerous on both surfaces to make the leaves harsh to the touch.

The capitula are arranged either as a dense terminal cluster on short peduncles or, while still clustered, are more loosely associated on longer peduncles arising from the axils of the cauline leaves. Only two specimens were seen in which the stem terminated in a single head. These were both from the same locality (Michelago, Murrumbidgee River) and accompanied by normal polycephalous plants.

Willis (1954*b*) refers to "a luxuriant specimen from the Upper Snowy River which . . . has a very broad spreading panicle bearing about 60 capitula". This, however, has the flattened stem and tufted appearance of fasciation and consequently the large number of heads is to be regarded as a pathological departure from the normal condition.

The number of lobes in the ligules of the ray florets, though commonly 3, is not invariable, since 2 or 4 teeth occur occasionally and specimens have been seen in which lobing has been completely suppressed.

As in the preceding species, the closest relative of *P. hieracioides* F. Muell. is *P. jaceoides* (Sims) Voss, and its present distribution suggests an origin as a highland sub-species which has spread along the Great Dividing Range.

5. Podolepis neglecta, n. sp.

(Text-figs. 33–40.)

Holotype and two *Paratypes*: Noosa Heads, Queensland, exposed situation among grasses on headland, 28.8.1955, G. L. Davis (NSW; BRI; MEL).

Herbae perennes, 13–63 cm. altae; stipitibus aut compluribus aut uno glabris vel exigue laniferis; foliis glabris aut hispidis aut non valde laniferis; foliis caulium usque ad 10 cm. longis, 2 cm. latis, oblongis aut etiam contractis lanceolatisque, acutis aut etiam acuminatis, sessilibus, arte decurrentibus; foliis radicalibus non dissimilibus sed in herbis novellis modoreperiendis; *capitulis* uno usque ad sedecim, sessilibus aut pedunculatis; *involucro* 1·5–2 cm. per lineam median menso, 2 cm. longo; squamis involucri lenibus nitentibus, rigidioribus, acutis, minime interrumptis, ac cum parte media dura et crassa et minime scariosa; squamis intermediis fere 1 cm. longis, 2 mm. latis, oblongis in quibus laminae non sunt acute ex unguinibus separatae; *floribus* marginum flavis, 34–50 numero, 8–20 mm. longis, 1·5 mm. latis cum alte trifurcis ligulis; pappo composito e 16–26 setis tenuibus, exiguissime hamatis et breviter in basi coniunctis; *frugibus* 2·5 mm. longis, 0·8 mm. latis, angustis oblongisque, cum spinis sursum inversis et exiguissimis.

Perennial plants 13–63 cm. high, with one or more glabrous or sparsely woolly stems. *Leaves* glabrous, hispid or slightly woolly; radical leaves present only on young plants. Cauline leaves up to 10 cm. long, 2 cm. broad, oblong to narrow-lanceolate, acute to acuminate, sessile, shortly decurrent. *Inflorescences* 1–16, sessile or pedunculate. *Involucres* 1·5–2 cm. diameter, 2 cm. long. *Involucral bracts* smooth, shining, rather stiff, acute, entire; the central region non-scarious, hard, thick and pale; intermediate bracts about 1 cm. long, 2 mm. broad, oblong, their laminae not sharply demarcated from the claws. *Florets* yellow, with a pappus of 16–26 fine microscopically barbellate bristles, united at the base. *Ray florets* 34-50, with ligules 8–20 mm. long, 1·5 mm. broad, and deeply 3-lobed. *Fruits* 2·5 mm. long, 0·8 mm. broad, terete, microscopically papillate.

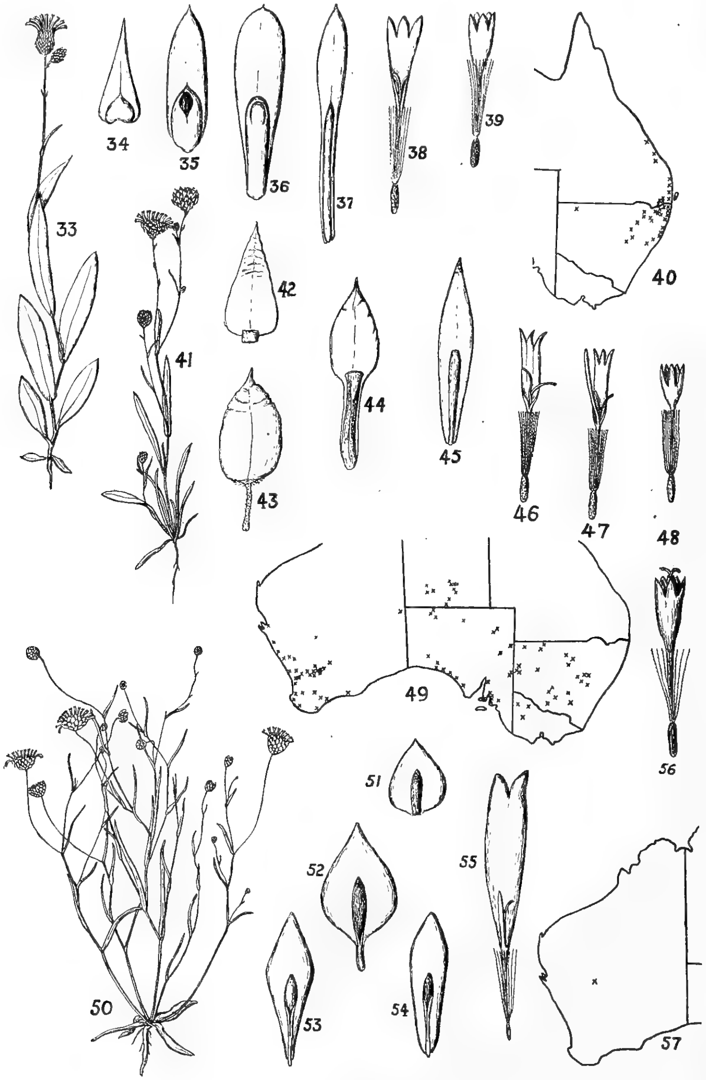
Habitat: Well drained situations.

Range: Widely spread throughout Queensland, extending into the North Coast and mid-western districts of New South Wales.

Specimens examined:

Queensland: Rockhampton, sides of mountain, 2.5.1868, P. O'Shanesy (MEL); Rockhampton, on the top of one of the highest mountains, 2.2.1863, Dallachy (MEL); Rosedale, summit of granite mountain, 10.5.1936, L. G. Dovey (BRI); Burnett R., F. Mueller (BRI); Noosa Heads, on grassy cliff-side, 19.4.1946, S. T. Blake n.15942 (BRI); Noosa Heads, exposed situation among grasses on headland, 28.8.1955, G. L. Davis (NSW.Holotype; BRI, MEL. Paratypes); Glasshouse Mts., 2.1920, W. D. Francis (BRI); Moreton Bay, F. Mueller (BRI); Stradbroke Is., 10.1916, E. W. Bick (BRI); Dunwich, 3.1892 (BRI); Sunnybank, cleared Eucalypt-forest, amongst *Themeda australis*, *Capillipedium parviflorum*, *Imperata cylindrica* var. *Koenigii*, etc., sandy soil, 130 ft., 27.7.1930, C. E. Hubbard n.3445 (BRI); Logan R., 1881, Scortechini (MEL); Currumbin, forest land on hillsides, 10.12.1932, C. T. White n.8738 (BRI); Robert's Plateau, 28.5.1929, C. T. White n.6048 (BRI); Macpherson Range, open forest country, 1.1919, C. T. White (BRI); the Summit, sandy soil among big granite blocks, 22.11.1946, S. L. Everist and L. J. Webb n.1331 (BRI); Stanthorpe, 12.1875, F. M. Bailey (BRI); Wallangarra, 11.1904, J. L. Boorman (NSW.25406); Mistake Range, 11.1920, C. T. White (BRI; ADW); Mt. Mistake, Eucalypt forest, on rocky slope among *Themeda* and *Poa*, 1,800 ft., 24.11.1930, C. E. Hubbard n.5238 (BRI).

New South Wales: Mt. Lindesay, 11.1912, H. M. R. Rupp (NSW.25404); Acacia Plateau, Rain Forest, edge of road, 17.5.1947, E. F. Constable (NSW.3562); Brunswick and Tweed Rivers, open sandy ground (MEL); Richmond R., C. Fawcett (MEL); Timbarra, C. Stuart (MEL); Little Mt. Spirabo, *Eucalyptus campanulata* assoc., steep slope of quartzite hill, 21.4.1954, R. W. Jessup and M. Gray (CAN); Torington, J. L. Boorman (NSW.25401); Rivertree, Upper Clarence R., 7.9.1911, R. H. Cambage (NSW. 25399); Clarence R., Beckler (MEL); Coff's Harbour to Grafton, 11.1903, J. H. Maiden and J. L. Boorman (NSW.25417); Bellinger R., (NSW.25416); Hat Head, Mt. Korogora Pt., 350 ft., occasional on slopes, conglomerate, 19.1.1953, E. Constable (NSW.22102); Glen Innes, 12.1913, J. L. Boorman (NSW.11963); Warialda, 1.1907, H. M. R. Rupp (NSW.25397); Howell, 12.1914, J. L. Boorman (NSW.25480); 6 miles from Bundarra, 9.3.1954, M. Gray (CAN); Mt. Lindesay Sta., Nandewar Mts., 11.1909, R. H. Cambage (NSW.25402); Warrumbungle Ranges, 1.1883, E. Betche (MEL; NSW.25354); Gonoo Forest and Mendooran, 1947, G. W. Althofer (NSW.25355); Dubbo, 12.1907, J. L. Boorman (NSW.25480); Denman, 10.1908, W. Heron (NSW.11962); Paroo R. district (NSW.25412).



Text-figs. 33-57.

33-40. *P. neglecta.*—33, Habit × 0·3; 34-37, outer, intermediate and inner Involucral Bracts × 3; 38, Ray floret × 3; 39, Disc floret × 3; 40, Distribution. 41-48. *P. canescens.*—41, Habit × 0·3; 42-45, outer, intermediate and inner Involucral Bracts × 3; 46, Ray floret × 3; 47, Ray floret with supernumerary lobe × 3; 48, Disc floret × 3; 49, Distribution. 50-57. *P. Gardneri.*—50, Habit × 0·3; 51-54, outer, intermediate and inner Involucral Bracts × 3; 55, Ray floret × 3; 56, Disc floret × 3; 57, Distribution.

The specific epithet refers to the fact that, in spite of its wide range and distinct characters, this species is hitherto undescribed. While closest to *P. jaceoides* (Sims) Voss, it is distinguished by the unique nature of the involucral bracts in which the apex of the claw is thickened and its central region depressed. In all the living specimens examined this depressed area is green and the surrounding thickened portion is paler than the lamina, which is not sharply demarcated from the claw. The laminae are stiff, rather than papery as in *P. jaceoides*, and are very commonly reddish-brown. The type specimens, when living, had an urn-shaped involucre, but as this characteristic is lost on pressing, it is not known whether it is general. Vegetatively, *P. neglecta* can be distinguished from *P. jaceoides* by the lack, in established plants, of radical leaves, and even when these are present in young plants, they are few in number.

Variation in habit is associated with the age of the plants and probably environmental factors. In this connection a specimen from the roadside in Rain Forest (Acacia Plateau) is interesting in that it was the only one examined from such a situation, and its stem was lax and almost wiry. Another specimen (Robert's Plateau) was of relatively immense proportions with crowded broad-elliptical cauline leaves up to 18·5 cm. long and 4 cm. broad, with overlapping leaf-bases. There is a collector's note accompanying this specimen to the effect that it was 2 ft. in height, but only the lower 15 cm. and upper 32 cm. have been preserved. The three inflorescences closely grouped at the stem apex do not reflect the gigantism of the vegetative parts and are, in fact, of normal size.

A most remarkable example of phenocopy (the production by the environment of a replica of a hereditary variant with a different genotype) was seen in two specimens collected at Mt. Spirabo by R. W. Jessup and M. Gray. Both were identical in all vegetative respects yet, while one was *P. neglecta*, the other was *Helichrysum bracteatum* (Vent.) Andr. Neither specimen was vegetatively typical of its species, and had they not been in flower it would have been impossible to distinguish between them. In a personal communication, Mr. Gray stated that the two plants were growing within 10 feet of each other and it was their resemblance in the field which led him to collect them.

6. **PODOLEPIS CANESCENS** A. Cunn. ex DC., *Prod.* 6 (1837): 163.
(Text-figs. 41–48.)

Synonyms: *P. inundata* A. Cunn. ex DC., *Prod.* 6 (1837): 163; *P. aristata* Benth. in *Enum. Pl. Hueg.* (1837): 64; *P. chrysantha* Endl. in *Bot. Zeit.*, 1 (1843): 458; *P. subulata* Steetz. in *Lehm. Pl. Preiss*, 1 (1845): 465; *P. aristata* Benth. var. *chrysantha* (Endl.) Steetz in *Lehm. Pl. Preiss*, 1 (1845): 465; *P. affinis* Sond. in *Linnaea*, 25 (1852): 507; *P. aristata* Benth. var. *minor* Benth., *Fl. Aust.*, 3 (1866): 605; *P. rubida* Maid. and Baker, PROC. LINN. SOC. N.S.W., 10 (1895): 587.

Type data: "On rocky hills around Croker's Range, New Holland, towards the western valley of Wellington, November flowering. Cunningham."

Lectotype: Croker's Range, 11.1825, A. Cunningham n.39 (BRI).

Branching annuals 6–83 cm. high with a varying amount of white wool on stems and lower surfaces of leaves. *Radical leaves* not always present, up to 7 cm. long, 1·5 cm. broad, oblanceolate, petiolate, acute. *Cauline leaves* up to 8 cm. long, 1·6 cm. broad, elliptical to lanceolate, sessile, decurrent, subacute to acute. *Inflorescences* 1–100, on peduncles up to 6 cm. long. *Involucres* 1·5–2·5 cm. diameter, 0·7–1·5 cm. long. *Involucral bracts* straw-coloured to golden- or reddish-brown, with microscopically serrulate, acute to acuminate, distally rugose laminae; intermediate bracts 0·6–1 cm. long, with oblong to lanceolate laminae 2–2·5 mm. broad, and long slender glandular claws. *Florets* yellow, with a pappus of 12–25 microscopically barbellate bristles. *Ray florets* 20–40, with a ligule 0·6–1 cm. long, usually 3-lobed. *Fruits* terete, 1·5–2 mm. long, 0·4–0·6 mm. broad, microscopically papillate.

Range: Western districts of New South Wales and Victoria; common throughout Northern Territory, South Australia and Western Australia.

Specimens examined:

New South Wales: Tibbooburra, 9.9.1923, MacGillivray (ADW); Caiwarro, Hungerford, 9.1885, T. Cotter (MEL); Paroo R. district, 9.1900, E. Betche (NSW.25434);

Bourke, 9.1884, L. Henry (MEL; NSW.25473); Upper Darling R., 1878, P. Day (MEL); Tarcoon, 11.1903, J. L. Boorman (NSW.25448); Byrock, 11.1890, E. Betche (NSW.25437); Paldrumatta Bore, Wilcannia, 10.1901, P. Corbett (NSW.11958; MEL); Fowler's Gap, Gibber plains, 13.8.1955, N. C. W. Beadle (NE); Silverton, 1884, Harris (MEL); Broken Hill, 9.1918, E. C. Andrews (NSW.25431); Broken Hill district, MacGillivray (ADW); Mossgiel, 10.1885, J. Bruckner (MEL); Croker's Range, 11.1825, A. Cunningham (BRI. Lectotype *P. canescens* A. Cunn. ex DC.); Dubbo, 9.1883, E. Betche (NSW.25471); Gulgong (MEL); Hillend, 10.1885, Lauterer (MEL); Perth, 3.1901, J. L. Boorman (NSW.25472); Bathurst, 1894 (NSW.25439); between the Darling and Lachlan Rivers, 1877, Burkitt (MEL); Lachlan R., 9.1878, F. Mueller (MEL); Wyalong, 10.1903, J. L. Boorman (NSW.25438); Murrumbidgee R., 1878, G. Day (MEL); Tarcutta, 1876, Chamberlin (MEL); Wanganella, 11. 1903, E. Officer (NSW.25432).

Victoria: Wimmera, Dallachy (MEL); Lake Lalbert, 6.12.1853, F. Mueller (MEL); near Murtoa, 3.10.1892, F. M. Reader (MEL).

Northern Territory: Base of Mt. Gillan, Alice Springs, rocky slope, 27.9.1955, N. T. Burbidge and M. Gray n.4357 (CAN); 13 miles S. of Storm Creek, Alice Springs, sand dune, 24.11.1954, G. Chippendale (NSW); Ewaninga, 25.8.1931, J. B. Cleland (JBC); Bundooma, 23.8.1932, J. B. Cleland (JBC); near Haast's Bluff, 8.8.1932, J. B. Cleland (JBC); 9 miles from Hermannsburg, red sandhill, 23.9.1945, N. T. Burbidge and M. Gray n.4265 (CAN); between Ooraminna and James Ranges, 20.7.1894, R. Tate (AD); Deep Well, 25.8.1931, J. B. Cleland (JBC); Finke R., 12.1879, Kempe (MEL); 15 miles N. of Kulgera, mulga-*Cassia eremophila* into Composite herbage, 8.10.1955, N. T. Burbidge and M. Gray (CAN); 28 miles S. of Kulgera H.S., open mulga area, 5.8.1954, G. Chippendale (NSW).

South Australia: North Musgrave Ranges, 7.1926, H. Basedow (P; NSW.25436); between Musgrave and Everard Ranges, 28.9.1945, J. B. Cleland (JBC); Lambina, 21.8.1933, J. B. Cleland (JBC); Kopperamana, Cooper's Creek, 1883, J. Flierl (MEL); between Stoke's Range and Cooper's Creek (MEL); Mt. Distance, J. Langley (AD); between Cockburn and Mingary, 14.8.1881, A. Morris (JMB); Murray Bridge, 10.1911, H. H. D. Griffith (JMB); Murray, F. Mueller (MEL. Cotype *P. affinis* Sond.); Hallett's Cove, 28.10.1932, J. B. Cleland (JBC); Brighton, 9.1904, J. M. Black (JMB; NSW.25433); Enfield, 10.11.1918, J. M. Black (JMB); Dublin, 15.9.1927, H. H. D. Griffith (JMB); St. Vincent's Gulf (MEL); Yorke Penin. 1879, Tepper (MEL); Port Pirie, 9.1901, M. Koch (NSW.3573); Coroona, Iron Knob, 6.1905, W. L. Cleland (JBC); Tumby Bay, C. Wilhelmi (MEL); Dombey Bay, F. Mueller (MEL. Cotype *P. affinis* Sond.); Port Lincoln, F. Mueller (MEL. Cotype *P. affinis* Sond.); Lake Hamilton, 10.1882, A. Richards (AD); Venus Bay, Warburton (MEL); Denial Bay, 7.1907, Pulleine (JMB); Fowler's Bay, Richards (MEL); Euria, T. Richards (AD); Ooldea, 1932, Bates (JBC).

Kangaroo Island: Rocky R., 24.11.1945; 4.12.1934, J. B. Cleland (JBC).

Western Australia: Shark Bay, 10.1877, F. Mueller (MEL); between Murchison River and Shark Bay, 10.1877, F. Mueller (MEL); Greenough R., 11.1877, F. Mueller (MEL); Greenough Flats, C. Gray (MEL); Cue, 10.1909, J. H. Maiden (NSW.25454); Moora, 10.1908, J. B. Cleland (NSW.25306); Wongan Hills, 5.10.1903, A. Morrison (P); Moore R., sandy soil, 10.1901, E. Pritzel (AD); Mt. Caroline, 1886, G. A. Sewell (MEL); lower Swan R., 1887, Gribble (MEL); in sandy soil between woodland and the Canning R., Preiss n.52 (MEL. Cotype *P. aristata* Benth. var. *chrysantha* (Endl.) Steetz); North Mundaring, 11.1909, J. H. Maiden (NSW.25460); Wooroloo, 10.1907, M. Koch (NSW. 25304); Northam-Perth highway, 4–6 miles from Northam, in bush and meadows, 30.10.1949, H. Selasso (NSW.25298); Northam, 10.1900, Gregory (P); near York, 1878 (MEL); Cowcowing Lakes, 9.1904, M. Koch (MEL; P; NSW.25307); between Grass Valley and Meenaar, gravelly soil, 22.10.1943, C. A. Gardner n.6507 (P); Boxvale, J. S. Wells (MEL); Cunderin, 10.10.1944, C. A. Gardner n.7459 (P); Tammin, 6.10.1914, C. H. Ostenfeld (P); Kellerberrin, 12.1903, F. H. Vachell (NSW.25465); Merredin, 9.10.1923, M. Koch (MEL; NSW.25309); Darling Range, 11.1907, M. Koch (P); Vasse district, barren muddy ground, Preiss n.54 (MEL); Hamelin Harbour, F. Mueller (MEL); Blackwood R., Oldfield (MEL); Wagin, 25.10.1920, C. A. Gardner (P);

between Swan R. and King George's Sound, 1881, J. Forrest (MEL); Stirling Range, 10.1867, F. Mueller (MEL); Plantagenet and Stirling Ranges (MEL); interior of King George III Gulf, Preiss n.60 (MEL); King George's Sound (MEL); Bremer Bay, 1900, J. Wellstead (P); Esperance Bay, 7.10.1930, Shell Oil Co. (MEL); near Mt. Squires, 25.8.1891, Elder Expl. Exped. (NSW.25452); W.A., J. Drummond, n.155 (MEL. Cotype *P. aristata* Benth. var. *minor* Benth.); W.A., 1854, J. Drummond, 6th Coll. n.155 (NSW. 25300. Cotype *P. aristata* Benth. var. *minor* Benth.); Hort. Bot. Hamburg, 9.1855, ex Hb. Sonder (MEL. Cotype *P. aristata* Benth. var. *chrysantha* (Endl.) Steetz).

P. canescens A. Cunn. ex DC. is a very widespread and variable species which, strangely enough, has not been recorded from Queensland.

The type locality, Croker's Range, is part of what are now known as the Harvey Ranges, near Wellington, and the lectotype is a slender plant with an almost glabrous, reddish stem and few leaves, while the capitula are surrounded by golden-brown, transversely wrinkled involucral bracts.

Bentham (1866) listed *P. inundata* A. Cunn. ex DC. and *P. affinis* Sond. as synonymous with *P. canescens* which he considered to be confined to the eastern half of Australia. Type material of *P. inundata* ("Flooded banks of the Lachlan R.") has not been examined and Cunningham did not make clear in what respect this species differed from *P. canescens*, which was described at the same time. Comparing the original descriptions of these two species, the only difference of any significance is that the involucral bracts of *P. canescens* were stated to be "subrugose", whereas those of *P. inundata* were not mentioned in this respect. Since Bentham cited Cunningham's material as having been personally examined, the synonymy is accepted on his authority.

Cotype specimens of *P. affinis* ("Murray, Port Lincoln. Dombey Bay") from Sonder's herbarium have been examined from each type locality, and found to be conspecific with each other and the lectotype of *P. canescens*.

The identity of *P. aristata* Benth. ("Swan River, Hugel") has been established by the present writer in a somewhat devious manner, since no type material is available in Australia. In the National Herbarium, Melbourne, there are two specimens collected by Preiss (n.60) from "the Interior of King George III Sound", one of which was originally from Lehmann's herbarium, and the other from that of Steetz. The second specimen is annotated by Steetz "this specimen agrees in all parts with the authentic specimen of Hugel, examined by the famous Bentham", and the first is mentioned by Steetz (1845) as "compared with Hugel's actual specimen in the Imperial Herbarium of Vienna". Both these specimens have accordingly been used as a basis of comparison for *P. aristata*, and both agree very closely with *P. canescens*. At the time of publication of *P. aristata* it is doubtful whether Bentham was aware of *P. canescens*, since both were described in the same year, but later (1866) he distinguished between them by referring to *P. canescens* as an eastern species with acute, smooth or slightly rugose bracts, and to *P. aristata* as a western species with very acuminate, smooth bracts. After handling a considerable number of specimens, the present writer is of the opinion that none of the bracts are, in fact, smooth, and in all specimens they are, to some extent, rugose. There being, then, no morphological discontinuity between these two species, *P. aristata* is reduced to synonymy.

P. chrysantha Endl. ("South-west New Holland") was relegated by Steetz (1845) to varietal status under *P. aristata*, with the note "the authentic specimen having been compared and examined repeatedly, I am satisfied that Endlicher's plant is nothing more than a variety of *Podolepis aristata* Benth. Cultivated plants are extremely variable both in size and indumentum". Two specimens are cited by Steetz in connection with his var. *chrysantha*: "Canning River, Preiss n.52", and "Cultivated in the Botanic Gardens of Hamburg". Both of these are in the National Herbarium, Melbourne, and have been nominated Cotypes for the variety, which is now abandoned as merely being a natural expression of that variability observed by Steetz under cultivation.

Cotype material of *P. subulata* Steetz ("Vasse R. district") was cited by Bentham (1866) in connection with his description of *P. aristata* var. *minor*, consequently the same specimen is a cotype of both names. Although this specimen is considerably taller than the lectotype of *P. canescens*, its capitula are very similar, and both *P. sublata* and *P. aristata* var. *minor* are accordingly reduced to synonymy under that species.

P. rubida Maid. and Baker ("Bathurst, W. J. C. Ross") was described on material which exactly matches the lectotype of *P. canescens* and was, in fact, collected not far from the type locality of that species. According to the authors, *P. rubida* is distinguished from *P. canescens* by the inner bracts being rugose whereas those of the latter species are "not rugose". This statement is in complete disagreement both with Cunningham's original description and his actual specimens, and the name *P. rubida* is consequently abandoned.

Typically *P. canescens* has a greyish-green appearance due to its woolly indumentum and, when many-stemmed, it may assume a rather bushy habit. Variation in height is considerable, from an upper limit of 83 cm. (Vasse R. district, Preiss n.54) to certain small ephemeral-like specimens 3·7–7 cm. high from the Stirling Range and the Wimmera district. That environmental factors are operative in such a great size range is suggested by a specimen from Waroona, W.A., where the elliptical leaves reach a length of 12·5 cm., and which is accompanied by the note "does well under cultivation, forming large branching plants 30 inches high, and 3 ft. through".

Since the involucral bracts vary in colour, size, and details of their apices, their salient feature is their slight rugosity, which involves only the terminal portion of the laminae and is often more distinct in the complete involucre than in the individual bracts.

7. PODOLEPIS GARDNERI, sp. nov.

(Text-figs. 50–57.)

Holotype and *paratype*: Meekatharra, Western Australia, Quartz rises, rays yellow, 20.7.1931, C. A. Gardner n.2358 (P).

Herbae annuae (?) multum furcillatae, usque ad 24 cm. altae; stipitibus rubeis et prope glabris; foliis caulium usque ad 7 cm. longis, 3 mm. latis, late linearibus, sessilibus, arte decurrentibus, obtusis, cum pilis brevibus et saeptatis; foliis radicalibus usque ad 7 cm. longis, 5 mm. latis, paululo prope basim contractioribus; *capitulis* 11–20 numero, in pedunculis quae sunt fili similes et nudae dispositis; involucro 9 mm. longo, 15 mm. lato; *squamis involucri* lenibus aut parum rugosis, minime interruptis cum apicibus subacutis; squamis intermediis fere 8 mm. longis, cum brevi ungula quae extenditur per fere dimidium mediae partis laminae rhomboeidis quae est 4 mm. lata; *floribus* omnino fulvis, cum pappo a saetis fere 15 numero, tenuibus, exiguissimis, barbillatis, capillaribus composito; floribus marginis fere 30 numero cum ligulis 9·5–11 mm. longis, 2 mm. latis, bifurcis, qui habent unam quasi lobam digitalem quae exstat e basi ligulae ipsa sola; floribus disci quinquies furcillatis, cum styli brachiis acutis ac longis caudis antherorum; frugibus maturis nondum visis.

Much-branched annuals (?) up to 24 cm. high with reddish, almost glabrous stems. *Cauline leaves* up to 7 cm. long, 3 mm. broad, broad-linear, shortly decurrent, obtuse, with short septate hairs. *Radical leaves* up to 7 cm. long, 5 mm. broad, tapering slightly to the base. *Inflorescences* 11–20, on filiform, naked, peduncles. *Involucres* 9 mm. long, 15 mm. broad. *Involucral bracts* smooth or slightly wrinkled, entire, with sub-acute apices; intermediate bracts about 8 mm. long, 4 mm. broad, with a short claw which continues about half-way along the centre of the rhomboidal lamina. *Florets* all yellow, with a pappus of about 15 fine microscopically barbellate capillary bristles. *Ray florets* about 30, the ligule 9·5–11 mm. long, 2 mm. broad, 2-lobed, with a finger-like, independent lobe arising from the base of the ligule. *Disc florets* 5-lobed, with pointed stylar arms and long tails to the anthers. *Fruits* not seen mature.

