THE

PROCEEDINGS

OF THE

LINNEAN SOCIETY

OF

NEW SOUTH WALES

FOR THE YEAR

1953

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ANNUAL GENERAL MEETING.

25th March, 1953.

The Seventy-eighth Annual General Meeting was held in the Society's Rooms, Science House, Gloucester Street, Sydney, on Wednesday, 25th March, 1953.

Mr. S. J. Copland, President, occupied the Chair.

The Minutes of the Seventy-seventh Annual General Meeting, 26th March, 1952, were read and confirmed.

Presidential Address.

My first duty is to pay a tribute and express gratitude on behalf of the Society to Dr. A. B. Walkom and Dr. W. R. Browne. We all know how capably they have filled the posts of honorary treasurer and editor, and honorary secretary, but I doubt if we are aware of the profound debt we owe them. The value of a society like ours resides in its published work. The appointment of a permanent secretary would mean little money for publishing and our proceedings would be thin indeed. Our present relatively comfortable position is almost entirely due to the self-sacrifice, energy and efficiency of these two men. I will now ask Mr. A. N. Colefax to propose a vote of thanks to Dr. Browne and Dr. Walkom so that our appreciation may be recorded.

Doing without a paid secretary has inevitably placed an added burden on our permanent Assistant Secretary, Miss G. L. Allpress. The Society has to thank her for loyal and willing service. I am grateful to her for compiling the first part of my address, which summarizes the activities of the Society during the past year.

Volume 77, Parts 1–4 of the Society's Proceedings were published in 1952 and Parts 5–6 in January, 1953. Volume 77 consists of 394 + lxv pages, 16 plates and 311 text-figures. The volume is much larger than previous ones due to the receipt of financial assistance from several sources as follows: An anonymous gift of £20 and a grant of £100 from the Commonwealth Publications Fund towards the cost of publication of the paper by Dr. Carl E. M. Gunther; the complete cost of publication (£82/18/4) of the paper by G. B. Fairchild by the Gorgas Memorial Institute of Tropical and Preventive Medicine, Washington, D.C., U.S.A.; and a grant of £150 by the University of Sydney towards the cost of publication of "Australian Rust Studies. IX" by W. L. Waterhouse.

Library accessions from scientific societies and institutions totalled 1,488 for the year. Unwanted periodicals from the libraries of the University of Melbourne, and C.S.I.R.O., Canberra, have been received to help complete sets in the Library. Miscellaneous duplicate reprints in the Society's possession were made available gratis to members and all reprints were disposed of. Requests for library loans, especially from interstate and C.S.I.R.O. libraries, have been as numerous as in the previous year. A volume of the history of the Holland Society of Sciences, issued on the occasion of the 200th anniversary of its foundation in May, 1752, was received for the library. New exchanges were commenced with The West of Scotland Agricultural College, Glasgow, Scotland (to receive the Abstract of Proceedings only); Louisiana Academy of Sciences, Baton Rouge, Louisiana, U.S.A.; Bioloski Institut u Sarajevu, Sarajevu, Jugoslavija; Ohio State University Library, Columbus, Ohio, U.S.A.; Instituto di Patologia Vegetale della Universita di Milano, Milan, Italy (to receive Botanical and Agricultural Reprints only).

At the following monthly meetings during the year programmes of special interest were given:

May: Lecturette by Mr. D. P. Clark entitled "Ecological Study of the Microfauna of the Soil".

June: Lecturettes on Mitochondria; Cytology and Function in Plants and Bacteria, by Miss Mary Hindmarsh, Dr. R. N. Robertson and Dr. Y. T. Tchan.

July: Lecturette dealing with various phases of the Natural History of Heard Island, illustrated by a colour film and exhibits, by Mr. K. G. Brown, who had been biologist to the Australian Antarctic Expedition in 1951.

September: Illustrated account of the new Botany School in the University of Oxford, by Professor T. G. B. Osborn, Sherardian Professor of Botany, University of Oxford.

October: Lecturette on "Preservation of Plant-tissues in Coal", by Professor C. E. Marshall.

November: Lecturette, illustrated by Kodachrome slides, on the Australian Museum Expedition to North-west Australia, by Mr. H. O. Fletcher, Leader of the Expedition.

We are indebted to and wish to thank all who contributed to these programmes.

No Ordinary Monthly Meeting was held in August, 1952, on account of the Sydney Meeting of the Australian and New Zealand Association for the Advancement of Science and the University Centenary Celebrations.

Two Special General Meetings were held on 30th July and 24th September, 1952, to consider and confirm the adoption of an alteration of the Rules of the Society recommended by Council, that a rule XVIA be inserted, to read: The Council may decide that the duties of the Secretary as set out in Rule XIX shall be carried out by one or more Honorary Secretaries. In this event the Council shall consist of eighteen members and the Honorary Secretaries shall be office-bearers to be elected by the Council in terms of Rules XXVIII and XVI.

Since the last Annual Meeting the names of 20 members have been added to the list, two members have been lost by death, three have been removed from the list under Rule VII, and nine have resigned. The number of members as at 15th March, 1953, is: Ordinary Members, 205; Life Members, 24; Honorary Member, 1; Corresponding Members, 2; Associate Member, 1; total, 233.

On account of his acceptance of the Chair of Botany of the University of Liverpool, Professor N. A. Burges resigned from the Council on 18th June, 1952, prior to his departure for England.

By decision of the Deputy Commissioner of Taxation the Society was approved as a scientific research institute, donations to which for purposes of research would be tax-free.

On behalf of the Society, a subscription was sent towards the memorial to the late Dr. Robert Broom.

The total net return from the Society's one-third ownership of Science House for the year was £642.

The Council of the Society endorsed the Fair Copying Declaration, as requested by the Royal Society of London.

A fourth Natural History Survey was made, under the leadership of Dr. W. R. Browne, in the Kosciusko region from 26th January to 9th February, 1953, when a party of seven scientists visited the area; transport and accommodation were offered again by the Kosciusko State Park Trust and the Snowy Mountains Hydro-electric Authority. 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) is indebted to the Australian and New Zealand Associtaion for the Advancement of Science for its Research Grant of £100 towards the work of this Survey.

Many members of the Society took part in the activities of the Sydney Meeting of the Australian and New Zealand Association for the Advancement of Science held from 20th to 27th August, 1952, in which over 2,000 participated. This meeting, the first to be held in Sydney since 1932, was a great success, many overseas scientists visiting Sydney for the occasion. The next meeting of the Association will be held in Canberra in January, 1954.

Congratulations are offered to: Professor N. A. Burges, who accepted an invitation to the Chair of Botany in the University of Liverpool; Dr. Daphne Eliot (*née* Davison) and Dr. Ian Fraser, on obtaining the degree of Ph.D. of the University of Cambridge; Miss Helen Lancaster, on obtaining the M.Sc. degree of the University of Sydney;

Dr. Marie E. Phillips, on the award of the Ph.D. degree of the University of Manchester; Professor W. L. Waterhouse, on the honour conferred on him as Emeritus Professor on his retirement from the University of Sydney; Professor J. B. Cleland, on the award of the Australian Natural History Medallion by the Field Naturalists' Club of Victoria; and Dr. G. F. Humphrey, on the award of a Nuffield Foundation Travelling Scholarship for 1953.

Linnean Macleay Fellowships.

In November, 1951, the Council reappointed Miss Mary Hindmarsh and Mr. T. G. Vallance to Fellowships in Botany and Geology respectively for 1952.

During 1952 Miss Hindmarsh studied two aspects of the effects of chemicals on root tips. An investigation of the effect of colchicine on the spindle, which was begun late in the previous year, was completed. It was found that the spindle could be observed in unstained plant cells by using the phase contrast microscope after acid fixation of the tissue. In roots treated with 0·1% colchicine the spindles had disappeared from cells in all stages of division in one hour and the abnormalities induced by colchicine could be directly related to destruction of the spindle or lack of its formation. These results were published in a short paper in Parts 5–6 of the Proceedings of the Society for 1952. Portion of the year was devoted to a study of the effects of p-aminobenzoic acid and sulphanilamide on the growth of roots. The effects of these two substances on cell division have been previously studied and it is known that p-aminobenzoic acid reverses sulphanilamide inhibition of cell division. This, however, does not explain effects of these substances on root elongation, since both inhibit elongation at the concentrations used for the cytological work. As well as reversing sulphanilamide inhibition of cell division, p-aminobenzoic acid has an independent effect on root elongation, perhaps by preventing the extension of cells behind the meristem of the root.

Mr. Vallance reports that the year 1952 has seen the conclusion of his research studies on the geology of the Wantabadgery–Adelong–Tumbarumba district, N.S.W. It was found that the metamorphism which affected the sediments (probably in the main of upper Ordovician age) of the area had an important thermal aspect though it was essentially regional in influence. An attempt was made to relate the metamorphic phenomena to a general scheme such as is provided by the Metamorphic Facies Principle. In this way he was able to establish that the metamorphic facies sequence in this area is complete and rather analogous to the well-known Barrovian zonal sequence, although Barrow's zones are more dynamothermal and belong to different subfacies types from those found in the present case. Many analogies were found between the metamorphic phenomena of the Cooma (N.S.W.) area and of the district under review. In addition, two series of plutonic (granitic) rocks were recognized and studied in some detail. It is believed that the members of the first (and earlier) series are more closely related to the general metamorphism than are those of the second series. Evidence was found which suggests that while the granites were not formed *in situ*, they are at all events not far from their place of origin.

In November, 1952, three applications were received by the Council. Miss Mary Hindmarsh and Mr. T. G. Vallance were reappointed to Fellowships in Botany and Geology respectively for 1953.

Miss Hindmarsh proposes to complete the work now in hand as follows: (1) An anatomical study of cells in the zone of elongation of roots treated with sulphanilamide and p-aminobenzoic acid will be made, to see whether inhibition of cell extension or polarization mechanisms or both are responsible for the results obtained during 1952. These results will be written up together with the cytological effects of sulphanilamide and p-aminobenzoic acid. (2) The technique of observing the presence or absence of the spindle after certain types of fixation will be used to find out whether sulphanilamide, sulphanilamide + p-aminobenzoic acid and nitrophenols have a similar effect to colchicine on spindles. This is important in comparing effects of mitotic poisons and studying their action on the cell division process. (3) The work on phosphate inhibition of cell division, begun in 1950–51, will be completed and written up. This work was done on onion seedling roots and it is thought to be an antagonism effect rather than a specific phosphate inhibition of cell division. It must be repeated on bulb roots to make certain that effects obtained were not due to a shortage of nutrient in the medium.

Mr. Vallance proposes to conclude his studies in the Ordovician metamorphic belt of the Wagga Wagga–Adelong region and prepare the results for publication; also to commence a new study on the geology of the pre-Cambrian rocks of the Broken Hill region of New South Wales, submitting for his new project the title "Studies in the Metamorphic and Plutonic Geology of the Broken Hill Region, N.S.W.".

Best wishes are extended to both Fellows for success in their research work.

Macleay Bacteriologist.

During the year 1952–53 Dr. Yao-tseng Tchan's researches were mainly concerned with two subjects: (1) Work on the N-fixing bacteria in northern Australia has shown some promising field for research. For the first time in Australia, *Beijerinckia*, a genus of tropical N-fixing bacteria, was isolated. From 48 samples nearly 30% are inhabited by these groups of organisms. The morpho-cytological research on *Azotobacter*, especially on the possibility of the presence of mitochondria, has shown that it is impossible to distinguish between the nucleus or nucleus-like bodies and the mitochondria or mitochondria-like bodies of *Azotobacter*. Will this suggest that the term Biodynamic centre should be used? In collaboration with the University of Technology, this problem is under investigation with the electronic microscope. (2) For the soil algae work, a new technique has been devised using the property of fluorescence of the chlorophylls. This technique provides a useful tool for soil algae studies. In collaboration with Miss Whitehouse of the University, investigations have been made on the ecology of soil algae. The daily variations and the horizontal distribution of algal population have been investigated with the new technique. The possibility of algae growing heterotrophically in the dark has been studied. Some preliminary experiments showed that the algal population in the soil can be used as an indication of soil fertility. In collaboration with the Department of Conservation and the Botany Department of the University, the N economy of semi-desert soils of the Broken Hill district will be investigated if suitable facilities are provided by the above departments.

Obituaries.

It is recorded with regret that the following members died during the year: Mr. Walter Mervyn Carne and Sir William Dixson.

Walter Mervyn Carne.

WALTER MERVYN CARNE, who died on 20th November, 1952, at Chatswood, N.S.W., had been a member of the Society for over forty years, having joined in 1905. He was born on 16th September, 1885, and educated at Fort Street, Sydney High School and Sydney Technical College. He also took courses at the University of Sydney and University of California. He held Government posts in the States of New South Wales and Western Australia and under the Council for Scientific and Industrial Research. He acted as lecturer in Economic Botany, Plant Pathology and Entomology at Hawkesbury Agricultural College and later as lecturer in the University of Western Australia. His total period of official service was forty-five years. He served four years in the A.I.F. (1915 to 1919), being mentioned in despatches and awarded the Serbian Silver Medal for services in the field. In 1931 he visited England at the invitation and expense of the Empire Marketing Board to examine Australian apples and pears. In 1938, being Principal Research Officer of the Council for Scientific and Industrial Research, he was seconded to the Department of Commerce to become the technical adviser under the title of Supervisor of Fresh Fruit and Vegetable Exports. In 1941 he was permanently transferred to the Department of Commerce. During his career he visited practically every agricultural college and research institution in Australia concerned with horticulture and plant pathology and travelled extensively to visit agricultural colleges and experiment stations in Great Britain, United States of America, Canada, South Africa, Holland, Palestine and Egypt. Plant taxonomy and ecology were among his earliest scientific interests, his first paper being published in 1910 in the Proceedings of this Society. Many articles on economic botany, parasitic diseases, and non-parasitic disorders also were published by him in various journals in Australia. He was widely recognized in Australia and overseas as the authority on the identification and incidence of the non-parasitic disorders in apples. From 1931 to 1950 he did much for ship carriage of fruit and vegetables and in connection with export inspection and the overseas marketing of Australian fruit. After his retirement in 1950 he came to New South Wales to reside at Chatswood. Of late years he attended meetings of the Society and took part in the discussions, the last occasion of his attendance being about a month before his death.

Sir William Dixson.

Sir William Dixson, who had been a Life Member of the Society since 1927, died on 17th August, 1952, aged 82. Sir William was born in Sydney on 18th April, 1870, and was educated at All Saints' College, Bathurst. When 19 years old he went to Scotland and served his time as an engineer, returning to Sydney in 1899 and joining the family business of Dixson and Sons Ltd., tobacco merchants. He became a director of the company and later of the British Australian Tobacco Company Ltd., into which Dixson and Sons was merged. Sir William, who had been collecting pictures about Australia, books and manuscripts, important prints and pictorial records of historical value for nearly fifty years, presented the nation with a valuable collection, which is housed in the Dixson Wing of the Mitchell Library, Sydney. The collection won him the reputation of being the greatest living collector of Australiana. In this he followed in the footsteps of his father, Sir Hugh Dixson, who acquired a copy of almost every publication about Australasia. Besides his gift to the Mitchell Library, Sir William gave £2,500 for a University Library at the New England University College, and in 1951 £15,000 more to the Public Library for additions to the Dixson Bequest. He was a bachelor and had lived at Killara. A munificent gift of books, manuscripts, charts, etchings, photographs, etc., to the Public Library of New South Wales, together with the establishment of a fund to be known as the William Dixson Foundation, was revealed in his will after his death.

Recent Australian Herpetology.

In choosing "Recent Australian Herpetology" for the subject of my address, I hope that the facts I have brought together will be of value to everyone interested in Australia's animals as well as to workers specializing in this particular field. I will bring forward some work on our common goanna.

The Blood Vascular System of the Trunk of the Goanna Varanus varius (Shaw).

This study is intended to provide a reasonably detailed description of the blood vessels of the trunk of an Australian member of the Varanidae, a homogeneous group of lizards, which probably originated in early Cretaceous time in south-east Asia and reached Australia soon afterwards. Their migration through southern Asia to Africa appears to have been much more recent. It is hoped to use this description as a basis to make systematic comparisons with other species of both *Varanus* and lizards of other genera. For this reason only a single specimen has been dealt with to avoid any possibility of making a composite account. At the same time a small series of other specimens was checked to ensure that the single specimen described is not abnormal. Only the main and more easily accessible vessels have been discussed. The veins and arteries of the limbs and head, which are unlikely to be of taxonomic importance because they are not so easily reached, have been excluded except for their proximal relationships. *Varanus varius* (Shaw) has been selected for the basic study because it may be regarded as the typical Australian goanna, being figured, described and reported as "not uncommon at Port Jackson" in 1789 in "The Voyage of Governor Phillip to Botany Bay" (London) and again described and named in the following year by Shaw in White's "Journal of a Voyage to New South Wales". I have reason to suspect that there is considerable subspecific differentiation in this widespread species.

Mr. E. Worrell collected the specimen examined (No. 4150 in the author's collection) at Uki on the Far North Coast of New South Wales at the end of October, 1948.

Ordinary ducoes in a medium of acetone and amyl acetate were used for the injections. The volatile constituents soon dry off, do not run, and can be used cold because of their small bulk. The usual injections were made into the great vessels near the heart and also the anterior abdominal vein while the heart was still beating. Chloroform and ether mixed have been found to be a more effective anaesthetic than either alone. Small aluminium alligator clips with the teeth filed flat and thin strips of cardboard tied over the jaws proved ideal forceps for the blood vessels.

I wish to thank Professor E. A. Briggs, who suggested my working on *Varanus*, and Professor P. D. F. Murray for much help and advice. P. R. Rowe Pty. Ltd. kindly supplied ducoes and other injecting fluids.

The only abbreviations used in the text-figures are: A, artery or arteries; V, vein or veins; L, left; and R, right; excepting those for a very few awkwardly long names. Abbreviations for these are explained in the legends under the figures in which they occur.

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

The heart lies slightly but noticeably to the right side, being displaced by the stomach. It is overlain ventrally to some extent by the anterior lobes of the liver and is bounded on the left by the stomach and on the right by the right lung. It is only moderately elongated, the width at its maximum across the atria being 28 mm. and the length 37 mm. The ventricle is rounded, but a little longer than broad. The two atria are about equal in size. The sinus venosus is noticeable externally and is asymmetrically placed. The large left precaval vein runs in a deep groove on the dorsal surface of the left atrium and then turns sharply right near the sulcus to enter the sinus venosus. The right precaval runs over and at the side of the right atrium, hiding it from view dorsally. The right precaval is almost in a line with the postcaval. The bases of the two great veins merge and they discharge their blood together into the sinus venosus. The heart and the bases of the great vessels are enclosed in a thin and transparent, but tough, pericardium. Mathur (1944) has recently treated the anatomy of the heart of *Varanus monitor* (Linné) in detail, but comparison of the internal anatomy with *Varanus varius* has been reserved for later treatment.

System of the Carotid Arch (Text-fig. 3).

The posterior position of the heart and the elongation of the neck have led to a striking development of the primary and common carotids. Loss of the ductus caroticus is a sequel to the wide separation of the carotid and systemic arches.

The primary carotid forks from the right systemic arch practically in the midline of the heart and about 5 mm. in front of it. It runs forward, following the right bronchus fairly closely. Because the heart is displaced towards the right, the primary carotid inclines to the left to regain the median axis of the body, which it does 55 mm. in front of the heart on the ventral surface of the trachea. It then divides into the right and left common carotids. The primary carotid gives off only three vessels. The pericardial artery (described under heading *A* following) is fairly large, but the other two (see following headings *B* and *C*) are small.

A. The pericardial artery (Figs. 3 and 11) comes off from the mid-ventral surface of the primary carotid immediately forward of its origin. It soon forks into right and left branches, which run back in close contact with the lateral abdominal veins and eventually anastomose with branches of the posterior epigastric artery. The right and left sides are joined by a loop near the front of the liver. This loop sends a small artery to parallel the median abdominal vein. Many small vessels run over the pericardium and extend more or less at right angles over the ventral and lateral body walls. A small, but interesting, branch is given off on each side near the origin of the pericardial artery. These run to the pectoral wall in close association with the small vessels from the lateral abdominal veins, which join the pectoral vein.

B. This small artery (Fig. 3) leaves the extreme anterior end of the primary carotid and runs to the right pectoral area, giving off branches to the right bronchus.

C. The more posterior artery (Fig. 3) originates 15 mm. further back and runs along the outer edge of the right bronchus for about 20 mm., sending in tiny branches between the cartilage rings. It then splits into three, one branch reticulating over the right bronchus until it breaks up over the surface of the lung; another running back as far as the pericardium over which it branches, and the third spreads over the connective tissue enveloping the right lung medially.

The common carotids (Fig. 3) swing outwards and dorsally round the trachea in the shape of a wishbone. The left one at once gives off a large branch, which supplies a rich network over the left bronchus as far back as the heart. The œsophagus lies rather to the right, and the right common carotid gives off a large artery about 10 mm. from its origin which splits and runs both ways along the ventral surface of the œsophagus.

The long ventral cervical comes off at right angles about 20 mm. in front of the fork. It has five groups of vessels (A–E, Fig. 3) running from it.

A: Two short but rather stout arteries to the posterior end of the thyroid gland.

B: A delicate vessel which runs over the thyroid gland dorsally and then forks into the body wall.

C: A large artery to the body wall.

D: Two further thyroid arteries run to the antero-lateral surface of the gland.

E: Tracheal branches which run in all directions over the trachea, supplying tiny twigs between each cartilage ring.

The ventral cervical artery in its long course runs ventrally under the common carotid and then dorsally over the posterior horn of the hyoid.

Posterior arteries to the thymus gland also supply neck muscles and on the right side send anterior and posterior branches along the oesophagus.

Branches are given off to the connective tissue surrounding the posterior horn of the hyoid and on the right side an additional vessel to the thymus.

Each common carotid splits into internal and external carotid branches level with the junction of the basihyal and posterior cornua. The right external carotid is considerably larger than the left. Both external carotids send large branches to the anterior ends of the respective thymus gland.

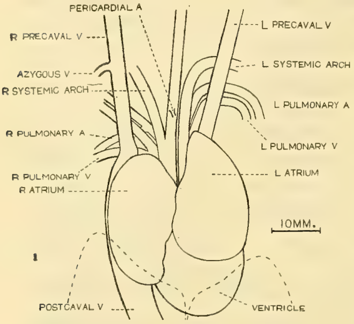
The Systemic Arch (Text-figs. 3, 4, 5, 6 and 8).

The great vessels leaving the ventricle twist clockwise about 90° so that the right systemico-carotid arch changes its position from a dorsal to a lateral position on the right, and the left systemic arch from a ventral to a lateral position on the left side. The right systemico-carotid is rather the larger arch, and gives off the primary carotid just clear of the heart. The heart is displaced towards the right by the stomach so that the two radices of the dorsal aorta are not symmetrically arranged and both incline to the left. The right radix rests in a groove on the median surface of the right lung as it runs almost dorsally round the right bronchus and then turns sharply caudad to the midline, where, about the level of the front of the heart, the common subclavian artery is given off. The arch then turns back 33 mm. medially before it is joined by the left radix. The left systemic arch takes a wide sweep under the stomach, crosses the left bronchus and runs back embedded in the left lung for most of the 50 mm. to its junction with the right radix. The left radix has no branches, and neither has the right until after giving off the subclavian. There are then four parietal arteries (A) before its junction with the left radix.

A. The parietal arteries (Fig. 5) are so irregular or modified that less than half their number may be said to be typically developed. There are 17 vertebrae between the origins of the subclavian and the iliac arteries, referred to here as 1st to 17th for convenience of description. Parietal arteries are apparently missing opposite the 6th and 10th, and six vessels are unpaired. Each gives off a branch to the vertebral artery at the margin of the vertebral column. The main vessels run laterally and ventrally close to the respective ribs. The parietals also give off long, thin, highly ramifying branches to the mesenteries, peritoneum and outer sheath of the aorta.

B. The coeliaco-mesenteric (Figs. 4 and 5), which is by far the largest branch of the dorsal aorta, leaves opposite the 5th vertebra. It is practically a continuation of the left radix. It immediately gives off the large left anterior gastric artery (*C*), and then runs back for about 40 mm. close to the midline before branching. The artery supplies the whole of the alimentary canal behind the pylorus. Its branches are treated in order.

C. The left anterior gastric artery (Figs. 4 and 8) runs ventrally for about 5 mm. before dividing symmetrically into three branches (*D*, *E*, *F*) (Figs. 4, 5 and 8).



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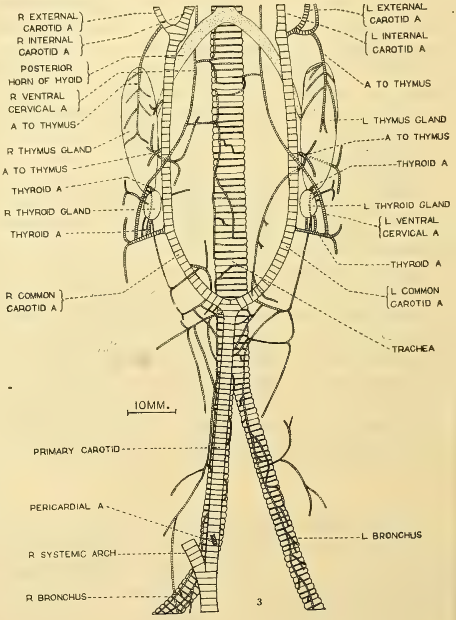

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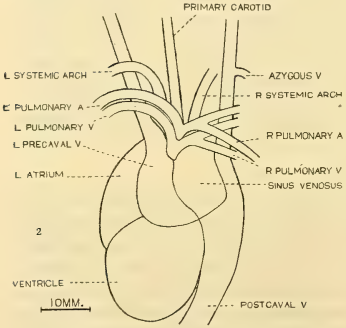

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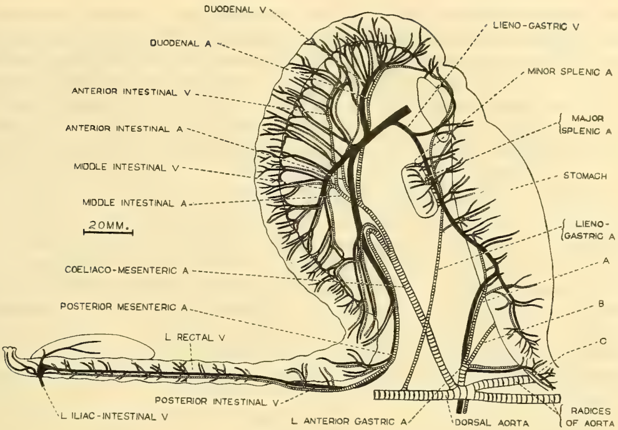
Fig. 1.—Heart. Ventral view. Dashes indicate position of lobes of liver.
Fig. 2.—Heart. Dorsal view.
Fig. 3.—The carotid arch as far forward as the hyoid. Ventral view.

D. The anterior oesophageal branch serves the posterior part of the oesophagus on the left side.

E. The middle gastro-hepatic branch passes to the opposite side of the stomach, where it forks into three. One runs a short distance along the lesser curvature of the stomach. A branch from it supplies the right posterior part of the oesophagus opposite to *D.* The third branch enters the anterior tip of the left lobe of the liver.

F. This branch supplies the anterior half of the stomach along the greater curvature.

G. The posterior mesenteric artery (Fig. 4) is the first offshoot of the coeliaco-mesenteric. Almost at once it gives off a large posterior mesenteric branch and—still running in the mesentery—four more branches to the posterior intestine before entering



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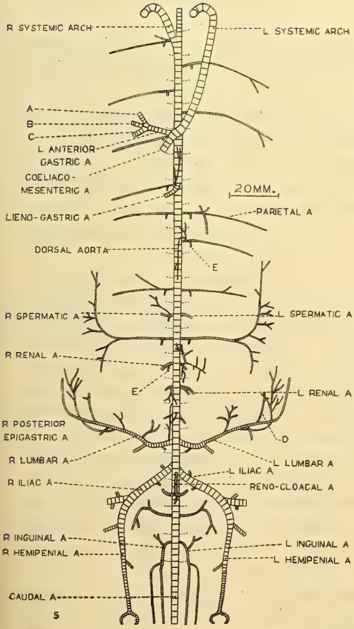

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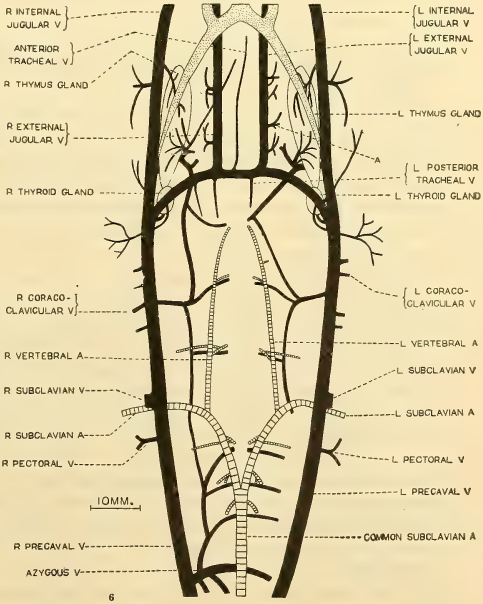

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Fig. 4.—The main arteries and veins of the viscera. View from the left side with the duodenum lifted vertically until the alimentary canal is straightened out. *A*, cardiac branch of left anterior gastric artery. *B*, gastro-hepatic branch of left anterior gastric artery. *C*, anterior oesophageal branch of left anterior gastric artery.

Fig. 5.—Ventral view of the dorsal aorta showing the origin of the principal branches. *A*, anterior oesophageal branch of left anterior gastric artery. *B*, gastro-hepatic branch of left anterior gastric artery. *C*, cardiac branch of left anterior gastric artery. *D*, left branch to fat body from lumbar artery. *E*, vertebral branch.

Fig. 6.—The precaval veins and their tributaries: also branches of the common subclavian artery. Ventral view. *A*, oesophageal veins of external jugular vein.

the coat of the rectum near the point of emergence of the rectal veins. As the rectal artery it then runs back to the cloaca, sending many small twigs into its walls.

H. The next branch, the middle intestinal artery (Fig. 4), supplies by far the greater part of the intestine, sending about two dozen main branches into its walls.

I. The anterior intestinal artery, which is given off practically simultaneously with the middle, is a long but comparatively unimportant vessel.

J. The remaining branch of the coeliaco-mesenteric artery is the large duodenal. It sends an offshoot to the pyloric region.

K. The lieno-gastric artery (Figs. 4 and 5) is given off opposite the 7th vertebra. It crosses the coeliaco-mesenteric artery dorsally and runs into the gastro-splenic mesentery. It sends two large branches into the left side of the stomach about half-way along its length before a minor artery to the spleen. A third gastric branch leaves on the opposite side to the main splenic artery, which bifurcates before entering the gland. A large branch is now given off which divides into a second minor splenic artery, two further gastric arteries and a pyloric artery. The main vessel next runs round to the opposite side of the stomach near the anterior end of the pancreas. It immediately divides into hepatic (*L*), pancreatic (*M*), and anterior gastric (*N*) arteries (Fig. 8).

L. The hepatic artery runs nearly parallel to the hepatic portal vein and enters the liver close to it between the two lobes.

M. The pancreatic artery enters the pancreas a few millimetres from its origin and ramifies through the tissue.

N. The anterior gastric artery closely parallels the anterior gastric vein, giving off almost identical branches along practically the whole of the stomach along the lesser curvature.

O. The spermatic arteries (Fig. 5) come off symmetrically on opposite sides of the aorta opposite the 12th vertebra. The right artery then inclines slightly forward and the left back. They supply the suprarenal glands as well as the testes.

P. The parietal artery (Fig. 5) opposite the 13th vertebra is considerably enlarged and sends many branches to the dorsal and lateral body wall.

Q. The right renal artery comes off opposite the 14th vertebra, and the left opposite the 15th.

R. The lumbar artery (Fig. 5) is the much enlarged parietal opposite the 17th vertebra. The usual vertebral branch is given off on the left side, and then a large posterior vessel which runs round the pelvis near the acetabulum and is distributed to the proximal preaxial and dorsal thigh muscles. The next branch is anterior, supplying a rather small area of body wall, and the posterior fourth runs dorsally to the posterior epigastric and then forward to serve a large superficial area of the back and side. The fifth is short, going to the dorsum of the thigh and a small section of back adjoining. The important sixth supplies the whole of the fat body on the left side. This single source of supply is in striking contrast to the profuse venous system of the same body. The main vessel runs laterally and then forward as the posterior epigastric artery to parallel the left lateral abdominal vein and a branch of it, the median abdominal vein. Many small branches extend out at right angles. Craniad small branches from the posterior epigastric artery and the pericardial artery anastomose.

The right artery is similar to the left except that there are two extra anterior twigs and no branch to the median abdominal vein.

S. The large common iliac arteries (Fig. 5) are given off opposite the 18th vertebra. Each passes outward and slightly backwards from the aorta over the dorsal side of the pelvis. Only the vertebral branch and a small vessel to the dorsal muscles are given off before it runs just posterior to the hip joint and almost simultaneously splits into five branches. The hemipenial arteries derived from the iliacs may be mentioned here.

T. The reno-cloacal artery (Fig. 5) leaves the aorta mid-ventrally between the iliacs. It divides and sends a branch to the rear end of each kidney. These run forward to meet the anterior renal arteries. A third branch passes ventrally between the posterior lobes of the kidneys to the dorsal side of the cloaca.

U. The artery opposite the 20th vertebra is quite large and branches repeatedly to the proximal postaxial muscles of the thigh.

V. Inguinal arteries come off opposite the 21st vertebra. They supply the area about the groin and hemipenial sheaths and anterior caudal muscles.

W. The dorsal aorta (Fig. 5) then passes into the haemal arches as the caudal artery. Small paired parietal arteries are given off to the tail muscles.

The Common Subclavian Artery (Text-fig. 6).

The common subclavian artery (Fig. 6) comes off from the right radix of the systemic arch and runs forward in the midline. It gives off a vertebral branch on each side and then bifurcates about 35 mm. in front of its origin. Each branch is similar. After sending off two combined vertebral and parietal branches as it diverges laterally, the artery forks into the vertebral and subclavian arteries. The subclavian as the main branch turns rather abruptly laterally and ventrally and passes just dorsal to the subclavian vein into the forelimb. The vertebral artery sends two branches to the vertebral column before it enters it about the level of the bifurcation of the jugular veins.

The Precaval Veins (Text-figs. 1, 2 and 6).

The right and left precavals (Figs. 1, 2 and 6) are wide, stout trunks. The left comes in asymmetrically through the pericardium, running obliquely over the dorsal surface of the left atrium towards the right, where it joins the sinus venosus. The right is nearly in a line with the postcaval vein, running almost directly backwards over the right dorsal surface of the right atrium to join the sinus venosus about the base of the postcaval. The left precaval is joined on the dorsal side by the large azygous vein (*A*) about 20 mm. in front of the heart. For the rest of their course the precavals are symmetrical, so only one will be described. The comparatively small pectoral vein (*B*) comes in 50 mm. in front of the heart. Only 5 mm. further on the very large subclavian vein (*C*) extends out at right angles. Four veins (*D*) are next received laterally and between them a large vein (*E*) comes in from the dorsal side. The precaval runs in a deep groove from the pectoral vein to the anteriormost of these veins. It then leaves the body wall and runs slightly medially. A short but quite stout thyroid vein enters practically at the junction with the large external jugular vein (*F*), which is little smaller than the internal jugular (*L*).

A. Veins of the azygous system (Fig. 6) drain practically the whole of the costal and vertebral areas although the azygous vein itself is only present on the right side. The left side is served by branches running over the vertebral column. The whole system may be divided into three parts (1–3).

1. The section of the azygous vein proper. Branches extend both back and forward as well as to the common jugular and internal jugular veins. The main branches fail about the sixth intercostal space, but small factors probably extend into the next section.

2. Five large veins from the intercostal spaces backward from the level of the origin of the lieno-gastric artery feed a large trunk which runs directly ventrally to enter the postcaval lobe of the liver.

3. There appear to be four tributaries to the trunk which runs into the spermatic vein just before its junction with the efferent renal vein.

There appears to be a small fourth vein running in near the anterior tip of the liver.

B. The pectoral vein (Fig. 6) soon forks, receiving branches from the ventro-lateral body walls.

C. The subclavian vein (Fig. 6) drains practically the whole of the forelimb. The subclavian artery runs over it dorsally.

D. The four coraco-clavicular veins serve the ventral and lateral sectors of the shoulder girdle and receive branches from the scapular and dorsal area. The large anterior vein of the four has two main tributaries from the proximal preaxial muscles of the forelimb and the other from the dorsal neck muscles.

E. This large vertebral vein connects anteriorly indirectly with the internal jugulars and posteriorly with the azygous vein.

F. The external jugulars (Fig. 6) immediately sweep inwards and form a very wide, band-like loop. The two main veins then run directly forward and pass over the hyoid. Near the base of the basihyal they make another prominent anastomosis and at the same place receive the large loops of the lingual veins. The left external jugular may be a trifle smaller than the right, but the difference is hardly noticeable. Its tributaries (*G–K*) are now noted (Fig. 6).

G. A large cutaneous vein comes in from the anterior superficial muscles and skin.

H. This vein serves much the same purpose as the preceding, but a more posterior area. It runs ventrally under the thyroid and then dorsally over the common jugular.

I. Two posterior tracheal veins serve the trachea behind the jugular anastomosis.

J. A single large anterior tracheal vein drains the ventral surface of the trachea at least as far forward as the basihyal.

K. Short stout oesophageal veins come in at short intervals from the oesophagus.

L. The internal jugular vein (Fig. 6) receives a very stout tributary (*M*) just before its junction with the external jugular. Another large vein (*Q*) comes in 15 mm. anteriorly just after the anterior thymus veins (*R*).

M. This stout vein runs dorsally over the thymus to its median side, where it divides into three branches (*N–P*) (Fig. 6).

N. A large vertebral vein connects with the azygous system and runs dorsally over the external jugular.

O. The largest tributary is received from the powerful dorsal neck muscles.

P. The posterior thymus veins drain a highly branching network over the gland.

Q. This vein with three main tributaries comes from the lateral and ventral muscles of the neck.

R. The anterior thymus vein is fed by numerous quite substantial tributaries. It comes mainly from the ventral surface of the gland.

The System of the Postcaval Vein (Text-figs. 1, 2 and 7).

The postcaval vein, which is a large, thin-walled vessel, is not free caudad to the liver, being formed by the union of the two efferent renals (*A*, *B*) (Fig. 7) at the extreme posterior edge of the postcaval lobe of the liver. It remains visible through the rather leaf-like lobe until it reaches the main right lobe. From then on it cannot be seen until it emerges at the anterior end about 15 mm. to the right of the midline. During its course it bends from the postcaval lobe until it is close to the right margin of the liver and then swings back again to the point where it emerges. Only about 5 mm. is free before it enters the sinus venosus. The walls of the postcaval are riddled with tiny openings of veins running from the substance of the liver. It also receives two large hepatic trunks (*C*, *D*).

A. The left efferent renal vein (Fig. 7) begins in a wide anastomosis with its fellow near the posterior end of the kidney, where it receives a short, but stout, tributary from the posterior lobe. From the start it is a large, thin-walled vessel running forward on the median and ventral face of the left kidney separated from the right efferent renal vein by the dorsal mesentery. It is fed by numerous, short, comparatively stout renal factors from the substance of the kidney. Small, very thin veins run in at irregular intervals from the mesentery. The junction with the large spermatic vein (*E*) is near the anterior tip of the kidney. Two smaller spermatic veins (*F*) are received from the posterior and anterior ends of the left testis. The vein then runs forward about 15 mm. before swinging right to pass through the mesentery to the postcaval lobe.

B. The right efferent renal vein is similar in diameter to its fellow, but shorter and straighter, running just to the right of the midline almost directly forward to the postcaval lobe. Its connections with the spermatic veins are more anterior because the right testis is more advanced craniad than the left.

C. The large left hepatic vein (Fig. 7) receives branches from all parts of the left lobe of the liver and joins the postcaval just as it is leaving the right lobe.

D. The right hepatic vein is smaller than the left probably because of the large amount of direct drainage into the postcaval. Its branches are most diffuse. It joins the postcaval nearly 20 mm. behind the point of entry of the left hepatic vein.

E. Each main spermatic vein (Fig. 7) is about 25 mm. long. It begins at the anterior end of the testis and runs back between it and the respective efferent renal vein to join about the level of the posterior end of the testis. It practically covers the suprarenal gland ventrally, receiving many small vessels from it. Two or three largish veins and many very small ones join it from the testis as well as a large one from the body wall.

F. The smaller spermatic veins on each side appear somewhat irregular, either running direct to the efferent renal vein and remaining quite distinct from the main spermatic, or else partly anastomosing with it.

System of the Caudal Vein (Text-figs. 7, 9 and 10).

The caudal vein (Fig. 7) is very long, extending practically the full 790 mm. length of the tail, the muscle segments of which contribute small paired factors. It runs forward in the haemal arches ventral to the caudal artery and leaving them divides cleanly and symmetrically into two afferent renal veins (renal portals) (*A*) 10 mm. behind the posterior tips of the kidneys.

A. Each afferent renal vein immediately receives a large vessel (*B*) (Fig. 10). At the level of the posterior end of the kidneys it is crossed by the prominent iliac-intestinal vein (*F*), to which it is joined by an extremely short trunk. The afferent renal vein (Fig. 7) does not enter its corresponding kidney at its extreme posterior tip but about 6 mm. forward. It at once occupies a wide groove, which extends almost to the anterior end of the kidney and contains the vein snugly. The large, thin-walled vessel hardly tapers at all and appears to act as an always-filled reservoir for the branches into the kidney substance. Besides smaller veins, about 13, short, thick interlobular veins are given off between each lobe of the kidney and each one branches repeatedly into the lobes on each side. A thin septum, concealed ventrally by the vas deferens, separates the afferent renal veins.

B. The inguinal vein is made up of three main branches (Fig. 10).

C. A rectal vein comes in 5 mm. from the afferent renal vein. It drains the ventral side of the rectum near the cloaca, and receives small branches from connective tissue about the cloaca, posterior end of the kidneys and vas deferens.

D. A large vertebral branch joins 5 mm. from the rectal vein.

E. This comparatively long vein has branches from the groin, the more anterior ventral tail muscles and the median side of the hemipenial sheath.

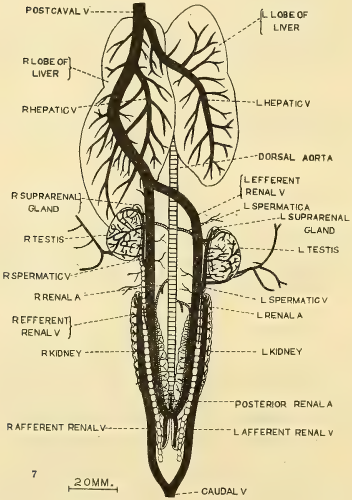
F. There appears to be no doubt that each afferent renal vein is a direct continuation of the corresponding branch of the caudal vein (Figs. 9 and 10). The large iliac-intestinal vein about 12 mm. long, joining the posterior end of the intestinal vein and the iliac vein, runs across it laterally nearly at right angles. There appears to be an extremely short trunk joining them rather than a four-way joint.

The Hepatic Portal System (Text-figs. 4, 8, 10, 11 and 12).

The hepatic portal vein (Fig. 8) is a wide trunk about 20 mm. long formed by the union of the anterior abdominal vein (*A*), the extension of which it appears to be, and the intestinal vein (*C*). It enters the liver at the extreme margin of the right lobe near the gall bladder and is mainly distributed by three large branches to the right lobe and one to the left.

A. The anterior abdominal vein is formed by the junction of the pelvic veins at the anteriormost point of the pelvic ring (Fig. 10). It runs from the midline slightly towards the left until it joins the intestinal vein about level with the craniad tip of the pancreas. It has only one tributary, the pancreatic vein (*B*).

B. Five veins with three separate sources of supply go to initiate the pancreatic vein (Fig. 8). The three anterior veins run from the stomach, in the line of the anterior gastric vein, through the pancreas. The fourth vein is a branch of the lieno-gastric and the fifth a branch of the duodenal vein. The fourth and fifth run from the opposite side of the stomach to the first three. The five veins are joined by small factors from the pancreas as they run through that gland. They form anterior and posterior branches which leave the pancreas separately but immediately join and run as a single vessel direct to the anterior abdominal.



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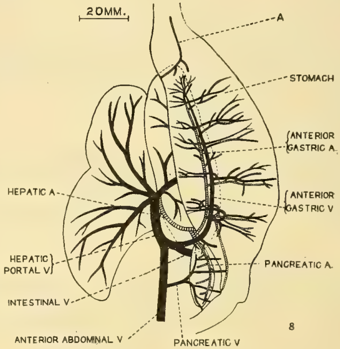

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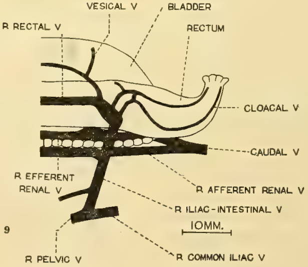

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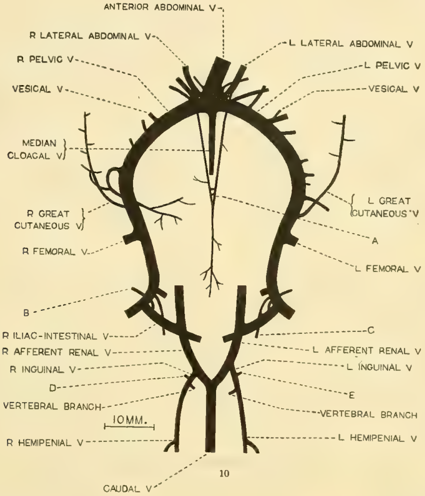
Fig. 7.—The systems of the caudal and postcaval veins. Ventral view.

Fig. 8.—Anterior relationships of the hepatic portal vein, also anterior gastric, hepatic and pancreatic arteries. The left lobe of the liver overlies the stomach as far as the dotted line, but it is only drawn as far as the right margin of the stomach to show the vessels it overlies. Ventral view. *A*, gastro-hepatic branch of left anterior gastric artery.

Fig. 9.—Detail of the relationships of the iliac-intestinal vein. View from right side.

C. The intestinal vein (Fig. 4) is formed by the union of the two rectal veins (*D*). It is from its origin a large, thin-walled vessel running in the mesentery. Its tributaries may be divided into (*E*), four fairly short, but important, independent veins draining the anterior section of the rectum and the portion of the intestine immediately adjoining, the large posterior intestinal vein (*F*), the still larger middle intestinal vein (*G*), a smaller anterior intestinal vein (*H*), (*I*) the duodenal vein equal in size to the middle intestinal, (*J*) the lieno-gastric, and finally just before joining the anterior abdominal the anterior gastric (*L*).

D. The rectal veins (Figs. 4 and 9) are both symmetrical, running along opposite sides of the rectum. They have most interesting origins in quite large, flask-shaped sacs on the right and left sides of the rectum about 15 mm. in front of the cloaca. A large vein runs from each sac directly dorsally to join the pelvic ring. The vein is joined by the now split caudal vein where it gives rise to the afferent renal vein.



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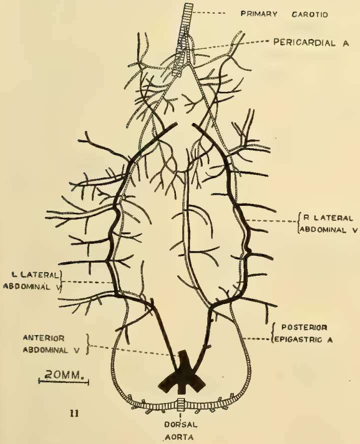

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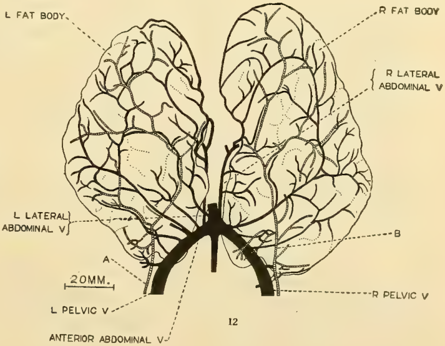

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Fig. 10.—Veins of the pelvic ring. Ventral view. *A*, cloacal branch of the left abdominal veins. *B*, branch of iliac-intestinal vein from superficial pelvic muscles. *C*, branch of iliac vein from dorsum of thigh. *D*, right rectal branch of inguinal vein. *E*, left rectal branch of inguinal vein.

Fig. 11.—The lateral and median abdominal veins. Also branches of the posterior epigastric and pericardial arteries. Dorsal view.

Fig. 12.—Relationships of the fat bodies to their blood supply. Dorsal view.

Each sac is joined by two comparatively large cloacal veins from the anterior and posterior lips of the cloaca. These veins anastomose into a ring and join the sac as a single vessel on the left side, but have separate entries on the right side after an anastomosis. There are also tributaries from the walls of the bladder and the posterior part of the rectum near the cloaca. After running forward for a little more than 100 mm., receiving numerous, wide, short tributaries from the rectum, the rectal veins converge and unite to form the intestinal vein as it enters the mesentery.

E. These four mainly anterior rectal veins (Fig. 4) extend over a length of 120 mm. along the alimentary canal. The posterior two are quite short, but the anterior two are longer and run a considerable distance in the mesentery before they reach the alimentary canal.

F. The posterior intestinal vein (Fig. 4) flows in close to the place where the coeliaco-mesenteric artery branches. It is formed by three main trunks which again are fed by about nine main tributaries from the intestine.

G. The middle intestinal vein comes in more than 30 mm. from the posterior. It is fed by six main branches formed by about two dozen smaller factors from the intestine.

H. The anterior intestinal vein, joining close to the middle intestinal vein, has two main branches and six or seven smaller tributaries.

I. The duodenal vein (Fig. 4) is very large. Tributaries from the duodenum form nine big veins which flow more or less direct into the main trunk. The most anterior vein has a branch from the pancreas. The duodenal and three intestinal veins are all joined by a continuous vessel about 320 mm. long formed by short loops, which runs from the pylorus to the posterior end of the intestine. There is also a conspicuous anastomosis between the main branches of the duodenal and anterior intestinal veins and again between the middle and posterior intestinal veins.

J. The lieno-gastric vein (Fig. 4) originates in a ramification of small vessels at the anterior extremity of the cardiac part of the stomach on the opposite side to the beginnings of the anterior gastric vein. After running about 40 mm. and receiving four or five stout tributaries from the stomach it is joined by a large vein from the azygous system. This vein is again joined near the level of the dorsal aorta by an important one from the posterior part of the oesophagus. The gastric vein receives a few other tributaries and then 20 mm. back becomes free of the stomach and runs in the gastro-splenic mesentery. It receives about eight small factors from the spleen on one side and three large gastric factors on the other. After its junction with the pyloric vein (*K*) the lieno-gastric vein runs a short distance to join the main intestinal vein about 10 mm. after the duodenal.

K. The pyloric vein connects through the pancreas with the pancreatic vein. The pancreatic branch continues along the lesser curvature of the pylorus and after being joined by a large gastric factor is a prominent vessel by the time it reaches the lieno-gastric.

L. The anterior gastric vein (Fig. 8) starts from a small group of vessels near the anterior end of the stomach and quickly increases in size as it runs backward in the gastro-hepatic omentum. It is just lapped ventrally through practically its whole course by the edge of the left lobe of the liver. It is fed by nine large veins which run transversely across the ventral and the greater part of the lateral walls of the stomach as far back as the duodenum. These tributaries are paired anteriorly where the gastric vein runs in the coat of the stomach, but further back, where the main vein becomes free, they have short common trunks. The posterior tributary receives a branch from the pancreas. Just as the anterior gastric vein reaches the level of the pancreas, from which comes a second branch direct, it turns sharply medially and, still concealed from ventral view by the posterior lobe of the liver, joins the large intestinal vein just before its junction with the anterior abdominal vein.

The Pelvic Ring (Text-figs. 8, 10, 11 and 12).

The pelvic ring may be taken as beginning with the symmetrical forking of the caudal vein to form the two afferent renal veins (Fig. 10). Each afferent renal vein almost immediately receives the inguinal vein with its vertebral, rectal and hemipenial branches. The vein then flows forward to the kidney. It is crossed almost at right angles by the iliac-intestinal vein, which connects the common iliac vein by way of the rectal vein with the intestinal system. Blood can either leave or enter the afferent renal vein through its connection by a very short trunk with the iliac-intestinal vein. Just before meeting the common iliac the iliac-intestinal is joined by a vessel from the superficial ventral pelvic muscles. Two branches, one vertebral and the other from the proximal dorsal thigh muscles, run into the common iliac, which now passes forward and laterally as the pelvic vein. The next tributary is the large femoral from the preaxial and dorsal sides of the thigh. About 5 mm. forward the great cutaneous vein joins. It can be traced forward in the muscles of the dorso-lateral body wall to the axillary region. The pelvic vein now turns medially to join its fellow in the midline and form the anterior abdominal vein (Fig. 10). Before the junction it receives about eight tributaries from the body wall, the ventral pelvic region and the fat bodies as well as a vesical vein (Figs. 10 and 12). The lateral abdominal veins start on each side of the anterior abdominal vein (Fig. 11). They run forward, each receiving a large vessel which serves as the main drainage of the fat bodies. Numerous small tributaries run in from the superficial ventral area. The right lateral abdominal vein gives off a median branch which forms a loop to rejoin near the front of the liver (Fig. 11). Each vein enters the liver at the anterior end of its respective lobe. A branch running forward on each side joins the right and left precavals. Each lateral abdominal vein near its origin is joined by long thin veins running from the anterior lip of the cloaca. They are independent of the stout, median cloacal vein. The anterior abdominal vein is joined by two or three small veins near its base and from then on receives only the pancreatic vein before merging with the intestinal vein to form the hepatic portal vein (Fig. 8).

The Pulmonary Vessels (Text-figs. 1 and 2).

The pulmonary arch is the most posterior and dorsal of the three. It bifurcates immediately close to the heart. The right artery has a reasonably direct path to the right lung, but the left is forced out widely to pass under the stomach. Just as it enters the lung each artery splits into anterior and posterior branches. The posterior branch runs back about 40 mm. along the median ventral surface to the tip of the lung. The anterior branch runs forward about 110 mm. to the anterior tip. Both main branches send out a rich system of small arteries which ramify through the lung.

There appears to be no trace of a ductus arteriosus (ductus Botalli). The radices of the systemic arch have been searched as well as the pulmonary arch.

The pulmonary veins follow paths in the lungs almost identical with those of the arteries, leaving the lungs just laterally to the arteries. They open by a single very short trunk into the dorso-medial border of the left auricle about half-way back.

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The main part of my address consists of a bibliography of Australian herpetological literature published since 1920 accompanied by a short review of work done during that time. I apologize in advance for many inevitable omissions.

I have been arbitrary in taking 1920 as the date to begin my survey of recent Australian herpetology, but may justify it as an approximate turning point from the older more static view of this branch of zoology. The newer viewpoint takes into account ecological and geographical factors as well as a more fluid concept of species, which is best expressed for the taxonomist in the modern concept of races or subspecies rather than hard and fast species.

The last 33 years of research on Australian reptiles and amphibia may best be outlined by describing in some detail the publications of four men whose works form the landmarks of Australian herpetology in that time. I refer to J. R. Kinghorn, of the Australian Museum, Arthur Loveridge, of the Museum of Comparative Zoology, Cambridge, Massachusetts, Heber A. Longman, of the Queensland Museum, and H. W. Parker, of the British Museum (Natural History).

Considerations of space preclude a full discussion of Kinghorn's work, but the more important of his activities can be noted briefly. Nearly every one of his many papers contains some important contribution towards tying up loose ends left by earlier herpetologists. His work outside Australia in the Solomons and New Guinea does not come within the scope of this survey, but its value may be noted here.

In 1920 Kinghorn published a comprehensive paper on the snake *Denisonia suta* Peters. Six well developed young in the oviducts of a snake captured at Willow Tree by W. W. Froggatt furnished a dramatic proof of the identity of *Denisonia frontalis* (Ogilby) with *D. suta* because the young snakes possessed among them the contrasted characteristics by which the two supposed species had been separated. *D. stirlingi* (Lucas and Frost), *D. frenata* Boulenger and *D. frontalis* var. *propinqua* De Vis were also united with *D. suta*. Next year he clarified the position of several snakes. He redescribed *Notechis ater* (Krefft) from the holotype, clearing up errors in the original description. *Notechis scutatus niger* was described as a new race from Deep Creek, Kangaroo Island. *Denisonia ornata* Krefft and *Dendrelaphis schlenckeri* Ogilby were sunk in the synonymies of *Denisonia maculata* (Steindachner) and *Dendrophis calligaster* Günther respectively. A full discussion was given of *Pseudechis mortonensis* De Vis, and Willow Tree is noted as its first locality record in New South Wales.

In 1923 he erected the genus *Oxyuranus* to accommodate the taipan and wrote, "*Oxyuranus* differs consistently from all allied genera by the extension of the maxillary beyond the palatine; by the peculiar anterior process of the palatine; the narrow anterior portion of the parietal; the strongly developed postfrontals; the fewer palatine and pterygoid teeth and the enlarged mandibular tooth. The same year he published a review of the Western Australian genera *Aprasia* and *Ophioseps*, restricting them to the three species *Aprasia pulchella* Gray, *A. repens* Fry, and *Ophioseps nasutus* Bocage. *Varanus boulengeri* was also described as new from Queensland, the type from Coquet Island and two paratypes from Townsville.

An annotated list dealt with eight forms of snakes, 39 of lizards and 13 of frogs collected in South Australia and Western Australia in 1920 by E. le G. Troughton, J. H. Wright, A. F. Basset Hull and H. S. Grant. Five specimens of *Leiolepisma guichenoti* Duméril and Bibron from Kangaroo Island form the first record I have been able to find of the occurrence of the lizard in South Australia.

Continued interest in the legless lizards led in 1924 to a review of the genus *Lialis* Gray, and culminated two years later in an excellent and comprehensive revision of the whole family Pygopodidae. All available specimens were assembled and thorough comparisons were made. Each species of the genera *Pygopus, Delma, Paradelma, Ophidiocephalus, Pletholax, Ophioseps, Aprasia* and *Lialis* was discussed. The new genus *Paradelma* was erected to include the former *Delma orientalis* Günther from Peak Downs and Gayndah, both in Queensland. However, the text should be followed instead of the faulty key for *Delma* as pointed out by Loveridge (1934: 315 and 316). Valuable work in clarifying the position of our snakes was added to in 1926 when he synonymized *Pseudelaps minutus* Fry with *Denisonia coronoides* (Günther).

He erected the genus *Lucasius* when he examined paratypes and topotypes of *Ceramodactylus damaeus* Lucas and Frost from Charlotte Waters, Central Australia, and other specimens from Perth, Ooldea and Pooncarie, and found that the species was not referable to *Ceramodactylus* Blanford or *Diplodactylus* Gray. An examination of 70 specimens led him to sink *Diplodactylus polyothalmus* Günther into the synonymy of *D. vittatus* Gray. *Diplodactylus strophurus* Duméril and Bibron was revived from the synonymy of *D. spinigerus* Gray to which it had been relegated by Zietz (1920: 185). He notes that *D. strophurus* has a shorter and deeper head than *D. spinigerus* and that the dorsal tubercules do not resemble spines. *D. ciliaris* Boulenger and *D. intermedius* Ogilby remain in the synonymy. Series of *Diplodactylus hilli* Longman, *D. conspicillatus* Lucas and Frost and *D. platyurus* Parker were compared and the decision reached that the only conspicuous differences were in the variable body scaling.

In Herpetological Notes No. 2 of 1931 he figures *Demansia guttata* Parker and *Rhinhoplocephalus bicolor* Mueller for the first time, notes other snakes, and describes two new races of the lizards *Egernia whitei* and *Tiliqua occipitalis.* The mating ceremonial of the Bearded Dragon *Amphibolurus barbatus* Cuvier is detailed, and interesting locality records, extending the ranges of snakes, lizards and frogs, are given for Groote Eylandt, Hinchinbrook Island, Cape York and other parts of Queensland. Later in the year he described a new snake *Rhynchoelaps roperi* collected near the Roper River, North Australia, by K. Langford Smith; and a new gecko *Heteronota walshi* from Boggabri, New South Wales.