Specimens examined: Type series only.

The habit and the rhomboidal shape of the involucral bracts of this species suggest a close relationship with *P. Georgii* Diels but, on the other hand, the clawed nature of the intermediate bracts and the presence of female florets with well-developed ligules indicates that any similarity between the two species is due to convergent evolution rather than close relationship. The lobing of the ligule into two teeth will probably be found not to be an invariable character when further specimens are collected, but the presence of a supernumerary independent lobe at the base of the ligule is interesting. This structure has been observed in only one other species, *P. canescens*, where its occurrence is rare.

P. Gardneri has been named after its collector, Mr. C. A. Gardner, Government Botanist of Western Australia, and placed in this revision, close to *P. canescens* A. Cunn. since the intermediate bracts are clawed, and the scarious portions of their laminae are slightly wrinkled. The relationship, however, if any, is not close.

8. PODOLEPIS AURICULATA DC., *Prod.*, 6 (1837): 162.

(Text-figs. 58–65.)

Synonymy: *P. pallida* Turcz., *Bull. Soc. Nat. Mosc.*, 24 (1851): 78.

Type data: "in New Holland, at Shark Bay, collected by Gaudichaud and sent to me."

Lectotype: Shark Bay, 1830, M. Gaudichaud (GENEVA).

Probably annuals, usually many-stemmed, with an indumentum of woolly hairs on the lower portions of the stems and the undersurfaces of the leaves. *Radical leaves* oblanceolate, acute, only present on young plants. Lower *cauline leaves* up to 7 cm. long, 1 cm. broad, lanceolate to broad-linear, acute, sessile, decurrent. *Inflorescences* 2–33, on peduncles up to 8 cm. long. *Involucres* up to 1·8 cm. broad, 1·5 cm. long. *Involucral bracts* with very deeply rugose triangular laminae, apices very acuminate; intermediate bracts 8–10 mm. long with slender microscopically glandular claws equal in length to the laminae. *Florets* with a pappus of 19–24 capillary bristles, minutely barbellate for the upper two-thirds of their length. *Ray florets* about 70, the ligule 1·5 cm. long, 3 mm. broad, 3–4-lobed. *Fruits* 2 mm. long, 0·6 mm. broad, terete, microscopically papillate.

Range: North-western districts of Western Australia, from the Fortescue to the Murchison River.

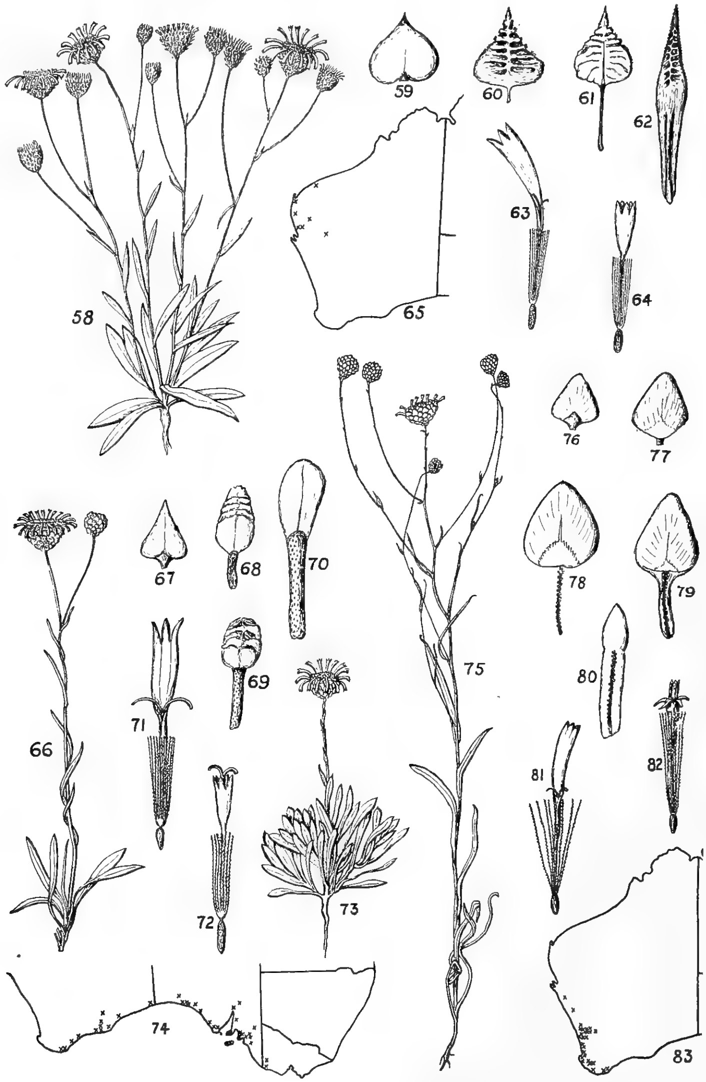
Specimens examined:

Western Australia: Between the Gascoyne and Fortescue Rivers, 1885, H. S. King (MEL); near Exmouth Gulf, 1885, Carey (MEL); Mia Mia Homestead, Minilya R., red loamy soil, 28.8.1932, C. A. Gardner n.3197 (P); head of Minilya R., 1882, J. Forrest (P; MEL); Kennedy Range, 8.9.1948, G. A. Thomas (MEL); Gascoyne R., with *Kochia*, 1882, J. Forrest (MEL); 20 miles E. of Carnarvon, red sand on rises in Wanum country, 20.9.1941, C. A. Gardner n.6027 (P); near Mt. Hale, 1884, C. Crossland (MEL); W.A., J. Drummond n.387 (MEL. Haptotype of *P. pallida* Turcz.).

From the original description of *P. auriculata*, in which de Candolle referred to the involucral bracts as being "transversely rugose and acuminate", it was clear that the specimen he handled was conspecific with either *P. canescens* A. Cunn. ex DC. or *P. pallida* Turcz. It not being possible to decide to which of these two species *P. auriculata* belonged, an appeal for information was made to the Botanic Gardens at Geneva, where de Candolle's herbarium is housed. The following is an extract from the reply by Mr. Raymond Weibel, Curator of the Herbarium: "The bracts of the involucre of *P. auriculata* are very rugose, as those of *P. pallida* Turcz. The capitulum is of a larger diameter than the one of *P. canescens*; the involucre of *P. auriculata* reaches, in sicco, a diameter of 1·5 cm.; the one of *P. canescens* seldom reaches 1 cm." The label of Gaudichaud's specimen bears the following information: "Baie des ch. (= chiens) marins" (Bay of Dogfish = Shark Bay). Also photographs of *P. canescens* and *P. auriculata* Type specimens were taken and sent, together with some of the involucral bracts from Gaudichaud's specimen. As a result of the careful observations and comparisons made by Mr. Weibel, and the photographs and material supporting those observations, there is no doubt that *P. auriculata* is not only synonymous with *P. pallida*, but has priority in nomenclature. A similar conclusion was reached by Diels (1905).

A haptotype of *P. pallida* ("West Australia", J. Drummond 5th Coll. no.387) was selected from five specimens in the National Herbarium, Melbourne, which bear the type data. There is no evidence that Turczaninow handled these specimens, and it is probable that they are duplicates of the type series.

The most distinctive feature of *P. auriculata* is the almost honeycombed appearance of the involucre, due to the deeply rugose nature of the laminae. This is a character which is shared only with *P. rugata* and relationship can be assumed.



Text-figs. 58-83.

58-65. *P. auriculata.*—58, Habit × 0·3; 59-62, outer, intermediate and inner Involucral Bracts × 3; 63, Ray floret × 3; 64, Disc floret × 3; 65, Distribution. 66-74. *P. rugata.*—66, Habit × 0·3; 67-70, outer, intermediate and inner Involucral Bracts × 3; 71, Ray floret × 3; 72, Disc floret × 3; 73, *P. rugata* var. *littoralis*, Habit × 0·3; 74, Distribution, *P. rugata* (x), var. *littoralis* (●). 75-83. *P. gracilis.*—75, Habit × 0·3; 76-80, outer, intermediate and inner Involucral Bracts × 3; 81, Ray floret × 3; 82, Disc floret × 3; 83, Distribution.

9. Podolepis rugata Labill., *Nov. Holl. Pl.*, II, 57 (1806):208.

Perennial plants 5–58 cm. high, glabrous or with a varying amount of loose white wool. *Cauline leaves* up to 10 cm. long, 3–13 mm. broad, oblanceolate, elliptical or linear, acute to acuminate, tapering to a shortly decurrent base; *radical leaves* up to

8 cm. long, seldom present. *Inflorescences* 1–24 or more. *Involucres* 3 cm. broad, 2 cm. long. *Involucral bracts* reddish-brown, with very deeply rugose, obtuse laminae; claws glandular; intermediate bracts about 6·5 mm. long with broadly ovate laminae. *Florets* with a pappus of 35–80 finely barbellate bristles, united at the base. *Ray florets* 35–70, the ligule 8·5–15 cm. long, 2–3 mm. broad, 3-lobed. *Fruits* 2·7 mm. long, 0·8 mm. broad, terete, microscopically papillate.

Key to the varieties.

Leaves of normal texture. Glabrous or woolly plants with erect habit .... var. *α rugata.*
Leaves fleshy. Glabrous plants with stunted often semi-prostrate habit .... var. *β littoralis.*

P. RUGATA Labill. var. *α* RUGATA.

(Text-figs. 66–72.)

Type data: "Van Leuwin's Land."

Erect perennials with elliptical or linear cauline leaves of normal texture.

Specimens examined:

Victoria: On the Glenelg R., 1857, F. Mueller (MEL); mouth of the Glenelg, W. Allitt (MEL).

South Australia: Coombe, 11.1952, W. H. Litchfield (ADW.8945); Murray Bridge, 26.10.1939, K. E. Orchard (ADW.3884); Wynarka, 10.1932, E. Ising (I.3856); Karoonda, 7.10.1915, J. M. Black (JMB); Pallamana, 26.10.1943, Erdman (ADW.5057); Sedan, 10.1924, J. M. Black (JMB); Mylor, 15.10.1925, J. M. Black (JMB); Birdwood, 10.1929, E. Ising (I.3854); Grange, 11.1897, O. E. Menzel (AD); Henley Beach, 24.10.1904, J. M. Black (NSW.25296; JMB); between Glenelg and Brighton, sandhills, 16.10.1906, J. M. Black (JMB); Brighton, sea coast, 11.1897, O. E. Menzel (NSW.25294); Eden, 30.10.1937, E. Ising (I.3849); Pt. Noarlunga, on cliffs, 5.11.1926, J. B. Cleland (JBC); Aldinga, 31.10.1928, J. B. Cleland (JBC); Yorke Penin., Tertiary soils, 1879, Tepper (MEL); Port Augusta, 1885, A. Richards (MEL); Cape Spencer, 1.1950, H. A. Behrens (MEL); Port Lincoln, F. Mueller (MEL); between Port Lincoln and Streaky Bay, 1882, Richards (MEL); Coffin Bay, Richards (AD); Lake Hamilton, 10.1882, A. Richards (AD); Venus Bay, Warburton (MEL); Koonibba, 19.8.1928, J. B. Cleland (JBC); Fowler's Bay, 10.1907, T. Brown (NSW.25435).

P. RUGATA Labill. var. *β.* LITTORALIS var. nov.

(Text-fig. 73–74.)

Holotype and two *Paratypes*: Cape Conedie, Kangaroo Island, 1.1907, R. S. Rogers (NSW.25380).

Herbae semi-pronae aut non numquam erectae, 9·5–26 cm. altae. Foliis caulium oblanceolatis aut etiam spatulatis, brevita acutis, saepissime stipatis.

Semiprostrate or occasionally erect plants 9·5–26 cm. high, with oblanceolate to spathulate, fleshy, shortly acute leaves which are often crowded.

Range: Kangaroo and Thistle Islands; neighbouring portions of the South Australian Coast.

Specimens examined:

South Australia: Aldinga, 31.10.1928, J. B. Cleland (JBC); Pt. Noarlunga, on cliffs, 5.11.1926, J. B. Cleland (JBC); Willunga, 24.9.1904, J. M. Black (JMB); Cape Spencer, 1.1950, H. A. Behrens (MEL).

Kangaroo Island: Between Kingscote and Vivonne Bay, 16.11.1924, J. B. Cleland (JBC); Vivonne Bay, 2.12.1934, J. B. Cleland (JBC); Pennington Bay, 6.3.1926, J. B. Cleland (JBC); d'Estrea Bay, sea cliffs, 12.1881, R. Tate (AD); Cape Conedie, 1.1907, R. S. Rogers (NSW.25380. Holotype. Paratypes); Rav. des Casvars, 31.1.1950, J. B. Cleland (JBC); Mouth of the Rocky R., 31.1.1940, J. B. Cleland (JBC); Kangaroo Is., 10.1908, H. H. D. Gordon (JMB).

Thistle Island: 1.1907, J. H. Maiden (NSW.25381).

P. rugata was described by Labillardière from specimens he collected at Cape Van Leeuwin, in the south-western corner of Western Australia, and the description was accompanied by figures of the habit and floral details. Further specimens were collected at Princess Royal Harbour by L. Preiss and referred by Steetz (1845) to this species, with the comment "I have not seen Labillardière's specimen, but have no doubt that these are the same, although their ligules are much more deeply incised than those of Labillardière. I have noticed that in other species of this genus, i.e. *P. acuminata*, the ligules vary in one and the same specimen, very often some having deep incisions and some very slight".

Labillardière's excellent drawings, in conjunction with his description, leave no doubt as to the identity of this species, in the absence of type material.

The only variation of any significance in *P. rugata* is the stunted, often semi-prostrate, habit and oblanceolate, rather fleshy leaves of a number of plants from Kangaroo Island and neighbouring parts of the mainland. Although this habit may be associated with an exposed habitat, normal plants have been collected from some of the same localities. The present writer is of the opinion that this variation has a genotypic basis, and consequently has accorded it varietal status.

P. rugata is closest in all respects to *P. pallida* Turcz., but particularly in the very rugose bracts which, *in situ*, give a honey-combed appearance to the involucres of both species. Since these species replace each other geographically the suggestion is that they had a common origin, perhaps from the widespread and variable *P. canescens* A. Cunn. ex DC., and that they diverged as geographic subspecies.

10. PODOLEPIS GRACILIS (Lehm.) R. Grah. in *Edinb. N. Phil. Journ.* (1828): 379.

(Text-figs. 75–83.)

Synonyms: *Stylolepis gracilis* Lehm. var. *glabra* Lehm., *Sem. Hort. Hamb.* (1828): 17; *S. gracilis* Lehm. var. *arachnoidea* Lehm., *l.c.*; *Podolepis rosea* Steetz in *Lehm. Pl. Preiss*, 1 (1845): 463; *P. filiformis* Steetz in *Lehm. Pl. Preiss*, 1 (1845): 465; *P. rosea* Steetz in Lehm. var. *mollissima* Walp., Rep. 6 (1847): 236; *P. Spenceri* Ewart in *Proc. Roy. Soc. Vict.*, N.S. 20 (1907): 83.

Type data: "Habitat in New Holland. Seeds sent from England" (i.e. to Hamburg).

Slender, usually branching annuals, 3–50 cm. high, sparsely woolly on the stems, leaf axils and lower leaf surfaces. Lowest *cauline leaves* up to 8 cm. long, 8 mm. broad, oblanceolate to broad-linear, sessile, shortly decurrent, acute to acuminate. *Radical leaves* seldom present. *Inflorescences* 1–25, on filiform peduncles. *Involucres* 0·9–2 cm. broad, 1 cm. long. *Involucral bracts* straw-coloured to reddish-brown, smooth and shining with a distinct midrib; intermediate bracts about 7 mm. long, the laminae smooth, triangular and acute, or ovate and subacute with a short mucro; claws slender, glandular, equal in length to the laminae. *Florets* with a pappus of 6–20 minutely barbellate bristles. *Ray florets* pink, the ligules 1–1·5 cm. long, 1·3–2·5 mm. broad, 2–3-lobed. *Fruits* 1–1·4 mm. long, 0·5 mm. broad, terete.

Range: Coastal belt of Western Australia from the Murchison River to King George's Sound.

Specimens examined:

Western Australia: Murchison R., Oldfield (MEL); between the rivers Murchison and Irwin, Sewell (MEL); Gingin and Moore Rivers, 12.1879, J. Forrest (MEL); upper Swan R., 1884, Sewell (MEL); between York and Perth, Jarrah woods, 11.1877, F. Mueller (MEL); near York, grassland, 11.1877, F. Mueller (MEL); Greenmount, 25.8.1897, R. Helms (P; NSW.25319); Midland Junction, wet places, 3.12.1902, C. Andrews (NSW.25312; 25315); Welshpool to Kalamunda, 9.1909, J. H. Maiden (NSW.25458); Bassandeen, sandy places among dense shrubs, L. Preiss n.51 (MEL); near Perth, 1878, Forrest (MEL); Perth, 10.1909, J. H. Maiden (NSW.25457; 25461); in fallow land not far from Perth, L. Preiss n.56 (MEL); South Perth, 1902, A. G. Hamilton (NSW.25323); near Limekilns, sandy woods not far from Perth, L. Preiss n.55 (MEL. Lectotype and lectoparatype *P. rosea* Steetz); Sandy rather shady places on the Swan R., above Perth, L. Preiss n.53 (MEL. Lectotype *P. rosea* var. *mollissima* Steetz); Wooroloo, 10.1906, M. Koch n.1509 (MEL. Holotype and paratype *P. Spenceri* Ewart.); Wooroloo, 10.1907, M. Koch (MEL; NSW.25316; 25320; 25324); Subiaco, 10.1912, F. Stoward (NSW.25474); Cottesloe, 22.9.1898, R. Helms (NSW.25464); Fremantle, Oldfield (MEL);

near Woodman's Point, L. Preiss n.57 (MEL; Cotypes *P. filiformis* Steetz); Armadale, 28.8.1897, R. Helms (P); Serpentine R., sandy meadows, 11.1877, F. Mueller (MEL); Pinjarra, 3.12.1877, F. Mueller (MEL); Pinjarra, 16.10.1920, C. A. Gardner (P); Harvey R., meadows, 5.12.1877, F. Mueller (MEL); Lowden, 12.1909, M. Koch (P; MEL; NSW.25313); Busselton, 1870, A. and E. Preis (MEL); Darling Ranges, moist places, 11.1907, M. Koch (NSW.25446; MEL); Balingup, 12.1917, R. H. Pulleine (NSW.25468); Blackwood R., 1875, McHard. (MEL); Bridgetown, gravelly soil, 29.1.1947, R. D. Royce (P); Manginup, 12.1921, M. Koch (P); Lake Muir, (MEL); 8–10 miles from Nornalup, 12.1917, R. H. Pulleine (NSW.25467); upper Hay R., 1870, M. Warburton (MEL); King George's Sound, coast heath, 10.1867, F. Mueller (MEL); W.A., J. Drummond n.327 (MEL); ex hort. bot. Hamburg, 1834 (MEL).

According to Lehmann (1828), plants were raised at the Botanic Gardens, Hamburg, from "seeds sent from England under the name of *Centaurea* sp.". He described these in the new monotypic genus *Stylolepis* (*S. gracilis*) and recognized two varieties, *glabra* and *arachnoidea*. There is a specimen from Sonder's collection in the National Herbarium, Melbourne, which is labelled "*Stylolepis gracilis* Lehm. ex hort. bot. Hamburg, 1834". Since the date given is six years after the publication of the name, it seems probable that this specimen is a descendant of the original material, and consequently it has been used as a basis of comparison for the species.

Graham (1828) independently gave the name *Podolepis gracilis* to a plant cultivated at Edinburgh and stated "the seeds of this plant were sent to us from New South Wales in November last by Mr. Fraser, as a specimen of *Centaurea*. The plants have been kept in the greenhouse of the Royal Botanic Gardens and will produce very few seeds". Since both authors mention *Centaurea* it would seem that the unspecified English source of Lehmann's material was Graham.

Variation in the involucral bracts, while small, was the basis of two species described by Steetz (1845), *P. filiformis* and *P. rosea*. With the reasonably large series of specimens now available, the characters used by Steetz are found to vary continuously so, although type selection has been made, both names are relegated to synonymy under *P. gracilis*.

P. Spenceri ("Woorooloo, 1906, M. Koch") was placed by Ewart "between *P. Lessoni* and *P. rugata*", both of which are very distinctive species with no resemblance to the specimens handled by Ewart, which are typical plants of *P. gracilis*. Again, type specimens have been nominated but the name abandoned.

P. angustifolia Hort. ex Vilmorin's Blumeng (ed. 3, Sieb. and Voss, 1 (1894): 537) was published as a synonym of *P. gracilis*, and according to Art. 40 of the International Rules of Botanical Nomenclature "a name of a taxonomic group is not validly published when it is merely cited as a synonym". The name, therefore, has no standing under the rules and should not be listed in Index Kewensis (Suppl. 9).

P. gracilis shows considerable variation in size, and the degree of branching. The smallest specimens examined were only 3 cm. high and with the typical ephemeral habit, but at the other extreme were much-branched plants 50 cm. in height with many capitula. An attempt was made to break up this species on details of the intermediate involucral bracts in investigating the validity of *P. filiformis* Steetz, since in certain specimens these bracts taper gradually to a fine point, and in others they end more abruptly so that the midrib projects as a short mucro. However, the number of specimens which occupied an intermediate position on this basis was so great that separate categories could not be upheld and it can only be assumed that this species varies, in this character, between the two conditions.

The colour of the ray florets was not always recorded by collectors, but in all the specimens cited a trace of pink pigmentation still remains and, although the ligules are usually 2–3 lobed, occasional capitula have been seen where lobing of the ligules is suppressed.

According to Sieber and Voss (1894) "ligulate florets numerous, tongue-shaped, fairly long, entire-margined, anteriorly truncate or somewhat emarginate, purple to purplish-violet, in var. *rosea* rose-red to flesh-coloured rose, in var. *alba* mother-of-pearl white, and var. *superba* hort. has only a fresher flower-colour than the parent form". They also state "flowering time: 10 weeks after commencement of sowing; July to September" (in Europe).

11. PODOLEPIS NUTANS Steetz in *Lehm. Pl. Preiss*, 1 (1845): 464.

(Text-figs. 84–91.)

Type data: "New Holland (Swan R. Colony), in sandy low-lying ground, L. Preiss, n.58."

Lectotype and *Lectoparatypes*: type data (MEL).

Branching annuals (?) with white woolly indumentum chiefly on young parts and lower surfaces of leaves. *Cauline leaves* up to 6 cm. long, 8 mm. broad, lanceolate, sessile, shortly decurrent, acute. *Radical leaves* only present on young plants. *Inflorescences* up to 35, on filiform peduncles. *Involucres* 1 cm. diameter, 0·8 mm. long. *Involucral bracts* reddish-brown, smooth and shining, without a distinct midrib; intermediate bracts 5·5 mm. long, 3·7 mm. broad, the laminae transversely elliptical with a short, acute, outwardly curved apex, and the claws slender and glandular. *Florets* with a pappus of 10–15 fine barbellate bristles, slightly thickened upwards. *Ray florets* about 20, the ligules 5 mm. long, 1 mm. broad, 3-lobed, "yellow tinged with purple at the apex". *Fruits* 1 mm. long, 0·4 mm. broad, terete, microscopically papillate.

Range: Swan R. district and King George's Sound.

Specimens examined:

Western Australia: Swan River Colony, in sandy low-lying ground, L. Preiss n.58 (MEL, lectotype and two lectoparatypes); near Perth, "ray yellow tinged with purple at the apex", W. V. Fitzgerald (NSW.25317); King George's Sound, R. Brown (MEL).

If the number of herbarium specimens of any species is proportional to its occurrence in the field, *P. nutans* must be regarded as rare and may no longer be in existence. Although very similar in habit to *P. gracilis*, *P. nutans* is distinguished by the varnish-like appearance of the involucral bracts, whose laminae are broader than they are long, the outermost being kidney-shaped.

Bentham (1866) was of the opinion that *P. nutans* is a variety of *P. gracilis*, but the present writer considers that it is of specific status, although probably it originated as a local variant of that species.

12. PODOLEPIS LESSONI (Cass.) Benth. *Fl. Aust.*, 3 (1866):606.

(Text-figs. 92–100.)

Synonymy: *Panaetia Lessonii* Cass., *Ann. Sci. Nat.*, 17 (1829):417; *Podolepis Gilberti* Turcz. in *Bull. Soc. Nat. Mosc.*, 24 (1851) 1:195.

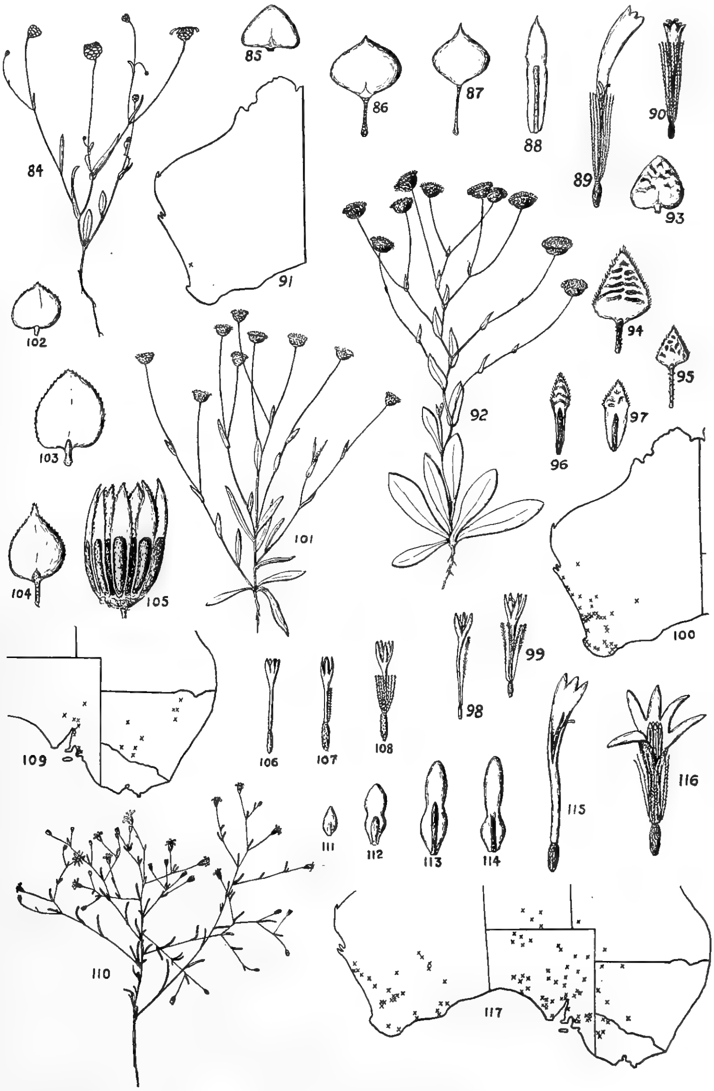
Type data: "This plant is found in the neighbourhood of the Port of King George, where it was collected in 1826 by M. Lesson. We have described it on specimens belonging to M. Mérat."

Annual plants 6·5–41 cm. high, with pseudo-dichotomous branching and seldom unbranched. Stems sparsely woolly on lower portions. *Cauline leaves* up to 7 cm. long, 1·5 cm. broad, lanceolate, sessile, decurrent, acute, sparsely septate-hairy on upper surface, densely woolly below. *Radical leaves*, when present, up to 4·5 cm. long, 1·2 cm. broad, oblanceolate, tapering to the base. *Inflorescences* 1–80, on naked filiform peduncles. *Involucres* 3–7 mm. long, 0·6–1·2 cm. broad. *Involucral bracts* pale, semi-transparent, soft, shallowly wrinkled, acute with fringed margins; intermediate bracts about 5·4 mm. long, the laminae triangular, 3 mm. broad with slender claws. *Ray florets* 8–16, slender and tubular, with 3–4 deep lobes and a single pappus bristle sub-plumose distally, which equals or exceeds the length of the corolla tube. *Disc florets* 4–5-lobed with 3–4 pappus bristles plumose distally. *Fruits* 1 mm. long, 0·4 mm. broad, terete, almost smooth.

Range: Western Australia from the Murchison River district to King George's Sound, and inland to Coolgardie.

Specimens examined:

Western Australia: Mt. Narryer, Murchison R., 12.1907, J. Tyson (MEL:P); Murchison R., Oldfield (MEL); between Moore and Murchison Rivers, among shrubs in sandy soil, 11.1901, E. Pritzel (NSW.25249); Champion Bay, 1871, Guerin (MEL); between Geraldton and Pethara, 9.1930, E. Ashby (ADW); Upper Irwin R., 11.1877, F. Mueller (MEL); Wongan Hills, grey sandy loam, 13.9.1947, R. D. Royce (P); New Forest Road, 20 miles from New Norcia, 10.9.1932, W. E. Blackall (P); Cowcowing



Text-figs. 84-117.

84-91. *P. nutans.*—84, Habit × 0·3; 85-88, outer, intermediate and inner Involucral Bracts × 3; 89, Ray floret × 3; 90, Disc floret × 3; 91, Distribution. 92-100. *P. Lessoni.*—92, Habit × 0·3; 93-97, outer, intermediate and inner Involucral Bracts × 3; 98, Ray floret × 3; 99, Disc floret × 3; 100, Distribution. 101-109. *P. Muelleri.*—101, Habit × 0·3; 102-104, outer and intermediate Involucral Bracts × 3; 105, inner Involucral Bracts forming "cup" × 3; 106, Ray floret × 3; 107, outer Disc floret × 3; 108, inner Disc floret; 109, Distribution. 110-117. *P. capillaris.*—110, Habit × 0·3; 111-114, outer, intermediate and inner Involucral Bracts × 3; 115, Ray floret × 6; 116, Disc floret × 6; 117, Distribution.

Lakes, 9.1904, M. Koch (NSW.25253); Upper Swan R., 1882, Sewell (MEL); Swan R., M. Price (MEL); Cottesloe Beach, 1902, A. G. Hamilton (NSW.25252); Fremantle, on limestone rocks, 11.1901, W. V. Fitzgerald (NSW. 25247); vicinity of Perth, 1915, Davis (NSW. 25246); King's Park, Perth, 10.1909, J. Sheath (BRI); Darlington, soils derived from granite, 17.10.1949, B. A. Roark (AD); Welshpool to Kalamunda, 9.1909, J. H. Maiden (NSW.25243); Woorooloo, 10.1906, M. Koch (MEL); Kelmscott, 11.9.1898, R. Helms (P; NSW.25251); Armadale, 11.1911, F. Stoward (NSW.25329); Toodyay, 8.1911, F. Stoward (NSW.25328); Northam-Perth highway, 3–4 miles from Northam, 11.9.1949, K. Salasoo (NSW.25238); Cunderdin, 9.1908, J. B. Cleland (NSW.25255; P); Tammin, 9.1909, J. H. Maiden (NSW.25459); Merredin, 5.10.1923, M. Koch (MEL); Coolgardie, 1900, L. C. Webster (NSW.25248); 3 mls. S. of Narrogin, open ground on railway clearing in Wandoo woodland, 9.9.1947, N. T. Burbidge (BRI); Wagin, 25.10.1920, C. A. Gardner (P); Pinjarrah, 10.1872, I. S. Price (MEL); Busselton, 1870, A. and E. Pries (MEL); Blackwood R., J. Forrest (MEL); Manjimup, 11.1920, M. Koch (MEL); Lake Muir, Muir (MEL); Gordon R., Oldfield (MEL); forest meadows towards the Kalgan R., 10.1857, F. Mueller (MEL); Kalgan R., Oldfield (MEL; NSW.25444); abundant on some of the more fertile forest ridges towards Mt. Barker, 10.1857, F. Mueller (MEL); Mt. Barker, 10.1900, B. T. Goadby (NSW.25250); King George's Sound, 1860, S. Hannaford (NSW.25256); King George's Sound, coast heaths, 11.1867, F. Mueller (MEL); interior of King George III Gulf, 8.11.1840, L. Preiss (MEL); Mt. Manypeaks, 8.1939, C. A. Gardner (P); plains S. of the Stirling Range, 10.1857, F. Mueller (MEL); basaltic meadows N. of the Stirling Range, 10.1857, F. Mueller (MEL); New Holland, 1852, Drummond n.386 (MEL); W.A., J. Drummond n.329 (MEL).

Cassini (1829) erected the monotypic genus *Panaetia* (*P. Lessonii*) to accommodate specimens collected near "Port of King George" (presumably the locality now called King George's Sound), and another species was added in 1852 when Sonder described *P. Muelleri* ("between Crystalbrook River and Spencer Gulf"). Bentham (1866) transferred both species to *Podolepis*, combining them under the name *P. Lessoni.* The present investigation shows that there are, in fact, two valid species involved, and that these correspond to the two species of *Panaetia.* These are each now given separate status and the name *Podolepis Lessoni* is used in its original restricted sense.

The identity of *P. Gilberti* Turcz. ("Western New Holland, Gilbert Coll. n.269 and 282") is somewhat in doubt, because no type specimens are available in Australia and the original description is of no assistance in deciding whether it is synonymous with Cassini's or with Sonder's species. However, since the ranges of these two species do not overlap, and the type locality of *P. Gilberti* is in Western Australia, it seems safe to assume its synonymy with *P. Lessoni* in its restricted sense.

The habit of *P. Lessoni* is variable in that plants either have a single main stem which subsequently branches, or branching may take place at or below ground level to give a many-stemmed condition. Although usually quite robust herbs, specimens from Stirling Range, plains south of Stirling Range, and Merredin have a typical ephemeral habit. The smallest of these is 6·5 cm. high, unbranched, with a single capitulum and 1–3 cauline leaves, but unfortunately no ecological notes accompany these specimens.

The ray florets are very inconspicuous and may account for the discrepancy in collectors' records of the colour, where Oldfield states "fls. pink" and Fitzgerald "fls. yellow". Possibly the first refers to the ray florets and the second to those of the disc.

13. PODOLEPIS MUELLERI (Sond.), comb. nov.

(Text-figs. 101–109.)

Synonymy: *Panaetia Muelleri* Sond. in *Linnaea*, 25 (1852):505; *Podolepis Lessoni* (Cass) Benth., *Fl. Aust.*, 3 (1866):606 (in part); *P. cupulata* Maid. and Betche in PROC. LINN. SOC. N.S.W., 38 (1913): 249.

Type data: "Between Crystalbrook River and Spencer's Gulf. Oct."

Lectotype: Between Crystalbrook River and Spencer's Gulf, 10.1851, F. Mueller (MEL).

Annual, usually branching, plants, 5–22 cm. high, the stems sparsely woolly towards the base. *Radical* and *lower cauline* leaves up to 5·5 cm. long, 1 cm. broad, lanceolate to broad-linear, sessile, decurrent, acute, sparsely hairy on upper surface, densely woolly on lower. *Inflorescences* 1–70, on naked filiform peduncles. *Involucres* 5–8 mm. long, 3·5–7 mm. broad, slightly longer than broad. *Involucral bracts* smooth, shining, semi-transparent, acute, golden brown; intermediate bracts spade-shaped with a slender claw and a scarious shortly torn-ciliate lamina 3 mm. broad; innermost bracts with hard thick claws united at the base to form an erect cup enclosing the florets. *Florets* 20–50, tubular, of four kinds: (1) 3–10 of the outermost, female with 3–4 finger-like corolla lobes and no pappus. (2) 3–7 of the outermost, bisexual with 5 finger-like corolla lobes and no pappus. (3) 1–3 inner florets, bisexual with 5 finger-like corolla lobes and a single pappus bristle. (4) Central florets, bisexual with 5 corolla lobes and 6-13 shortly plumose pappus bristles. *Fruits* 1·5 mm. long, 0·6 mm. broad, terete, minutely papillate.

Range: Western and south-western New South Wales to the eastern half of South Australia.

Specimens examined:

New South Wales: Cuttabri, Pilliga scrub, large masses in low moist alluvial places, 8.1913, J. L. Boorman (NSW.25236); Moree to Narrabri, plains, 8.1917, O. D. Evans (NE); Nea, via Curlewis, 11.1949, A. S. Taylor (NSW.25237); Tarella, Wilcannia, 8.1889, W. Bauerlen (NSW.25478); Darling R. (MEL); Lachlan R., 9.1878, F. Mueller (MEL); Hay-Balranald Road, open plain, in grey clay-pan, 10.10.1947, E. F. Constable (NSW.4476); Wanganella, 10.1903, E. Officer (NSW.25259; 25443, Holotype *P. cupulata* Maid. and Betche); Zara, Wanganella, 9.1915, E. Officer (NSW.25487; BRI; AD).

South Australia: Mt. Lyndhurst, 9.1898, M. Koch (MEL; BRI; AD); the Crabholes, Pimba, 8.1947, A. R. R. Higginson (JBC); between Spencer's Gulf and Flinders Range, 10.1851, F. Mueller (MEL); Hookina, 25.8.1883, R. Tate (AD); Hawker, 3.9.1941, J. B. Cleland (JBC); Carrieton, 29.9.1916, J. M. Black (JMB); Baroota, 21.9.1906, J. M. Black (JMB); Crystal Brook, F. Mueller (MEL); between Crystalbrook R. and Spencer's Gulf, 10.1851, F. Mueller (MEL. Lectotype and lectoparatypes of *Panaetia Muelleri* Sond. and *Podolepis Muelleri* (Sond.) G.L.D.); St. Vincent's Gulf, 1898, F. Mueller (MEL); Marino, 11.8.1906, J. M. Black (JMB; N.S.W.25254); Hallett's Cove, 9.10.1920, J. B. Cleland (JBC); Clarendon, 1852, Tepper (MEL); Willungra, 24.9.1904, J. M. Black (JMB; NSW.25240); Aldinga Bay, cliffs, 31.10.1928, J. B. Cleland (JMB; JBC); Sellick's Beach, cliffs, 18.10.1941, J. B. Cleland (JBC).

Originally described by Sonder as *Panaetia Muelleri* ("between the Crystalbrook River and Spencer's Gulf"), this species was transferred by Bentham (1866) to *Podolepis* as a synonym of *P. Lessoni* (Cass.) Benth. Both species are, however, distinct and replace each other geographically, in that *P. Muelleri* occurs in South Australia and Western New South Wales, while *P. Lessoni* is confined to Western Australia. Although there is a strong superficial similarity between these two species, they are readily distinguished by the involucral bracts of *P. Muelleri* being smooth and shining whereas those of *P. Lessoni* are softly wrinkled and dull. The chief diagnostic character of *P. Muelleri*, however, is the partial union of the innermost bracts to form a cup-like structure which encloses the florets. This "cup" is best seen at maturity of the capitulum, when the claws of the bracts are hard and thick, and is the character on which Maiden and Betche based *P. cupulata*, which is now reduced to synonymy.

Only relatively few of the florets of the outermost whorl are female, and these are thought to be sterile, since none have been seen with normal fruit.

The statement by various authors that the pappus bristles of the outer florets are readily deciduous has not been substantiated, and dissection of a number of capitula shows that in all the outermost florets, whether female or bisexual, pappus development is suppressed.

Variation in habit involves size and degree of branching which, in turn, controls the number of inflorescences.

14. PODOLEPIS CAPILLARIS (Steetz) Diels, *Engl. Jahrb.*, 35 (1905): 621.
(Text-figs. 110–117.)

Synonymy: *Siemssenia capillaris* Steetz in *Lehm. Pl. Preiss*, 1 (1845): 467; *P. Siemssenia* F. Muell. ex Benth., *Fl. Aust.*, 3 (1866): 607.

Type data: "In limosis porrectis illustribus sylvae haud procul a rustico cl. J. Moore, terrae superioris cl. 10. Sept. 1839, Herb. Preiss no. 72."

Lectotype and *Lectoparatype*: Type data (MEL).

Annual plants up to 43 cm. high with slender wiry branches. Stems commonly reddish with a grey waxy coating, and glabrous except for small clusters of septate hairs at the leaf axils. *Cauline leaves* 0·5–4 cm. long, 0·5–1·5 mm. broad, sessile, linear, entire, obtuse to sub-acute, with strongly recurved margins. *Radical leaves* up to 4·5 cm. long, 1·1 cm. broad, elliptical, flat, present only on young plants. *Inflorescences* 6 to 100 or more, on filiform peduncles, naked or with a single bract. *Involucres* 6–7 mm. long, 6 mm. broad, obconical. *Involucral bracts* golden-brown, shining, glabrous, obtuse, entire, sessile, the broad scarious margins indented about half-way along each side; intermediate bracts up to 5 mm. long, 1·5 mm. broad. *Ray florets* 9–12, the ligule 2·5 mm. long, 0·8 mm. broad, 3-lobed with frequently a purple line along the central lobe; pappus absent. *Disc florets* 17–22, with a pappus of 15–18 delicate barbellate capillary bristles. Fruits 1 mm. long, 0·3 mm. broad, terete, microscopically papillate.

Habitat: Sandy soil, often among stones on hillsides.

Range: Western districts of the eastern States, throughout Central and South Australia and southern half of Western Australia.

Specimens examined:

Queensland: Mulligan River, 2.1904, H. Clarke (NSW.25280); Bulloo River, 1887, L. Morton (MEL).

New South Wales: Tibooburra, 700 ft., erect spreading habit, on stony ground, granite, 24.10.1949, E. F. Constable (NSW.10737); Paroo R. district, 9.1900, E. Betche (NSW.25477); Mt. Robe, 23.8.1925, A. Morris (NSW.25271; ADW); Darling R., Goodwin and Dallachy (MEL; NSW.25261).

Victoria: Shifting sandhills on the Murray (MEL); between Euston and Mildura, 18.8.1946, J. Vickery (NSW.2040); Lake Coorong, mallee, 10.1825 (MEL); Lake Albacutya, 1901, St. Eloy d'Alton (NSW.25277); Rainbow, d'Alton (MEL).

Northern Territory: 11 mls. W. of Alice Springs, on Hermannsburg Road, flat plain, 4.10.1955, N. T. Burbidge and M. Gray (CAN.4537); Rudall's Creek, 1886, H. Kempe (MEL); about 4 miles S. of Erldunda Sta., base of low red sand dune, 9.10.1955, N. T. Burbidge and M. Gray (CAN.4568).

South Australia: Between Ernabella and Morrilyanna, 20.8.1933, J. B. Cleland (JBC); west of Everard Ranges, S. A. White (JMB); Arceoilinna, 25.5.1891, R. Helms (NSW.25264); Wantnapella Swamp, near Alberga R., 21.8.1914, J. M. Black (JMB); 20 mls. W. of Lambinna, 23.8.1914, S. A. White (JMB); Macamba R., 2.1.1927, J. B. Cleland (JMB); Ross' Waterhole, Macamba R., 21.1.1927, J. B. Cleland (JMB; JBC); between Stoke's Range and Cooper's Creek, Wheeler (MEL); Hergott to Strangeways, W. L. Cleland (JBC); Mt. Lyndhurst, 10.1899, M. Koch (NSW.25263); Flinder's Range, entrance to Wilpena Pound, stony rocky hillsides about 1,800 ft., 30.8.1946, S. T. Blake n.16870 (BRI); Wilpena Pound and Hawker, 10.1937, (ADW.2740); near Stuart's Range, 1885, Winnecke (MEL); Termination Hill, 6.1883, R. Tate (AD); Mt. Eba, 1880, E. Giles (MEL); Arcoona, bluebush flat, 8.1927, J. B. Murray (AD); near Lake Torrens, 8.1906, L. Gee (JMB); Monalena, 7.1909, H. Deane (NSW.25270); Ooldea, 31.10.1916; 1.1917, J. M. Black (JMB); Barton, on ridges and slopes of low sandhills, in reddish-brown sand, 23.4.1931, C. E. Hubbard n.8336 (BRI); Pidinga, 1880, Richards (AD; MEL); Tarcoola, 19.9.1920, J. M. Black (JMB); 17 miles N.W. Tarcoola, 30.10.1929, J. B. Cleland (JBC); Koonibba, 18.8.1928, J. B. Cleland (JBC); N. of Fowler's Bay, E. Giles (MEL); Gawler Range, W. of Yardea, 19.10.1953, J. B. Cleland (JBC); W. of Nonning, 12.10.1954, J. B. Cleland (JBC); Nonning, 23.8.1928, J. B. Cleland (JBC); Minnipa, 11.11.1951, J. M. Black (JMB); Wudinna, 5.9.1938, E. H. Ising (I.3816); Kyancutta, 25.8.1928, J. B. Cleland (JBC); near Spencer's Gulf, 1881, Lattorf (MEL); Nonning, 3.1931, Pulleine (JBC); between Belo Hill, Bookaloo and Yudnapinna Sta., 26.8.1951, E. Robertson (ADW.7114); Mt. Gunson, 9.1913, Berkwith (JMB); 30 mls. N. of Pt. Augusta, 9.11.1928, J. B. Cleland (JBC); Burunga Range, 22.7.1884, S. Dixon (AD); Blanchetown, R. Tate (AD); Loxton, 15.10.1909, J. M. Black (JMB); Berri, 11.1923, H. W. Andrews (JMB); Loveday, 23.8.1937, E. H. Ising (I.3814).

Western Australia: South Hutt, Oldfield (MEL); Geraldton, 10.1907, J. B. Cleland (NSW.25274); Greenough R., 11.1877, F. Mueller (MEL); Upper Irwin's R., 11.1877, F. Mueller (MEL); Minginew, 10.1909, J. H. Maiden (NSW.25265; BRI); Lat. 31° 11′ S., Long. 119° E., A. Forrest (MEL); between Coorow and Arrino, 15.9.1932, W. E. Blackall (P); Cowcowing, 9.1904, M. Koch (MEL; P); 2 mls. E. of Carrabin, 22.8.1929, W. E. Blackall (P); Merredin, 15.9.1923, M. Koch (MEL; NSW.25273); Hine's Hill, 2.10.1923, M. Koch (NSW.25272); Kellerberrin, loamy woodland soil, 4.1943, C. A. Gardner (P); Tammin, 9.1909, J. H. Maiden (NSW.25266); Northam, 9.1900, E. Pritzel (AD; NSW.25275); Avon district, cleared forest land near Northam, 11.1900, E. Pritzel (AD); Flooded parts of the Bannister, Oldfield (MEL); 100 miles N. of Stirling Range, 1879, Muir (MEL); Fraser's Range, 1876, Dempster (MEL); between Esperance Range and Fraser's Range, 1876, Dempster (MEL); Cape Arid Bay, sandy places, mouth of Thomas R. (MEL); half-way between Mt. Ragged and Victoria Springs, 1886, S. Brooke (MEL); west end of Great Bight, 1877, Carey (MEL); Coolgardie, 10.1900, E. Kelso (P); Kalgoorlie, 8.10.1914, C. H. Ostenfeld (P); Skull Creek, Laverton, alluvial soil, 9.8.1931, C. A. Gardner (P); Laverton, 9.1909, J. H. Maiden (NSW.25268); 5 miles S. of Lawlers, 18.10.1945, C. A. Gardner (P); "in limosis porrectis illustribus sylvae haud procul a rustico cl. J. Moore, terrae superioris, cl. 10.Sept.1839, Herb. Preiss no. 72 (MEL. Lectotype and lectoparatype); W.A., J. Drummond n.171 (MEL); W. A., J. Drummond, 2nd Coll., 1844, n.171 (NSW.25262).

P. capillaris (Steetz) Diels is a very widespread species in the drier parts of Australia, and is remarkable for its lack of variation. The most characteristic vegetative feature is the frequent pseudo-dichotomous branching of the slender, rather wiry stem, each branch terminating in an inflorescence. The leaves are never numerous, and show some variation in size. In a specimen from Cowcowing Lakes the maximum leaf-size is 3 mm., but as the plant is incomplete it is possible that the lower leaves were of larger size.

The capitula, with their shining involucres and the greyish "bloom" on the stems, are both constant and distinctive features, and the whole plant has a delicate appearance.

The shape of the involucral bracts is unusual and is seen elsewhere in the genus only in *P. microcephala* Benth.

15. PODOLEPIS MICROCEPHALA Benth., *Fl. Aust.*, 3 (1866): 607.

(Text-figs. 118–125.)

Type data: Shark's Bay, Milne.

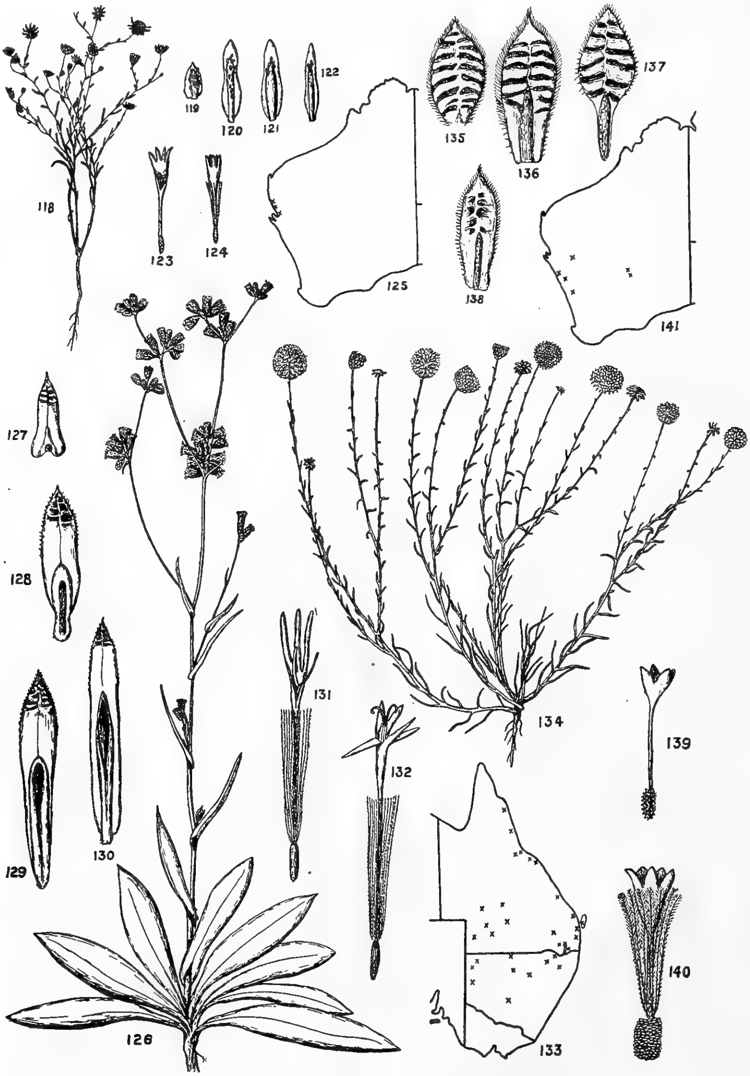
Slender branching annuals up to 22 cm. high, the stems reddish-purple with a waxy grey bloom. *Leaves* cauline, up to 3·5 cm. long, 1·5 mm. broad, linear, sessile, obtuse, the margins recurved. *Inflorescences* up to 10, on filiform peduncles bearing small ovate leaf-like bracts. *Involucres* 8 mm. broad, 5 mm. long. *Involucral bracts* sessile, the median portion herbaceous and densely glandular, with narrow scarious margins; laminae acute, entire; margins of intermediate and inner bracts laterally constricted at the centre. *Ray florets* 6, the ligule 4-lobed, 2 mm. long, 0·5 mm. broad, pappus absent. *Disc florets* with a pappus of about 14 barbellate capillary bristles. *Fruits* 0·8 mm. long, 0·4 mm. broad, terete, microscopically tuberculate.

Range: Confined to the Shark Bay district of Western Australia.

Specimens examined:

Western Australia: Shark Bay, 10.1877, F. Mueller (MEL; NSW.25281; P); Carnarvon, 1906, W. V. Fitzgerald (NSW.25282); Hamelin Harbour (? Pool), 10.1877, F. Mueller (MEL).

In the absence of type material, specimens collected from the type locality and identified by Mueller were used as a basis of comparison. These agreed with Bentham's description and there is no reason to doubt that they are conspecific with the material he handled.



Text-figs. 118-141.

118-125. *P. microcephala.*—118, Habit × 0·3; 119-122, outer, intermediate and inner Involucral Bracts × 3; 123, Ray floret × 3; 124, Disc floret × 3; 125, Distribution. 126-133. *P. arachnoidea.* —126, Habit × 0·3; 127-130, outer, intermediate and inner Involucral Bracts × 3; 131, Ray floret × 3; 132, Disc floret × 3; 133, Distribution. 134-141. *P. Kendallii.*—134, Habit × 0·3; 135-138, outer, intermediate and inner Involucral Bracts × 3; 139, Ray floret × 3; 140, Disc floret × 3; 141, Distribution.

Since Hamelin Harbour is at the south-west of the State it is assumed that this name was written in mistake for Hamelin Pool, which is in the type-district. Support is lent to this view by the fact that the specimen was collected by Mueller in the same month and year as others from Shark Bay.

Owing to the very limited material, little can be said about variation, which apparently concerns the degree of branching and the size of the leaves.

An unusual condition, however, was seen in certain of the outermost florets, in which a deeply bi-lobed tongue of corolla tissue arises from the apex of the corolla tube at a point where it passes into a broad 3-lobed ligule. These florets are therefore 2-lipped, and the fact that they are bisexual and bear a normal pappus indicates that they belong, morphologically, to the disc rather than the ray.

The peculiar "hour-glass" shape of the involucral bracts of *P. microcephala* suggests a close relationship with *P. capillaris* and its restricted distribution indicates its origin as a local variant of that species and is now, perhaps, extinct.

16. PODOLEPIS ARACHNOIDEA (Hook.) Druce in *Rep. Bot. Exch. Cl. Brit. Isles* (1917):640. (Text-figs. 126–133.)

Synonymy: *Rutidosis arachnoidea* Hook. in *Mitch. Trop. Austr.*, (1848):341; *Rutidochlamys Mitchelli* Sond. in *Linnaea*, 25 (1852):497; *Podolepis rhytidochlamys* F. Muell., *Frag.*, 4, (1864):79 (cited as *P. rutidochlamys* F. Muell. by Bentham, *Fl. Aust.*, 3 (1866):603).

Type data: Entry in Mitchell's Journal for 6th Oct. "a new *Rutidosis*, a tall herbaceous perennial". (Mitchell's position on that date was on the flats at the base of the ranges, apparently near Mt. Pluto, Mt. Playfair and Mt. Hutton, to the south-west of the Warrego, Maranoa and Nive.)

Many-stemmed perennials up to 80 cm. high, forming large clumps; white woolly indumentum on the stems and both surfaces of the young leaves. *Radical leaves* clustered, up to 13·5 cm. long, 1·8 cm. broad, oblanceolate, acute, petiolate, woolly on both surfaces or only on the lower. *Cauline leaves* up to 11 cm. long, 1·6 cm. broad, acute, broad-linear, stem-clasping, decurrent. *Inflorescences* very numerous, in clusters of 3–10, almost sessile at the ends of branches. *Involucres* 10 mm. long, 6 mm. broad, reddish-brown. *Involucral bracts* narrow elliptical, acute, hardly clawed, the scarious laminae apically rugose with minutely torn-ciliate margins; intermediate bracts about 1 cm. long, 2 mm. broad. *Florets* with a pappus of 25–30 microscopically barbellate bristles. *Ray florets* 5–7, yellow, the ligule 2·5 mm. long, 1·5 mm. broad, 3–4-lobed. *Fruits* 2 mm. long, 0·5 mm. broad, terete, minutely papillate.

Range: Throughout Queensland; north-west and western districts of New South Wales.