Kinghorn in 1932 noted that *Typhlops leonhardi* Sternfeld was synonymous with *T. endoterus* Waite. Both were collected at Hermannsburg, Central Australia. The snake *Stegonotus modestus* Duméril and Bibron, of the Moluccas and Papuasia, was definitely recorded from Australia when two specimens were collected at Rocky River, near Coen. Another Queensland specimen from Ripple Creek, near Cardwell, had been in the Australian Museum collection since 1897, but the locality was in doubt. New subspecies *Sphenomorphus isolepis foresti* from Forest River, Western Australia; *Sphenomorphus tenuis intermedius* from the North Coast of New South Wales; and *Sphenomorphus quoyi kosciuskoi* from Mount Kosciusko were described. *Tympanocryptis cephalus* Günther was retained as a subspecies of *T. lineata* Peters. Ecological notes were added on *Moloch horridus* Gray, *Limnodynastes tasmaniensis* Günther, *Myobatrachus gouldii* Gray and *Hyla citropus* Günther. Information on colour, colour changes, mating and distribution of the *Hyla* was especially valuable.

In 1939 he discussed differences between the closely allied genera *Glyphodon* and *Aspidomorphus*, described *Glyphodon barnardi* as new and redescribed and figured *Denisonia muelleri* Fischer for the first time. Both snakes were collected at Coomooboolaroo Station, 15 miles south of Duaringa, Queensland.

Typhlops yirrikalae [nearest relative *T. nigrescens* (Gray)] from Arnhem Land was described as new in 1942. Examination of a large series of specimens led to the confirmation of Loveridge's action in reducing *Demansia olivacea* and *D. torquata* to the synonymy of *D. psammophis* (Schlegel), and to the addition of *D. ornaticeps* (Macleay) to the list. Four other snakes were considered. Extreme variation in the markings and scalation were demonstrated for the gecko *Oedura marmorata* Gray, and *O. tryoni, O. fracticolor, O. ocellata, O. cincta, O. monolis, O. castelnaui* and *O. meyeri* were placed in its synonymy. Kinghorn in 1945 reported on the collections of the Simpson Desert

Expedition of 1939. H. O. Fletcher was in charge of the biological collecting, which produced 120 specimens, comprising 18 genera, 20 species of lizards, three of snakes and one frog.

Kinghorn's handbook, the "Snakes of Australia" was published in 1929 with 137 drawings in colour by Ethel A. King. It is the only recent authoritative book on the same field, and it is a great pity that it is out of print. One hopes that it will be republished and brought up to date so as to include the important findings of Loveridge, Kinghorn himself, and others. In 1943 he published in conjunction with C. H. Kellaway a valuable small guide "The Dangerous Snakes of the South-West Pacific Area", which was widely circulated among the Australian and United States armed forces. The title indicates its contents. *Oxyuranus* was retained as a separate genus and separated from its nearest relatives by possessing 21 or 23 rows of keeled scales at midbody, an undivided anal, and one or two small teeth behind large fangs.

In concluding this short review of Kinghorn's work, I can safely take it upon myself to thank him on behalf of all herpetologists for unselfish and ever ready assistance.

Our greatest debt to Loveridge is for his catalogues of Australian and New Guinea reptiles and amphibians in the Museum of Comparative Zoology at Harvard College, Massachusetts. Discussion of 267 forms of crocodilians, chelonians, snakes and lizards, and 78 species or races of frogs (of a total of 88 known then) shows the comprehensiveness of the two Australian catalogues. But their main value is in the analytical approach to the whole question of Australian systematics. Dealing with the reptiles, five species and three races were described as new, including *Nephrurus wheeleri*, *Amphibolurus darlingtoni*, *Sphenomorphus schevilli*, *Rhodona nichollsi* and *Lygosoma darlingtoni*. Eight species of lizards and snakes were revived from synonymy, among them *Typhlops nigrescens* (Gray), the common blind snake around Sydney, from *polygrammicus* (Schlegel) from Timor. Important contributions were made towards clearing up the status of the Brown and Whip Snakes; *Lycodon reticulatus* and *L. olivaceus*, both of Gray, were reduced to races of *Demansia psammophis* (Schlegel), and *Pseudonaja nuchalis* Günther and *P. affinis* Günther to races of *Demansia textilis* (Duméril and Bibron). Five species of lizards were regarded as subspecies.

Loveridge's onslaught on synonyms shortened the list of Australian species by at least one of chelonians, 10 of snakes and 65 of lizards. I am confident that only a very few (such as *Hemiergis initiale* Werner) will be revived. Wealth of experience has enabled him to compare analogous ranges in the variation of Australian snakes with those of exotic genera, such as *Leptophis* with *Dendrophis*, and *Prosymna* with *Rhynchoelaps*.

On one small point I cannot agree with his use of the name *Ablepharus lineoocellatus anomalus* for New South Wales and other eastern skinks. Gray's *Morethia anomalus* was described from Western Australia. This usage would mean that the type locality of the eastern skinks would be within the range of the western race of *Ablepharus lineoocellatus*.

All local frogs known in 1935 are listed and all but ten of them discussed in Loveridge's catalogue of amphibia, which is for all practical purposes the only handbook covering the whole class in Australia. His "New Guinean Reptiles and Amphibians" issued in 1948 is the most comprehensive modern treatment of the area and its importance is acknowledged here because of discussions of forms common to New Guinea and Australia, for example *Gymnodactylus pelagicus* (Girard), *Leiolepisma fusca* (Duméril and Bibron), *L. bicarinata* (Macleay), *L. novaeguineae* (Meyer), *Ablepharus boutonii* (Desjardin), *Chondropython viridis* (Schlegel), *Natrix mairii* (Gray) and *Hyla bicolor* (Gray).

Loveridge's 17 papers on the Australian fauna include his description in 1945 of a new species of blind snake *Typhlops tovelli* from Koonowarra Sports Ground, seven miles from Darwin. The snake is near *T. broomi* Boulenger from Muldiva, north-east Queensland, of which it may be a subspecies. In 1949 he dealt with T. R. Tovell's collection made within 60 miles of Darwin of seven snakes, 16 lizards and eight frogs. Next year he described as new *Cyclorana slevini*, near *C. australis* (Gray) from Noondoo, South Queensland, *Hyla kinghorni*, near *H. latopalmata* Günther; and *Hyla aurea ulongae*. The latter two are from Ulong, west of Coff's Harbour. A key is given for the four races of *Hyla aurea*. Other papers include treatment of the snakes *Pseudechis australis* (Gray) and *Fordonia papuensis* Macleay; new lizards of the genera *Nephrurus, Amphibolurus, Physignathus, Sphenomorphus, Rhodona* and *Lygosoma*; seven new Crinine frogs; and a review of the frogs of Tasmania.

It is unfair to leave our review of Loveridge's work without paying tribute to P. J. Darlington and W. E. Schevill, an entomologist and a geologist, who collected so many specimens on which Loveridge based his papers. Their contributions towards the collection of the Museum of Comparative Zoology totalled at least 1500 reptiles and frogs.

Most of Longman's work on living reptiles preceded 1920 and our main concern is with his activities as a vertebrate palaeontologist. Much of his work in this field dealt with fossil mammals, which again must be excluded, so that we are restricted to his research as a palaeoherpetologist. His most spectacular work was perhaps the description of Australia's only well known dinosaurs. There had been three previous records of these reptiles in Australia, but they had been based only on fragments. H. G. Seeley described *Agrosaurus macgillivrayi* from the north-east coast, and A. Smith Woodward an ungual phalange of a carnivorous dinosaur from Cape Patterson, Victoria, and a tooth and a posterior caudal vertebra of a small Megalosaurian from Lightning Ridge. Longman's first species was *Rhoetosaurus brownei* from Durham Downs, near Roma. The description was mainly based on 22 vertebrae. The gigantic herbivorous Jurassic dinosaur was probably more than 40 ft. long. Material recovered later enabled the reconstruction of a 5-ft. femur. A second dinosaur *Austrosaurus mckillopi*, which was found on Clutha Station, near Maxwelton, in 1932, came from the Cretaceous and was about 50 ft. long.

In 1922 he described in detail a large skull of *Ichthyosaurus australis* found at Galah Creek, 12 miles from Hughenden, and gave a general discussion on the stapes. In 1935 he noted the finding of the greater part of a complete skeleton of the ichthyosaur from Telemon Station, also near Hughenden; and gave locality records of *Megalania prisca, Notochelone costata* and several plesiosaurs. Careful analysis of vertebrate evidence on the origin of the Australian fauna indicated for Longman dispersal from a northern centre without any need of postulating an Antarctic land bridge. He questioned any conclusions drawn from frogs because phylogenetic relationships in the Anura are still so incompletely known.

A well at Brigalow brought to light Chelonian remains and fragments of the extinct crocodile *Pallimnarchus pollens* De Vis as well as bones of that extraordinary marsupial *Euryzygoma dunense* Longman. A limestone quarry at Marmor, 24 miles south of Rockhampton, afforded vertebrae of the huge Varanid *Megalania prisca* Owen. Vertebrae of a snake allied to *Python variegata* were found in a pocket of cave earth at the same place. Longman set out a table enabling separation of several groups of Australian snakes by means of the characters of the vertebrae.

Other work included the description of *Kronosaurus queenslandicus* from Hughenden. The huge Cretaceous pliosaur is believed to be the largest known marine reptile yet recorded. Tara Creek, North Queensland, afforded remains of *Chelodina insculpta* De Vis and a new crocodile *Crocodilus nathani*. The first fairly complete cranium of the large crocodile *Pallimnarchus pollens* was unearthed during the sinking of a tank near Tambo. An amphibian jaw found in the Brisbane River, near Lowood, in 1941 was named *Austropelor wadleyi*. The jaw was that of a Jurassic Stegocephalian.

Parker has made outstanding contributions to our knowledge of Australian frogs and to a more limited extent the reptiles. In 1926 from a collection of reptiles and frogs made by Capt. G. H. Wilkins in Queensland and the Northern Territory, he described as new *Diplodactylus platyurus* (near *D. hilli* Longman and *D. conspicillatus* Lucas and Frost) from Torrens Creek; *Rhodona wilkinsi* (near *R. bipes* (Fischer)) from Torrens Creek; *Demansia guttata* (near *D. textilis* (Duméril and Bibron)) from Winton; and

Pseudophryne fimbrianus (near *P. guentheri* Boulenger and *P. mjobergi* Andersson) from the St. George district. In the same year he described *Lygosoma* (*Rhodona*) *terdigitatum* (near *L. fragile* Günther) from Flinders Island, South Australia.

He next described as new *Typhlops nigroterminatus* from Roebuck Bay, north-west Australia. The blind snake is fairly closely allied to *Typhlops kenti* Boulenger from Queensland.

His thorough revision in 1934 of frogs of the family Microhylidae included treatment of three of Fry's North Queensland species, *Sphenophryne gracilipes*, *S. robusta* and *Cophixalus ornatus*. In 1938 he did much towards clearing up the problem of the races of *Hyla aurea* (Lesson) when he advocated the adoption of two races *Hyla aurea aurea* and *H. a. raniformis* (Keferstein). *Hyla aurea* var. *cyclorhynchus* Boulenger was given full status as *H. cyclorhynchus*.

Parker's major work from the Australian viewpoint is his review of the Leptodactylidae, which appeared in 1940. Its importance can be judged from the fact that about 70 per cent. of Australia's frogs are monographed in this paper. Full systematic descriptions and geographical ranges are given for 63 species and races. Of these 12 are new, namely *Cyclorana cultripes*, *Heleioporus centralis*, *H. wilsmorei*, *Limnodynastes dorsalis insularis*, *L. spenceri*, *Philoria loveridgei*, *Notaden nichollsi*, *Glauertia orientalis*, *Crinia signifera englishi*, *C. s. montana*, *Pseudophryne occidentalis*, and *P. major*. The history and development of classification of our frogs is discussed with reference to anatomical as well as the usual taxonomic characteristics. Then the family Leptodactylidae is shown to fall into two subfamilies, the Cycloraninae and Myobatrachinae, differing in the shape of the tongue, arrangement of the ducts of the intermaxillary glands, development of the prevomers and their teeth, muscles and shape of the hyoid, distribution of the semitendinosus muscle, and characters of the vertebrae.

Important contributions to Australian herpetology can be expected from Francis J. Mitchell, of the South Australian Museum, who has already published four valuable papers. He began by putting the difficult Agamid genus *Tympanocryptis* Peters in order, recognizing five species and two subspecies as new. In a report on the six lizards known from the Greenly Islands, South Australia, he with A. C. Behrndt described *multiscutata* as a new race of *Egernia whitii* and gave critical notes on *Ablepharus lineoocellatus*. He next monographed the Scincid genera *Egernia* and *Tiliqua*, sinking *Hemisphaeriodon* and *Trachysaurus* in *Tiliqua*. While not denying its close agreement with *Tiliqua*, I would like to retain *Trachysaurus* as a monotypic genus if only on the grounds of its gross scalation. *Egernia*, which previously was in a state of confusion, now has its 16 forms well defined. The same remarks apply to *Tiliqua* with 14 species and subspecies. The discussion with descriptions and drawings based on six specimens of *Tiliqua adelaidensis*, the status of which had been in doubt since its description by Peters in 1863, is especially interesting. Clear keys are given for both genera. He published in 1951 a systematic list of South Australia's 32 snakes, describing *Demansia acutirostris* from Lake Eyre and *Denisonia brunnea* from Eyre Peninsula as new species, and *Denisonia nigrostriata brevicauda* from Fowler's Bay as a new subspecies. Examination of three specimens of the rare snake *Brachyaspis curta* Schlegel led Mitchell to sink *Brachyaspis* in the synonymy of *Denisonia*.

C. Anderson, former Director of the Australian Museum, was a noted mineralogist before he turned to vertebrate palaeontology. In 1925 he dealt in detail with the extinct Chelonian *Meiolania platyceps* Owen from the consolidated coral sands of Lord Howe Island, and described as new *Meiolania mackayi* from Walpole Island, 100 miles from New Caledonia. In 1930 he reasoned from associated limb bones of a turtle that *Meiolania* was terrestrial. In the same year he discussed and gave plates of the teeth and limb bones of *Megalania prisca* Owen. He judged its length to have been between 15 and 17 feet, and for it to have been more heavily and strongly built than any of its relatives. Later notes dealt with a jaw of *Pallimnarchus pollens* from North Queensland.

Waite's "Reptiles and Amphibians of South Australia" is an excellent handbook with which to begin the study of Australian herpetology although it is confined to South Australian examples. A general introduction is given for each class, order, family and genus, and the whole book is enriched by a wealth of data on habits, reproduction, range, life histories, preservation, collecting notes and other information gained during a lifetime devoted mainly to a study of the cold-blooded classes. The systematic part of the handbook is adequate, but is based on Boulenger's Catalogue and is therefore to a large extent out of date. The author has also tried to take several short cuts with unhappy results such as lumping *Hinulia lesueurii* and by implication the whole *taeniolata-essingtonii-maculata-lesueurii* (= *australis*) - *inornata-dorsale-spaldingi-leae-fischeri-strauchii* group under *Hinulia taeniolata* (Shaw) = *Sphenomorphus taeniolatus taeniolatus* (Shaw). He also reproduced Boulenger's figure of *Lygosoma dorsale* = *Sphenomorphus spaldingi* (Macleay) under the heading of *Hinulia taeniolata*, a species to which it bears little resemblance. Waite's work was issued by the British Science Guild (South Australian Branch) as a Handbook of the Flora and Fauna of South Australia. Publication of a similar handbook in each State would lead to a tremendous advance in Australian herpetology.

C. H. Kellaway and his school produced at least 32 papers on snake venom and venomous snakes between 1929 and 1937. Sixteen authors participated. This work cannot be considered in detail here, but it is important for the taxonomist because of the emphasis placed on systematics. These workers realized that their intensive research would be largely worthless unless backed by a thorough systematic knowledge of the snakes they were dealing with.

Work of Kellaway and Williams on serological and blood relationships of Australian snakes offers possibilities of tracing systematic relationships between the reptiles.

Thomson (1933) deals extensively with the taipan. He points out that *Pseudechis scutellatus* and *Oxyuranus maclennani* are synonymous, but some of the characters stressed by Kinghorn distinguish the snake so clearly from all other *Pseudechis* that the genus *Oxyuranus* should be retained and the taipan known as *Oxyuranus scutellatus* (Peters). He notes that the taipan is nowhere numerous and reaches 2760 mm. in length. The poison and method of attack are discussed and the author believes that the snake has caused many deaths among the aborigines. *Pseudechis platycephalus* is described as new in the same paper, from a collection of snakes made by P. Cahill in Arnhem Land. The new snake is near *Pseudechis australis* but distinguished inter alia by the shape and form of the scales and the pointed snout.

In 1934 he described the new species *Rhynchelaps wood-jonesii* from two specimens collected on the Lower Archer River, Gulf of Carpentaria, and gave a key to eight known members of the genus. He records the snake as harmless and inoffensive and as a burrowing reptile turned up in loose soil by aborigines.

In the following year he reported on more than 200 snakes collected in 1928, 1929 and 1932 on Cape York Peninsula. He showed their affinities with New Guinea reptiles through the discovery of *Chondropython viridis* Schlegel in Australia, and gave notes on *Hypsirhina polylepis* and *Acrochordus javanicus*. Six species of Boidae were collected of which five are common to Australia and New Guinea, the exception being *Aspidites melanocephalus* which is confined to Australia. *Chondropython viridis* was found to be not uncommon in jungle country, where it frequents by choice dense clumps of bamboo. Its food and habit of rolling itself into a tight coil are noted. The important paper deals with about 15 species of snakes including tree snakes, members of the Boidae, freshwater snakes, and the poisonous *Demansia olivacea*, *D. nuchalis*, *Pseudechis australis* and *Oxyuranus scutellatus*. The last is the taipan, which is described as an aggressive snake, depending on the speed of its movements more than on its strength.

Somewhat off the main tracks of systematics and morphology was that lovable personality George H. Longley, who died in 1947. To a scientific training at Leeds University and Plymouth Marine Biological Station he added unfailing patience and what was almost love for his reptiles. His main successes were in breeding Australian lizards particularly *Tiliqua*. He contributed exact notes on about a dozen lizards and snakes, dealing mainly with aspects neglected by other Australian herpetologists. His detailed notes on reproduction, growth, food and care of the Pink Tongued Skink *Hemisphaeriodon gerrardii* (Gray) are typical. Longley spent nearly every spare minute on the care of his vivarium and his charges. He thought nothing of spending the whole night with a lantern collecting moths and other insects to feed the reptiles in his care.

Eric Worrell has published many interesting notes on Australian reptiles including our own crocodiles *Crocodylus johnstoni* and *C. porosus*, and the rare Orange-naped Whipsnake *Aspidomorphus christieanus* (Fry) from the Northern Territory. In 1951 he compiled a complete key and classification of the Australian Boidae, accompanied by ecological, distributional and field notes. Data include a note that the Water Python *Liasis fuscus* Peters feeds between October and December principally on juvenile *Crocodylus johnstoni*, which it hunts in the water at night. He noted in 1947 that a tortoise identified in 1946 as *Emydura krefftii* had been confused with another specimen still unidentified. His finely illustrated book "Dangerous Snakes of Australia" appeared last year. Only about 23 of Australia's 120-odd species are considered dangerous. Notes on habitat and behaviour are given for most species considered. Treatment of snake bite and preparation of sera are fully discussed.

Black in 1930 gave field notes on the three snakes known to occur in Tasmania, *Denisonia superba*, *D. coronoides* and *Notechis scutatus*.

Brongersma has pointed out that *Pseudelaps* Duméril is a synonym of *Aspidomorphus* Fitzinger.

Neill gives a full account of being bitten in 1943 near Port Moresby by a 44-inch *Demansia olivacea* (Gray), which occurs in both New Guinea and north and north-east Australia. Loveridge places the snake as a subspecies of *Demansia psammophis*. The bite of this snake is conventionally described in Australian literature as about equivalent to that of a bee, but Neill was much more seriously affected by the neurotoxic poison, although he concluded as a result of his experience that the snake was not dangerous to man.

Hunt compiled in 1947 a valuable key to the identification of Australian snakes. It is the only recent key known to me and is apparently based mainly on Kinghorn's "The Snakes of Australia". Progress since about 1929 has been disregarded. Users will have to add species described since then and on the other hand discard those recently established as synonyms such as *Pseudechis cupreus* Boulenger and *P. darwiniensis* Macleay.

Glauert in 1950 produced an excellent handbook on the snakes of Western Australia. There are many illustrations, and species are dealt with under the headings of introduction, scalation, colour, distribution and remarks.

H. Claire Weekes in a series of eight papers has done much to advance our knowledge of placentation and reproduction in Australian reptiles.

Werner (1917) describes two new species, *Egernia lohmanni*, near *Egernia cunninghami*, and *Lygosoma* (*Siaphos*) *lacertorum*, both from Western Australia.

Ahl in 1926 described four new species, *Amphibolurus modestus*, *A. tibialis*, *A. vitticeps* and *Physignathus incognitus*, all from Australia, but unfortunately without definite locality records. It is perhaps a good thing that Loveridge (1934) was able to sink them all except *tibialis* in the synonymy. In 1935 he described as new *Lygosoma* (*Rhodona*) *goerlingi* from Marloo Station, Western Australia, and compared it with *R. fragilis* Günther and *R. walkeri* Boulenger; and also *Hyla inguinalis* from South Australia, possibly Adelaide. Ahl classes it as near *H. jeudii* Werner from New Guinea.

Brazenor recorded *Physignathus gilberti* Gray in 1932 from Werrimull in the extreme north-west of Victoria as the first locality record for the State.

Taylor in 1935 reported on a small collection made near Perth by Professor George Nicholls. Included were *Typhlops bituberculatus* Peters, *Crinia signifera* (Girard), *C. georgiana* Tschudi, *Myobatrachus gouldii* (Gray), *Pseudophryne mjobergi* Anderson, *Hyla aurea* Lesson, *H. adelaidensis* Gray, *Helioporus albopunctatus* Gray and *Limnodynastes dorsalis* (Gray).

Mertens has discussed Australian varanids and contributed an elaborate revision of the races of *Ablepharus boutonii*.

Malcolm Smith in 1937 reviewed the heterogeneous group of skinks included in the genus *Lygosoma*. This stimulating paper was the first comprehensive work on these lizards since 1887. Structural changes bearing on phylogeny and classification were discussed. Several genera were abandoned. I believe that when dealing with this unwieldy genus of perhaps 300 species, new genera should be erected and old ones retained whenever possible. *Hemiergis*, which is a purely Australian genus, well differentiated and capable of being defined, should I think be retained.

Barbour (1943: 56) gives notes on two interesting photographs of defence postures of *Varanus gouldii* standing at bay on its hind legs. The photographs were taken by W. E. Schevill at Yandil in Western Australia.

Roberts (1941) describes the finding of two small unnamed lizards entangled in the web of a Red-backed Spider (*Latrodectus hasseltii*). Spots of blood indicated that the spider was able to puncture the lizards' skin and feed on blood. I have seen adult specimens of *Leiolepisma guichenoti* dead in the webs of *Latrodectus hasseltii* in Kangaroo Valley. On another occasion at Emerald, Queensland, I chased two geckoes (*Heteronota binoei*) among boards and rubbish. A centipede which was also disturbed seized the two lizards in turn behind the neck. Both geckoes at once collapsed and became limp. They were unconscious when picked up and put in a tin. I looked in the tin half an hour later and the lizards had completely recovered and were running about actively.

Stokely in 1947 studied the post-cranial skeleton of *Aprasia repens* Fry, using a cleared specimen with the bones and calcified cartilage stained with alizarin sulfonate of sodium. He compared it with other burrowing lizards with vestigial limb girdles.

Pratt (1948) analyses the morphology of the nasal organs of *Sphenodon* and other lizards, including the Australian genera *Amphibolurus*, *Physignathus*, *Trachysaurus*, *Lialis*, *Lygosoma* and *Ablepharus* from the viewpoint of function.

Snyder (1952), in an interesting summary of locomotion in lizards, concluded that hind leg and body action of *Amphibolurus* during bipedal progression indicated a more efficient locomotor cycle than in bipedal iguanids.

An unusual problem arises in the relationship between lizards and mosquitoes and certain other blood-sucking flies. Attempts are being made by D. J. Lee and other workers engaged in research on mosquitoes capable of spreading myxomatosis to prove that lizards—the water-loving *Sphenomorphus quoyii*—are in fact the major source of blood for some of the more obscure mosquito species. Should it be possible to prove this point, then such mosquitoes will be regarded as of no importance in the transmission of diseases of man, other mammals or birds. On the other hand, a useful lead will be given to those wishing to study the life cycles of some of the reptilian blood parasites.

Procter in 1924 described as new and gave a coloured plate of *Hyla blandsuttoni*, allied to *H. aurea* common about Sydney. The two species had probably long been confused.

D. Fleay has published a number of notes on lizards, snakes and frogs, including the Green Python, Black Snakes and Blue-tongued Lizards. An interesting note in 1935 deals with Golden Bell Frogs (*Hyla aurea*) swallowing small Tiger and other snakes. Two of the frogs were photographed eating the same young Tiger Snake from opposite ends.

L. Harrison discussed Western Australian frogs in 1927. He concluded that *Crinia michaelseni* Werner was synonymous with *C. leai* Fletcher, and described as new *C. rosea* from Pemberton, and *Pseudophryne nichollsi* from Pemberton and Nornalup.

Two important papers published in the one year by E. R. Dunn and M. M. Metcalf in the *American Naturalist*, on the origin and distribution of amphibians, cannot be neglected by any student of the origin and dispersal of these animals. Special emphasis is placed on phylogeny.

Buxton deals in an interesting manner with the habits of *Hyla rubella*, *Limnodynastes ornatus*, *Heleioporus pictus* and *Cyclorana platycephalus*, and describes their methods of withstanding long periods of drought and of taking advantage of short periods of rainfall to reproduce and survive. Unlike the others, *Hyla rubella* does not burrow and therefore dies when its waterhole dries up. It depends for its existence on very rapid and prolific breeding, which enables recolonization after heavy rain of areas where it has died out in previous dry weather.

Alden B. Dawson (1948) touches an almost virgin field as far as Australia is concerned when he deals with histology and genetics of the frog *Cyclorana* (*Chiroleptes*) *alboguttatus* (Günther) and suggests ecological implications. The specimen on which the paper was mainly based was collected in the Cox's River Valley, New South Wales. Dawson says: "The renal nuclear phenomena were quite unexpected and the picture is equally as complicated as that found in the mammalian liver. . . . Whether or not exposure to periodic desiccation is in any way related to the nuclear phenomena in the kidney cannot be determined. . . . In addition to large cells with very large single nuclei an exceptionally large number of binucleate, trinucleate and quadrinucleate cells were found in the proximal convoluted segments of one specimen of *alboguttatus*. . . . It is suggested that these variations in nuclear number, in size, in kidney cells, as in mammalian liver cells, are primarily the result of varying degrees of failure of the mitotic process, possibly complicated by the occurrence of amitosis, nuclear fusion or even cell fusion. . . ." Dawson says that both species of *Cyclorana* he deals with make permanent burrows, store up water and aestivate during periods of drought.

Caziot has described the finding of a living *Moloch horridus* by a bather at Nice on May 14, 1924. The lizard was identified by de Witte and was believed to be one of the reptiles released by Armand Janet, who was experimenting in acclimatization well before the 1914 war. The writer expressed surprise that the lizard had been able to live so long in surroundings so different from its original habitat. The finding of the lizard poses a problem. *Moloch horridus* is notoriously hard to keep in captivity because its only food in the wild state is small ants. It is difficult to believe that it could have found a substitute in Europe for more than ten years, and I would like to suggest that the lizard had only been released shortly before its capture by a sailor who had visited Australia. Myers has reported the capture of two skinks believed to be Australian *Tiliqua scincoides* near San Mateo in California. It is not known how the animals came to be there.

Oliver notes the killing of a 12¼-inch specimen of the Australian *Pygopus lepidopodus* in Taranaki Street, Wellington, on May 10, 1921. It was probably carried unintentionally to New Zealand in a cargo ship.

Australia has not been without its sea serpent. A. H. E. Mattingley reported in the *Victorian Naturalist* that four men in two launches had seen a huge animal about 60 feet long with a head like a turtle, near Townsville. The men said that the head was carried eight feet out of the water and that the animal had scales the size of saucers. A queer feature was that similar reports were received from Mourilyan Harbour, Bowen and Mackay about the same time in August, 1934.

E. C. Chisholm in five papers gave us faunal lists for the Comboyne Plateau and the Marrangaroo and Katoomba districts. These locality lists are common in America and elsewhere overseas but rare in Australia. Their scarcity hampers zoogeographical work.

Alexander in 1922 listed three snakes, 19 lizards and two frogs from Houtman's Abrolhos, although Helms in 1903 had given a total of four frogs.

Teichert concluded that the land fauna reached the Houtman's Abrolhos when they were connected with the mainland. An interesting fact is that the two land mammals found on the islands are now only represented in the cooler and therefore more southern parts of the mainland. This would indicate that the islands were colonized when the climate was cooler, i.e., during a glacial period in the Pleistocene when the sea level was low allowing connection with the mainland. Teichert criticizes Dakin's suggestion that the Abrolhos Islands have been separated from the mainland by river erosion on several grounds. He concludes that the vertebrates must have been long established on the islands and that they reached them "on dry foot".

Consett Davis in 1941, and again with D. J. Lee in 1944, published short papers on taxonomic categories and the type concept in taxonomy, which are of interest to herpetologists. Davis, with M. F. Day and D. F. Waterhouse, brought out their first and basic paper on the terrestrial ecology of the Five Islands, off Wollongong (inhabited by at least four species of lizards) and it is to be regretted that this painstakingly compiled foundation has not been built on.

A. Musgrave's "Bibliography of Australian Entomology" has perhaps a forbidding title for a herpetologist, but its range is much more than its specialized title indicates. It is packed with information about authors, collectors and expeditions (such as the early French ones) between 1775 and 1930. It should be in the hands of all Australian zoologists.

Professor J. A. Moore, the American authority on the distribution of frogs and their life histories, is at present working in Australia. He is concentrating on the collection of all forms of frogs occurring in eastern New South Wales, descriptions of life histories, breeding habits and dispersal. His results when published will include keys, diagnoses, descriptions of tadpoles and distributional maps. He has already dealt with at least one member of each genus. About 20 hybridization experiments have shown that Western Australian and New South Wales *Crinia signifera* when crossed behave almost like full species. This also applies to *Hyla aurea*.

The present author's ambition is to make as many comprehensive studies of Australian species as possible, dealing with them one at a time. It is felt that only when a large proportion of our reptiles are treated fairly fully from the systematic and zoogeographical aspects can a solid basis be formed, on which a superstructure of ecological, developmental and allied studies can be added.

Examination of type specimens at the Macleay Museum has shown that *Hinulia pardalis* Macleay and *Mocoa nigricaudis* Macleay are distinct species. *Hinulia pardalis* is identical with *Lygosoma atromaculatum* Garman, which must now be known as *Sphenomorphus pardalis pardalis* (Macleay). This means that lizards previously referred to as *Sphenomorphus pardalis pardalis* should be known as *Sphenomorphus nigricaudis nigricaudis*. *Lygosoma* (*Hinulia*) *elegantulum* Peters and Doria is conspecific with *S. nigricaudis*, but is a distinct race. *S. n. nigricaudis* (Macleay) should be used for the lizards with blackish tails and *S. n. elegantulus* (Peters and Doria) for the more uniformly coloured brownish lizards with more or less developed narrow dark bars.

Lygosoma dorsale Boulenger (1887) was shown to be synonymous with a third of Macleay's species *Sphenomorphus spaldingi* (1877). A lectotype was selected and with the three paratypes was compared with other specimens from Queensland, the Northern Territory and Torres Straits. The lizard *Hemiergis decresiensis* (Fitzinger) hitherto believed to be very rare was shown to be quite common in restricted localities between New England and South Australia, and was divided into four races.

A revision of Australian members of the genus *Ablepharus* was begun. I believed that the species had all been described and that the revision would be at the subspecies level, but two of the first three papers published had to be devoted to descriptions of new species—*Ablepharus kinghorni* from western New South Wales and *A. davisi* from the Kimberleys. *Ablepharus burnetti* Oudemans has been analysed and shown to consist of three races, including a new one from near Sydney. A short paper was prepared on the reptiles occurring above the winter snowline at Mt. Kosciusko. The rare lizard *Lygosoma truncatum* (Peters), previously known only from islands in Moreton Bay, was collected on the mainand for the first time and described as a new subspecies. The anatomical part of this address is based on work done as a partial requirement for the M.Sc. degree at the University of Sydney.

It is now relevant to make some remarks on the problems and the future of Australian herpetology. Even in the United States, where herpetology is in as advanced a state as anywhere in the world, the basic task of describing and naming endemic species has not been completed. Australia may safely be said to be at least 50 years behind America in this matter alone. When specific studies are about completed there will still be a great need for revisions of genera and families so that phylogenetic and zoogeographical problems can be solved.

The fields of ecological preferences, reproduction, breeding migrations, courtship patterns, variation, habits, temperature tolerance, food, frog calls, hibernation and aestivation, responses to rainfall and moisture, anatomy and genetics have scarcely been touched in Australia. Lack of records of maximum, minimum and average sizes and weights, size at which sexual maturity is reached, and life spans by no means exhausts the list of our omissions. No complete book on the anatomy of any Australian chelonian, snake, lizard or frog has been published.

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The Honorary Treasurer, Dr. A. B. Walkom, presented the Balance Sheets for the year ended 28th February, 1953, 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 year to be duly made:

President: J. M. Vincent, B.Sc.Agr.

Members of Council: R. H. Anderson, B.Sc.Agr.; W. R. Browne, D.Sc.; A. N. Colefax, B.Sc.; S. J. Copland, M.Sc.; Professor J. Macdonald Holmes, B.Sc., Ph.D., F.R.G.S., F.R.S.G.S.; Professor J. L. Still, B.Sc., Ph.D.; and J. M. Vincent, B.Sc.Agr.

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

Finally I wish to thank you for the honour of electing me President, especially as I have been the only non-professional scientist to hold the office for many years. I take the opportunity of wishing the Society every success in the future.

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

LINNEAN SOCIETY OF NEW SOUTH WALES.

GENERAL ACCOUNT. Balance Sheet at 28th February, 1953.

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				10,368	1	4
Accumulated Funds				30,368	1	4
Bookbinding Account	450	7	6			
Income Account	757	14	1			
Current Liabilities				1,208	1	7
				£31,576	2	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	994	7	6			
Science House (one-third share), at cost	14,835	4	4			
				30,878	1	10
Current Assets—						
Cash in hand	10	0	0			
Commercial Banking Company of Sydney, Ltd.	688	1	1			
				698	1	1
				£31,576	2	11

INCOME ACCOUNT. Year Ended 28th February, 1953.

	£	s.	d.	£	s.	d.
To Salaries				458	6	8
,, Printing Proceedings	1,251	2	6			
,, Printing Reprints	379	2	0			
,, Blocks	174	15	2			
				1,804	19	8
,, Insurance				21	10	11
,, Postage	67	12	2			
,, Petty Cash	27	18	1			
				95	10	3
,, Audit	13	2	6			
,, Printing and Stationery	89	0	1			
,, Expenses	46	13	11			
,, Cleaning	39	0	0			
,, Bank Expenses	2	12	9			
				190	9	3
,, Transfer to Bookbinding Account ..				33	12	8
,, Balance to 1953–54				757	14	1
				£3,362	3	6

	£	s.	d.	£	s.	d.
By Balance from 1951–52				396	5	4
,, Subscriptions: 1952–53	349	13	0			
Arrears	34	13	0			
In advance	10	10	0			
Associate		10	0			
				395	6	0
,, Entrance Fees				19	19	0
,, Interest				520	6	3
,, Science House				642	0	0
,, Sales				193	12	8
,, N.S.W. Government Grant (1½ years)				225	0	0
,, Fellowships Account (surplus income at 28th February, 1953, transferred)				266	6	3
,, Bank Expenses				3	6	11
,, Grants towards printing				335	15	0
,, Sale of reprints				364	6	1
				£3,362	3	6

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 28th February, 1953, 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 28th February, 1953, as shown by the books. Certificates of the investments have been inspected.

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

Sydney, 11th March, 1953.

A. B. Walkom,
Hon. Treasurer.

4th March, 1953.

LINNEAN SOCIETY OF NEW SOUTH WALES.

LINNEAN MACLEAY FELLOWSHIPS ACCOUNT.

BALANCE SHEET at 28th February, 1953.

LIABILITIES.	£	s.	d.
Accumulated Funds.			
Amount bequeathed by Sir William Macleay ..	35,000	0	0
Surplus Income Capitalized	18,725	18	4
	£53,725	18	4

ASSETS.	£	s.	d.	£	s.	d.
Fixed Assets.						
Commonwealth Loans, at cost	30,450	0	0			
Debentures:						
Metropolitan Water, Sewerage and Drainage Board, at cost	15,006	14	9			
Rural Bank of N.S.W., at cost ..	2,172	15	0			
Inscribed Stock:						
Metropolitan Water, Sewerage and Drainage Board, at cost ..	1,005	0	0			
Loan on Mortgage	4,950	0	0			
				53,584	9	9
Current Assets.						
Commercial Banking Company of Sydney, Ltd. ..				141	8	7
				£53,725	18	4

INCOME ACCOUNT. Year Ended 28th February, 1953.

	£	s.	d.
To Salaries of Linnean Macleay Fellows	1,366	13	4
,, Research and Field Expenses	90	0	0
,, Payroll Tax	7	6	3
,, Balance, being Surplus Income transferred to General Account	266	6	3
,, Capital Account	143	6	8
	£1,873	12	6

	£	s.	d.
By Interest	1,873	12	6
	£1,873	12	6

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 28th February, 1953, 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 28th February, 1953, as shown by the books. Certificates of the investments have been inspected.

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

Sydney, 11th March, 1953.

A. B. Walkom,
Hon. Treasurer.

4th March, 1953.

LINNEAN SOCIETY OF NEW SOUTH WALES.

BACTERIOLOGY ACCOUNT.

BALANCE SHEET at 28th February, 1953.

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 28th February, 1953	964	11	7			
Commercial Banking Company of Sydney, Ltd.	878	17	5			
Current Liabilities.				1,843	9	0
				£19,973	9	0

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	9	0
				£19,973	9	0

INCOME ACCOUNT. Year Ended 28th February, 1953.

	£	s.	d.	£	s.	d.
To Salary and Allowance				1,162	15	4
,, Equipment and Repairs				59	5	6
,, Insurance				16	11	
,, Payroll Tax				4	0	
,, Ramsgate Property:						
Insurance	5	12	6			
Rates	18	7	4			
Repairs	11	9	10			
				35	9	8
,, Balance to 1953–54				964	11	7
				£2,223	3	0

	£	s.	d.
By Balance from 1951–52	993	2	6
,, Interest	501	13	10
,, Donations	450	0	0
,, Rent	238	6	8
,, Sale of Microscope	40	0	0
	£2,223	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 28th February, 1953, 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 28th February, 1953, as shown by the books. Certificates of the investments have been inspected.

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

Sydney, 11th March, 1953.

A. B. Walkom,
Hon. Treasurer.

4th March, 1953.

AUSTRALIAN RUST STUDIES. XI.

EXPERIMENTS IN CROSSING WHEAT AND RYE.

By W. L. WATERHOUSE,
The University of Sydney.

(Plates i–ii.)

[Read 25th March, 1953.]

Synopsis.

Crossing of wheat and rye that has been in progress for many years has shown that whilst some vulgare wheats set a little grain when pollinated with rye, "Geeralying" when used as the ovule parent gives as much as 85% grain-setting. Certain 14-chromosome wheats were also used.

The F1 plants were tested with stem and leaf rusts of wheat, stem and leaf rusts of rye, bunt, flag smut of wheat, stalk smut of rye, and with ergot. The disease reactions show that the F1s have a closer relationship to wheat than to rye. Despite sterility in the F1 plants, inoculations with bunt led to the formation of bunt balls, and with ergot to the formation of large sclerotia. The nature of the stimulus given has not been determined.

Abnormalities in the F1s took the form of durum-like heads, of twinned heads, and of double and triple embryos.

INTRODUCTION.

It has long been known that wheat and rye cross, but usually with very low setting of grain. A few notable exceptions have been recorded. Earlier work (Waterhouse, 1930) gave the usual result, but in a later communication (Waterhouse, 1939) work was reported in which the wheat variety known as "Geeralying" gave as much as 70% of grain-setting when pollinated with rye.

Crosses have produced wheat varieties of agronomic value in other countries, largely because of the hardiness contributed by the rye parent. Here the work has been carried forward primarily with the aim of transferring the disease-resistant qualities of rye to wheat, and particularly its resistance to stem rust. Clearly large numbers of plants are required for success in the operation, and hence a good deal of further work has been done on the problem.

VULGARE × RYE CROSSES.

Before the compatibility of "Geeralying" with rye was found, a number of other vulgare wheats were used as ovule parents. The results are set out in Table 1.

The overall result of 1% grain-setting is in accord with most recorded work for vulgare crosses, although some exceptional cases have been described (Lein, 1943). He also gives an excellent review of the subject.

A strict comparison between the compatibilities shown by these varieties cannot be made, since six different rye varieties were used in the crossing. However, in twelve of the crosses which were made in the same season, "Rosen" rye was the pollen parent: no significant differences in compatibility were shown: three yielded 2% grain-setting, whilst others gave none.

A further complication was due to the fact that 20% of the grains set failed to germinate and were presumably parthenocarpically formed.

It is to be noted that "Steinwedel", "Improved Steinwedel", and "Garra", which show striking compatibility in crosses with the refractory "Khapli" emmer (Waterhouse, 1952), are incompatible with rye.

Again, a Russian vulgare, "(Wheat × Rye) 1579", obtained in Moscow by Professor E. Ashby in 1946, shows no compatibility.

"GEERALYING" CROSSES.

This variety, which was derived from crossing "Bunyip" with "Huguenot" (McMillan, 1933), was first used in rye crosses in 1932, when it gave the unexpected result of a 50% grain-setting. In subsequent years the cross has been made many times. Forty-two named varieties of rye have been used, and in addition nine inbred lines. In the former, grain-setting reached 85% in three cases, and in more than a dozen of the crosses 75% was found. The overall figure of 36% is rather lower than that obtained from intra-specific wheat crosses made during the period, and includes figures from a number of bad seasons for crossing work.

TABLE 1.

Results of Crossing Different Vulgare Wheats with Varieties of Rye.

Vulgare Parent.	Number of Grains Set.	Number of Pollinations.	Percentage Grain-setting.
Bobin	5	136	4
Bunyip	2	122	2
Canberra	0	38	
Clarendon	0	94	
Charter	0	24	
Federation	5	875	0·6
Florence	4	64	6
Garra (two strains) ..	0	72	
Gresley	0	23	
Gullen	2	118	2
Hard Federation	1	350	0·3
Improved Steinwedel ..	0	36	
Purple Straw	0	44	
Ranee	1	26	4
Rymer	0	38	
Steinwedel	0	40	
Sunset	1	64	2
Thew	0	44	
Waratah	5	142	3·5
Warrah	0	38	
(Wheat × Rye) 1579	0	116	
Totals	26	2504	1

Details of the crossing are set out in Table 2.

There are variations in the compatibilities shown by certain of the rye varieties. Strict comparison cannot be made from the figures given; side-by-side crossing under controlled conditions becomes necessary if this is to be done.

Chromosome counts of some of the varieties showed that x = 7. One tetraploid of "Rosen" rye obtained from U.S.A. was also used, and from 170 pollinations no grain was set. This is in accord with other workers' findings.

In addition to the stated varieties of rye, inbred types were also used. This is material originally selected and since maintained for either rust resistance or susceptibility.

The crossing results are given in Table 3.

Taking the grand totals, 4,154 grains were set in "Geeralying" from 11,864 pollinations, or 35%. The setting in the inbreds is significantly lower than in the varieties. Defective anthers commonly occur in the former and account for some of the failures. An unusual happening was found in one head where twinned anthers were present. It is important to note that a rye which has been inbred for 20 generations for stem rust resistance will still give as much as 30% grain-setting in crosses with "Geeralying".

CROSSES INVOLVING OTHER WHEAT SPECIES.

Apart from the 21-chromosome wheats, others were used and gave the result shown in Table 4.

Of the 21 grains obtained from the "Timopheevi" cross, only 11 germinated. Eight yellowed and died in the early rosette stage. The three that came to maturity showed the dense hairy character of the wheat parent and were sterile.

The two grains from the "Timococcum" cross failed to germinate.

TABLE 2.

Results of Crossing "Geeralying" Wheat with Certain Varieties of Rye.

Variety.	Number of Grains Set.	Number of Pollinations.	Percentage Grain-setting.
Stakman's Rye	95	314	30
Rosen 2	132	398	33
Black Winter	131	303	43
Slav	203	513	39
Slav Selection	202	448	45
Abruzzes	160	435	37
Rye 12	148	454	33
Borris Rug	194	424	46
Petkus Rug	218	525	42
March	168	417	40
Star No. 1	133	390	34
Star No. 2	239	449	53
Bathurst 20	178	387	46
Cowra 21	151	347	43
Cowra 22	184	502	37
Werribee 23	38	67	57
Vern	268	718	30
Cowra 27	199	504	40
Rosen 28	19	112	17
Swedish	78	304	26
Prolific 30	70	517	14
Dakold 31	64	234	27
Colourless	91	331	28
Weibull	155	545	28
Dwarf Rye 34	142	426	33
Emerald Winter	16	38	42
Imperial Winter 38	25	86	29
Horton	18	78	23
Imperial Winter 40	35	74	47
Petkus	7	48	15
Ottawa Selection	26	71	37
Poland 43	6	20	30
Poland 44	2	24	18
Poland 45	18	46	39
Poland 47	17	38	45
Poland 48	17	38	45
Maryland	30	76	40
Prolific 51	21	56	37
Dakold 52	17	84	20
Blackheath 53	17	26	65
Linteno	16	44	36
Totals	3,948	10,911	36

F1 TESTS.

As already stated, some grains failed to germinate. No detailed information on the cause was obtained. On a few rare occasions it was found that the "F1" was actually a wheat plant resulting from accidental pollination; suitable corrections have been made for these. The practice has been to test the seedlings in pots and then to transplant to outdoor plots and to bring the plants to maturity.

Puccinia graminis tritici.

Seedling tests were made with races 34, 43, 45, 126, and 222. "Geeralying" is resistant to r.45, but susceptible to the other races. The rye varieties typically show about 5% susceptible and the remainder resistant seedling reactions, but the inbred ryes are homozygous for either resistance or susceptibility.

With rare exceptions in which a "3" reaction was shown, the F1 reaction was a "fleck" where the rye varieties had been used. Susceptible inbred ryes gave F1s which were susceptible, and resistant inbreds gave resistant F1s.

TABLE 3.

Results of Using Certain Inbred Ryes to Pollinate "Geeralying" Wheat.

Inbred Rye.	Generations of Inbreeding.	Number of Grains Set.	Number of Pollinations.	Percentage Grain-setting.
No. 24	5	5	60	18
No. 26	4	51	278	18
No. 27	7	7	28	25
No. 34	2	45	164	27
1015M	4	28	108	26
1015M	20	29	133	22
1015P	4	18	104	17
1015P	20	23	78	30
Totals ..	—	206	953	21

P. graminis secalis.

A culture of race 3 derived from aecidia on a barberry infected from teleutospores on *Agropyron repens* sent from England was used in a limited series of inoculations. With the wheat varieties giving resistant and the rye varieties susceptible reactions, the F1s gave a clear-cut resistant reaction.

TABLE 4.

Results of Crossing "Geeralying" with Certain Wheats and Related Plants.

Ovule Parent.	Number of Pollinations.	Number of Grains Set.
T. dicoccum var. "Khapli" ..	150	0
T. durum var. "Gaza"	169	0
T. Timopheevi	195	21
T. Timococcum	92	2
T. monococcum	43	0
Aegilops ovata	66	0
A. comosa	20	0
Totals	735	23

P. triticina.

Seedling tests with races 26, 95, and 138 show "Geeralying" susceptibility and rye reactions which in the main vary between "fleck" and "X" (resistance). The F1 reaction was usually "4c", a near approach to the susceptibility of the wheat parent, and sometimes a clear "4" reaction.

P. dispersa.

F1 seedlings from the same crosses as those used in the tests with *P. triticina*, and in some instances the very same plants after removal of the rusted first leaves, were tested with the stock culture of rye leaf rust. Attention has been called elsewhere (Waterhouse, 1952) to the absence of clear definition of the physiologic races present, and hence the stock culture was used. Whereas "4" reactions (susceptibility) were shown by the rye variety and "flecks" and "1" reactions by the wheat, the F1 gave "fleck" and "1" reactions.

Urocystis spp.

Grain was inoculated, some with *U. tritici* Kcke. and some with *U. occulta* (Wallr.) Rab., and sown under favourable conditions for infection. "Geeralying" is resistant to both smuts, and the ryes to *U. tritici*. From these crosses no infection was found. In one case where "Federation" was the vulgare parent, infection by *U. tritici* occurred in the F1. In all the tests made no infection by *U. occulta* was found.

Tilletia spp.

The two common species, *T. caries* (D.C.) Tul., and *T. foetida* (Wallr.) Liro, were used in mixed inoculum dusted on the grain. "Geeralying" is susceptible to bunt, and in the case of rye very occasional susceptibility is found. In each sowing that was made, bunted grain of "Federation" was sown as a check because of its extreme susceptibility. In some seasons, when conditions were unfavourable for bunt development, none developed in "Federation", but in general good infections were found. On numerous occasions bunt (both species) developed in the F1 heads (Plate ii, fig. 7). The bunt "balls" were almost as large as rye grains. This is very striking because of the sterility shown by the F1s. The nature of the stimulus given to "grain" production by the bunt fungus is worthy of full attention. Chlamydospores from the bunted F1 plants were used in the following season to inoculate "Federation" and produced normal infections.

Claviceps purpurea.

A culture derived from ergots on wheat collected at Glen Innes, N.S.W., was used to give a conidial suspension that was sprayed on the plants at flowering time in the Sydney University plot. There were marked seasonal variations in the amount of infection, but this occurred also in both wheat and rye parents. An unexpected happening was the abundant production of ergots in the sterile F1 plants (Plate ii, fig. 5). As in the case of bunt, some remarkable stimulus is given by the fungus to the ovarian tissues of these sterile spikes which leads to the formation of ergots. These are quite as large as those formed in wheat and rye. A weighing of 100 ergots shaken from the F1 plants and 100 shaken from the rye ears showed no significant difference between them. Lightly buried in garden soil and frozen for four months in the ice box of a refrigerator, ergots "germinated" in four weeks and produced normal stromatic heads and perithecia.

In the process of spraying the flowering ears with the conidial suspensions, adjacent rows of *Triticum aegilopoides* Bal. and *T. monococcum* L. were inoculated by chance and produced numerous infected heads (Plate ii, fig. 6). It is usually reported that these species are resistant to ergot attack.

STRUCTURE OF F1 PLANTS.

In general there was close similarity between the F1 plants derived from the "Geeralying" crosses. All were very tall with foliage resembling that of rye, and produced many heads (Plate i, fig. 1). Beard production was greater from some rye varieties than from others. One unusual head type resembling a durum wheat occurred in one plant of "Geeralying" crossed with "Segales" rye, whereas in all other cases the result was the typical long lax ear (Plate i, fig. 2). No grain was formed in it, so further studies could not be made.

In all cases complete sterility was found in bagged heads. Only very rarely was any grain formed in open-pollinated heads. This makes it more striking that bunt and ergot should have developed in these ears. Grain that was produced was used in later generation work, the resultant plants showing the widest segregation for morphological and rust resistant characters. Vulgare types producing the sharp "flecks" characteristic of rye have been selected.

Back-crosses with wheat have been made widely, and further promising material produced, with, of course, much sterility in numerous crosses.

Polyembryony has shown up in the rye varieties several times in the form of twinned embryos (Plate ii, fig. 1). One such occurrence was also found in the F1 of "Geeralying" × "Cowra 22" (Plate ii, fig. 2). No differences were evident between the two primary shoots. Each gave the same seedling reaction for rust resistance. At maturity all the heads were of the same nature. Twinning may well have occurred following upon fertilization of a single ovule.

An even more striking abnormality was a triple embryo in the F1 of "Geeralying" × "Petkus Rug". From the grains sown in a pot for inoculation purposes, one weak and two strong shoots were noted close together. Investigation showed that all three emerged from the one grain (Plate ii, fig. 3). The seedling reactions for rust resistance were the same on all three primary leaves. As growth proceeded, secondary tillers developed, being weaker from the shoot already mentioned (Plate ii, fig. 4). At maturity no differences between the heads were apparent, and again there is no evidence that more than one ovule was actually concerned in the happening.

Chlorophyll deficiencies have shown up frequently in the form of albinotic and variegated seedlings of the rye parents; the former have soon died, and in no case has it been possible to establish a variegated strain from them, although this has been done in certain inbred ryes. No chlorophyll deficiency has been found in the F1s.

Branching of the rye ears has occurred. Sometimes this has started about half-way along the length of the spike, at other times there has been a double spike from the base of the rachis (Plate i, fig. 4). From many branched ears in rye varieties progeny have been obtained, but in no case have they shown branching. The branched F1 ears were sterile.

In two of the seasons F1 plants were treated with colchicine, using the agar method. No grain was set in the selfed ears.

CONCLUSION.

The relationship between wheat and rye which makes it possible to cross them can be a matter of great importance. In the past the cross has been used in the incorporation of hardiness in wheat varieties, but its potentialities for the transference of disease-resistant characteristics of rye to wheat are very promising. This has a particular application where a highly specialized pathogen like the rust fungus is involved.

As a rule the cross is difficult to make, and the finding of the marked compatibility of "Geeralying" wheat with rye makes the work much easier. As much as 85% grain-setting has been obtained when rye pollen is used, as compared with only 1% when rye was the ovule parent. Sterility in the F1 still poses a serious problem.

Studies of the inheritance of resistance to a number of diseases that attack the parents show that there is a closer relationship of the F1 to the wheat than to the rye parent.

There has been little opportunity of carrying out cytological investigation of the happenings, or of examining the effects of colchicine on the F1, but preliminary work with the latter gave negative results. There is a real need for detailed studies along these lines, as well as for investigation of the stimulus imparted to the gynoecia of sterile F1 plants which leads to the formation of bunt balls when the grain is inoculated with *Tilletia* sp., and of ergots when a suspension of conidia of *Claviceps purpurea* is sprayed upon the stigmas at flowering time.

Acknowledgements.

At many stages valuable help has been given by Drs. I. A. Watson and E. P. Baker. Miss D. E. Shaw has helped consistently in the ergot work. Without the loyal and efficient help of the technical staff the investigations could not have been carried out. To all, grateful thanks are tendered.

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EXPLANATION OF PLATES.

Plate i.

1. General view of "Geeralying" × rye F1 plants at flowering time, showing abundant ear production. Many of them are bagged to ensure self-pollination.

2. Typical spikes of "Geeralying" × rye F1 plants showing the long lax structure. × ½.

3. Unusual spike of "Geeralying" × "Segales" rye, showing compact structure resembling a durum wheat. × ½.

4. Branched spike of "Geeralying" × "Slav" rye F1 plant. × ½.

Plate ii.

1. Double embryo in "Star No. 2", showing two plumules arising from the one grain. Natural size.

2. Double embryo in F1 of "Geeralying" × "Cowra 22", showing emergence of two plumules from the one coleoptile. Natural size.

3. Triple embryo in F1 of "Geeralying" × "Petkus Rug" rye, showing one weak and two strong plumules arising from the one grain. Natural size.

4. View of the same triple embryo F1 at a later stage of growth, still showing one shoot weaker than the others. × ½.

5. Four spikes of "Geeralying" × rye F1 (to the left) and one of rye (to the right), showing ergot formation. × ½.

6. Spikes of *Triticum aegilopoides*, showing formation of ergots. × ½.

7. Top group, grains of "Geeralying" wheat; bottom group, grains of open-pollinated rye; and middle group, bunt balls produced in bunted grain of "Geeralying" × rye F1 spikes.

GENETIC CONTROL IN EUCALYPTUS DISTRIBUTION.

By L. D. Pryor.

(Thirteen Text-figures.)

[Read 25th March, 1953.]

Synopsis.

It is deduced that interbreeding *Eucalyptus* species occupy distinctly different ecological situations and that species which grow extensively together are reproductively isolated. Hybrids giving rise to hybrid swarms occurred at the junction of species-areas before settlement. The extensive spread of hybrid swarms is considered to have followed settlement.

INTRODUCTION.

Most *Eucalyptus* forests have two prominent features. The first is the sensitivity of many species to habitat changes which generally results, in any one area, in the presence of a considerable number of species each occupying somewhat different ecological situations. The second is that at the same time, and in a contrary way, there is usually more than one species available to occupy a given ecological situation, so that two or more species are frequently combined as dominants in a single stand.

An examination of these features in some of the *Eucalyptus* communities on the Southern Tablelands of New South Wales in the light of genetic relationships of the species, brings out some striking facts which may be summarized in two statements, viz., (1) interbreeding *Eucalyptus* species occupy distinctly different ecological situations; (2) many reproductively isolated *Eucalyptus* species occur together in pairs which are ecologically co-extensive for major portions of their range, though usually separated at their extremes.

AREAS OF DETAILED STUDY.

Blue Range.

This may be illustrated first by considering an area at Blue Range, Australian Capital Territory, on which the forest types were mapped in detail for another purpose in 1937. The area shows considerable habitat variation with some 2,000 ft. difference in elevation and also with marked differences in aspect (Text-fig. 1). The species present are *E. maculosa*,* *E. Dalrympleana*, *E. viminalis*, *E. rubida* and *E. Cordieri*, belonging to the group Macrantherae of the genus; and *E. pauciflora*, *E. fastigata*, *E. Robertsoni*, *E. dives*, *E. macrorrhyncha* and *E. stellulata*, which belong to the group Renantherae.

Extensive field examination and some manipulated cross pollinations have failed to disclose or produce any hybrids between these two groups of species, but there is evidence that hybridizing can and does occur between most of the species within the two groups. The extent to which this has been detected and confirmed is shown in Table 1.

It will be noticed from Text-figure 2 that, if the area covered by all species in the Macrantherae group taken together is set out and that covered by the Renantherae group is similarly marked, apart from the area occupied by a pure stand of *E. fastigata* and that occupied by a pure stand of *E. Cordieri*, the whole is covered completely at the same time by each group of species. On the other hand (see Text-fig. 3) it will be noticed that there is no area which is occupied by any two species from the one group, Macrantherae or Renantherae.

The area was mapped to show the distribution of the dominant trees, most of which have been living probably since before settlement of the region (about 120 years). Saplings or youthful trees were disregarded in classifying the stands. It is important

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* Nomenclature throughout according to Blakely, "A Key to the Eucalypts" (1934).

Text-figures 1-3.

to note this basis of mapping, as the distribution of species in the pre-settlement period follows a more precisely determined pattern and corresponds more closely with habitat than is the case with the communities regenerated following much increased burning, ringbarking and felling after settlement.

The actual combinations of the two species belonging one to each group which occur at any point are affected by the habitat range of either species. The limit for one may be exceeded at a point still within the zone for successful growth of the other species with which it has been associated, and the combination may therefore change only in one species. This is illustrated in Text-figure 3, where it is seen that *E. Dalrympleana* combines with *E. dives* over a portion of the range of each species, but *E. dives* is able to descend to much lower altitudes than *E. Dalrympleana* and is then commonly combined with *E. maculosa.* This indicates that where two non-interbreeding species can compete for the essentials of life they can grow successfully together. A pure stand no doubt results when the conditions either exceed that possible for all other species in the area, e.g., the *E. Cordieri* pure stand, or otherwise are so favourable to one species that it eliminates the others by competition. This is perhaps the case in the *E. fastigata* pure stands, but in passing it is to be remembered there is a likelihood that pure stands such as *E. fastigata* and other related species, such as *E. gigantea*, are favoured in some circumstances by firing, which, while much less frequent in pre-settlement days, may nevertheless have been a permanent feature of the habitat and, in contrast with the greater frequency following settlement, may have, at the lower pre-settlement frequency, favoured the regeneration of some of these species. Fire may not have been the only cause of such changes; severe storms at occasional intervals may have had the same effect. In this case, therefore, the pure stand of *E. fastigata* may not be a simple elimination of other species by competition, but may be partly conditioned by the regeneration period and, if fire and other possible causes were eliminated, it may in time pass over in many cases to a mixed stand, which in this case would be *E. viminalis–E. fastigata.*

The mapping of Blue Range was designed to express in a broad way the distribution of the vegetation types or associations, and does not fully represent the position with regard to distribution of the species, as the boundaries of the various types are shown as a line on the plan. The types had been decided in advance by inspection of the area. The whole area was mapped according to one or other of the predetermined types. This is an over-simplifiaction as, in fact, the boundary between types is really a zone where the adjoining species are mixed. The extent of the mixed zone depends on several factors, but is generally quite small in relation to the total distribution of either species. For example, in the case of *E. dives* and *E. pauciflora,* the mixed zone occupied not more than one-fiftieth of the altitudinal range of *E. dives* and a still smaller percentage of the altitudinal range of *E. pauciflora.*

Pierce's Creek.