Specimens examined:

Queensland: Endeavour R., 1883, Persich (MEL); 12 miles from Ravenshoe, 2,900 ft., sandy soil, 11. 1943, C. Davis (NE); Ravenswood, 1879, S. Johnson (MEL); Charters Towers, 1.1891, C. F. Plant (BRI); Upper Burdekin R., F. Mueller (MEL); Bowen (MEL); Port Denison (MEL); Emu Park, sea shore, Thozet (MEL); Burnett R., F. Mueller (MEL); Fraser Is., near Ocean Beach, 5.1925, C. T. White n.25757 (BRI); Fraser Is., on sand hill near sea, in open place, with *Helichrysum*, 15–16.10.1930, C. E. Hubbard, n.4428 (BRI); Sunshine Beach, Noosa Heads, on old sand dune behind beach, 30.8.1955, G. L. Davis (NE); Miles, 12.1890, F. M. Bailey (BRI); Brisbane R., 1876, Bailey (MEL); Bybera, very sandy soil, *Angophora lanceolata* forest, 20.1.1934, C. T. White n.9704 (BRI); Warwick, 3.1911, J. L. Boorman (NSW.24323); Glen Niven, 5.1921, E. Cheel (NSW.25426); Applethorpe Swimming Hole, granite sand on flat in Stringybark forest, 22.11.1946, S. L. Everist and L. J. Webb n.1324 (BRI); Stanthorpe, grassland, cleared *Eucalyptus* forest, granite residue soil (sandy grit), 3,000 ft., 11.3.1931, C. E. Hubbard n.5672 (BRI); Wallangarra, common in open forest lands, 11.1904, J. L. Boorman (NSW.25427); sources of the Thomson R., 1871, Birch (MEL); Jericho, 4.1946, M. S. Clemens (BRI); Nive R., in yellow sand, 10.1939, S. L. Everist n.1911 (BRI); near Adavale, 29.8.1923, W. MacGillivray (BRI; ADW); Charleville, 9.1920, A. J. Turner (BRI); Cooper's Crk., sandhills, 10.7.1884, J. McLeod (AD); Bokkara Crk., undulating forest ground, 22.12.1845 (MEL).

New South Wales: Wallangra, 11.1912, J. L. Boorman (NSW.25475; BRI); Warialda, 11.1905, H. M. Rupp (NSW.25429); Tingha, 3.1917, J. L. Boorman (NSW.25476); Liverpool plains, C. Moore (MEL); near Queensland border, N. of Bourke, 9.1884, L. Henry (MEL); Bourke, 8.1884, L. Henry (NSW.25428); Tibooburra, 625 ft., sandy ridge, 25.10.1949, E. F. Constable (NSW.10744); Evelyn Crk., north of Barrier Range, 1887, A. King (MEL); Lachlan R., 1879, Tucker (MEL); Darling plains, Neilsen (MEL); Murray R. (MEL).

In the National Herbarium, Melbourne, there is a specimen from Sonder's collection, collected by Mitchell ("camp near the Pyramids, 27.10.1846"), which is accompanied by a draft description of *Rutidochlamys Mitchelli* Sond. This has been nominated lectotype of that species, but unfortunately no type material has been examined either of *Rutidosis arachnoidea* Hook. or *Podolepis rhytidochlamys* F. Muell. With regard to the latter species, several specimens of Mueller's have been examined from the type locality ("from the northern plain of the Burdekin River, through dry country to near the Murray R."); these are undated, however, and may have been collected after publication of the name.

Bentham (1866), in citing this species as *P. rutidochlamys*, was, presumably, correcting Mueller's original epithet which was derived from his former genus *Rutidochlamys*.

P. arachnoidea is a very distinct species which, in spite of its wide range, shows virtually no variation. Its relationships are obscure, although the slightly rugose nature of the involucral bracts suggests an affinity with *P. canescens* A. Cunn. ex DC. From the ecological data supplied by collectors, *P. arachnoidea* shows a strong preference for sandy situations.

17. PODOLEPIS KENDALLII (F. Muell.) F. Muell. in Wing, *South. Sci. Record*, 3 (1883): 68. (Text-figs. 134–141.)

Synonymy: *Helipterum Kendallii* F. Muell., *Frag. Phytog. Austr.*, 8 (1874): 168; *P. Kendallii* F. Muell. in Wing, var. *nanus* Ewart in *Proc. Roy. Soc. Vict.*, 20 (1907): 83.

Type data: "near Champion Bay, Miss Guerin."

Holotype and *paratype*: Champion's Bay, 1871, Guerin (MEL).

Slender annuals (?) with one to many stems, 9·5–35 cm. high, sparsely woolly on young parts, otherwise glabrous. *Leaves cauline*, up to 5 cm. long, 2 mm. broad, linear to filiform, subacute, stem-clasping, shortly decurrent, crowded. *Inflorescences* 1–27, terminal on leafy stems. *Involucres* 1·2 cm. long, 1·7–2 cm. broad. *Involucral bracts* light brown, elliptical, acuminate, the scarious laminae rugose, with a marginal fringe of short hairs; intermediate bracts clawed, 8 mm. long, 3 mm. broad. *Florets* all tubular, apparently yellow; 4–6 florets of the outermost row female, slender, with a 4-lobed corolla and no pappus; remainder of the florets bisexual, 5-lobed with a large pappus of 7–10 shortly plumose capillary bristles. *Fruits* 2 mm. long, 1 mm. broad, thick, with long finger-like papillae.

Range: Neighbourhood of the Murchison River, Western Australia, and westward to Laverton.

Specimens examined:

Western Australia: Murchison district, 9.1903, W. V. Fitzgerald (NSW.25289); Champion's Bay, 1871, Guerin (MEL. Holotype and paratype of *Helipterum Kendallii* F. Muell. and *P. Kendallii* (F. Muell.) F. Muell.); Arrino, 9.1903, W. V. Fitzgerald (NSW.25291); Beria, clay soil, C. A. Gardner n.2455 (P); Watheroo Rabbit Fence, 8.1906, M. Koch n.1359 (MEL; NSW.25290. Syntypes *P. Kendallii* var. *nanus* A. J. Ewart); Laverton, 9.1909, J. H. Maiden (NSW.25325; 25326); Laverton, 8.1931, W. E. Blackall (P); W.A., J. Drummond (MEL).

Herbarium specimens suggest that in many-stemmed plants, some branches are ascending, rather than erect. Radical leaves are represented only in young plants, and as it was on one of these, with a single stem and inflorescence that Ewart described his var. *nanus*, this variety is now abandoned as representing merely a growth-form.

In the nature of the fruits with long papillae, and the linear leaves, this species is quite distinct and variation concerns only the degree of branching and the height of the plant.

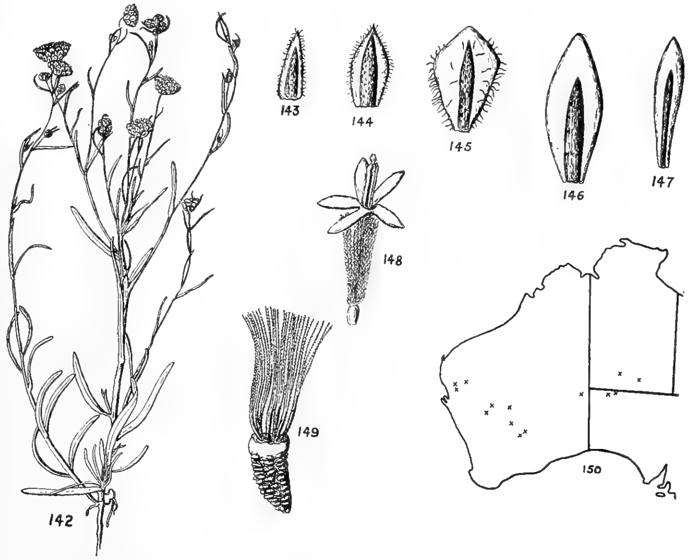
18. **Podolepis Georgii** Diels. in *Engl. Jahrb.*, 35 (1905): 619.

(Text-figs. 142–150.)

Type data: "In the Austin district near Murrinmurrin, from whence it was sent by the collector W. J. George."

Clastotype: Murrinmurrin, 1902, George (MEL).

Branching annuals (?), 11–40 cm. high, with a sparse septate-hairy indumentum. *Leaves cauline*, up to 7 cm. long, 7 mm. broad, narrow-lanceolate to broad-linear, obtuse, sessile, not decurrent. *Inflorescences* up to 50, on slender peduncles with 1–2 bract-like leaves. *Involucre* 1·5 cm. diameter, 1 cm. long. *Involucral bracts* rhomboidal, with a broad scarious margin and a central green, glandular portion, sessile, acute, entire; outermost bracts bear long hairs laterally; intermediate bracts about 7 mm. long, 5 mm. broad. *Florets* all tubular, slender, with a 5-lobed corolla; outermost row bisexual, with 160–200 barbellate pappus bristles, united at the base into about 10 bundles; remainder of the florets male with aborted stylar arms, and distally plumose pappus bristles. *Fruits* 4 mm. long, 2 mm. broad, thick, dark brown, with a smooth distal collar forming an apical cup-like depression enclosing the base of the persistent pappus.



Text-figs. 142-150.

142-150. *P. Georgii.*—142, Habit × 0·3; 143-147, outer, intermediate and inner Involucral Bracts × 3; 148, Disc floret × 3; 149, Fruit × 3; 150, Distribution.

Range: Central Australia into the north-western portion of South Australia, and from the Central to the North-Western Divisions of Western Australia.

Specimens examined:

Northern Territory: Mt. Liebig, 11.8.1932, J. B. Cleland (JBC); 9 miles N. of Alice Springs, 22.8.1932, J. B. Cleland (JBC); Alice Springs, 23.8.1932, J. B. Cleland (JBC).

South Australia: Mann Ranges, 22.8.1954, J. B. Cleland (JBC); between Musgrave and Mann Ranges, 21.8.1954, J. B. Cleland (JBC); Musgrave Ranges, 19.8.1954, J. B. Cleland (JBC); Kenmore Park, 17.8.1954, J. B. Cleland (JBC); Camp 15, 6.7.1891, Elder Expl. Exped. (NSW.25449).

Western Australia: Kennedy Range, 8.9.1948, C. Teichert (MEL); near Jimba Jimba, sandy clay in watercourse, 21.9.41, C. A. Gardner n.6087 (P); south of Meekatharra, red stony soil in creek, 7.1931, C. A. Gardner n.2297 (P); Cue, 30.7.1903, C. Andrews (NSW.25469); 10 miles from Willuna, red sand, 16.10.1945, C. A. Gardner n.7915 (P); Mt. Sir Samuel, 8.1931, C. A. Gardner (P); between Melahur and Laverton, 8.8.1931, W. E. Blackall (P); Murrinmurrin, 1902, George (MEL. Clastotype); near Mt. Squires, 24.8.1891, Elder Expl. Exped. (NSW.25450).

A small piece of Diels' type specimen is in the National Herbarium, Melbourne, and has been nominated a clastotype.

This species shows several unusual features, the most remarkable being the absence of female florets, whose place in the capitulum is taken by a single row of 16–18 bisexual ones and the remainder are functionally male. It is apparently the end of an evolutionary tendency concerning reduction in size and number of the female ray florets, which in *P. Kendallii* are reduced to 4–6 with tubular corollas, and in *P. Georgii* are absent altogether. The nature of the pappus is also unique in this genus, as is the structure of the fruits, and the question arises as to whether a species which departs from a generic concept in so many particulars should be retained within it. The writer is of the opinion that since *P. Georgii* does not conform to any other genus more satisfactorily, the difficulty could be met only by erecting a new monotypic genus. This action, at present, would be precipitate, and it seems preferable, for the time being, to treat this species as an atypical *Podolepis,* since it is possible that further collecting to the north of its present recorded range will produce related and undescribed forms.

NOMINA DUBIA.

The identities of the following species are in doubt, since neither type material nor named specimens are available in Australia. In each case the original description has been translated and is quoted in full.

It is to be regretted that when overseas botanists describe new species of Australian plants they rarely deposit a specimen in any of the Australian public herbaria. The result of this omission is that the Types are inaccessible to the very botanists who have most need to refer to them, and Australian taxonomy is burdened with names the application of which is either uncertain or unknown. In the early days of Australian botany, explorers of necessity took or sent their collections to England or Europe for identification, and there was no place for storage of duplicates in Australia; but the National Herbarium was established in Melbourne a century ago, and a similar institution in Sydney slightly later. There is now a public herbarium in each State, and it would seem only reasonable that at least one type specimen of every species should be permanently retained in the country of its origin. These remarks apply particularly to a purely Australian genus such as *Podolepis*, in which three species have been described by European botanists this century, yet the meaning of each of these names is unknown and cannot be established in Australia.

PANAETIA FULVA Lindl. in *Bot. Reg.*, 1 (1838): Misc. 47.

"Leaves oblong, acute, sessile, entire, with a cobweb-like indumentum. Inflorescences clustered. Involucral bracts linear-lanceolate, acute, scarcely serrulate, the intermediate ones fringed. Pappus bristles of the ray [florets] 5–6, of the disc 9–10." (Trans. ex Latin.)

"A beautiful little annual plant with the habit of a *Gnaphalium*, introduced from the Swan River by R. Mangles Esq. It flowered in May 1838, and proved to differ from *P. Lessoni* in the shape of the involucral scales, in the number of setae of the pappus, and in being a larger plant covered with a cobweb-like hoariness. The flower-heads are of the red-gold colour of *Helichrysum bracteatum*, dry like many everlasting flowers, and although small, very pretty."

Apart from the original description, the only reference to this species in the literature is in Index Kewensis where it is listed in italics. Presumably its transfer to *Podolepis* was assumed, when Bentham (1866) incorporated both *Panaetia Lessoni* and *P. Muelleri* into that genus, but the new combination was never made.

Lindley's comments on the plant raise considerable doubt that it is a *Podolepis.*

PODOLEPIS CONTORTA Lindl. in *Bot. Reg.*, 1 (1838): Misc. 64.

"Erect rather glabrous plants with oblong fleshy sessile leaves, indistinctly 3-veined, pedunculate leaves longer and sparsely scabrous; single inflorescence, at first pendulous but erect at maturity. The involucral bracts are cordate, acuminate and glabrous; the outer ones are sessile, the intermediate clawed and the inner ones are linear-lanceolate. Ligules 3-toothed, twisted to the left." (Trans. ex Latin.)

"A native of Van Diemen's Land, whence seeds of it were sent to the Horticultural Society by Mr. J. Bunce. It is a pretty perennial, with dark green fleshy leaves, a flower stem from 6–9 inches high, and solitary golden yellow flower heads. The latter are the size and form of the common *Amberboa moschata* or Yellow Sultan, and are remarkable for the florets of the ray having all a distinct twist to the left, so as to give the flower-head the appearance of what is called a Catherine Wheel. The species will perhaps be hardy, at least it will only require moderate protection in winter. It is very different from the old *Podolepis acuminata* figured in the Botanical Magazine, t.956, under the name of *Scalia jaceoides*, in its leaves not being sagittate, and in its much dwarfer habit. As, however, M. de Candolle takes no notice of the remarkable sagittate leaves of *P. acuminata*, it must be doubted whether he had that plant, or the present one, before him when he framed his definition for the Prodromus."

This species is probably *P. jaceoides*, which is the only species recorded from Tasmania and with which Lindley's description agrees in all respects except the reported "contortion" of the ligules. This peculiarity has not been referred to in the literature before or since. It has been noticed by the present writer that when a large number of ray florets are developed in the capitulum of *P. jaceoides*, some of the ligules are frequently twisted for mutual accommodation. Since Lindley's specimens were raised from seeds, under cultivation, it is possible that they were more than usually luxuriant and an extreme condition resulted whereby all the ligules assumed the orientation he described.

PODOLEPIS GNAPHALIOIDES Domin in *Biblioth. Bot.*, 89 (1929): 676.

"An erect branching plant, probably perennial, about 4 dm. high, with a hoary-white, very soft woolly indumentum; the branches elongated, one-headed, naked distally or with small narrow bracts. Basal leaves broad, sessile, oblong-spathulate, or oblong to linear-oblanceolate, acuminate; the broad leaves up to 5 cm. long and 1·2 cm. wide, the narrow leaves up to 3·5 cm. long and 3–4 mm. broad. Inflorescences shiny, straw-coloured, 1·6 cm. diameter across the base. Involucre hemispherical, the bracts very numerous, scarious, acute but not very sharp; the outer bracts wrinkled, with glandular hairs, shortly acute with a rather stiff apex at the end of an opaque line; the inner bracts sessile, straight, about 5–5·6 mm. long, dorsally keeled. Receptacle flat, naked, about 8 mm. diameter after fruiting. Florets yellow, almost equal, very numerous, crowded, markedly exceeding the involucre, 5-lobed. Fruits glabrous, pappus bristles numerous, white, very shortly barbellate, shortly united at the base." (Trans. ex Latin.)

"Queensland: Mt. Remarkable as well as Savanna forests near Pentland." (Domin III.1910.)

"This species is very different from the other Australian *Podolepis* species, but it is hard to place in another genus. The bracts are not radiating and, although they are scarious, are not as thin as in the rest of the typical representatives of this genus. The outer bracts are on short claws and sharply bent backwards, while the inner ones are sessile, and all of them are finely pointed. I have not seen any female outer florets, only bisexual ones, and all are of the same form. The anthers have an appendage which is only very short." (Trans. ex German.)

Despite the detailed description, the identity of this species is a mystery. Only one species (*P. Georgii*) is known in which no female florets occur, and this is quite different in details of the involucral bracts and vegetative characters. Had it not been for the statement that the stems are single-headed, the widespread *P. arachnoidea* could be considered as a possibility since the female florets in that species are few and easily overlooked. The specific epithet, presumably, implies that the plant is *Gnaphalium*-like, but that genus is polycephalous, and it is to be regretted that Domin did not clarify his choice of epithet.

Until the type specimens are located and compared with other species, the possibility must remain, therefore, that this is indeed a valid species.

PODOLEPIS LAEVIGATA Gdgr. in *Bull. Soc. Bot. France*, 65 (1918): 46.

"Completely glabrous plants with greyish linear leaves. Involucral bracts obtuse, whitish, much shorter than the florets. Pappus snowy. Australia, Victoria at Wimmera (Reader), Keilor Plains (Walter) and Mentone (Tovey)." (Trans. ex Latin.)

PODOLEPIS PAPILLOSA Gdgr. in *Bull. Soc. Bot. France*, 65 (1918): 46.

"Roughly hispid on the lower parts of the plant with papillose hairs. Leaves broad linear. Involucral bracts lanceolate, pale yellow, considerably surpassed by the florets. Pappus yellowish. Australia, N. S. Wales at Warrumbungle Range (Forsyth), Victoria (Walter)."

"Both these species are related to *P. acuminata* R. Br. The stem is a foot in length, stiff, with a single flower, and they are conspicuous with their large, silvery, very scaly inflorescences." (Trans. ex Latin.)

There are no specimens of either *P. laevigata* or *P. papillosa* in any Australian herbarium and Gandoger stated neither the source of his material nor the location of the Type specimens.

Although Gandoger admitted that both species are related to *P. acuminata* (i.e. *P. jaceoides*) he made no comparison and the present writer is of the opinion that when the Type specimens of both species are examined they will prove to be conspecific with *P. jaceoides*.

ORIGINS AND AFFINITIES OF THE SPECIES.

The distributions of the various species of *Podolepis* suggest that this genus would be a rewarding field for cytological studies of speciation processes. While certain species fall readily into well-defined groups of an Artenkreiss nature, the affinities of others can only be guessed at, and the question as to whether these originated as a result of step-by-step evolution, allopolyploidy or even intergeneric crosses, can be solved only by a cytological approach.

The two great species of *Podolepis* are *P. jaceoides* and *P. canescens*, of which the latter occupies the larger area. Both species are variable and apparently strongly heterozygous, and both successfully maintain themselves against competition. These two species have a number of characters in common and, on morphological grounds, appear to be at the same level of evolutionary development. Since both have retained generalized morphological characteristics, the present hypothesis is that one originated from the other, and each subsequently gave rise to further species.

The fact that *Podolepis* is represented in Tasmania only by *P. jaceoides* and that this is the predominant species in Victoria, suggests that the two populations, now separated by Bass Strait, were once panmictic. It is suggested that colonization took place from Subantarctica and that *P. jaceoides* became established in Tasmania and spread to the mainland of Australia by means of the land connections which existed intermittently in late Tertiary times. Since specimens from Tasmania and Victoria are identical it would seem that the species had evolved to its present level before the last land connection was severed. From Victoria, *P. jaceoides* now extends throughout New South Wales into the central western districts of Queensland and the eastern half of South Australia.

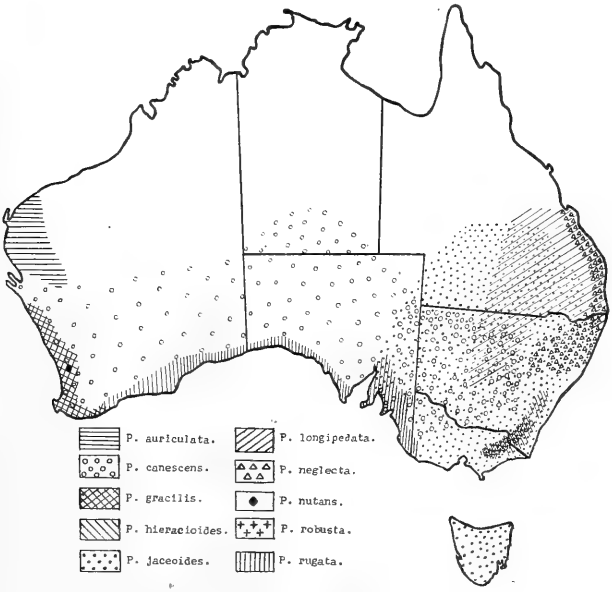
P. canescens, on the other hand, is chiefly a species of central and western Australia, and probably originated as an early geographic subspecies of *P. jaceoides*. At the present time it appears to be migrating eastwards and has come slightly to overlap the westerly range of the parent species.

Four of the five other eastern Australian species have distributions indicative of origins as independent geographic subspecies of *P. jaceoides*.

With overlapping centres of distribution in south-east Queensland are *P. longipedata* and *P. neglecta*, which extend as divergent tongues deep into New South Wales.

In the south there are two highland species, *P. robusta* and *P. hieracioides*, which also share a common centre of distribution in the Kosciusko Plateau and extend north and south along the highlands.

P. canescens occupies the southern half of Western Australia, the whole of South Australia, and extends into the Northern Territory and the western districts of New South Wales and Victoria. Around the southern, western and northern borders of its range, *P. canescens* either co-exists with or is replaced by some other species, and the fact that these other species replace each other geographically can only be interpreted as the expression of a clearly defined Artenkreiss. Three of these species, *P. rugata*, *P. gracilis* and *P. auriculata*, occupy the southern, western and north-western coastal belts respectively and their origin as geographic subspecies of *P. canescens* seems clear. Towards the centre of the area occupied by *P. gracilis* there is the closely related *P. nutans*, which probably originated as a local variant and may well now be extinct.



Text-fig. 151.—Relative distributions of *Podolepis* spp. forming an Artenkreiss.

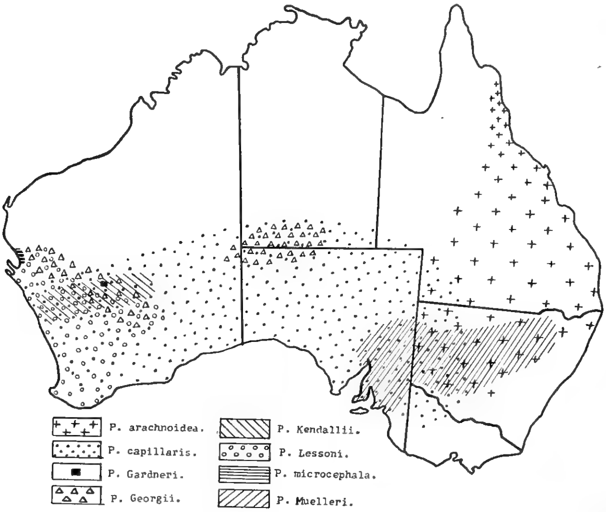
The origins of the remaining eight species of *Podolepis* are not so clearly indicated, although certain of them occupy a large territory.

P. capillaris, for example, occurs throughout the whole of South Australia, the western districts of the eastern States, the southern portion of the Northern Territory, and the southern half of Western Australia. Throughout the whole of its range its lack of variation is extraordinary, and the only other species with which it can be compared is *P. microcephala*, which replaces it in the Shark Bay district of Western Australia.

P. Lessoni and *P. Muelleri* form another pair of species which replace each other geographically, the former apparently with its centre of origin in the south-west of Western Australia and western New South Wales. Both these species are extraordinarily similar in habit and gross morphology, and in both the ray florets are tubular and considerably reduced in size and number. This peculiarity of the florets may indicate an evolutionary tendency continued in *P. Kendallii* (which replaces *P. Lessoni* to the north) and reaching a climax in *P. Georgii*, in which no female florets are present. Both *P. Kendallii* and *P. Georgii* are, however, very distinct species and a hybrid origin is indicated.

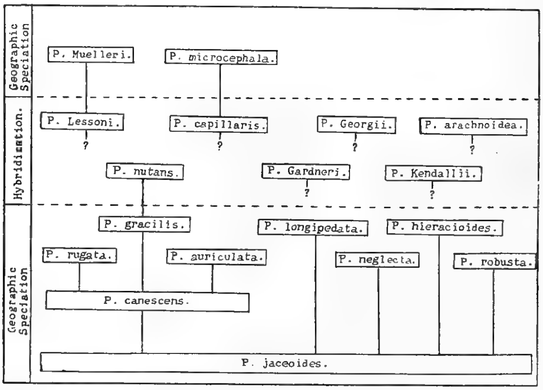
The newly-described *P. Gardneri* is known, so far, only from Meekatharra (W.A.) and its relationships are obscure. Vegetatively it is very similar to *P. Georgii*, but certain features of the involucral bracts suggest *P. canescens*. Since it occurs at the overlap between these two species, a hybrid origin is possible.

P. arachnoidea extends from northern Queensland into the western districts of New South Wales, and is a very distinctive species entirely lacking in variation, and cannot be associated with any others. It is hoped that a cytological study will throw some light on its origin.



Text-fig. 152.—Relative distributions of *Podolepis* spp. of uncertain affinities.

The present distribution of the species of *Podolepis* strongly indicates Rassenkreiss formation in the past, leading to the establishment of nine (possibly ten) species in an Artenkreiss. This appears to have been followed by hybridization (perhaps intergeneric as well as interspecific) and further subspeciation to give rise to the two brackets of species, *P. Lessoni–P. Muelleri* and *P. capillaris–P. microcephala*. If hybridization was responsible for the origins of the four isolated species, *P. arachnoidea, P. Kendallii, P. Georgii* and *P. Gardneri*, geographic subspeciation has not yet occurred, and there is only the apparent evolutionary pattern of the genus to suggest that it will do so in the future.



Text-fig. 153.—Diagram to illustrate the apparent patterns of speciation.

Acknowledgements.

In a revision of a genus, the need to examine as many specimens as possible, from all available sources, unfortunately involves a number of people in considerable inconvenience. For example, the time involved in sorting and packing specimens for despatch is considerable and, perhaps more important, the trustees or owners of the specimens are denied access to the material of a complete genus for a protracted time. But despite what can only be described as the "nuisance value" of my requests of this nature, they have been invariably received with the greatest cooperation from all concerned. I would like to thank, therefore, the Directors and Staffs of all the institutions from which I have borrowed specimens, as well as Professor J. B. Cleland of Adelaide and Mr. E. H. Ising of Stirling West (S.A.) who made their private herbaria available to me.

I wish, also, to thank Mr. Raymond Weibel, Curator of the Herbarium of the Botanic Gardens, Geneva, for photographing and making a detailed examination of certain of de Candolle's type specimens on my behalf. These photographs of *P. canescens* and *P. auriculata* have now been deposited in the National Herbarium, Melbourne.

Finally, my thanks are due to Dr. Adair Dale of the Classics Department, University of New England, who devoted considerable time and thought to the translation of original descriptions and texts, and was responsible for compiling the Latin diagnoses of the new species described in this Revision.

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STUDIES ON AUSTRALIAN THYNNIDAE (HYMENOPTERA). II.

A SHORT HISTORY OF THYNNID TAXONOMY.

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[Read 31st October, 1956.]

Synopsis.

An account is given of investigations leading to the recognition of the generic characters, geographical distribution, and association of the very dissimilar sexes, as well as an account of the promotion of the Fabrician genus *Thynnus* to the family category Thynnidae. Male wasps became known to science as *Thynnus* and females as *Tiphia* in 1775. Subsequently, as collections came from Australia many new species were described and new genera were erected. These genera were later grouped together into a single genus *Thynnus* by Klug, whose ideas strongly influenced Smith, and later Dalla Torre (1897). Not till early in this century was the genus *Thynnus* reclassified into a number of genera, firstly by Ashmead (1903) and later by R. E. Turner. This author published a major revision with the first key to species in 1907-8 and a generic revision in 1910. He described many new species. It has now been suggested by Pate (1947) that the reduction of Thynnidae and some half dozen related families to the rank of subfamilies of the family Tiphiidae would better illustrate their phylogenetic relationships.

INTRODUCTION.

The history of Thynnid taxonomy forms part of a project which, when completed, will be a monographic revision of the family. It is the second paper of this series and follows in sequence with the catalogue read to this Society on 25th November, 1953. Revisions bring their changes, and it is anticipated that some modifications of former classifications will be suggested. A brief account is presented here of the contributions on the Thynnidae made by earlier naturalists, which are now our heritage. The works of these contributors are reviewed in chronological order, and the influence exerted by one author over others is most evident. There is a great deal to be learnt from an examination of the achievements of these pioneers, and it is most interesting to trace the account of the discoveries they made of the various features which are of fundamental significance in this study.

The object of the present paper is to review the work of some forty naturalists published between 1775 and 1947, as taxonomic revisions are founded on the achievements of earlier workers. It is the second step in this revision and tells of the accumulation of our knowledge of Thynnidae over a period of one hundred and thirty-eight years. The present paper is an acknowledgement of the achievements of former workers, as the information they have compiled on the numerous known species makes it possible to carry out further investigation in this field.

SUMMARY.

Fabricius introduced flower-wasps to Science when he described them from the Joseph Banks collection. The male specimens he called *Thynnus dentatus*, *Thynnus emarginatus*, and *Thynnus integer*, while certain apterous, ant-like individuals in the collection he named *Tiphia pedestris*, unaware that they were the females of his new genus *Thynnus*. Since Fabricius, many naturalists have contributed towards our knowledge of this interesting group. A suitable taxonomic character that would separate *Thynnus* from other wasps was recognized in thynnid wing-venation by Jurine (1807). Klug's description of *Scotaena trifasciata* showed that thynnid wasps occurred in South America as well as in Australia and, as their absence was noted from collections made in other countries, the geographical isolation of these insects in South America and Australia was established.

As a result of the voyage of the *Coquille*, the number of species of thynnid known was increasing, and to Guérin-Méneville, these forms differed sufficiently from *Thynnus* to be described as separate genera. Soon afterwards, Klug (1840) published a monograph in which all of Guérin's genera were discarded and his species united into one single genus, *Thynnus*. Like most Linnaean and Fabrician genera, *Thynnus* became elevated to family rank. It was first disassociated from its allies and classified as a separate family by Shuckard (1840) and (1841). Guérin (1842) opposed the conception held by Klug of the use of the generic category, and erected further genera. Additional species were described by Westwood (1844), and in later years many more were added to the family by Frederick Smith and by Saussure (1868). Froggatt (1891) and Dalla Torre (1897) catalogued Thynnidae, but while Froggatt retained many existing genera, Dalla Torre listed all species alphabetically into one single genus, *Thynnus*. Taxonomic categories have a different value in different periods of taxonomy and Ashmead (1903) gave a classification of Thynnidae into a series of new genera. Dominating all else in this history is the contribution made to our knowledge of the Thynnidae by Rowland Edward Turner, a British hymenopterist who travelled extensively and made an enormous collection of these insects. In particular we are indebted to him for his revision of the Thynnidae (1907) and (1908), with its many new species. We are also indebted to Rowland Turner for his important generic revision, *Genera Insectorum* (1910), and for the many descriptions of new species that were contributed by him during the years that followed. Montet (1922) described more new species of the Thynnidae. The use of the most appropriate taxonomic category was again reviewed by Pate (1947), who contended that in the interests of phylogeny the family Thynnidae should be demoted in favour of subfamily Thynninae, family Tiphiidae. This brief history of the study of thynnid taxonomy begins with Cook's first voyage and terminates with Pate's suggested grouping of the thynnids as a subfamily of the family Tiphiidae.

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HISTORICAL REVIEW OF LITERATURE ON THYNNIDAE.

Johann Christian Fabricius, Johann Roemer, and Christ.

The history begins in 1770 when Captain James Cook in H.M. Barque "Endeavour" sailed homeward along the shores of northern Queensland and made collections at various landings on the coast. The type locality is presumed to be Endeavour River, now Cooktown, since Cook was delayed there for seven weeks between 18th June and 5th August, or possibly Bustard Head on 24th May, or Thirsty Sound on 30th May, 1770 (Wharton, 1893). Three species of male wasp and one species of female were collected and the original specimens have been preserved to this day in the Joseph Banks Collection in the British Museum.

The insect collections from New Holland were sent to Johann Christian Fabricius (1745–1810) of Denmark for description. Our flower-wasps were first described in his *Systema Entomologiae* (1775). The males were named *Thynnus dentatus*, *Thynnus emarginatus* and *Thynnus integer*, and as the dissimilarity between the sexes is so very great the female became known as *Tiphia pedestris*.

Our present-day Order Hymenoptera had already been established by Linnaeus (1707–1778), who had selected the general form of the wings in insects as a means of separating one group from another. Linnaeus had already defined our Orders Hymenoptera, Coleoptera, Hemiptera, Lepidoptera and Neuroptera in the tenth edition of his *Systema Naturae* (1758). On the other hand, Fabricius had been investigating the mouth-parts of many of his genera of insects, and set out to create a classification based on the comparative morphology of mouth-parts. In his *Systema* (1775) Fabricius grouped in his Order Synistata the *Ephemera, Lepisma, Podura, Hemerobius, Myrmeleon* and all Hymenopterous genera including *Thynnus*. Difficult though it is to believe, this group even included *Oniscus*. An abridged version of the *Systema* (1775) followed, called the *Species Insectorum* (1781). This was a reprinting word for word of the initial, abbreviated statement that he gave in his former work to define his genus and species. Six years later the *Mantissa Insectorum* (1787) was produced and here for the third time his original, cryptic definition was printed and his Order Synistata remained unchanged.

Roemer (1789) magnificently illustrated many of the genera that had been described by both Linnaeus and Fabricius, and a beautiful (hand coloured) illustration exists of *Thynnus dentatus*, accompanied by the classic Fabrician extract. This was followed by the thirteenth edition of the *Systema Naturae* which was revised and enlarged by Gmelin (1790), twenty-two years after the death of Carl von Linné. Gmelin retained the Linnean Order Hymenoptera rather than the Fabrician Synistata, and supplied a little more information on the structure of their mouth-parts.

Christ (1791) in *Naturg. d. Insect.* considered that the genus *Thynnus* should be sunk as a synonym for *Vespa*, that *Tiphia pedestris* should become *Sphex pedestris*, and that *integer* should become *integra*.

For eighteen years Fabricius retained his *Thynnus, Tiphia*, and all the hymenopterous genera in this heterogenous order Synistata, until eventually he modified this extraordinary classification in his *Entomologia Systematica emendata et aucta* (1793). With mouth-parts still his taxonomic characters, he separated the genera which comprise our Hymenoptera from his Order Synistata and placed them in a group by themselves, the *Piezata*. The descriptions of 1775 were duplicated in full, with one additional contribution, *Thynnus abdominalis*, from Africa, a species which subsequently was shown to be a bee. Three years later came the *Index Alphabeticus Entomologiam Systematicam emendatam et auctam* (1796), which gave the page references to the preceding Fabrician volume. Then Fabricius (1804) produced his *Systema Piezatorum*, embodying eighty-three hymenopterous genera classified on their antennae and mouth-parts. Coloured illustrations of *Thynnus dentatus, Thynnus emarginatus, Thynnus integer* were given by Donovan (1805).

Pierre Andre Latreille and Louis Jurine.

Thirty years after the generic name *Thynnus* had been proposed by Fabricius, Latreille, who was at that time working at the Paris Museum, published his *Histoire Naturelle des Crustaces et des Insectes* (1805). During that thirty-year period flower-wasps had been mentioned in ten separate publications, but the only additional information contributed were the illustrations of Roemer (1789) and of Donovan (1805). In fact, monotony characterized the recurring Fabrician contributions of those early, static years. Several interesting comments were made on *Thynnus* by Latreille (1805), which were based on information supplied to him by the Rev. W. Kirby, of England. "Cette division générique de Fabricius est composée de quatre espèces qui sont presque d'autant de genres différens. 1^e^ Le thynne denté, figuré par Roemer, peut être pris pour le type du genre; la 2^e^ espèce paroît être encore un thynne; la 3^e^ est une mégachile, et la 4^e^ est probablement une myzine. Le savant entomologiste anglais Kirby a eu la complaisance de me donner des éclaircissemens très-bien détaillés sur ces thynnes de Fabricius, qui ont été décrits dans la collection de Banks." It is evident that Latreille's concepts of the generic category differed considerably from those held by Fabricius, and other examples in this history show the truth of the following statement: "A genus or other category has a different value in different historic periods of taxonomy" (Mayr *et al.,* 1953).

Jurine (1807) described the genus *Thynnus* in his *Nouvelle Méthode de Classer les Hyménoptères et les Diptères.* He characterizes the genus as having "*Cellule radiale,* une, étroite, très-alongée. *Cellules cubitales,* quatre, presque égales et carrées: la 2^e^ et la 3^e^ récoivent les deux nervures recurrentes; la 4^e^ atteint le bout de l'aile."

Latreille (1809) in his *Genera Crustaceorum et Insectorum* gave a new description of *Thynnus,* and a new genus for *Tiphia pedestris.* For *Thynnus* he even attempted to discriminate between the males and what he thought, *in error,* to be the females! As for *Tiphia pedestris,* he was no longer satisfied that this ant-like insect was in any way related to the genus *Tiphia,* and he therefore removed *T. pedestris* to a new genus, *Myrmecodes,* which he had erected for it. Latreille considered that *Thynnus* should belong to the family Scolietae together with *Scolia, Sapygia, Myzine, Tengyre,* and others. On the other hand, *Tiphia pedestris* was grouped in the family Mutillariae, and so Latreille divided the males into male and female sexes, and succeeded in classifying the males (*Thynnus*) and the true females (*Myrmecodes*) into separate families. His reference to wing-venation reads: "Areola marginalis anastomosi obsoletissima" and "*Alae superae* areola marginali soluta seu costae immediate non adjecta; areola submarginali prima anastomosi distincta secata."

Klug, Olivier and Lamarck.

By 1810 the first thynnid wasp from South America had arrived in Berlin, and it was described by Dr. Klug as *Scotaena trifasciata.* The existence of Thynnids in the unique faunas of both South America and New Holland was thus established, and as collecting continued in other countries, it was found that thynnids did not occur elsewhere. About the same time another interesting event occurred. This was the discovery of a second female thynnid. Olivier (1811) associated it with Latreille's *Myzine* (1804) and it became *Myzine aptera.* This drew attention to Latreille's recent new genus, *Myrmecodes.* Only a half-dozen thynnids were known in 1811. There were four males, *Thynnus dentatus, T. emarginatus, T. integer,* and *Scotaena trifasciata,* and two females, *Tiphia* (*Myrmecodes*) *pedestris* and *Myzine* (*Myrmecodes*) *aptera.* Lamarck (1744-1829) gives a short account of *Thynnus* in his *Animaux sans Vertèbres* (1817) and presents, almost word for word, a well-edited version of the ill-conceived notions set forth by Latreille (1809) regarding the differentiation of the sexes. Although *Myrmecodes* had been shown to be the female of *Thynnus* some time before the second edition (1835) appeared, his editors omitted to rectify this error. Lamarck's version of Latreille (1809) on sex differences reads: "Antennes filiformes, presque sétacées, plus courtes et plus épaisses dans les femelles que dans les mâles. Mandibules étroites, saillantes, arquées, subunidentées plus fortes dans les femelles. Les yeux des femelles entiers. Corps alongé, presque linéaire dans les mâles."

Leach and Kirby.

In 1818, forty-three years after Fabricius had named them, there was still only a little information recorded on *Thynnus.* There were some specimens from New Holland which were collected by Robert Brown, who had come here as the botanist on the Matthew Flinders Expedition, which set out from England in the *Investigator* in 1801. This expedition is linked in our history with the adoption of the name "Australia" for our continent. Its use had been advocated by Flinders as early as 1804 rather than either New Holland or New South Wales, and in his *Voyage to Terra Australis* (1814) preference for the name was expressed by this explorer (Australian Encyclopaedia, 1925). Robert Brown left Port Jackson in 1805, and the thynnids in his collection were described by Kirby (1818) and by Leach (1819). Kirby gave us *Thynnus variabilis,* adopting his name from Leach's manuscript, and also *Thynnus annulatus.* Leach followed this with a variant of *T. annulatus* which he named after Brown; however, *brownii* has become a synonym for *T. annulatus.* In the same year Latreille (1818) produced his celebrated *Nouveau Dictionnaire d'histoire naturelle,* which refers both to *Thynnus* and to *Myrmecodes.*

Lepeletier de Saint-Fargeau.

The work of Lepeletier (1825) is a reproduction of Latreille and the idea that the winged form was bisexual is retained. He also gives Jurine's description of wing-venation. In his second paper (1845) his error regarding sex differentiation is omitted, and his description of wing-venation reads: "*Caractères des ailes.* Une radiale ovale, grande. Quatre cubitales; la première séparée en deux par une nervure descendant de la côte sans atteindre le cubitus. La seconde reçoit la première nervure récurrente. La troisième cubitale reçoit la deuxième récurrente. La quatrième, assez courte, atteint le bout de l'aile."

Van der Linden, Friedrich Klug, Boisduval, John Westwood and William Shuckard.

Interesting contributions regarding the discovery that *Thynnus* and *Myrmecodes* were in fact male and female forms of the same insect group were made. Van der Linden (1829), with Wesmael, showed that a European species related to *Thynnus*, *Methoca ichneumonoides* (♀) (Famille des Mutillaires), was the female form of *Tengyra sanvitali* Latreille (1809) (♂) (Famille des Scolietes). A little later Klug (1831), in discussing the eyes of insects, writes: "In den Gattungen *Mutilla* und *Apterogyna* haben die Mannchen deutliche, die ungeflugelten Weibchen dagegen keine Ocellen. Ebenso verhalt es sich mit den Gattungen *Myrmosa*, ferner *Tengyra*, zu welcher *Methoca* und *Thynnus*, zu welcher die Gattung *Myrmecoda* als Weibchen gehort" (p. 307). Then Boisduval (1835) gave his short description in the *Voyage de l'Astrolabe* of *Thynnus australis*, Port Weston, but unfortunately his type was lost, so his species has never been finally determined from his illustrations, or his few colour characters. This was followed by Westwood (1835), who defined *Diamma bicolor*, female, in a few well-chosen words. By strange coincidence the next species described was the male of *Diamma bicolor* Shuckard (1836), which the author named *Psamatha chalybea*, stating: "It may subsequently prove to be the male of Westwood's *Diamma*." Shuckard had guessed from analogy that *Myrmecodes* was the female of *Thynnus*, and this supposition was confirmed by a Mr. Lewis, of Sydney, N.S.W., who observed *Thynnus variabilis in copula* with an apterous female congeneric with *Tiphia* (*Myrmecodes*) *pedestris*.

Guérin-Méneville.

An event which could be called a "milestone" in this history was the contribution made by Guérin-Méneville (1838) in the Duperrey's memoirs of the *Voyage Autour du Monde* by the corvette *La Coquille* (1822-1825), which had visited both New Holland and South America. This voyage was by Royal Command, and therefore the account of its achievements was published on an appropriately lavish scale. Guérin's Atlas (1832) illustrated *Thynnus* (?) *rubripes* (♂), and also *Myzine australis* (♂) (later *Anthobosca australis*), showing mouth-parts and hypopygium; it bears the date (Novemb. 15th, 1831). Guérin's contribution on the thynnids in the Duperrey memoirs was a monograph. Hymenopterous genera allied to *Thynnus* and the wingless nature of their females were discussed and an important advance was made in the classification of the wasps belonging to this group. The thynnids were placed in the *Mutillaires*, which were "Hyménoptères vivant solitairement et n'offrant que des mâles ailés et des femelles aptères", etc. The scheme followed was simple:

Famille des *Heterogynes*:
    Tribu: I. *Formicaires*: Ants.
    Tribu: II. *Mutillaires*: Eighteen genera, including *Thynnus*.
Famille des *Fouisseure*:
    Tribu: I. *Scolietes*: *Scolie*, *Tiphie* & others.
    Tribu: II. *Sapygites*: *Sapyge* & others.

A key is given to the eighteen genera of the Mutillaires. All his new species were described in every detail with complete disregard for printing costs. Former descriptions of the earlier species were reprinted, some with additional information. Eleven new species and the genera *Rhagigaster*, *Agriomyia*, *Thynnoides* and *Tachypterus* were described from Australia.

William Shuckard and Ferdinand Erichson.

Shuckard (1840) was the first to elevate *Thynnus* Fabricius (1775) to the taxonomic category family *Thynnidae.* Of preceding authors, Latreille (1809, 1819) associated *Thynnus* with famille Scolietae; Kirby (1819), Sphegidae; Latreille (1818) and Lepeletier (1825), famille des Fouisseure, tribu des Sapygites; while Westwood (1835), Shuckard (1836), and Guérin (1838) grouped them with Mutillidae. When more material was examined (presumably), the separation of the Thynnids from Mutillids would naturally follow, as these insects are quite dissimilar. The extent of Shuckard's acquaintance with this group is illustrated by this abstract from *On the History and Natural Arrangement of Insects* (1840): "Apterogyna: *Thynnus* has apterous females, numerous cognate genera and many species. The legitimate partners of several of them are known. The latter were ascertained from observations of friends in New Holland, where except for several genera, the whole *family* is found. It is into this family that *Elis* F. enters. The females of the *Thynnidae* show remarkable structures." Shuckard's index reads: "Thynnidae, structure of p. 176." In the following year a new genus and species was described by Shuckard (1841) in *Grey's Journal of Two Expeditions*; this was *Oncorhinus xanthospilosus.* This description is under the heading "Hymenoptera (Family Thynnidae Shuckard)", and in the introduction he writes: "My reasons for establishing the Family Thynnidae, I shall expose in my monograph of that family, which would have been published ere this but for the difficulty in procuring specimens for dissection . . . ."

In those days there was an annual report compiled by Erichson, in which an account was given of the current entomological publications. Prior to 1841, thynnid publications were listed with Mutillidae. In Erichson (1843), *Bericht über die Wissenschaftlichen Leistungen im Gebiete der Entomologie während des Jahres 1841,* in which *Oncorhinus xanthospilus* Shuckard appears, Erichson follows Shuckard's lead and classifies his information for that year and for all subsequent years under the title *Family Thynnidae.* Erichson (1842), *Beitrag zur Fauna von Vandiemensland,* etc., described four new species of *Thynnus* and erected the new genus *Ariphron*, using the female. These new genera and species were duly noted by Erichson in his next *Bericht* for the year 1842, published in 1844, but no description of the characters of the family Thynnidae as such were set out in Erichson's works. Although Erichson had definitely established Shuckard's priority as the original author of the taxonomic category *Family Thynnidae* by publishing his report of Shuckard's *Oncorhinus* paper of 1841 in the *Bericht* for that year, and by reporting his own *Ariphron* paper of 1842 in the subsequent *Bericht* for the year 1842, Louis Agassiz in the *Nomenclator Zoologicus* credits as its author: "Family Thynnidae Erichson, in Weigmann Arch. 1842." This blatant error has been duplicated by Thynnid workers to the present day.

Shuckard's promised monograph on the family Thynnidae, in which his taxonomic characters were to be presented, unfortunately never appeared. In its stead, Klug (1840) produced his monumental work on *Über die Insectenfamilie Heterogyna Lat. und die Gattung Thynnus F. insbesondere.* It was clear that these two authors held opposing views as regards splitting and grouping of genera, and it is regretted that Shuckard's work was lost. Presumably this author's manuscript was abandoned with the entry of both Klug (1840) and Guérin (1838) into the field.

Dr. Klug.

Klug, who was a doctor of medicine in Berlin, wrote a most impressive monograph on these insects, which he classified as *Insectenfamilie Heterogyna* Latreille, *Gattung Thynnus*, Fabricius. It would be impossible to deal both adequately and briefly with his work. Klug retained the older concept of the genus, as held by Linnaeus and Fabricius, and refused to accept the modern outlook of Guérin-Méneville, and consequently grouped all the genera erected by Guérin and others into one single, all-embracing genus, *Thynnus*. However, he erected a new genus, *Aelurus*, from Brazil. He divided the genus *Thynnus* into four *Unterabtheilung*, and the method he employed will be discussed by the present author in a subsequent paper. It is safe to say that the subsequent workers in this field were strongly influenced regarding the usage of the taxonomic category *genus*, by the Linnaean concept held by this medical practitioner.

Guérin-Méneville.

After Klug (1840), Guérin-Méneville (1842), one of the leading entomologists of that period, produced his final paper on the Australian Thynnidae, *Matériaux sur les Thynnides,* which is illustrated by some very excellent figures. In his opening lines he begins: "Depuis la publication de notre travail dans le *Voyage* de Duperrey nous avons augmenté notre collection de Thynnides, . . . Déjà M. Klug, dans sa monographie du genre *Thynnus*, a fait connaître quelques unes des espèces sur lesquelles nous avions fait des études sérieuses, et il est probable que les observations qui nous restent seront perdues, si nous attendons que M. Shuckard ait donné la monographie des Thynnides, qu'il prépare."

Guérin considered that many species were sufficiently distinct to justify their classification into separate genera. In his latest contribution Guérin added three more new genera and twelve new species to the ever-growing list of Thynnidae, showing his thorough disregard for Hrn. Friedrich Klug and his monograph! Although Klug had sunk every single genus of the Thynnidae that had been erected by Guérin, and had amalgamated them all into *Thynnus*, the concept of the generic category held by this celebrated author remained unchanged. The specific names selected perpetuate the names of his contemporaries—Shuckard, Westwood, Spinolae and Klug, in fact with a twist of humour, Guérin attaches Klug's name to a new species belonging to yet another of his new genera. In Guérin's second group of Australian genera were *Tachynomyia*, *Catocheilus* and *Lophocheilus*.

John Westwood.

In three papers, Westwood (1844) presented a summary of the more important parts of Guérin's outstanding contributions, made appropriate comments on Klug (1840), summed up the taxonomic characters of ten species of *Rhagigaster*, gave us additional information on *Diamma* (1835) and other species, and made very full descriptions of twenty-one species of Thynnideous insects. No entomologist at that time set so fine an example, no one but Westwood could more appropriately deliver the following simple exhortation to his fellow workers: "The recent monographs of Dr. Klug and Guérin-Méneville . . . and the different results at which these distinguished hymenopterologists have arrived respecting the generic arrangement of these insects, render the observation of every fact, tending to determine the question at issue, absolutely necessary." Despite Westwood's careful work and his call for explicit descriptions, the second half of the century was characterized by ambiguity and brevity in most of the descriptive work written on the Thynnidae. Klug's influence prevailed and in the subsequent decades the only genus to be erected was *Zeleboria* Saussure.

Frederick Smith.

In complete contrast to the peak in this history attained in the early forties by such competent workers as Shuckard, Guérin, Klug and Westwood, the latter part of the nineteenth century gave rise only to numbers of meagre descriptions of new species. The principal figures in this era were Frederick Smith and Henri de Saussure; while of lesser consequence were Ritsema (1876), Olliff (1889), and David Sharp (1900). The catalogues of Froggatt (1891) and Dalla Torre (1897) brought the period to a close.

Outstanding amongst his contemporaries for the numbers of new species of Thynnidae he described was Mr. Frederick Smith, hymenopterist in the British Museum, who from 1859 to 1879 described one hundred and sixty-nine Australian and twelve South American species of Thynnidae. In 1859 Smith published his catalogue of the Hymenoptera in the British Museum and, according to this volume, the Thynnidae comprised two hundred and nineteen species. Of these, forty-eight came from South America and one hundred and seventy-one species came from Australia. That the family was limited to these two geographically isolated continents was now well established. It is of interest to notice that Frederick Smith's work was published in the same year as Darwin's "Origin" and also that Smith's name is mentioned by

Darwin in connection with *Formica sanguinea*, a slave-making ant. Not only was Smith acknowledged in "The Origin of Species", but by coincidence the family Thynnidae became associated also with the work of Alfred Russel Wallace, as it was Frederick Smith (1859-65) who made a catalogue of the Hymenoptera collected by A. R. Wallace, which included a dozen Thynnidae from such places as Aru, Batchian, Ceram, Gilolo, Mysol, Waigiou, Bouru, Salwatty, Morty and New Guinea. So these extensive collections made in the East by A. R. Wallace showed that the Thynnidae range into Austro-Malaya.

Many of Smith's earlier descriptions were based on superficial features alone. In fact, colour pattern was the chief feature that Smith attempted to describe, with brief reference to pubescence and surface puncturing. In consequence, many of the descriptions in the Catalogue of 1859 are hopelessly inadequate, and their identification, from literature that deals with so many species so very briefly, would be completely impossible. Of the array of species described by this author there are some that have had to be sunk as synonyms of his own species, for Smith was apparently prepared to make a new species out of any of the various colour variants that he could find. It is not without interest to notice the effects upon Frederick Smith of the two conflicting schools of thought which immediately preceded him. Klug's impressive monograph had re-established the genus *Thynnus* as conceived by Fabricius. Consequently the line of least resistance would be to name new Thynnidae as species of the genus *Thynnus*. This course was far easier for Smith than the erection of new genera, and the subsequent discrimination of generic characters; thus many complications were fortunately avoided. Klug's new genus *Aelurus* was now in vogue, and the fact that Klug's two species were South American did not deter Smith from following Westwood's lead and cataloguing *Agriomyia* (*Tachynomyia*) *abdominalis* Guérin (1842) as the first example of an *Aelurus* from Australia. Guérin's other genera, *Thynnoides*, *Agriomyia*, *Lophocheilus* and *Catocheilus*, were regarded by Smith, as they were by Westwood, as being merely of subgeneric value. Likewise, *Enteles* Westwood and *Eirone* Westwood were grouped with *Thynnus*. The genera which Smith retained were: *Rhagigaster* Guérin (1838), *Oncorhinus* Shuckard (1841), *Ariphron* Erichson (1842), *Diamma* Westwood (1835), *Tachypterus* Guérin (1838), *Iswara* Westwood (1851), and *Anthobosca* Guérin (1838). He accepted Louis Agassiz (1842-6) regarding authorship of Thynnidae even with publication by Shuckard (1841) beside him. *Iswara* and *Anthobosca* do not belong to the Thynnidae.

Henri de Saussure.

In 1868, concurrent with Frederick Smith in England, Henri de Saussure published his descriptions of Hymenoptera collected on the voyage of the *Fregatte Novara*. This included twenty-four species of the family Thynnidae. By Saussure the family was regarded as *Tribus Thynnii*, which was divided into two *Legio*:

Legio 1ª (♂) Prima areola cubitalis apice haud divisa.
Prima vena transverso-cubitalis integerrima.
Mandibulae tridentatae. (♀) incognitae.
Legio 2ª (♂) Prima areola cubitalis apice per ramum venae transverso-cubitalis divisa (vel appendiculata).
Venae recurrentes sigillatim a 2ª et 3ª areola cubitali exceptae.
Mandibulae bidentatae. (♀) Thorax transverse tripartitus.

In the first legion were *Tachypterus* Guérin and *Oncorhinus* Shuckard, which were separated on the relationship between the *vena recurrentes* and the *areola cubitali*; it also included *Anthobosca*, which is not Thynnidae. In the second legion were *Elaphroptera* Guérin, *Rhagigaster* Guérin, *Thynnus* Fabricius, *Tachynomyia* Guérin, *Iswara* Westwood, *Elaphroptera* Guérin, *Zeleboria* Saussure, *Aelurus* Klug. Separation of these genera was achieved by means of the form of the hypopygium, first cubital cell, the segments of the maxillary palp, and the shape of the abdomen. The subgenera *Agriomyia* Guérin and *Thynnoides* Guérin were retained, together with the subdivision of *Thynnus* proposed by Klug (1840). Recognition was also made of the genera *Eirone* Westwood (1844), *Enteles* Westwood (1844), *Diamma* Westwood (1835), and *Ariphron*

Erichson (1842). This author holds the distinction of being the only systematist to erect a new genus in the fifty-nine years that elapsed from 1844 to 1903. This is the genus *Zeleboria* Saussure (1868). *Z. carinata* is Saussure's type; it also includes *Thynnus xanthorrhei* Smith (*see further* Turner, 1910, and Rohwer, 1910).