The nature of the boundaries between species is displayed more clearly at Pierce's Creek, A.C.T., where it is more complicated and has more varied kinds of boundaries. It was selected for mapping for this reason and the method of mapping was changed to display particularly these features.

The whole area was covered by a strip survey and each rectangular piece of ground two chains wide by two and a half chains long over the whole area, was assessed objectively, the species on each parcel of ground simply being recorded in three classes: (1) Dominant: large trees, probably mostly living at the time of settlement; (2) Subdominant: middle-aged trees, somewhat smaller and generally younger than the dominants; and (3) Dominated: seedling coppice and suppressed saplings generally up to about thirty years of age.

This differs from the method of mapping used at Blue Range where, as mentioned above, the combinations of species to be mapped as types were pre-determined by inspection.

In the case of Pierce's Creek there was no pre-determination of types. The species were mapped almost to individual trees, as they actually occurred, and a more precise picture could only be obtained by mapping individual trees.

The species present are: Macrantherae: *E. rubida, E. Stuartiana, E. maculosa;* Renantherae: *E. dives, E. pauciflora, E. Robertsoni, E. macrorrhyncha, E. Rossii.*

As with the groups of species mentioned before at Blue Range their interbreeding position is similar, and is indicated in Table 1.

TABLE 1.

Renantherae.

	pauciflora	*fastigata*	*Robertsoni*	*dives*	*macrorrhyncha*	*stellulata*	*Rossii*
pauciflora		xx	xx	xx	x	—	xx
fastigata			xx	x	—	—	—
Robertsoni				x	x	xx	xx
dives					x	—	xx
macrorrhyncha						xx	xx
stellulata							—
Rossii							—

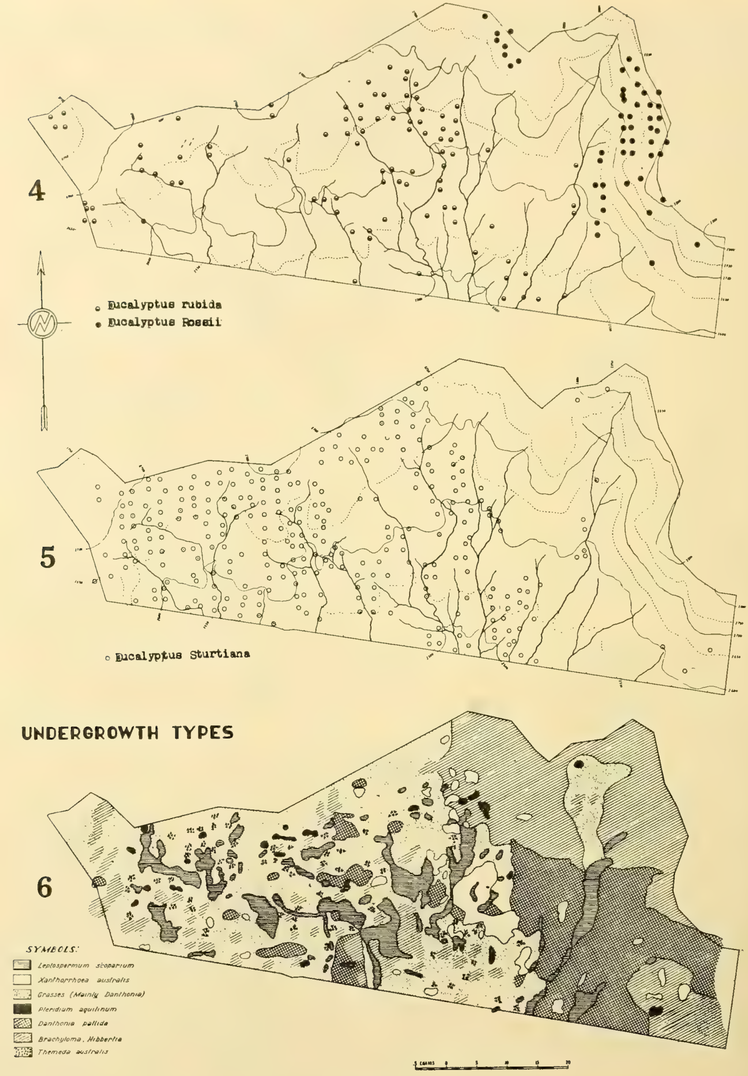
Macrantherae.

	maculosa	*Dalrympleana*	*viminalis*	*rubida*	*Cordieri*	*Stuartiana*
maculosa		—	x	xx	xx	x
Dalrympleana			xx	—	—	—
viminalis				xx	xx	xx
rubida					xx	x
Cordieri						—
Stuartiana						—

x = Hybrid determined on morphological evidence.
xx = Hybrid determined on evidence of segregation in a progeny test.

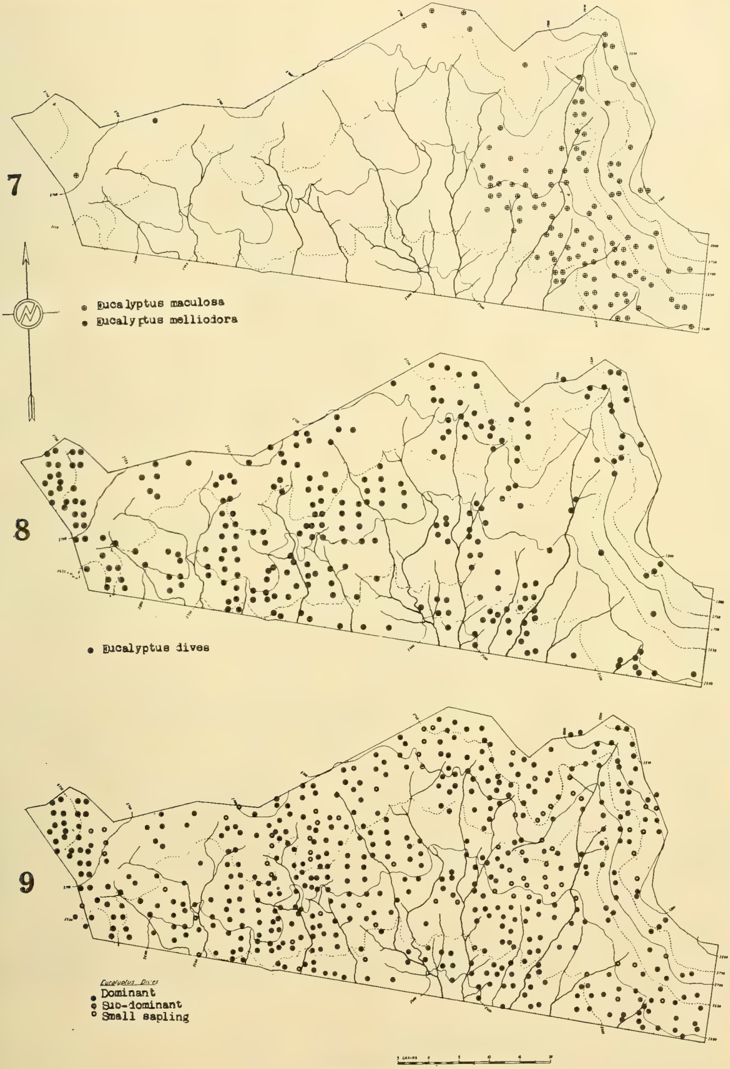
The area displays as a whole features in conformity with the two generalities mentioned at the outset.

The most striking exception is the apparent overlap in the interbreeding species *E. rubida* (Text-fig. 4) and *E. Stuartiana* (Text-fig. 5). The explanation here, however, is simple. The distribution of *E. rubida* in this area is mainly due to the presence of soil which is periodically swampy, and in most cases is represented by narrow flats along drainage channels, and is frequently associated with an understorey of *Leptospermum juniperinum.* This habitat is very sharply cut off from the surrounding areas and is a narrow strip of accumulated soil in contrast with the soil of most of the area which is developed *in situ.* If the *E. rubida* distribution is compared with *Leptospermum* (Text-fig. 6) it will be seen that there is close correspondence. The mixing with *E. Stuartiana* is conditioned by the habitat and is an expression of the mosaic of two distinct habitats. On well-drained soils *E. Stuartiana* and *E. rubida* are not co-dominants in mixed stands. In this particular area the remaining species belonging to the Macrantherae, *E. maculosa* (Text-fig. 7) is almost completely separated from *E. Stuartiana* as it occupies here soils derived from sedimentary rock, while *E. Stuartiana* is mainly on soils derived from granite. In the group of species belonging to the Renantherae it will be seen that all pairs of species, with one exception, are almost entirely separated in their distribution. The exception is *E. dives* and *E. macrorrhyncha,*



Text-figures 4-6.

which show some overlap. For the area concerned the overlap of these two species is about 15% of their total distribution, which compares with only about 1% between *E. dives* and *E. Rossii* within the same limits. While this difference needs further explanation, it will be seen at once that the amount of overlap is quite different from that of non-interbreeding species which, for example, in the case of *E. macrorrhyncha* is co-extensive with *E. maculosa* for about 75% of the area covered by the latter species.



Text-figures 7-9.

It is obvious that the extent of overlap is partly related to the habitat requirements of the species. For example, *E. Robertsoni* requiring good soil and sheltered conditions needs a habitat which is strongly contrasted with that occupied by *E. Rossii* which can survive naturally only on exposed slopes with poor rocky soil. These habitats are strongly contrasted and any intermediate zone is usually too exposed for *E. Robertsoni* or too sheltered for *E. Rossii*, their place being taken by the Renantherous species

E. macrorrhyncha. This difference is reflected in the fact that they do not overlap at all in the area and barely come into contact in one or two places. On the other hand, the requirements of *E. dives* and *E. macrorrhyncha* are much closer and at their junction there is obviously a gently grading habitat which can readily accommodate both species. In a broad view extending to the full range of these species beyond the marginal area being studied, *E. dives* and *E. macrorrhyncha* do not occur together as co-dominants in stands. *E. dives* is distributed at elevations above *E. macrorrhyncha*, so that as one proceeds higher on the Southern Tablelands the same habitat which carried *E. macrorrhyncha* alone or with a non-interbreeding species at the warmer northern end is found to have *E. dives* alone or similarly combined in the colder southern areas, as, for example, to the south of Michelago towards Cooma and Jindabyne. The rather broad overlap of the two species in the subject area, however, probably results from another cause. This is illustrated by Text-figures 8, 9, 10 and 11, showing the distribution of *E. macrorrhyncha* and *E. dives*. It will be noticed if these figures are compared, that since settlement, which has meant burning and partial clearing followed by extensive regeneration, *E. dives* has extended its range much more than *E. macrorrhyncha*. The new conditions favour *E. dives*, as indicated from the figures. The dominants are large, old trees which would correspond quite closely to the virgin stand. Co-dominants are mostly the early regeneration following settlement and the saplings or dominated trees are plants up to about thirty years of age. The response of various species to the new conditions resulting from settlement is quite variable; some are aggressive and spread rapidly, like *E. dives*, whereas others tend to remain restricted or even diminish, as, for example, *E. maculosa*. It is likely, therefore, that the overlap between *E. dives* and *E. macrorrhyncha* was even less than the figures indicate but, on the other hand, in the future the overlap will become still greater as *E. dives* extends its range in accordance with the regeneration already established and the favouring of further regeneration by present conditions. In the virgin state the zone of overlap between *E. dives* and *E. macrorrhyncha* is small and quite precise compared with present-day conditions.

This area illustrates particularly well another type of junction zone of interbreeding species.

As mentioned above, *E. Rossii* and *E. Robertsoni*, as a result of their habitat requirements, do not overlap and barely approach one another at one or two points. The intermediate habitat zone is occupied by *E. macrorrhyncha* in so far as Renantherae are concerned (Text-figs. 4 and 12).

When the survey of this area was carried out in 1938 trees distinct from either *E. Robertsoni* or *E. Rossii* but possessing some of the characters of either, were recognized in this intermediate zone. In particular, their Peppermint affinity was quite apparent, but as at that stage nothing was known of their genetic make-up, they were accordingly recorded as a new species of *Eucalyptus* with Peppermint affinities. The genetic constitution of these trees has been subsequently determined, and it is clear that they are *E. Rossii* × *E. Robertsoni* hybrids. Text-figure 13 shows three features of the occurrence of these hybrids which are of interest. Firstly, they are in the intermediate habitat; secondly, there are some old trees which were present before settlement; and thirdly, the range and number of the hybrids have extended in regrowth since settlement.

CHARACTERISTICS OF SPECIES JUNCTIONS.

From similar field studies it is found that in the area where two interbreeding species of *Eucalyptus* meet there is usually a zone of hybrids between the two species to a greater or lesser degree. The extent of this zone and the number of actual hybrids are affected by several things. First of all it is likely that the ease of hybridizing between all pairs of parents is not the same, and secondly, the viability of the offspring from the combinations is apparently not uniform. In addition, the type of habitat and the rapidity of change in gradation between the two habitats at times eliminate most of the space in which hybrids with growth requirements approximately between the two parents can thrive, or it may be practically non-existent, as in the case of the very sharp transition from the swampy accumulated soils ordinarily occupied by *E. stellulata* to those occupied by, say, *E. macrorrhyncha*.

A careful examination of a number of species junctions in different areas shows that old hybrid trees, which were growing before settlement, occur in many cases, even though rather sparsely, e.g., *E. pauciflora* × *E. fastigata* at the upper limit of the *E. fastigata* is fairly frequent, and *E. gigantea* × *E. pauciflora* is found. The same kind of thing has been observed in widely different regions, for example, between *E. melanophloia* and *E. albens* about thirty miles west of Tenterfield on the Bonshaw road; between *E. micrantha* and *E. campanulata* at the edge of the scarp about fifteen miles east of Tenterfield; between *E. sideroxylon* and *E. albens* in the vicinity of Gundagai; and *E. leucoxylon* and *E. odorata* on the Adelaide plains. As a result of this reconstruction of the conditions of hybrid occurrence in virgin stands, it is shown that in many cases the formation of hybrids has been going on for an indefinitely long time, but under virgin conditions they have been able to thrive successfully only in a small area at the junction of the two species.

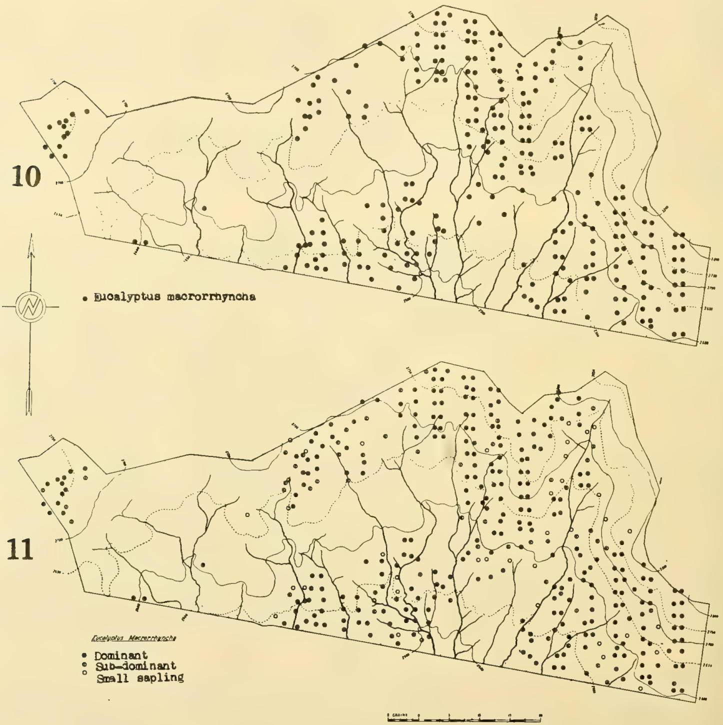
There is some evidence that in addition to the occurrence of hybrids in the junction zone there is a degree of introgression by either species, one into the other, usually present. Further study is necessary, however, to understand fully the position in this particular respect.

Spread of Hybrid Swarms.

It is not difficult to account for the extensive development of hybrid swarms between various species combinations following settlement, and it does not seem necessary to postulate an altered rate of hybridization between any given pair of species to account for the present condition. At the time of settlement a reservoir of hybrids was already present, and the result of settlement has been the upset of balance, the "hybridization of the habitat" (Anderson, 1949), which has favoured the spread of progeny derived from hybrids of one kind or another at the expense of species occupying the adjoining zones in the virgin state. It has already been mentioned in the case of *E. dives* that the conditions following settlement favour the regeneration of that species. This fact is clear and it can be demonstrated easily that it is associated with fire, although all the details of the process are not yet known. The result is, however, that certain hybrid combinations derived from species favoured in their growth by the new conditions are even more successful than their parents in spreading at the expense of other species, and this is expressed in mountain areas in the Australian Capital Territory by the advance of certain Renantherous species at the expense of some of the Macrantherae. Moreover, this often makes available to Renantherous species a site which was not well, or even at all, occupied by either of them in the virgin state. In such circumstances hybrids often thrive better than either of the invading parent species.

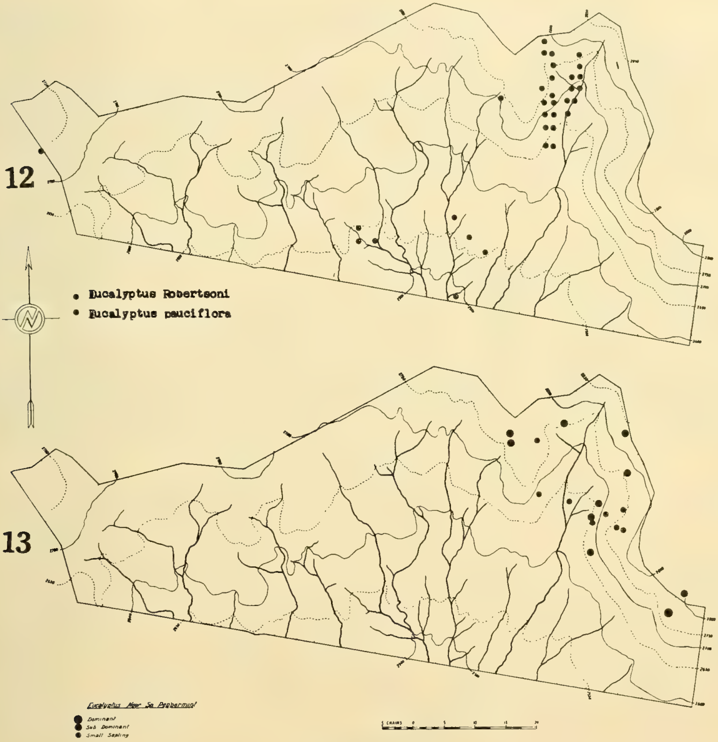
A good example of this is provided by the area in the vicinity of Lees Springs, A.C.T. Approaching the top of the range there is a gently grading broad gully which gradually becomes less sheltered and, while at first carrying a stand of *E. gigantea* and *E. Dalrympleana*, gives way to a substantial area of well-grown *E. Dalrympleana* alone or with some *E. pauciflora* where the site is still favourable but not quite good enough for *E. gigantea*. At the upper limit *E. Dalrympleana* is replaced entirely by *E. pauciflora*. On adjoining, sharp, exposed ridges at the same elevation as *E. Dalrympleana* there is a stand of *E. dives* mixed with depauperate *E. Dalrympleana*. This at its upper limit and at approximately the same elevation as the upper limit of *E. Dalrympleana* joins the pervading *E. pauciflora* stand. The usual hybrids between *E. pauciflora* and *E. dives* occur at the stand junction between these two on rather poor sites which immediately adjoins the good site carrying large trees of *E. Dalrympleana*. The comparative failure of *E. Dalrympleana* to regenerate and the vigorous regeneration of *E. dives* and *E. pauciflora* have resulted in the replacement in regeneration under the now large fire-damaged trees of *E. Dalrympleana* of that species by a swarm of *E. dives* × *E. pauciflora*. A new habitat has become available for this hybrid combination which was not available for it to colonize under virgin conditions, as it was fully occupied by *E. Dalrympleana*. As there is apparently some hybrid vigour or, at least in the early stages, rapid growth of the hybrids as compared with either parent, *E. dives* or *E. pauciflora*, the hybrid swarm has become the most biologically effective population to occupy this area.

This kind of thing appears to be common, and a further good illustration with some variation is provided at Badja, some 20 miles north-east of Cooma. The arrangement of the species in the virgin condition in one section of this area is a little unusual in that there is a temperature inversion due to the physiography of the country, which results in *E. radiata* occurring towards the upper part of ridges, with *E. pauciflora* near the flat basin at the bottom, and *E. Dalrympleana* interposed in the intermediate zone between them. This arrangement is not unique and occurs in various similar areas in the highlands of the southern part of New South Wales. Here, where the stands have been subject to repeated fire since settlement, regeneration of *E. Dalrympleana* is very scarce. The old stands are opening up due to gradual destruction by burning, and regeneration of *E. radiata* and *E. pauciflora* is abundant under the old stand, to the exclusion of *E. Dalrympleana*, entering from above and



Text-figures 10-11.

below into the original *E. Dalrympleana* stand. The regeneration under the *E. Dalrympleana* is a hybrid swarm between *E. radiata* and *E. pauciflora*, but the morphological characters indicating hybrid origin, which are well known from numerous progenies of this combination studied, if taken as an average at a series of points, show a definite gradation in the regeneration from almost pure *E. pauciflora* stock under the original *E. pauciflora* stands, through a series of graded intermediates to almost pure *E. radiata* regeneration under the *E. radiata* stand. In short, there is a hybrid swarm replacing the *E. Dalrympleana* and the swarm is graded according to the graded habitat conditions through the intermediate zone.



Text-figures 12-13.

SYSTEMATICS AND PLANT SOCIOLOGY.

The above considerations have a bearing on two other aspects of study dealing with *Eucalyptus*. Firstly, in considering the validity of any described species, it is fair to say, following the rule induced from the majority of established species, that if they are interbreeding they occupy distinctly different ecological habitats, any new forms being studied should be considered only as species or sub-species if they represent a population which occurs in a zone ecologically distinct from that occupied by related interbreeding species. If this criterion is applied to *Eucalyptus* species as at present described, the classification of the genus is at once somewhat simplified and a number of forms described as species can be properly placed in perspective in relation to the remainder. In the systematic revision of the genus which must be made at some time in the future, this criterion must be prominent in delimiting species.

In the field of plant sociology most workers describe forest types—or, as they are now generally called, "associations"—as proposed by Beadle and Costin (1952), in communities dominated by *Eucalyptus* species and they characterize them by the combination of dominant *Eucalyptus* species present. From the above study it is apparent that *Eucalyptus* communities fall into three distinct kinds:

1. The extensive (or ecologically unique) stable communities having dominants of combinations of two or more non-interbreeding species of *Eucalyptus* which might be called the *primary associations*.

2. Those which are of a limited extent and are unstable and occur only in a mixed zone at the junction between the two main species areas, and may therefore properly be described as *ecotones*.

3. Those resulting from combinations produced by disturbance following settlement which might be described as *secondary associations*, which are unstable in the absence of continued interference by man, and which generally (though it is not commonly recognized) contain trees which are members of hybrid swarms and are certainly not as genetically circumscribed as the species characteristic of virgin stands.

SUMMARY.

There is evidence that interbreeding *Eucalyptus* species occupy distinctly different ecological situations and that pairs of species which grow together in virgin conditions over substantial areas are reproductively isolated. Evidence is produced to show that hybrids occurred before settlement at the junction of two species-areas, and that this hybrid zone is probably the main source of hybrid swarms which have become prominent following settlement.

It is considered that the spread of hybrid swarms has been a direct result of settlement due to the major upset in balance of the plant communities by firing and clearing. The impact of these facts on *Eucalyptus* systematics and plant sociology is indicated.

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ON AUSTRALIAN HELODIDAE (COLEOPTERA). I.

DESCRIPTION OF NEW GENERA AND SPECIES.

By J. W. T. ARMSTRONG.

(Thirteen Text-figures.)

[Read 29th April, 1953.]

Synopsis.

Three genera and fourteen species are described as new. *Elodes olliffi* Blackb., *montivagans* Blackb., *variegata* Cart., *atkinsoni* (Waterh.), *cincta* Blackb. and *costellifera* Cart., are found to have characters incompatible with that genus and are transferred to a new one, *Pseudomicrocara,* to which eleven new species are added. *Elodes tigrina* is considered a synonym of *variegata* Cart. A key is given to the species. One new species is placed in *Macrocyphon* Pic, thus adding this genus to the Australian fauna. Additional generic characters are given. *Elodes australis* (Er.) cannot remain in that genus and is transferred to a new one, *Hetrocyphon,* to which a new species is added. The position of *Macrodascillus* Cart. is commented on and *Elodes scalaris* Lea transferred to it. One new species is placed in *Peneveronatus,* n. gen. The shape of the mesosternal cavity is noted as a very useful taxonomic character, especially in *Cyphon.*

INTRODUCTION.

The author has been studying this family for a number of years and had much of the available Australian material before him. He has, also, representatives of most of the older described exotic genera of the Helodinae, and it soon became evident that many Australian species were misplaced in them. (*Elodes* does not occur in the Australian fauna.) It was therefore necessary to erect new genera for their reception. The shape of the mesosternal cavity has been found very useful in distinguishing species especially in *Cyphon* which will be dealt with in a later paper. In measuring the length of the insects the head has been excluded, as its position makes a material difference. The microscope used in preparing the figures reverses the images.

PSEUDOMICROCARA, n. gen. Helodinae.

Genotype, *Pseudomicrocara orientalis,* n. sp.

Form rather elongate, subdepressed, facies of *Microcara.*

Head covered by prothorax when withdrawn, with quite definite antennal fossae beneath eyes, front lightly convex, produced in a short muzzle. *Eyes* moderately prominent. *Mandibles* simple, wide, sharply pointed, but not long, very slender nor strongly overlapping. *Antennae* filiform, slender, about half length of body, second joint small, moniliform, third variable, remainder usually becoming progressively narrower. *Maxillary palpi* moderately slender, terminal joint a little shorter than penultimate. *Labial palpi*: terminal joint subcylindrical, slender, arising at an angle from end of penultimate. *Labrum* with apex broadly curved, tending to be constricted at base, separated from frons by a rather wide membranous area.

Prothorax about one-third narrower than elytra, semicircular in outline, sides and apex explanate, the latter extending a little over head, base bisinuate, anterior angles merged in general outline. *Elytra* usually about four times as long as prothorax. *Legs* of moderate length, moderately slender. *Hind tarsi* not bicarinate above, first joint long, second about half length of first, third about half that of second, fourth bilobed. *Prosternum* very narrow before coxae, prosternal process more or less diamond shaped, extending to about half-way between coxae but not nearly level with them. *Mesosternum* emarginate to receive prosternal process. *Metasternum* not produced forward between middle coxae. *Fore* and *middle coxae* narrowly separated, *hind coxae* contiguous, the latter transverse.

Distinguishing Characters.—This genus is separated from *Microcara* Thoms. and *Elodes* Latr. by the terminal joint of the labial palpi arising from the end of the penultimate, and from the latter also by the hind tarsi not being flat and bicarinate above and the second joint not overlapping and obscuring part of the third, etc. From *Macrohelodes* Blackb. it differs in being pubescent, in the metasternum not being produced forward between the middle coxae, and in many other respects. *Peneveronatus*, n. gen., has toothed mandibles, different palpi and a very differently shaped metasternum, etc. Typical species of *Cyphon* have a very different prothorax, the 4–11th antennal joints shorter in comparison with their width, and the mandibles distinctly toothed.

Discussion.

Pseudomicrocara orientalis, n. sp., has been chosen as the genotype as it is typical and appears to be the commonest species on the mainland. Six described species are transferred from the palaearctic and North American genus *Elodes* Latr., which is a well-characterized genus having the terminal joint of the labial palpi arising from the side of the penultimate and the hind tarsi bicarinate above with the second joint overlapping and concealing part of the third. This genus and *Microcara* also differ from *Elodes* conspicuously in the mesocoxae being transverse and narrowly separated, not elongate and contiguous, and in the hind coxae being much less strongly oblique from the transverse. It is noticed that in *Microcara testacea* L. the lateral prolongation of the posterior coxal plate deviates from the posterior margin of the metasternum.

The six species transferred are *Helodes atkinsoni* (Waterh.), *H. olliffi* Blackb., *H. cincta* Blackb., *H. montivagans* Blackb., *Elodes variegata* Cart. (= *tigrina* Cart.), and *E. costellifera* Cart. Eleven species are now described as new, making a total of seventeen.

Key to the species of Pseudomicrocara.

1-32. Apex of the pronotum rounded, prosternal process more or less diamond shaped, intervals between elytral costae, when these are present, not convex.
2- 3. Third antennal joint about as long as 4th .... *olliffi* (Blackb.).
3- 2. Third antennal joint distinctly shorter than 4th.
4- 5. Pronotum testaceous, elytra black .... *montivagans* (Blackb.).
5- 4. Not so.
6-11. Upper surface having a distinctly mottled or spotted appearance.
7- 8. Explanate pronotal margins reflexed, abdominal segments spotted (2-4-4-4-2) with black .... *maculiventris*, n. sp.
8- 7. Not so.
9-10. Wider, larger, 6-9 mm. .... *variegata* (Cart.) (= *tigrina* (Cart.)).
10- 9. Narower, smaller, 3·25-4 mm. .... *picta*, n. sp.
11- 6. Upper surface not having a mottled or spotted appearance.
12-17. Without trace of costae on elytra.
13-14. Elytral punctures very fine .... *atkinsoni* (Waterh.).
14-13. Elytral punctures rather coarse, at least on the disc.
15-16. Elytral punctures uneven in size and distribution, size larger .... *dixoni*, n. sp.
16-15. Elytral punctures coarse and even, size smaller .... *infuscata*, n. sp.
17-12. At least three costae discernible on each elytron.
18-23. Size smaller, less than 4·5 mm.
19-20. Pronotum usually dark with pale lateral and apical margins, form elongate ovate .... *variabilis*, n. sp.
20-19. Colour of upper surface uniform, form elongate sub-parallel.
21-22. Pronotum less convex, subobsoletely punctate .... *minor*, n. sp.
22-21. Pronotum more convex, finely but visibly punctate .... *elongata*, n. sp.
23-18. Size larger, more than 4·5 mm.
24-25. Mesosternal cavity twice as long as wide (length of insect 8 mm.) ...... *spencei*, n. sp.
25-24. Mesosternal cavity not longer than wide (smaller).
26-27. Rather wider, red with centre of pronotum near base and disc of each elytron infuscated .... *cincta* (Blackb.).
27-26. Narrower, colour of pronotum and elytra uniform.
28-29. Elytra more elongate by comparison with pronotum, mesosternal cavity as wide as long .... *elstoni*, n. sp.
29-28. Elytra less elongate by comparison with pronotum, mesosternal cavity transverse.
30-31. Elytral punctures fine, eyes more prominent .... *orientalis*, n. sp.
31-30. Elytral punctures rather coarse, eyes less prominent .... *occidentalis*, n. sp.
32- 1. Apex of pronotum subtruncate, prosternal process acuminate, elytral intervals between costae convex .... *costellifera* (Cart.).

This key should be used with caution and as a guide to the descriptions, as there are probably still very similar species undescribed. It does not attempt to place the species in their natural order. They may, however, be provisionally grouped as follows:

A.—*cincta, spencei, olliffi, orientalis, occidentalis, elstoni, minor, elongata, picta, variabilis, montivagans.*

B.—*atkinsoni, dixoni, infuscata.*

C.—*variegata.*

D.—*maculiventris.*

E.—*costellifera.*

D. and E. are aberrant.

PSEUDOMICROCARA MONTIVAGANS (Blackb.).

Blackburn, T., 1892, PROC. LINN. SOC. N.S.W., vi: 519 (Helodes).

Type in British Muesum.

Type locality.—Victoria, alpine district.

Synonym: *Helodes montivagans* Blackburn, *loc. cit.*

NOTE.—This species must also be removed from *Elodes* for the reasons given under *P. cincta* (Blackb.). It is at once distinguished from all other species assigned to this genus by the contrast between the testaceous prothorax and the black elytra. On nearly all the specimens before me the scutellum is black and on the majority the head, with the exception of the mouth parts, also is black. The infuscation of the pronotum mentioned in the original description is due to the head showing through from beneath. This species has a very close superficial resemblance to the American *Cyphon collaris* Guer.

Distribution.—Victoria: Alpine district (Blackburn Coll.), Heathmont (Ringwood) (Pottinger and Dixon), Bayswater (Dixon); South Australia: Murray River, Myponga, Mt. Lofty Rn. (Elston); N.S.W.: Sydney (Spence), Illawarra, National Park (Bryant), Wallace Lake (Carter), Dorrigo (Heron), George's R. (Davidson), Orange (Armstrong); Western Australia: King George's Sound (Macleay Museum). Any specimens dated were taken either in October or November.

PSEUDOMICROCARA VARIEGATA (Cart.).

Carter, H. J., 1935, PROC. LINN. SOC. N.S.W., lx: 192 (*Elodes*).

Types in Coll. F. E. Wilson.

Type locality.—Warburton, Victoria.

Synonyms: *Elodes variegata* Cart., *loc. cit.*; *Elodes tigrina* Cart., *loc. cit.*, 193, n. syn.

NOTE.—Mr. F. E. Wilson's paratype of *P. variegata* is before me, also a specimen taken by Dr. Nicholson at the same time as the types of *E. tigrina* which I believe to be this species and which is identical with the former. The only point at variance with the description is that the third antennal joint is much shorter than the following. Unfortunately the types of *E. tigrina* which should have been in the Macleay Museum seem to have been lost. In addition to the longitudinally carinate terminal abdominal segment in one sex (? ♀) the penultimate has a pronounced transverse brush of hairs. The original description omits to note two foveate depressions between the eyes. The head and pronotum are rugosely punctate, the antennae become progressively a little more slender in the female, the elytra are proportionately longer.

Distribution.—Victoria: Warburton, Millgrove, Belgrave (F.E.W.); N.S.W.: Dorrigo (Heron), Kosciusko (Nicholson), Narrabeen (Musgrave); Tasmania.

PSEUDOMICROCARA COSTELLIFERA (Cart.). Fig. 9.

Carter, H. J., 1935, PROC. LINN. SOC. N.S.W., lx: 192 (*Elodes*).

Type in Coll. F. E. Wilson.

Type locality.—Warburton, Victoria.

Synonyms: Carter, *loc. cit.*, *Elodes costellifera.*

NOTE.—Types examined. This species also has labial palpi simple etc., and therefore cannot remain in *Elodes*. It is here placed in *Pseudomicrocara* with considerable hesitation pending more material for examination, as it is at least aberrant in its acuminate prosternal process and subtruncate pronotum.

PSEUDOMICROCARA CINCTA (Blackb.).

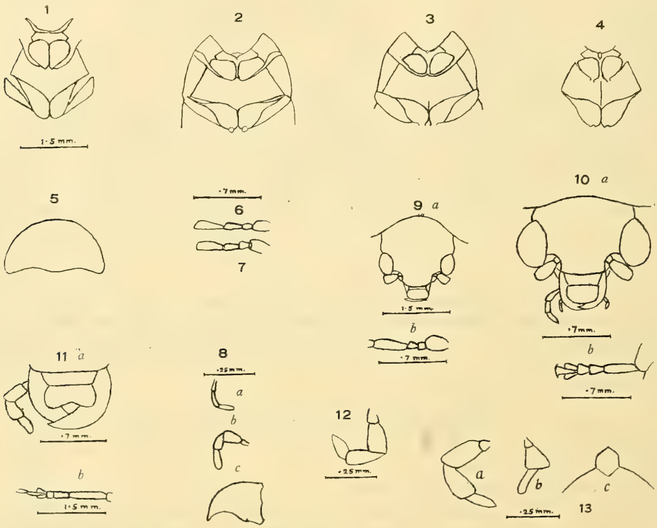
Blackburn, T., 1892, PROC. LINN. SOC. N.S.W., vi: p. 518 (*Helodes cinctus*).

Type in British Museum.

Type locality.—Victoria, alpine district.

Synonym: *Helodes cinctus* Blackburn, *loc. cit.*

NOTES: This species has the third joint of the labial palpi arising from the end of the second, which excludes it from the genus *Microcara* as well as from *Elodes*. The hind tarsi are not bicarinate above, nor is the third joint in great part concealed by the prolongation of the upper edge of the second, as is the case in the latter genus.



Text-figures 1-13.

1-4. Meso-metasternal regions of (1) *Elodes minuta* (L.), (2) *Microcara testacea* (L.), (3) *Pseudomicrocara olliffi* (Blackb.), and (4) *Heterocyphon australis* (Er.), drawn to same scale for comparison.

5. *Pseudomicrocara orientalis*, n. sp. Pronotum to same scale.

6. *P. elstoni*, n. sp. Antenna, first four joints.

7. *P. orientalis*, n. sp. Antenna, first four joints.

8. *P. variabilis*, n. sp. *a*, Labial palpus; *b*, maxillary palpus; *c*, mandible.

9. *P. costellifera* (Cart.). *a*, Head; *b*, antenna, first four joints.

10. *P. orientalis*, n. sp. *a*, Head; *b*, hind tarsus.

11. *Macrodascillus denticornis* Cart. *a*, Labrum, etc.; *b*, hind tarsus. (From type.)

12. *Heterocyphon australis* (Er.). Maxillary palpus.

13. *Peneveronatus australis*, n. sp. *a*, Maxillary palpus; *b*, labial palpus; *c*, mesosternal cavity.

A broad species, rather less than twice as long as wide, and very constant in colour which in combination renders it easily distinguishable from the other species placed in this genus.

Antennae: Second and third joints *very* small. *Mesosternal cavity* almost as long as wide, rounded at apex.

Distribution.—Victoria: Alpine district; New South Wales: Mt. Irvine, Acacia Plateau, Comboyne (Armstrong), Dorrigo (Heron).

PSEUDOMICROCARA OLLIFFI (Blackb.). Fig. 3.

Blackburn, T., 1892, Proc. Linn. Soc. N.S.W., vi: 518 (*Helodes*).

Carter, H. J., 1935, *l.c.*, lx: 191 (*Elodes*).

Types.—Type in British Museum, cotypes in South Australian Museum.

Type locality.—Myponga, South Australia; cotypes Port Lincoln, South Australia.

Synonym: *Helodes olliffi* Blackburn, *loc. cit.*

Note.—This species is excluded from the genera *Elodes* and *Microcara* for the reasons given under *Pseudomicrocara cincta* (Blackb.). It resembles *P. orientalis*, n. sp., and less closely *P. occidentalis*, n. sp., from both of which it is readily distinguished by the third antennal joint being not at all shorter or perhaps slightly longer than the fourth. *Mesosternal cavity* triangular, as long as wide.

Distribution.—New Holland (Edwards); South Australia: Myponga (Blackburn and Elston), Port Lincoln (Blackburn Coll.); Victoria: Vic. Alps, Inglewood; N.S.W.: Sydney (Bryant Coll.).

PSEUDOMICROCARA ATKINSONI (Waterh.).

Waterhouse, C. O., 1877, *Ent. Mo. Mag.*, xiv: 27 (*Helodes*).

Type in British Museum.

Type locality.—Tasmania.

Synonym: *Helodes atkinsoni* Waterh., *loc. cit.*

Original Description.—Oblongus, piceus, griseo-pubescens; thorace fere semi-circulari, basi late bi-emarginato, elytris haud lineatis. Long. 3 lin., lat. 1¾ lin.

General form of *H. lividus*, but with the thorax nearly semicircular, a little narrower than the elytra, broadest at the posterior angles which (although their extreme point is a little blunted) are a little less than right angles, the lateral margins are a little impressed, the base is broadly but not deeply bi-emarginate, the two emarginations occupying the whole base. The scutellum is a trifle longer than in *H. lividus*, not raised in the middle, extremely closely and rather finely punctured. The elytra have no traces of raised lines. The head is very closely and finely granulate-punctate; the three basal joints of the antennae are pitchy, the rest nearly black. The punctation of the thorax is extremely close and very fine, that on the disc of the elytra is less close and less fine, and quite distinct, that on the sides is much finer and more close, especially posteriorly, where it becomes less distinct. The epipleural fold of the elytra is at right angles with the side of the elytra, slightly concave at the base, finely and rather thickly punctured.

Discussion.

Some twenty specimens of this species examined include one compared with type by G. J. Arrow. In addition to the details given in the description, the following may be useful: *Antennae*: Second joint small, moniliform, third longer than second, but considerably shorter than fourth, which is about equal to the two preceding combined, remainder approximately equal. *Mesosternal cavity* longer than wide, rounded at apex.

Distinguishing Characters.—It is distinguished from *P. olliffi* (Blackb.) by the third antennal joint being distinctly shorter than fourth, etc., and from *P. orientalis* and *P. occidentalis*, n. spp., by the complete absence of raised lines on the elytra and rather more regularly elongate-ovate and convex form and by the shape of the mesosternal cavity.

Distribution.—Tasmania: Franklin, Huon R. (J.J.W.); Victoria: Baxter (Dixon), Mooroodue (Dixon).

PSEUDOMICROCARA ORIENTALIS, n. sp. Figs. 5, 7, 10.

Types.—Holotype in Coll. Armstrong, paratypes in British, National and Queensland Museums and Coll. Brooks.

Type locality.—Gloucester, N.S.W.

Elongate-ovate, moderately shining, depressed, brown (some specimens lighter with pronotum infuscated), three basal joints of antennae and other appendages paler, remaining antennal joints sometimes narrowly paler at apices, clothed with fine short depressed pubescence.

Head finely and closely punctate, invisible from above when retracted, bi-impressed between eyes; eyes rather large and prominent. *Antennae*: First joint large globular, second small moniliform, third twice as long as second and expanding towards apex, fourth about twice as long as third, remainder similar to fourth but becoming progressively slightly shorter. *Labial palpi*: Third joint long, thin, cylindrical, arising from a little to one side of apex of second and at rather less than right angles to it, resembling the maxillary palpi.

Pronotum a little more than one and a half times as wide as long, almost semicircular in outline, base slightly bisinuate, sides and apex explanate, finely and closely punctate. *Scutellum* triangular, finely punctate. *Elytra* four times as long and not quite one and a half times as wide as prothorax, not quite half as wide as long, sides subparallel for about half length, less finely and very closely punctate with three slightly elevated costae on each. *Mesosternal cavity* broadly subtriangular, twice as wide as long, apex rounded.

Size: 7·75–5·5 × 3–2·75 mm.

Distribution.—N.S.W.: Gosford (H. J. Carter), Gloucester (H. J. Davidson and J. Armstrong), Comboyne and Hastings R. (H. J. Davidson), Woy Woy (Nicholson), Richmond, Tenterfield (Brooks); Queensland: Brisbane and National Park (H. Hacker); Victoria: Baxter and Bendigo; Tasmania: Huon R. (Lea).

Discussion.

Thirty-two specimens examined all appear to belong to this species, which has often been identified as *Elodes olliffi* Blackb. or *E.* (*Cyphon*) *australis* (Er.). It is at once distinguished from the former by the third antennal joint being distinctly shorter than the fourth and the pronotum less convex and the anterior "angles" thereof less depressed. From the latter it differs in its larger pronotum, which is wider in relation to the elytra, conspicuously shorter legs, less noticeably raised elytral costae, etc.

PSEUDOMICROCARA OCCIDENTALIS, n. sp.

Types.—Holotype and paratypes in the British Museum (B.M. 136–28), paratypes in Coll. Armstrong and the National Museum.

Type locality.—Yanchep, Western Australia.

Elongate-ovate, moderately shining, fusco-castaneous, disc of pronotum darker, head variably infuscated, first three joints of antennae flavo-testaceous, the others with apices pale, clothed with very fine short depressed pubescence.

Head finely and closely punctate; eyes rather large. *Pronotum* twice as wide as long, almost semicircular in outline, base slightly bisinuate, sides explanate, finely and closely punctate. *Scutellum* triangular, finely punctate. *Elytra* four times as long as the prothorax and half as wide again, two-thirds as wide as long, rather coarsely and not quite so closely punctate as pronotum, with three very faint costae on each. *Antennae* as in *P. orientalis*, n. sp. *Mesosternal cavity* broadly triangular.

Size: 7–5·5 × 3·5–3 mm.

Distribution.—W.A.: Yanchep, 32 m. N. of Perth (H. E. Turner, Nov.-Dec., 1935), S.W.A.

Distinguishing Characters.—The eleven specimens examined differ from *P. olliffi* (Blackb.), *inter alia*, in the following respects: third joint of antennae shorter, form less parallel, pronotum not as convex, with anterior angles more or less depressed, elytra more coarsely punctate, colour of antennae (3rd–11th joints uniformly brown in *P. olliffi*). The species is very close to *P. orientalis*, n. sp., of which it is evidently the western counterpart, but is slightly broader with the elytral punctures decidedly coarser and the eyes not so prominent.

PSEUDOMICROCARA DIXONI, n. sp.

Types.—Holotype in National Museum, paratype in Coll. Armstrong.

Type locality.—Baxter, Victoria.

Elongate-ovate, moderately convex, flavo-testaceous, clothed with fine moderately long pale pubescence, antennal joints 4 to 11 darker except for apices.

Head very closely and finely punctate. *Pronotum* approximately semicircular as seen from above, slightly more than twice as wide as long, closely punctate, base lightly bisinuate, posterior angles slightly less than right angles, sides narrowly margined. *Scutellum* sub-triangular, as long as wide, punctured as pronotum. *Elytra* three-fifths as wide as long, as wide at base as prothorax, slightly widened to shoulders then parallel to apical third whence evenly rounded to apex, narrowly margined without any trace of costae, much more strongly but less closely punctate than pronotum, with an impunctate area on each elytron behind middle, punctures becoming finer and closer towards sides, with a faint subsutural stria. *Antennae* moderately long, first joint stout, second and third short, combined length slightly less than fourth, third slightly longer than second, remainder approximately equal.

Size: 5·5–5 × 2·8–2·6 mm.

Distinguishing Characters.—Two specimens examined are very close to *P. atkinsoni* (Waterh.), which occurs in the same locality, but that species differs in its comparatively uniformly close fine elytral punctures. It is also somewhat darker.

PSEUDOMICROCARA INFUSCATA, n. sp.

Types.—Holotype and paratype in Australian Museum, paratypes in Macleay Museum and the author's collection.

Type locality.—King George's Sound, W.A. (Macleay coll.).

Elongate-ovate, rather convex, shining, brownish more or less infuscated, head and underside darker, legs not infuscated, 4–11th antennal joints infuscated.

Head rather finely and closely punctate. *Antennae*: Third joint small, less than half length of fourth. *Pronotum* one and four-fifths as wide as long, finely and not closely punctate, basal angles rounded. *Scutellum* large triangular, about as wide as long, finely and closely punctate. *Elytra* three and a half times as long as pronotum, one and a half times as long as wide, sides slightly curved, expanding to about middle, apex rounded, coarsely and closely punctate, not costate. *Mesosternal cavity* not examined.

Size: 3·75–3 × 2–1·5 mm.

Distinguishing Characters.—Six specimens examined are allied to *P. atkinsoni* (Waterh.) and *dixoni*, n. sp., but are much smaller with coarser elytral punctures and these not showing the irregularity of the latter.

PSEUDOMICROCARA VARIABILIS, n. sp. Fig. 8.

Types.—Holotype in the British Museum, paratypes in the National and Queensland Museums, Tasmanian Dept. of Agriculture and the author's colls.

Type locality.—Hobart, Tasmania (91–88).

Elongate-ovate, rather convex, nitid, colour variable, but mostly with the medial area of the pronotum piceous and the sides flavo-testaceous, head piceous, elytra piceous to light brown but suture usually dark, underside piceous to dark brown, femora, antennae and maxillary palpi dark, tibiae, tarsi, mandibles and labial palpi paler.

Head closely and finely punctate, punctures finer than eye facets. *Antennae*: Second joint moniliform, third smaller than second, together as long as fourth, fourth-eleventh of equal length. *Pronotum* from above approximately semicircular, posterior angles obtuse, anterior "angles" not depressed, more finely and less closely punctate. *Scutellum* subtriangular, elongate, sides lightly rounded, punctures closer and a little coarser than on pronotum. *Elytra* four times as long as prothorax, not quite half as wide again, twice as long as wide, rather coarsely and closely punctate, the punctures tending to cause transverse wrinkling. *Mesosternal cavity* transversely triangular.

Size: 3·8–3 × 2–1·8 mm.

Distinguishing Characters.—There are 28 specimens of this variably coloured species under examination. Typical specimens are readily distinguished by the pale lateral margins of the pronotum. It is smaller than *P. atkinsoni* (Waterh.) and has a very different mesosternal cavity.

Distribution.—Tasmania: Hobart (J. J. Walker), Cradle Mt. (Carter, Lea, Turner), Mt. Wellington (Lea), Launceston (Lea).

NOTE.—Since the above was written the author took a long series of this species on flowers at various localities in Western Tasmania and at Cradle Mt. during January, 1949. It appeared to be the most abundant species of this family in that State.

PSEUDOMICROCARA MINOR, n. sp.

Type, unique, in Australian Museum.

Type locality.—Mt. Lofty Ranges, S.A. (A. H. Elston).

Elongate, gently convex, shining, stramineous, head, scutellum, antennae, and palpi brown, finely pubescent.

Head finely and closely punctate; eyes large. *Antennae* much as in *P. orientalis*, but of uniform thickness to apex, joints two and three together as long as four. *Pronotum* not quite twice as wide as long, subobsoletely punctate, anterior "angles" not strongly depressed. *Scutellum* triangular, as long as wide, finely and not very closely punctate. *Elytra* nearly four times as long as pronotum, one and four-fifths as long as wide, sides subparallel, apex less rounded than usual, coarsely and rather closely punctate, very faintly costate. *Underside* not examined.

Size: 3·25 × 1·5 mm.

Distinguishing Characters.—Close to *P. occidentalis*, n. sp., but that species, besides being larger, has the pronotum definitely punctate and the antennae becoming a little more slender towards apex.

PSEUDOMICROCARA ELSTONI, n. sp. Fig. 6.

Types.—Holotype in Australian Museum, paratype in the author's coll.

Type locality.—Melrose, South Australia (A. H. Elston).

Elongate-ovate, gently convex, shining, luteo-testaceous, antennae and palpi brownish, head infuscated at base and sides, finely pubescent.

Head finely and closely punctate. *Antennae* much as in *P. orientalis*, n. sp., rather long, decreasing in width. *Pronotum* twice as wide as long, basal "angles" but little depressed, very finely and rather closely punctate. *Scutellum* triangular, as long as wide. *Elytra* about four and two-thirds as long as pronotum, twice as long as wide, sides parallel, apex rounded, moderately and closely punctate, each feebly tricostate, suture slightly raised. *Mesosternal cavity* triangular, as wide as long.

Size: 5–4·5 × 2·1–2 mm.

Distinguishing Characters.—Two examples examined represent a species close to *P. occidentalis*, n. sp., but smaller, narrower, antennae a little longer and more slender, pronotum not so explanate, mesosternal cavity more sharply pointed, etc. It is larger than *P. minor*, n. sp., differently sculptured and with noticeably different antennae. The elytra are proportionately longer than in *P. infuscata*, n. sp.

PSEUDOMICROCARA ELONGATA, n. sp.

Type.—Holotype and paratype in author's coll., paratype in Australian Museum.

Type locality.—Hazelbrook, N.S.W.

Elongate, rather convex, shining, castaneous, finely pubescent.

Head large, finely and closely punctate. *Antennae*: Third joint small, fourth about one and a half times as long as third. *Pronotum* slightly more than twice as wide as long, the sides depressed, disc convex, posterior angles rounded, anterior angles strongly so, finely and fairly closely punctate. *Scutellum* convex, subtriangular, finely and closely punctate. *Elytra* a little wider than and five and a half times length of pronotum, nearly twice as long as wide, sides slightly widening, apex rounded, rather coarsely punctate, each faintly tricostate. *Mesosternal cavity*: sides converging, about as long as wide, apex rounded.

Distinguishing Characters.—Three specimens examined represent a species very distinct from the others placed in this genus by their narrow, elongate, subcylindrical form, with a certain resemblance to an elongate Anobid when the head is withdrawn.

Distribution.—N.S.W.: Hazelbrook (the author), Blue Mts. (K. K. Spence i.33).

PSEUDOMICROCARA SPENCEI, n. sp.

Type, unique, in Australian Museum.

Type locality.—Megalong, Blue Mts., N.S.W. (K. K. Spence xii.34).

Elongate-ovate, moderately convex, shining, castaneous-brown tending to piceous on disc of elytra and pronotum, clothed with fine short depressed pubescence.

Head finely and contiguously punctate, impressions between the eyes obsolete. *Antennae*: Second and third joints very small, submoniliform, fourth about three times as long as third. *Pronotum* finely and closely granulate punctate, convex, about one and two-thirds times as wide as long, basal angles but little rounded. *Scutellum* triangular, as long as wide, finely and very closely punctate. *Elytra* a little less than four times length of pronotum, a little less than twice as long as wide, sides lightly curved, disc very slightly depressed at basal fourth, suture very slightly raised, very closely and rather more coarsely punctate, tending to be wrinkled, each inconspicuously tricostate. *Mesosternal cavity* U-shaped, slightly more than twice as long as wide.

Size: 8·5 × 4 mm.

Distinguishing Characters.—A large species resembling an overgrown *P. orientalis*, n. sp., but differing in most details; not apparently close to any other known species.

PSEUDOMICROCARA PICTA, n. sp.

Types.—Holotype in National Museum, paratypes in the National Museum, Victorian Dept. of Agriculture, and the author's coll.

Type locality.—Baxter, Victoria (J. E. Dixon).

Elongate-ovate, moderately convex, shining, dark brown, pronotum and elytra testaceous, the former with disc more or less infuscated (almost entirely brown in one example), the latter with the suture, base and part of the anterior lateral margin narrowly piceous, and the following piceous markings: two elongate dark maculae on each at basal third, an irregular zig-zag fascia at apical third and a more or less extensive spot before the apex of each; mouth parts, tibiae, tarsi and basal joints of antennae testaceous, clothed with fine pubescence much the colour of the underlying derm.

Head closely punctate, punctures about as coarse as eye-facets. *Antennae*: Third joint shorter than fourth (cannot see clearly). *Pronotum* approximately semicircular in outline, base slightly bisinuate, basal angles acute, more finely and much less closely punctate than head. *Scutellum* triangular, finely and more closely punctate. *Elytra* a little wider than pronotum and about three times as long, two-thirds as wide as long, much more coarsely and closely punctate than pronotum, costae barely discernible. *Mesosternal cavity* a little longer than wide, sides converging, apex rounded.

Size: 4–3·25 × 1·9–1·75 mm.

Distinguishing Characters.—Eight specimens examined all from the same locality are readily distinguished by their narrow form in combination with the marked elytral pattern. The pattern, however, may vary in the case of more widely collected material.

PSEUDOMICROCARA MACULIVENTRIS, n. sp.

Types.—Holotype in the author's coll., paratype in Macleay Museum.

Type locality.—Moe, Victoria (C. Gooding).

Elongate-ovate, but little convex, light brown, more or less infuscated on head, pronotum, elytra, ventral surface, antennal joints after the third and femora, clothed with very short fine pubescence.

Head finely and rugosely punctate with two infuscated foveate depressions between eyes, infuscation of base of head enclosing a subtriangular area with apex rearwards and attenuated angles. *Antennae*: Third joint shorter than second, these, combined, slightly more than half length of fourth. *Pronotum* a little less than twice as wide as long, widest at basal third, hind angles strongly rounded, sides widely explanate and somewhat reflexed, finely and contiguously punctate. *Scutellum* subtriangular, as wide as long, punctured as pronotum, not infuscated. *Elytra* four times as long as pronotum, twice as wide as long, sides subparallel, more coarsely but still contiguously punctate, each with four distinct costae, infuscation occupying most space between these, encroaching but little on the margins and raised suture. *Mesosternal cavity* small subtriangular (cannot see well with available material). *Abdomen* with ten dark foveate spots, one on each side of each segment, also two (not foveate) near the centre of the second, third and fourth segments.

Size: 8·5 × 4 mm.

Distinguishing Characters.—Two specimens examined belong to a large species perhaps closest to *P. variegata* (Carter), but the reflexed pronotal margins alone separate it from this.

NOTE.—The second specimen from Victoria in the Macleay Museum is much less infuscated, so that the elytra may be regarded as spotted.

PSEUDOMICROCARA ANOBIOIDES, n. sp.*

Types.—Holotype in Queensland Museum, paratypes in Queensland Museum and the author's coll.

Type locality.—Brisbane, Queensland (H. Hacker, 3.10.26).

Elongate-ovate, rather convex, nitid, brown, somewhat more infuscated on pronotum, a tendency to faint mottling on the elytra, head, antennae (except basal joints) and meso-metasternal region dark; pubescence pale, rather dense, short, fine with a tendency to form a darker zig-zag fascia behind middle of elytra.

Head closely and rugosely punctate. *Pronotum* approximately semicircular in outline, base bisinuate, widely lobed in middle, basal angles rounded, anterior widely rounded depressed, disc depressed before scutellum, sides of depression emphasized by arrangement of pubescence so as to appear as two tubercles, finely and closely granulate-punctate. *Scutellum* triangular, slightly wider than long, finely and closely granulate-punctate. *Elytra* a little wider than prothorax and three times as long, approximately one and a third times as long as wide, a little depressed at basal third, closely and finely granulate-punctate costae scarcely discernible. *Antennae* a little stouter than usual, second joint ovate, third smaller, obliquely truncate, about a third length of fourth, this longer than fifth *et seq.* and about as long as eleventh. *Mesosternal cavity* semicircular.

Size: 3–3·5 × 1·6–1·75 mm.

VAR.—Four specimens from Brisbane are piceous with legs infuscated.

Discussion.

Sixteen specimens, under examination, may be compared with *P. picta*, n. sp., and *P. elongata*, n. sp., from both of which they may be distinguished by their more closely and evenly (granulate) punctate upper surface and the bituberculate appearance of the base of the pronotum. Superficially the species resembles some of the less compact Anobiids.

Distribution.—Queensland: Brisbane (H. Hacker, 3.10.26, 9.9.12, 18.9.11), Stradbroke I. (H. Hacker, 17.9.15), Sunnybank (H. Pottenger, 7.9.46).

NOTE.—Seven specimens from Caloundra, also in the Queensland Museum, seem to represent a smaller paler variety of this species.

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* This species was described subsequently to the compilation of the Key to Species.

HETEROCYPHON, n. gen. Helodinae.

Genotype, Heterocyphon (Cyphon) australis (Er.). Figs. 4, 12.

Form rather elongate, facies of *Veronatus.*

Head covered by prothorax when withdrawn, without marked antennal fossae beneath eyes, front convex, produced in a short muzzle; eyes not very prominent. *Labrum*: Apex slightly rounded, sides strongly so, narrowed to base, separated from frons by a rather wide membranous area. *Mandibles* slender, sharply pointed, but little exposed, with an acute tooth on each, points protruding laterally. *Antennae* filiform, slender, about half length of body, second joint moniliform, small, third shorter than remainder. *Maxillary palpi* not very slender, terminal joint acuminate and shorter than penultimate. *Labial palpi*: Terminal joints slender, arising from end of penultimate.

Prothorax small, approximately semicircular in outline as seen from above, in fact subtruncate, base bisinuate, with a small depressed area on the basal margin near the deepest part of each situation, posterior angles rounded, anterior widely so. *Elytra* about five times length of pronotum and considerably wider, basal margin strongly depressed behind shoulders to permit the anterior angles of the pronotum to overlap the elytra when these are fully expanded. *Prosternum* excessively reduced, prosternal process diamond-shaped, not continuing visibly between coxae. *Coxae*: Middle separated, not transverse; posterior strongly contiguous, plates wide, more strongly oblique from the transverse than in *Pseudomicrocara.* Legs long, slender; hind tarsi slender, first joint long, second about half that of first, third about half that of second, fourth bilobed.

Distinguishing Characters.—This genus differs from *Microcara* and *Helodes* in the same way as *Pseudomicrocara* except that the shape of the middle and hind coxae is somewhat intermediate. From *Pseudomicrocara* it differs by the differently shaped pronotum, longer, looser form, longer legs, and less strongly transverse arrangement of the middle and hind coxae, and toothed mandibles. *Veronatus* has a strongly emarginate labrum.

HETEROCYPHON AUSTRALIS (Er.). Figs. 4, 12.

Erichson, W. F., 1842, *Arch. Naturgesch.*, viii: 144 (*Cyphon*).

Types.—Location unknown to the author.

Type locality.—Tasmania.

Synonyms: *Cyphon australis* Er., *loc. cit. Cyphon australis*, Guér., 1843, *Spec. et Icon.* fasc. 3, nr. 9, p. 15. *Elodes australis*, Cart., 1935, PROC. LINN. SOC. N.S.W., lx: 191.

Original Description.—"42. *Cyphon australis*: *Oblongus*, obscure testaceus, griseo-pubescens, elytris obsolete 3-liniatis. Long. 2½ lin.

"Oblongus, C. livido sesqui longior licet eiusdem latitudinis, saturate testaceus, thoracis disco corporique infra fuscocentibus, cello humerali dilutiore, totus dense pube grisea cericante vestitutis. Antennae fuscae, articulis singularis apice testaceus. Caput confertissime subtiliter punctatum. Thorax parvus, coleopterus angustior, latitudine duplo brevior, lateribus et apice rotundatus, basi prope medium utrinque emarginatus, angulis posterioribus obtusiusculis, confertissime punctatus, disco pone medium utrinque leviter impressus, margine laterali reflexo. Scutellum confertissime punctatum, disco elevato. Elytra dense subtiliter punctata, oblique inspecta liniis tribus elevatis obsoletissimis. Femora medio fuscesunt."

Two specimens in the Queensland Museum (with the place label Strahan Tas., 25.1.34, A. J. Turner) agree better with the above description than do those herein described as *Pseudomicrocara orientalis*, some of which were regarded by Carter as belonging to Erichson's species. *P. orientalis* does not have the narrow reflexed lateral margin to the pronotum, the disc of the scutellum is not noticeably raised, the antennal joints, if at all, are only very slightly testaceous at the apex and the base of the pronotum gives no hint of emargination. This latter character does not strictly apply to the Strahan specimens either, but a suddenly depressed area on each side of basal lobe gives the appearance of emargination. It seems as if the elytra when expanded lock with the hind margin of the pronotum, which is truly remarkable.

Additional Descriptive Details.—*Head*: Punctures somewhat granulate. Two foveate impressions between eyes. *Antennae*: Second joint moniliform, third slender, about twice as long as second, shorter than fourth. *Mesosternal cavity* longer than wide, sides slightly converging, apex rounded and produced in a short carina.

HETEROCYPHON MACEDONENSIS, n. sp.

Type.—In collection Victorian Dept. Agriculture.

Type locality.—Mt. Macedon, Victoria.

Elongate-ovate, not very convex, nitid, dark castaneous, head and scutellum brighter, legs and antennae dull testaceous, antennal joints lighter towards apex, clothed with very fine and short pubescence.

Head finely rugose with a short medial carina and a sinuate elevation running from near each eye towards but not meeting the base of this carina, front somewhat flattened, three indefinite depressions at base. *Antennae* nearly half length of body, slender, first joint rather large, second and third very small moniliform, the latter obliquely truncate, together shorter than fourth, remainder elongate, but eleventh elongate-ovate. *Pronotum* one and three-quarter times as wide as long, sides and apex lightly rounded, base rather strongly bisinuate, posterior angles rounded, overlapping elytra, anterior widely rounded, sides explanate, apex less so, disc transversely depressed at middle behind which a medial thickly Y-shaped elevation stands between two basal reniform ones, very finely and closely punctate. *Scutellum* subtriangular, convex, almost impunctate. *Elytra* about twice as wide as pronotum, two and a half times as long as wide, sides subparallel, apex and shoulders rounded, basal depressions not as marked as in *H. australis* (Er.), more coarsely than on pronotum, but still closely and finely punctate, each with three distinct, and one shorter less distinct, costae. *Mesosternal cavity* very slightly transverse, almost quadrate, apex slightly rounded, apical angles rounded.

Size: 8 × 4 mm.

Distinguishing Characters.—The unique specimen is at once distinguished from *H. australis* (Er.) by its shorter clothing, differently-shaped mesosternal cavity and shorter third antennal joint, etc.

NOTE.—Since the above was written an additional eleven specimens have come before me. Each mandible has a small tooth.

Distribution.—Victoria: Mt. Macedon, Olinda Creek (Dixon, 17/6/15), Belgrave (F. E. Wilson, Jan., 1937).

MACROCYPHON Pic.

Mel. exot.-ent., 29, 1918: 14.

The species described hereunder exhibits the following characters in common with *M. elongatum* Pic, *incostatum* Pic and *minor* Pic, specimens of which are before me: *Form* elongate. *Head* convex, eyes rather small. *Labrum* small, short, slightly emarginate, exposing much of the mandibles. *Mandibles* not long or greatly crossed. *Labial palpi* simple. *Antennae* filiform, joints after second elongate. *Prothorax* narrowed towards base and apex, this bisinuate but more strongly so than in Pic's species, and rather wider. *Prosternal process* large, broadly spatulate, rather widely separating front coxae. *Middle coxae* separated. *Elytra* elongate, parallel-sided but not at all gibbose at base or transversely impressed as in Pic's three species examined.

MACROCYPHON SPENCEI, n. sp.

Types.—Holotype and paratype in author's coll., paratype (headless) in Macleay Museum.

Type locality.—Central eastern N.S.W. (K. K. Spence).

Elongate, moderately convex, shining, fusco-castaneous, clothed with short, recumbent, pale pubescence.

Head large, convex, a little flattened between eyes, closely and finely punctate. *Pronotum* twice as wide as long, sides explanate, sinuate, constricted to base and apex, this strongly bisinuate, base slightly arcuate, posterior angles obtuse, not rounded, anterior broadly produced, rounded, disc longitudinally subcanaliculate, finely and not so closely punctate. *Scutellum* cordate, depressed before apex, finely and closely punctate. *Elytra* about four and a half times as long as pronotum and wider than it, twice as long as wide, perpendicular at sides, these parallel for greater part of length, apex rounded, closely, more or less confluently and more coarsely punctate, each distinctly tricostate. *Mesosternal cavity* broadly rounded.

Size: 10–8 × 4–3·5 mm.

Distinguishing Characters.—Differs from *M. pendleburyi* Pic (according to the description) by the pronotum being punctate, not granulose, and the elytra not arcuately impressed, and from the three species mentioned above in many respects.

MACRODASCILLUS Cart.

PROC. LINN. SOC. N.S.W., lx, 1935: 187.

Genotype, M. denticornis Cart.

Discussion.

This genus belongs to the Helodinae and has no relation to *Dascillocyphon* Everts. It differs from *Prionocyphon* Redt. by its simple labial palpi. It is very close to *Byrrhopsis* Shp. (= *Byrrhodes* Shp.) from New Zealand, but in that genus the eyes are less prominent, the antennae more slender and not at all serrate. *Labrum* emarginate at apex, subcordate, separated from frons by a fairly wide membranous area.

MACRODASCILLUS DENTICORNIS Cart. Fig. 11.

Loc. cit., 187, f. 3.

Type in National Museum.

Type locality.—Barrington Tops, N.S.W.

NOTE.—Type examined.

MACRODASCILLUS SCALARIS (Lea).

Loc. cit., 1895: 230 (*Helodes*).

Types.—Holotype and two cotypes in South Australian Museum.

Type locality.—Galston, N.S.W.

Synonymy: *Helodes scalaris* Lea, *loc. cit. Elodes scalaris*, Carter, *loc. cit.*, lx, 1935: 191.

Discussion.

Types examined. This species has all the characters of *Macrodascillus*. It resembles *M. denticornis* Cart., but differs in its head being wider between eyes, its darker colour and coarser punctures, more convex shape, antennal joints rather longer and more parallel sided in female. It is evident that Carter had not fully understood the species as a specimen from Kuranda in the National Museum is labelled by him "near *Macrohelodes princeps* Blackb.", and others not belonging to the same genus in the Wilson collection are labelled as "*Helodes scalaris*". *Pronotum* twice as wide as long.

Distribution.—N.S.W.: Galston (Lea); Victoria: Toolangi (F. E. Wilson, 3/4/42); Queensland: Kuranda (Dodd).

PENEVERONATUS, n. gen. Helodinae. Fig. 13.

Genotype, Peneveronatus australis, n. sp.

Form rather elongate, rather depressed, facies of *Veronatus*.

Head, when withdrawn, covered by prothorax, with marked grooves or fossae beneath eyes for reception of antennae, front almost flat and produced in a short muzzle below insertion of antennae. *Eyes* moderately prominent. *Labrum*: Sides and apex rounded, the latter slightly emarginate, very slightly narrowed at base, separated from the frons by a narrow membranous area. *Mandibles* slender, sharply pointed, with a small tooth placed well back, prominently exposed. *Antennae* filiform, slender, about half length of body; first joint rather large, second small moniliform, third very short and obliquely truncate, remainder elongate.

Maxillary palpi not slender, terminal joint acuminate and a little shorter than penultimate (Fig. 13, *a*). *Labial palpi*: Penultimate joint subtriangular and broad at apex, terminal slender, cylindrical, slightly bent, arising from the inner half of apex of penultimate (Fig. 13, *b*). *Prothorax* small, approximately semicircular as seen from above, rather depressed, base bisinuate, sides and to a less extent apex explanate, disc with a short sulcus at either side of basal lobe. *Elytra* about five times length of prothorax and considerably wider. *Legs* long, slender; hind tarsi slender, first joint twice length of second, second twice that of third, fourth bilobed. *Prosternum* very narrow in front of coxae; prosternal process spatulate, extending to about half-way between coxae but not level with them. *Mesosternum* rather deeply emarginate to receive prosternal process (Fig. 13, *c*). *Coxae* all transverse, fore and middle pairs narrowly separated, posterior contiguous.

Distinguishing Characters.—This genus seems to be quite close to the New Zealand *Veronatus*, but, *inter alia*, the pronotum is explanate and covers the head in repose, the mouth parts are very different, the maxillae, in at least some species of the New Zealand genus, having one lobe produced so as to appear like extra, hairy palpi. From *Heterocyphon* it differs in the wider penultimate joint of the labial palpi, the more oblique sides of the metasternum, more transverse posterior coxal plates and in the labrum.

PENEVERONATUS AUSTRALIS, n. sp. Fig. 13.

Types.—Holotype and paratype in the author's coll.

Type locality.—Acacia Plateau, N.S.W. (H. J. Davidson).

Elongate-ovate, rather depressed, moderately shining, fusco-rufous, head, basal and apical third of 4–11th joints of antennae, scutellum, margin of pronotum, tarsi, knees and epipleurae fusco-testaceous, the under side, to a variable extent, red, clothed with short depressed fine pubescence.

Head finely and rugosely punctate, with a depression behind each eye. *Pronotum* twice as wide as long, finely and closely punctate, disc somewhat uneven. *Scutellum* triangular, longer than wide, extremely minutely and closely punctate. *Elytra*: One and a half times as wide as prothorax, one and three-quarter times as long as wide, widest at apical third, with four costae traceable on each, of which the exterior one is only visible on the apical half and the two middle are quite distinct, very closely, more distinctly, but not much more coarsely punctate than pronotum.

Size: 7–6 × 3·5–3·1 mm.

Discussion.

Three specimens examined have a close superficial resemblance to *Heterocyphon australis* (Er.) with which it was at first confused.

It is intended to give a key to genera and a bibliography at the conclusion of these studies.

ACKNOWLEDGEMENTS.

Very grateful thanks are especially due to the authorities and entomologists of the British, Australian, National, South Australian, Queensland and Macleay Museums, the Victorian and Tasmanian Departments of Agriculture, the C.S.I.R.O., and to Messrs. F. E. Wilson, H. J. Davidson and E. C. Gourlay (New Zealand) for the loan of material and other help; to Messrs. Henry Dietrich of Cornell University, Walter Wittmer of Buenos Aires, V. Kalik of Czechoslovakia, and others for transcribing literature; and to Mrs. R. T. Backhouse for typing the MS.

A NEW SPECIES OF *AUSTROASCA* LOWER (CICADELLIDAE, HOMOPTERA).

By Harry F. Lower, Waite Agricultural Research Institute,
The University of Adelaide.

(Eight Text-figures.)

[Read 29th April, 1953.]

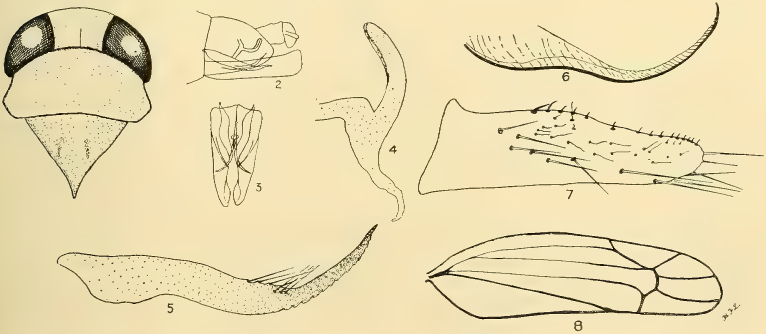
In an earlier paper (Lower, 1952), descriptions of every known species of *Austroasca* were given. Another species, since discovered, is here described as a further contribution to our knowledge of the genus.

Austroasca (Austroasca) infulata, n. sp.

(Text-figures 1–8.)

Length. Male 3·3 mm. *Colour* green.

Head. Crown (Text-fig. 1) very little produced; anterior and posterior margins parallel; CI = 18. Pale yellow-green with indefinite darker and lighter markings. *Face* typical, pale green. *Antennae* typical, dark green. *Eyes* brown.



Text-figures 1-8. *A.* (*A.*) *infulata*, sp. nov. 1, Crown, pronotum, and scutellum; 2, male genitalia (lateral view); 3, male genitalia (ventral view); 4, aedeagus; 5, harpagone; 6, brachone; 7, sub-genital plate; 8, tegmen.

Thorax. Pronotum: length slightly less than twice that of crown (5·3 : 3). Pale green; anteriorly, obscurely patterned with lighter shades of green; posteriorly, greenish-white and translucent. *Scutellum* light green with two small faint brown comma-shaped marks. *Legs* typical, bright green.

Wings. Tegmen (Text-fig. 8) pale green tending to brownish apically. Venation very similar to that of *A. merredinensis* Lower. *Hind wing* typical, colourless, veins greenish-white.

Abdomen. Dorsally, bright yellow, the anterior of each tergite marked transversely with black, more prominently so on the posterior tergites; ventrally, yellowish-green.

Genitalia. Green (Text-figs. 2 and 3). *Sub-genital plate* (Text-fig. 7) short and wide, its length less than three times its greatest width; thirteen to fourteen ensiform bristles in two groups, six about one-third from base, remainder more or less terminal; dorsal margin with setae; some thin scattered hairs centrally. *Harpagone* (Text-fig. 5) stout and long, terminating in a blunt spine; about thirteen unequal denticulations;

seven or so bristles in two series. *Brachone* (Text-fig. 6) in form of a long, ribbon-like band, its dorsal edge strengthened by a sclerotized "rib". Brachone widens basad until it merges imperceptibly with the pygophore. *Aedeagus* (Text-fig. 4) large, its free lobes gently curved dorsally.

Type.—Holotype male, pinned; genitalia and right tegmen mounted on slide. In Coll. Division of Entomology, C.S.I.R.O., Canberra, A.C.T.

Type locality.—Wild Horse Plains, South Australia, 28th August, 1951. Feeding and breeding on saltbush, *Atriplex nummularia* Lindl. (H. F. Lower).

Comments.—This is one of the species of the primitive *viridigrisea–merredinensis* sub-group, as is shown by the tegmen venation, the shape and chaetotaxy of the sub-genital plates, and the broad-based brachone with its simple curved tip. In my recent key (Lower, 1952) this species will trace out to section 4 (3). The characteristic shape of the brachone, however, will serve at once to distinguish it from the other two species of the sub-group.

Reference.

LOWER, H. F., 1952.—A Revision of Australian Species Previously Referred to the Genus *Empoasca* (Cicadellidae, Homoptera). PROC. LINN. SOC. N.S.W., 76 (5-6): 190-221.

FACTORS WORTH CONSIDERING WHEN MAKING MEASUREMENTS OF TROMBICULID LARVAE.

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(Three Text-figures.)

[Read 29th April, 1953.]

Synopsis.

The effects of the type and thickness of the mount, and of the degree of engorgement and the age of the larva, on measurements, body shape, and setae, are discussed, and certain standards for comparison are suggested.

Absolute measurements are useful in describing larval mites, but they have no value at all in differentiating species (by which I merely mean that over-all parallel differences in size do not indicate racial or specific differences, but only climatic and nutritional influences). However, in differentiating between some species, certain ratios between measurements of selected features can be most useful (as, for example, the ratio between length of scutum and width), and so it is important to know just how nearly accurate the basic measurements are, or can be.

1. Mounting Medium.

The type and age of the mount is the first factor to be considered. After several hours in gum-chloral the body becomes distended, and its over-all measurements are greatly increased. On the other hand, after some months in balsam the body shrinks slightly. It might therefore be laid down that critical body measurements should be made within an hour of mounting in gum-chloral, or within a week of mounting in balsam.

Distension of the body may cause some forward tilting of the scutum, especially in those species (cf. *Trombicula robusta* mihi, 1941) where the scutum is placed far forward on the anterior slope of the body. Distension or shrinking may alter the general impression of body-shape. And finally, distension spreads the body-setae, making them easier to place, while shrinking crowds them. Fortunately, the age and type of mount have no practical effect on the size of the hard appendages.

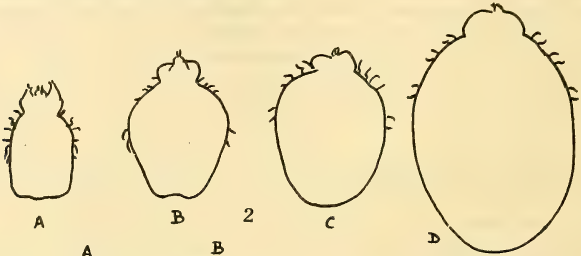
2. Thickness of Mount.

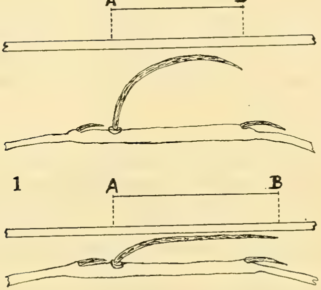
If the coverglass is pressed down too far the body usually bursts and its contents escape; its measurements and shape are thereby altered. Apart from this, the thickness of the mount can perhaps influence the apparent length of the sensillae. When a trombiculid larva is viewed from the side, it is seen that while the scutal and body setae lie fairly flat, more or less following the contours of the body, the sensillae are arched high up in a backward-sweeping curve. From this it is obvious that their function is to give warning when the larva is crawling into a shelving space, so that it does not go too far in and become trapped—a function analogous to that of a cat's whiskers, only in the vertical instead of the horizontal dimension. A thick mount may not disturb the sensillae, whereas in a thin one the coverglass may press them flat, thus altering their apparent length (see Text-fig. 1).

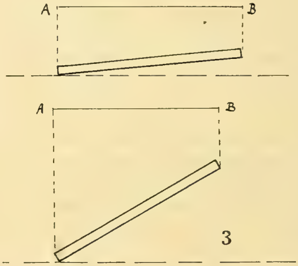
3. Degree of Engorgement.

This is the most important factor. Since trombiculid larvae feed only once—if forcibly detached before they have become fully engorged, their hypopharynx is torn off, and they do not re-attach themselves to the host, but just die; if fully engorged, they disengage themselves and proceed to pupate—it can be assumed that specimens taken running free, as in boot collections, are newly hatched and unfed. But any taken attached to hosts must be regarded as having fed and grown, to an unascertainable degree.

Now many species have a characteristic shape when newly hatched, which alters as they become engorged (see Text-fig. 2). Consequently, a description of such a species should contain references to any change of shape due to engorgement.







Text-fig. 1.—Demonstrating the possible effect of a thin mount on the apparent length of the sensillae (A-B).

Text-fig. 2.—*Trombicula hirsti* Sambon, 1927: Body outlines: A, newly hatched; B, partly engorged; C, half grown; D, fully engorged.

Text-fig. 3.—Demonstrating how forward tilting of the scutum may affect the apparent longitudinal measurements (A-B).

Since the larva grows while feeding, it is not sufficient to measure the bodies of all specimens and average them—it has been my practice to group them, when enough specimens were available, into newly-hatched, half-grown, and fully-engorged, and to give averages for as many specimens in each group as I could secure; also to give the actual size of the largest specimen observed. I believe this method is preferable to simply quoting the measurements of the specimen selected as the type. From Table 1 it will be seen that the actual measurements of any one individual, or a general average alone, would give no true picture at all of the size of the larva.

TABLE 1.

Body measurements (in microns) of Trombicula hirsti *Sambon, taken at Bulolo in* 1939 *(averages of* 10 *observations in each group).*

	Length.	Greatest Width.
Relatively unengorged	176	147
Partly engorged	268	206
Fully engorged	450	364
Largest seen	480	390
Average of all observations	298	239

The body-setae number the same throughout the life of the larva, but in the newly-hatched specimen they are crowded together in a smaller space (cf. the extreme figures in Table 1), and so they are harder to estimate, both in number and arrangement, than in the fully-engorged specimen. The newly-hatched larva, too, is relatively flat and thin, and so there is often considerable difficulty in allotting the posterior rows of setae to the dorsum or the venter. And the older larva has been subjected to more stresses, and so may have had many of its setae rubbed off; although the pits may remain, these are not always reliable guides; however, in some species conspicuous pits or tubercles leave no chance of error. Allowances for these difficulties should always be made.

Scutal measurements are of particular importance. Finnegan was the first to point out, in print, the chief trouble, when she stated (1945) that the apparent length of the scutum of *Leeuwenhoekia australiensis* Hirst, 1925, varies with the degree of engorgement. In a flat, unfed larva the scutum usually lies so nearly in the horizontal plane that there is no appreciable parallax error; or alternatively, in such larvae the angle between the scutum and the horizontal will be substantially the same in all specimens, and so every measurement, even by different observers at different times, will be subject to the same amount of parallax error. But with engorgement the scutum becomes progressively more and more tilted forwards. Text-figure 3 shows how this can affect longitudinal measurements of the scutum and its parts, but since there is no lateral tilting with engorgement, ratios between, say, the length and the width of the scutum may be materially altered.

Hence it may be laid down that where ratios between transverse and longitudinal measurements of the scutum or its parts are of importance in differentiating species, comparisons should be made only between newly-hatched specimens.

A NEW SPECIES OF *PELECORHYNCHUS* (DIPTERA, TABANOIDEA) FROM THE DORRIGO PLATEAU, NEW SOUTH WALES.

By I. M. Mackerras and M. J. Mackerras, Queensland Institute of Medical Research, Brisbane.

(Three Text-figures.)

[Read 29th April, 1953.]

Synopsis.

Pelecorhynchus lunulatus, n. sp., is described from near Ebor, New South Wales, at about 4,000 feet above sea-level. Seven species of the genus are recorded from the area.

It is rarely that one encounters in the Diptera a single species so distinctive that it is worth describing by itself. The Dorrigo Plateau is rich in Pelecorhynchidae, and it is the type locality of two very striking forms, *Pelecorhynchus tillyardi* Tayl. and *P. distinctus* Tayl. Nevertheless, the discovery of another equally striking species was as surprising as it was exciting. Only three specimens were obtained in a fortnight's strenuous collecting, but they are sufficient to justify description.

The new species belongs to the *fusconiger* Group, as defined in an earlier paper (Mackerras and Fuller, These Proceedings, 67: 9–76, 1942), but it fits uneasily in any of the series into which the group was divided. In the key to Australian species on pp. 45–47, it will run to caption 18, less certainly thence to 27, where it will be lost, the ruff being black and white and the post-mesopleural tuft yellow to orange, while the brownish-fawn scutum, with narrow black dorsocentral lines and black margins, will immediately separate it from any of the species in succeeding captions. The conspicuous enlargement of the upper facets of the eyes of the male is unique in the genus, although slight differentiation into upper and lower zones can be seen in a few species.

The seven species now known from the plateau, chiefly from a triangular area of high country to the south-west, bounded by Ebor, Point Lookout and a point 12½ miles along the Ebor-Armidale road, are:

personatus Group: *P. nigripennis* Ric.
fulvus Group: *P. distinctus* Tayl.
fusconiger Group: *P. fusconiger alpinensis* M. & F., *P. nero* M. & F., *P. interruptus* M. & F., *P. tillyardi* Tayl., and *P. lunulatus*, n. sp.

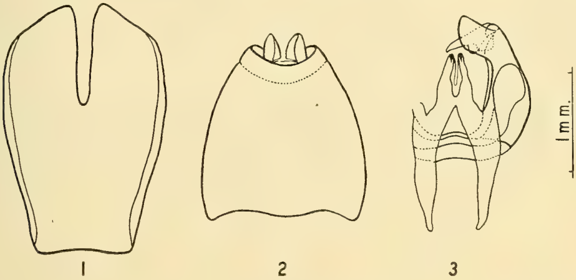
Pelecorhynchus lunulatus, n. sp.

Types: Holotype ♂, from swamp 12½ m. S.W. of Ebor on Armidale road, N.S.W., 14 Dec., 1952, in the Division of Entomology, C.S.I.R.O., Canberra, A.C.T.; allotype ♀, from Coutt's Water, 12 m. E. of Ebor on Dorrigo road, 15 Dec., 1952, in the School of Public Health and Tropical Medicine, University of Sydney; paratype ♀, from swamp 12 m. S.W. of Ebor on Armidale road, 17 Dec., 1952, in the Queensland Institute of Medical Research, Brisbane.

A large brown species, with a fawn-brown scutum marked by narrow black median and dorsocentral lines and strongly margined by black hairs; pleural hairs black, except for two small tufts of white and a conspicuous, lunulate, orange-yellow post-mesopleural tuft; legs reddish-brown; wings largely flavid; abdomen bright mahogany-brown. Length: ♂, 18 mm. with hypopygium retracted; ♀, 20–21 mm. excluding ovipositor.

♂. *Head.* Eyes blackish; upper facets about three times as big as lower, and separated from them by a fairly well-defined line. Ocellar triangle brownish-black. Frons brownish-fawn, with a black zone around base of each antenna. Face brown to fawn, with long, silky, black hairs. Parafacials brownish-fawn, except for a narrow, ashy-grey line along eye margin; upper parafacials bare, lower part with black hairs which merge into the ruff. Antennae with basal segments brown, with black hairs; third segment bright brownish-orange. Palpi with basal segment blackish, second segment brown, becoming yellowish at apex, both with black hairs, except for one or two dull golden hairs apically. Proboscis short, stout, black. Ruff a mixture of black and ashy white.

Thorax. Ground colour of scutum a curious brownish-fawn with a tinge of yellow, and covered with long, brown hairs; median line black, very narrow but continuous, widening somewhat at anterior margin and distinctly in front of the scutellum; dorsocentral lines black, wider than median line, and fading out midway between suture and scutellum; the lateral margins and the scutellum are blackish-brown and covered with dense, black hairs, so that the scutum is surrounded by a well-defined black zone laterally and posteriorly; infra-scutellar tuft black. Pleurae blackish-brown above, pale grey below between the bases of the coxae; rather densely covered with long, black hairs, except for a small, white tuft on the propleura, another on the metapleura just at the basal lateral angle of the abdomen, and a brilliant, yellow to orange, lunulate, post-mesopleural tuft from which the species has been given its name.



Text-figs. 1-3. Male genitalia of *Pelecorhynchus lunulatus*, n. sp. 1, Eighth sternite. 2, Ninth tergite. 3, Hypopygium.

Legs. Coxae brown, fore and mid with black hairs, hind with rather conspicuous silvery-white hairs; remaining segments bright yellowish-brown, becoming paler on the tarsi; hairs mixed brown and gold on the femora, and mostly golden-brown to bright golden on the tibiae and tarsi.

Wings. Greyish, strongly suffused with yellow basally, anteriorly, and along the veins, leaving the centres of the cells paler and giving the wing a vaguely mottled appearance. The basicosta is bare and black; the basal section of the costa is blackish-brown, with short, black hairs, and its distal section and the other veins are bright to yellowish-brown; the venation is normal. Upper squame brownish-orange, with marginal black hairs; lower squame a more greyish light brown, with black hairs below and a white tuft distally and dorsally. Halteres with light brown stem, blackish-brown knob.

Abdomen. A shining bright mahogany-brown. First tergite considerably darkened basally and in the median area, and with strong, dense, sublateral and lateral black hairs; there is a crescentic paler area covered by rich red-gold hairs on each side of the dark median area. Second and subsequent tergites more uniform in colour, and bearing quite dense, rich red-gold hairs; their lateral margins with predominantly black hairs on the second tergite, and red-gold on subsequent tergites. Venter shining mahogany-brown, with red-gold hairs on disc, a crescentic patch of shining silvery-white hairs at lateral margin of second sternite, and a less conspicuous one at the lateral margin of the third sternite.

Hypopygium. The eighth tergite is normal; the eighth sternite (Text-fig. 1) is deeply cleft distally, and is remarkably long and narrow, more like the females than the males of other species. The ninth tergite (Text-fig. 2) is strongly arched laterally, and shaped much as in the Chilean *P. longicaudus* (Big.). The coxite (Text-fig. 3) is distinguished by a very large dorsal hood, the hood and style being not unlike those of *P. fascipennis* M. & F., while the aedeagus is broadly similar to that of *P. fusconiger* (Walk.). *P. lunulatus* thus fits as incompletely into existing series on hypopygial as on external characters.

♀. Generally similar to male. The facets of the eyes are uniformly small. The frons is a little longer than wide, brown above, fawn below, and with brownish-golden hairs; there is the same black zone around the bases of the antennae as in the male. Face similar to male, but with red-gold hairs mixed with some black ones. Thorax similar to male, but median line evanescent and dorsocentral lines narrower. Legs similar to male, femora a little darker brown. Wings with the greyish suffusion distally and posteriorly more marked than in male, and with a less mottled appearance. Abdomen as in the male, but the first tergite is entirely blackish and the crescentic, silvery white, lateral patches of hair on the venter are equally conspicuous on the second and third sternites. Ovipositor yellowish to brownish-fawn.

Habitat.—The three specimens were taken on flowers of *Leptospermum* sp., two in low, swampy areas, the third on the banks of a small, burbling trout-stream. A fourth was seen flying low over short grass between the *Leptospermum* bushes on one of the swamps.

Distribution.—New South Wales: Known only from the type group of localities near Ebor, at approximately 4,000 feet above sea-level. Collections were made in the area from 10th to 24th December, but *P. lunulatus* was seen only between the 14th and 17th.

A NEW SUBSPECIES OF *CERMATULUS NASALIS* (WESTWOOD) (HEMIPTERA–HETEROPTERA: PENTATOMIDAE).

By T. E. Woodward, Department of Entomology, University of Queensland.

(*Communicated by Mr. F. A. Perkins.*)

(Two Text-figures.)

[Read 25th March, 1953.]

Synopsis.

The new and very distinct subspecies, *Cermatulus nasalis rufusensis*, is described from Mt. Rufus, Tasmania, and the differences are listed between it and the three previously described subspecies.

Subfamily ASOPINAE.

Cermatulus nasalis (Westwood).

Aelia nasalis Westwood, 1837, *Cat. Hem. Coll. Hope*, 1: 32.

Cermatulus nasalis Dallas, 1851, *List Hem. Ins. Brit. Mus.*, 1: 106; pl. 2, fig. 3.

(A full synonymy is given by Woodward, 1953, p. 317.)

Cermatulus nasalis rufusensis, n. subsp.

Length of female holotype 11 mm.; width across abdomen 6 mm.; width across posterior pronotal shoulders 6 mm.

Head. Apices of juga moderately broadly rounded. Disc of tylus with fine but distinct punctures. Eye about 2/5 as wide as interocular space (7·5 : 18). Width across eyes: median length: width across juga :: 33 : 30 : 16. Sides of first rostral segment convex, not at all flattened. Relative length of antennal segments I–IV, 6 : 20 : 18 : 22.

Pronotum. Sides with anterior half strongly and irregularly crenulated; posterior half smooth, projecting outward and backward at a marked angle from anterior half. Postero-lateral angles produced well beyond bases of hemelytra as prominent, subacute spines. Posterior margin, in front of scutellum, straight. The small posterior triangular processes (laterad of scutellar base and overlapping clavus) not extending so far back as in typical *nasalis* and not covering the punctures of the second row from the claval suture; postero-lateral margins between these processes and the posterior spines sinuate and biconcave, with the convexity raised as a dorsal tubercle. As in *nasalis* and *turbotti*, and unlike *hudsoni*, the main anterior part of pronotum strongly declivous and forming a markedly different plane from that of the posterior part. Pronotum and whole of dorsal surface more finely punctate than in *nasalis*. Calli black, sunken; disc with a transverse ridge behind them separated from posterior part of pronotum by a transverse groove; at each side of ridge, surface depressed. Sides of pronotum with a broad, sublateral dark band, black except for a few small ochreous markings, and finely and closely punctate, without any impunctate areas as in *nasalis*; extreme margin yellowish ochreous. Width between postero-lateral angles proportionately greater than in *nasalis*, 2·7 times anterior width (23 : 8·5), 2·56 times median length (23 : 9).

Scutellum. Posterior lobe narrower and more nearly parallel-sided than in *nasalis*. Proportionate measurements of scutellum: total length 60; total width at base 49·5; basal width between inner margins of lateral fossae 45; width at anterior end of narrower apical lobe 19; width half-way along apical lobe 17; length of apical lobe 26. Apex ochreous, in type specimen not sharply demarcated by colour.

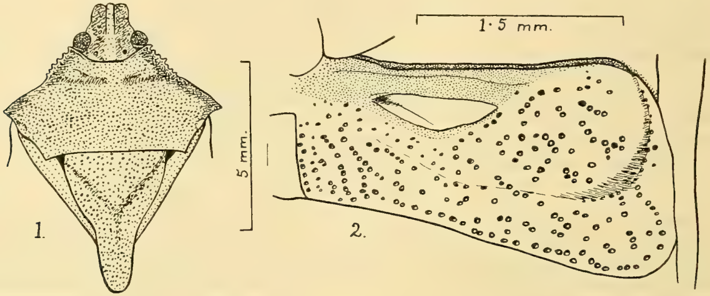
Metathorax. Punctation of ventral surface, as of venter generally, somewhat finer than in *nasalis*. Plate of scent-gland orifice narrower (antero-posteriorly) and less raised than in *nasalis*; length (transverse) : breadth (antero-posteriorly) :: 13 : 5. The granular impunctate evaporating area very narrowly margining plate behind, and in front of plate with only a shallow transverse groove, the anterior edge of plate not abruptly raised above it.

Legs. Posterior tibia 0·7 times as long as outer margin of corium (15 : 21).

Abdomen. In the female, the outer margin of the two postero-lateral sectors of the eighth tergum visible from beneath, markedly deflexed.

Other structural features and colour (except as given above) as for typical *nasalis*. Without any metallic greenish or bronzy reflections.

Diagnosis. The outstanding characters distinguishing *rufusensis* from the other three described subspecies are: the subacute, spinous postero-lateral angles of the pronotum; the transverse ridge and groove behind the calli; the smaller and less raised metathoracic scent-gland plate; the absence of a deep transverse sulcus in the evaporating area before the plate; the deflexed outer margin of the eighth abdominal tergum of the female.



Text-figs. 1, 2. *Cermatulus nasalis rufusensis*, n. subsp. 1, Head, pronotum, scutellum and clavi. 2, Venter of metathorax (left half); evaporating area finely stippled.

Locality.—Mt. Rufus, central Tasmania; 27 January, 1948; 1 female; coll. Key, Carne and Kerr.

Type.—Holotype female in Collection of the Division of Entomology, C.S.I.R.O., Canberra, Australia.

Discussion.—*Rufusensis* differs from typical *nasalis* to a greater degree than do the New Zealand subspecies *turbotti* and *hudsoni*, but in the absence of male material it has seemed preferable in the meantime to give it only equal taxonomic status with these forms. If the male genitalia were to prove significantly distinct, it would have to be raised to a full species. But in either case the new form is of interest as another example of the structural divergence of *Cermatulus nasalis* in isolation, in this instance no doubt accentuated by adaptation to an alpine environment. The typical subspecies is widespread in Australia, Tasmania and New Zealand; subspeciation has followed the isolation of small sections of the population, either by geographic barriers, as in the case of *turbotti*, from the Three Kings Islands, north of New Zealand, or topographic and ecological, as with the alpine forms *hudsoni* and *rufusensis*. The subject has been further discussed by the author in earlier papers (1950, 1953).

ACKNOWLEDGEMENT.

I wish to express my gratitude to Mr. T. G. Campbell, of the Division of Entomology, C.S.I.R.O., Canberra, for the loan of this interesting specimen and the opportunity of studying and describing it.

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WOODWARD, T. E., 1950.—A New Species of *Cermatulus* Dallas from the Three Kings Islands, New Zealand (Heteroptera: Pentatomidae). *Rec. Auck. Inst. Mus.*, 4 (1): 24-30.

———, 1953.—The Heteroptera of New Zealand. Part I. Introduction; Cydnidae; Pentatomidae. *Trans. Roy. Soc. N.Z.*, 80 (3 and 4): 299-321.

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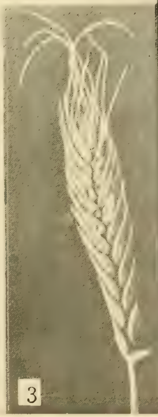

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Crosses of Wheat and Rye.

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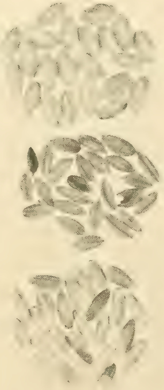

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Crosses of Wheat and Rye.

ANTHER SHAPE IN EUCALYPTUS GENETICS AND SYSTEMATICS.

By L. D. PRYOR.

(Plates iii–iv; four Text-figures.)

[Read 27th May, 1953.]

Synopsis.

Systematic units determined by anther shape within the genus *Eucalyptus* do not correspond closely with either freely interbreeding or reproductively isolated groups of species. Anther shape is inherited in hybrid combination like many other *Eucalyptus* morphological characteristics.

ANTHER SHAPE IN CLASSIFICATION.

Eucalyptus has always been difficult to classify because of the large number of species and the difficulty in finding characters which are uniform within one species or group of species but distinct from those in others. Bentham's treatment of the genus was the first comprehensive account. The difficulties experienced in selecting suitable characters he reviewed and summarized in these terms (Vol. 3, p. 188): ". . . for great as are the differences observed, we have very seldom means of judging whether they are individual or specific", and earlier (p. 186) he says: "I have been compelled to establish groups upon such characters as appeared to me the most constant among those which are supplied by the specimens; in the first place upon the form of the anthers, and secondly, upon that of the fruit, and in some cases on the inflorescence or the calyx." From this point onward the shape of the anthers has played a prominent part in the various schemes for classification that have been used. In Mueller's "Eucalyptographia" the classification into the main groups is by anther shape. Likewise, this feature was employed to a large extent by Maiden (1924) and finally was very considerably elaborated by Blakely in "A Key to the Eucalypts" in 1934. While Blakely's treatment is the most detailed yet to be presented and the series and sub-series he has established are in the main satisfactory, the relation of these to the anther sections is confusing and difficult to employ, as mentioned by Burbidge (1947). Blakely nevertheless retains the anther shape as the primary feature of the classification.

The result has been that classification according to anther shape is often regarded as having a special place, perhaps more than of convenience, in the taxonomy of the genus. In many ways more weight has been placed upon anther morphology than is justified. Another difficulty has been that the anthers are often rather small and not nearly as conveniently available for field determination as inflorescence, buds, fruits, leaves and bark. It is true that examination of the shape of the anther will often place a specimen precisely, whereas other characters still leave it in doubt, but the converse is also the case. Likewise, anther shape is sometimes the best character available to indicate the affinities of a species, but on other occasions it is like so many features of the genus such as style and stigma shape which are shared in common by a large number of species. Such species are often diverse in their affinities and in such cases it is like them, of no conclusive taxonomic value.

In view of the importance that has been attached to anther shape in all major works on the taxonomy of the genus, it is desirable to review the significance of the character in the genus as a whole, particularly in relation to *Eucalyptus* genetics.

ANTHER GROUPS.

The principal anther groups given by Blakely are:

Macrantherae, containing 295 species and varieties.
Renantherae, containing 145 species and varieties (including Renantheroideae).
Porantheroideae, containing 95 species and varieties.
Terminales, containing 25 species and varieties.
Platyantherae, containing 37 species and varieties.

These groups cover 597 species and varieties out of a total of 605 listed by Blakely. The other anther groups which he uses contain very few species and are not markedly distinct.

Since it is common to find within any genus some groups of species which have been determined on morphological grounds which, when put to the test, are genetically isolated from other groups, it is of considerable interest to determine whether anther shape does coincide with the limits of interbreeding groups. Because it is known that to some extent this is true, e.g., Renantherae will not cross with Macrantherae (Pryor, 1951), an attempt was made to locate experimental material which would give a set of hybrids between parents belonging to different anther groups, and which would then indicate the nature of the inheritance of anther shape, as well as one aspect of the genetic relationships of one pair of groups of species within the genus.

EXPERIMENTAL MATERIAL

About two miles north of the well-known "Tuckerbox" near Gundagai there is an apparent hybrid swarm derived from *E. sideroxylon* and *E. albens*. These species belong respectively to the anther groups Terminales and Porantheroideae. There are a number of trees in this area exhibiting different combinations of characters between the two parents which, when pure and in the virgin state, occur there on different soils. The two species have many field characters which are strongly contrasted, which makes the recognition of hybrid swarms a comparatively easy matter. The main ones of these are summarized in Table 1.

TABLE 1.

Field Characters.

	E. sideroxylon.	*E. albens.*
Bark	"Ironbark", furrowed, almost black.	Box, uniformly subfibrous, grey.
Stem	Straight; generally more than half total height without fork.	Generally forked below half height.
Crown	Narrow; branches spreading, twisted.	Spreading, umbrageous. Branches long, half upright.
Leaves	Narrow-lanceolate.	Ovate-lanceolate.
Fruit	Truncate-spherical.	Long, conical, contracted at orifice.
Pedicel	Slender, longer than fruit.	Very short, thick.
Inflorescence	Three-flowered.	Multi-flowered.

On morphological evidence there are trees in this area which are hybrids between the two species. A few trees were selected from this group which appeared to be hybrid, and also individuals somewhat removed from the hybrid swarm, which appeared to be typical examples of *E. albens* and *E. sideroxylon*. Seed was collected from these trees, and about fifty plants were raised from each of them. The form of the juvenile leaves in the species is substantially different, and while approaching one another comparatively closely in the early state, they diverge after about the fourth pair of leaves. In the case of *E. sideroxylon* the juveniles are shortly petiolate, narrow-oblong to linear, whereas in *E. albens* they have rather long petioles and are ovate or broadly lanceolate.

Figures 1, 2, 3, Plate iii, illustrate the variation obtained from the different hybrid trees in comparison with either parent (Pl. iii, figs. 4, 5). There is marked segregation in the juvenile leaf characters in the various progenies and this is lacking in the supposedly genetically pure parents. This clearly indicates in accordance with previous studies (Pryor, 1951) that the trees which appear to be hybrids from their general morphology are, in fact, of mixed genetic origin. It is also clear that the extent of the influence from one or other parent differs in the different individuals, which implies that the trees are members of a segregating swarm in which various combinations of characters derived from either parent are present in different degrees in separate individuals.

A series of measurements of leaves was taken to give quantitative expression to this condition. As in other studies (Pryor, 1952) the ratio length to breadth of leaf was used, about the eighth pair of leaves being selected in the seedling for measurement. The logarithms of the ratio were used, as this gives a better expression by the reduction of variance in the progenies from the pure parents to a more nearly similar figure than is the case with the arithmetical data. The intermediate position which is occupied by the hybrids is clearly indicated by the histograms (Text-fig. 4).

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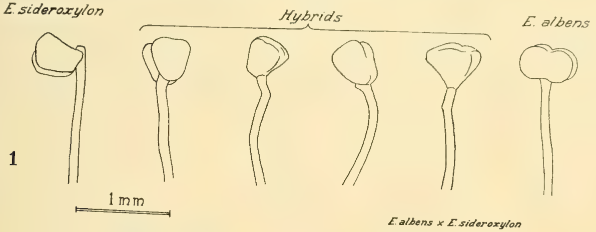

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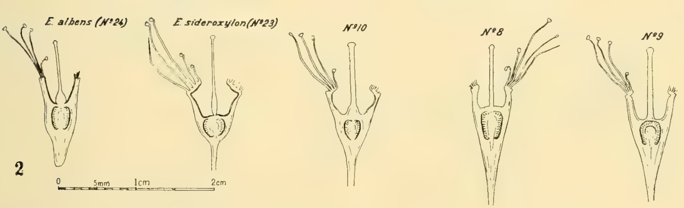

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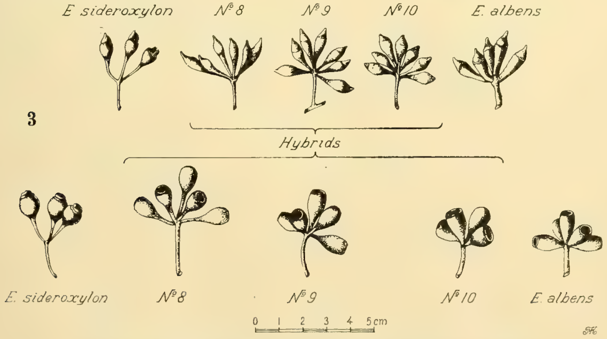


Text-fig. 1.—Outlines of anthers of hybrids and parents.

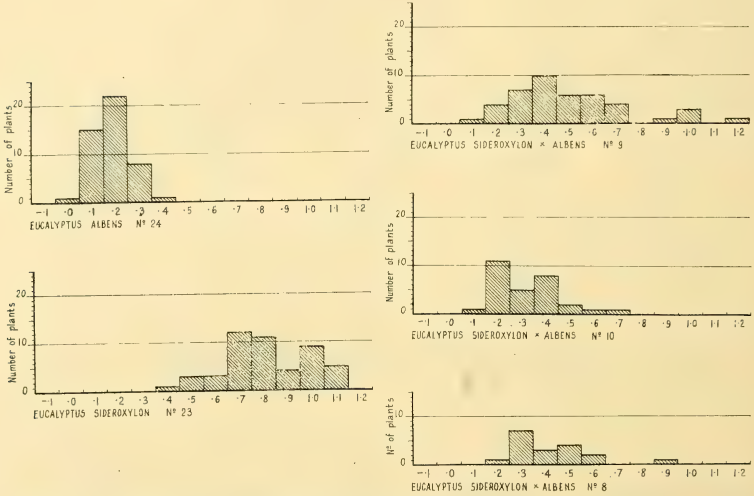
Text-fig. 2.—Variation in the staminal ring and the receptacle shape of the parents in the hybrid progeny.

Text-fig. 3.—Buds and fruit of parents and the hybrids in comparison.

From these selected hybrids a detailed study of the floral characteristics, and in particular of the anther shape, was made. I am greatly indebted to Dr. E. Gauba for the painstaking preparation and examination of the floral material. It is at once apparent (Text-fig. 1) that the anther shape, as displayed by the hybrids, is intermediate in varying degrees between the anther shape of either parent, one derived from the Terminales group and one from the Porantheroideae group. The anthers of the Terminales are laterally placed on the filament, a small portion of which generally projects beyond the point of attachment. The anther is somewhat rectangular in shape, and dehisces by terminal spores. There is no gland obvious. The anther is generally longer than it is wide (Pl. iv, fig. 1).

In the Porantheroideae the anther is adnate and terminal on a rather slender filament. It is generally broader than long; it has a rather prominent gland at the distal end, and opens by half lateral, more or less round pores (Pl. iv, fig. 2). The anther shape is clearly subject to blending in inheritance in the same way as many other morphological features of the genus are known to be. The hybrids have anthers which are somewhat variable in shape even within the one tree as well as between different hybrid trees. The most common shape is a more or less wedge-shaped form which is apparently a blend of the principal characters of the two species (Pl. iv, fig. 3).

Some additional features of interest appear in the floral characteristics of the hybrids. In the case of *E. sideroxylon* there are a number of staminodia (Pl. iv, fig. 4) which end in a point without any trace of anther or gland. In the case of some of the hybrids, the staminodia occur but are tipped with a gland (Pl. iv, fig. 5), whereas in *E. albens* there are no staminodia present (Pl. iv, fig. 6). In addition, there are glands in the filaments of *E. sideroxylon* but none are present in *E. albens*, whereas some are to be found in some of the hybrids. The staminal ring extends inward over the receptacle in *E. sideroxylon*, but is narrow and not projecting inwards in *E. albens*. The hybrids are obviously intermediate in this character. The base of the style in flower is also bulbous in the case of *E. albens*, and practically cylindrical in the case of *E. sideroxylon* (see Text-fig. 2).



Text-fig. 4.—Histograms of the logarithm of the ratio leaf length/leaf breadth of parents and hybrids between *E. sideroxylon* and *E. albens*.

From these studies it is seen there are a number of floral characters which are subject to blending in hybrid combination along with that of anther shape. At the same time it suggests that there may be additional floral characters which are submacroscopic, but which can be fairly readily examined and may thus aid in determination and placing of species if they are thoroughly examined.

A number of other characters of bud, inflorescence and fruit are also shown to be intermediate in different degrees in the hybrids examined. For example, the length of pedicel and its thickness showed this very clearly, both in the bud and the fruit.

The shape of the fruit and of the bud also show the characteristics, and the distinctive three-flowered umbel characteristic of *E. sideroxylon* shows itself in the hybrid form as an occasional three-flowered umbel mixed with multi-flowered umbels of the type derived from *E. albens* (Text-fig. 3).

DISCUSSION.

It is clear from the examination of the above material that in the two species belonging to the anther groups examined there has been interbreeding, and from the widespread occurrence of similar forms it appears that interbreeding between these two particular groups of the genus is especially easy. From information previously obtained, therefore, the grouping of species according to anther shape does not correspond with a pattern of reproductive isolation within the genus, although at some points the grouping of species by anther shape and their genetic relationship is in accord.

Of the anther groups given by Blakely, the relationship of the Platyantherae to the other groups is not yet known, as this group is almost entirely western and central Australian. Of the remaining four groups, viz., Macrantherae, Renantherae, Terminales and Porantheroideae, it is clear that the Macrantherae contains a very diverse set of species falling into a number of distinct sub-groups, most of which apparently do not interbreed. All the species within each of the other three groups, viz., Renantherae, Porantheroideae and Terminales, can apparently interbreed with each other. None of the Macrantherae seem to be able to interbreed with any of them nor can any of the Renantherae interbreed with any other group, but by contrast the Porantheroideae and the Terminales not only can, but frequently do, interbreed with one another.

Therefore, so far as anther groups are concerned, from a genetic point of view there are complete contradictions—Porantheroideae and Terminales are a free interbreeding pair of groups which on anther shape are quite morphologically distinct, whereas the Renantherae seems to be an entirely isolated group of species which can breed only with members of its own group. In the case of the species belonging to the two anther groups Terminales and Porantheroideae, there is particular interest, because it is apparent (and to some extent indicated by Blakely himself) that a number of described species are, in fact, hybrids between parents derived one from either of these two groups.

The following species and varieties given by Blakely are almost certainly hybrids and their suggested parentage is stated:

"Species."	*Probable Parentage.*
affinis	= Caleyi × albens
Auburnensis	= melliodora × melanophloia
Blackburniana	= odorata × sideroxylon
calcicultrix var. obscura	= odorata × fasciculosa
Ednaeana	= sideroxylon × microcarpa
Forsythii	= melliodora × crebra*
hybrida	= hemiphloia × paniculata
jugalis	= odorata × leucoxylon
Murphyi	= crebra × conica
odorata var. refracta	= odorata × leucoxylon
Taylori	= crebra × conica
tennandrensis	= melliodora × crebra

There are, no doubt, a number of other combinations which can be found, as, indeed, in the case discussed above of *E. sideroxylon* × *E. albens*, or *E. leucoxylon* × *E. microcarpa* which has been located in the field near Inglewood, Victoria, but which have not been described in any taxonomic work.

Wherever field junctions can be found between two species belonging one to either of these groups it is highly probable that some hybrid trees exist (Pryor, 1953).

Blakely's presentation of these "species" is not consistent, although in general he hints at, or recognizes, their probable origin. There is no doubt that he was to some

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* *E. crebra* is the correct name for the species listed by Blakely (1934) as *E. racemosa*. The latter name is correctly applied to quite a different species.

extent aware of the position, and other workers at that time were also acquainted with the probable explanation of these facts. For example, Cambage (1908) describes precisely and suggests the origin of *E. affinis* in his account of the occurrence of this tree at the junction of stands of *E. Caleyi* and *E. albens* near Torrington.

The above discussion has been confined to hybrids between pairs of species belonging one each to Terminales and Porantheroideae, but it is clear that a similar situation exists between species belonging to the same anther group in this pair. In the Porantheroideae hybrids have been found in the field between *E. microcarpa* and *E. albens*; *E. melanophloia* and *E. albens*, and a number of other combinations which, however, will be discussed elsewhere, and at the same time between members of the Terminales, such as *E. leucoxylon* × *E. melliodora* and *E. sideroxylon* × *E. leucoxylon.*

SUMMARY.

As a result of floral examination and progeny testing of trees from a hybrid swarm of *E. sideroxylon* and *E. albens*, it is deduced that anther group within the genus *Eucalyptus* does not correspond with interbreeding groups, although at some points they are in agreement. The inheritance of anther shape in hybrids between species in the Terminales and Porantheroideae is shown to be subject to the same kind of combinations as other morphological inheritance within the genus, such as juvenile leaf shape.

A number of "species" quoted by Blakely are very likely hybrids between parents belonging one to each of these two anther groups.

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EXPLANATION OF PLATES III-IV.

Plate iii.

1-3.—Hybrids between *E. sideroxylon* and *E. albens*. 1, Tree No. 9 ; 2, Tree No. 10 ; 3, Tree No. 8. 4.—Tree No. 23, *E. sideroxylon*. 5.—Tree No. 24, *E. albens*, outlines of anthers of hybrids and parents.

Plate iv.

1.—An anther of *E. sideroxylon*. 2.—Tree No. 24, an anther of *E. albens*. 3.—An anther of hybrid No. 9. 4.—The anther range of *E. sideroxylon*, Tree No. 23 ; note the sterile tipped staminodia to the left. 5.—Tree No. 10 ; note the glands on the tips of the two staminodia on the right. 6.—Anthers of *E. albens*.

AN UNDESCRIBED SPECIES OF *GREVILLEA* FROM THE RYLSTONE DISTRICT.

By H. S. McKee.

[Read 27th May, 1953.]

GREVILLEA EVANSIANA, sp. nov.

Frutex erectus vel nonnunquam semiprostratus, 0·2–2 m. altus, intricatus, ramosissimus; ramis gracilibus; ramulis novellis angulatis sparse pubescentibusque; foliis breviter petiolatis, margine integra, 2·5–6 cm. longis, 0·5–1 cm. latis, oblongo-lanceolatis, rariter lineari-lanceolatis, obtusis, acuminibus callosis, supra viridibus laevibus glabrisque, subtus pilis sericeis copiose indutis; nervis tenuibus (praeter medium), medio prominenti, lateralibus vix conspicuis supra subtusque; alabastris tomentosis, robiginosis; racemis terminalibus, subsphaericis, compactissimis; pedunculis brevibus, robustis; pedicellis brevissimis, crassis, hirsutis; floribus 10–40, subsessilibus; perianthio extra argenteo-hirsuto, intus barbato, segmentibus oblongo-lanceolatis, 5 mm. longis, 2 mm. latis, apicibus connatis dense tectis crinibus robiginosis; stylo 6–8 mm. longo, curvato, glabro, rubido vel rarius viridi; disco stigmatico rotundo, late conico, nitido, 1 mm. lato, sublateraliter posito; fructu oblique cylindrico, extra nigro, intus robiginoso, 10–12 mm. longo, stylo neglecto, 4–6 mm. lato; seminibus anguste ovatis, ad funiculum obtusis, ad apicem acutis, dorsaliter convexis, ventraliter concavis, marginibus revolutis. Habitat in rupibus prope fluminem Cudgegong in regione Rylstonense.

Hanc plantam dicavi dignissimi O. D. Evans, cujus benignitati ego, cum multis aliis, primum introductionem ad cognitionem plantarum Novo-Austro-Cambriae debeo.

An erect, occasionally semi-prostrate, intricately branched shrub, 0·2–2 m. high. Branches slender, young shoots angular, sparsely pubescent. Leaves shortly petiolate, entire, 2·5–6 cm. long, 0·5–1 cm. wide, oblong-lanceolate, rarely linear-lanceolate, obtuse with a small callous point; green, smooth and glabrous above, densely covered with silky hairs below. Midrib prominent, lateral veins indistinct above and below. Buds covered with long rust-coloured hairs. Racemes terminal, very dense, almost spherical, on short stout peduncles. Pedicels very short, thick, hairy. 10–40 flowers per raceme. Perianth covered with silky hairs outside, bearded inside, with oblong-lanceolate segments 5 mm. long, 2 mm. wide, connate at the apex and there densely covered with rust-coloured hairs. Style dark red, rarely green. Stigmatic disc circular in outline, broadly conical, shining, 1 mm. wide. Fruit obliquely cylindrical, black outside, rusty brown inside, 10–12 mm. long without the persistent style, 4–6 mm. wide. Seeds narrow, ovate, obtuse at funicular end, acute at apex, convex above, concave below, with revolute margins.

The species is named after Mr. O. D. Evans, Department of Botany, University of Sydney, to whom I, like many others, owe my first introduction to the study of the flora of New South Wales.

The following specimens have been examined: H. S. McKee s.n., 4.6.1950 (NSW 22648), buds; L. A. S. Johnson, 1.9.51 (NSW 22649), flrs.; L. A. S. Johnson, 2.9.51 (NSW 22650), flrs.; H. S. McKee s.n., 2.9.51 (NSW 22651), flrs., holotype; C. K. Ingram, 28.8.52 (NSW 22652), flrs.; H. S. McKee 21, 21.9.52 (NSW 22653), buds; H. S. McKee 51, 22.9.52 (NSW 22654), flrs.; H. S. McKee 52, 22.9.52 (NSW 22655), flrs.; H. S. McKee 53, 22.9.52 (NSW 22656), flrs.; H. S. McKee 54, 22.9.52 (NSW 22657), flrs.; H. S. McKee 469, 10.1.53 (NSW 22658), frts.; H. S. McKee 470, 11.1.53 (NSW 22659), frts.

Comparatively little variation has been noted within the species. McKee 21 represents a form with short, broad leaves, McKee 51 a form with leaves rather longer than usual. McKee 52 and McKee 54 represent a form with green flowers, known only from a few plants growing near one another. The style, stigma and base of the perianth were green, with only a faint tinge of pink at the upper end of the style, and of brown at the apex of the perianth. In typical flowers the style is dark red and the perianth reddish-brown.

The species is known only from a small area about 15 miles east of Rylstone, N.S.W., on the road from Olinda to Mount Coricudgy. The locality lies south of the dam on the Cudgegong River and is known in the district by the alternative names of "Khyber Pass" and "Curran's Mountain Gap", neither of which seems to figure on maps. It lies at about 2400′ and consists of sandy ground broken by a complex set of ridges and pinnacles of Permian sandstone. The present species, together with several other plants which are rare or unknown elsewhere, is confined to the tops and sides of these rocky outcrops. It is, however, one of the most abundant plants in many parts of this restricted area.

The nearest affinities of the species are with *Grevillea capitellata* Meissn., and especially with a broad-leaved form now referred to that species, but which it is understood is to be described as a separate species by Mr. L. A. S. Johnson, of the National Herbarium of New South Wales.

AUSTRALIAN FUNGI.

NEW SPECIES AND REVISIONS.

I. THE MELIOLACEAE OF AUSTRALIA.

By C. G. HANSFORD, Sc.D., Waite Agricultural Research Institute,
University of Adelaide.

(Forty-two Text-figures.)

[Read 24th June, 1953.]

In this paper an attempt has been made to include all species hitherto recorded in Australia and belonging to the Meliolaceae. All are parasites of living plants, mostly occurring on leaves, though a few attack also young stems, and forming black rounded colonies on the surface of these parts, sometimes thick and velvety with the erect setae, but more often quite thin and almost smooth. I am indebted to the authorities in charge of the following Herbaria for their co-operation in allowing me to examine their collections: The University of Melbourne, The University of Tasmania, the Departments of Agriculture in Victoria and New South Wales, the Brisbane Botanical Garden (through Dr. R. F. Langdon), as well as to several private collectors, especially Dr. Lilian Fraser. A few of the older collections were received from the Royal Botanic Gardens, Kew. I am particularly grateful to the staff of the National Herbarium of New South Wales for correction of the names of the host plants.