C. Ritsema, Arthur Olliff, Walter Froggatt, William Kirby and David Sharp.

Ritsema, Olliff, Froggatt, Kirby and Sharp contributed towards our knowledge of the Thynnidae. *Aelurus flavopictus* Ritsema (1876), n. sp., first recorded from Aru Island, but later known from North Queensland and New Guinea; a common mainland species, *T. campanularis* Sm. was found to roam as far as Lord Howe Island, Olliff (1899); Froggatt (1891) records *T. pulchralis*, *T. brenchleyi* from Narrabri, N.S.W., and *Rhagigaster integer* from Victoria Desert, S.A. *Thynnus taeniolatus* Froggatt (1893), n. sp., was described from the Elder Expedition. Kirby (1898) mentions three species discovered at Palm Creek and Illamurta by the Horn Expedition to Central Australia, and briefly describes *Rhagigaster illustris*. Lastly, Sharp (1899), in *Cambridge Natural History*, writes a short note on these insects, using *Methoca ichneumonoides* as an example.

Walter Froggatt.

An important contribution to our knowledge of the Thynnidae was made by Walter Froggatt (1891) in his catalogue of the described Hymenoptera of Australia, in which there were twenty pages listing the species of this family. The ten genera which had been retained by the preceding authors are given by Froggatt, and the number of described species amounted at that time to two hundred and fifty-one. He writes: ". . . there is, no doubt, a good deal of confusion in this family, and a revision of the Thynnidae would be very useful work." This catalogue gives the author, date, sex, and locality of the described species, but as the complications of synonymy had never been investigated, the work is primarily a register of specific names. In the genus *Thynnus*, one hundred and ninety-two species had been described by 1891, among which, included as subgenera, were Guérin's *Agriomyia*, *Lophocheilus*, *Catocheilus* and *Thynnoides*, together with Westwood's *Eirone*. The type species of *Aelurus* Klug came from Brazil, but it is interesting to notice that Smith (1859) had catalogued *Tachynomyia abdominalis* Guérin, the type species for *Tachynomyia*, into Klug's genus *Aelurus*, and that this genus now contained some seventeen Australian species, many of which had been described by Smith. *Tachynomyia*, cut off from its type species, only contained the two species that Saussure had described. *Rhagigaster* Guérin had twenty-six species, *Zeleboria* Saussure had four species while *Anthobosca* Guérin, later to become family Anthoboscidae, contained five species. The three, historically important, monotypic species, *Diamma bicolor* Westwood (1835) (♀), *Oncorhinus xanthospilus* Shuckard (1841) (♂), and *Ariphron bicolor* Erichson (1842) (♀), were all retained, while a synonym for the male of *Diamma*, *Tachypterus fasciatus*, was also listed. This was *T. crassicornis* Smith, which has subsequently been removed to the Anthoboscidae.

Dalla Torre.

The nineteenth century closed with the publication of the *Catalogue of Hymenoptera* by Dalla Torre (1897). It was fortunate that Froggatt had completed and published his list of our native species before the appearance of Dalla Torre's work, in case, like Shuckard's monograph, Froggatt's catalogue had also to be abandoned. These two catalogues provide interesting comparisons, as Froggatt listed, without alteration, the genera and species described, while Dalla Torre introduced certain taxonomic changes in his contribution. With several exceptions this author united all the genera of Thynnidae into one single genus, *Thynnus*. The exceptions were *Tachypterus*, which Dalla Torre combined with *Diamma* and *Psamatha*, and *Iswara* from India, which belongs to family Myzinidae. By thus grouping together *Aelurus*, *Ariphron*, *Anthobosca*, *Zeleboria*, *Tachynomyia*, *Rhagigaster* and *Oncorhinus* into one genus, *Thynnus*, a number of species which shared the same specific names became automatically congeneric and duplication of various names resulted once their former genera had lapsed.

Dalla Torre therefore proposed new names, but unfortunately certain errors resulted. However, fourteen of these have subsequently been rectified by Schulz (1906). The Dalla Torre catalogue is an alphabetical inventory of world Thynnidae, in effect of the genus *Thynnus*, and contains three hundred and thirty-seven species, with valuable references. The influence of Klug's monograph, followed by the addition of Smith's numerous species to *Thynnus*, resulted in the inclusion within this genus of a very great diversity of forms. The work of various authors was inconsistent and, as a study of comparative morphology had never been made, the taxonomy of Thynnidae was now highly confused.

William H. Ashmead.

Ashmead (1903) considered that the Myrmosidae, the Mutillidae, and the Thynnidae were three separate families of the superfamily Vespoidea. In his opinion, the family Thynnidae should be divided into three distinct subfamilies, the Thynninae, the Rhagigasterinae, and the Methocinae. According to this author, the subfamilies Thynninae and Rhagigasterinae comprised thirty-seven genera from Australia and South America and also an Indian genus, *Iswara*. There are no Methocids in Australia.

Ashmead constructed keys to the subfamilies and genera of the family Thynnidae, using the morphology of the hypopygium, thorax, mandibles and wing-venation as his taxonomic characters. His publication appeared in 1903; following soon after the Dalla Torre catalogue, it shows an important advance in the history of Thynnid taxonomy. Here, after sixty years, was a complete reversal of Klug's concept, and this was the first constructive attempt towards a generic classification of the group since 1838, when Guérin gave his simple keys to the thynnid wasps found on the voyage of *La Coquille*. In seventy-five years construction of keys to this group had become a complex problem. When Guérin worked on the Thynnidae there were only thirty-eight species recognized from South America and Australia, but by 1903 the number of described species had increased to three hundred and forty. Furthermore, much of Smith's work was so superficial that it could have been of little assistance to Ashmead. Although it is evident that Ashmead made a study of these insects and was acquainted with their morphology, the use of his generic key would be quite impracticable. Insufficient was known of the Thynnidae at that time, and this work seems to have gone to press prematurely. Ashmead at least presented a notable attempt, which was made more difficult for him by the excessive number of species and the total inadequacy of the preceding literature. Considered in relation to the period when his study was made, Ashmead presented a positive approach to the problem of a classification of the family into subsidiary taxonomic categories. His was the only comparative study of these wasps since the days of Guérin and Westwood, and it stands in marked contrast with Frederick Smith's descriptions and the index presented by Dalla Torre.

Ashmead's generic keys contain anomalies which are difficult to comprehend. For instance, this author erected a new genus *Aeolothynnus*, using as its type the name of a manuscript species *Aeolothynnus multiguttatus* Ashmead, and omitted to publish his description or define this species in any way. In Ashmead's key to the male Thynninae, taxonomic characters of *Myrmecodes* Latreille (type species, *Tiphia pedestris* Fabricius) are set out, but the male of this classical species has never yet been recognized. It is difficult to understand how Ashmead could have placed conspecific species into separate genera. For instance, *Agriomyia abdominalis* and *Agriomyia spinolae* are conspecific, but Ashmead identified one of these as Guérin's original type species for *Tachynomyia*, and used the other as the type for his new genus *Pseudaelurus*. *Agriomyia maculata* Guérin and *Thynnus* (*Agriomyia*) *odyneroides* Westwood, which are also synonymous, were classified respectively as Guérin's type species for *Agriomyia* and Ashmead's type species for his new genus, *Cephalothynnus*. Two genera which do not belong to the Thynnidae, *Anthobosca* and *Iswara,* appear in this generic key.

Gunther Enderlein, Peter Cameron, and W. A. Schulz.

Enderlein (1904) described his new genus, *Homalothynnus*, which has subsequently been discarded. *Thynnus albopilosellus* Cameron (1906) was described from expeditions into Dutch New Guinea. Schulz (1906) corrected certain errors in the Dalla Torre catalogue, and followed this (1908) with descriptions of *Enteles wagneri* and *E. sanguineiventris*, n. sp.

Rowland Edward Turner.

This field of research has since been dominated by Rowland Edward Turner, who worked voluntarily for the British Museum of Natural History for thirty years on various Hymenoptera and became a recognized authority on the Thynnidae. Turner's *Revision of the Thynnidae of Australia*, Part i, 1907; Part ii, 1908, contained the first key to the species, with synonymy, redescriptions of earlier species, and many additional descriptions of new species. This was followed in 1910 by Turner's key and catalogue to world Thynnidae. Here the family is divided into three subfamilies, the Diamminae, the Rhagigasterinae and the Thynninae. Turner recognized forty-seven genera, of which thirty-four are Australian, and in his catalogue he lists three hundred and fifty-six species from this country. Thynnid taxonomy was completely changed by the advent of this new classification.

Rowland Turner, Allen Rohwer, G. Montet, Joseph Bequaert and Delfa Guiglia.

There have been one hundred and thirty-three new species described, one genus erected, and adjustments made to four generic names since 1910. Thus the combined total number of species would amount to 489 but for the fact that a number are synonyms; the number recognized by Turner appears to be 475. Of the above authors, Turner described one hundred and fifteen new species and a new genus in his series of fifteen papers. Fourteen species were contributed by Montet (1922), Rohwer gave us three, while a single species was added by Rayment. Rohwer's paper of 1910 is important, as it clears several errors made by Turner in his generic names. Bequaert (1926) established the date of Guérin in Duperrey as 1838, and Guiglia (1948) described the condition of Guérin-Méneville's types preserved in the Museo di Genova.

V. S. L. Pate.

Pate (1947), in his *A Conspectus of the Tiphiidae* states: "The Tiphiid wasps have for the most part been treated as a collection of separate and distinct families: the Bradynobaenidae, Myrmosidae, Anthoboscidae, Tiphiidae, Myzinidae, Thynnidae and Methocidae . . . it is not difficult to show that a division which accords many, if not each, of these groups separate family status gives no adequate picture of the phylogeny of the group. Indeed there is much to say in favour of including all these wasps in the single family Tiphiidae, which may then be divided into a number of subfamilies corresponding to as many phylogenetic strains." In the thynnids the values placed on taxonomic categories have varied at different times in this history. So also has the application of these categories by various authors in general zoology, and the assignment of the rank of superfamily, family, or subfamily is subjective. According to Mayr, Linsley and Usinger (1953): "*A family may be defined as a systematic category including one genus or a group of genera of common origin, which is separated from other families by a decided gap.*" Further investigation will be required before the extent of such a "gap" can be assessed. However, should these seven groups prove to be sufficiently dissimilar one from another and by Mayr's definition conform to family rank, then in conformity with established taxonomic procedure, it would be more appropriate to use the categories Superfamily and Family in place of Family and Subfamily, provided that no inconsistencies arise between existing superfamilies and such a new superfamily as Tiphioidea.

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VARIATION IN SNOW GUM (*EUCALYPTUS PAUCIFLORA* SIEB.)

By L. D. Pryor.

(Plates xv-xvi; two Text-figures.)

[Read 28th November, 1956.]

Synopsis.

Variation in Snow Gum (*E. pauciflora* Sieb.) populations is described. In continuous stands, linear correlation between a number of characters and elevation is found. Genotypic variation is found to accompany phenotypic variation. Heritable variation is found likewise in stands which occur separately over wide areas. The Snow Gum population varies clinically in several directions showing correlation with habitat variation and it is implied that such a variation has adaptive value. Taxonomically it is considered that the whole population should be regarded as one species and referred to *E. pauciflora* Sieb. The term "cline-form" is proposed for a reference point within any part of the population, and it is considered that *E. niphophila* Maiden and Blakely, *E. de Beuzevillei* Maiden and *E. pauciflora* Sieb. var. *nana* Blakely should be suppressed and regarded not as species or varieties but as cline-forms. Many *Eucalyptus* species exhibit in some degree the same kind of variation.

Eucalyptus Populations.

On distribution maps it is the custom to show species of *Eucalyptus* which have a wide geographic range as occupying relatively few and often large, continuous areas. This is, in all but a very few cases, a considerable over-simplification. *Eucalyptus* species usually occupy quite sharply limited ecological situations and, while there may be numerous repetitions of the site which carry the particular species, each is usually surrounded by other sites supporting different species, so that a closer approximation to fact would be to show, if practicable, a large number of distinctly separate stands through the general area of distribution of the species.

In most species it is obvious that there is phenotypic divergence in such separate stands, and it is clear that this is accompanied as a rule by parallel genotypic difference. What is more, in *Eucalyptus* it may well be that Clausen's (1951) comment is applicable, namely, that genetically controlled physiological divergence between different populations of the same species is present at the same time, or even before any character detectable in the phenotype. The degree of difference between any pair of stands is generally related to the distance by which they are geographically separated, and more especially to the extent to which the two sites differ in some broad, changing environmental feature such as is correlated with altitude or latitude change. It is likely that separate stands are often largely interbreeding populations, each isolated to a considerable degree from the other.

This distribution pattern fits Snow Gum (which is usually referred to as *Eucalyptus pauciflora* Sieb.) in some of its range, but only partly so, because this species is one of the few exceptions within the genus which also covers quite large geographic areas which it continuously occupies. *E. pauciflora*, *sensu lato*, not only occurs in disjunct stands through a wide area, but also forms pure stands on the highlands of south-eastern Australia above about 4,000 feet, and all the areas between about 5,000 and 6,000 feet elevation in this part of the country are occupied almost exclusively by the species.

It therefore offers an opportunity for study of the variation which accompanies two patterns of distribution in a *Eucalyptus* species. In studying the stands of *E. pauciflora* at high elevations, this epithet is taken to embrace the species *E. niphophila* Maiden and Blakely and *E. de Beuzevillei* Maiden, both of which can be regarded as part of *E. pauciflora* Sieb., according to a viewpoint, which will be elaborated below.

Variation in a Continuous Stand.

The Brindabella Range, Australian Capital Territory, was selected for the examination, since the species occurs continuously between 4,000 and 6,000 feet over a distance of 20 miles, and extends well beyond this too. By inspection, there is an obvious correlation between the height of the dominants of the stand and the elevation at which it is growing; the stands from high elevations are short or even dwarf, while those at 4,000 feet are from 70 to 90 feet tall (Plate xv, *a-e*). To establish whether such a correlation is heritable, or merely the result of direct environmental action on the individual to alter the phenotype, requires experiment. A number of other characters can easily be seen to vary with altitude, but the degree and nature of the correlation is too difficult to assess without metrical study. These characters therefore were examined statistically.

Method.

Five sites were chosen in saddles on the Brindabella Range (as this presented an essentially similar physiographic situation in each case), separated by approximately 500 feet elevation. Five dominant trees were taken at each site and measurements made of the maximum total height of the stand, bark thickness, fruit diameter and leaf length. Open pollinated seed was collected from each tree, and a progeny raised from each. Subsequently, growth of the progenies was measured after one year in tubes in the nursery, and then some were planted out at different elevations, viz.: 5,500 feet, 4,000 feet and 2,000 feet.

Various precautions were taken to make the measurements in each case as nearly comparable as possible. Bark thickness was made at breast height with a bark gauge taking the average of four readings, one in each quadrant of the trunk. The maximum fruit diameter was measured in each case, and these were confined to the same fruit crop. Ten capsules were measured from each tree.

In measuring leaf length attention must be given to the morphology of the short leaf-bearing shoot. On mature trees of *E. pauciflora* growing at 4,000 feet or above, the short leaf-bearing shoot usually consists of about four or five somewhat separated pairs of leaves (Jacobs, 1955). The leaf shape and size follow a sequence from the first pair, which are relatively small and rather short in relation to length, through successive pairs to a maximum beyond which they diminish again in size. This shoot represents one growing season. The third pair of leaves is usually the longest and in each case the longest leaf on the shoot was measured. Ten measurements were made on each tree.

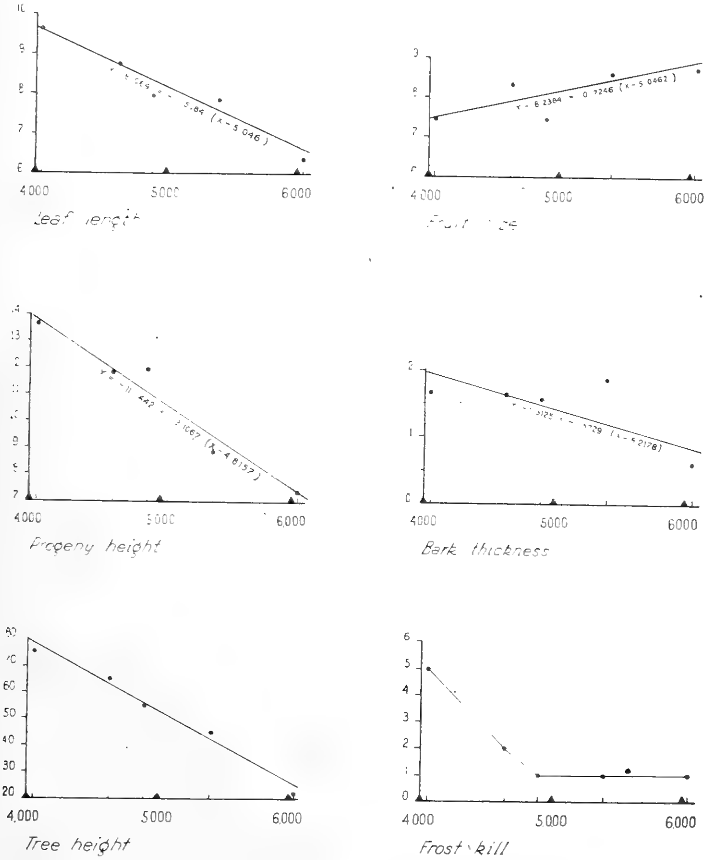
In the progeny tests, sowings were made with seed from all trees, but in some cases the plants were lost, and in others they were relatively few; nevertheless, the numbers were sufficiently large to permit examination of some aspects of progeny character in relation to parental character.

The capacity to withstand low temperatures was tested by planting five individuals from each group of the trees in the original stands at different elevations, one of which was 5,500 feet, near the upper altitudinal limit where the frosts were near the extreme experienced by the species.

Results.

The results of the measurements and trials are set out graphically in Text-figures 1 and 2. The most obvious correlation is that of tree height with elevation. There is a very regular fall-off in height as one ascends, the correlation being closely linear. Such a variation might at first seem entirely phenotypic, and could be a direct effect of environment on the plant without corresponding genotypic gradation. However, the correlation of progeny height (based on growth in the nursery for one year) with elevation of origin is also linear and high. This implies that the rate of growth of seedlings in the first year is correlated with the elevation of seed source, and therefore it is highly probable (especially since it is known from less precise experiments that reduced growth rate is maintained for the first eight years of growth) that this is maintained throughout the life of the tree, and the total height which the tree reaches at any age in the environment of the experimental garden or in any given particular environment is in a large measure genetically determined.

In testing the capacity to withstand frost, although the numbers involved in the trial are few, it is obvious also that this is closely related to the origin of seed since, when they are all planted at a high elevation, those from high elevations are able to withstand temperatures which kill seedlings from plants from lower elevations. A second test with the same material carried out near Rules Point by R. M. Moore (1955) leads to a similar conclusion.



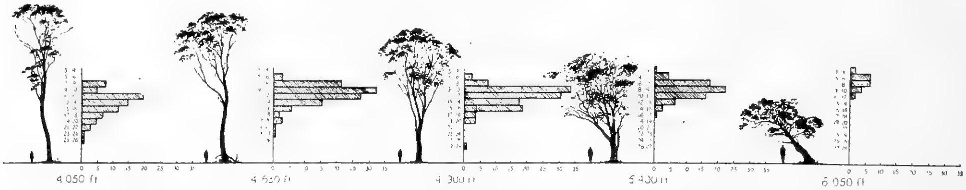
Text-fig. 1.—Showing correlation between elevation and leaf length, fruit size and bark thickness and total height on the mature trees, and also the correlation between progeny height at 1 year of age and killing by frost. Leaf length: cm.; fruit size (diam.): mm.; bark thickness: inches; progeny height: inches at 12 months; tree height: feet; frost kill: number killed out of 5 planted from each stand sampled.

In all the characters measured there are gradual changes and, except for bark thickness where there is significant residual variance, there is linear correlation of high significance between these characters and elevation. It is seen that at the higher limits the trees are shorter in total height, with shorter leaves, larger fruit, thinner bark, greater resistance to low temperature, and giving progeny with slower rate of growth. It is obvious that slower growth and greater frost resistance are strongly adaptive characters. This can easily be explained, as faster growth in this case means a longer growing season, and the initiation or continuation of growth beyond the normal time for trees in a cold area would make an individual more susceptible to early or late frost, which is a feature of the higher elevations. Such individuals would tend to be eliminated by simple environmental selection, since they would be in a more susceptible condition to early and late frosts.

On the other hand, where there is simply superior physiological resistance to low temperatures, those individuals which cannot withstand the temperatures ordinarily experienced at the higher elevations would be killed outright, or so retarded that they would be lost in competition with the more effective but slower growing individuals.

With regard to the other characters examined, it is also easy to imagine that shorter leaves would be able to withstand the stronger winds at higher elevations and the more severe icing if only because of the mechanical advantage which they possess, and therefore it seems this is of adaptive value. The adaptive significance, which indeed it seems must be so, of fruit size and bark thickness is not apparent at first sight, and it might seem, for example, that the thin bark would be less satisfactory for survival at higher elevations than thicker bark.

There are other characters which are probably of adaptive value, such as glaucousness. This increases with elevation in a manner comparable with that described by Barber (1955) for some Tasmanian species, but it is not so easily susceptible to measurement and has not been examined in detail in this case.



Text-fig. 2.—Histogram showing the progeny height in inches of all the plants raised from each stand at the elevations indicated The form of the parent tree is indicated in silhouette. The number of plants in each height class is indicated on the horizontal axis.

It is apparent that populations of *E. pauciflora* on the Brindabella Range, though continuous and graded in accordance with elevation, and showing close linear correlation with elevation of a number of characters, are at any point in some degree genetically heterogeneous. Irregularities in trees at a particular site in fruit size, frost resistance and other characters point to a degree of heterozygosity for these characters in any particular stand.

The general conclusion from these facts is that most characters of *E. pauciflora* vary continuously in stands above 4,000 feet elevation without any discontinuity, and that they are closely correlated with habitat.

Variation in Disjunct Stands.

E. pauciflora, in addition to the type of stand described above, occurs as many quite small separated stands from near the Queensland border through New South Wales and Victoria to the South Australian border, and in Tasmania. It is a species of the colder areas, and is frequently found on the tops of hills or ranges, so that as these are often of small extent the stands are small and well separated from each other. On the southern tablelands also there is a distinct habitat formed by cold air drainage, which leads to the development of frost hollows (Pryor, 1954; Moore, 1955). These frost hollows, when conditions are not too extreme for trees, carry *E. pauciflora*, which is evidently the species best able to withstand such conditions. Frost hollows are separated one from the other so that there is a disjunct habitat distribution which is comparable with that of the hilltops. This also leads to separate stands of relatively small extent occurring in different areas. The form of *E. pauciflora* in the more extreme frost hollows of the Monaro area of New South Wales is pendulous and very distinct from other forms of the species.

Five collections of *E. pauciflora* were made from disjunct sites, as follows: Mt. Hotham, Victoria (about 5,500 feet); Kybean Peak on the Dividing Range east of Cooma (about 4,000 feet); Numeralla (Murrumbidgee Valley, 40 miles south of Canberra, about 2,400 feet); Bright Valley, Victoria (about 1,500 feet); and a frost hollow near Adaminaby (about 3,000 feet elevation). Progeny was raised from each of these and planted out. At six years of age the rate of growth has differed widely in progeny from the different collections, and an analysis of variance of height growth leads to the results in Table I, showing the differences in means which in all but one case are significant.

TABLE 1.

Locality.	Number of Plants.	Mean Height (In.).
1. Adaminaby (frost hollow)	3	251·67
2. Hotham	10	69·61
3. Kybean	44	142·26
4. Numeralla	49	180·17
5. Bright	61	144·78

Differences of Means.

	No. 3.	No. 5.	No. 4.	No. 1.
No. 2	72·65[3]	75·17[3]	110·56[3]	182·06[2]
No. 3	—	2·52	37·91[3]	109·41[1]
No. 5	—	—	35·39[2]	106·89[1]
No. 4	—	—	—	71·50[1]

[1] Significant at 0·05 level.
[2] ,, ,, 0·01 ,,
[3] ,, ,, 0·001 ,,

There are many other differences besides rate of growth, some of which are not so easy to measure. Some are relatively minor differences, such as colour of the leaf-bearing stems, which, for example, in the Kybean population is consistently dark red. The leaves of the Bright Valley form are coarser and larger than the others, whereas the Adaminaby form is a very markedly pendulous type with the habit of the Weeping Willow, narrow leaves and very glaucous stems (Plate xvi). The characters within each progeny are relatively uniform, but they are sharply distinct from the progenies from other areas. The same is true of the parent stands. This indicates, therefore, that the phenotypic differences are supported by corresponding genotypic differences, and that these variations seen from stand to stand are strongly inherited. It will be noted that the correlation of rate of growth with altitude of origin applies generally only to stands from higher elevations, and that as one descends to lower elevations, say below 4,000 feet, other factors beside elevation come into the relationship and it no longer holds.

The pendulous form in frost hollows does not in single cases show the graded sequence to the surrounding more common form of *E. pauciflora*, as is the case with graded variation described above in the continuous stands at higher elevations. The transition is a sharply graded cline—occupying a zone of 100 yards or so. However, if one seeks situations where the frost hollows are less extreme a series of stands can be found which can be arranged in clinal sequence for the character of pendulous habit. Thus the pendulous form, although often relatively isolated in any given situation from the surrounding stand of *E. pauciflora*, is clinally connected with that stand and with the whole population in the variation pattern of the species.

Taxonomic Treatment.

Taxonomic treatment according to the classical basis is unsatisfactory if applied to such a population. The whole is rather distinctly cut off from other species within the genus, and if the type specimen *E. pauciflora* Sieb. is applied to the whole population and this is regarded as the species, this is satisfactory as far as it goes. The degree of variation is such, however, that it is important to know more about it, and taxonomic attempts to describe it have been made by selecting types from different points within the population and erecting them as species. Two such species and one variety have been thus erected—*E. niphophila* Maiden and Blakely, *E. de Beuzevillei* Maiden and *E. pauciflora* Sieb. var. *nana* Blakely. There are two other forms which are equally distinct from *E. pauciflora* Sieb., but they have not been described. For the purposes of discussion they might be referred to as "*montana*", which is the 80-feet forest tree occurring at 4,000 feet on the Brindabella Range, and "*pendula*", which is the frost-hollow form near Adaminaby. If on this basis an attempt is made to classify any particular stand or individual of the *E. pauciflora* population, there is an immediate difficulty. For example, *E. niphophila* is the upper altitudinal end-point of the cline of *E. pauciflora* on Mt. Kosciusko, having been described from near the old hotel site. As one descends, there is the same kind of correlation characteristic of the continuous stand on the Brindabella Range, so that the other terminal point is the "*montana*" form. The *montana* form is, in the herbarium, distinctly closer to *E. pauciflora* Sieb. than it is to *E. niphophila*, although if field characters are taken into account it is equally distinct. It is clear, then, that any determination of the limits of *niphophila* will be highly subjective, and it is not likely that any two systematists will give the same answer, since there is no precise boundary to the stands, or no discontinuity which might be referred to as the limits of *niphophila*. Likewise, *de Beuzevillei* is the upper altitudinal end-point of the cline of *E. pauciflora* on the Jounama Range. The Jounama Range is distinctly more continental in its environment than the Kosciusko Range. This is reflected in the character of the population. If a series of ranges is considered, such as Mt. Kosciusko, Brindabella Range and Jounama Range, the forms of *E. pauciflora* at the tree line in each case (that is the end-point of each cline by which each is connected to the *montana* form of *E. pauciflora*) are themselves clinally arranged (though perhaps "stepped") according to increasing "continentality". The position is only apparently simpler with the disjunct stands which go to make up the remainder of the *E. pauciflora* species population since, if enough stands are considered, although there is a tendency for the gradation between stands to be stepped so that there are small discontinuities, the magnitude of these discontinuities is found to be reduced continually the more stands that are considered, and there are so many separate stands that there is no effective difference between those exhibiting continuous variation and those occurring as separate stands.

Where stands at first appear discontinuous, as where a sharp habitat change, such as frost hollow site carrying "*pendula*" changes over abruptly to a more usual tableland site carrying a population nearer the type, *E. pauciflora* Sieb., it is found by examining a series of frost hollows each less intense than the last that they are connected clinally.

It is clear, therefore, that if *E. pauciflora* Sieb. is "split" in the taxonomic sense by erecting a series of species based on single type specimens, very considerable confusion develops. On the other hand, if the described species and variety *E. niphophila*, *E. de Beuzevillei* and *E. pauciflora* var. *nana* are suppressed and "lumped" into *E. pauciflora* Sieb., the population is still not adequately described. Classical taxonomy uses a single type specimen to define the species and then subjective opinion of the taxonomist determines which other individuals and populations will be related to the species. If the described types could conveniently be taken to represent populations of *E. pauciflora* in distinct geographic areas, and without gradual intergradation, they could well be regarded as subspecies, as can apply perhaps in some cases with other species of *Eucalyptus*. Since the various populations lack distinct boundaries, however, the erection of these types as subspecies does not help classification. The variation of *E. pauciflora* is multi-dimensional and for all practical purposes continuous. While ultimately it may be possible to use some metrical system for defining the species which would allow precise description of continuously varying systems, the most practical way at the moment of treating the population is to preserve the type *E. pauciflora* Sieb., as representing the species, and to use the other described forms and any which it may be considered worth while adding from time to time as points of reference within a population for aiding description.