Each species of *Meliola* and related genera is restricted to comparatively a narrow range of hosts, often to a single genus or to a group of species within a genus, and rarely occurs on hosts belonging to more than a single family. Hence it is convenient to describe the Australian species under the headings of the host families on which they have been recorded: in the following pages these host families have been arranged in alphabetical order for convenience of reference.

Family APOCYNACEAE.

(1) **MELIOLA MELODINI** Hansf., n. sp. (3111.5323). (Fig. 1.)

Plagulae epiphyllae, usque ad 2 mm. diam., tenues, subvelutinae. Mycelium ex hyphis atrobrunneis, subrectis vel leniter undulatis, 6–8μ crassis (cellulis plerumque circa 25μ longis), opposite acuteque ramosis, laxe reticulatis compositum. Hyphopodia capitata alternata, plus minusve antrorsa, recta vel curvula, 25–35μ longa, cellula basali cylindracea, 6–13μ longa, cellula apicali cylindracea vel ovata, integra, 16–23 × 8–11μ. Hyphopodia mucronata in hyphis distinctis evoluta, opposita vel alternata, ampullacea, curvata, 15–24 × 6–8μ, collo suberecto, 3μ crasso praedita. Setae myceliales sat numerosae, dispersae, erectae, rectae, simplices, acutae, usque ad 700 × 9–11μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 160μ diam. Sporae atrobrunneae, cylindraceae utrinque rotundatae, 4-septatae, constrictae, 45–52 × 19–21μ.

Hab. in foliis *Melodini australis*, National Park, N.S.W., leg. L. Fraser 224.

Colonies epiphyllous, to 2 mm. diam., rather thin, thinly velvety. Mycelium of substraight to slightly undulate dark brown hyphae 6–8μ thick, the cells mostly about 25μ long, branching usually opposite at acute angles, loosely reticulate. Capitate hyphopodia alternate, more or less antrorse, straight or bent, 25–35μ long; stalk cell cylindric, 6–13μ long; head cell ovate-cylindric, entire, 16–23 × 8–11μ, widely rounded at apex. Mucronate hyphopodia on separate mycelial branches, opposite or alternate, bent ampulliform, 15–24 × 6–8μ, neck upturned, 3μ thick. Mycelial setae rather numerous, scattered, erect, straight, simple, when fully mature acute, up to 700 × 9–11μ. Perithecia scattered, black, globose, verrucose, up to 160μ diam. Spores dark brown, cylindric, obtuse, 4-septate, constricted, 45–52 × 19–21μ.

(2) **Meliola carissae** Doidge, var. **parsonsiae** Hansf., n. var. (3111.4232). (Fig. 2.)

Plagulae epiphyllae, atrae, 1–2 mm. diam., densae, subcrustosae, velutinae. Mycelium ex hyphis atrobrunneis, subrectis vel undulatis, 8–9μ crassis (cellulis plerumque 15–20μ longis), opposite vel irregulariter ramosis (circa 45°), dense reticulatis compositum, in centro plagularum subsolidum. Hyphopodia capitata alternata, antrorsa, recta vel varie curvata, 18–30μ longa, cellula basali cylindracea vel cuneata, 5–11μ longa, cellula apicali versiformia, irregulariter rotundato-lobata, 12–23 × 12–18μ. Hyphopodia mucronata plerumque in hyphis distinctis evoluta, opposita vel alternata, ampullacea, curvata, 15–22 × 7–9μ, collo suberecto, 3–4μ crasso praedita. Setae myceliales numerosae, dispersae etiam juxta perithecia aggregatae, erectae, rectae, simplices, acutae vel subacutae, usque ad 480 × 10–11μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 220μ diam. Sporae atrobrunneae, cylindraceae vel ellipsoideae, obtusae, 4-septatae, leniter constrictae, 45–51 × 18–21μ.

Hab. in foliis *Parsonsiae stramineae*, Currumbin Creek, Qld., C. T. White 10 (typus in Herb. Queensland, Brisbane); National Park, N.S.W., Fraser 91, 162; Williams R., N.S.W., Fraser 129; Orara, N.S.W., Fraser 187; Clyde Mountain, N.S.W., Fraser 169.

Colonies epiphyllous (in later collections also hypophyllous), dense, black, velvety, often subcrustose, 1–2 mm. diam. or sometimes confluent and larger. Mycelium of dark brown hyphae 8–9μ thick, the cells mostly 15–20μ long, more or less straight on upper surface of leaf, undulate to flexuous below, branching opposite or irregular at acute angles, densely reticulate and often forming almost a solid plate in centre of older colonies. Capitate hyphopodia alternate, more or less antrorse, straight or variously bent, 18–30μ long; stalk cell cylindric, 5–11μ long; head cell versiform, irregularly sinuate-lobed or often 3-stellate, 13–21 × 9–17μ (in type 12–23 × 12–18μ). Mucronate hyphopodia mostly on separate hyphae towards the centre of the colony, alternate or opposite, bent ampulliform, 15–22 × 7–9μ, neck upturned, 3–4μ thick. Mycelial setae numerous, closely scattered and also grouped around the perithecia, erect, straight, simple, acute or somewhat obtuse, up to 480 × 10–11μ. Perithecia closely scattered, black, globose, verrucose, up to 220μ diam. Spores dark brown, cylindric, the ends obtusely rounded, 4-septate, slightly constricted, 45–51 × 18–21μ.

These Australian collections also resemble *Meliola laevigata* Syd., known only from a single collection on *Paralstonia*, Philippine Is., and I am inclined to reduce this species to varietal status under the much better known *M. carissae* from South and East Africa, in spite of Sydow's species being of older date.

Family CUNONIACEAE.

(3) **Irene megalongensis** Hansf., n. sp. (2201.5230). (Fig. 3.)

Plagulae amphigenae, usque ad 5 mm. diam., subtenues, leves. Mycelium ex hyphis atrobrunneis, undulatis vel flexuosis, 6–8μ crassis (cellulis plerumque 25–35μ longis), alternatim vel irregulariter ramosis, laxe reticulatis compositum. Hyphopodia capitata alternata, saepe curvata, 25–35μ longa, cellula basali cuneata vel cylindracea, 6–14μ longa, cellula apicali irregulariter lobata, saepe fortiter curvata, 15–22 × 10–17μ, versiformia. Hyphopodia mucronata pauca, illis capitatis commixta, alternata, ampullacea, curvata, 20–25 × 7–9μ, collo suberecto, 3–4μ crasso praedita. Setae myceliales nullae. Perithecia laxe dispersa, atra, globosa, usque ad 250μ diam., superne cellulis pluribus parietis in appendicibus productis; appendices larviformes, erecto-patentes, curvatae, dilute brunneae, continuae, transverse striatae, apice obtusae, usque ad 75 × 15μ, sursum leniter attenuatae, tenuiter tunicatae. Sporae atrobrunneae, cylindraceae vel ellipsoideae, obtusae, 3-septatae, leniter constrictae, 44–51 × 16–19μ, cellulis mediis longioribus.

Hab. in foliis *Ceratopetali apetali*, Megalong Valley, Blackheath, N.S.W., Fraser 209 (typus in Herb. Dept. Agric., Sydney); *loc. cit.*, Fraser 179; Wahroonga, N.S.W., Fraser 166 p.p.;

in foliis *Ackamae paniculatae*, Williams R., N.S.W., Fraser 214, 157, 130; Hastings R., N.S.W., Fraser, s.n. (April, 1952).

Colonies amphigenous, to 5 mm. diam., rather thin, smooth. Mycelium of undulate to crooked dark brown hyphae, 6–8μ thick, the cells mostly 25–35μ long, branching alternate or irregular, not opposite, forming wavy meshes, loosely reticulate. Capitate hyphopodia alternate, often bent, 25–35μ long; stalk cell cuneate to cylindric, 6–14μ long; head cell irregularly lobed and often sharply bent, 15–22 × 10–17μ, versiform. Mucronate hyphopodia few, mixed with the capitate, alternate, bent ampulliform, 20–25 × 7–9μ, the neck 3–4μ thick. Mycelial setae none. Perithecia loosely scattered, black, globose, very rough, up to 250μ diam., with many cells of the upper half produced into erect-spreading, curved, larviform appendages, which are translucent pale brown with darker tip and base, continuous, transversely striate, obtuse, straight or with bent tips, thin-walled, up to 75 × 15μ, somewhat attenuate upwards. Spores dark brown, cylindric to ellipsoid, obtuse, 3-septate, slightly constricted, 44–51 × 16–19μ, the middle cells often longer and sometimes wider than the end cells.

(4) MELIOLA CERATOPETALI Hansf., n. sp. (3111.5221). (Fig. 4.)

Plagulae amphigenae, tenues, usque ad 5 mm. diam. Mycelium ex hyphis atrobrunneis, subrectis, 6–7μ crassis (cellulis plerumque 30–40μ longis), opposite acuteque ramosis, laxe reticulatis compositum. Hyphopodia capitata alternata, recta vel curvata, 17–25μ longo; cellula basali cylindracea, 3–6μ longa, cellula apicali cylindracea apice rotundata, integra, recta vel curvata, 13–20 × 7–10μ. Hyphopodia mucronata illis capitatis commixta, alternata, raro opposita, ampullacea, curvata, 15–25 × 6–8μ, collo suberecto, 3μ crasso praedita. Setae myceliales paucae, juxta perithecia evolutae, erectae, rectae, simplices, obtusae, usque ad 150 × 7–8μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 160μ diam., cellulis parietis obtuse conoideis. Sporae atrobrunneae, cylindraceae, obtusae, 4-septatae, 43–51 × 17–18 × 14–16μ.

Hab. in foliis *Ceratopetali apetali*, National Park, N.S.W., Fraser 151 (typus in Herb. Dept. Agric., Sydney); Narrabeen, N.S.W., Fraser 88; Wahroonga, N.S.W., Fraser 166, p.p.

Colonies amphigenous, thin, up to 5 mm. diam. Mycelium of substraight dark brown hyphae 6–7μ thick, the cells mostly 30–40μ long, branching opposite at acute angles, loosely reticulate. Capitate hyphopodia alternate, straight or bent, 17–25μ long; stalk cell cylindric, 3–6μ long; head cell cylindric with rounded apex, entire, straight or bent, 13–20 × 7–10μ. Mucronate hyphopodia mixed with capitate, alternate, rarely opposite, bent ampulliform 15–25 × 6–8μ, neck upturned, 3μ thick. Mycelial setae very few, only around the perithecia, erect, straight, simple, obtuse, up to 150 × 7–8μ. Perithecia scattered, black, globose, verrucose, up to 160μ diam., the surface cells bluntly conoid. Spores dark brown, cylindric, obtuse, 4-septate, 43–50 × 17–18 × 14–16μ.

The mycelium of this species is very different from that of the preceding, so that separation of the two when occurring in mixed infection on the leaves is simple. Many colonies are almost devoid of mycelial setae and then appear to belong to *Irenina*.

Family CYPERACEAE.

(5) MELIOLA ARGENTINA Speg., in *Anal. Soc. Cient. Argent.*, 9: 177, 1880 (3411.5233).

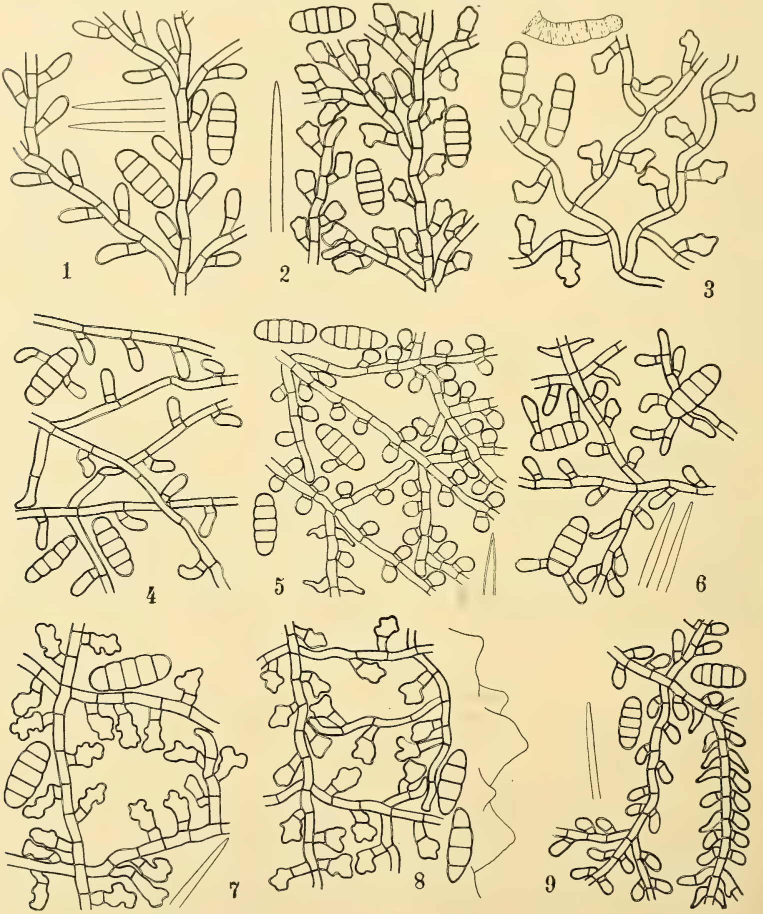
On *Gahnia clarkei*, Urunga, N.S.W., Fraser 227; on *Gahnia* sp., Pennant Hills, N.S.W., Fraser 8; Narrabeen, Fraser 119.

Colonies amphigenous, up to 1 mm. diam., scattered, black, dense, somewhat velvety, not usually confluent. Mycelium closely reticulate, of dark brown, substraight to slightly flexuous hyphae, 7–9μ thick, the cells mostly 20–25μ long, branching usually alternate or irregular, rarely opposite, at acute angles. Capitate hyphopodia alternate, straight or bent, 20–35μ long; stalk cell cylindric, 3–12μ long; head cell straight or bent, more or less oblong, irregularly angulose to lobed, versiform, 16–25 × 10–18μ. Mycelial setae scattered and also grouped around the perithecia, erect, straight, simple, obtuse, up to 600 × 11–13μ. Perithecia closely scattered, black, globose, verrucose, up to 270μ diam., with about six erect-spreading, simple, obtuse or acute, more or less circinate, setae on upper half, up to 120 × 9–11μ. Spores dark brown, cylindric with obtuse ends, 4-septate, constricted, 47–56 × 15–18 × 12–14μ.

This species has now been recorded on various genera of this family throughout the warmer regions of the world; its range of variation and the precise differentiation from other very closely related species still remain to be elucidated.

Family DILLENIACEAE.

(6) MELIOLA WORMIAE Hansf., n. sp. (3113.4221). (Fig. 5.)



Text-figures 1-9.*

1, *Meliola melodini.* 2, *M. carissae* var. *parsonsiae.* 3, *Irene megalongensis.* 4, *Meliola ceratopetali.* 5, *M. wormiae.* 6, *M. diospyricola.* 7, *M. diospyri-pentamerae.* 8, *M. cyathodis* var. *trochocarpae.* 9, *M. petalostigmatis.*

Plagulae epiphyllae, densae, subvelutinae, usque ad 4 mm. diam. Mycelium ex hyphis atrobrunneis, subrectis, 7μ crassis (cellulis plerumque $15-30\mu$ longis), opposite ramosis (circa 45°), dense reticulatis compositum, subsolidum. Hyphopodia capitata opposita vel alternata, plerumque recta, $11-17\mu$ longa, cellula basali cylindracea, $2-6\mu$ longa, cellula apicali globosa, integra, $10-13\mu$ diam. Hyphopodia mucronata illis capitatis

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* All figures are × 250. Mycelium, hyphopodia, spores and setal tips are shown, with outlines of perithecial cells for *Irenina* spp. and perithecial appendage for *Irene* spp.

commixta, opposita vel alternata, ampullacea, curvata, 14–25 × 7–9μ, collo suberecto, 3μ crasso praedita. Setae myceliales numerosae, dispersae, erectae, rectae, simplices, acutae, usque ad 250 × 9–11μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 180μ diam. Sporae atrobrunneae, cylindraceae, obtusae, 4-septatae, constrictae, 40–47 × 15–17μ.

Hab. in foliis *Wormiae alatae*, Johnstone R., Qld., Bailey 484.

Colonies epiphyllous, black, dense, up to 4 mm. diam., somewhat velvety. Mycelium of substraight dark brown hyphae, 7μ thick, the cells mostly 15–30μ long, branching opposite at 45°, forming a very dense and almost solid network. Capitate hyphopodia opposite or alternate, somewhat antrorse, usually straight, 11–17μ long; stalk cell cylindric, 2–6μ long; head cell globose, entire, 10–13μ diam. Mucronate hyphopodia mixed with capitate, opposite or alternate, bent ampulliform, 14–25 × 7–9μ, neck erect, 3μ thick. Mycelial setae numerous, erect, straight, simple, acute, up to 250 × 9–11μ. Perithecia scattered, black, globose, verrucose, up to 180μ diam. Spores dark brown, cylindric, obtuse, 4-septate, constricted, 40–47 × 15–17μ.

Family EBENACEAE.

(7) Meliola diospyricola Hansf., n. sp. (3113.4233). (Fig. 6.)

Plagulae amphigenae, plerumque hypophyllae, densae, velutinae, usque ad 4 mm. diam., interdum confluentes. Mycelium in epiphyllo ex hyphis subrectis vel leniter undulatis, atrobrunneis, 6–7μ crassis (cellulis plerumque 15–25μ longis), opposite ramosis (60–90°), subdense reticulatis compositum. Hyphopodia capitata alternata vel circa 3% opposita, plus minusve antrorsa, recta vel curvula, 16–24μ longa, cellula basali cylindracea, 4–9μ longa, cellula apicali ovata vel cylindracea, integra, superne saepe leniter recurvata, 11–18 × 8–11μ. Hyphopodia mucronata illis capitatis commixta, alternata vel opposita, conoidea vel ampullacea, 15–25 × 7–8μ, collo suberecto, 3–4μ crasso praedita. Setae myceliales numerosae, dispersae, erectae, rectae, simplices, acutae vel subacutae, usque ad 750 × 9–11μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 240μ diam. Sporae atrobrunneae, cylindraceae vel subellipsoideae, obtusae, 4-septatae, constrictae, 40–48 × 16–19μ.

Hab. in foliis *Diospyri australis*, Williams R., N.S.W., Fraser 104A (typus in Herb. Dept. Agric., Sydney); *loc. cit.*, Fraser 104; National Park, N.S.W., Fraser 156.

Colonies amphigenous, mostly hypophyllous, dense, velvety, up to 4 mm. diam., usually smaller and sometimes confluent. Mycelium on upper surface of substraight to slightly undulate dark brown hyphae 6–7μ thick, the cells mostly 15–25μ long, branching opposite at wide angles, closely reticulate. On the lower leaf surface the mycelium is much more crooked and irregular. Capitate hyphopodia alternate or about 3% opposite, more or less antrorse, straight or bent, 16–24μ long; stalk cell cylindric, 4–9μ long; head cell ovate to cylindric, often slightly recurved at the tip, entire, 11–18 × 8–11μ. Mucronate hyphopodia mixed with capitate, alternate or opposite, conoid-ampulliform, 15–25 × 7–8μ, neck upturned, 3–4μ thick. Mycelial setae numerous, scattered, erect, straight, simple, acute or subacute, up to 750 × 9–11μ. Perithecia scattered, black, globose, verrucose, up to 240μ diam. Spores dark brown, cylindric, obtuse, 4-septate, constricted, 40–48 × 16–19μ.

(8) Meliola diospyri-pentamerae Hansf., n. sp. (3113.6333). (Fig. 7.)

Plagulae amphigenae, densae, velutinae, usque ad 3 mm. diam. Mycelium in epiphyllo ex hyphis atrobrunneis, subrectis vel leniter undulatis, 7–8μ crassis (cellulis plerumque 20–25μ longis), opposite vel irregulariter ramosis (30–60°), dense reticulatis compositum, in centro plagularum subsolidum. Hyphopodia capitata alternata, saepe curvata, 22–40μ longa, cellula basali cylindracea, 5–15μ longa, cellula apicali irregulariter lobata et curvata, 17–26 × 10–19μ. Hyphopodia mucronata illis capitatis commixta, alternata, conoidea vel ampullacea, 24–29 × 7–9μ, collo suberecto, 3–4μ crasso praedita. Setae myceliales paucae vel numerosae, dispersae, erectae, simplices, acutae, usque ad 600 × 8–11μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 240μ diam. Sporae atrobrunneae, cylindraceae vel subellipsoideae, 4-septatae, constrictae, 50–59 × 19–23μ.

Hab. in foliis *Diospyri pentamerae*, Tweed R., N.S.W., Fraser 53 (typus in Herb. Dept. Agric., Sydney); Mt. Warning, N.S.W., Fraser s.n.; Williams R., N.S.W., Fraser 140, 202.

Epiphyllous colonies are dense, up to 2 mm. diam., with few setae, probably due to parasites. Mycelium of substraight to slightly undulate dark brown hyphae, 7–8μ thick, the cells mostly 20–25μ long, branching opposite or irregular at wide angles, densely reticulate and becoming almost solid. Capitate hyphopodia alternate, often bent, 22–40μ long; stalk cell cylindric, 5–15μ long; head cell very irregularly bent and lobed, 17–26 × 10–19μ. Mucronate hyphopodia mixed with capitate, alternate, conoid-ampulliform, 24–29 × 7–9μ, neck upturned, 3–4μ thick. Mycelial setae few scattered, erect, straight, simple, acute, up to 600 × 8–11μ. Perithecia scattered, black, globose, verrucose, up to 240μ diam. Spores dark brown, cylindric to subellipsoid, 4-septate, constricted, 50–59 × 19–23μ.

The hypophylious colonies are more velvety, slightly larger, the hyphae more crooked, and the hyphopodia less lobed but more variable in shape and size, from globose and entire to ovate and often somewhat pointed at the apex, with others irregularly rounded-angular and often sharply curved to almost uncinate, 13–25 × 10–15μ. The stalk cells vary in length from 5–30μ and are often much bent. The spores are variable, occasional ones are only 45μ long, while others reach 62μ. Colonies of this species also occur on *Diospyros australis*, Williams R., N.S.W., Fraser 104, on the underside of the leaf only.

In many characters this species resembles the description of *M. megalocarpa* Syd., on *Maba buxifolia*, Philippines, but differs especially in that the hyphopodia of the latter are given as oblong and entire. Specimens of Sydow's species have not yet become available to me for comparison.

Family EPACRIDACEAE.

(9) Meliola cyathodis Hansf., in *Proc. Linn. Soc. London*, 157: 180, 1946 (2111.6232).

Colonies hypophyllous, rather thin, up to 2 mm. diam. Mycelium of dark brown, flexuous to sinuous hyphae, 7–9μ thick, the cells mostly 10–30μ long, branching usually opposite at acute angles, loosely to rather closely reticulate. Capitate hyphopodia alternate or less than 1% opposite, more or less antrorse, straight or bent, 25–35μ long; stalk cell cylindric, 7–14μ long; head cell very irregularly 2–5-lobed or merely angular, often bent, 15–25 × 10–20μ. Mucronate hyphopodia scattered amongst the capitate, few, alternate, bent ampulliform, 18–22 × 7–9μ, neck upturned, 3–4μ thick. Perithecia in a central group, black, globose, verrucose, up to 240μ diam. Spores dark brown, cylindric to ellipsoid, bent, the ends more or less attenuate-rounded, 3-septate, constricted, 53–63 × 16–18μ.

On leaves of *Cyathodes glaucus*, Tasmania, L. Rodway 421 (type in Herb. Pretoria).

(10) Meliola cyathodis Hansf., var. trochocarpae Hansf., n. var. (2113.5241). (Fig. 8.)

Plagulae amphigenae, plerumque hypophyllae, subdensae, leves, usque ad 2 mm. diam. Mycelium ex hyphis atrobrunneis, undulatis, 6–7μ crassis (cellulis plerumque 20–25μ longis), opposite vel irregulariter ramosis (60–90°), dense reticulatis compositum. Hyphopodia capitata alternata vel circa 1% opposita, plus minusve antrorsa, recta vel varie curvata, 22–35μ longa, cellula basali cuneata vel cylindracea, 6–20μ longa, cellula apicali rotundato-lobata, versiformia, 15–23 × 12–18μ. Hyphopodia mucronata illis capitatis commixta, plerumque alternata, ampullacea, curvata, 14–20 × 6–9μ, collo suberecto, 3–4μ crasso praedita. Setae myceliales paucae, juxta perithecia evolutae, erectae, rectae vel flexuosae, simplices, obtusae, usque ad 200 × 6–8μ. Perithecia laxe aggregata, atra, globosa, verrucosa, usque ad 350μ diam., cellulis parietis conoideis vel mammillatibus, usque ad 30μ alt. et inferne circa 50μ diam. Sporae atrobrunneae, ellipsoideae, curvatae, 3-septatae, constrictae, 45–54 × 16–18μ, cellulis terminalibus minoribus et rotundato-conoideis.

Hab. in foliis *Trochocarpae laurinae*, Williams R., N.S.W., Fraser s.n. (typus in Herb. Dept. Agric., Sydney); Bulga, N.S.W., Fraser 63.

Colonies amphigenous, mostly hypophyllous, rather dense, smooth, up to 2 mm. diam. Mycelium of undulate dark brown hyphae 6–7μ thick, the cells mostly 20–25μ long, branching opposite or irregular at wide angles, closely reticulate. Capitate hyphopodia alternate or about 1% opposite, more or less antrorse, straight or variously bent, 22–35μ long; stalk cell cylindric-cuneate, 6–20μ long; head cell irregularly rounded-lobate, versiform, 15–23 × 12–18μ. Mucronate hyphopodia mixed with capitate, mostly alternate, bent ampulliform, 14–20 × 6–9μ, neck upturned, 3–4μ thick. Mycelial setae very few, around the perithecia, erect, straight or upcurved, simple, obtuse, up to 200 × 6–8μ, sometimes flexuous and descending to the mycelium. Perithecia in loose central group, black, globose, up to 350μ diam., the surface cells conoid-mammillate, projecting about 30μ and about 50μ diam. at the base. Spores dark brown, bent ellipsoid, 3-septate, constricted, 45–54 × 16–18μ, the end cells smaller than central cells and rounded-conoid.

This variety differs from the type in its denser colonies, obtuse setae around the perithecia only, larger perithecia and considerably smaller spores, which tend to be more fusoid.

Family EUPHORBIACEAE.

(11) MELIOLA PETALOSTIGMATIS Hansf., n. sp. (3113.4232). (Fig. 9.)

Plagulae epiphyllae, densae, usque ad 1 mm. diam., velutinae. Mycelium ex hyphis atrobrunneis, subrectis, 6–7μ crassis (cellulis plerumque 15–20μ longis), opposite ramosis (30–60°), dense reticulatis compositum, in centro plagularum subsolidum. Hyphopodia capitata alternata vel opposita, plus minusve antrorsa, recta vel curvata, 14–23μ longa, cellula basali cylindracea, 3–7μ longa, cellula apicali ovata, ellipsoidea vel piriformia, apice late rotundata, integra, recta vel curvula, 10–16 × 7–10μ. Hyphopodia mucronata numerosa, illis capitatis commixta, ampullacea, curvata, 15–20 × 7–8μ, collo suberecto, 3μ crasso praedita. Setae myceliales praecipue juxta perithecia evolutae, erectae, rectae, simplices, obtusae vel subacutae, usque ad 350 × 7–8μ. Perithecia laxe aggregata, atra, globosa, verrucosa, usque ad 240μ diam. Sporae atrobrunneae, cylindraceae vel ellipsoideae, obtusae, 4-septatae, constrictae, 36–44 × 15–17μ.

Hab. in foliis *Petalostigmatis quadrilocularis*, Lawrence, N.S.W., Fraser 229, in Herb. Dept. Agric., Sydney.

Colonies epiphyllous, dense, up to 1 mm. diam., becoming velvety. Mycelium of substraight dark brown hyphae 6–7μ thick, the cells mostly 15–20μ long, branching opposite at acute angles, densely reticulate and almost solid in the centre. Capitate hyphopodia alternate or opposite, more or less antrorse, straight or bent, 14–23μ long; stalk cell cylindric, 3–7μ long; head cell ovate, ellipsoid to piriform, broadly rounded at apex, entire, straight or slightly bent, 10–16 × 7–10μ. Mucronate hyphopodia numerous, mixed with capitate, bent ampulliform, 15–20 × 7–8μ, neck upturned, 3μ thick. Mycelial setae mostly around perithecia, erect, straight, simple, obtuse to subacute, up to 350 × 7–8μ. Perithecia in loose central group, black, globose, verrucose, up to 240μ diam. Spores dark brown, cylindric to subellipsoid, obtuse at ends, 4-septate, constricted, 36–44 × 15–17μ, mostly about 39 × 15μ.

(12) IRENOPSIS CROTONIS (Stev. & Tehon) Stev., in *Ann. Mycol., Berlin*, 25: 441, 1927 (3401.3220).

Colonies amphigenous, thin, smooth, up to 5 mm. diam. or sometimes confluent. Mycelium of substraight to slightly undulate dark brown hyphae, 6–7μ thick, the cells mostly 25–40μ long, branching opposite at acute angles, loosely reticulate-radiating. Capitate hyphopodia alternate, antrorse, usually straight, 13–20μ long; stalk cell cuneate to cylindric, 4–7μ long; head cell globose to piriform and entire, or sometimes rounded-angulose and slightly irregular, 10–13 × 9–11μ. Mucronate hyphopodia mixed with capitate, alternate or opposite, bent ampulliform, 18–24 × 6–8μ, neck upturned, 3μ thick. Mycelial setae none. Perithecia loosely scattered, black, globose, verrucose, up to 160μ diam., with 2–10 erect-spreading setae on upper half; setae simple, obtuse, thick-walled, continuous, smooth, up to 120 × 6–10μ, apex nearly straight or uncinate but not coiled. Spores dark brown, cylindric, obtuse, 4-septate, constricted, 33–38 × 14–16μ.

On *Croton verreauxii*, Williams R., N.S.W., Fraser s.n., April, 1952.

(13) Irenina malloti Hansf. & Thirum., *Farlowia* 3: 289, 1948 (3101.5330).

Colonies hypophyllous, less commonly also epiphyllous, up to 4 mm. diam. or sometimes confluent, rather dense. Mycelium of substraight to undulate dark brown hyphae 6–8μ thick, the cells mostly 20–35μ long, branching opposite or irregular, loosely to rather closely reticulate. Capitate hyphopodia alternate, at varying angles, straight or often bent, 14–30μ long; stalk cell cylindric, 5–12μ long; head cell clavate or irregularly rounded-angulose, rarely sublobate, 10–20 × 11–16μ. Mucronate hyphopodia mixed with capitate, alternate or sometimes opposite, bent conoid-ampulliform, 17–22 × 7–10μ, neck upturned, 4–5μ thick. Mycelial setae none. Perithecia scattered, black, globose, up to 230μ diam., the surface cells mammillate to obtusely bent-conoid, projecting up to 30μ. Spores dark brown, subellipsoid, obtuse, 4-septate, constricted, 48–55 × 19–24μ.

On *Baloghia lucida*, Williams R., N.S.W., Fraser 148, 219.

Family FLACOURTIACEAE.

(14) Meliola scolopiae Doidge, var. zeylanica Hansf., in *Proc. Linn. Soc. Lond.*, 158: 35, 1946 (2111.5334).

Colonies amphigenous, dense, up to 2 mm. diam. or sometimes confluent, velvety. Mycelium of dark brown, more or less undulate hyphae 7–9μ thick, the cells mostly 15–20μ long, branching alternate or irregular, rarely opposite, closely reticulate. Capitate hyphopodia alternate, straight or bent, 20–35μ long; stalk cell cylindric, 6–15μ long; head cell deeply 3–6-lobed, straight or very irregularly bent, 15–25 × 15–25μ. Mucronate hyphopodia few, alternate or unilateral, scattered amongst capitate, conoid-ampulliform, bent, 18–25 × 7–8μ, neck upturned, 3–4μ thick. Mycelial setae numerous, scattered and also around the perithecia, erect, more or less straight, simple, obtuse to subacute, up to 1100 × 9–11μ. Perithecia scattered, black, globose, verrucose, up to 240μ diam. Spores dark brown, bent ellipsoid, obtuse, 3-septate, constricted, 53–59 × 18–22μ.

On *Scolopia brownii*, Williams R., N.S.W., Fraser 105, 203 p.p.

The range of spore size is greater in the Australian material than in the type from Ceylon, and occasional spores reach a length of 69μ.

Family GESNERIACEAE.

(15) Irenopsis fieldiae Hansf., n. sp. (3401.3220). (Fig. 10.)

Plagulae epiphyllae, tenues, leves, usque ad 1 mm. diam. vel. confluentes. Mycelium ex hyphis atrobrunneis, undulatis vel flexuosis, 6–8μ crassis (cellulis plerumque 15–30μ longis), opposite vel irregulariter ramosis, laxe reticulatis compositum. Hyphopodia capitata alternata, rarissime opposita, plus minusve antrorsa, recta vel curvata, 17–25μ longa, cellula basali cylindracea, 4–9μ longa, cellula apicali interdum ovata integraque, interdum rotundato-angulosa vel lobata, versiformia, 14–18 × 9–14μ. Hyphopodia mucronata in hyphis distinctis evoluta, opposita, ampullacea, curvata, 13–18 × 6–8μ, collo suberecto, 3–4μ crasso praedita. Setae myceliales nullae. Perithecia laxe dispersa, atra, globosa, verrucosa, usque ad 160μ diam., superne setis 2–12, erecto-patentibus, rectis vel subrectis, simplicibus, obtusis vel subacutis, 3–4-septatis, usque ad 180 × 7–8μ, sursum attenuatis ornata. Sporae atrobrunneae, cylindraceae, obtusae, 4-septatae, constrictae, 32–39 × 13–15μ.

Hab. in foliis *Fieldiae australis*, Mt. Wilson, N.S.W., Fraser 5 (typus in Herb. Dept. Agric., Sydney); Comboyne, N.S.W., Fraser 190; Blackheath, N.S.W., Fraser 210.

Colonies epiphyllous, closely scattered, up to 1 mm. diam., thin, smooth, sometimes confluent. Mycelium of crooked dark brown hyphae 6–8μ thick, the cells mostly 15–30μ long, branching opposite or irregular at varying angles, loosely reticulate. Capitate hyphopodia alternate, very rarely opposite, more or less antrorse, straight or bent, 17–25μ long; stalk cell cylindric, 4–9μ long; head cell sometimes ovate and entire, more often shallowly rounded-lobate or irregular, versiform, 14–18 × 9–14μ. Mucronate hyphopodia on separate hyphae in centre of colony, opposite, bent ampulliform, 13–18 × 6–8μ, neck upturned, short, 3–4μ thick. Mycelial setae none. Perithecia loosely scattered, black, globose, verrucose, up to 160μ diam., with 2–12 erect-spreading setae arising from upper half; setae more or less straight, simple, obtuse to subacute, 3–4-septate, up to 180μ long, 7–8μ thick at base, gradually attenuate towards apex. Spores dark brown, cylindric, obtuse, 4-septate, constricted, 32–39 × 13–15μ.

Family ICACINACEAE.

(16) Meliola citronellae Hansf., n. sp. (3111.5332). (Fig. 11.)

Plagulae amphigenae, densae, velutinae, usque ad 3 mm. diam. Mycelium ex hyphis atrobrunneis, undulatis, 7–8μ crassis (cellulis plerumque 20–35μ longis), opposite acuteque ramosis, dense reticulatis compositum, in centro plagularum subsolidum. Hyphopodia capitata alternata, antrorsa, recta vel curvata, 30–40μ longa, cellula basali cuneata vel cylindracea, 6–15μ longa, cellula apicali cylindracea vel clavata, apice rotundata, integra, saepe curvula, 20–31 × 10–14μ. Hyphopodia mucronata pauca, illis capitatis commixta, alternata vel opposita, ampullacea, curvata, 20–30 × 6–9μ, collo suberecto 3–4μ crasso praedita. Setae myceliales numerosae, erectae, rectae, simplices, acutae, usque ad 350 × 9–11μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 250μ diam. Sporae atrobrunneae, cylindraceae vel subellipsoideae, obtusae, 4-septatae, constrictae, 45–53 × 19–23μ, cellula media saepe leniter longiore et crassiore.

Hab. in foliis *Citronellae moorei*, Williams R., N.S.W., Fraser 66 (typus in Herb. Dept. Agric., Sydney); *loc. cit.*, Fraser 201.

Colonies amphigenous, dense, velvety, to 3 mm. diam., usually distinct. Mycelium of undulate dark brown hyphae 7–8μ thick, the cells mostly 20–35μ long, branching usually opposite at acute angles, closely reticulate and becoming almost solid in the centre of older colonies. Capitate hyphopodia alternate, antrorse, straight or bent, 30–40μ long; stalk cell cuneate to cylindric, 6–15μ long; head cell cylindric to clavate, rounded at apex, entire, often bent, 20–31 × 10–14μ. Mucronate hyphopodia few, scattered amongst capitate, alternate or opposite, bent ampulliform, 20–30 × 6–9μ, neck 3–4μ thick, upturned. Mycelial setae numerous, erect, straight, simple, acute, up to 350 × 9–11μ. Perithecia scattered, black, globose, verrucose, up to 250μ diam. Spores dark brown, cylindric, obtuse, 4-septate, constricted, 45–53 × 19–23μ, the centre cell often slightly longer and wider than the others.

Family LABIATAE.

(17) Meliola prostantherae Hansf., n. sp. (3111.4221). (Fig. 12.)

Plagulae epiphyllae, numerosae et late confluentes, usque ad 1 mm. diam., subtenues. Mycelium ex hyphis atrobrunneis, undulatis vel flexuosis, 6μ crassis (cellulis plerumque 20–30μ longis), opposite acuteque ramosis, laxe reticulatis compositum. Hyphopodia capitata alternata, recta vel curvata 16–23μ longa, cellula basali cylindracea vel cuneata, 3–6μ longa, cellula apicali subglobosa vel late ovata, integra, 11–15 × 8–11μ. Hyphopodia mucronata praecipue in hyphis distinctis evoluta, opposita vel alternata, ampullacea, curvata, 15–20 × 7–9μ, collo suberecto, 3μ crasso praedita. Setae myceliales laxe dispersae, simplices, obtusae, rectae, usque ad 220 × 6–7μ, saepe apice leniter clavatae. Perithecia laxe dispersa, atra, globosa, verrucosa, usque ad 140μ diam. Sporae atrobrunneae, cylindraceae, obtusae, 4-septatae, constrictae, 31–40 × 13–15μ.

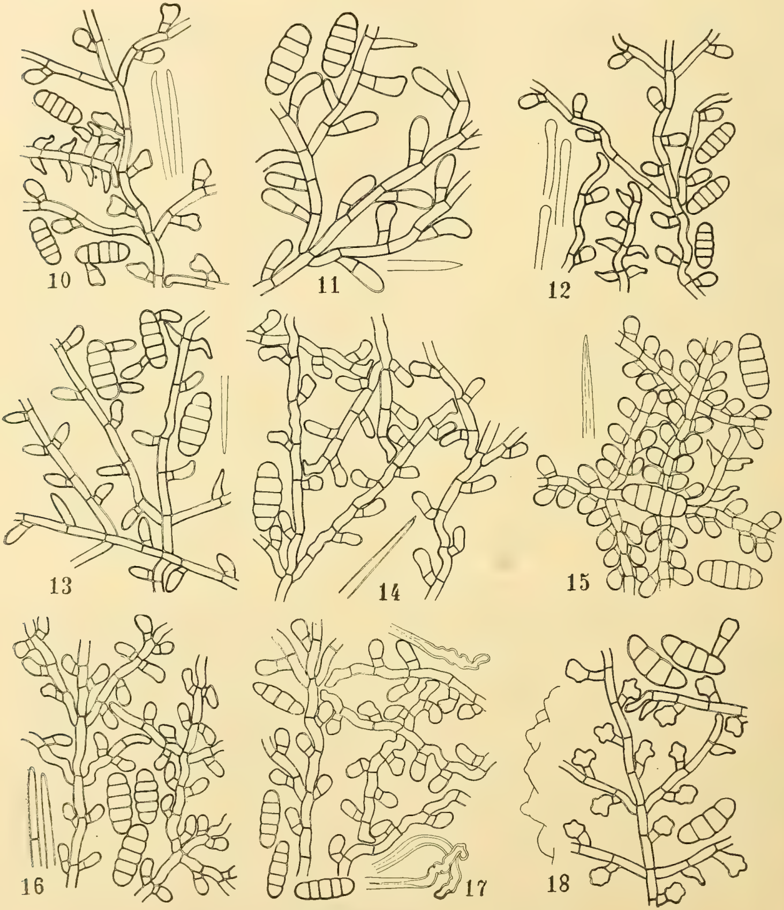
Hab. in foliis *Prostantherae sieberi*, National Park, N.S.W., Fraser 28 (typus in Herb. Dept. Agric., Sydney).

Colonies epiphyllous, numerous and confluent over leaf, up to 1 mm. diam., rather thin. Mycelium of crooked dark brown hyphae 6μ thick, the cells mostly 20–30μ long, branching usually opposite at acute angles, loosely reticulate. Capitate hyphopodia alternate, at varying angles, straight or bent, 16–23μ long; stalk cell cylindric or cuneate, 3–7μ long; head cell subglobose to wide ovate, entire, 11–15 × 8–11μ. Mucronate hyphopodia mostly on separate hyphae, opposite or alternate, bent ampulliform, 15–20 × 7–9μ, neck upturned, 3μ thick. Mycelial setae thinly scattered, simple, obtuse to often slightly clavulate, straight, up to 220 × 6–7μ. Perithecia loosely scattered, black, globose, verrucose, up to 140μ diam. Spores dark brown, cylindric, obtuse, 4-septate, constricted, 31–40 × 13–15μ.

Family LAURACEAE.

(18) ARMATELLA LITSEAE (P. Henn.) Theiss & Syd., in *Ann. Myc., Berl.*, 13: 255, 1915.

Colonies amphigenous, thin, up to 10 mm. diam. or confluent, smooth. Mycelium of substraight to somewhat undulate dark brown hyphae 5–7μ thick, the cells 15–30μ long, branching alternate or irregular, loosely reticulate. Capitate hyphopodia alternate, at wide angles, 15–22μ long; stalk cell cylindric 2–8μ long; head cell ovate to subglobose with numerous rounded shallow lobes, 8–15 × 10–15μ. No mucronate hyphopodia, nor mycelial setae. Perithecia loosely scattered, black, globose, up to 180μ diam., the surface cells bluntly conoid; the perithecia are easily secedent, leaving an areole of radiating hyphae without hyphopodia around their sites. Spores oblong with rounded



Text-figures 10-18. (× 250.)

10, *Irenopsis fieldiae*. 11, *Meliola citronellae*. 12, *M. prostantherae*. 13, *M. dactylopoda* var. *brevipoda*. 14, *M. dysoxylicola*. 15, *M. dysoxyli*. 16, *M. brisbanensis*. 17, *Irenopsis berggrenii*. 18, *Irenina daphnandrae*.

ends, 1-septate, slightly constricted, smooth, 34–42 × 12–15μ; at germination the upper cell becomes much darker than the lower and forms a hyphopodium at its apex, while the lower cell collapses.

On *Cinnamomum virens*, Comboyne, N.S.W., Fraser 184; on *Cinnamomum* sp., Russell R., North Qld., Mueller, 1892, in National Herb., Victoria.

(19) IRENE KIRAIENSIS Yamamoto in *Trans. Nat. Hist. Soc., Formosa*, 31: 47, 1941. (2201.5230).

Colonies hypophyllous, dense, smooth, up to 1 mm. diam. Mycelium of substraight to slightly undulate dark brown hyphae 6–8μ thick, the cells mostly 20–30μ long, branching opposite or irregular at wide angles, closely reticulate. Capitate hyphopodia alternate, more or less antrorse, straight or bent, 22–40μ long; stalk cell cylindric, 5–19μ long; head cell irregularly rounded-lobed, 16–22 × 14–22μ. Mucronate hyphopodia few, mixed with capitate, alternate, bent ampulliform, 15–22 × 8–10μ, the neck 3μ thick, upturned. Setae none. Perithecia in central group, black, globose, immature; many cells prolonged into larviform appendages, spreading-erect, incurved at the tips, simple, obtuse, continuous, translucent brown, transversely striate, up to 80μ long and 30μ diam. at the base, tapering to 15μ at the apex. Spores dark brown, bent ellipsoid, 3-septate, slightly constricted, 47–54 × 17–19μ.

On *Cinnamomum virens*, Comboyne, N.S.W., Fraser 184.

This differs in some respects, notably in the dense colonies, from the original description, and further collections may make it necessary to erect a new species for the Australian fungus.

(20) IRENINA FRASERIANA (Syd.) Hansf., n. comb. (3101.4230).
= *Meliola fraseriana* Syd. in *Ann. Mycol., Berl.*, 35: 27, 1937.

Colonies hypophyllous, up to 4 mm. diam., or confluent, dense. Mycelium of dark brown, substraight to undulate hyphae 8–10μ thick, the cells mostly 20–30μ long, branching opposite at wide angles, closely reticulate. Capitate hyphopodia alternate, more or less antrorse, straight or bent, often slightly recurved, 25–35μ long; stalk cell cylindric, 4–10μ long; head cell ovate to cylindric, rounded at apex, entire, 17–25 × 10–14μ. Mucronate hyphopodia mixed with capitate, opposite or alternate, bent ampulliform, 18–23 × 9–11μ, neck upturned, 3–4μ thick. Mycelial setae none. Perithecia scattered, each on radiate subiculum, black, globose, verrucose, up to 350μ diam., the surface cells bluntly conoid, projecting up to 15μ. Spores dark brown, ellipsoid, obtuse, 4-septate, constricted, 42–48 × 18–20μ.

On *Cryptocarya meissneri*, N.S.W., Fraser (type); on *C. glaucescens*, Williams R., N.S.W., Fraser 208; Comboyne, Fraser 200; Clyde Mountain, Fraser 153.

(21) MELIOLA DACTYLOPODA Syd., var. BREVIPODA Hansf., n. var. (3113.4223). (Fig. 13.)

Plagulae amphigenae, tenues, usque ad 5 mm. diam., vel in hypophyllo effusae confluentesque. Mycelium ex hyphis atrobrunneis, subrectis vel leniter undulatis, 6–7μ crassis (cellulis plerumque 20–30μ longis), opposite acuteque ramosis, laxe reticulatis compositum. Hyphopodia capitata alternata vel circa 2% opposita, plus minusve antrorsa, recta vel curvula, 16–27μ longa, cellula basali cylindracea, 3–9μ longa, cellula apicali saepius ovata, apice obtuse attenuata, vel interdum cylindraceae et apice obtusa, 13–20 × 7–10μ. Hyphopodia mucronata illis capitatis commixta, alternata vel opposita, ampullacea, curvata, 14–23 × 6–8μ, collo elongato, suberecto, 3μ crasso praedita. Setae myceliales laxe dispersae, etiam juxta perithecia aggregatae, erectae, plus minusve rectae, simplices, acutae, usque ad 900 × 8–9μ. Perithecia laxe dispersa, atra, globosa, verrucosa, usque ad 190μ diam. Sporae atrobrunneae, cylindraceae vel subellipsoideae, obtusae, 4-septatae, constrictae, 38–46 × 15–20μ.

Hab. in foliis *Cryptocaryae patentinervis*, Williams R., N.S.W., Fraser s.n., April, 1952 (typus in Herb. Dept. Agric., Sydney).

Colonies amphigenous, thin, to 5 mm. diam. or, especially on the lower surface of the leaf, effuse and confluent. Mycelium of substraight to somewhat undulate dark brown hyphae 6–7μ thick, the cells mostly 20–30μ long, branching opposite at acute angles, loosely reticulate. Capitate hyphopodia alternate or about 2% opposite, more or less antrorse, straight, or slightly bent, 16–27μ long (considerably shorter than in the type from S. Africa); stalk cell cylindric, 3–9μ long; head cell mostly ovate with somewhat pointed apex, sometimes bent cylindric with bluntly rounded apex, 13–20 × 1–10μ. Mucronate hyphopodia mixed with capitate, alternate or opposite, bent ampulliform, 14–23 × 6–8μ, neck rather long, upturned, 3μ thick. Mycelial setae thinly scattered and shorter ones grouped around the perithecia, erect, more or less straight, simple, acute, up to 900 × 8–9μ. Perithecia loosely scattered, black, globose, verrucose, up to 190μ diam. Spores dark brown, cylindric-ellipsoid, obtuse, 4-septate, constricted, 38–46 × 15–20μ.

(22) **Meliola praetervisa** Gaill., Le Genre *Meliola*, 1892, p. 78 (3112.5333).

Colonies mostly epiphyllous, up to 2 mm. diam. or numerous and sometimes confluent, dense, somewhat velvety. Mycelium of straight dark brown hyphae 8–9μ thick, the cells mostly 15–20μ long, branching opposite at wide angles, densely reticulate and almost solid in the centre. Capitate hyphopodia opposite save where crowded, more or less antrorse, straight or slightly bent, 16–22μ long; stalk cell cylindric, 5–6μ long; head cell piriform to cylindric with rounded apex, entire, 11–17 × 8–11μ. Mucronate hyphopodia rather few, mixed with capitate, opposite or alternate, bent ampulliform, 15–23 × 7–9μ, neck upturned, 4–5μ thick. Mycelial setae few to fairly numerous, scattered and also grouped around perithecia, erect, straight, simple, obtuse, up to 450 × 12–14μ. Perithecia in loose central group, black, globose, verrucose, up to 240μ diam. Spores dark brown, cylindric to subellipsoid, obtuse, 4-septate, constricted, 50–59 × 23–28μ.

On *Endiandra sieberi*, Woodburn, N.S.W., Fraser 233; on undetermined Lauraceae, Hastings R., N.S.W., Fraser s.n., April, 1952. (The latter specimen has setae up to 650μ long.)

Family MELIACEAE.

(23) **Meliola dysoxylicola** Hansf., n. sp. (3113.4224). (Fig. 14.)

Plagulae hypophyllae, atrae, usque ad 1·5 mm. diam., subtenues. Mycelium ex hyphis atrobrunneis, leniter undulatis, 6–8μ crassis (cellulis plerumque 25–30μ longis), opposite ramosis (30–60°), laxe reticulatis compositum, in centro plagularum, subsolidum. Hyphopodia capitata alternata, vel circa 1% opposita, plus minusve curvata, 15–25μ longa, cellula basali cylindracea, 5–8μ longa, cellula apicali cylindraceo-clavulata, saepe curvula, integra vel lenissime angulosa, 10–19 × 7–11μ. Hyphopodia mucronata illis capitatis commixta, opposita vel alternata, pauca, ampullacea, curvata. Setae myceliales dispersae, erectae, recte, simplices, acutae, usque ad 1100 × 8–9μ. Perithecia non visa. Sporae ellipsoideae, atrobrunneae, 4-septatae, constrictae, 42–46 × 17–19μ.

Hab. in foliis *Dysoxyli* spec. indet., Murwillumbah, N.S.W., July, 1896, Baker (typus in Herb. Dept. Agric., Melbourne).

Colonies hypophyllous, black, orbicular, up to 1·5 mm. diam., rather thin. Mycelium of slightly undulate, dark brown hyphae 6–8μ thick, the cells mostly 25–30μ long, branching usually opposite at acute angles, forming a loose network, becoming dense in centre of colony. Capitate hyphopodia alternate or about 1% opposite, more or less bent, 15–25μ long; head cell cylindric-clavate, often bent, entire or slightly angulose, 10–19 × 7–11μ; stalk cell cylindric-cuneate, 5–8μ long. Mucronate hyphopodia mostly on separate hyphae but mixed with a few capitate, opposite or alternate, few, ampulliform with bent neck. Mycelial setae scattered, erect, straight, simple, acute, up to 1100 × 8–9μ. Mature perithecia not seen. Spores dark brown, cylindric to ellipsoid, 4-septate, obtuse, constricted, 42–46 × 17–19μ.

(24) **Meliola dysoxyli** Hansf., n. sp. (3112.4221). (Fig. 15.)

Plagulae epiphyllae, usque ad 1 mm. diam., vel confluentes, densae. Mycelium ex hyphis subrectis, atrobrunneis, 7μ crassis (cellulis plerumque circa 15μ longis), opposite lateque ramosis, densissime reticulatis compositum, subsolidum. Hyphopodia capitata opposita, plus minusve antrorsa, 14–20μ longa, cellula basali cylindracea, 2–5μ longa, cellula apicali globosa vel late ovata, integra, 11–16 × 9–12μ. Hyphopodia mucronata illis capitatis commixta, opposita vel alternata, ampullacea, curvata, 15–20 × 7–10μ, collo suberecto 3μ crasso praedita. Setae myceliales erectae, rectae, simplices, acutae, usque ad 450 × 10–11μ. Perithecia in centro plagularum aggregata, atra, globosa, verrucosa, usque ad 180μ diam. Sporae atrobrunneae, ellipsoideae, obtusae, 4-septatae, constrictae, 42–48 × 17–19μ.

Hab. in foliis *Dysoxyli*, spec. indet., Peradeniya, Ceylon, Thwaites (typus in Herb. Kew); in petiolibus *Dysoxyli fraseriani*, Allyn R., N.S.W., Fraser 218.

The Australian collection corresponds closely to the type from Ceylon: Colonies on petioles only, up to 2 mm. long, or sometimes confluent, dense. Mycelium of substraight dark brown hyphae 7μ thick, the cells mostly about 15μ long, branching opposite at wide angles, very densely reticulate and almost solid. Capitate hyphopodia opposite or alternate, more or less antrorse, 14–20μ long; stalk cell cylindric, 2–5μ long; head cell globose to wide ovate, entire, 11–16 × 9–12μ. Mucronate hyphopodia mixed with capitate, opposite or alternate, bent ampulliform, 15–20 × 7–10μ, neck upturned, 3μ thick. Mycelial setae erect, straight, simple, acute, up to 450 × 10–11μ. Perithecia in central group, black, globose, verrucose, up to 180μ diam. Spores dark brown, ellipsoid, obtuse, 4-septate, constricted, 42–48 × 17–19μ.

(25) Meliola macalpini Sacc. & Syd. in *Sacc. Syll. Fung.*, 14: 471, 1899.
= *Meliola denticulata* McAlp. in Proc. Linn. Soc. N.S.W., 1897, p. 700 (non Winter) (3133.4221).

The type collection on *Dysoxylum* sp., Byangum, N.S.W., Baker, July, 1896, from the Herbarium of Dept. Agric., Melbourne, has been examined.

Colonies epiphyllous, about 0·5 mm. diam., black, scattered, velvety, dense. Mycelium of substraight dark brown hyphae 7–8μ thick, branching usually opposite at wide angles, the cells mostly 14–20μ long, closely reticulate. Capitate hyphopodia alternate or opposite, more or less antrorse, straight or bent, 16–20μ long; head cell ovate to cylindric with rounded apex, 11–15 × 7–10μ; stalk cell cylindric, 5–8μ long. Mucronate hyphopodia mixed with capitate, few, opposite or alternate, conoid to ampulliform with short upturned neck. Mycelial setae thickly scattered, erect, straight, slightly thickened and usually 3-dentate to 10μ at apex, up to 280 × 9–11μ. Perithecia black, globose, verrucose, immature. Spores dark brown, cylindric, obtuse, 4-septate, constricted, 47 × 18μ (few seen).

Apparently this species has not yet been re-discovered, as no other Australian collection I have seen corresponds with it, particularly in the dentate setae.

Family MIMOSACEAE.

(26) Meliola brisbanensis Hansf., n. sp. (3113.4223). (Fig. 16.)

Plagulae amphigenae, tenues vel densae, usque ad 2 mm. diam., vel confluentes. Mycelium ex hyphis atrobrunneis, subrectis vel flexuosis, 6–7μ crassis (cellulis plerumque 20–30μ longis), opposite ramosis, laxe vel dense reticulatis compositum. Hyphopodia capitata opposita vel alternata, recta vel curvula, 13–20μ longa, cellula basali cylindracea, 3–7μ longa, cellula apicali ovata, apice rotundata, integra, 9–16 × 7–10μ. Hyphopodia mucronata illis capitatis commixta, alternata vel opposita, ampullacea, 15–20 × 6–8μ, collo suberecto, 3μ crasso praedita. Setae myceliales dispersae, etiam juxta perithecia aggregateae, erectae, rectae, simplices, obtusae, usque ad 530 × 7–9μ (in typus 250μ longae). Perithecia dispersa vel laxe gregaria, atra, globosa, verrucosa, usque ad 190μ diam. Sporae atrobrunneae, cylindraceae vel subellipsoideae, obtusae, 4-septatae, constrictae, 38–51 × 15–18μ.

Hab. in foliis *Acaciae cunninghamii*, Brisbane, Qld., Bailey 184 (typus in Herb. Queensland, Brisbane); Sunnybank, Qld., C. T. White 4; in foliis *Acaciae binervatae*, National Park, N.S.W., Fraser 171, 25, 79; in foliis *Acaciae*, spec. indet., Woodburn, N.S.W., Fraser 234.

Colonies amphigenous, thin to dense, up to 2 mm. diam. or confluent and larger, black. Mycelium of substraight to irregularly flexuous dark brown hyphae 6–7μ thick, the cells mostly 20–30μ long, branching usually opposite at variable angles, becoming closely reticulate towards the centre of older colonies. Capitate hyphopodia opposite or alternate, in thinner parts of colonies mostly opposite, more or less bent, 13–20μ long; head cell ovate to somewhat irregularly rounded-angulose, often bent, 9–16 × 7–10μ; stalk cell cylindric, 3–7μ long. Mycelial setae thinly scattered, erect, straight, simple, obtuse, up to 250 × 6–8μ in the type to 530μ in other specimens quoted. Perithecia scattered, black, depressed globose, verrucose, immature in type, up to 190μ diam. in other specimens. Spores dark brown, cylindric with obtuse ends, 4-septate, constricted, 38–45 × 15–17μ in type specimen, up to 51 × 18μ in other specimens. No other differences were found between the type and the other specimens, so that the ranges of measurements given in the diagnosis have been extended to include these. A further specimen is on *A. harpophylla*, Rosewood, Qld., C. T. White, 1911.

(27) Irenopsis berggrenii Hansf. in *Proc. Linn. Soc. London* (in press) (3403.4230). (Fig. 17.)

Colonies hypophyllous, scattered, black, circular, 1–3 mm. diam., dense, smooth. Mycelium of dark brown, substraight to somewhat sinuous hyphae, 8–9μ thick, the cells mostly 15–25μ long, branching usually opposite at wide angles, closely reticulate. Capitate hyphopodia alternate or about 1% opposite, straight or bent, 14–30μ long; stalk cell cylindric, straight or bent, 4–16μ long; head cell from wide ovate to piriform or cylindric-clavulate, often irregularly bent, entire, rounded angulose or shallowly lobate, 10–18 × 8–12μ. Mucronate hyphopodia on few separate hyphae in centre of colony, opposite or alternate, ampulliform, more or less bent, 15–20 × 7–10μ, neck suberect, bent, 3–4μ thick, rather short. Mycelial setae none. Perithecia closely scattered, black, globose, slightly verrucose, up to 250μ diam., the surface cells rounded-convex; each with 20–30 erect-spreading setae arising from upper half; setae pale brown, thick-walled in lower part, thinner above, indistinctly 1–2-septate, apex simple, obtuse, variously twisted or contorted, smooth, up to 100 × 7–10μ. Spores dark brown, cylindric, obtuse, 4-septate, 38–45 × 12–15μ; in the original diagnosis the spores were given as 3-septate, but these are abnormal, as shown by collections examined since, which contain even a few obviously abnormal 2-septate spores.

On *Acacia melanoxylon*, Melbourne, Vict., Berggren 381 (typus in Herb. Stockholm, also represented at Herb. Kew); on *Acacia linifolia*, National Park, N.S.W., Fraser 10A; on *A. penninervis*, Clyde Mountain, N.S.W., Fraser 168; on *A. maidenii*, Williams R., N.S.W., Fraser 102; on *A. mabellae*, Myrtle Gully, N.S.W., Fraser 158.

Family MONIMIACEAE.

(28) Irene kiraiensis Yamamoto.

I find no difference between the following specimens and that on *Cinnamomum*, described under No. 19 above:

On *Doryphora sassafras*, National Park, N.S.W., Fraser 26; Clyde Mountain, N.S.W., Fraser 178; on *Atherosperma moschatum*, Kallista, Vict., Fraser 193.

(29) Irenina daphnandrae Hansf., n. sp. (2101.5240). (Fig. 18.)

Plagulae amphigenae, usque ad 2 mm. diam., tenues vel subdensae, saepe numerosae confluentesque, leves. Mycelium ex hyphis atrobrunneis, leniter undulatis, 7μ crassis (cellulis plerumque 20–25μ longis), opposite lateque ramosis, subdense reticulatis compositum. Hyphopodia capitata alternata, plus minusve antrorsa, recta vel curvata, 18–28μ longa, cellula basali cylindracea, 5–12μ longa, cellula apicali irregulariter lobata, 12–17 × 11–16μ. Hyphopodia mucronata illis capitatis commixta, alternata, ampullacea, curvata, 15–20 × 7–9μ, collo erecto, 3μ crasso praedita. Setae myceliales nullae. Perithecia dispersa vel laxe aggregata, atra, globosa, verrucosa, usque ad 330μ diam., cellulis parietis obtuse conoideis vel mammillatibus, usque ad 20μ alt. Sporae atrobrunneae, curvato-ellipsoideae, 3-septatae, constrictae, 44–52 × 16–19μ.

Hab. in foliis *Daphnandrae micranthae*, Williams R., N.S.W., Fraser 132 (typus in Herb. Dept. Agric., Sydney), 297.

Colonies amphigenous, to 2 mm. diam., thin to rather dense, often numerous and confluent, smooth. Mycelium of slightly undulate dark brown hyphae 7μ thick, the cells mostly 20–25μ long, branching opposite at wide angles, rather closely reticulate. Capitate hyphopodia alternate, more or less antrorse, straight or bent, 18–28μ long; stalk cell cylindric, 5–12μ long; head cell irregularly lobed, 12–17 × 11–16μ. Mucronate hyphopodia mixed with capitate, alternate, bent ampulliform, 15–20 × 7–9μ, neck erect, 3μ thick. Perithecia scattered or in a loose central group, black, globose, verrucose, up to 330μ diam., the surface cells bluntly conoid to mammillate, projecting up to 20μ. Spores dark brown, bent ellipsoid, ends obtuse, 3-septate, constricted, 44–52 × 16–19μ.

The hyphopodia and spores are very close to those of *Irene kiraiensis*, but the general character of the colonies and mycelium is distinct, and the perithecia do not bear larviform appendages even when fully mature.

(30) IRENINA HEDYCARYAE Hansf., n. sp. (3101.5330). (Fig. 19.)

Plagulae amphigenae, plerumque epiphyllae, atrae, densae, subcrustosae, leves, usque ad 3 mm. diam., numerosae et interdum confluentes. Mycelium ex hyphis atrobrunneis, subrectis, 7–10μ crassis (cellulis plerumque circa 30μ longis), opposite acuteque ramosis, dense reticulatis compositum. Hyphopodia capitata alternata, antrorsa, 30–37μ longa, cellula basali cylindracea, 5–11μ longa, cellula apicali clavulato-cylindracea, apice late rotundata, saepe lenissime curvata, 22–28 × 11–18μ. Hyphopodia mucronata pauca, illis capitatis commixta, opposita vel alternata, ampullacea, curvata, 18–28 × 8–11μ, collo suberecto 3–5μ crasso praedita. Setae myceliales nullae. Perithecia laxe aggregata, atra, globosa, verrucosa, usque ad 320μ diam., cellulis parietis rotundatibus, vix prominentibus. Sporae atrobrunneae, cylindraceae vel subellipsoideae, obtusae, 4-septatae, constrictae, 54–59 × 21–24μ.

Hab. in foliis *Hedycaryae*, spec. indet., Fern Gully, Kallista, Vict. (typus in Herb. Melbourne University).

Colonies amphigenous, mostly epiphyllous, black, dense, subcrustose, smooth, up to 3 mm. diam., numerous and sometimes confluent, with a central loose group of perithecia. Mycelium of dark brown substraight hyphae 7–10μ thick, the cells mostly about 30μ long, branching usually opposite at acute angles. Capitate hyphopodia alternate, more or less antrorse, 30–37μ long; head cell cylindric-clavulate, widely rounded at apex, often slightly bent, 22–28 × 11–18μ; stalk cell cylindric, 5–11μ long. Mucronate hyphopodia few, often scattered around the edge of the colony, opposite or unilateral, ampulliform with short bent neck, 18–28 × 8–11μ. Setae none. Perithecia each on a solid disc of radiating exhyphopodiate hyphae up to 180μ long, paler than the rest of the mycelium; black, flattened globose, up to 320μ diam. and about 200μ high, verrucose, the surface cells rounded and scarcely projecting from the general surface. Spores dark brown, bent cylindric with rounded ends, 4-septate, constricted, 54–59 × 21–24μ.

Family MORACEAE.

(31) MELIOLA PSEUDOMORI Hansf., n. sp. (3411.52x2). (Fig. 20.)

Plagulae hypophyllae, tenues, usque ad 2 mm. diam. Mycelium ex hyphis atrobrunneis, undulatis vel flexuosis, 7–8μ crassis (cellulis plerumque 25–40μ longis), alternatim vel irregulariter ramosis, laxe reticulatis compositum. Hyphopodia capitata alternata, plerumque irregulariter curvata, 30–60μ longa, cellula basali cylindracea, 12–35μ longa; cellula apicali irregulariter profundeque lobata, versiformia, 18–30 × 15–25μ. Hyphopodia mucronata praecipue in hyphis distinctis evoluta, opposita vel alternata, ampullacea, curvata, 18–22 × 7–9μ, collo suberecto, 3–4μ crasso praedita. Setae myceliales laxe dispersae, etiam juxta perithecia aggregatae, erectae, subrectae, simplices, obtusae, usque ad 350 × 8–10μ, sursum attenuatae. Perithecia laxe dispersa, atra, globosa, verrucosa, immatura; superne setis 0–4, erecto-patentibus, simplicibus. obtusis, continuis, apice curvatis, non uncinatis, usque ad 60 × 8μ, extus minute sparseque granulosis ornata. Sporae atrobrunneae, cylindraceae, obtusae, 4-septatae, 48–54 × 17–18μ.

Hab. in foliis *Pseudomori pendulinae* var. *australianae*, Brushy Mountain, N.S.W., Sept., 1897, J. H. Maiden.

Colonies hypophyllous, thin, to 2 mm. diam. Mycelium of undulate to crooked dark brown hyphae 7–8μ thick, the cells mostly 25–40μ long, branching alternate or irregular, not opposite, loosely reticulate. Capitate hyphopodia alternate or more scattered, usually irregularly bent, 30–60μ long; stalk cell cylindric, 12–35μ long, often bent; head cell very irregularly and deeply lobed, versiform, 18–30 × 15–25μ. Mucronate hyphopodia mostly on separate hyphae, opposite or alternate, bent ampulliform, 18–22 × 7–9μ, neck upturned, 3–4μ thick. Mycelial setae thinly scattered and around the perithecia, erect, more or less straight, simple, obtuse, up to 350 × 8–10μ, gradually attenuate upwards. Perithecia loosely scattered, black, globose, verrucose, immature; on upper half each with 0–4 spreading-erect setae, simple, obtuse, continuous, up to 60 × 8μ, apex sometimes bent but not uncinate, surface minutely and sparsely granulose. Spores dark brown, cylindric, obtuse, 4-septate, 48–54 × 17–18μ.

Family MYRTACEAE.

(32) MELIOLA QUEENSLANDICA (E. Fisher) Hansf., n. comb.

= *Meliola polytricha* K. & C., var. *queenslandica* E. Fisher in *Proc. Roy. Soc. Vict.*, 62: 134, 1950 (3113.6333).

Colonies amphigenous, rather dense, thinly velvety, 1–2 mm. diam. Mycelium of dark brown, substraight to undulate or even flexuous hyphae 7–9μ thick, the cells mostly 15–25μ long, branching usually opposite at acute angles, closely reticulate. Capitate hyphopodia opposite or alternate, more or less antrorse, often bent, 23–42μ long; stalk cell cylindric, 5–12μ long; head cell elongate, irregularly sinuous-bent, versiform, variously lobed or almost entire, 18–30 × 11–18μ. Mucronate hyphopodia mixed with capitate, opposite or alternate, ampulliform with upturned rather short neck. Mycelial setae variable in number, scattered, erect, straight, simple, obtuse or acute, up to 640 × 8–11μ, in some specimens not exceeding 400μ long. Perithecia scattered, black, globose, verrucose, up to 250μ diam. Spores dark brown, cylindric to ellipsoid with obtuse ends, 4-septate, slightly constricted, 55–65 × 16–22μ.

On *Callistemon viminalis*, Gold Creek, Brisbane, Qld., Fisher (type); Goodna, Qld., C. T. White 5; Gladstone, Qld., Tryon; Woodenbong, N.S.W., Fraser 235; on *C. salignus*, Hunter R., N.S.W., R. Brown 570 (in Herb. Kew); Williams R., N.S.W., Fraser 50, 106; on *C.* spp. indet., North Queensland (in Herb. Stockholm, collector unknown); Brisbane, Qld., Bailey 633.

In the original diagnosis "conidia" were included, which probably belonged to *Helminthosporium capense* Thuem., a common parasite of *Meliola* spp. in Australia and elsewhere. No true conidial stage is known for any species of this genus.

(33) MELIOLA DENSA Cooke in *Grevillea*, 12: 85, 1884 (3121.4221).

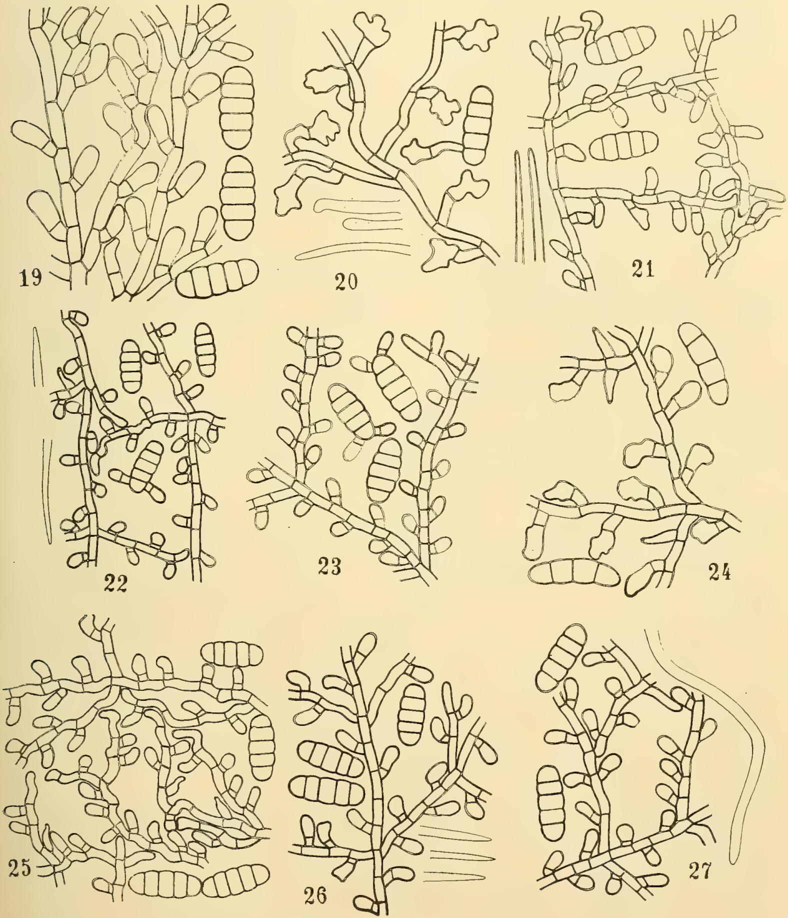
Colonies hypophyllous, black, dense, somewhat velvety, 1–3 mm. diam. or confluent and larger. Mycelium of crooked dark brown hyphae 7–8μ thick, the cells mostly 20–25μ long, branching irregular, closely reticulate, the meshes enclosing the stomata of the host leaf. Capitate hyphopodia alternate, rarely also opposite, variously bent, mostly 15–25μ long; stalk cell cylindric or irregularly bent, 5–14μ long; head cell from ovate and entire to cylindric-clavate or variously bent and angulose, sometimes broadly truncate at apex, 12–20 × 7–10μ. Mycelial setae numerous in some colonies, erect, simple, obtuse, broadly arcuate to uncinate above, but in other colonies almost straight and varying to acute, up to 280 × 8–10μ. Perithecia scattered, black, globose, verrucose, up to 180μ diam. Spores dark brown, cylindric with rounded ends to somewhat ellipsoid, 4-septate, constricted, 43–48 × 16–19μ.

On *Eucalyptus* spp., Queensland.

The type was described from Herbert R., Queensland, and other specimens examined include Bailey 556, 587, also collected in Queensland. Outside Australia, what appears to be the same species occurs on *Eugenia* spp. in West Africa.

(34) MELIOLA EUGENIAE-JAMBOLOIDIS Hansf., var. AUSTRALIENSIS Hansf., n. var. (3113.5334). (Fig. 21.)

Plagulae hypophyllae, atrae, 1–2 mm. diam. vel in confluendo majores, tenues vel subdensae, interdum tenuiter velutinae. Mycelium ex hyphis atrobrunneis, flexuosis, 6–8μ crassis (cellulis plerumque 20–30μ longis), opposite vel irregulariter ramosis, laxe dein subdense reticulatis compositum. Hyphopodia capitata alternata vel usque ad 15% opposita, antrorsa, saepe irregulariter curvata, 20–30μ longa, cellula basali cylindracea, 5–15μ longa, cellula apicali cylindracea vel ovata, apice late rotundata, interdum angulosa et curvata, 12–20 × 6–12μ. Hyphopodia mucronata alternata vel opposita, illis capitatis commixta, ampullacea, curvata, 20–25 × 7–9μ, collo suberecto, 3μ crasso praedita. Setae myceliales dispersae, paucae vel numerosae, erectae, rectae, simplices, obtusae, usque ad 1100 × 7–10μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 220μ diam. Sporae atrobrunneae, ellipsoideae, obtusae, 4-septatae, constrictae, 45–51 × 18–21μ.



Text-figures 19-27. (× 250.)

19, *Irenina hedycaryae.* 20, *Meliola pseudomori.* 21, *M. eugeniae-jamboloidis* var. *australiensis.* 22, *M. leptospermi.* 23, *Irenina acmenae.* 24, *I. eucalyptorum.* 25, *I. australiana.* 26, *Meliola notelaeae.* 27, *M. emmenospermatis.*

Hab. in foliis *Tristaniae*, spec. indet., Queensland, Bailey 587 in Queensland Herb., Brisbane; in foliis *Tristaniae suaveolentis*, Urunga, N.S.W., Fraser 228; in foliis *Rhodomyrti psidioidis*, N.S.W., Williams R., Fraser 216; Grafton, Fraser 195.

Colonies hypophyllous, black, 1–2 mm. diam. or confluent and larger, thin to subdense, sometimes thinly velvety. Mycelium of rather flexuous dark brown hyphae 6–8μ thick, the cells mostly 20–30μ long, branching opposite or irregular at wide angles, forming first a loose network, becoming rather dense in centre of older colonies. Capitate hyphopodia alternate or up to 15% opposite, antrorse, frequently irregularly bent, 20–32μ long; stalk cell cylindric, 5–15μ long; head cell cylindric to ovate, widely rounded at apex, often irregularly angulose and bent, 12–20 × 6–12μ. Mucronate hyphopodia alternate or opposite, mixed with capitate, long ampulliform with bent neck. Mycelial setae scattered, few to fairly numerous, erect, straight, black, simple, obtuse, up to 1100 × 7–10μ thick at the base. Mature perithecia up to 220μ diam., scattered, black, globose, verrucose. Spores dark brown, ellipsoid with rounded ends, 4-septate, constricted, 45–51 × 18–21μ.

(35) Meliola leptospermi Hansf., n. sp. (3113.4231). (Fig. 22.)

Plagulae amphigenae, subdensae, usque ad 2 mm. diam. vel confluentes. Mycelium ex hyphis atrobrunneis, subrectis vel flexuosis, 6–7μ crassis (cellulis plerumque 15–20μ longis), opposite lateque ramosis, dense reticulatis compositum. Hyphopodia capitata alternata vel usque ad 2% opposita, recta vel curvata, 10–16μ longa, cellula basali cylindracea, 2–5μ longa, cellula apicali subglobosa vel oblonga, apice late rotundata, integra, 7–12 × 6–9μ. Hyphopodia mucronata illis capitatis commixta, alternata vel opposita, ampullacea, curvata, 15–20 × 6–8μ, collo suberecto, 3μ crasso praedita. Setae myceliales paucissimae, praecipue juxta perithecia evolutae, erectae, plus minusve rectae, simplices, obtusae vel subacutae, usque ad 290 × 7–8μ. Perithecia laxe aggregata, atra, globosa, verrucosa, usque ad 215μ diam. Sporae atrobrunneae, cylindraceae, obtusae, 4-septatae, constrictae, 36–43 × 14–16μ.

Hab. in foliis *Leptospermi brachyandri*, Orara R., N.S.W., Fraser 189 (typus in Herb. Dept. Agric., Sydney).

Colonies amphigenous, rather dense, up to 2 mm. diam. or confluent. Mycelium of substraight to crooked dark brown hyphae 6–7μ thick, the cells mostly 15–20μ long, branching opposite at wide angles, closely reticulate. Capitate hyphopodia alternate or about 2% opposite, straight or bent, 10–16μ long; stalk cell cylindric, 2–5μ long; head cell subglobose to oblong, widely rounded at apex, entire, 7–12 × 6–9μ. Mucronate hyphopodia mixed with capitate, alternate or opposite, bent ampulliform, 15–20 × 6–8μ, neck upturned, 3μ thick. Mycelial setae very few, mostly round the perithecia, erect, more or less straight, simple, obtuse to subacute, up to 290 × 7–8μ. Perithecia closely scattered, black, globose, verrucose, up to 215μ diam. Spores dark brown, cylindric, obtuse, 4-septate, constricted, 36–45 × 14–16μ.

(36) Irenina acmenae Hansf., n. sp. (3103.5330). (Fig. 23.)

Plagulae epiphyllae, interdum etiam hypophyllae, leves, densae, usque ad 2 mm. diam. Mycelium ex hyphis atrobrunneis, subrectis vel sinuosis, 7–8μ crassis (cellulis plerumque 12–20μ longis), opposite acuteque ramosis, dense reticulatis compositum. Hyphopodia capitata alternata vel usque ad 1% opposita, plus minusve antrorsa, plerumque recta, 13–18μ longa; cellula basali cylindracea, 2–5μ longa, cellula apicali globosa vel oblonga, integra, 10–13 × 8–10μ. Hyphopodia mucronata illis capitatis commixta, alternata vel opposita, ampullacea, curvata, 15–22 × 7–9μ, collo suberecto, 3–4μ crasso praedita. Setae nullae. Perithecia laxe aggregata, atra, globosa, verrucosa, usque ad 220μ diam., cellulis parietis obtuse conoideis, usque ad 20μ alt. Sporae atrobrunneae, ellipsoideae, obtusae, 4-septatae, constrictae, 45–52 × 20–23μ.

Hab. in foliis *Acmenae smithii* var. *minoris*, Grafton, N.S.W., Fraser 199 (typus in Herb. Dept. Agric., Sydney); in foliis *Acmenae smithii*, National Park, N.S.W., Fraser 15; Myrtle Gully, N.S.W., Fraser 159; Williams R., N.S.W., Fraser 103; in foliis *Eugeniae ventenatii*, Grafton, N.S.W., Fraser 185.

Colonies epiphyllous, less commonly also hypophyllous, smooth, dense, to 2 mm. diam. Mycelium of substraight to sinuous dark brown hyphae 7–8μ thick, the cells mostly 12–20μ long, branching usually opposite at acute angles, closely reticulate. Capitate hyphopodia alternate or about 1% opposite, more or less antrorse, usually straight, 13–18μ long; stalk cell cylindric, 2–5μ long; head cell globose to oblong, entire, 10–13 × 8–10μ. Mucronate hyphopodia mixed with capitate, alternate or opposite, bent ampulliform, 15–22 × 7–9μ, neck upturned, 3–4μ thick. Setae none. Perithecia in loose central group, black, globose, verrucose up to 215μ diam., surface cells bluntly conoid, projecting up to 20μ. Spores dark brown, ellipsoid, obtuse, 4-septate, constricted, 43–52 × 20–23μ.

(37) Irenina eucalyptorum Hansf., n. sp. (2101.6340). (Fig. 24.)

Plagulae amphigenae, densae, usque ad 5 mm. diam., leves. Mycelium ex hyphis atrobrunneis, sinuosis vel flexuosis, 8–9μ crassis (cellulis plerumque 20–30μ longis), opposite vel irregulariter ramosis, dense reticulatis compositum. Hyphopodia capitata alternata, plus minusve curvata, 22–35μ longa, cellula basali cylindracea, 7–15μ longa, cellula apicali versiformia, ex rotundato-angulosa vel irregulariter lobata, saepe curvata, 15–25 × 12–18μ. Hyphopodia mucronata illis capitatis commixta, ampullacea, 17–25 × 8–10μ, collo suberecto, 3–4μ crasso praedita. Setae nullae. Perithecia dispersa, atra, globosa, verrucosa, usque ad 330μ diam., cellulis parietis conicis, usque ad 25μ alt. Sporae atrobrunneae, cylindraceae vel ellipsoideae, curvatae, obtusae, 3-septatae, leniter constrictae, 54–69 × 17–20μ.

Hab. in foliis *Eucalypti salignae*, Williams R., N.S.W., Fraser 84 (typus in Herb. Dept. Agric., Sydney); Narara, N.S.W., Fraser s.n., May, 1941; in foliis *E. trianthae*, Williams R., N.S.W., Fraser 85; in foliis *E. microcorydis*, Bulga, N.S.W., Fraser 49; in foliis *E.* spec. indet., Bellbrook, N.S.W., Fraser 182 p.p.; Brisbane, Qld., Bailey s.n.; in foliis *Backhousiae myrtifoliae*, Blackheath, N.S.W., Fraser 217; Myrtle Gully, N.S.W., Fraser 167.

Colonies amphigenous, dense, up to 5 mm. diam., smooth. Mycelium of sinuous to crooked dark brown hyphae 8–9μ thick, the cells mostly 20–30μ long, branching opposite or irregular, becoming closely reticulate. Capitate hyphopodia alternate, more or less bent, 22–35μ long; stalk cell cylindric, bent, 7–15μ long; head cell versiform, from rounded-angulose to irregularly lobed, often bent, 15–25 × 12–18μ. Mucronate hyphopodia mixed with capitate, alternate or opposite, bent ampulliform, 17–25 × 8–10μ, neck upturned, 3–4μ thick. Setae none. Perithecia scattered, each on radiate disc, black, globose, verrucose, up to 330μ diam., surface cells conical, projecting up to 25μ. Spores dark brown, bent ellipsoid, obtuse, 3-septate, slightly constricted, 54–69 × 17–20μ.

(38) Irenina australiana Hansf., n. sp. (3101.4240). (Fig. 25.)

Plagulae epiphyllae, atrae, densae, leves, 1–2 mm. diam. vel confluentes. Mycelium ex hyphis atrobrunneis, tortuosis, 6–7μ crassis (cellulis plerumque 15–25μ longis), opposite vel irregulariter ramosis, dense reticulatis compositum. Hyphopodia capitata alternata, rarissime etiam opposita, recta vel curvula, 11–21μ longa, cellula basali cylindracea 2–8μ longa, cellula apicali cylindraceo-clavata, integra, saepe curvula, 8–15 × 7–11μ. Hyphopodia mucronata illis capitatis commixta, opposita vel alternata, ampullacea, curvata, 15–25 × 7–9μ, collo suberecto 3μ crasso praedita. Setae nullae. Perithecia dispersa, atra, globosa, verrucosa, usque ad 350μ diam., cellulis parietis conicis, usque ad 25μ alt. Sporae atrobrunneae, cylindraceae vel subellipsoideae, obtusae, 4-septatae, constrictae, 42–49 × 17–19μ.

Hab. in foliis *Eucalypti*, spec. indet., Brisbane, Qld., Bailey s.n. (typus in Herb. Queensland, Brisbane); Bellbrook, N.S.W., Fraser 182 p.p.

In both these collections this species occurs mixed with *I. eucalyptorum*.

Colonies epiphyllous, black, dense, smooth, 1–2 mm. diam. or confluent. Mycelium of crooked dark brown hyphae 6–7μ thick, the cells mostly 15–25μ long, branching opposite or irregular, forming a close reticulum. Capitate hyphopodia alternate, very rarely opposite, straight or bent, 11–21μ long; stalk cell cylindric, 2–8μ long; head cell cylindric-clavate, entire, often more or less bent, 7–15 × 7–11μ. Mucronate hyphopodia scattered amongst capitate, opposite or alternate, bent ampulliform, 15–25 × 7–9μ. Setae none. Perithecia scattered, black, globose, up to 350μ diam., verrucose, the surface cells conical, projecting up to 25μ; each perithecium seated on a radiate disc of exhyphopodiate hyphae. Spores dark brown, cylindric with rounded ends, 4-septate, constricted, 42–49 × 17–19μ.

Family OLEACEAE.

(39) **Meliola notelaeae** Hansf., n. sp. (3111.5321). (Fig. 26.)

Plagulae amphigenae, atrae, densae, velutinae, usque ad 3 mm. diam. vel confluentes. Mycelium ex hyphis atrobrunneis, subrectis vel undulatis, 6–7μ crassis (cellulis plerumque 20–25μ longis), opposite acuteque ramosis, dense reticulatis compositum. Hyphopodia capitata alternata, plus minusve antrorsa, recta vel curvata, 18–28μ longa, cellula basali cylindracea, 4–11μ longa, cellula apicali oblonga, piriformia integraque, vel irregulariter sinuoso-curvata et sublobata, 12–18 × 9–12μ. Hyphopodia mucronata pauca, illis capitatis commixta, alternata vel opposita, ampullacea, 20–25 × 6–8μ, collo suberecto, 3μ crasso praedita. Setae myceliales numerosae, erectae, rectae, simplices, obtusae vel subacutae, usque ad 270 × 7–9μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 200μ diam. Sporae atrobrunneae, cylindraceae, obtusae, 4-septatae, constrictae, 43–52 × 17–20μ.

Hab. in foliis *Notelaeae reticulatae*, Grafton N.S.W., Fraser 197 (typus in Herb. Dept. Agric., Sydney); in foliis *N. longifoliae*, Church Point, N.S.W., Fraser 160; in foliis *N. venosae*, National Park, N.S.W., Fraser 13C, 13D.

Colonies amphigenous, black, dense, velvety, up to 3 mm. diam. or sometimes confluent. Mycelium of substraight to undulate dark brown hyphae 6–7μ thick, the cells mostly 20–25μ long, branching usually opposite at acute angles, densely reticulate. Capitate hyphopodia alternate, more or less antrorse, straight or bent, 18–28μ long; stalk cell cylindric, 4–11μ long; head cell from oblong-piriform and entire to irregularly sinuous-bent and sublobate, 12–18 × 9–12μ. Mucronate hyphopodia few, mixed with capitate, alternate or opposite, bent ampulliform, 20–25 × 6–8μ, neck upturned, 3μ thick. Mycelial setae numerous, erect, straight, simple, obtuse to acute, up to 270 × 7–9μ. Perithecia scattered, black, globose, verrucose, up to 200μ diam. Spores dark brown, cylindric, obtuse, 4-septate, constricted, 43–52 × 17–20μ.

Family PROTEACEAE.

(40) **Meliola lanosa** Pat., in *Rev. Mycol.*, 10: 136, 1888.

= *Meliola funerea*, McAlp., Proc. Linn. Soc. N.S.W., 21: 104, 1896.

= *Meliola macrocarpa* Mont. in *Herb. Mus. Paris, pro parte.*

= *Meliola negeriana* Syd. in *Ann. Mycol. Berl.*, 2: 170, 1904 (2111.6341).

The type was described on *Lomatia* sp. in Chile, as was Sydow's species, of which I find the type to be identical with Australian collections.

Colonies amphigenous, mostly epiphyllous, dense, subcrustose, velvety, black, numerous but not usually confluent. Mycelium of dark brown hyphae, 8–11μ thick, the cells mostly 20–30μ long, flexuous to undulate, branching usually opposite at wide angles, closely reticulate and with the hyphopodia almost solid in the centre. Capitate hyphopodia alternate, more or less bent, antrorse, 26–34μ long; stalk cell cylindric, 5–11μ long; head cell very irregularly and shallowly palmately 3–7-lobed, the lobes blunt, 18–25 × 15–23μ. On the lower surface of the leaves the head cells are less lobed, but even more irregular in shape and the hyphae more crooked. Mucronate hyphopodia few, mixed with capitate, alternate, bent ampulliform, 15–20 × 7–10μ, neck suberect, short, 3–4μ thick. Mycelial setae numerous, erect, straight, black, simple, acute, up to 540 × 10–11μ. Perithecia in loose central group, black, globose, verrucose, up to 420μ diam. Spores dark brown, bent cylindric, 3-septate, constricted, obtuse at ends, 50–64 × 20–24μ.

On leaves of *Lomatia* sp., Taggerty, Vict., Dixon, May, 1930; on *L. fraseri*, South Gippsland, Vict., July, 1891, C. French; on *L. arborescens*, Williams R., N.S.W., Fraser 141, 204; on *L. myricoides*, National Park, N.S.W., Fraser 48; on *L. silaifolia*, Lauriston, N.S.W., Fraser 123; on *Stenocarpus salignus*, Williams R., N.S.W., Fraser 110, 223; on *Orites excelsa*, Williams R., N.S.W., Fraser 109; on *Grevillea robusta*, Lismore, N.S.W., J. H. Maiden, March, 1896 (type of *M. funerea* McAlp.).

Family RANUNCULACEAE.

(41) Meliola knowltoniae Doidge, in *Bothalia*, 1: 308, 1924 (3111.4222).

Colonies mostly epiphyllous, thin to subdense, black, up to 2 mm. diam. Mycelium of substraight to undulate dark brown hyphae 8–10μ thick, the cells mostly 30–40μ long, branching opposite at acute angles, closely reticulate. Capitate hyphopodia alternate, more or less antrorse, 27–35μ long; stalk cell cylindric, 5–10μ long; head cell from subglobose to cylindric with rounded, often recurved apex, sometimes rounded-angulose to sublobate, 20–28 × 10–13μ. Mucronate hyphopodia fairly numerous, mixed with capitate, opposite or alternate, bent ampulliform, 16–20 × 7–9μ, neck short, upturned, 3μ thick. Mycelial setae mostly around the perithecia, erect, straight or slightly bent, up to 450 × 9–10μ, apex acute or subacute. Perithecia in central group, black, globose, verrucose, up to 190μ diam. Spores dark brown, cylindric to ellipsoid, obtuse, 4-septate, constricted, 40–47 × 17–19μ.

On *Clematis glycinoides*, National Park, N.S.W., Fraser 27, 176.

Family RHAMNACEAE.

(42) Meliola emmenospermatis Hansf., n. sp. (3123.5232). (Fig. 27.)

Plagulae hypophyllae, atrae, densae, usque ad 5 mm. diam. vel confluentes, subcrustosae. Mycelium ex hyphis atrobrunneis, rectis vel undulatis, 7–8μ crassis (cellulis plerumque 15–25μ longis), opposite lateque ramosis, dense reticulatis compositum, in centro plagularum subsolidum. Hyphopodia capitata alternata vel usque ad 3% opposita, plus minusve antrorsa, recta vel curvata, 13–24μ longa, cellula basali cylindracea, 3–10μ longa, cellula apicali subglobosa vel piriformia, integra, 10–17 × 7–11μ. Hyphopodia mucronata pauca, illis capitatis commixta, alternata vel opposita, ampullacea, curvata, 15–20 × 7–9μ, collo suberecto, 3μ crasso praedita. Setae myceliales numerosae, erectae, irregulariter flexuosae, arcuatae vel subuncinatae, simplices, obtusae, usque ad 450 × 8–10μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 220μ diam. Sporae atrobrunneae cylindraceae, obtusae, 4-septatae, constrictae, 48–55 × 17–19 × 14–16μ.

Hab. in foliis *Emmenospermatis alphitonioidis*, Williams R., N.S.W., Fraser 212 (typus in Herb. Dept. Agric., Sydney).

Colonies hypophyllous, black, dense, to 5 mm. diam or sometimes confluent, subcrustose. Mycelium of substraight to undulate dark brown hyphae 7–8μ thick, the cells mostly 15–25μ long, branching opposite at wide angles, closely reticulate and solid in centre of older colonies. Capitate hyphopodia alternate or about 3% opposite, more or less antrorse, straight or bent, 13–24μ long; stalk cell cylindric, 3–10μ long; head cell subglobose to piriform, entire, 10–17 × 7–11μ. Mucronate hyphopodia few, mixed with capitate, alternate or opposite, bent ampulliform, 15–20 × 7–9μ, neck upturned, 3μ thick. Mycelial setae numerous, erect, irregularly flexuous, arcuate or subuncinate, simple, obtuse, up to 450 × 8–10μ. Perithecia scattered, black, globose, verrucose, to 220μ diam. Spores dark brown, cylindric, obtuse, 4-septate, constricted, 48–55 × 17–19 × 14–16μ.

(43) Meliola pomaderridis Hansf., in *Proc. Linn. Soc. London*, 157: 179, 1946 (2111.4232).

Colonies epiphyllous, black, rather dense, velvety, up to 3 mm. diam. Mycelium of closely reticulate, irregularly branched, dark brown, substraight hyphae 7–9μ thick, the cells mostly 20–32μ long. Capitate hyphopodia alternate, somewhat antrorse, straight or bent, 26–35μ long; stalk cell cylindric-cuneate, 6–16μ long; head cell irregularly lobed, versiform, 18–23 × 12–20μ. Mucronate hyphopodia few, mixed with capitate, alternate or opposite, ampulliform with short bent neck. Mycelial setae numerous, erect, substraight, not uncinate, apex attenuate-rounded but not acute, up to 350 × 9–10μ. Perithecia scattered, black, globose, verrucose, up to 230μ diam. Spores dark brown, bent ellipsoid, obtuse, 3-septate, constricted, 41–48 × 16–17μ.

On *Pomaderris apetala*, Tasmania, Rodway 833 (type in Herb. Pretoria, also in Herb. Tasmania); Mt. Drummer, Vict., Fraser 194; Clyde Mountain, N.S.W., Fraser 155; Warburton, Vict., French and Brittlebank.

Family ROSACEAE.

(44) IRENE CALOSTROMA (Desm.) von Hoehnel in *Ann. Mycol.*, Berlin, 16: 213, 1918 (2201.4220).

Colonies mostly epiphyllous, rather thin, up to 2 mm. diam., sometimes causing a red leaf-spot on host, sometimes numerous and widely confluent. Mycelium of dark brown, substraight to undulate hyphae 6–8μ thick, the cells mostly 20–30μ long, branching opposite or irregular, loosely reticulate. Capitate hyphopodia alternate, more or less antrorse, straight or bent, 20–35μ long; stalk cell cylindric, 5–18μ long; head cell sometimes subglobose to piriform and entire, more usually rounded-angulose to irregularly and shallowly lobed, 12–20 × 11–17μ. Mucronate hyphopodia mixed with capitate, fairly numerous, opposite or alternate, ampulliform, 14–24 × 6–9μ, neck upturned, 3μ thick. Setae none. Perithecia usually in a central group, black, globose, rough, up to 250μ diam., the surface cells conic to mammillate, but some growing out into larviform appendages 60–110μ long, 20–25μ diam. at the base, recurved above and tapering to obtuse apex, brown, somewhat translucent, transversely striate. Spores dark brown, cylindric, straight or somewhat bent, obtuse, 3-septate, slightly constricted, 38–45 × 13–15μ.

On *Rubus moluccanus*, Williams R., N.S.W., Fraser 112; Megalong Valley, Blackheath, N.S.W., Fraser 206; National Park, N.S.W., Fraser 6, 163.

Family RUBIACEAE.

(45) MELIOLA WOODIANA Sacc. in *Hedwigia* 38: 132, 1899 (3121.5332).

Colonies mostly frequently epiphyllous, very dense, velvety, up to 3 mm. diam. or confluent and larger. Mycelium of radiating, dark brown, straight or slightly undulate hyphae 6–9μ thick, the cells 15–30μ long, branching opposite at acute angles, densely reticulate and nearly solid. Capitate hyphopodia alternate, more or less closely antrorse, 20–30μ long; stalk cell somewhat cuneate, 4–12μ long; head cell ovate or slightly rounded-angulose, 14–22 × 9–14μ. Mucronate hyphopodia on separate hyphae, not numerous, opposite or alternate, ampulliform with short upturned neck 3–4μ thick, 12–20 × 7–10μ. Mycelial setae numerous, closely scattered, curved to falcate-uncinate, simple, acute to obtuse, up to 400 × 8–11μ. Perithecia scattered, black, globose, verrucose, up to 230μ diam. Spores dark brown, cylindric to subellipsoid, 4-septate, constricted, 40–54 × 16–21μ, ends obtuse.

On *Morinda jasminoides*, Williams R., N.S.W., Fraser 52.

Family RUTACEAE.

(46) MELIOLA KISUBIENSIS Hansf., var. PHEBALII-DENTATI Hansf., n. var. (31⅓1.4321). (Fig. 28.)

Plagulae epiphyllae, densae, usque ad 1 mm. diam. vel confluentes. Mycelium ex hyphis brunneis, subrectis, 7–9μ crassis (cellulis plerumque 15–20μ longis), opposite lateque ramosis, dense reticulatis compositum, in centro plagularum subsolidum. Hyphopodia capitata alternata, saepius subrecta et plus minusve antrorsa, 17–27μ longa; cellula basali cylindracea, 5–9μ longa, cellula apicali ovata vel cylindracea, apice rotundata, integra, 12–18 × 9–11μ. Hyphopodia mucronata pauca, illis capitatis commixta, saepius alternata, ampullacea, curvata, 15–20 × 7–9μ, collo suberecto, 3μ crasso praedita. Setae myceliales paucae, dispersae, etiam juxta perithecia aggregatae, erectae, rectae, usque ad 230 × 8–9μ, apice simplices acutaeque vel 2-dentatae usque ad 8μ. Perithecia laxe aggregata, atra, globosa, verrucosa, usque ad 180μ diam. Sporae atrobrunneae, cylindraceae vel ellipsoideae, 4-septatae, constrictae, 45–50 × 17–21μ, obtusae.

Hab. in foliis *Phebalii dentati*, Berowra, N.S.W., Fraser 7 (typus in Herb. Dept. Agric., Sydney).

Colonies epiphyllous, dense, to 1 mm. diam. or sometimes confluent. Mycelium of substraight dark brown hyphae 7–9μ thick, the cells mostly 15–20μ long, branching opposite at wide angles, closely reticulate and almost solid in centre. Capitate hyphopodia alternate, mostly straight and more or less antrorse, 17–27μ long; stalk cell cylindric, 5–9μ long; head cell ovate-cylindric with rounded apex, entire, 12–18 × 9–11μ.

Mucronate hyphopodia few, mixed with capitate, mostly alternate, bent ampulliform 15–20 × 7–9μ, neck upturned, 3μ thick. Mycelial setae rather sparse, scattered and around the perithecia, erect, straight, up to 230 × 8–9μ, apex simple and acute or 2-dentate to 8μ. Perithecia in loose central group, black, globose, verrucose, up to 180μ diam. Spores dark brown, cylindric to ellipsoid, 4-septate, constricted, 45–50 × 17–21μ. In some colonies about 1% of capitate hyphopodia are opposite.

(47) MELIOLA KISUBIENSIS Hansf., var. BOSISTOAE Hansf., n. var. (3111.5332). (Fig. 29.)

Plagulae saepius hypophyllae, densae, velutinae, usque ad 2 mm. diam. Mycelium ex hyphis atrobrunneis, subrectis vel undulatis, 7–8μ crassis (cellulis plerumque 20–25μ longis), opposite lateque ramosis, dense reticulatis compositum. Hyphopodia capitata alternata, plus minusve curvata, saepe antrorsa, 18–25μ longa, cellula basali cylindracea, 5–9μ longa, cellula apicali cylindracea apice rotundata, recta vel curvula, 11–21 × 8–11μ. Hyphopodia mucronata illis capitatis commixta, pauca, alternata vel opposita, ampullacea, curvata, 14–23 × 7–9μ, collo suberecto, 3–4μ crasso praedita. Setae myceliales paucae vel numerosae, erectae, rectae, simplices, acutae, usque ad 500 × 9–11μ. Perithecia laxe aggregata, atra, globosa, verrucosa, usque ad 260μ diam. Sporae atrobrunneae, cylindraceae, obtusae, 4-septatae, constrictae, 44–53 × 19–23 × 16–18μ.

Hab. in foliis *Bosistoae evodiiformis*, Bulga, N.S.W., Fraser 51 (typus in Herb. Dept. Agric., Sydney).

Colonies mainly hypophyllous, dense, velvety, to 2 mm. diam. Mycelium of substraight to undulate dark brown hyphae 7–8μ thick, the cells mostly 20–25μ long, branching opposite at wide angles, closely reticulate. Capitate hyphopodia alternate only, more or less bent, often antrorse, 18–25μ long; stalk cell cylindric, 5–9μ long; head cell cylindric with rounded apex, often bent, 11–21 × 8–11μ. Mucronate hyphopodia mixed with capitate, few, alternate or opposite, bent ampulliform, 14–23 × 7–9μ, neck ascending, 3–4μ thick. Mycelial setae few to numerous, erect, straight, simple, acute, or subacute, up to 500 × 9–11μ. Perithecia in a central group, black, globose, verrucose, up to 260μ diam. Spores dark brown, cylindric, obtuse, 4-septate, constricted, 44–55 × 19–23 × 16–18μ.

(48) MELIOLA KISUBIENSIS Hansf., var. MEDICOSMAE Hansf., n. var. (3111.5331). (Fig. 30.)

Plagulae epiphyllae, atrae, densae, 1–2 mm. diam.,. subcrustosae. Mycelium ex hyphis atrobrunneis, subrectis, 8–10μ crassis (cellulis plerumque 15–20μ longis), opposite ramosis, dense reticulatis compositum, subsolidum. Hyphopodia capitata alternata, rarissime etiam opposita, leniter antrorsa, 20–30μ longa, cellula basali cylindracea, 5–10μ longa, cellula apicali ovata vel cylindraceo-clavata, integra, apice rotundata, 15–22 × 10–14μ. Hyphopodia mucronata illis capitatis commixta, opposita vel alternata, ampullacea, collo curvato praedita. Setae myceliales paucae, dispersae, erectae, rectae, usque ad 280 × 9–11μ, apice obtusae vel subacutae. Perithecia dispersa, atra, globosa, verrucosa, usque ad 240μ diam. Sporae atrobrunneae, cylindraceae vel ellipsoideae, obtusae, 4-septatae, constrictae, 50–56 × 20–23μ.

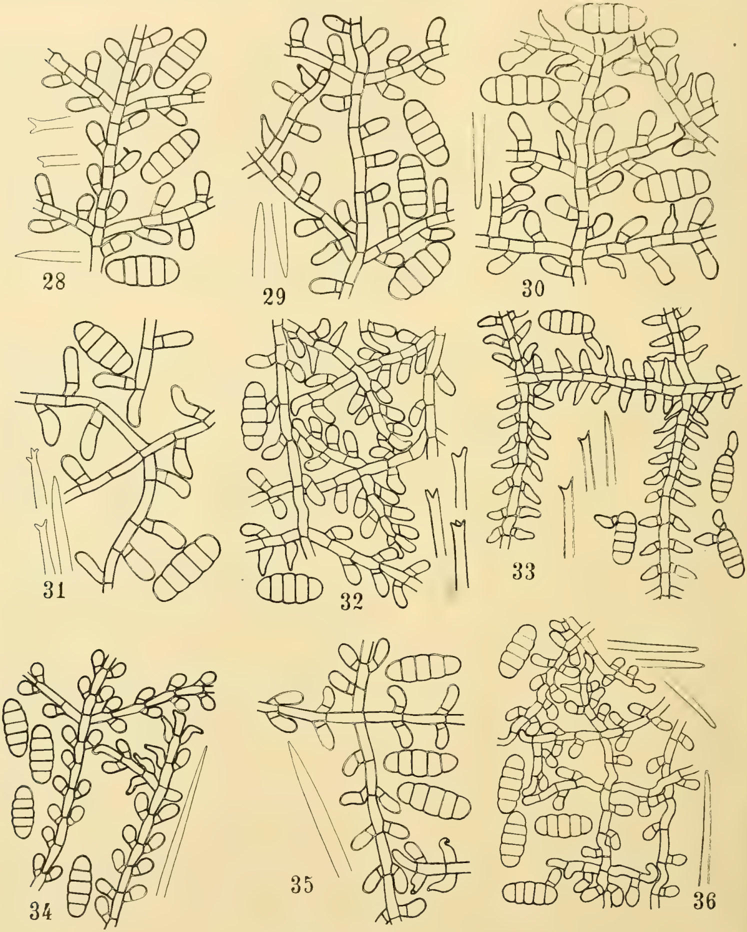
Hab. in foliis *Medicosmae cunninghamii*, Goodna, Qld., C. T. White (typus in Herb. Queensland, Brisbane).

Colonies epiphyllous, black, dense, 1–2 mm. diam., subcrustose. Mycelium of dark brown hyphae, substraight, 8–10μ thick, the cells mostly 15–20μ long, branching opposite at wide angles, forming an almost solid network. Capitate hyphopodia alternate, rarely also opposite, slightly antrorse, 20–30μ long; stalk cell cylindric, 5–10μ long; head cell ovate to cylindric-clavate, entire, widely rounded at apex, rarely with few blunt lobes, usually straight, 15–22 × 10–14μ. Mucronate hyphopodia scattered amongst capitate, opposite or alternate, ampulliform with bent neck. Mycelial setae few, scattered, straight, up to 280 × 9–11μ, erect, obtuse to subacute. Perithecia scattered, each on radiate disc, up to 240μ diam., black, flattened globose, verrucose. Spores dark brown, cylindric to ellipsoid with rounded ends, 4-septate, constricted, 50–56 × 20–25μ.

Many colonies are completely devoid of setae. Occasionally the capitate hyphopodia are rounded-angulose, and they are on average distinctly larger than those of the two preceding varieties.

(49) MELIOLA BOUCHARDATIAE Hansf., n. sp. (31⅓1.5332). (Fig. 31.)

Plagulae hypophyllae, subtenues, usque ad 3 mm. diam. vel confluentes, effusae, tenuiter velutinae. Mycelium ex hyphis atrobrunneis, subrectis vel undulatis, 7–9μ crassis (cellulis plerumque 20–30μ longis), opposite vel irregulariter ramosis, laxe reticulatis compositum. Hyphopodia capitata alternata, patentia, recta vel curvula, 22–37μ longa, cellula basali cylindracea vel cuneata, 4–11μ longa, cellula apicali cylindracea apice rotundata, saepe curvata, 17–28 × 8–11μ. Hyphopodia mucronata illis capitatis commixta, alternata, ampullacea, curvata, 15–22 × 7–9μ, collo suberecto, 2μ crasso



Text-figures 28-36 (× 250.)

28, *Meliola kisubiensis* var. ***phebalii-dentati***. 29, *M. kisubiensis* var. ***bosistoae***. 30, *M. kisubiensis* var. ***medicosmae***. 31, *M.* ***bouchardatiae***. 32, *M.* ***baileyi***. 33, *M. capensis* var. ***baileyana***. 34, *M. capensis* var. ***diploglottidis***. 35, *M.* ***fraseri***. 36, *M.* ***alectryonis***.

praedita. Setae myceliales dispersae, etiam juxta perithecia aggregatae, erectae, rectae, usque ad 450 × 9–11μ, apice acutae vel 2–3-dentatae usque ad 7μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 240μ diam. Sporae atrobrunneae, cylindraceae, obtusae, 4-septatae, constrictae, 45–56 × 19–22μ.

Hab. in foliis *Bouchardatiae neurococcae*, Mt. Warning, N.S.W., Fraser 230 (typus in Herb. Dept. Agric., Sydney).

Colonies hypophyllous, rather thin, to 3 mm. diam. or confluent and effuse, thinly velvety. Mycelium of substraight to undulate dark brown hyphae 7–9μ thick, the cells mostly 20–30μ long, branching opposite or irregular at wide angles, loosely reticulate. Capitate hyphopodia alternate, at wide angles, straight or bent, 22–37μ long; stalk cell cylindric or cuneate, 4–11μ long; head cell cylindric with rounded apex, often bent, 17–26 × 8–11μ. Mucronate hyphopodia mixed with capitate, alternate, bent ampulliform, 15–22 × 7–9μ, neck upturned, 3μ thick. Mycelial setae scattered and around the perithecia, erect, straight, up to 450 × 9–11μ, apex simple and acute or 2–3-dentate to 7μ. Perithecia scattered, black, globose, verrucose, up to 240μ diam. Spores dark brown, cylindric, obtuse, 4-septate, constricted, 45–56 × 19–22μ.

(50) **Meliola baileyi** Hansf., n. sp. (3133.4222). (Fig. 32.)

Plagulae hypophyllae, 1–2 mm. diam. vel numerosae et confluentes, densae. Mycelium ex hyphis atrobrunneis, subrectis, 7–9μ crassis (cellulis plerumque 15–25μ longis), opposite lateque ramosis, dense reticulatis compositum, in centro plagularum subsolidum. Hyphopodia capitata opposita vel alternata, antrorsa, 15–23μ longa, cellula basali cylindracea, 3–8μ longa, cellula apicali ovata vel cylindracea, apice rotundata, integra, interdum curvata, 11–18 × 7–10μ. Hyphopodia mucronata illis capitatis commixta, alternata vel opposita, ampullacea, collo curvato. Setae myceliales dispersae, numerosae, erectae, rectae, usque ad 320 × 8–10μ, obtusae vel saepius 2–3-dentatae usque ad 10μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 180μ diam. Sporae atrobrunneae, cylindraceae vel ellipsoideae, obtusae, 4-septatae, constrictae, 43–48 × 18–20μ.

Hab. in foliis *Flindersiae collinae*, Brisbane, Qld., Bailey 611 (typus in Herb. Queensland, Brisbane); in foliis *Eriostemi lanceolati*, Wahroonga, N.S.W., Fraser 152; in foliis *Phebalii squamulosi*, National Park, N.S.W., Fraser 7A; in foliis Rutacearum spec. indet., Brisbane, Qld., Bailey 645.

Colonies hypophyllous, 1–2 mm. diam., or numerous and confluent, black, dense. Mycelium of substraight dark brown hyphae, 7–9μ thick, the cells mostly 15–25μ long; branching opposite at wide angles, forming a close network and almost solid in the centre. Capitate hyphopodia opposite or alternate, antrorse, 15–23μ long; stalk cell cylindric, 3–8μ long; head cell ovate to cylindric with rounded apex, entire, sometimes slightly bent, 11–18 × 7–10μ. Mucronate hyphopodia mixed with capitate, alternate or opposite, ampulliform with bent neck. Mycelial setae thickly scattered, erect, straight, up to 320 × 8–10μ thick at the base, obtuse or usually 2–3-dentate to 10μ. Perithecia scattered, black, globose, verrucose, up to 180μ diam. Spores dark brown cylindric, obtuse, 4-septate, constricted, 43–48 × 18–20μ.

The specimen on *Eriostemon lanceolatum* has the colonies amphigenous and velvety, the perithecia up to 240μ diam., with spores 45–54 × 19–22 × 15–17μ. The spores of Fraser 7A on *Phebalium squamulosum* measure only 40–47 × 17–20μ and the mycelial setae reach 540μ in length. In Herb. Kew the host of Bailey 645 is labelled *Citrus australis.*

Family SAPINDACEAE.

(51) **Meliola capensis** (K. & C.) Theiss., var. **baileyana** Hansf., n. var. (31⅓2.3222). (Fig. 33.)

Plagulae epiphyllae, atrae, 1–2 mm. diam., subdensae. Mycelium ex hyphis atrobrunneis, subrectis, 7–8μ crassis (cellulis plerumque 10–20μ longis), opposite subrectangulariter ramosis, dense reticulatis compositum. Hyphopodia capitata opposita, leniter antrorsa, 12–20μ longa, cellula basali cylindracea, 2–5μ longa, cellula apicali cylindracea vel subconoidea, apice rotundata, saepe leniter recurvata, 10–16 × 7–9μ.

Hyphopodia mucronata illis capitatis commixta, opposita vel alternata, ampullacea, curvata, 18–23 × 6–8μ, collo suberecto, 3μ crasso praedita. Setae myceliales laxe dispersae, erectae, rectae, usque ad 320 × 7–9μ, apice acutae vel 2–3-dentatae usque ad 10μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 180μ diam. Sporae atrobrunneae, cylindraceae vel ellipsoideae, obtusae, 4-septatae, constrictae, 34–38 × 14–16μ.

Hab. in foliis Sapindacearum spec. indet., Tringithurra Creek, Qld., Bailey 817 p.p. (typus in Herb. Queensland, Brisbane).

Colonies epiphyllous, black, 1–2 mm. diam., rather dense. Mycelium of substraight dark brown hyphae 7–8μ thick, the cells mostly 10–20μ long, branching regular, opposite at near right angles, forming close network. Capitate hyphopodia opposite close, somewhat antrorse but often reflexed towards the apex, 12–20μ long; stalk cell short cylindric, 2–5μ long; head cell cylindric to somewhat conic with rounded apex, often bent, 10–16 × 6–9μ. Mucronate hyphopodia frequent, mixed with capitate, opposite or alternate, elongate bent ampulliform, 18–23 × 6–8μ wide at base. Mycelial setae thinly scattered, erect, straight, apex simple and acute or 2–3-dentate to 10μ, up to 320 × 7–9μ. Mature perithecia not seen, immature to 180μ diam., black, globose, verrucose. Spores dark brown, cylindric with rounded ends, 4-septate, constricted, smooth, 34–38 × 14–16μ.

(52) MELIOLA CAPENSIS (K. & C.) Theiss., var. DIPLOGLOTTIDIS Hansf., n. var. (3112.4222). (Fig. 34.)

Plagulae plerumque hypophyllae, subdensae, velutinae, usque ad 8 mm. diam. vel confluentes, in epiphyllo minores. Mycelium ex hyphis atrobrunneis, rectis, 6–7μ crassis (cellulis plerumque circa 20μ longis), opposite lateque ramosis, laxe vel subdense reticulatis compositum. Hyphopodia capitata opposita, plus minusve antrorsa, 13–21μ longa, cellula basali cuneato-cylindracea, 3–6μ longa, cellula apicali globosa vel oblonga, integra, 9–17 × 8–10μ. Hyphopodia mucronata illis capitatis commixta, opposita vel alternata, ampullacea, curvata, 15–25 × 6–8μ, collo suberecto 3–4μ crasso praedita. Setae myceliales dispersae, etiam juxta perithecia aggregatae, erectae, rectae, simplices, acutae, usque ad 400 × 7–8μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 190μ diam. Sporae atrobrunneae, cylindraceae vel ellipsoideae, obtusae, 4-septatae, constrictae, 35–43 × 16–18μ.

Hab. in foliis *Diploglottidis australis*, National Park, N.S.W., Fraser 164 (typus in Herb. Dept. Agric., Sydney); Williams R., N.S.W., Fraser 137.

Colonies mostly hypophyllous, rather dense, velvety, to 8 mm. diam., or sometimes confluent, much smaller on upper surface of leaf. Mycelium of straight dark brown hyphae 6–7μ thick, the cells mostly about 20μ long, branching opposite at wide angles, loosely to closely reticulate. On lower surface the hyphae less straight and the cells often longer. Capitate hyphopodia almost entirely opposite save where crowded, more or less antrorse, 13–21μ long; stalk cell cuneate to cylindric, 3–6μ long; head cell globose to oblong, entire, 9–17 × 8–10μ. Mucronate hyphopodia mixed with capitate, opposite or alternate, bent ampulliform, 15–25 × 6–8μ, neck upturned, 3–4μ thick. Mycelial setae scattered and around the perithecia, erect, more or less straight, simple, acute, up to 400 × 7–8μ, gradually attenuate to apex. Perithecia scattered, black, globose, verrucose, up to 190μ diam. Spores dark brown cylindric to ellipsoid, obtuse, 4-septate, constricted, 35–43 × 16–18μ.

(53) MELIOLA FRASERI Hansf., n. sp. (3113.5333). (Fig. 35.)

Plagulae amphigenae, tenues vel subdensae, usque ad 8 mm. diam. vel confluentes et effusae. Mycelium ex hyphis atrobrunneis, subrectis vel undulatis, 7–8μ (cellulis plerumque 25–30μ longis), opposite lateque ramosis, laxe reticulatis compositum. Hyphopodia capitata alternata vel opposita (– 90%), recta vel curvata, leniter antrorsa, vel recurvata, 17–25μ longa, cellula basali cylindracea, 3–6μ longa, cellula apicali cylindracea, apice rotundata, integra, 12–20 × 8–12μ. Hyphopodia mucronata pauca, illis capitatis commixta, alternata vel opposita, ampullacea, curvata, 15–22 × 7–9μ, collo suberecto, 3–4μ crasso praedita. Setae myceliales dispersae, etiam juxta perithecia aggregatae, erectae, rectae, simplices, acutae, usque ad 650 × 9–12μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 215μ diam. Sporae atrobrunneae, ellipsoideae, obtusae, 4-septatae, constrictae, 46–55 × 18–21μ.

Hab. in foliis *Mischocarpi* spec., Williams R., N.S.W., Fraser 215 (typus in Herb. Dept. Agric., Sydney); in foliis Sapindacearum spec. indet., Hastings R., N.S.W., Fraser s.n., April, 1952.

Colonies amphigenous, thin to rather dense, up to 8 mm. diam. or confluent and effuse. Mycelium of substraight to undulate dark brown hyphae 7–8μ thick, the cells mostly 25–30μ long, branching usually opposite at wide angles, loosely reticulate, becoming close in centre of larger colonies. Capitate hyphopodia alternate or up to 90% opposite, straight or bent, at wide angles or somewhat antrorse, 17–25μ long; stalk cell cylindric, 3–6μ long; head cell cylindric with rounded apex, entire, often bent, 12–20 × 8–12μ. Mucronate hyphopodia few, mixed with capitate, alternate or opposite, bent ampulliform, 15–22 × 7–9μ, neck upturned, 3–4μ thick. Mycelial setae scattered and around the perithecia, erect, straight, simple, acute, up to 650 × 9–12μ. Perithecia scattered, black, globose, verrucose, up to 215μ diam. Spores dark brown, ellipsoid, obtuse, 4-septate, constricted, 46–55 × 18–21μ.

(54) MELIOLA FRASERI Hansf., var. MINOR Hansf., n. var. (3113.4222).

Plagulae epiphyllae, 1–2 mm. diam., tenuissimae. Mycelium ex hyphis atrobrunneis, subrectis vel undulatis, 6–7μ crassis (cellulis plerumque 25–40μ longis), opposite acuteque ramosis, laxe reticulatis compositum. Hyphopodia capitata alternata vel usque ad 50% opposita, leniter antrorsa, 20–25μ longa, cellula basali cylindracea, 3–7μ longa, cellula apicali cylindraceo-clavata, integra, recta vel curvula, 14–19 × 7–10μ. Hyphopodia mucronata illis capitatis commixta, alternata vel opposita, ampullacea, 19–23 × 6–9μ. Setae myceliales tenuiter dispersae, erectae, rectae, simplices, acutae, usque ad 350 × 7–10μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 190μ diam. Sporae atrobrunneae, cylindraceae vel ellipsoideae, obtusae, 4-septatae, constrictae, 40–44 × 16–18μ.

Hab. in foliis Sapindacearum spec. indet., Tringithurra Creek, Qld., Bailey 817 p.p.

In the type this occurs mixed with *M. capensis* var. *baileyana*.

Colonies epiphyllous, black, 1–2 mm. diam., very thin. Mycelium of substraight to slightly undulate dark brown hyphae 6–7μ thick, the cells mostly 25–40μ long, branching usually opposite at acute angles, loosely reticulate. Capitate hyphopodia alternate or up to 50% opposite, somewhat antrorse, 20–25μ long; stalk cell cylindric, 3–7μ long; head cell regular, cylindric-clavate, rounded at apex, straight or slightly bent, 14–19 × 7–10μ. Mucronate hyphopodia scattered amongst capitate, alternate or opposite, bent ampulliform, 19–23 × 6–9μ. Mycelial setae thinly scattered, erect, straight, simple, acute, up to 350 × 7–10μ. Mature perithecia up to 190μ diam., black, globose, verrucose. Spores dark brown, cylindric to ellipsoid, obtuse, 4-septate, constricted, 40–44 × 16–18μ.