A term is needed in *Eucalyptus* taxonomy to refer to types within the total species population which are to be used as such reference points. Neither the term "subspecies" nor "variety" will meet the case, the former for the reasons mentioned above, and the latter because it has been applied in too many different ways in botanical study (Clausen, 1941). It is proposed, therefore, that the term "cline-form" be used. *E. pauciflora* Sieb., therefore, has three described cline-forms—*niphophila, de Beuzevillei* and *nana*—which are arrived at by suppressing the species *E. niphophila* Maiden and Blakely, *E. de Beuzevillei* Maiden and variety *E. pauciflora* Sieb. var. *nana* Blakely. To these might well be added for convenience the yet-to-be-described forms "*montana*" and "*pendula*". Taxonomically, then, any stand of Snow Gum is at once conveniently referred to the species *E. pauciflora* Sieb. When more precision is required, as it is for many purposes, a particular stand can be referred to its position in relation to cline-forms, e.g., approaching or identical with cline-form *niphophila*, or between two cline-forms, as the case may be. There is no need to limit the number of cline-forms to be described; the number would simply be determined as that necessary for adequate description of the population.

Acknowledgements.

Grateful acknowledgement is made to Mr. G. A. McIntyre for the statistical comparisons, to Mr. O. Ruzicka for the drawings, and to Mr. W. Pedersen for the photographs.

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EXPLANATION OF PLATES XV-XVI.

Plate xv.

a, b, c, d, e: *E. pauciflora* on the Brindabella Range from 4,000 to 6,000 feet elevation, each stand separated by approximately 500 feet elevation from the adjoining one.

Plate xvi.

a, b, c, d, e: 6-year-old plants from Snow Gum from different localities: *a*: Mt. Hotham; *b*: Kybean; *c*: Numeralla; *d*: Bright Valley; *e*: Frost hollow, Adaminaby.

DESCRIPTION OF A NEW AUSTRALIAN RAPHIGNATHOID MITE, WITH REMARKS ON THE CLASSIFICATION OF THE TROMBIDIFORMES (ACARINA).

By R. V. Southcott.

(Two Text-figures.)

[Read 28th November, 1956.]

Synopsis.

A new Australian Raphignathoid mite, *Camerobia australis,* n. gen., n. sp., is described, from Queensland and South Australia, from underneath Eucalypt bark. This mite has its mouthparts modified to a camerostome, the gnathosoma being a hinged eversible structure rotating underneath the propodosoma. The movable chelae are styliform, but comparatively short. The palpi are of 5 segments, rather slight, and the palpal tarsus does not form a "thumb" to the palpal tibia. Palpal tibia without claw. The genus is placed in a new family, Camerobiidae.

The relationships of the superfamilies Tetranychoidea and Raphignathoidea of the Trombidiformes are discussed. The Raphignathoidea Grandjean 1944 is defined, and is considered as consisting of the families Raphignathidae Kramer 1877, Camerobiidae, n. fam., and Neophyllobiidae, n. fam. Neophyllobiidae, n. fam., is erected for *Neophyllobius* Berlese 1886. The relationships between these are discussed, and a key is submitted.

INTRODUCTION.

A new Australian Trombidiform mite is described from specimens collected on a small number of occasions, mainly or entirely from under the bark of *Eucalyptus* spp., in Queensland and South Australia. Superficially the mite has affinities with either the Raphignathoidea or the Tetranychoidea. A study of the mite and these groups indicates that the species should be placed in the Raphignathoidea, but is clearly new in the possession of a camerostome. A description follows.

CAMEROBIA, n. gen.

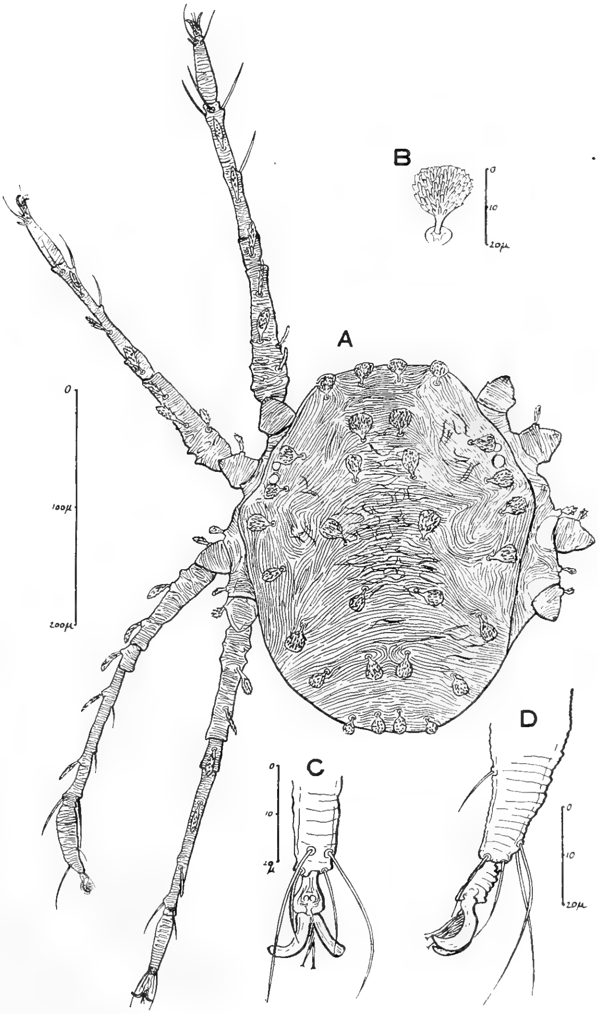
Definition: With the mouthparts modified to a camerostome. The gnathosoma a hinged eversible structure lying beneath the propodosoma; in eversion with the palpi directed forwards, and in retraction with the palpi directed posteriorly, and folding into the camerostome. Palpi rather slight, of 5 segments. Palpal tibia without claw, and palp without thumb-complex. Movable chelae styliform, short. No dorsal shields to idiosoma. Eyes two on each side. Dorsal setae expanded. Perineum placed posteriorly on ventral surface. All legs with coxae and 5 movable segments. Tarsal claws falciform, tarsus with a well-developed pulvillus.

Genotype, Camerobia australis, n. sp.

CAMEROBIA AUSTRALIS, n. gen., n. sp. Text-figs. 1, 2.

Description of Adult (Text-figs. 1, 2) (mostly from Type specimen ACC 329; other specimens compared and used as indicated in text): Colour in life red. Body roughly ellipsoid dorsally, flattened ventrally. Body (idiosoma) 295μ long by 275μ wide at the widest point (the "shoulders" between the levels of the first and second pairs of coxae). The integument of the body is everywhere striate. Eyes two on each side, at the edge of the propodosoma, at the level of the second coxae. The anterior eye nearly circular, 9μ across, placed slightly medial to the posterior eye, which is larger, 13μ long, with its medial side slightly flattened. The dorsum of the body carries no sign of a scutum or crista metopica. In the central part of the dorsum, as indicated in Text-fig. 1, A, underlying the cuticular striations is a reticular arrangement of chitin which presumably serves to strengthen that part of the animal. The dorsal setae are palmate or fanlike, with numerous small radiating projections dorsally; setae 18–25μ long by 12–20μ wide.

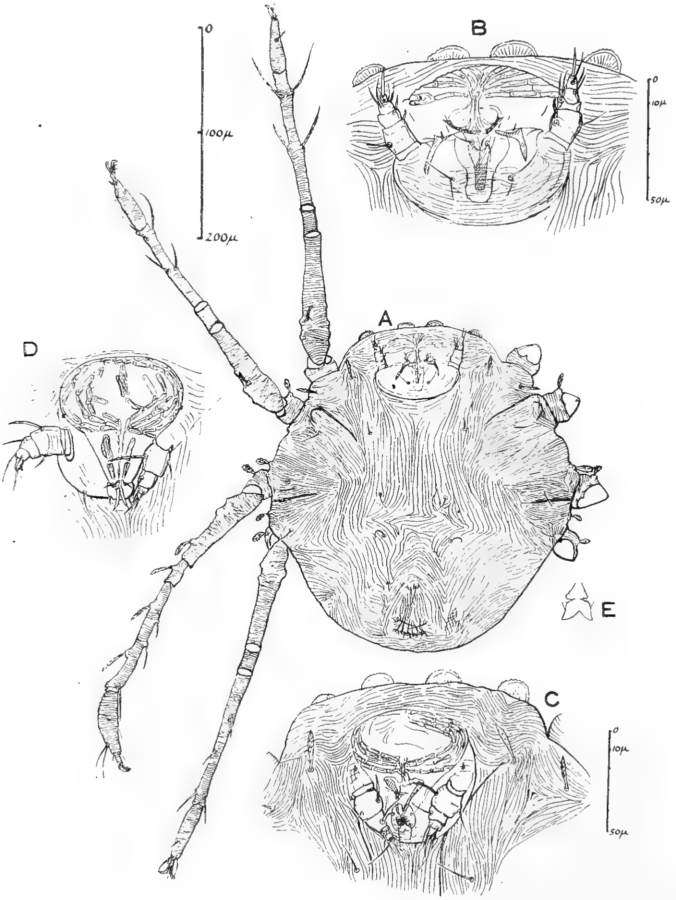
The ventral surface of the body is rather flattened, and is striate as figured. The perineum is situated at the posterior part of the ventral surface (hysterosomal, i.e.), the genital and anal apertures being contiguous. A pair of anterior genital spines 21μ long is situated at the anterior end of the genital aperture. A pair of similar posterior genital spines is placed rather more laterally at the posterior end of the genital aperture. Behind the anus is a transverse row of 4 anal spines, 18–20μ long. Within the body, above the genital aperture, is a lightly chitinized genital apparatus, with a "cloven hoof" outline (Text-fig. 2, E). No penis is visible for certain in any of the 4 specimens. The "cloven hoof" structure is present in each of the 4 specimens. (It corresponds to



Text-fig. 1.—*Camerobia australis*, n. gen., n. sp. Adult: A, Dorsal view; B, Dorsal seta; C, Tarsus IV, from above (left); D, Tarsus III, posterior (= medial) surface (right). All figures from type specimen ACC 329; to nearest scale.

the "cup-shaped invagination with stiffened walls (plate 10, figure 46)" . . . "on the dorsal surface of the seminal vesicle" which Blauvelt (1945, page 31) describes in *Tetranychus telarius* Linn. The four specimens of *C. australis* available are therefore possibly male.)

The coxae of the legs are not in the holotype specimen sharply demarcated from the remainder of the ventral surface of the body. Narrow epimera separate coxa I from II, and III from IV. The coxae can, however, be made out by the character and flow of the cuticular striations. The striations of the coxal areas are weaker and finer than those of the body (this point is not brought out very strongly in Text-fig. 2, A), and more closely set. In long-mounted specimens the coxae stand out clearly, as in these the fine coxal striations are difficult to see. The distinction, however, between the two types of striations is not absolute, as in places there is some intergrading and intermingling. The four coxae are practically contiguous along each side of the idiosoma, as coxa II and coxa III are separated by only a narrow space involving 4–5 of the normal idiosomal striations. In the region of coxa I are two setae, which are clearly the



Text-fig. 2.—*Camerobia australis*, n. gen., n. sp. Adult: A, Ventral view; B, Ventral view of mouthparts with the gnathosoma everted; C, Ventral view of mouthparts with the gnathosoma retracted within the camerostome, with the palpi pointing posteriorly; D, Same from another specimen but with the chelicerae protruding; E, Outline of chitinized internal genital structure of "cloven hoof" shape, placed level with its position within the hysterosoma, to scale of A. A, B, D from type specimen ACC 329; C from paratype ACC 330; E from paratype ACC 332. To scales indicated, A, E to same scale; B, C, D to same scale.

anterior and posterior coxal setae. The anterior coxal seta is clavate, spindle-shaped, spiculate with sharp strong projections, and is 22μ long by 4μ wide. The posterior seta of coxa I is similar, but rather more slender, 20μ long by 3μ wide. Coxa II bears a spiniform seta 20μ long; coxa III bears a similar seta 20μ long; IV similarly, 18μ long.

The ventral surface of the body carries 3 pairs of spiniform setae: a pair of sternal setae, curved, 19μ long, at the level of coxae I and II; an anterior metapodosomal pair, placed centrally, at the level of coxa III, 21μ long; a posterior metapodosomal pair at the level of coxa IV, but well ahead of the perineum, 14μ long.

The legs are rather thin. Besides the coxa, each leg has 5 (movable) segments. The chaetotaxy of the legs is as figured. The proximal setae of the legs tend to be clavate, whereas the distal tend to be spiniform. Tarsus I and II (but not III or IV) each carry distally and dorsally a single short sensory peg or nail, indistinctly solenoidal (striate), 8μ long, and with a rounded distal end and a slightly constricted base. Genu I and II each carry a short microsensory tack-like seta (famulus or "ε" of Grandjean). The striations of the legs tend to flow around the bosses, which are most marked in the proximal part of the femur, where they form "lenses" among the striations. Each tarsus carries a pair of strong falciform claws. Between the claws is a pulvillus of two brush-like groups of vibrissae with gathered ends, terminating in little cup-like discs (see Text-fig. 1, C, D). Tarsus I is 54μ long by 15μ high, exclusive of claws and pretarsus (onychium); II similarly 53μ long, III 55μ, IV 59μ. Metatarsus I 118μ long, II 96μ, III 118μ, IV 132μ.

The gnathosoma is considerably modified, to a camerostome lying beneath the propodosoma, at the level of the anterior part of the first pair of coxae; it is invisible from above. The gnathosoma is a hinged eversible structure fitting into the camerostomal cavity. This is best understood by reference to Text-fig. 2, A, B, C, D. In the retracted position (Text-fig. 2, C, D) the palpi point posteriorly, and the rostrum with its chelicerae lies between the converging palpi. On eversion the palpi and chelicerae point anteriorly, and the palpi diverge.

The palpi are weak, of 5 segments, totalling 30μ long (exclusive of the terminal setae). The palpal tarsus does not form a "thumb" to the penultimate segment (tibia). Palpal femur, genu, tibia, tarsus with 2, 1, 2, 3 setae respectively. The setae are linear-lanceolate, spiniform or blade-like, except that the internal femoral seta (see Text-fig. 2, B for positions) has adpressed bractate ciliations. The palpal tarsus has a terminal seta, curved, swordlike, 10μ long.

With the gnathosoma everted a pair of spiniform hypostomal setae, 9μ long, can be seen at the centre of the gnathosoma. A pair of basal setae (i.e. of the basis capituli) is present more posteriorly, 20μ long, with their bases 21μ apart (Text-fig. 2, B). With the palpi retracted a pair of short pegs, 4μ long, can be seen, arising anterior to the palpal coxae, and level with the anterior coxal setae of the legs. These are shown best in Text-fig. 2, C, D. With the palpi everted these pegs are difficult to identify, but they are then probably in a position anterior to the basal seta on each side, and level with the proximal end of the palpal femur (Text-fig. 2, B).

The anterior cuticular part of the gnathosoma is a rounded bladder-like structure, carrying a group of peculiar radiating striations (Text-fig. 2, B, C, D), of unusual appearance, appearing to consist of a number of jointed segments, resembling fungal hyphae (which of course they are not). No stylophore can be seen to the gnathosoma, nor is there a mandibular plate apparent (as McGregor (1950) describes in *Neophyllobius*).

The chelicerae (movable chelae) are in most specimens difficult to identify, but in one paratype, figured in Text-fig. 2, D, they are clearly visible, slightly exserted, and are styliform, rather short. At the tip of the rostrum, seen clearly with the gnathosoma retracted, is a rounded structure with two pairs of short spiniform curved setae, possibly a hypostomal feeding lip (Text-fig. 2, C, D), similar possibly to that of the Erythraeidae in the larval stage (Trombidiformes: Erythraeoidea).

Localities.

Queensland: Type specimen, ACC 329, from under bark of *Eucalyptus* sp., at Kaban, Atherton Tableland, 24th August, 1944, Map Reference Palmerston 1:63,360 270981; Paratype specimen ACC 330 from same site and date; Paratype ACC 332 from Grovely, near Brisbane, 25th August, 1945, probably from similar habitat.

South Australia: Glen Osmond, under bark of *Eucalyptus camaldulensis*, 17th March, 1937, Paratype specimen ACC 331.

(All specimens collected by writer; in writer's collection.)

THE AFFINITIES OF THE GENUS CAMEROBIA, WITH REMARKS ON THE CLASSIFICATION OF THE TROMBIDIFORMES.

As indicated above, the general appearance of this mite, together with the observation that the chelicerae are styliform, suggests that it is related to, e.g., the well-known families Tetranychidae Donnadieu 1875 and Raphignathidae Kramer 1877, there being, for example, a strong superficial resemblance to the genus *Neophyllobius* Berlese 1886. It is, however, only of recent years that the relations between these forms have begun to be clarified. In 1944 Grandjean set up the superfamily Raphignathoidea for the families Raphignathidae Kramer 1877, Stigmaeidae Oudemans 1931 and Caligonellidae Grandjean 1944, recognizing that these formed a distinct group. It was not until the work of McGregor (1950) that *Neophyllobius* was excluded from the Tetranychidae, this being the last genus to be excluded, as Baker and Pritchard (1953) have pointed out. McGregor's morphological study was supported by the observation of R. J. Pence (in McGregor, 1950) that *Neophyllobius* was predaceous. Baker and Pritchard (*loc. cit.*) set up the superfamily Tetranychoidea Baker and Pritchard 1953 for a number of phytophagous mites, linked by morphological characters, these being the families Tetranychidae Donnadieu 1875, Linotetranidae Baker and Pritchard 1953, Tuckerellidae Baker and Pritchard 1953 and Phytoptipalpidae Ewing 1922 (this last family being considered as including the Pseudoleptidae Oudemans 1928, Trichadenidae Oudemans 1938 and Tenuipalpidae Sayed 1950).

Baker and Pritchard (1953) proposed the following definition of the Tetranychoidea (summarized): Chelicerae very long, needlelike, strongly recurved proximally, set in an eversible sac, the stylophore. Feeding on higher, living, plants. Baker and Wharton (1952), in their Textbook of Acarology, generally did not discuss the superfamilies of the Trombidiformes, but kept the family Raphignathidae in a broad sense, justifying the fusion of this family with the Stigmaeidae and Caligonellidae with the comment "The discovery of two genera with the peritremes in the cheliceral bases but with large palpal claws and terminal anus has led to combining these three families, since they now grade into one another . . .".

The justification for the retention of the superfamily Raphignathoidea lies in the fact that, like the Tetranychoidea, its members constitute a distinct group in the Trombidiformes. Grandjean (1944) did not propose a formal definition of his superfamily Raphignathoidea, nor does any subsequent author up to the present appear to have done so. With the definition of the Tetranychoidea above in mind (the nearest superfamily in the Trombidiformes) we may submit the following:

RAPHIGNATHOIDEA Grandjean, 1944.

Definition: Chelicerae needlelike, of only moderate length or short. Stylophore absent. Tarsi of legs with pulvilli, which may be elaborate or comparatively simple. Predaceous.

Returning to *Camerobia*, it is observed that although the complete gnathosoma is eversible, there is no eversible sac attached only to the movable chela. The movable chelae are in fact difficult to identify as such in most specimens, and it was not until one specimen with partly extruded chelae was observed that the writer was sure of their identity (*see* Text-fig. 2, D). On morphological grounds therefore the genus should be placed in the Raphignathoidea. There are, however, significant differences from the family Raphignathidae, using this term as accepted by Baker and Wharton (1952). These authors state that all genera of the family have a small to large palpal tibial claw. In some genera the palpal tarsus forms a "thumb" to the palpal tibia, as occurs also in the Tetranychoidea. Baker and Wharton (*loc. cit.*) included the genus *Neophyllobius* in the Raphignathidae, despite the fact that it lacks a tibial claw, as McGregor (1950) had shown. Both *Camerobia* and *Neophyllobius* stand apart from the other genera allotted to the Raphignathidae, both in the above character, and in the lack of dorsal body shields. The principal difference between *Camerobia* and *Neophyllobius* lies in the former's possession of a camerostome.

Modification of the mouthparts is seen in various groups in the Acarina, and often appears to be a response to a specialized feeding habit. Thus the families Myobiidae Mégnin 1877, Ophioptidae Southcott 1956 and Speleognathidae Womersley 1936 may be cited as examples. The Myobiidae are well known as specialized feeders upon the hairs (and possibly other substances) of certain mammals and the feathers of birds, with reduced palpi. The Ophioptidae, which are external parasites of certain snakes, show other modification of the palpi (Southcott, 1956). The method of feeding of the latter is unknown, but presumably the styliform chelicerae pierce the skin of the host and the mite feeds on tissue foods from the host. In the Speleognathidae a further reduction of the palpi is seen. This family was erected by Womersley (1936) for *Speleognathus australis*, a species captured originally by the present writer running freely over the surface of water in cattle (and horse) troughs at Glen Osmond, South Australia, and observed by the writer over 1934-1941. Since that time other members of the family have been taken in the mucus-lined respiratory passages of birds and other vertebrates in various parts of the world. (Womersley's statement (1936, 1953) that the specimens were captured by myself from moss is in error; unfortunately it has been repeated by a number of other writers.) Although the method of feeding of the Speleognathidae is not known, it is possible that the family (and the probably related genus *Riccardoella*) are mucus feeders.

The above examples indicate that considerable variations may occur in the mouthparts within the Trombidiformes. In various places within the Acarina a camerostome may be seen—e.g. within the Spelaeorhynchidae (Mesostigmata), the Uropodina and the Cryptostigmata (*see* Baker and Wharton, 1952). Generally speaking the presence of a camerostome may be considered as worthy of family status, possibly more.

It is on the above considerations that the writer considers that the genera *Camerobia* nov. and *Neophyllobius* Berlese 1886 should be separated by family status from the Raphignathidae and from each other. The following are therefore proposed:

CAMEROBIIDAE, n. fam.

Definition: Raphignathoid mites with the mouthparts modified to a camerostome, the eversible gnathosoma (capitulum) rotating around a transverse axis within the camerostome. Palpi simple, of five segments, without tibial claw, and the palpal tarsus does not form a "thumb" to the palpal tibia. No dorsal shields to body. Tarsal claws with a pulvillus. Type genus, *Camerobia* nov.

NEOPHYLLOBIIDAE, n. fam.

Definition: Raphignathoid mites, with the mouthparts placed anteriorly on the body, without camerostome, and with the palpus without tibial claw or thumb-complex. No dorsal shields to body. Tarsal claws with a pulvillus.

As at present, therefore, the superfamily Raphignathoidea is considered as containing the families Raphignathidae, Camerobiidae and Neophyllobiidae. There is only one other family of mites which merits consideration for possible inclusion. Baker (1949) erected a family Pomerantziidae for *Pomerantzia charlesi* Baker 1949, a North American mite found in soil. In discussing this family Baker (*loc. cit.*) stated that the "presence of the three pairs of genital suckers, the large number of sensory setae on tarsus I, and the lack of pulvilli separate this new family from the closely related

Raphignathidae-Stigmaeidae-Caligonellidae complex as well as from the Pseudocheylidae, none of which has genital suckers and in all of which there is only one sensory seta on tarsus I. The first group possesses a pulvillus with tenent hairs while the tarsi of the Pseudocheylidae are variously arranged but not as above". Elsewhere in the same article Baker commented on the difficulty in the classification of the mites. He did not finally indicate whether the Pomerantziidae should, in his opinion, be classified close to the Raphignathidae or elsewhere. Although in the family key submitted by Baker and Wharton (1952) the Pomerantziidae and the Raphignathidae are included in the same caption, at present there does not appear much evidence to include the Pomerantziidae in the Raphignathoidea (the definition of which would need to be widened); it is therefore excluded at present. A key to the classification of the families of the Raphignathoidea follows.

Key to the Families of the Raphignathoidea.

1\. Palpal thumb-complex present. Palpal tibia with claw. Dorsal body shields present. Anus terminal .... Raphignathidae Kramer 1877
Palpal thumb-complex absent. Palpal tibia without claw. Dorsal body shields absent. Anus subterminal 2

2\. Mouthparts inferior, forming a camerostome. Mandibular plate apparently absent.. Camerobiidae nov.
Mouthparts anterior, not included in a camerostome. Mandibular plate present.. Neophyllobiidae nov.

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ABSTRACT OF PROCEEDINGS.

ORDINARY MONTHLY MEETING.

28th March, 1956.

Mr. S. J. Copland, President, in the chair.

The Chairman referred to the deaths of Mr. E. A. Hamilton on 25th February, 1956, and of Dr. B. Horowitz on 10th October, 1955. Mr. Hamilton had been a member of the Society since 1928 and Dr. Horowitz since 1943.

The Chairman announced that Library Accessions amounting to 75 volumes, 453 parts or numbers, 65 bulletins, 11 reports and 34 pamphlets, total 638, had been received since last meeting.

PAPERS READ (by title only).

1. Coastal Sandrock Formation at Evans Head, N.S.W. By J. W. McGarity.
2. A Note on the Identification of Plant Remains in Sandrock near Evans Head, N.S.W. By K. Bamber and J. W. McGarity.
3. A Revision of *Saulostomus* Waterhouse and Description of a New Ruteline Genus (Scarabaeidae, Coleoptera). By P. B. Carne.
4. Australian Fungi. III. New Species and Revisions, continued. By C. G. Hansford.

ORDINARY MONTHLY MEETING.

18th April, 1956.

Mr. S. J. Copland, President, in the chair.

The following were elected Ordinary Members of the Society: Messrs. R. A. S. Barnard, Sydney University; R. C. Carolin, Sydney University; T. C. Chambers, Sydney University; J. P. Freeland, Como, N.S.W.; Dr. Doreen E. Maxwell, Ottawa, Canada; Mr. R. H. Mulder, Kogarah, N.S.W.; Miss Joan E. Steinberg, Sydney University; and Mr. L. R. Woodhouse, Armidale, N.S.W.

The Chairman announced that the Council had elected the following office bearers for the 1956–57 session: Vice-Presidents: Mr. A. N. Colefax, Dr. Lilian Fraser, Professor J. M. Vincent and Dr. F. V. Mercer; Honorary Treasurer: Dr. A. B. Walkom; Honorary Secretaries, Dr. W. R. Browne and Dr. A. B. Walkom.

The Chairman also announced that Library Accessions amounting to 12 volumes, 93 parts or numbers, 1 report and 10 pamphlets, total 116, had been received since the last meeting.

The papers taken as read at the March Ordinary Monthly Meeting were discussed.

PAPERS READ.

1. The Wing Venation of Lomatiinae (Diptera-Bombyliidae). By G. H. Hardy.
2. Some Dendroid Graptolites from New South Wales. By Kathleen Sherrard.
3. Chlorosis and Lack of Vigour in Seedlings of Renantherous Species of *Eucalyptus* caused by Lack of Mycorrhiza. By L. D. Pryor.
4. Resistance to *Puccinia graminis tritici* in Khapstein, a *vulgare* Derivative of Khapli Emmer. By D. S. Athwal and I. A. Watson.

NOTES AND EXHIBITS.

Mr. G. H. Hardy exhibited specimens of a species belonging to the family Lonchopteridae which has not been recorded from Australia. However, Dr. A. J. Nicholson had informed him that in the Canberra Collection, C.S.I.R.O., there are two females from Tasmania, one collected near Kempton and another at Queenstown on the 18th and 29th January, 1948, respectively. They were found by Messrs. Key, Carne and Kerr, of that Institution. From Katoomba a series of 18 females has now accumulated, found in his garden and adjacent land from 29th October, 1955, to 20th February, 1956. Mr. D. McAlpine found another in the Royal National Park. The species seems to be the European *Lonchoptera furcata* Fallen, but it requires the male to be certain of this specific identification. It appears at present that the species has been introduced and is now established, thus adding a new family to the Diptera in Australia.

LECTURETTE.

A lecturette entitled "Soil Development in Relation to Vegetation in South-Eastern Alaska" was given by Professor R. L. Crocker.

ORDINARY MONTHLY MEETING.