(55) MELIOLA ALECTRYONIS Hansf., n. sp. (3113.4222). (Fig. 36.)

Plagulae amphigenae, plerumque epiphyllae, etiam petiolicolae, tenuiter velutinae, 1–2 mm. diam., densae. Mycelium ex hyphis atrobrunneis, undulatis vel flexuosis, 7μ crassis (cellulis plerumque 15–20μ longis), opposite lateque ramosis, dense reticulatis compositum. Hyphopodia capitata alternata vel opposita, recta vel curvata, plus minusve antrorsa, 11–19μ longa, cellula basali cylindracea, 3–6μ longa, cellula apicali ovata vel clavato-cylindracea, integra, 8–13 × 7–9μ. Hyphopodia mucronata pauca, illis capitatis commixta, ampullacea, 13–17 × 6–8μ, collo suberecto 3μ crasso praedita. Setae myceliales dispersae, erectae, rectae, simplices, obtusae, usque ad 330 × 7–9μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 170μ diam. (immatura). Sporae atrobrunneae, cylindraceae vel ellipsoideae, obtusae, 4-septatae, constrictae, 37–42 × 15–18μ.

Hab. in foliis *Alectryonis subcinerei*, Ballina, N.S.W., Baker 630 (typus in Herb. Dept. Agric., Melbourne); Williams R., N.S.W., Fraser 165.

Colonies amphigenous, mostly epiphyllous and on petioles, black, thinly velvety, 1–2 mm. diam., dense, not crustose. Mycelium of dark brown, undulate to flexuous hyphae 7μ thick, the cells mostly 15–20μ long, branching usually opposite at wide angles, forming a close network. Capitate hyphopodia alternate or opposite, straight or bent, usually more or less antrorse, 11–19μ long; stalk cell cylindric, 3–6μ long; head cell ovate to cylindric-clavate, widely rounded at apex, entire, 8–13 × 7–9μ. Mycelial setae scattered, erect, straight, black, opaque, simple, obtuse, up to 330 × 7–9μ. Perithecia scattered, black, flattened-globose, verrucose, immature (to 170μ diam.). Spores dark brown, cylindric with obtuse ends, 4-septate, constricted, 37–42 × 15–18μ.

(56) MELIOLA GUIOAE-SEMIGLAUCAE Hansf., n. sp. (3113.5332). (Fig. 37.)

Plagulae saepius hypophyllae, tenues, effusae, usque ad 15 mm. diam. vel late confluentes, tenuiter velutinae. Mycelium ex hyphis atrobrunneis, subrectis vel flexuosis, 6–8μ crassis (cellulis plerumque 20–30μ longis), opposite lateque ramosis, laxe reticulatis compositum. Hyphopodia capitata alternata vel circa 2% opposita, recta vel curvata, in epiphyllo 20–30μ longa, in hypophyllo saepe longiora, cellula basali 5–20μ longa, cylindracea, recta vel curvata, cellula apicali oblonga vel late ovata, in hypophyllo subglobosa vel irregulariter rotundato-angulosa, 15–23 × 10–14μ. Hyphopodia mucronata illis capitatis commixta, alternata vel opposita, ampullacea, curvata, 16–22 × 6–9μ, collo suberecto, 3–4μ crasso praedita. Setae myceliales dispersae, etiam juxta perithecia aggregatae, erectae, plus minusve rectae, simplices, acutae, usque ad 450 × 7–9μ. Perithecia laxe dispersa, atra, globosa, verrucosa, usque ad 210μ diam. Sporae atrobrunneae, cylindraceae vel ellipsoideae, 4-septatae, constrictae, 45–54 × 19–21μ, obtusae.

Hab. in foliis *Guioae semiglaucae*, Williams R., N.S.W., Fraser 116 (typus in Herb. Dept. Agric., Sydney); National Park, N.S.W., Fraser 150, 86; Williams R., N.S.W., Fraser, April, 1952.

Colonies mostly hypophyllous, thin and effuse, up to 15 mm. diam. or widely confluent, thinly velvety. Mycelium of substraight to crooked dark brown hyphae 6–8μ thick, the cells mostly 20–30μ long, branching opposite at wide angles, loosely reticulate. Capitate hyphopodia alternate or about 2% opposite, straight or bent, on upper surface 20–30μ long, on lower surface more variable with longer stalk cells; stalk cell 5–20μ long, cylindric, straight or bent; head cell oblong to widely ovate, on lower surface from subglobose to irregularly rounded-angulose, 15–23 × 10–14μ. Mucronate hyphopodia mixed with capitate, alternate or opposite, bent ampulliform, 16–22 × 6–9μ, neck upturned, 3–4μ thick. Mycelial setae scattered and around the perithecia, erect, more or less straight, simple, acute, up to 450 × 7–9μ. Perithecia loosely scattered, black, globose, verrucose, up to 210μ diam. Spores dark brown, cylindric to ellipsoid, 4-septate, constricted, 45–54 × 19–21μ.

(57) IRENINA DODONAEAE Hansf., n. sp. (3103.4230). (Fig. 38.)

Plagulae amphigenae, usque ad 1 mm. diam., densae, leves, saepe numerosae sed raro confluentes. Mycelium ex hyphis atrobrunneis, 7–8μ crassis (cellulis plerumque 15–20μ longis), opposite lateque ramosis, dense reticulatis compositum, in centro plagularum subsolidum. Hyphopodia capitata opposita vel alternata, plus minusve antrorsa, 16–25μ longa, cellula basali cylindracea, 4–10μ longa, cellula apicali subglobosa vel late piriformia, integra, 12–16 × 9–13μ. Hyphopodia mucronata pauca, illis capitatis commixta, alternata vel opposita, ampullacea, curvata, 14–20 × 7–9μ, collo suberecto, 3–4μ crasso praedita. Setae nullae. Perithecia in centro plagularum aggregata, atra, globosa, leniter verrucosa, usque ad 240μ diam., cellulis parietis conoideis, vix prominentibus. Sporae atrobrunneae, cylindraceae, obtusae, 4-septatae, constrictae, 40–46 × 16–18μ.

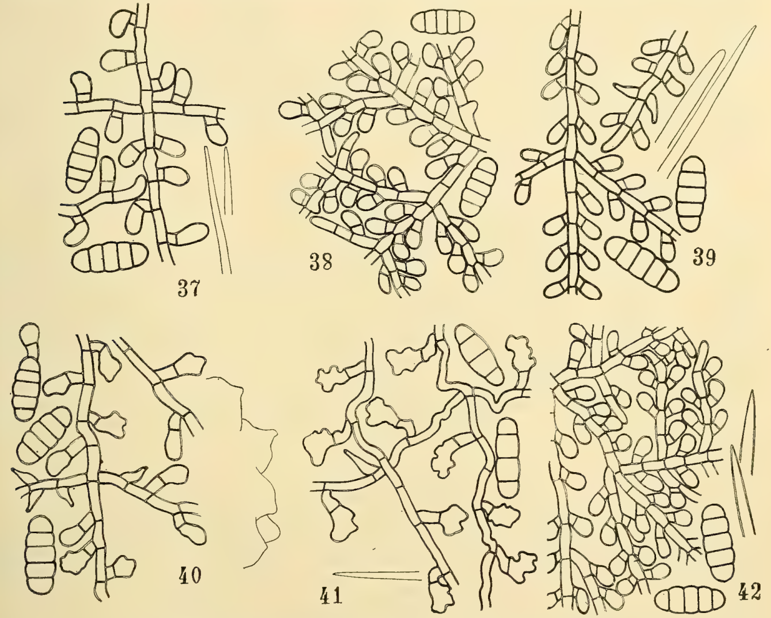
Hab. in foliis *Dodonaeae triquetrae*, National Park, N.S.W., Fraser s.n., Nov., 1935 (typus in Herb. Dept. Agric., Sydney).

Colonies amphigenous, to 1 mm. diam., black, dense, smooth, often numerous but rarely confluent. Mycelium of substraight dark brown hyphae 7–8μ thick, the cells mostly 15–20μ long, branching opposite at wide angles, densely reticulate and almost solid. Capitate hyphopodia opposite or alternate, more or less antrorse, 16–25μ long; stalk cell cylindric, 4–10μ long, head cell subglobose to wide piriform, entire, 12–16 × 9–13μ. Mucronate hyphopodia few, mixed with capitate, alternate or opposite, bent ampulliform, 14–20 × 7–9μ, neck upturned, 3–4μ thick. Setae none. Perithecia in central group, black, globose, slightly verrucose, up to 240μ diam., the surface cells rounded-conoid, scarcely projecting. Spores dark brown, cylindric, obtuse, 4-septate, constricted, 40–46 × 16–18μ.

Family SMILACACEAE.

(58) **Meliola ripogoni** Hansf., n. sp. (3113.5331). (Fig. 39.)

Plagulae saepius epiphyllae, usque ad 5 mm. diam., densae, velutinae. Mycelium ex hyphis atrobrunneis, subrectis, 7–9μ crassis (cellulis plerumque 20–25μ longis), opposite acuteque ramosis, dense radianto-reticulatis compositum. Hyphopodia capitata opposita vel alternata, plus minusve antrorsa, recta vel curvula, 16–25μ longa, cellula basali cylindracea, 3–8μ longa, cellula apicali subglobosa vel oblongo-cylindracea, apice late rotundata, integra, 12–18 × 8–13μ. Hyphopodia mucronata pauca, illis capitatis commixta, ampullacea, curvata, 16–21 × 8–9μ, collo suberecto, 3–4μ crasso praedita. Setae myceliales numerosae, dispersae, erectae, rectae, simplices, obtusae vel acutae, usque ad 300 × 8–10μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 220μ diam. Sporae atrobrunneae, cylindraceae vel ellipsoideae, obtusae, 4-septatae, constrictae, 46–56 × 18–22μ.



Text-figures 37-42. (× 250.)

37, *Meliola guioae-semiglaucae*. 38, *Irenina dodonaeae*. 39, *Meliola ripogoni*. 40, *Irenina duboisiae*. 41, *Meliola cissi-antarcticae*. 42, *M. lomandrae*.

Hab. in foliis *Ripogoni albi*, Williams R., N.S.W., Fraser 64 (typus in Herb. Dept. Agric., Sydney); *l.c.*, Fraser 122.

Colonies mostly epiphyllous, to 5 mm. diam., black, dense, becoming velvety. Mycelium of substraight dark brown hyphae 7–9μ thick, the cells mostly 20–25μ long, branching opposite at acute angles, densely radiating-reticulate. Capitate hyphopodia opposite or less frequently alternate, more or less antrorse, usually straight, 16–25μ long; stalk cell cylindric, 3–8μ long; head cell from subglobose to oblong-cylindric, widely rounded at apex, entire, 12–18 × 8–13μ. Mucronate hyphopodia few, mixed with capitate, opposite or alternate, bent ampulliform, 16–21 × 8–9μ, neck upturned, 3–4μ thick. Mycelial setae numerous, closely scattered, erect, straight, simple, obtuse to acute, up to 300 × 8–10μ. Perithecia scattered, black, globose, verrucose, up to 220μ diam. Spores dark brown, cylindric-ellipsoid, obtuse, 4-septate, constricted, 46–56 × 18–22μ.

Family SOLANACEAE.

(59) Irenina duboisiae Hansf., n. sp. (3101.5330). (Fig. 40.)

Plagulae epiphyllae, densae, usque ad 1 mm. diam. vel confluentes, leves. Mycelium ex hyphis atrobrunneis, subrectis vel undulatis, 7–9μ crassis (cellulis plerumque 20–25μ longis), opposite lateque ramosis, dense reticulatis compositum. Hyphopodia capitata alternata, leniter antrorsa, recta vel curvula, 20–35μ longa, cellula basali cylindracea, 5–15μ longa, cellula apicali oblongo-clavata vel irregulariter rotundato-lobata, versiformia, 15–23 × 12–18μ. Hyphopodia mucronata illis capitatis commixta, opposita vel alternata, ampullacea, curvata, 15–20 × 7–9μ, collo suberecto, 3–4μ crasso praedita. Setae myceliales nullae. Perithecia in centro plagularum laxe aggregata, atra, globosa, verrucosa, usque ad 270μ diam., cellulis parietis conoideis vel mammillatibus, usque ad 20μ alt. et ad basim 40μ diam. Sporae atrobrunneae, ellipsoideae, obtusae, 4-septatae, constrictae, 44–53 × 19–22 × 16–19μ.

Hab. in foliis *Duboisiae myoporoidis*, Comboyne, N.S.W., Fraser 198 (typus in Herb. Dept. Agric., Sydney); Bulga, N.S.W., Fraser 67.

Colonies epiphyllous, dense, up to 1 mm. diam. or confluent, smooth. Mycelium of substraight to undulate dark brown hyphae 7–9μ thick, the cells mostly 20–25μ long, branching usually opposite, closely reticulate. Capitate hyphopodia alternate, somewhat antrorse, straight or bent, 20–35μ long; stalk cell cylindric, 5–15μ long; head cell oblong-clavate or irregularly rounded-lobate, versiform, 15–23 × 12–18μ. Mucronate hyphopodia mixed with capitate opposite or alternate, bent ampulliform, 15–20 × 7–9μ, neck upturned, 3–4μ thick. Mycelial setae none. Perithecia in loose central group, black, globose, rough, up to 270μ diam., surface cells conoid to mammillate, projecting up to 20μ and about 40μ diam. at the base. Spores dark brown, ellipsoid, obtuse, 4-septate, constricted, 44–53 × 19–22 × 16–19μ.

Family VITACEAE.

(60) Meliola cissi-antarcticae Hansf., n. sp. (2111.5232). (Fig. 41.)

Plagulae hypophyllae, raro etiam epiphyllae, 1–4 mm. diam. vel confluentes, tenues, tenuiter velutinae. Mycelium ex hyphis atrobrunneis, flexuosis, 6–7μ crassis (cellulis plerumque 25–40μ longis), opposite vel irregulariter ramosis, laxe reticulato-intertextis compositum. Hyphopodia capitata alternata, irregulariter curvata, 25–40μ longa, cellula basali cylindracea, 7–17μ longa, cellula apicali irregulariter stellato-lobata, saepe curvata, 18–25 × 15–23μ. Hyphopodia mucronata illis capitatis commixta, alternata, ampullacea, curvata, 20–28 × 8–9μ, collo suberecto, 3μ crasso praedita. Setae myceliales subnumerosae, dispersae, etiam juxta perithecia aggregatae, erectae, rectae, simplices, acutae, usque ad 350 × 7–8μ. Perithecia dispersa, atra, globosa, verrucosa, usque ad 280μ diam. Sporae atrobrunneae cylindraceae vel ellipsoideae, 3-septatae, leniter constrictae, 40–53 × 16–20μ, cellulis terminalibus minoribus, zona subhyalino, angusto, subterminali praedita.

Hab. in foliis *Cissi antarcticae*, Hastings R., N.S.W., Fraser, April, 1952 (typus in Herb. Dept. Agric., Sydney).

Colonies hypophyllous mostly, 1–4 mm. diam. or confluent, thin, thinly velvety. Mycelium of crooked dark brown hyphae 6–7μ thick, the cells mostly 25–40μ long, branching opposite or irregular, closely reticulate-interwoven. Capitate hyphopodia alternate or more distant, irregularly bent, 25–40μ long; stalk cell cylindric, 7–17μ long; head cell very irregularly stellate-lobate and bent, 18–25 × 15–23μ. Mucronate hyphopodia mixed with capitate, alternate, bent ampulliform, 20–28 × 8–9μ, neck upturned, 3μ thick. Mycelial setae fairly numerous, scattered and around the perithecia, erect, straight, simple, acute, up to 350 × 7–8μ. Perithecia scattered, black, globose, verrucose, up to 280μ diam. Spores dark brown, cylindric to ellipsoid, 3-septate, slightly constricted, 40–53 × 16–20μ, the central cells much larger than the end cells, which have a faint subhyaline subterminal band, like those of *Meliolina* spp.

Family XANTHORRHOEACEAE.

(61) **Meliola lomandrae** Hansf., n. sp. (3113.5332). (Fig. 42.)

Plagulae amphigenae, atrae, densae, velutinae, crustosae, usque ad 3 mm. diam. Mycelium ex hyphis atrobrunneis, subrectis, 7–9μ crassis (cellulis plerumque 15–30μ longis), opposite ramosis, subsolide reticulatis compositum. Hyphopodia capitata opposita vel alternata, antrorsa, 15–23μ longa; cellula basali cylindracea, 4–10μ longa, cellula apicali subglobosa vel late ovata, integra, 10–15 × 9–13μ. Hyphopodia mucronata pauca, illis capitatis commixta, alternata vel opposita, ampullacea, 15–20 × 7–9μ, collo suberecto, 3–4μ crasso praedita. Setae myceliales numerosissimae, dispersae, erectae, rectae, acutae, simplices, usque ad 340 × 8–9μ. Perithecia subaggregata, atra, globosa, verrucosa, usque ad 210μ diam. Sporae atrobrunneae, cylindraceae vel subellipsoideae, obtusae, 4-septatae, constrictae, 48–53 × 18–21μ.

Hab. in foliis *Lomandrae*, spec. indet., Queensland, H. Tryon 501 (typus in Herb. Queensland, Brisbane); *l.c.*, Bailey 634; in foliis *L. montanae*, Williams R., N.S.W., Fraser 220.

Colonies amphigenous, black, very dense, velvety, crustose, to 3 mm. diam. Mycelium of substraight dark brown hyphae 7–9μ thick, the cells mostly 15–30μ long, branching usually opposite at variable angles, forming almost a solid plate in centre. Capitate hyphopodia opposite or alternate, antrorse, 15–23μ long; stalk cell cylindric, 4–10μ long; head cell regular, entire, subglobose to widely ovate, 10–15 × 9–13μ. Mucronate hyphopodia few, mixed with capitate, alternate or opposite, ampulliform, 15–20 × 7–9μ. Mycelial setae very numerous, scattered, erect, straight, acute, simple, up to 340 × 8–9μ. Perithecia closely scattered, black, globose, verrucose, up to 210μ diam. Spores dark brown, cylindric, obtuse, 4-septate, constricted, smooth, 48–53 × 18–21μ.

In addition to the species recorded above, I have seen two other specimens from the Queensland Herbarium on undetermined hosts, which I have been unable to match with other species of *Meliola* or related genera. Until further collections of these can be made, and the hosts determined, it is not possible to describe them as new species.

Of the species previously recorded in Australia, which I have been able to trace, many obviously refer to one or other of those given above, though in some cases it is impossible to be certain of the exact species when more than one has been recorded on a host genus, and no specimens to substantiate these old records have been traced. In his Handbook of Australian Fungi, 1892, Cooke recorded the following:

Meliola corallina Mont.—All specimens of this species I have so far encountered are on *Drimys* spp. in South America, and although this host genus is recorded for Australia, I have seen no record of a true *Meliola* on it here.

Meliola amphitricha Fr.—The older mycologists used this name to include almost every *Meliola* they encountered, and, as was pointed out by Stevens, the true identity of the species is now irretrievably lost, so that the name must be abandoned.

Meliola musae Mont.—The host of this species has recently been determined for me at Kew as *Ravenala guyanensis*, and there is no record for any part of the world of this species on *Musa*; it appears to be limited to S. America. Cooke's record for Queensland on *Musa* can only be a mis-determination of a fungus not truly belonging to *Meliola*; there is no specimen in Herb. Kew.

Meliola orbicularis B. & C.—I have examined collections from the Queensland Herbarium, which appear to be correctly referred to this species; the host is a twig of an unknown plant. It appears to me very doubtful whether this fungus really belongs to *Meliola*, but further collections are required in fresh condition to elucidate its structure and parasitism.

Meliola loganiensis Sacc. & Berl., on *Smilax*, Qld.—According to description is not a *Meliola*, but probably belongs to Chaetothyriaceae.

Meliola octospora Cooke and *M. mollis* B. & Br. are now placed in the genus *Meliolina*, which is very doubtfully related to *Meliola*.

Meliola tetracerae Thuem. is, *ex descr.*, certainly not a true *Meliola*; Saccardo in *Syll. Fung.*, 14: 474, 1890, referred it to *Limacinia*, but re-examination is required of the type specimen before it can be placed with certainty. I have seen no Australian specimen to support Cooke's record.

STUDIES OF N–FIXING BACTERIA. III.

AZOTOBACTER BEIJERINCKII (Lipman, 1903), VAR. ACIDO-TOLERANS (Tchan, 1952).

By Y. T. TCHAN, Macleay Bacteriologist to the Society.

[Read 27th May, 1953.]

Synopsis.

Azotobacter beijerinckii (Lipman, 1903) *acido-tolerans* (Tchan, 1952), var. nov., is described. It can grow at pH 4·75 in media much too acid for other species of the genus.

It is generally accepted that the genus *Azotobacter* contains only species growing on a medium with a pH not much below 6. This property has been used by Derx (1950) to prevent the growth of *Azotobacter* by using an acid medium (pH = 5). In a previous work, *Azotobacter* has been successfully isolated from acid soils in the Sydney district (Tchan, 1952). The present paper describes the morphology and physiology of the species.

MORPHOLOGY.

The cells are rods to ellipsoids of 4–2 × 3–1·5μ. Their cytoplasm is reduced to a kind of net by the presence of many fatty bodies staining with Sudan III. Cysts are readily formed in old cultures, especially with acetate as carbon source. They can be easily and specifically stained by the triple stain with violamin recommended by Winogradsky (1938). Living cells examined under the dark field or phase-contrast microscope did not show any motility nor in 0·2% agar medium. The controls with other *Azotobacter*, except *Azot. beijerinckii*, gave a typical culture of motile bacteria. This confirms the non-motility of *Azot. beijerinckii.*

The acid-fast stain gives red spots in the cells of all species of *Azotobacter*, but they are large and more numerous in *Azot. beijerinckii* and its new variety.

CULTURAL CHARACTERS.

For this study a Petri dish is divided into sectors. On the agar medium the new variety of *Azotobacter* is inoculated in one sector and in each of the others controls are inoculated (*Azotoc. agilis, Azot. chroococcum, Azot. vinelandii, Azot. beijerinckii, Beijerinckia indica, Beijerinckia indica* var. *alba*). Thus any variation due to the medium may be easily noticed by the abnormal growth of controls. Different sugars, organic acids and alcohols are used.

Glucose: On glucose, Winogradsky's salt agar medium, colonies appear within 24–48 hours; first white, then becoming yellow, but never brown-black. After two weeks the diameter of the colony may reach 1 cm. or sometimes more. The colour is then slightly ochreous. In liquid glucose medium the culture is first uniformly turbid and becomes cloudy. A yellow deposit can be seen after a week of incubation.

Sucrose, raffinose: Practically identical with glucose except a leaven (as described by Derx) is produced.

Maltose, inulin: Dark ochreous colour is developed after two weeks.

Mannose, galactose, rhamnose, xylose, lactose: The culture remains yellow after two weeks.

Dextrin: Identical with glucose.

Acetate, succinate (K or Na salt): The colony is first milky white and becomes lemon-yellow after two weeks.

Tartrate: Slightly ochreous after two weeks.

Benzoate: A typical benzoatase (Tchan, 1946) is developed after a week.

Methanol, glycerol: Colonies are yellow.

Ethanol: Colonies are creamy.

INFLUENCE OF pH.

Agar media containing Winogradsky salts solution and glucose were buffered to different pH values. (The pH was measured with a glass electrode potentiometer.) The $CaCO_3$ was replaced by $CaCl_2$. The same inoculating technique was used as for the study with different carbon sources.

At values up to pH 6·2 all cultures gave a positive growth within three days. At pH 5·6 *Azotoc. agilis, Azot. vinelandii, Azot. chroococcum, Azot. beijerinckii* gave only very slight growth after ten days. At pH 5·4 all four species failed to grow even after one month, only the new variety and the two species of *Beijerinckia* forming colonies. At pH 4·75 the new variety showed slight growth after five days, but between this pH and pH 3·5 only *Beijerinckia* grew.

Little or no acid was formed on the different media.

DISCUSSION AND CONCLUSION.

There has been no recent study on *Azot. beijerinckii* and the present work can fill this gap in part. It shows that the genus *Azotobacter* contains one non-motile species. If we accept the conception that the non-motile bacteria have no flagellae then the definition of the genus "*Azotobacter*" given in Bergey's Manual should be modified. (Further electronic microscopical study is needed to clarify this point.) The positive acid-fast stain for all species of *Azotobacter* may relate them to the Mycobacteria. It may have some taxonomic significance.

The limits of a pH of 5·8 for *Azotobacter* could not be confirmed in the present study (Pochon and Tchan, 1948). On the other hand, these results are in accordance with Blinkow's work (1951), which showed a critical pH of 5·5–5·6 for the well-known species, but with the new variety the limiting pH is 4·75, which is nearly one unit below that for the other species. This tolerance to acid conditions is important in two ways. When other *Azotobacter* are excluded from acid soils this organism may grow and play a role in the N economy. On the other hand, Derx's acid medium does not exclude it unless modified to give a pH of 4·5 or better 4·0.

Morphologically this organism is an *Azotobacter*, very similar to *Azot. beijerinckii.* Therefore, it cannot be raised to specific rank. Since the remarkable tolerance to acid conditions is unusual, it is proposed to distinguish it as a new variety, *Azotobacter beijerinckii acido-tolerans* (Tchan, 1952), var. nov.

ACKNOWLEDGEMENT.

My sincere thanks are due to Dr. H. S. McKee for his help.

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STUDIES OF N–FIXING BACTERIA. IV.

Taxonomy of Genus Azotobacter (Beijerinck, 1901).

By Y. T. Tchan, Macleay Bacteriologist to the Society.

[Read 24th June, 1953.]

Synopsis.

The confusion in the taxonomy of *Azotobacter* is created by the contradiction between morphology, serology, physiology and chemical composition of different species. A critical examination of different arguments leads to a rearrangement of the family of Azotobacteriaceae. The classification is based on the combined morphological, physiological and ecological characters.

The genus *Azotobacter* Beijerinck, 1901, originally contained two species—*Azot. chroococcum* and *Azot. agilis* (Beijerinck, 1901). In 1903 Lipman (1903) isolated *Azot. vinelandii,* in 1904 *Azot. beijerinckii* and *Azot. woodstownii,* in 1909 *Azot. hilgardii.* Lipman and Burgess (1915) isolated *Azot. smyrnii. Azot. vitreum* was isolated by Löhnis and Westermann (1908). This early period of "splitters" was followed by a "lumper" period. Greene (1935), Aso and Yoshida (1928), Löhnis and Smith (1923), and Smith (1948) all reduced the genus *Azotobacter* to two species—*Azot. chroococcum* and *Azot. agilis.* Recent publications have added some new species: *Azot. indicum* Starkey and De (1939), *Azot. insigne* Derx (1950), *Azot. lacticogenes* Kauffmann and Toussaint (1951), and two new varieties: *Azot. agilis* var. *atypica* Kluyver and Van den Bont (1936), *Azot. beijerinckii* var. *acido-tolerans* Tchan (1953).

Winogradsky (1938) recognized four good species of *Azotobacter*: *Azot. agilis, Azot. vinelandii, Azot. chroococcum,* and *Azot. beijerinckii.* Most authors are agreed that *Azot. woodstownii, Azot. hilgardii, Azot. smyrnii* and *Azot. vitreum* cannot be regarded as species.

The arguments for reducing the number of species in the genus *Azotobacter* are more or less unsatisfactory.

(1) According to Greene (1935) a significant difference could be found in the amount of hemicellulose, crude protein and ash for the *agilis–vinelandii* group, and a greater content of lignin-like material for the *chroococcum-beijerinckii* group. It is doubtful whether these differences have a real value in identifying *Azot. agilis–Azot. vinelandii* and *Azot. chroococcum–Azot. beijerinckii.* Using Greene's Table 4, we can calculate the ratio $\frac{\text{Basic N}}{\text{Humin N}}$ for the four species. They give respectively 2·05 (*agilis*), 2·08 (*chroococcum*), 1·90 (*beijerinckii*) and 1·46 (*vinelandii*), using the same reasoning as Greene (1935). This would lead to quite a different conclusion regarding the classification of these species.

(2) According to Aso and Yoshida (1928) the genus *Azotobacter* is grouped into three serological types, i.e. *Azot. chroococcum* type (*chroococcum-beijerinckii*), *Azot. vinelandii* type, *Azot. vitreum* type; *Azot. agilis* was not tested. The data from Aso and Yoshida already showed some slight difference between *Azot. chroococcum* and *Azot. beijerinckii.* They concluded that *Azot. beijerinckii* is a variety of *Azot. chroococcum,* but regarded *Azot. vitreum* as a distinct species. According to Löhnis and Smith, *Azot. vitreum* is a variety of *Azot. agilis,* therefore we should expect that *Azot. agilis* could be serologically different from *Azot. vinelandii.* This is contrary to Greene's chemical hypothesis, and to evidence produced by Löhnis *et al.* in their identifications. However, as we know that serological tests are much more sensitive than chemical analysis, we still cannot accept the serological test without reservations. Immuno-chemistry has shown that the production of antibodies by an animal does

not necessarily involve the whole structure of the antigenic protein. Landsteiner (1939) has shown that the specificity of an antiserum can be affected by a specific group or a compound. So it is possible to detect two different organisms by the same serum if the hapten responsible for the production of antibodies is the same in both. It is well known that the agglutination test for the *Rickettsia prowazekii* can be carried out with *B. proteus OX19* as antigen. Also for *Tryp. pallidum*, the antigen in the complement fixation test is extracted from ox heart. Such tests therefore cannot determine identity. Serological tests are not to be neglected, but cannot override other characters.

The mutation of $R \rightleftharpoons S$ in bacterial culture is well known, and Kyle and Eisenstark (1951) report that Smith and Hofer regard *Azot. beijerinckii* as a non-pigmented rough strain of *Azot. chroococcum*. (However, it is well known that *Azot. beijerinckii* produces a yellow pigment!)

Indeed, it is probable that many species occurring in nature differ in ways comparable with the mutation observed in experimental culture. If only one character of a species is affected by a stable mutation in natural conditions, it is convenient to regard the new organism as a variety of the species. If the variation affects several characters, a new species should be logically accepted. This is not the place to discuss the genetic variations, but these considerations may prove useful as a working tool for taxonomy of the genus *Azotobacter*.

Morphological and physiological differences of the species of *Azotobacter* have been described by Beijerinck (1901), Lipman (1903), and more recently by Winogradsky (1938) and Starkey (1939). In this paper only a few characteristic and important points are discussed.

Morphological Differences.

Azot. chroococcum and *Azot. beijerinckii* differ in size. There is no doubt that *Azot. beijerinckii* is bigger. Both contain fatty bodies in the cell, but *Azot. beijerinckii* has so many that the cytoplasm is reduced to a minimum. Motility is absent in *Azot. beijerinckii*, which may affect the presence of flagellae and also the lack of H antigen.

Azot. vinelandii and *Azot. agilis* also differ in size and form. The most remarkable character is the absence of cyst formation in *Azot. agilis*. This peculiarity is important with regard to its ecological conditions and taxonomy. Winogradsky (1938) considers *Azot. agilis* a separate genus, *Azomonas*. This generic name is not suitable because *azo* in French does not mean nitrogen.

Physiological Differences.

Azot. chroococcum produces a brown-black pigment and *Azot. beijerinckii* produces a yellow one. The cell suspensions in liquid media are also different (Tchan, 1953).

Azot. vinelandii uses mannitol and benzoate, but *Azot. agilis* does not. Both grow in the presence of 1% of benzoate in their culture media. This peculiarity has been used successfully by Derx (1950-51) to cultivate specifically these two species in the presence of other species of *Azotobacter*.

A new species of *Azotobacter*, *Azot. insigne* Derx, 1952, is different from these four species. It is rod or oval shaped, 3·1 × 1·9μ, very motile, with cilia directly visible under the dark-field microscope. The cilia are rigid or nearly so, and are 5–6μ in length. The cells contain refractive bodies. This species does not use glucose, mannitol or benzoate. On media with ethanol, a blue-greyish colour is formed which later becomes violet.

Recent papers described acid-forming species of *Azotobacter*—*Azot. indicum* (Starkey and De, 1939) and *Azot. lacticogenes* (Kauffmann and Toussaint, 1951). These species should not be referred to *Azotobacter*.

(1) There is no reason why all aerobic non-symbiotic N-fixing bacteria should be classified in one genus. Aerobic cellulose-decomposing bacteria are classified into different genera, disregarding the common character of decomposing cellulose (Tchan, Pochon and Prévot, 1948).

(2) The morphology of *Azot. indicum* and *Azot. lacticogenes* is completely different from other species of *Azotobacter*. *Azot. indicum* is a motile rod with usually two fatty bodies at each end of the cell. *Azot. lacticogenes* is a non-motile coccobacillus containing fatty bodies. Physiologically they can grow in acid conditions at a pH as low as 3·5, and produce acid in their media. They do not produce any cyst. *Azot. indicum* produces a slimy substance but *Azot. lacticogenes* does not. The pigments produced by both are different from those of other species of *Azotobacter*. *Azot. lacticogenes* requires a very narrow temperature range (20–30°C.).

It is clear that there is no reason to classify rod or cocci-shaped organisms into the genus *Azotobacter*, which has a yeast-like morphology.

Derx already referred to a new genus, *Beijerinckia*. Later he successfully isolated a new species, *Beij. mobile*, and a new variety, *Beij. indica* var. *alba* (1951).

Azot. lacticogenes is also a *Beijerinckia* which has been mistaken for an *Azotobacter*.* The species becomes *Beij. lacticogenes* (Kauffmann and Toussaint) Tchan, comb. nov., syn. *Azot. lacticogenes*.

Beijerinckia provisionally could be included in the family Azotobacteriaceae. They are relatively large Gram-negative organisms. At least, in certain stages of their development their morphology shows somewhat oval shape cells and evolution forms. Further information is needed to clarify this point.

After this critical examination of morphology and physiology of the representatives of the genus *Azotobacter* the following classification is proposed.

AZOTOBACTERIACEAE Bergey, Bree, Murray, 1938.

Cells relatively large rods or cocci, sometimes almost yeast-like in appearance, especially in media with sugar, motile or non-motile, Gram-negative.

The family has three genera:

1. *Azotobacter* Beijerinck, 1901.

Cells rod or oval shaped, motile or non-motile; when motile, ciliation is peritrichous. In media with alcohol or organic acid as the energy source, cysts are formed. Acid is usually not produced in the media containing sugar. N is fixed in media free of combined N. Aerobic.

Three species and one variety are accepted.

Species typica, *Azotobacter chroococcum* Beijerinck.

Distinguishing Characters for Different Species.

	Morphology.	Motility.	Pigmentation.	Physiology.	Habitat.
Azot. chroococcum	Oval or rod. 2–3 × 1·5 μ	+	Brown black.	Growth inhibited by 1% of benzoate but uses benzoate at 0·5%.	Soil.
Azot. vinelandii	Rod. 2·5 × 1·5 μ	+	Green fluorescent.	Uses benzoate at 1% or less.	Soil, water.
Azot. beijerinckii	Oval. 3·3–25 × 2 μ	–	Yellow.	Uses benzoate at 0·5% but growth inhibited by 1% benzoate.	Soil.
Azot. bei. var *acido-tolerans*	,,	,,	,,	*Id.* except the tolerance to acidity of media.	Soil.

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* Dr. Kauffmann has kindly provided a culture of *Azot. lacticogenes*. On preliminary examination it was concluded that this species should be classified as a *Beijerinckia* and Dr. Kauffmann now agrees with this view.

2. *Azotococcus*, gen. nov., Tchan, 1953.

Cells oval, motile. Cyst is not formed; usually no acid is formed in media containing sugars.

Species typica, *Azotococcus agilis* (Beijerinck) Tchan, comb. nov., syn. *Azotobacter agilis*.

Distinguishing Characters of Different Species.

	Morphology.	Motility.	Pigmentation.	Physiology.	Habitat.
Azotococcus agilis	Oval. 3·5–2×2·5–2 μ	+	Green fluorescent.	Does not use mannitol or benzoate but 1% benzoate does not inhibit growth.	Water.
Azotococcus agilis var. *atypica*.	,,	,,	None.	Mannitol is a poor nutrient.	Water.
Azotococcus insigne	Rod 3·8–2·5× 1·6–2 μ	Cilia directly visible under dark-field microscope.	Greyish blue turn to violet.	Does not use glucose or mannitol or benzoate.	Water.

Azotococcus insigne (Derx) Tchan, comb. nov. (syn. *Azotobacter insigne*) is provisionally classified here since Derx did not mention the formation of cysts, and the aqueous habitat of the species is similar to that of *Azotococcus*.

3. *Beijerinckia* Derx, 1950.

Rods straight or slightly curved or irregular, locally swollen, characterized by the presence of highly refractive spherical bodies, presumably consisting of lipoids. No endospore. Motile or non-motile. Gram-negative. Aerobic. Nitrogen is fixed in media free of combined nitrogen. Acid is produced in media containing sugar.

Three species and one variety.

Species typica, *Beij. indica* (Starkey and De) Derx (syn. *Azotobacter indicum*).

Distinguishing Characters of Different Species.

	Pigmentation.	Motility.	Leaven Formation.	Slime Formation.	Fatty Bodies.
Beij. indica	Fulvous.	+	++	++	++
,, ,, var. *alba*	None.	±	++	++	++
,, *motile*	Amber brown.	++	–	+	Ascoccus form.
,, *lacticogenes*		–	?	–	++

Key to the genera of Azotobacteriaceae.

1. Cysts formed .... *Azotobacter.*
2. Cysts not formed—
   (*a*) Rod with fatty bodies at each end of the cell .... *Beijerinckia.*
   (*b*) Yeast-like oval cell .... *Azotococcus.*

CONCLUSION.

The confusion in the taxonomy of *Azotobacter* is created by the contradiction between morphology, serology, physiology and chemical composition of the different species. The classification in Bergey's Manual is not acceptable. The different tests used are not satisfactory if they are used without precautions. The proposed classification is based, as for the species of *Cytophaga* (Tchan *et al.*, 1948), on the combined morphological, physiological and ecological characters. It has the advantage of leaving the genera *Azotobacter* and *Azotococcus* as a homogenous group. The acid-forming non-symbiotic N-fixing bacteria are excluded and classified separately. The genus *Beijerinckia* is accepted for *Azot. indicum* and *Azot. lacticogenes.*

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STUDIES IN THE METAMORPHIC AND PLUTONIC GEOLOGY OF THE WANTABADGERY–ADELONG–TUMBARUMBA DISTRICT, N.S.W.

PART I. INTRODUCTION AND METAMORPHISM OF THE SEDIMENTARY ROCKS.

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(Plates v-vi; nine Text-figures.)

[Read 24th June, 1953.]

Synopsis.

An area consisting mainly of miogeosynclinal sediments (partly, at least, of upper Ordovician age) and plutonic masses is discussed. The sediments, typically pelites and psammopelites, suffered a metamorphism which was regional in extent yet had an important thermal aspect. Variations in metamorphic intensity are represented by isogradal lines introducing the several zones established here. The metamorphic progression is from (1) a low-grade zone (with chlorite-muscovite slates and phyllites) characteristic of the country rocks of the region to (2) a biotite zone, followed by (3) a knotted schist zone (with andalusite and/or cordierite porphyroblasts) which passes into (4) a high-grade zone where the sediments become granulites which, in places, carry sillimanite and potash felspar. The zones are fairly evenly distributed around the Wantabadgery and Green Hills granite masses but do not display any constant relation to the other granites. In proximity to acid veins from the Wantabadgery and Green Hills granites the metasediments may be enriched in brown tourmaline. Late addition of alkalis has caused extensive retrogression in the high-grade rocks whereby the aluminous minerals (except pink andalusite) tend to become altered to muscovite. The zonal sequence (above) is examined in the light of the principle of metamorphic facies, and its relation to the well-known scheme of Barrow is indicated.

INTRODUCTION.

The Wantabadgery–Adelong–Tumbarumba district is situated in the South-Western Slopes region of New South Wales, nearly 300 miles from Sydney. Text-figure 1 indicates its geographical position. The main centres of population within the district are the townships of Adelong, Batlow and Tumbarumba. The north-western limit of the area examined is about six miles east of the city of Wagga Wagga.

No extensive systematic geological mapping had been undertaken previously in this area and thus the accompanying sketch map (Plate v) was compiled as a basis for the subsequent petrological studies (some of the country to the west of the present area has been mapped by Whiting, 1950). Field mapping was carried on at intervals over the period 1949–1952 and, in all, an area of about 900 square miles has been examined in more or less detail. The survey of the southern and south-western parts of the area has been of a reconnaissance nature.

The district studied constitutes only a part of a great belt of metasediments and granitic masses which extends from north-eastern Victoria across the Murray River into New South Wales and, trending in a north-north-westerly direction, may be followed (with some breaks) at least as far as Condobolin. At various localities, parts of the southern section of the belt have been examined in some detail, and here should be mentioned the pioneering work of A. W. Howitt (1888) and the later studies of Tattam (1929) and Crohn (1950) in Victoria, and of Joplin (1947) in the Albury–Jingellic region of New South Wales. All of this work displays evidence of the remarkable uniformity shown by many of the rock-types (both metasediments and granites) in this belt. Similar rocks have been found in a smaller, more easterly, parallel-trending belt which is well exposed in the Cooma district of New South Wales (Browne, 1914; Joplin, 1942).

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Geological Setting.

Of the metasediments and granitic rocks occurring in this area, only the former will be discussed in this paper. The granites are to form the subject of a later contribution but it may be useful to furnish here a brief account of the general geology of the region.

The country rocks are mainly of sedimentary origin and include arenites and argillites, now converted into phyllites, schists, and granulites by a metamorphism which was apparently in some way related to certain large granitic masses. Basic rocks of igneous origin occur in a belt which has been traced in a north-north-westerly direction from Batlow to beyond Adelong. Although intermediate to basic rocks have also been found in isolated bands away to the north-west near Nangus, the "basic belt" really loses its character just west of Bangandang Trig. Station and, for the most part, gives place to metasediments. Amphibolites and metamorphosed diorites or gabbros are the chief rock types in this "basic belt". The Adelong norite or hypersthene-gabbro forms a small mass in Adelong township which may be related to the other basic rocks.

(THE AREA DESCRIBED IN THIS PAPER IS SHADED)

Text-figure 1.—Locality map.

The basic rocks have been invaded by granite-granodiorite of the Ellerslie (west of Adelong, between the Nacka Nacka and Yaven Creeks) and Wondalga plutonic masses. The rocks of these two masses are practically identical and resemble specimens from the smaller Belmore mass (between Westbrook and Tarcutta). For this reason the three masses are grouped together in Plate v. Metamorphic activity at the contacts between these granites and the metasediments appears to have been variable but often relatively slight.

Another group of plutonic rocks constitutes the Wantabadgery and Green Hills (west of Batlow) masses. It also includes biotite granite-granodiorite types, but these rocks are lithologically quite distinct from the granites of the other group mentioned above. Highly altered inclusions of the metasediments are common in the Wantabadgery and Green Hills granites and the extensive metamorphism of the original sedimentary terrain was perhaps related to these two masses. The rough parallelism between the limits of the metamorphic zones and the outlines of the granite masses points to some relation between them. Field evidence suggests that the granites of this group were emplaced earlier than the Ellerslie, Wondalga and Belmore granites.

It is of interest to note that the Ellerslie-type plutonites are lithologically similar to the rocks of the Murrumbidgee batholith (Browne, 1943) north of Cooma, whilst the Wantabadgery–Green Hills-types resemble the Cooma gneiss (Browne, 1914) and the Albury gneiss (Joplin, 1947). A small portion of another plutonic mass (here called the Kyeamba adamellite mass) outcrops within the area mapped, but it has not been studied in detail (more of this mass was mapped by Whiting (1950)).

Tertiary basalt flows overlying auriferous deep-leads occur at Tumbarumba (Anderson, 1890; Booker, 1950). These have not been studied and their outcrop shown on Plate v is taken mainly from Booker's maps. Extensive alluvium of probable Tertiary–Recent age is found along the Murrumbidgee River and many of its tributaries.

METASEDIMENTS.

Variations in metamorphic intensity have wrought important mineralogical and textural changes in the metasediments, but throughout the area these rocks tend to preserve a certain uniformity in chemical composition. Probably the best approach to the study of the results of the metamorphism is by considering the reactions of members of groups of rocks with comparable chemical compositions (isochemical series) to the variations in metamorphic intensity. The terms pelite, psammopelite, and psammite were used by Joplin at Cooma and Albury, and other metamorphic petrologists have also employed them to denote isochemical groups. As understood by sedimentary petrologists, however, these terms denote a grain-size type rather than a chemical one, and to avoid confusion it seems necessary to state clearly the sense in which they are used. In the present case the classification is based on texture, but analytical work indicates that here there is a rough correlation between texture and composition, and so the terms can, for the most part, be taken as indicating chemical groups. Chemically, as well as texturally, there are gradations between the three types.

Of the members of the pelite-psammopelite-psammite series, the psammopelites are certainly the most abundant in this area. Pelites are quite common, but sand rocks (psammites) have a somewhat more restricted occurrence. The absence of coarse sediments (conglomerates) has been noted by most workers in this belt. In addition to these groups, red jaspers, a little limestone, and some serpentine-bearing siliceous rocks occur in the Nangus district on the north-eastern side of the present area. These rocks only outcrop within the low-grade zone of metamorphism.

Psammopelites and Psammites.

The psammopelites, in addition to their abundance, are of interest because of their lithology. They are characterized by an appreciable amount of silt-sand material (mainly quartz, some felspar) in an extensive micaceous matrix (representing the original clay fraction). Sorting has, in places, produced finely banded rocks in which the relative proportions of the silt-sand and clay fractions vary. These are like the banded psammopelites of Joplin (1942). Even in the more advanced stages of metamorphism such rocks may have their sedimentary banding preserved.

The more homogeneous (non-banded) psammopelites are usually more massive and less cleaved than their banded relatives but are equally widespread. In their case, however, there is a greater tendency for metamorphic processes to obliterate the original sedimentary features—as a rule the coarsest types preserving their individuality most tenaciously. The petrography and mineralogy of these rocks will be discussed in connection with the various zones in which they occur, but it may be worth while to note here several salient features. These sediments are characterized by abundant detrital quartz grains, usually rather angular and somewhat poorly sorted. Detrital felspar is widely distributed but is not really abundant (does not exceed 10% by volume). Small rock fragments are not uncommon in the sand fractions along with the quartz and felspar. All of this material is typically held in an argillaceous matrix.

Beds of such rock, often from a few inches to a few feet thick, alternate with slaty (pelitic) bands and may show such sedimentation features as current-bedding and graded-bedding. Very few small-scale slump-structures have been seen. The relatively unmetamorphosed representatives of the psammopelitic rocks may be regarded as subgreywackes following Pettijohn's (1949, p. 255) definition.

Table 1 gives analyses of psammopelites and sandier rocks from this area and from Cooma as well as a subgreywacke from Arkansas (U.S.A.) and an average of 371 sandstones. No. 10 represents a lime-rich type of sandy rock (now a granulite) from Cooma. Similar rocks have been found in this area near Mundarlo but none of these was analysed.

TABLE 1.

Analyses of Psammopelites and Psammites.

	1	2	3	4	5	6	7	8	9	10
SiO_2	68·17	69·98	74·59	76·28	79·37	84·21	73·64	74·43	84·86	71·26
Al_2O_3	16·76	14·66	12·71	12·87	11·47	9·12	13·89	11·32	5·96	12·42
Fe_2O_3	2·34	1·91	0·61	1·68	2·43	0·93	0·70	0·81	1·39	0·68
FeO	2·51	4·45	4·21	1·09	0·56	1·40	4·04	3·88	0·84	4·47
MgO	2·06	2·39	0·78	0·73	0·97	0·88	1·98	1·30	0·52	2·13
CaO	0·28	0·19	0·67	0·18	0·22	0·37	0·28	1·17	1·05	7·73
Na_2O	0·76	0·50	1·31	0·82	1·02	1·01	1·12	1·63	0·76	0·31
K_2O	3·08	3·92	3·29	3·67	2·50	1·23	2·88	1·74	1·16	0·01
H_2O+	2·59	0·89	1·29	1·90	0·79	0·55	0·42	2·15	1·47	0·19
H_2O-	0·38	0·18	0·17	0·36	0·25	0·28	0·07	0·20	0·27	0·02
TiO_2	0·88	0·71	0·63	0·27	0·53	0·21	0·63	0·83	0·41	0·47
P_2O_5	0·22	n.d.	n.d.	n.d.	0·10	0·11	n.d.	0·18	0·06	abs.
MnO	0·05	0·04	0·03	0·05	0·04	n.d.	0·06	0·04	tr.	0·55
CO_2	—	—	—	—	—	—	—	0·48	1·01	0·13
Etc.	—	—	—	—	—	—	—	0·29	0·10	—
	100·08	99·82	100·29	99·90	100·25	100·30	99·71	100·45	99·86	100·37

1. Fine-grained psammopelite (Biotite Zone). Por. 36, Par. of Yabtree, Co. Wynyard. Anal. T. G. Vallance.
2. Cordierite-rich granulite. East side of Por. 35, Par. of Dutzon, Co. Wynyard. Anal. T. G. Vallance.
3. Quartz-rich granulite. Por. 66, Par. of Cunningdroo, Co. Wynyard. Anal. T. G. Vallance.
4. Grey-green phyllite (very fine-grained psammopelite). Por. 187, Par. of Mundarlo, Co. Wynyard. Anal. T. G. Vallance.
5. Psammopelite (subgreywacke). Por. 30, Par. of Yabtree, Co. Wynyard. Anal. T. G. Vallance.
6. Quartz-rich psammite (Knotted Schist Zone). West side of Por. 56, Par. of Yabtree, Co. Wynyard. Anal. T. G. Vallance.
7. Corduroy granulite. Cooma area. Anal. G. A. Joplin. PROC. LINN. SOC. N.S.W., 67, 1942: 168.
8. Subgreywacke. Near Mena, Arkansas. Anal. B. Bruun. Pettijohn, "Sedimentary Rocks", 1949, p. 256.
9. Average of 371 sandstones. *U.S. Geol. Surv. Bull.* 695, 1920: 539.
10. Amphibole-bearing granulite. Cooma area. Anal. G. A. Joplin. PROC. LINN. SOC. N.S.W., 67, 1942: 167.

Pelites.

The more lowly metamorphosed pelites of this area occur as buff- to grey-coloured slates with good cleavage and fine grain-size. With increase in metamorphic grade they pass into phyllites and schists and finally in places into high-grade granulites. Throughout all these stages the pelites retain a certain chemical uniformity, as may be seen from the analyses of rocks from various parts of the metamorphic progression. In Table 2 pelites from other districts in the metamorphic belt are included for comparative purposes.

Examination of the analyses indicates that the pelites have a rather distinctive composition. Text-figure 2 graphically depicts this. A group of 29 analyses of pelites from the metamorphic belt (and from Cooma) has been plotted on an alkali-lime diagram along with analyses of slates and phyllites from various parts of the world, including the U.S.A., Wales, France, Germany, Victoria, and New South Wales. It can be readily seen that the pelites from the metamorphic belt tend to fall in the potash-rich, lime-poor field and are well away from the average shale and slate. Another feature of these pelites is their high alumina content.

Emmons and Calkins (1913) noted that the pelites of the Silver Hill formation (Cambrian) of the Phillipsburg area, Montana (see Table 2) were remarkably potash-rich and suggested that the original rocks may have been glauconitic. The composition of these rocks is roughly comparable with those now studied, but in view of the lack of an abnormal iron content there appears to be little evidence for a glauconitic origin

TABLE 2.

Analyses of Aluminous Pelites.

	1	2	3	4	5	6	7	8
SiO_2	56·28	54·01	49·53	54·18	55·49	56·33	60·15	53·29
Al_2O_3	23·02	24·41	26·53	25·48	24·45	22·94	16·45	22·38
Fe_2O_3	1·82	1·39	2·17	2·99	2·21	2·19	4·04	6·57
FeO	5·84	5·95	6·01	3·08	4·92	4·54	2·90	
MgO	3·28	2·91	3·15	3·13	2·88	3·27	2·32	2·10
CaO	0·14	0·36	0·37	0·41	0·35	0·25	1·41	0·53
Na_2O	1·21	1·09	1·23	0·73	0·54	0·88	1·01	1·11
K_2O	4·97	5·45	5·90	5·70	5·21	6·10	3·60	7·43
H_2O+	2·82	2·64	3·79	2·88	2·09	3·07	3·82	4·12
H_2O-	0·24	0·28	0·31	0·48	0·07	0·80	0·89	
TiO_2	0·77	0·85	1·03	0·73	0·78	—	0·76	0·91
P_2O_5	0·10	0·15	—	0·07	0·20	0·13	0·15	—
MnO	0·06	0·07	0·06	0·03	0·09	tr.	tr.	—
CO_2..	—	—	—	—	0·30	—	1·46	0·58
C	—	—	—	0·34	0·03	—	0·88	—
Etc.	—	—	—	—	—	—	0·62	—
	100·55	99·56	100·08	100·23	99·61	100·50	100·46	99·02

1. Knotted schist. Por. 65, Par. of Yabtree, Co. Wynyard. Anal. T. G. Vallance.
2. Spotted granulite. Mt. Pleasant Creek, Por. 32, Par. of Wallace, Co. Wynyard. Anal. T. G. Vallance.
3. Spotted granulite. East end of Yaven Creek bridge, Por. 51, Par. of Dutzon, Co. Wynyard. Anal. T. G. Vallance.
4. Chlorite-sericite-schist. Cooma area. Anal. G. A. Joplin. PROC. LINN. SOC. N.S.W., 67, 1942 : 164.
5. Knotted schist. Albury area. Anal. G. A. Joplin. *Ibid.*, 72, 1947 : 88.
6. Phyllite. Ensay area. Anal. A. W. Howitt. *Proc. Roy. Soc. Vict.*, 22, 1886 : 68.
7. Average of fifty-one Paleozoic shales (H. N. Stokes). From *U.S. Geol. Surv. Bull.* 616, 1916 : 546.
8. Slightly altered shale. Phillipsburg area (Montana). Anal. W. T. Schaller. *U.S. Geol. Surv. Prof. Paper no.* 78, 1913 : 57.

for the potash in the present case. It seems reasonable to relate the richness in potash to an original richness in micaceous constituents.

Pelites with less than the usual amount of magnesia have been found in this area, as at Albury and in Victoria. In Table 3 some examples of such rocks are given. The rock no. 2 of this table has high alkali values, due mainly to the presence of an abnormal amount of finely-divided sodic felspar. Lime, too, is rather higher than normal here. The dominance of potash over soda is, however, clear in these examples just as in the "normal" pelites.

In the low-grade zone, in particular, there is a certain development of grey-green to buff coloured slaty rocks which, when analysed, are found to contain much more silica than is usual for apparently comparable rocks of this area. Some of these slates consist of an admixture of fine silty material (mainly quartz) and clay (now represented by mica) and are not unlike the psammopelites in mineralogy and chemical composition. They seem to be merely finer-grained equivalents of the subgreywackes and, if unmetamorphosed, would have probably fallen into the category of "subgreywacke shales" (Dapples, Krumbein and Sloss, 1950). Text-figure 3 is an uncorrected ACF diagram depicting the fields of the so-called "normal" pelites and "siliceous" pelites (from Joplin, 1945). On this have been plotted several analyses of the siliceous rocks in question as well as some psammopelites from this area and from Cooma. There is an apparent gradation (textural as well as chemical) between the various types. An analysis of a fine-grained psammopelite (it is nearly fine enough to be called a pelite) is given in Table 1 (no. 4). The composition of the grey-green slates is probably not greatly different from this. Texturally these rocks are pelites but chemically they approach psammopelites; they will be referred to here as siliceous pelites.

Black well-cleaved siliceous slates, important at Cooma but absent at Albury, are not very abundant in this area. These rocks may have a different origin from that of the grey-green or buff coloured slates mentioned above. The black, sometimes graptolite-bearing, slates may be derived from volcanic ash (Joplin, 1945). It seems not improbable that there are two distinct sedimentary types (the silty "subgreywacke shales" and the carbonaceous black slates) included under the name "siliceous pelite" in the literature on the rocks of this metamorphic belt and from Cooma.

TABLE 3.

Pelites Poor in Magnesia.

	1	2	3	4
SiO_2	52·55	57·55	53·88	52·91
Al_2O_3	23·55	21·36	27·95	24·49
Fe_2O_3	5·01	2·60	5·04	5·45
FeO	4·52	1·76	0·69	1·50
MgO	1·90	0·98	1·02	1·80
CaO	0·37	1·34	0·19	0·29
Na_2O	0·27	3·16	0·34	1·08
K_2O	6·64	7·99	5·64	6·60
H_2O+	3·48	2·30	3·44	3·81
H_2O-	0·55	0·17	0·72	0·61
TiO_2	0·75	0·81	1·12	0·83
P_2O_5	0·11	—	0·07	0·10
MnO	0·02	0·06	0·03	0·06
BaO	—	—	—	0·06
C	—	—	0·53	0·19
	99·72	100·08	100·66	99·78

1. Phyllite. Near Humula Trig. Stn., Por. 224, Par. of Umbango, Co. Wynyard. Anal. T. G. Vallance.
2. Phyllite. Por. 194, Par. of Ellerslie, Co. Wynyard. Anal. T. G. Vallance.
3. Dark grey slate. Jingellic area. Anal. G. A. Joplin. PROC. LINN. SOC. N.S.W., 72, 1947: 89.
4. Slate. Tallangatta area. Anal. C. M. Tattam. *Geol. Surv. Vict., Bull.* 52, 1929: 35.

GEOSYNCLINAL ENVIRONMENT.

The lithological assemblage just described appears to be fairly typical of what one would expect of sedimentation under miogeosynclinal conditions. The essential rock types are alternating shales (slates) and subgreywackes with only local signs of contemporaneous igneous activity and one very restricted patch of limestone. Jaspers, which occur in the Nangus area, are probably not original sediments.

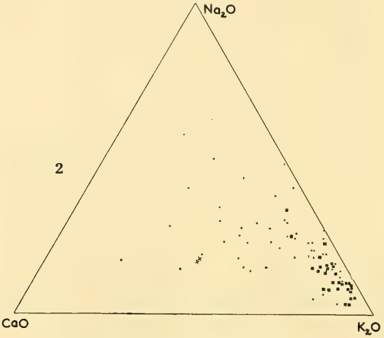
The association shale(slate)-subgreywacke with no conglomerates and not much orthoquartzitic material suggests that the sediments were deposited towards the axial parts of the miogeosyncline. Sedimentary facies indicative of the marginal and shelf environments have not been recognized. They may be buried beneath later deposits further to the west.

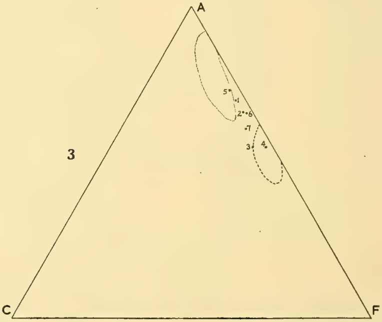
It may be noted that the Phillipsburg area referred to above (Emmons and Calkins, 1913) is also characterized by miogeosynclinal sediments (see Kay, 1951) in which plutonic masses have been emplaced. The metamorphic changes induced in the Phillipsburg pelites are somewhat similar to those to be described here. Such cases are of interest in view of Misch's (1949) dictum that plutonic activity is confined to eugeosynclinal regions.

GENERAL REMARKS ON STRATIGRAPHY AND STRUCTURE.

Our knowledge of the stratigraphy of this region of New South Wales and north-eastern Victoria is still only fragmentary, mainly because of the rarity of fossils and the overall lithological uniformity of the metasediments. No fossils have been found in the area under discussion, but at several localities in this belt graptolites of upper

Ordovician (usually Eastonian) age have been recorded. Rather poorly preserved graptolites occur in black slates near Moorong Trig. Station, a few miles west of Wagga Wagga (Joplin, 1945) and at Carboona Gap (about half-way between Tumbarumba and Jingellic; found by R. A. Keble, noted by Sherrard, 1951). Graptolites have been found elsewhere in the same Ordovician belt both in Victoria and in New South Wales (Joplin, 1945). They also occur at Cooma (Browne, 1914). Gradations from graptolitic slates into more intensely metamorphosed sediments have been observed in Victoria and at Cooma, and as a result of such evidence the latter are now regarded as also being in part, at least, of upper Ordovician age. Early writers have referred these metasediments to a variety of ages, ranging from pre-Cambrian to Silurian and even Devonian. By analogy with other parts of the metamorphic belt it is believed that the metasediments of the present area are also partly of upper Ordovician age.