30th May, 1956.

Mr. S. J. Copland, President, in the chair.

The Chairman conveyed the congratulations of the meeting to Dr. F. V. Mercer, who has been the recipient of a British Council award to enable him to undertake research at Cambridge and elsewhere overseas.

The Chairman announced that Library Accessions amounting to 11 volumes, 117 parts or numbers, 8 bulletins, 2 reports and 27 pamphlets, total 165, had been received since the last meeting.

PAPERS READ.

1. The Identity of *Eucalyptus subviridis* Maiden and Blakely. By L. D. Pryor.
2. An F1 Hybrid between *Eucalyptus pulverulenta* and *E. caesia.* By L. D. Pryor.
3. Notes on Australian Mosquitoes (Diptera, Culicidae). I. Some Species of the Subgenus *Neoculex.* By N. V. Dobrotworsky.
4. A Note on a Uredospore Colour Mutant in Barley Leaf Rust, *Puccinia hordei* Otth. By N. H. Luig and E. P. Baker.

NOTES AND EXHIBITS.

Miss Nola J. Hannon exhibited a self-irrigating "bottle-jar" arrangement for growing large species of legumes under bacteriologically controlled conditions.

Mr. A. J. Bearup exhibited *Dibothriocephalus latus*, the largest human tapeworm which, during its life-cycle, uses as intermediate hosts first the small water crustaceans (*Diaptomus* and *Cyclops*) and then fish which include these crustaceans in their food. The larvae which have developed in the body cavity of the crustaceans are not digested in the gut of the fish; instead they pass through the intestinal wall into the muscles and liver where they can live for many months. If now this infected muscle is eaten by man (and the larva has not been killed by cooking) it develops to a mature tapeworm, perhaps 30 feet long, in a few weeks. The symptoms are like those ascribed to other large tapeworms, but occasionally patients develop symptoms of pernicious anaemia. Owing to the peculiar requirements of the life cycle, the worm is generally found in association with fishing communities on large freshwater lakes such as are common in Baltic countries and in the lake systems of North America. It has not yet become established in Australia where the lakes are small and the only freshwater fishing industry of importance is on the Murray River system. The area of freshwater lakes in Australia will be increased by the Snowy and Upper Murrumbidgee storages now under construction. A second factor which, if true, would operate in our favour would be the scarcity of suitable crustaceans for developing the first larval stage. The genus

Diaptomus (the most favourable vector in Europe) is not well represented in Australia and has been reported only from Northern Australia. The nearest genera would be *Boeckella* and *Gladioferens*. Recently a case of *D. latus* from Europe provided sufficient material to test the infectibility of crustacea in the Sydney district. Species of Cyclopidae seemed to be resistant to infection, the larvae hardly ever penetrated into the body cavity and those that did died soon after. Only one species of *Boeckella* was tested and the tapeworm larvae were able to penetrate into the body cavity and develop through the first larval stage.

Mrs. Mary B. Williams exhibited plants of *Nitella* which had been treated with colchicine. The apical cells were swollen abnormally. This was interesting as an instance of colchicine acting on the cell wall itself, instead of on the spindle mechanism of cell-division.

Mrs. Mary B. Williams also exhibited, for Mrs. Eva Morgan, live fern antherozoids escaping from antheridia of a cultured fern gametophyte.

Dr. T. C. Backhouse exhibited a prismatic microscope of novel design made by Dr. John McArthur of 101 Chiltern Court, London. The microscope is specially adapted for field work but is also suitable for general use.

Dr. I. V. Newman exhibited two discs of *Pinus taeda* (loblolly pine) showing the comparison between normal wood and reaction wood. The normal tree was perfectly concentric in ring development. The abnormal tree had been placed out of the vertical during the 5th or 6th year of that part of the tree. The remainder of that year and the next 5 or 6 years showed tremendous excess cambial activity on the under side producing reaction wood—of compression wood type as this is a conifer. Had this been a dicotyledon angiosperm the reaction wood would have been on the upper side and of tension wood type. The effect of the reaction wood is regarded as tending to restore the proper form, i.e. upright trunk of the tree—compression wood by expansion, tension wood by contraction.

A similar exhibit showing the comparison between normal wood and tension wood in mountain ash (an angiosperm) was shown by Dr. F. V. Mercer for Mr. R. Vickery. Tension wood is formed under conditions similar to those forming compression wood.

Mr. R. Barnard exhibited some spiders which are commonly confused with the Funnel Web by the public. These are the Mouse Spider (*Missulena* spp.), the Brown Trapdoor (*Arbanitis fuscipes*), the Black House Spider (*Ixeuticus robustus*), and the Web Spider (*Lycosa* sp.). He endeavoured to indicate points of identification which can be determined quickly and macroscopically.

Miss Kathleen English exhibited specimens of Crofton Weed, *Eupatorium adenophorum*, bearing galls caused by the Crofton Weed Gall Fly, *Procecidochares utilis* Stone, collected at Shirley Road, Roseville, N.S.W. This fly, belonging to the family Trypetidae or Tephritidae, was introduced into The Hawaiian Islands from Mexico in 1945. Later a study was made on behalf of the Commonwealth of Australia on the reaction of *P. utilis* to other plants. As a result consignments of the insects were forwarded to Australia in February, 1952 (*Proc. Hawaiian Ent. Soc.*, XV, No. 1, p. 41, 1952). Mr. C. E. Chadwick released about 500 adults in September, 1954, at East Roseville and the galls have been noticed for some months on plants at Shirley Road, more than a mile from the place of release.

ORDINARY MONTHLY MEETING.

27th June, 1956.

Mr. S. J. Copland, President, in the chair.

Mr. J. M. Thomson, Cronulla, N.S.W., was elected an Ordinary Member of the Society.

The Chairman announced that Professor R. L. Crocker had been elected a Member of Council in place of Mr. T. C. Roughley.

The Chairman offered the congratulations of members to Professor W. L. Waterhouse on the award of the Stakman Medal of the University of Minnesota.

The Chairman announced that Library Accessions amounting to 14 volumes, 128 parts or numbers, two bulletins, three reports and nine pamphlets (total 156) had been received since last meeting.

PAPERS READ.

1. Three New Australian Chigger Nymphs (Acarina, Trombiculidae). By Robert Domrow.

2. Notes on Australian Buprestidae with Descriptions of Three New Species and Two Subspecies of the Genus *Stigmodera*, Subgenus *Castiarina*. By C. M. Deuquet.

3. The Status of Nitrogen in the Hawkesbury Sandstone Soils and their Plant Communities in the Sydney District. I. The Significance and Level of Nitrogen. By Nola J. Hannon, Linnean Macleay Fellow in Botany.

LECTURETTE.

A lecturette entitled "Plant Drugs in Modern Medicine" was given by Professor R. H. Thorp.

ORDINARY MONTHLY MEETING.

25th July, 1956.

Mr. S. J. Copland, President, in the chair.

The Chairman announced that Library Accessions amounting to 11 volumes, 202 parts or numbers, 11 bulletins, 6 reports and 2 pamphlets, total 232, had been received since last meeting.

PAPERS READ.

1. A List of Corals collected in the Vicinity of Singapore. By R. D. Purchon. (*Communicated by Mr. K. E. W. Salter.*)

2. The Australian Aleyrodidae (Hemiptera-Homoptera). By L. J. Dumbleton. (*Communicated by Dr. J. W. Evans.*)

LECTURETTE.

A lecturette entitled "Filariasis in Malaya" was given by Mr. R. H. Wharton, B.Sc.

ORDINARY MONTHLY MEETING.

29th August, 1956.

Mr. S. J. Copland, President, in the chair.

The Chairman announced that Library Accessions amounting to 20 volumes, 156 parts or numbers, 66 bulletins, 3 reports and 23 pamphlets, total 268, had been received since last meeting.

PAPERS READ.

1. The Pelagic Nudibranch, *Cephalopyge trematoides* (Chun, 1889), in New South Wales, with a Note on Other Species in this Genus. By Joan E. Steinberg.

2. The Family Discozerconidae (Acarina, Mesostigmata) in Australia. By Robert Domrow.

NOTES AND EXHIBITS.

Mr. A. N. Colefax gave a short talk on frog-collecting in the far South Coast of New South Wales, and exhibited live specimens of the frog, *Uperoleia marmorata*, which he had collected in a recent field trip to that area.

Mr. A. J. Bearup showed specimens of *Halicyclops aequoreus* Fischer (Crustacea, Copepoda) collected from the tidal zone of a small stream flowing into Dee Why Lagoon. This species has a wide distribution in brackish waters, and has been recorded from the Continents of Europe, America and Africa, and from Java and New Zealand. This is, however, the first record of it from the Australian Continent.

Dr. D. F. McMichael exhibited three species of Nudibranchs all of which had been received for identification at the Australian Museum within recent weeks: (1) *Euselenops* *luniceps* (Cuvier), a Pleurobranch which occurs occasionally in Australian waters: (2) *Glossodoris westraliensis* O'Donoghue, a Western Australian species now recorded for the first time from Queensland, and (3) *Phyllidia elegans* Bergh, the first record for Australia. These specimens indicate that much remains to be learned about the Australian Nudibranch fauna.

Dr. D. F. McMichael also exhibited three shells which were exhibited at the September meeting of this Society in 1891 by Dr. James Cox. They were considered to be an introduced English species, *Helicella* (*Xerophila*) *ericitorum* (Muller) and were thought to have been introduced a few years earlier in imported English grass seed, tried out on a farm near Warooka, Yorke's Peninsula, South Australia. Today this snail is a serious pest in a restricted area of Yorke's Peninsula, where it is known as the Warooka Snail. Nine smaller shells, also exhibited, were collected a few weeks ago at Warooka, where they are extremely abundant, Cotton (1949) having recorded 462 shells in an area of one square yard. The shells climb to the heads of barley, to the top of fence posts, etc., on hot days, sometimes forming masses several inches across. The presence of the snails on barley heads causes serious crop losses, for they are crushed with the grain in the harvester. The species has recently been correctly identified as *Helicella* (*Xerocincta*) *neglecta* (Draparnaud), a common European and British species. Investigations on the control of this pest are being made.

Dr. F. V. Mercer exhibited a number of electron micrographs illustrating the submicroscopic structure of the blue-green algae cell. The photographs were obtained by Mr. J. D. McLean and Dr. A. J. Hodge and Dr. F. V. Mercer. Several interesting features were seen in the photographs: No obvious nucleus is present in the cells of *Nostoc* and *Anabaena*, and no differentiation of the protoplast into cytoplasm, mitochondria, etc., is apparent. In fact, the structure of the cells strongly supports the view that the blue-green algae are primitive organisms.

ORDINARY MONTHLY MEETING.

26th September, 1956.

Mr. S. J. Copland, President, in the chair.

Miss Lynette A. Holder, Eastwood, N.S.W., and Dr. R. F. N. Langdon, Brisbane, Queensland, were elected Ordinary Members of the Society.

The Chairman referred to the death, on 3rd September, 1956, of Rev. H. M. R. Rupp, who had been a Corresponding Member of the Society since 1942.

The Chairman offered congratulations to Dr. F. V. Mercer on his appointment as Associate Professor of Botany in the University of Sydney.

The Chairman announced that the Council is prepared to receive applications for Linnean Macleay Fellowships tenable for one year from 1st January, 1957, from qualified candidates. The range of actual salary is £650-£800 according to qualifications. Applications should be lodged with the Honorary Secretary not later than Wednesday, 7th November, 1956.

The Chairman announced that Library Accessions amounting to 9 volumes, 55 parts or numbers, 5 bulletins, 5 reports and 1 pamphlet, total 75, had been received since last meeting.

PAPERS READ.

1. Some Acarina Mesostigmata from the Great Barrier Reef. By Robert Domrow.
2. A Review of the Fossil Freshwater Mussels (Mollusca, Pelecypoda) of Australasia. By D. F. McMichael.
3. *Cyclocephala signaticollis* Burmeister, an Introduced Pasture Scarab (Coleoptera). By P. B. Carne.

LECTURETTE.

A lecturette on "Glimpses of Plants and People of Ceylon" was delivered by Dr. I. V. Newman.

ORDINARY MONTHLY MEETING.

31st October, 1956.

Mr. S. J. Copland, President, in the chair.

The following were elected Ordinary Members of the Society: Messrs. K. J. Clinton, Sydney University; H. G. Cogger, Granville, N.S.W.; S. J. J. F. Davies, B.A., Homebush, N.S.W.; Miss Berenice M. Kindred, Kingsgrove, N.S.W.; and Mr. N. R. McKenna, Rosehill, N.S.W.

The Chairman announced that the Council is prepared to receive applications for Linnean Macleay Fellowships tenable for one year from 1st January, 1957, from qualified candidates. The range of actual salary is £650–£800, according to qualifications. Applications should be lodged with the Hon. Secretary not later than Wednesday, 7th November, 1956.

The Chairman announced that Library Accessions amounting to 10 volumes, 119 parts or numbers, 9 bulletins, 5 reports, and 21 pamphlets, total 164, had been received since last meeting.

PAPERS READ.

1. Revision of the Genus *Podolepis* Labill. By Gwenda L. Davis.
2. Studies on Australian Thynnidae (Hymenoptera). II. A Short History of Thynnid Taxonomy. By K. E. W. Salter.

NOTES AND EXHIBITS.

Mr. A. N. Colefax exhibited two frog specimens which were collected from a limestone cave near Braidwood, N.S.W. One of them was the Great Barred River Frog *Mixophyes fasciolatus* and the other a *Hyla lesueurii*. The former was taken at the 120 feet level underground, and the other at ninety feet. In neither case is there any conspicuous difference from the corresponding types which inhabit the outside world. This find provides evidence of the great distances underground to which these frogs may penetrate.

Mr. Colefax also exhibited a frog of the genus *Uperoleia* which was collected at Rooty Hill, near Sydney. It is intermediate in structure between the normally-occurring coastal form, *U. marmorata*, and the related *U. rugosa*, which to date has been recorded only from west of the Great Dividing Range and Queensland.

LECTURETTE.

A lecturette entitled "An Ecologist in Brazil" was delivered by Dr. L. C. Birch.

ORDINARY MONTHLY MEETING.

28th November, 1956.

Mr. S. J. Copland, President in the chair.

Messrs. I. F. B. Common, M.A., M.Sc.Agr., Canberra, A.C.T.; K. A. W. Crook, M.Sc., Armidale, N.S.W.; and Miss Alison McCusker, B.Sc., Armidale, N.S.W., were elected Ordinary Members of the Society.

The Chairman announced that Miss Nola J. Hannon, B.Sc., and Mrs. Mary B. Williams, B.Sc., had been reappointed to Linnean Macleay Fellowships in Botany for one year from 1st January, 1957.

The Chairman announced that Library Accessions amounting to 11 volumes, 162 parts or numbers, 3 bulletins, 4 reports and 19 pamphlets, total 199, had been received since last meeting.

PAPERS READ.

1. Description of a New Australian Raphignathoid Mite, with Remarks on the Classification of the Trombidiformes (Acarina). By R. V. Southcott.
2. Variation in Snow Gum (*Eucalyptus pauciflora* Sieb.). By L. D. Pryor.

LECTURETTE.

A lecturette entitled "Climatological Changes and Species Formation in Australian Animals" was given by Dr. J. A. Keast.

LIST OF MEMBERS.

(15th December, 1955.)

ORDINARY MEMBERS.

(An asterisk (*) denotes Life Member.)

1940 Abbie, Professor Andrew Arthur, M.D., B.S., B.Sc., Ph.D., c.o. University of Adelaide, Adelaide, South Australia.
1927 *Albert, Michel Francois, "Boomerang", 42 Billyard Avenue, Elizabeth Bay, Sydney.
1940 *Allman, Stuart Leo, B.Sc.Agr., M.Sc., Entomological Branch, Department of Agriculture, Farrer Place, Sydney.
1922 Anderson, Robert Henry, B.Sc.Agr., Botanic Gardens, Sydney.
1927 *Armstrong, Jack Walter Trench, "Callubri", Nyngan, N.S.W.
1952 Ashton, David Hungerford, B.Sc., 92 Warrigal Road, Surrey Hills, E.10, Victoria.
1912 Aurousseau, Marcel, B.Sc., 229 Woodland Street, Balgowlah, N.S.W.

1952 Baas-Becking, L. G. M., Ph.D., D.Sc., C.S.I.R.O., Division of Fisheries, P.O. Box 21, Cronulla, N.S.W.
1951 Backhouse, Thomas Clive, M.B., B.S., D.P.H., D.T.M. & H., F.R.A.C.P., School of Public Health and Tropical Medicine, Sydney University.
1952 Baehni, Professor Charles, Dr.sc., Conservatoire botanique, Université de Genève, 192, rue de Lausanne, Genève, Switzerland.
1949 Baker, Eldred Percy, B.Sc.Agr., Ph.D., Faculty of Agriculture, Sydney University.
1950 *Barber, Professor Horace Newton, M.A., Ph.D., Department of Botany, University of Tasmania, Hobart, Tasmania.
1955 Barlow, Bryan Alwyn, B.Sc., Department of Botany, Sydney University.
1956 Barnard, Robert Alexander Stephen, c/- Department of Zoology, Sydney University.
1954 Baur, George Norton, B.Sc.Agr., Dip.For., c.o. Forest Office, Coff's Harbour Jetty, N.S.W.
1935 *Beadle, Professor Noel Charles William, D.Sc., University of New England, Armidale, 5N, N.S.W.
1946 Bearup, Arthur Joseph, 66 Pacific Avenue, Penshurst, N.S.W.
1940 Beattie, Joan Marion, D.Sc. (*née* Crockford), c.o. Radium Hill Project, Radium Hill, South Australia.
1952 Bennett, Miss Isobel Ida, Department of Zoology, Sydney University.
1907 Benson, Professor William Noel, B.A., D.Sc., F.G.S., University of Otago, Dunedin, New Zealand.
1948 Besly, Miss Mary Ann Catherine, B.A., 7 Myra Street, Wahroonga, N.S.W.
1954 Black, Roger Foster, B.Sc., Department of Botany, Sydney University.
1941 Blake, Stanley Thatcher, M.Sc., Botanic Gardens, Brisbane, Queensland.
1929 Boardman, William, M.Sc., Zoology Department, University of Melbourne, Carlton, N.3, Victoria.
1946 Brett, Robert Gordon Lindsay, B.Sc., 7 Petty Street, West Hobart, Tasmania.
1955 Briggs, Miss Barbara Gillian, 13 Findlay Avenue, Roseville, N.S.W.
1924 Browne, Ida Alison, D.Sc. (*née* Brown), Department of Geology, Sydney University.
1949 Browne, Lindsay Blakeston Barton, Ph.D., C.S.I.R.O. Division of Entomology, P.O. Box 109, City, Canberra, A.C.T.
1911 Browne, William Rowan, D.Sc., Department of Geology, Sydney University.
1952 Bunt, John Stuart, B.Sc.Agr., Antarctic Division, 187 Collins Street, Melbourne, Victoria.
1949 Burden, John Henry, 1 Havilah Street, Chatswood, N.S.W.
1931 *Burges, Professor Norman Alan, M.Sc., Ph.D., Professor of Botany, University of Liverpool, Liverpool, England.
1920 Burkitt, Professor Arthur Neville St. George Handcock, M.B., B.Sc., Medical School, Sydney University.

1955 Cameron, Miss Beryl Marlene, B.Sc., Department of Zoology, Sydney University.
1927 Campbell, Thomas Graham, Division of Economic Entomology, C.S.I.R.O., P.O. Box 109, City, Canberra, A.C.T.
1934 *Carey, Professor Samuel Warren, D.Sc., Geology Department, University of Tasmania, Hobart, Tasmania.
1949 Carne, Phillip Broughton, B.Agr.Sci. (Melb.), Ph.D. (London), D.I.C., C.S.I.R.O., Division of Entomology, P.O. Box 109, City, Canberra, A.C.T.
1956 Carolin, Roger Charles, B.Sc., A.R.C.S., Department of Botany, Sydney University.
1936 *Chadwick, Clarence Earl, B.Sc., Entomological Branch, Department of Agriculture, Farrer Place, Sydney.

1956 Chambers, Thomas Carrick, M.Sc. (N.Z.), Department of Botany, Sydney University.
1947 Christian, Stanley Hinton, Malaria Control, Department of Public Health, Banz, Western Highlands, via Lae, New Guinea.
1932 *Churchward, John Gordon, B.Sc.Agr., Ph.D., 55 Belmont Street, Mosman, N.S.W.
1946 Clark, Laurance Ross, M.Sc., c.o. C.S.I.R.O., Division of Entomology, P.O. Box 109, City, Canberra, A.C.T.
1947 Clarke, Mrs. Muriel Catherine, M.Sc (*née* Morris), 122 Swan Street, Morpeth, N.S.W.
1901 Cleland, Professor John Burton, M.D., Ch.M., 1 Dashwood Road, Beaumont, Adelaide, South Australia.
1956 Cogger, Harold George, 4 Blane Street, Granville, N.S.W.
1931 Colefax, Allen Neville, B.Sc., Department of Zoology, Sydney University.
1946 Colless, Donald Henry, Department of Parasitology, University of Malaya, Sepoy Lines, Singapore, Malaya.
1956 Common, Ian Francis Bell, M.A., M.Sc.Agr., c/- Division of Entomology, C.S.I.R.O., P.O. Box 109, City, Canberra, A.C.T.
1942 Copland, Stephen John, M.Sc., Chilton Parade, Warrawee, N.S.W.
1947 Costin, Alec Baillie, B.Sc.Agr., Island Bend, via Cooma, 4S, N.S.W.
1908 Cotton, Professor Leo Arthur, M.A., D.Sc., 113 Queen's Parade East, Newport Beach, N.S.W.
1950 Crawford, Lindsay Dinham, B.Sc., 4 Dalton Avenue, West Hobart, Tasmania.
1955 Crocker, Professor Robert Langdon, D.Sc., Department of Botany, Sydney University.

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LIST OF NEW FAMILIES, GENERA AND SPECIES.

Vol. 81.

Families.

Genera.

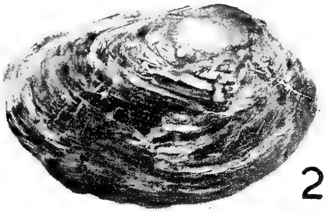
Species.

INDEX.

1956

73635

1



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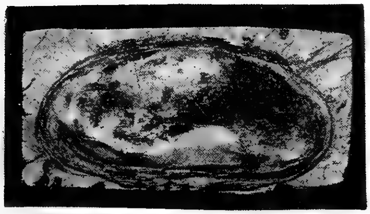

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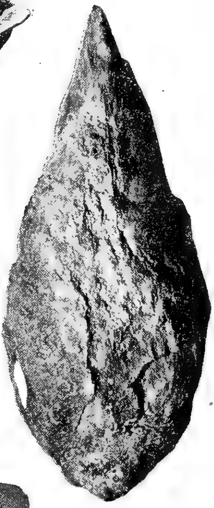

7

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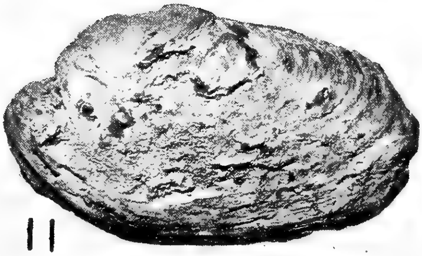
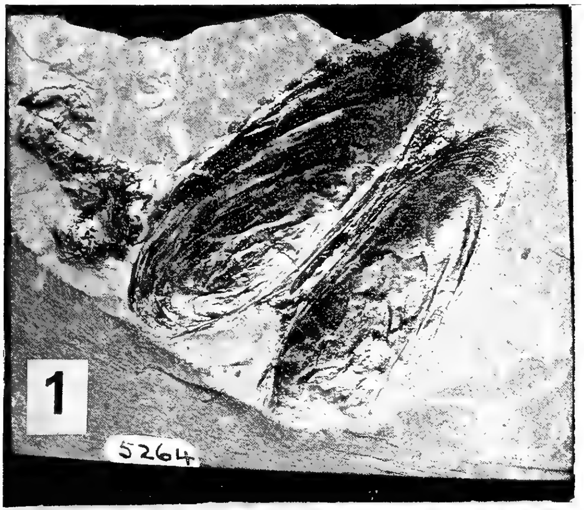


11

12

Fossil Freshwater Mussels of Australasia.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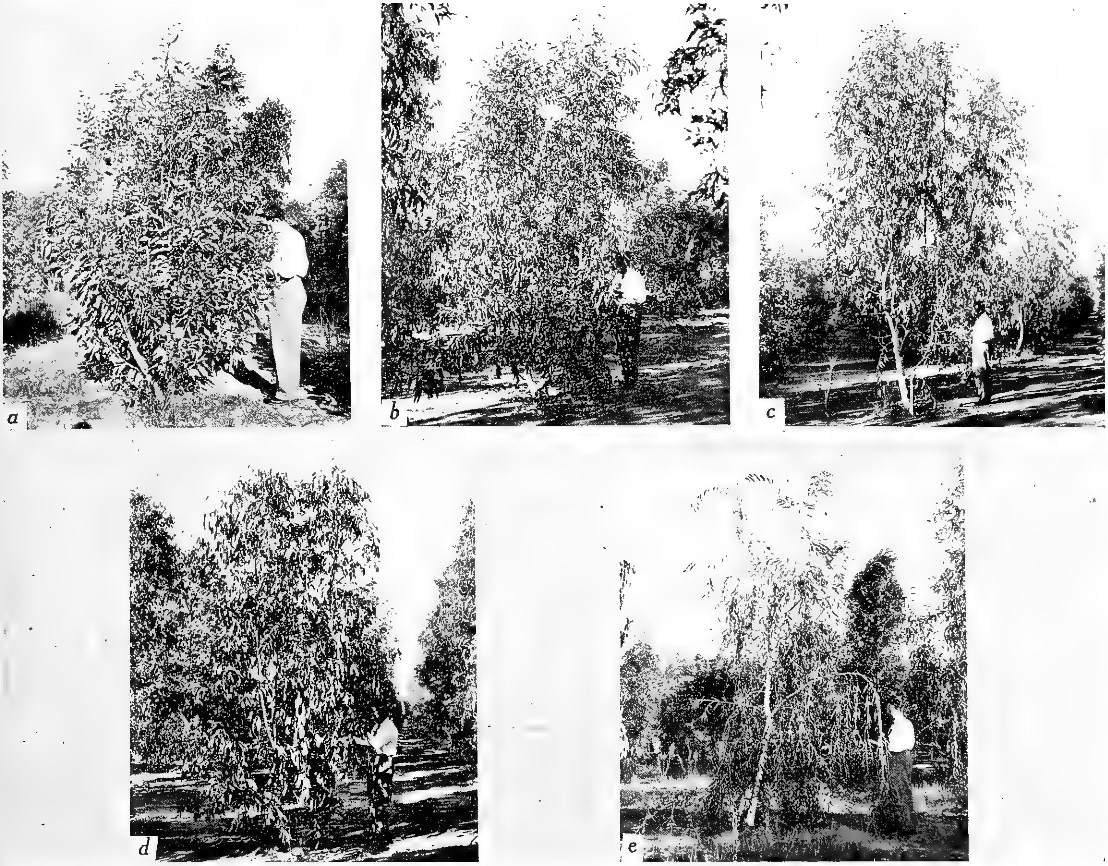
Fossil Freshwater Mussels of Australasia.

Eucalyptus pauciflora: Five stands from 4000 to 6000 feet elevation.



Snow Gum: 6-year-old plants from different localities.

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Part 1.

No. 380

THE

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OF THE

LINNEAN SOCIETY

OF

NEW SOUTH WALES

FOR THE YEAR

1956

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[Plates i-ix.]

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References.—References should be carefully checked by the author, who is alone responsible for their accuracy. They should be listed alphabetically at the end of the manuscript, and should be cited in the text by the author's name, e.g., Bullough (1939) or (Bullough, 1939); and in the list thus:

> BULLOUGH, W. S., 1939.—A Study of the Reproductive Cycle of the Minnow in Relation to the Environment. *Proc. Zool. Soc. Lond.*, 109, A, Pt. 1:79-108.

Abbreviations.—Standard abbreviations should be used in tabulations and after numerals in the text. The abbreviations of names of periodicals should conform to those in the World List of Scientific Periodicals.

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PROCEEDINGS, LXXXI, PART 1, 1956

CONTENTS.

Corrigendum.

PROCEEDINGS, 1955, Part 3 (Vol. lxxx), p. 208, line 14, *for* PUMILIS, *read* PUMILUS.

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