Text-figure 2.—Alkali/lime diagram for pelites from various parts of the world. Two average shales (from Clarke, *U.S. Geol. Surv. Bull.* 616) are marked by crosses. Pelites from the north-eastern Victoria-N.S.W. metamorphic belt (and from Cooma) are marked by black squares.

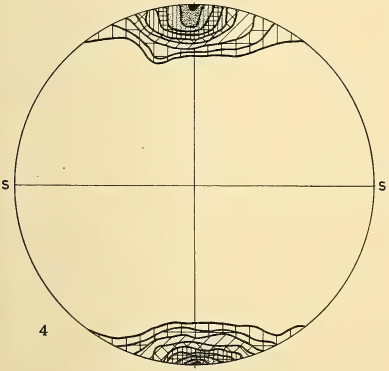
Text-figure 3.—ACF diagram illustrating chemical relations between normal (i.e. aluminous) pelites and the black siliceous pelites. Psammopelites and at least some of the grey-green siliceous slates fall between the two fields which are taken from Joplin (1945).

Point no. 1, This paper, Table 1, no. 4. 2, This paper, Table 1, no. 5. 3, This paper, Table 6, no. 8. 4, Joplin (1942), Table 5, no. IV. 5, Joplin (1942), Table 2, no. III. 6, Joplin (1942), Table 2, no. IV. 7, This paper, Table 6, no. 9.

No successful attempt has ever been made to subdivide stratigraphically the sediments of this metamorphic belt. At Cooma, Joplin (1942) separated the upper Ordovician into the Coolringdon Beds and the Binjura Beds. The former characteristically have black siliceous slate and display low-grade metamorphic features, whilst the Binjura Beds consist of more aluminous pelites and psammopelites and exhibit a much greater range in metamorphic grade. The Coolringdon Beds are regarded by Joplin as lying on top of the Binjura Beds, but the opposite view is favoured by Browne (1943). Possible equivalents of the Binjura Beds were noted at Albury (Joplin, 1947), but analogues of the Coolringdon Beds have not been found. In the Wantabadgery–Adelong–Tumbarumba area the metasediments have not been subdivided into such units. The higher-grade rocks here are quite similar to the Binjura Beds at Cooma, but there does not appear to be any extensive development of lithological equivalents of the Coolringdon Beds.

The thickness of the sediments in the main metamorphic belt (north-eastern Victoria, Albury, Wagga Wagga, etc.) is not known, but it seems reasonable to expect that it is much in excess of that given (2,500 ft.) for the Gisbornian, Eastonian, and Bolindian in the Australian upper Ordovician type-area, north-west of Melbourne.

Over most of the area examined the metasediments display a remarkable uniformity of strike which is, in general, parallel to the north-north-west–south-south-east trend of the whole metamorphic belt. A notable exception to this rule is found along the Murrumbidgee River between Oura and Wantabadgery, where the strike swings round sympathetically with the margin of the Wantabadgery granite mass. Cleavage and/or schistosity have been induced in most of the metasediments but bedding features are rarely destroyed. Bedding and cleavage or schistosity are often coincident but this is not universal (cf. Crohn, 1950). Lineation, though not always common in the low-grade rocks, may become an obvious feature in the knotted schists. Both a-lineation and b-lineation have been seen, though usually not in the same locality. The a-lineation is of some interest. In the Mundarlo district, for example, lineation is almost always at a high angle to the horizontal. Fold axes, where they can be seen, are commonly much more flat-lying and the impression one gains is that the lineation is about normal to the fold axes. Boudinage structures have been noticed in this area (Vallance, 1951) with the flattened "barrels" lying nearly horizontal on the steeply-dipping bedding planes and with a lineation (a-lineation) across the boudins in the direction of extension of the beds. The fabric (Text-fig. 4) of a rock from the same locality as the boudins indicates a remarkable preferred orientation of mica flakes. The patterns displayed by the optic axes of quartz grains (Text-fig. 5) and the mica cleavages suggest some "flattening" of the rock due to pressure across the schistosity. It seems not unreasonable to associate this with the possible development of boudinage due to tectonic flowage in the a-direction (normal to the fold axes).



Text-figure 4.—Fabric diagram based on 200 poles normal to the (001) cleavage of biotite from a knotted schist zone psammopelite. The schistosity plane is marked and the plane of the projection is normal to the lineation. Contour intervals (in percent.) 32-25-20-15-10-8-4-2-1-0.

Text-figure 5.—Fabric diagram based on 300 poles of optic axes of quartz from same rock as Text-fig. 4. Contour intervals (in percent.) 3-2-1-0.

Lack of good, continuous exposures makes it difficult to develop the overall structural picture in this area. In general the evidence points to a high degree of fairly close folding (perhaps not truly isoclinal) in the metasediments. Steep dips are the rule, but often little reliance can be placed on them because of the extensive hill-creep.

Despite Tattam's (1929, p. 10) remarks on the lack of strike faulting in the north-east Victorian metamorphic complex it does appear to have been rather important in the present area. Local small-scale strike faults may be seen in such exposures as road cuttings, although they may not be otherwise apparent on the ground. In the Tumbarumba district there is evidence of a considerable fault which has brought the Green Hills granite and low-grade metasediments into juxtaposition. A remarkably straight ridge of siliceous (silicified (?)) sediments trending north-north-west from Tumbarumba probably represents the fault line. From what evidence has been obtained the fault is thought to dip steeply to the east and perhaps dies out along the strike to the west of Westbrook. The suggested fault has removed from sight the middle- and high-grade metamorphic zones, but the extent of the movement may not be very great because of the apparent narrowing of the zones in this region. The very matter of this restriction in width of the zones may be related to further strike faulting (or perhaps to a marked steepening of the margins of the granite mass).

Whether the whole area is dominated by a major fold structure on which the local tight folding was superimposed (as suggested by Howitt in Victoria, and by Joplin (1943) at Cooma) is a question which has not been answered.

METAMORPHIC ZONES.

In the course of this work it has been established that certain mineralogical and textural variations in the metasediments take place with remarkable regularity as some of the granite masses are approached. With increase in metamorphic intensity the slates become more lustrous and micaceous and pass through phyllites into mica schists. These schists may develop porphyroblasts (knotted schists) and eventually grade into granulites or even migmatites. It has been found possible to divide the metasediments of this series into zones based on mineralogical and textural criteria. Under favourable conditions such zones may be plotted on the map.

The pioneer in this type of work was George Barrow (1893, 1912), who divided the Dalradian of the south-east Highlands of Scotland into seven zones as follows (from low to high grade): (1) zone of clastic mica, (2) zone of digested clastic mica, (3) zone of biotite, (4) zone of garnet, (5) zone of staurolite, (6) zone of kyanite, and (7) zone of sillimanite. Tilley (1925) later combined (1) and (2) as a zone of chlorite, and made the garnet zone more specific by using almandine as the index mineral. It is interesting to notice, as Joplin (1947, p. 91) has pointed out, that Howitt in 1889, whilst working at Omeo, was thinking along the same lines as Barrow.

Barrow's series was a great advance, but it is quite evident that it can be specific only for a certain isochemical series under the impress of metamorphism comparable with that which affected the Dalradian. As might be expected, Barrow's sequence has been observed in other parts of the world, but exceptions to it are, at least, equally widespread and numerous. These apparent anomalies make it necessary to consider variations in metamorphic grade against a more comprehensive classification such as is provided by the principle of metamorphic facies. In this way Barrow's sequence acquires its true perspective and it becomes clear that it cannot, by itself, be used as a general classificatory system. On the other hand, a relatively simple system of zones, based on the same style of reasoning as Barrow's zones, is usually more readily applied in the field than are the more complex mineral facies based on the phase rule. Thus in the present study a series of fairly obvious mineralogical and textural features which can be plotted on the map and correlated with the facies concept have been selected as zonal markers.

In the lowest grade of metamorphism in this area, chlorite may be produced along with sericite (muscovite). The zone in which such minerals are stable is here called the low-grade zone (= chlorite zone of Joplin, 1942). Next in the metamorphic sequence brown biotite appears and any chlorite present tends to be converted to biotite; this development of brown biotite marks the outer limit of the biotite zone. Porphyroblasts of andalusite or cordierite may be formed in the two-mica schists and these typically occur in the zone of knotted schists (andalusite zone of Joplin, 1942). Near the Green Hills granite mass the knotted schists pass into more granular rocks in which sillimanite may appear. Against the granites these granulites may grade into mixed rocks or migmatites. The granular rocks and migmatites correspond to what Joplin (1942) has called the permeation- and injection-zone rocks at Cooma. It has not been considered practicable to separate the high-grade rocks of this area into two comparable zones and thus they are here regarded as members of one high-grade zone. Correlation of these zones with the facies concept will be attempted after the zones and their characteristic metasediments have been described.

I. Low-grade Zone.

Low-grade metasediments outcrop over a large part of the Nangus district and extend in a south-easterly direction along the strike to the Tumblong State Forest (just north of Bangandang Trig. Station). Apparently similar rocks are found to the east along the railway line between South Gundagai and Tumblong. On the western side of the area they are developed in a belt extending from Lower Tarcutta through Tarcutta and Humula to Tumbarumba. On the geological map (Plate v) the low-grade rocks occupy all the area of metasediments outside the biotite isogradal line.

(i) *Pelites.*

Pelites in the low-grade zone are commonly fine-grained, buff- to grey-coloured rocks with a good slaty cleavage. Most of them have acquired a certain lustre as a result of the metamorphism and with increase in grade merge into phyllites and schists.

Apart from occasional white mica flakes few of the mineral constituents of these rocks are visible to the naked eye. Sericite (muscovite) and quartz are the chief constituents; chlorite is less common. The platy minerals are characteristically arranged to produce a schistosity. Although the grain-size is very small it would appear that all the mica has been recrystallized. The tiny flakes of sericite are usually colourless to pale green. With increase in grade (i.e. towards the biotite zone) two separate micas may appear; white mica (muscovite) and a greenish type which in the next zone passes into biotite (cf. Tilley, 1925). Increase in grain-size accompanies increase in grade.

Fine quartz granules between the mica flakes have presumably been derived from the detrital quartz by recrystallization. Chlorite, where it occurs, is found as dimensionally oriented flakes of rather variable size. The pleochroism is usually weak, most commonly from pale green or nearly colourless to yellow-green; $\beta = 1{\cdot}585$ (one determination); optical sign doubtful; birefringence varies to ca. 0·008; anomalous brownish interference colours are not unusual. Such flakes may carry inclusions of iron ore, micas, tourmaline and zircon.

Chlorite is not as abundant here as it is in the low-grade pelites at Cooma. The reason for this is not readily apparent. In composition the low-grade rocks resemble those from Cooma, although in some cases the pelites of the present area have a slightly higher soda content. Excess alkalis might tend to give rise to mica (sericite) rather than chlorite when magnesia is not abundant. Barth (1936) found that there was no development of pre-biotite chlorite in Dutchess County, New York. This matter was briefly considered by Bailey (1937), who suggested that it may have been due to a combination of high soda content of the rocks and "exceptionally dry conditions of metamorphism". Bailey's suggestion, particularly with regard to the soda content, has not been clearly established. The question is not settled, but the reason for the absence or paucity of chlorite in some cases, at least, may be more physical than chemical.

The grey-green to buff siliceous slates and phyllites (page 94) are often not readily distinguishable in hand-specimen from the less siliceous pelites. In the low-grade zone these siliceous rocks are widespread, particularly to the south of Nangus, and south-east of Borambola through Tarcutta to Tumbarumba. The main difference in thin section between these rocks and the normal aluminous pelites is in the proportion of quartz to mica and chlorite. In other respects they resemble the normal pelites.

Fine-grained black siliceous rocks occur within this zone near Tarcutta Hill to the south of Yabtree Trig. Station. These rocks are more often blocky and jointed than slaty, and may be associated with cherts. Highly siliceous cherts occur just west of Tumbarumba. The essential minerals of the black rocks are quartz and sericite with varying quantities of such accessories as iron ore and carbonaceous matter. Chlorite is rarely found. Gaps suggesting negative pyrite crystals are sometimes seen but fresh pyrite is quite rare. Isotropic material in the base of some of these siliceous rocks may be similar to what Joplin (1942) has suggested to be massive chalcedony or very fine quartz.

(ii) *Psammopelites and Psammites.*

Although the psammopelites are the commonest rocks in this area, they may profitably be studied after the pelites. Their mineralogy is similar to that of the pelites (except for the quartz/mica–mineral ratio) and thus they should be expected to reflect the mineralogical changes seen in the pelites.

Recrystallization has occurred to varying degrees in all these sandy rocks, but in no case have the signs of their clastic origin been obliterated. Quartz and felspar grains of somewhat irregular shape and size are commonly embedded in a much finer matrix of sericite, quartz, and some chlorite. The matrix behaves much as do the pelites mentioned previously. As a rule the more argillaceous psammopelites acquire cleavage and schistosity before the sandier types. The larger quartz and felspar grains tend to be oriented along the schistosity.

The quartz grains may display undulose extinction and with increase in metamorphic intensity they become granulated. This granulation has been noted in the low-grade zone but, as a rule, the larger grains retain their clastic appearance at least as far as the knotted schist zone. Both twinned plagioclase (usually oligoclase or oligoclase-andesine) and untwinned orthoclase may be present in the "sand" fractions of these rocks. Often the felspar is rather fresh, but there is an obvious tendency with increase of metamorphic grade for its conversion to such minerals as sericite and albite. Tourmaline, zircon and iron ores are the chief accessories.

(iii) *Jaspers.*

Immediately to the west of the village of Nangus is a low ridge composed in the main of red jaspers. Southwards, these rocks continue across the Murrumbidgee River but gradually fade out along the strike into low-grade rocks laced with quartz veins. It seems probable that the jaspers also die out to the north, but mapping was not extended in that direction. To the east and west these rocks are flanked by low-grade metasediments, but a blanket of alluvium obscures the exact relations between them. The age, origin, and metamorphic significance of the jaspers have not been finally settled, but as they outcrop entirely within the low-grade zone they are considered here.

Typically the jaspers are fine-grained, hard siliceous rocks with a rather patchy appearance and varying in colour from bright red to black (even in the same hand-specimen). They outcrop as large blocks showing practically no sign of any regular structure apart from jointing. Slickenside-markings are not unusual on some of the more platy-jointed types.

Under the microscope the essential minerals are seen to be quartz and haematite. Sometimes a little magnetite is present. Commonly the haematite is veined by granular quartz and in places the rock has the appearance of a haematite-breccia with the iron ore patches sharply separated by granular quartz. The quartz, though always granular, has a distinctly variable grain-size. Some of it is finely dusted with haematite whilst other, later, quartz may be perfectly clear. The larger grains may show undulose extinction. Haematite occurs mainly as irregular, dark, opaque patches, as smaller opaque grains and occasionally as minute red translucent euhedral plates.

Accessory constituents are variable, but perhaps the commonest is a yellow-green chlorite which may be sparsely scattered through these rocks. Apatite has been doubtfully recognized and calcite is present in some cases. One specimen has very fine needles of a pale yellow to orange-yellow; feebly pleochroic mineral with rather high relief and strong birefringence. Extinction angles vary up to about 20°; the needles seem to be length-slow. The mineral may be an iron-rich amphibole, but its presence here is very puzzling in view of the low grade of metamorphism. Amphiboles of the grunerite-cummingtonite series are known from metamorphosed jaspers (Miles, 1946) and other iron-rich rocks, but they are normally produced only in the higher grades of metamorphism (see Tilley, 1936). There is a possibility that a small mass of hornblende-augite-porphyrite might have locally affected the jaspers at Nangus, but this has not been established.

Occasionally specimens have been noted in which haematite wraps around quartz grains, the arrangement giving the impression that the iron oxide is in process of replacing a sandy rock. Generally compact, the jaspers at times have dark porous patches of haematite and limonite along fracture planes. In extreme cases cavities may be lined with botryoidal iron ore. These colloform growths are usually composed of radiating goethite with striking concentric zones. Haematite may form the cores of such growths, which are no doubt due to the hydration of the ferric oxide.

One of the jaspers has been analysed and the result is given in Table IV. For comparison, jaspers from Anglesey and Western Australia are included. Analyses 1 and 2 display a remarkably specialized composition—mainly silica and ferric oxide. The third rock quoted has a roughly comparable silica content but is really a quartz-rich ironstone of different origin from the first two.

TABLE 4.

Jaspers.

	1	2	3
SiO_2	85·51	88·07	77·94
Al_2O_3	0·21	1·31	0·24
Fe_2O_3	12·94	10·75	9·47
FeO	0·61	—	7·72
MgO	tr.	—	1·91
CaO	tr.	—	1·17
Na_2O	0·09	nil	0·04
K_2O	0·05		0·10
H_2O+	0·18	—	0·41
H_2O-	0·20	—	0·20
TiO_2	nil	—	nil
P_2O_5	tr.	—	0·09
MnO	0·30	—	0·39
FeS_2	—	—	0·04
CO_2	nil	—	0·79
	100·09	100·13	100·51

1. Red jasper. Por. 259, Par. of Tenandra, Co. Clarendon. Anal. T. G. Vallance.
2. Gwna-jasper. Mona complex, Anglesey, Wales. Anal. J. O. Hughes. *Geol. Surv. England and Wales, Anglesey Memoir*, I, 1919: 87.
3. Siliceous jaspilite. Southern Cross area (W.A.). Anal. H. Bowley. *Geol. Soc. London, Quart. Jour.*, 102, 1946: 142.

The slates and phyllites near the jaspers often have signs of intense deformation and silicification. Plate vi, A, illustrates one such rock which has been contorted and ruptured, apparently after the development of the schistosity. Limonite frequently stains the fractures, which are usually filled by patches of granular quartz. The more intense the deformation, the more granular quartz is deposited. Rocks approaching silicified phyllite-breccias tend to be produced by this action, but their original sedimentary nature can usually still be recognized.

Various theories of origin have been proposed to account for such rocks as jaspers and it appears that the question is by no means uniquely solved. The following are among the hypotheses advanced: (1) Original deposits. This origin was ascribed by Greenly to the Anglesey jaspers which he thought to be radiolarian cherts. The Nangus jaspers have no fossils and no traces of bedding—features often found in original sediments of this type. Sedimentary ironstones for the most part have less silica than these jaspers. (2) Replacement of earlier-formed rocks. (*a*) Surface effects. Zealley (1918) suggested that certain jaspers in Rhodesia were surface features due to the solution and deposition of silica and iron during weathering. There is no evidence that the

Nangus rocks are superficial. (*b*) Metasomatic action related to magmatic bodies. This theory was applied by Van Hise and Leith (1911) to account for certain jaspers. The jaspers of the Bowling Alley series of the Great Serpentine Belt (N.S.W.) were believed by Benson (1915) to be due to the action of adjacent spilite and keratophyre masses. At Nangus, a few small porphyrite masses are associated with the jaspers but they are hardly extensive enough to have been responsible for the production of all the jaspers. In any case, similar rocks near Oaky Creek, south of Nangus, are associated with more normal metasediments and have not jasperized them. (*c*) Jasperization related to serpentine. This relation has been suggested by several workers; some of the Woolomin jaspers have had such an origin ascribed to them (see Browne, 1950, p. 206). A small patch of serpentine-bearing rocks has been found south of Nangus, but as these rocks themselves have been silicified and are so limited in extent they could hardly have provided sufficient silica and iron to satisfy the jaspers. Osborne (1950) has noted the association of jasper and serpentine at Wood's Reef, N.S.W. He believes that "medium to high-temperature (hydrothermal) solutions containing silica and iron" have caused jasperization of the Tamworth series and stresses the importance of the siliceous nature of the original sediments and their tectonic setting as determinative factors in the jasper-formation. This view leads us to (*d*) solution and re-deposition of silica and iron in the metasediments during a period of dynamic activity. The case has already been cited of the deposition of granular quartz in the deformed and smashed metasediments near the jaspers. The evidence of the jaspers themselves indicates that the formation of haematite preceded the silicification. It is probable that the silicification affected a greater area than did the haematite enrichment. The reason why all trace of regular directional structures such as schistosity should be obliterated in the jaspers is not known. It is certainly strange that this should be the case if intense dynamic action were involved in the jasperization (a possible explanation of this is that the final stage of the jasperization took place under rather static conditions and complete replacement might mask all such structures; only where silicification alone has taken place do the directional features become apparent). Benson (1918) in discussing the Eastern series jaspers of the Woolomin district, N.S.W., stated that "they result from intense silicification along zones of shattering, and are not primary deposits". If the Nangus jaspers are iron-enriched, silicified sediments, as is tentatively suggested here, it is a matter of no little difficulty to account for the components of the sediments which would have been displaced.

The age of the jasperization is not much more definitely known than is its origin. If the jasperization and the silicification of the neighbouring metasediments are related, then the jasper-formation is post-schistosity, i.e. it occurred at least after the "schistosity-forming" phase of the metamorphism. On the other hand, some of the igneous bodies associated with the jaspers have not been jasperized, yet they have suffered low-grade metamorphism. To the south apparently comparable rocks of igneous origin display an increase in grade sympathetically with the metasediments. It is therefore suggested that the jaspers were formed during the period of metamorphic activity but that they do not belong to the first phases of the action.

(iv) *Limestone and Serpentine Rock.*

Limestone has been found at one locality (T.S.R. 44,174, Par. Mundarlo, Co. Wynyard) in this region. It occurs on the south bank of the Murrumbidgee River south of Nangus, and was once quarried and burned for lime. The deposit is recorded by Carne and Jones (1919) but their description is rather inaccurate. Their report classifies the associated rocks as "clayshales, mudstones, and sandstones", whereas, in actual fact, highly siliceous rocks, often akin to jaspers, occupy the area near the limestone. The limestone appears to form a lens following the major strike of the region, but the rock has not been traced far from the river-bank. A deep red soil covering obscures its southerly continuation.

The rock is a white, rather massive, fine-grained marble which, while not dislocated on the same scale as the surrounding rocks, may show some signs of cracking—the cracks usually being emphasized by limonite stains. A few pyrite cubes may be found at times but, as is indicated by the analysis (Table 5), the limestone is generally a very pure calcium carbonate rock. It is a strange fact that in an area of intense silicification the limestone does not appear to have suffered much addition of silica.

In close proximity to the limestone, often between it and the jaspers, there are a few outcrops of a patchy green rock which, although apparently fibrous, is compact and hard. When sheared, the rock develops a poor cleavage and becomes much jointed. Surface weathering produces a red clayey soil and this covering often masks critical boundaries.

These fine-grained green rocks consist mainly of fibrous antigorite and chalcedony, with smaller amounts of talc, iron ore, and sometimes carbonate minerals. The antigorite often has a distinctly variable grain-size and not infrequently relatively large aggregates with common orientation are associated with finer criss-cross patches (as in Plate vi, B). Colourless or stained yellow (optical sign –ve; length-slow; parallel extinction; birefringence about 0·007) the antigorite appears to alter to fine aggregates of a flaky mineral (strong birefringence; parallel extinction; biaxial –ve; small 2V; length-slow) which is probably talc (the paragenesis suggests talc rather than muscovite). The alteration is at best only local and patchy. Silica fills cavities and veins and, in general, gives the impression of having been added to the rocks. It is usually chalcedonic and has an aggregate appearance. The silica-filled cavities are sometimes lined with small concentric growths of an unidentified mineral (colourless; refractive index lower than balsam; high relief; almost isotropic). Limonite commonly stains the antigorite, and magnetite may appear as small granules. Carbonate minerals occur in some cases but often are not abundant.

TABLE 5.

	1	2	3	4
SiO_2	0·44	74·41	46·44	46·44
Al_2O_3	0·91	2·35	10·12	4·85
Fe_2O_3		5·68	3·98	11·75
FeO		0·30	8·30	0·61
MgO	0·16	10·86	21·32	22·46
CaO	55·27	0·22	6·54	0·45
Na_2O	0·03	0·15	0·78	0·30
K_2O	0·09	0·18	0·28	0·36
H_2O+	0·08	4·21	1·41	12·60
H_2O-		1·87	0·08	
TiO_2	—	tr.	0·20	—
MnO	—	0·09	0·12	0·18
CO_2	43·03	—	—	—
	100·01	100.32	99·57	100·00

1. Limestone (fine-grained marble). North-east corner of T.S.R. 44,174, Par. of Mundarlo, Co. Wynyard. Anal. T. G. Vallance.
2. Siliceous serpentine-bearing rock. North-east corner of T.S.R. 44,174, Par. of Mundarlo. Anal. T. G. Vallance.
3. Ultrabasic inclusion in Wantabadgery granite. Por. 52, Par. of Mundarlo. Anal. T. G. Vallance.
4. Analysis No. 2 recalculated to 100% on the basis of 46·44% SiO_2.

In Table 5 is given an analysis of a rock of this type. The most remarkable feature is the high silica content coupled with an abnormal amount of magnesia.

There are perhaps two possible theories of origin: that the rocks are derived (1) from carbonate rocks, or (2) from ultrabasic igneous rocks. Serpentinization of calcium carbonate rocks by magnesia-silica metasomatism has been mentioned by various authors. In the present instance there seems to be no ready source of magnesia necessary to convert the limestone and so this mechanism must be rejected. Eskola (1951) has discussed the derivation of serpentine rocks from dolomites by the addition of silica to the carbonate rocks. In that case the excess lime is removed as bicarbonate and would be eventually deposited as calcite. Where lime is less free to escape from the system, low-temperature silica metasomatism of dolomite would produce amphibole. At Mundarlo, the carbonate rock now exposed is definitely deficient in magnesia and as far as could be determined in the field there are few reaction features between the limestone and the serpentinous rock. If the latter were derived from dolomite little trace of the parent material remains. There is, however, at least one argument against the serpentine rock being derived from this source. These rocks appear to occur within the low-grade zone which includes pelites characteristic of the muscovite-chlorite subfacies of the Greenschist Facies (see page 118). In such an environment the association dolomite-quartz is stable (Turner, 1948, p. 96). There is no evidence to suggest an increase in metamorphic grade in proximity to the serpentine rocks.

The mineralogy of these rocks suggests that the silica content is not all original. If we ignore the high silica it can be seen that the mineral assemblage is such as might be expected to result from the low-grade metamorphism of, say, a silica-poor, magnesia-rich (ultrabasic) igneous rock. The only ultrabasic rock known in this area occurs as a large inclusion in the Wantabadgery granite near Mundarlo (serpentine derived from ultrabasic rocks occurs to the east in the vicinity of Gundagai). The composition of the Mundarlo inclusion is given in Table 5. This rock has been rather strongly metamorphosed and, whilst not being strictly comparable with the siliceous serpentine, it does provide the basis for an interesting comparison. The silica-rich analysis has been recalculated to 100% on the basis of the SiO_2 content of the inclusion. The result (which is not far from the composition of antigorite, although MgO is rather low), when compared with the analysis of the inclusion, indicates roughly equivalent iron and magnesia but dissimilar alumina and lime contents. In the absence of more definite evidence it is suggested that the antigorite-bearing rock was derived from ultrabasic igneous material in sills by processes of low-grade metamorphism and, later, silicification. The reaction antigorite → talc may have been related to the latter process:

$$\underset{\text{antigorite}}{Mg_3(OH)_4Si_2O_5} + 2SiO_2 \rightarrow \underset{\text{talc}}{Mg_3(OH)_2Si_4O_{10}} + H_2O$$

G. A. Macdonald (1941) indicates that the conversion of serpentine to talc is the first stage in the progressive metasomatism (i.e. silica metasomatism) of serpentine in the Sierra Nevada of California.

II. Biotite Zone.

The outermost isogradal line drawn on the map represents the incoming of brown biotite in the phyllites and schists. As a general rule this biotite isograd displays a remarkable parallelism to the margins of the Wantabadgery and Green Hills granite masses. Near the northern end of the Ellerslie mass the isograd turns to the east, apparently following the outline of that mass. Little or no change in the biotite zone seems to occur near the Belmore mass.

The zone appears to be widest where it extends across the regional trend of the country. It attains its maximum surface width (about three miles) in the Borambola district. Between Rosewood and Westbrook the zone becomes quite restricted and disappears entirely further south. Biotite has been noticed in phyllites near Humula Trig. Station and to the west near the Kyeamba adamellite. This suggests an increase in metamorphic grade in this area but, as only reconnaissance mapping has been undertaken west of Humula, isogradal lines have not been plotted.

Biotite zones of comparable metamorphic status have been found at Cooma (Joplin, 1942) and at Albury (Joplin, 1947). At Omeo (Victoria), Crohn (1950) mentions a biotite zone but he has not plotted its limits on the map.

Certain lithological types—jaspers, limestone, and silicified serpentine—found in the low-grade zone do not occur here, but otherwise the rock types of both zones are comparable.

(i) *Pelites.*

By this stage of the metamorphism most of the pelitic rocks merit the title fine-grained mica schist. Cleavage and schistosity are usually obvious; finely plicated schistosity is somewhat unusual. The increase in metamorphic grade generally produces a darker colour (commonly dark olive-green) in these pelites relative to that of the lower-grade pelites. Colour variation is, however, not a sufficiently reliable criterion to be specific as a zonal indicator. In actual fact, the mapping of the biotite isograd has proved to be one of the most tedious operations associated with these studies because the appearance of biotite can only be determined with the aid of a microscope.

Mineralogically, these pelites contain biotite, muscovite, quartz, a little felspar and chlorite, and the common accessories zircon, tourmaline, iron oxides and rutile. Biotite, the index mineral for the zone, occurs as small light brown to brown (the colour tends to deepen somewhat with increase in metamorphic intensity) flakes aligned along the schistosity. In the higher-grade parts of this zone there may be a tendency for biotite porphyroblasts to be formed across the schistosity and this feature is most marked in the mica-rich rocks. Pleochroism is strong and for biotite towards the upper (metamorphic) limit of the zone a typical scheme is: X = very pale yellow-brown; Y = dark red-brown; Z = dark red-brown; $Z = Y \gg X$. Greenish mica, mentioned as occurring in some low-grade pelites, may continue into the biotite zone but at an early stage gives place to brown biotite. Chlorite, likewise, is almost all converted to biotite quite soon after the biotite isograd is reached. Muscovite is an important constituent of these schists but apart from an increase in grain-size is not much different from its low-grade counterpart.

Quartz is finely granular and commonly oriented along the schistosity. Felspar may appear as an accessory. One unusual rock contains an abnormal amount of finely granular felspar (the analysis is given in Table 3, no. 2). The high soda content is accounted for by the presence of small untwinned albite grains. Albite in relatively low-grade schists has been attributed to a variety of causes, including addition of soda (Clough; see Harker, 1939, p. 212). Mica-schists rich in soda and lime occurring at Sulitelma are mentioned by Vogt (1927), who suggested that they were related to an incomplete weathering of the source material. Similar rocks are found elsewhere in the Caledonides of Scandinavia, where, as in Scotland, there appear to be two schools of thought on the matter of their origin. Some authors (e.g. Strand, 1951) favour a metasomatic origin for the sodic felspar in such rocks. In view of the local development of the albite-bearing rocks in the present case the best explanation seems to be that the felspar is of detrital derivation. It is interesting to note that here there is no tendency for albite porphyroblasts to form, whilst in the Dalradian of Scotland such large albites may appear even before biotite (Harker, 1939). Harker apparently associated the porphyroblast development with stress influence.

Odd grains of tourmaline are not uncommon. Variable in colour, the blue-grey is more commonly found than the brown type. Graphite flakes occur in some aluminous pelites. Where carbonaceous material becomes abundant it is usually associated with chlorite and a pale yellowish-green mica as well as sericite, quartz and the common accessories with perhaps a preponderance of iron ore. Such rocks may occur near the non-carbonaceous pelites in which brown biotite and muscovite are abundant. Comparison of the two assemblages suggests a lag in the response to the metamorphic variations in the first case relative to the second. This phenomenon seems reasonably to be explained by the inhibitive action of the carbon (see Harker, 1939, p. 224; and Turner, 1948, p. 158).

In general, the siliceous pelites reflect the mineralogical and textural changes observed in the more aluminous types. Brown biotite appears at roughly the same stage in both cases. Exceptions to this rule are provided by the black siliceous rocks which, as might be expected from their carbon content, show a distinct lag. The black siliceous types are not extensive in the biotite zone but they do pass into it near Tarcutta Hill. Quartz, sericite, chlorite, a little biotite, iron ore and carbonaceous matter constitute the greater part of these rocks, which are not unlike their counterparts in the low-grade zone. Biotite is not common and in some cases is quite absent. Occasionally pale greenish mica flakes are apparent. Quartz is the major constituent of all these rocks. It is usually finely granular but distinct grain-size variations are common even in the one thin section. Quartz veins frequently occur and the coarser quartz-rich patches are often associated with them. Some of these veins in the more massive rocks display intricate fold-patterns (cf. ptygmatic veins in granitized regions). Where the carbonaceous matter is present in patches the carbon-rich portions have the finest-grained quartz associated with them. Local haematite staining is rather common and some, at least, of the iron oxide has been derived from the breakdown of pyrite.

(ii) *Psammopelites and Psammites.*

The mineralogical changes typifying the pelites of the biotite zone also occur in the sandier rocks. Chlorite and green mica are converted to biotite just as in the pelites. Most of these sandy rocks have sufficient matrix material available to produce the index mineral biotite and are thus quite useful for zoning purposes. Biotite appears to form in the sandy rocks earlier than in the pelites but the lag is never great. Harker (1939, p. 224) considered that the more psammitic rocks should lag behind the pelites during progressive metamorphism, but the opposite relations found during the present study also obtain at Cooma (Joplin, 1942, p. 170). Ray (1947) suggests that "more quartzose schists are prone to indicate by virtue of their inherent rigidity a slightly lower grade of metamorphism than a pelitic schist showing the same index mineral". In the present case (as at Cooma) the metamorphism has an important thermal factor (Ray and Harker were considering almost exactly equivalent zonal sequences) which may overcome the "inherent rigidity". Joplin (1942) suggested that the pelite lag might have been due to enhanced diffusion related to the presence of pore-fluid in the sandy rocks.

Quartz is the major constituent of these rocks and is usually associated with muscovite, biotite, chlorite and green mica (near the biotite isograd) and the usual accessories. Epidote has been noted as a rare accessory. As in the low-grade zone the large quartz grains tend to become granulated and recrystallized but original clastic characters often remain (preservation of original features has been observed in the biotite zone of the Woomargama and Burrumbuttock districts at Albury (Joplin, 1947); at Cooma they have usually been obliterated). Detrital plagioclase may survive well into the biotite zone, though it is definitely unstable under these conditions. The general tendency is, however, for the plagioclase to be replaced by albite.

III. *Knotted Schist Zone.*

With increase in metamorphic intensity the pelitic rocks acquire the appearance of knotted schists by the development of porphyroblasts. These "knotted" rocks are readily recognizable in the field and an isogradal line may be drawn joining the points where the porphyroblasts appear. Such an isograd was used at Cooma and Albury by Joplin to introduce a zone of knotted schists (at Cooma called andalusite zone) and to separate it from the biotite zone. Tattam and Crohn (see Crohn, 1950, p. 16), working on the Victorian end of the metamorphic complex, have noted the development of porphyroblasts of cordierite in biotitic schists. Crohn believes, however, that this feature "cannot be used to define a new zone" because of the difficulty of distinguishing between spots of incipient cordierite and micaceous aggregates due to retrogressive alteration of the cordierite. He therefore considers these rocks as members of the biotite zone rather than as characteristic of a separate zone. Whilst there may be some justification for Crohn's claim, my experience in this area has been that a knotted schist zone can be defined and mapped without undue ambiguity. The term knotted schist zone is used here rather than, say, andalusite and/or cordierite zone because it is often a matter of some difficulty to prove unequivocally which of these minerals was present originally as porphyroblasts.

Schists characteristic of this zone are found in proximity to the Wantabadgery mass except at its south-eastern end where high-grade rocks occur. A definite high-grade zone separates the knotted schists from the Green Hills granite mass. As in the case of the biotite isograd, the outer limit of the knotted schist zone roughly parallels the margins of the granite masses. Knotted schists occur along part of the northern end of the Ellerslie mass and have been traced as far as Bangandang Trig. Station. Again, like the biotite zone, this zone appears widest where it transgresses the regional strike of the metasediments. The eastern belt of knotted schists becomes increasingly narrow as one passes from south to north. The western (i.e. to the west of the granites) belt is widest to the east of Tarcutta and is more restricted both to the north and south. The Belmore mass has not had much effect on the knotted schist zone, for in many places knotted rocks do not appear at all and the granite comes into contact with biotite-zone rocks. Where the zone swings round sympathetically with the Wantabadgery granite it increases in width as it passes westwards and finally achieves a surface width of about five miles in the vicinity of Alfred Town. To the south-west of Westbrook the knotted schist zone narrows and finally disappears. South of Tumbarumba, along the valley of Tumbarumba Creek, fragments of knotted schists have been found in the tributaries draining the country to the west (Mt. Garland area). This seems to indicate that away from the fault line the knotted schists reappear in this southern area.

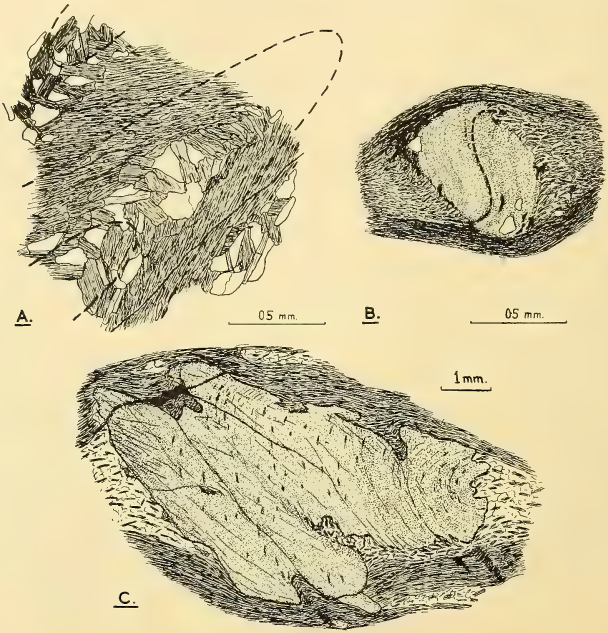
(i) *Pelites.*

The index feature of this zone is displayed typically by the pelites. With approach to the granite masses biotite-bearing schists become spotted by the incipient clots from which form quite rapidly the definite porphyroblasts responsible for the knotted appearance of the pelitic schists.

These pelites are highly lustrous and micaceous and not uncommonly display small-scale plications of the schistosity. The lepidoblastic base of these schists, although somewhat coarser, is comparable with the biotite-zone schists. Mineralogically they may be identical. Brown biotite, muscovite and quartz are the essential constituents with the same accessories as were noted in the biotite-zone schists. Biotite as well-developed flakes is of the strongly pleochroic brown or red-brown type: X = pale straw-yellow; Y = dark brown or red-brown; Z = dark brown or red-brown; $Z = Y \gg X$; $\gamma = 1{\cdot}639$; 2V very small. Generally the orientation of the flakes is parallel to the schistosity but with advancing recrystallization exceptions to this rule are not unusual. Occasionally large porphyroblasts (up to ca. 2 mm.) occur. Radioactive inclusions with associated pleochroic haloes are sometimes present. Muscovite blades and flakes aligned along the schistosity are abundant though often subordinate to biotite. Untwinned albite is an accessory in the knotted schists (at least in the outer parts of the zone). Potash felspar (untwinned), presumably a relic, has also been recorded on rare occasions. The presence of carbonaceous matter appears to cause a slight lag in the formation of porphyroblasts in the carbon-rich rocks.

The porphyroblasts usually stand out as dark knots on weathered surfaces. Traces of original idioblastic outlines are common but deformation has, in some cases, induced oval or almond shapes. The knots increase in size with approach to the granite margins and occasionally reach a length of from three-quarters to one inch. In all cases the porphyroblasts are more or less, often completely, altered to pseudomorphic greyish micaceous aggregates. Where cores of unaltered material have been found the original mineral is a clear, colourless variety of andalusite. The alteration products are mainly sericitic mica, with some biotite and occasionally a little chlorite. Biotite becomes more important in the altered knots of the higher-grade zone and usually has a minor role in the aggregates found in the knotted schist zone. In addition to micaceous aggregates with andalusite cores (and the more abundant comparable aggregates without such relics), pseudomorphs with a distinctly yellowish colour and relict poikiloblastic structure suggestive of pinitized cordierite are occasionally apparent. Fresh cordierite has, however, not been found in these rocks. Cordierite is recorded as an important constituent of knotted schists at Albury and in the Kiewa region of Victoria (Tattam, 1929), but in view of the extent of alteration in the present case it is difficult to assess the relative importance of cordierite and andalusite as porphyroblast minerals. The impression gained from an examination of thin sections would suggest that andalusite was the commoner of the two minerals.

Thin section examination often reveals that the knots have suffered a rotation which has tended to twist them into the plane of the schistosity. Rotation has therefore been greatest in the case of the porphyroblasts elongated directly across the schistosity. Text-figure 6, B, illustrates such a rotated porphyroblast. Patches richer in quartz and of coarser grain-size than the rest of the base are often developed on the "protected" sides of the porphyroblasts. Even when alteration to mica is complete the lines of inclusions in the pseudomorphs indicate the degree of rotation.



Text-figure 6.

A. Camera lucida sketch of folds in a banded psammopelite showing undeformed biotite flakes in the crests and troughs of the folds. The dark lines in the pelitic bands represent post-crystalline shears.

B. Micaceous pseudomorph after andalusite (?) showing signs of rotation in a somewhat carbonaceous pelite.

C. Large pseudomorph after andalusite (?) showing signs of rotation as well as deformation due to post-crystalline shears. Undeformed biotite has, in places, crystallized along the sutured margin of the porphyroblast.

Study of these porphyroblasts leads to some interesting information concerning time relations of crystallization of the various constituents in these rocks. The factors causing deformation of the porphyroblasts may also have produced minor plications in the base of these rocks. Such plications are shown in Text-figure 6, A. It can be seen that on the inside of the folds the biotite has crystallized without distortion, suggesting a para-crystalline environment (cf. Read, 1949, p. 117). Text-figure 6, C, shows a porphyroblast which has suffered apparent post-crystalline deformation and associated with this are plications in the micaceous base displaying para-crystalline features. This suggests that the porphyroblast crystallized before the final crystallization of mica. Evidence of rotation is also seen in this porphyroblast, but the twisting apparently took place before the final deformation. Local shears in such rocks are not unusual and indicate stress influence even after the final mica crystallization. Although there is a tendency for the porphyroblasts to be aligned along the schistosity or rotated towards that plane, there does not appear to be much orientation of them parallel to the lineation. This may be because the lineation and the schistosity were initiated before the porphyroblasts formed, although it is clear that some stress influence and mica crystallization continued after this stage. The evidence available regarding the growth of these schists seems to point to a sequence of events rather like the following: (*a*) initial crystallization of micas producing a schistosity, (*b*) formation of porphyroblasts, and (*c*) final (minor) crystallization of mica. The suggested sequence may be related to variations in the thermal/stress balance during the metamorphism with the thermal peak coinciding with the porphyroblast formation.

These observations suffice to indicate that the metamorphic processes which affected these rocks were by no means simple and that the knotted schists as seen today were built in stages. It seems logical to regard all these stages as parts of the one overall metamorphism rather than as completely unconnected events. "The dictum of our master Becke", as Read (1949, p. 106) has remarked, must be rejected, for, in actual fact, simultaneous crystallization in schists is often the exception rather than the rule. It is reasonable to expect that the other rocks here bear cryptic evidence of comparable relations, for all of them have, in a general way, suffered the same metamorphism though they have been affected to different degrees.

Garnet has been mentioned as a constituent of certain schists in the Parishes of Cunningdroo and South Wagga Wagga by Whiting (1950). The former locality has been examined during the course of this work, but the occurrence of garnet has not been confirmed.

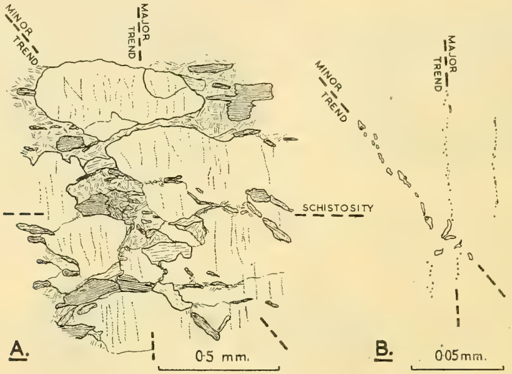
Black siliceous pelites appear to pass into a knotted schist zone environment to the north-west of Yabtree Trig. Station, but elsewhere they do not figure in this zone. Their composition precludes the development of andalusite or cordierite and thus they display no superficial indication of a change in metamorphic grade. Recrystallization merely causes an increased grain-size of the mineral constituents, which are the same as those found in comparable rocks of the biotite zone.

(ii) *Psammopelites and Psammites.*

The reaction of the sandier rocks to knotted schist zone conditions has been foreshadowed by the remarks already made. Quartz-rich psammites, poor in alumina, obviously would be unable to develop andalusite or cordierite no matter what the grade of metamorphism. On the other hand, it is quite conceivable that the more aluminous psammopelitic rocks could provide the materials necessary for the growth of andalusite or cordierite porphyroblasts, and this is exactly what happens in the rocks studied. The mica-rich portions of the banded psammopelites behave in the same manner as do the pelites themselves. The porphyroblasts make their appearance in such rocks before they do in the more homogeneous psammopelites. In the latter rocks the knots are quite comparable with those in the true pelites, except that where the supply of material is limited the grain-size of the porphyroblasts is diminished.

In the absence of "knots", a coarser grain-size is the only feature which might distinguish sandy rocks in this zone from their analogues in the biotite zone. Some of these metasediments still bear witness to their original clastic nature. Irregularities in size and a certain angularity of the sand grains may persist, but in the more intensely recrystallized parts of this zone such features often disappear. In the banded metasediments even such fine structures as graded bedding may be preserved into the knotted schist zone.

Quartz remains the dominant component of these rocks but a little felspar (plagioclase and relict K-felspar) may also be represented in the sand fraction. The orientation of the optic axial directions of quartz grains in a psammopelite from this zone has been represented in a fabric diagram (Text-fig. 5). Not infrequently the quartz grains in these rocks are traversed by lines of minute inclusions. These small inclusions are often opaque but occasionally larger examples are found which are rather irregular in outline and may contain small bubbles suggesting that the inclusions are liquid. Often the lines of inclusions can be proved to be end-sections of planes which display a remarkable constancy of orientation from grain to grain. Text-figure 7 gives sketches of these liquid inclusion planes which here cut across the schistosity. Tuttle (1949) has given an excellent discussion of the subject of liquid inclusions. He found that, at times, such planes have a remarkably uniform orientation over large areas. In Text-figure 7, B, it will be noted that there are two major orientations of planes of inclusions in these rocks and, applying Tuttle's (1949, p. 334) criteria, it can be seen that the "subordinate" group (minor trend) is probably of somewhat later age than the "dominant" group. It is quite obvious that there is no uniform relation between the orientation of these inclusion planes and crystallographic directions in the quartz. The planes of inclusions have certainly formed in the rocks after consolidation and cannot have been present in the original clastic grains. Tuttle believed that deformative processes were responsible for the development and uniform orientation of the inclusion planes in the Washington, D.C., area, and the same explanation seems reasonable in this case. No attempt has been made to apply petrofabric methods to this problem, but observations made suggest that such studies would bear fruitful results.



Text-figure 7.

A. Camera lucida sketch of a knotted schist zone sandy rock showing planes of liquid inclusions, in the quartz grains, cutting across the schistosity.

B. Camera lucida sketch giving details of the inclusions in one of the quartz grains.

In addition to the sandy rocks with admixed clay as matrix material, odd bands of calcareo-arenaceous rocks are found in this zone. Mineralogically these latter rocks consist mainly of quartz and granular clinozoisite-epidote with subordinate dirty pale green amphibole and iron ore. Rocks of similar composition occur as inclusions in the Wantabadgery granite. It is interesting to note that it is such limy rocks which display boudinage structures at Mundarlo (Vallance, 1951). A few examples of psammopelites with abnormal lime have been found to the west of Bangandang Trig. Station. The development of crystals of pleochroic bluish-green or green amphibole along with brown biotite indicates an enhanced lime content. A rock containing a few subhedral, colourless garnets (associated with quartz and small aggregates of colourless amphibole) was also found here. This is the only occurrence of garnet in the country rock metasediments found during this study and is perhaps due to an unusual lime content; the rock has not been analysed.

IV. High-grade Zone.

When discussing the knotted schist zone it was mentioned that, whereas the knotted schists extended almost to the margin of the Wantabadgery granite, these schists were separated from the Green Hills granite by a zone of higher-grade rocks. The latter are typically more granular than the schists and may contain sillimanite. Near the granite contact they may become migmatites or injection rocks.

Actually these high-grade rocks do occur at the margin of the Wantabadgery granite mass but they are usually restricted to a zone often only a few feet wide. At the south-eastern end of this mass, however, such rocks are more extensive and a separate high-grade zone is mappable. Continuing southwards along the strike from Yaven Trig. Station, the high-grade zone widens rather remarkably until in the vicinity of Sargood Trig. Station it is about four to five miles across. The zone then narrows to the south, passing between the Green Hills and Belmore masses, and finally disappears some miles to the north of Tumbarumba. From the map it will be seen that the isograd defining this zone roughly follows the western margin of the Green Hills granite mass. Isolated masses of similar metasediments with the appearance of roof pendants occur at Hugel Trig. Station and in the area east of Tumbarumba (for example in the Nurenmerenmong Range).

The boundary drawn between the zone of knotted schists and the high-grade zone lacks the precision that characterizes the other isograds because of the personal factor probably involved in its mapping. The isograd has been drawn through points where knotted schists tend to lose their good cleavage and high lustre and acquire a more granular appearance. Joplin (1942) at Cooma was faced with a similar problem and remarked that "the boundary between this [i.e. the andalusite or knotted schist zone] and the succeeding permeation-zone was a somewhat arbitrary one, determined in the field by the appearance of slightly more granular and less schistose rocks". It will be noted that at Cooma the term permeation-zone was used to include the high-grade rocks which did not show injection by tongues of gneiss (injection zone). Because of the lack of a sharp contrast between these permeation and injection rocks in this area compared with Cooma the two zonal subdivisions have not been used in this study and all the rocks are considered in the one high-grade zone.

(i) *Pelites.*

Within the zone defined on the map there is a gradual change in the appearance of the rocks with approach to the granite contact. At the outer edge of the zone the rocks retain some schistosity and have knots apparently comparable with those of the knotted schists. In thin section, however, it may be seen that the knots have a slightly different appearance from those in the lower-grade zone. Typically, the knots, which in the knotted schist zone were composed of fine flakes of sericite, now consist of much coarser aggregates of mica flakes with a base of sericite and iron ore fragments. Muscovite blades are quite common, whilst a green biotite (pleochroic from pale yellow-green to medium greenish-brown) may also occur as less well-defined flakes (brown biotite is found in some cases). Both micas in the aggregates show little trace of preferred orientation which is in contrast to the mica of the base of these rocks. Brown pleochroic (pale straw to dark reddish-brown) biotite is the characteristic dark mica of the two-mica base. Occasionally unaltered cores of andalusite (clear and colourless) remain in the knots and the occurrence of both biotite and muscovite replacing it surely indicates an addition of bases from some external source. Compared with the altered porphyroblasts in the knotted schists these knots often have more diffuse boundaries against the micaceous base. Definite K-felspar and oligoclase have not been recorded here and in this respect these rocks differ from the higher-grade types in this zone.

These rocks are followed in the metamorphic progression by varieties comparable with the spotted granulites of Cooma. Schistosity is much less obvious and the term granulite seems quite appropriate for such rocks. Their characteristic appearance is due to the dark micaceous aggregates or spots scattered through a much lighter-coloured base. With increase in grade the spots tend to merge with the base, but right to the granite contact some heterogeneity expressed by a mottled appearance is preserved. Red-brown biotite similar to that of the base becomes commoner in the micaceous patches and along with it may occur sub-radiating patches of pale chlorite flakes (pleochroic, pale yellow-green to mid brownish-green; parallel extinction; +ve (?); sometimes anomalous blue interference tints; length-fast). The chlorite is probably of a later age than the biotite. Blades of muscovite become more numerous and extensive as the granite is approached. Quartz is usually not abundant in the pelites and is commonly interstitial.

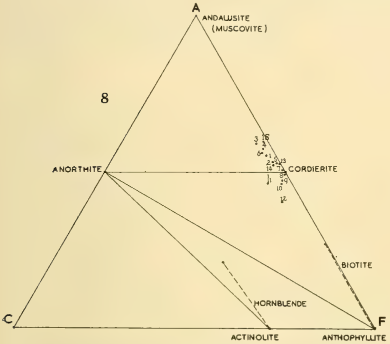
Andalusite may occur in these rocks as pleochroic (Z, Y = colourless; X = pale pink; pleochroism variable within a single grain) porphyroblasts with markedly ragged and poikiloblastic (mainly quartz and biotite inclusions) margins and almost inclusion-free centres. These porphyroblasts are often surrounded by zones enriched in biotite. Thin wisps and needles of sillimanite may be associated with the andalusite which, in contrast to the colourless andalusite of the knotted schists, shows no sign of alteration to micas. Joplin (1942, p. 180) has suggested that the pink pleochroic andalusite, occurring in a similar environment at Cooma, has been deposited from solution, i.e. it is of metasomatic origin. The colourless andalusite of the knotted schists is certainly of metamorphic origin. Whether any general relation exists between colour and origin of andalusite is not known, but in the literature there does seem to be a tendency for coloured andalusite to be recorded more often in granitic or metasomatic than in purely metamorphic environments (see for example, Hills, 1938; Santos Pereira, 1950). Cordierite poikiloblasts which are sometimes associated with the andalusite in these rocks are always more or less altered. In places the cordierite has subidioblastic outlines against quartz and the mica pseudomorphs have a markedly tabular form. The cordierite is sometimes large enough to be easily visible to the naked eye and may attain a diameter of from one-quarter to one-half inch. That the mica is replacing cordierite may be proved in many cases by the unaltered cores in the aggregates. It will be remembered that fresh cordierite was never found in the knotted schists and although the diagnosis of the mineral in that zone was always rather doubtful, it did not appear to be as abundant as andalusite. In the high-grade zone, however, cordierite is quite an important constituent of the pelites.

A glance at an ACF diagram (Text-fig. 8) on which the pelites have been plotted suggests that all of them (both knotted schists and high-grade rocks) should have abundant cordierite, yet it seems that the mineral becomes more important in the high-grade rocks. This brings to mind the suggestion of Potgieter (1950), who says that in rocks where both andalusite and cordierite are possible mineral phases the formation of andalusite might be favoured by a slight stress influence which would perhaps prevent crystallization of cordierite (because of its lower crystalloblastic force). It may be that when the knotted schists were formed a certain stress environment existed which favoured the andalusite (it is realized, however, that cordierite is reported to appear abundantly in knotted schists at Albury and in Victoria) whereas cordierite came into its own in the high-grade zone where the stress influence was slight.

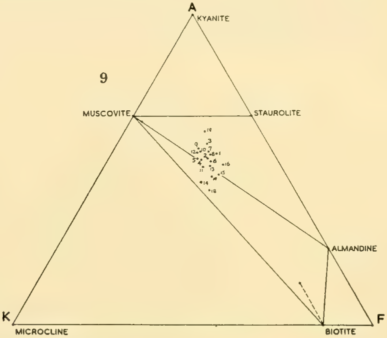
At this stage of the metamorphism potash felspar may appear, but examination of the role it plays is rendered difficult by the amount of alteration (mainly sericitization) which it has suffered. Commonly, however, there is no extensive development of felspar porphyroblasts as has been described in the high-grade rocks at Cooma and it is not until the granite contact is reached that relatively large felspars are seen. The potash felspar is typically untwinned and is commonly associated with grains of albite-twinned (and some untwinned) oligoclase (Ab_{85-90}). Perthitic intergrowths are a common feature and they become obvious in the porphyroblasts at the granite contact. Small felspar grains displaying myrmekite have been noted in some high-grade rocks. As both felspar and cordierite tend to be converted to micaceous aggregates it is sometimes difficult to distinguish the completely altered patches. Usually, however, the sericitic aggregates after felspar have a greyish or brownish colour and a more patchy appearance than the alteration products of cordierite, which are often yellowish, have iron oxide-stained cracks and, occasionally, haloes round small inclusions.

Both biotite and muscovite are abundant in the high-grade rocks. The biotite is normally of the red-brown, intensely pleochroic variety (Z = dark red-brown; Y = dark red-brown; X = pale straw-yellow; $Z \geqslant Y \gg X$; $\gamma = 1{\cdot}637$–$1{\cdot}640$) characteristically rich in inclusions with pleochroic haloes. Near the granite contacts the biotite often seems to become unstable and breaks down to chlorite, with the TiO_2 of the mica being released as rutile forming sagenite webs. Such rutile is sometimes seen in the red-brown biotite (though more common in chlorite), apparently indicating that the TiO_2 is lost (in part at least) before the mica is changed to chlorite. Contrasted with the behaviour of the coloured mica, muscovite increases in importance near the granite and large plates of white mica are often developed enclosing pre-existing mineral grains.

8



9



Text-figure 8.—ACF diagram for the cordierite-anthophyllite subfacies of the Amphibolite Facies. Rocks with deficient K_2O and excess SiO_2. (After Eskola.)

Key: 1-4, This paper, Table 6, nos. 1-4. 5, Joplin (1947), Table 1, no. IV. 6, Joplin (1942), Table 7, no. VII. 7, This paper, Table 6, No. 5. 8, Tattam (1929), Table III, no. 22. 9, This paper, Table 6, no. 6. 10, Joplin (1942), Table 5, no. IV. 11, This paper, Table 6, no. 8. 12, This paper, Table 6, no. 9. 13, This paper, Table 2, no. 1. 14, Joplin (1942), Table 3, no. IV. 15, Joplin (1947), Table 1, no. I. Nos. 1-12 high-grade rocks; 13-15 knotted schists.

Text-figure 9.—AKF diagram for rocks with excess SiO_2 and Al_2O_3 in the staurolite-kyanite subfacies of the Amphibolite Facies. (After Turner, 1948.)

Key: 1, This paper, Table 2, no. 1. 2, Joplin (1942), Table 3, no. IV. 3, Joplin (1947), Table I, no. 1. 4, Tattam (1929), Table 1, no. 3. 5, Tattam (1929), Table 1, no. 5. 6, Tattam (1929), Table 1, no. 6. 7, This paper, Table 6, no. 1. 8, This paper, Table 6, no. 2. 9, Joplin (1942), Table 7, no. IV. 10, Joplin (1942), Table 7, no. V. 11, Joplin (1947), Table 1, no. IV. 12, Joplin (1942), Table 7, no. VII. 13, This paper, Table 6, no. 5. 14, Tattam (1929), Table 3, no. 22. 15, This paper, Table 6, no. 6. 16, Joplin (1942), Table 5, no. IV. 17, This paper, Table 6, no. 8. 18, This paper, Table 6, no. 9. 19, This paper, Table 1, no. 1.

Nos. 1-6 are knotted schist zone rocks, 7-18 are high-grade rocks, 19 belongs to the biotite zone.

Near the granite contact at the north-western end of the Green Hills mass large porphyroblasts (up to half an inch long) of sillimanite appear in the pelitic granulites. In every case the sillimanite displays extensive alteration to white mica, only small unaltered cores remaining to indicate the original nature of the porphyroblasts. Small rods and needles of the mineral occur further from the granite margin but the porphyroblastic development is quite localized. Biotite has, in some cases at least, provided the material for the formation of sillimanite (the change biotite → sillimanite is particularly obvious in the pelitic inclusions in the granite). The production of sillimanite probably represents the peak of the thermal metamorphism. As needles of sillimanite occur in the pink andalusite (Plate vi, F) in some cases it is suggested that the latter formed after the sillimanite.

The alteration of sillimanite to mica is probably due to the metasomatic addition of bases (mainly potash) and is reminiscent of the New England region studied by Billings (1938) where sillimanite-schists have been "muscovitized" by the introduction of potash. Owing to the absence of analyses of completely "unmuscovitized" high-grade rocks we cannot demonstrate the chemical changes involved as well as Billings did. Table 7 does, however, show that a high-grade rock (2) has a distinctly higher potash/alumina ratio than that of a lower-grade (biotite zone) rock (1) and that the differences are of the same order as those found by Billings (columns A, B, and C).

TABLE 6.
High-grade Metasediments.

	1	2	3	4	5	6	7	8	9
SiO_2	49·53	54·01	54·63	56·05	63·97	69·98	73·64	74·59	81·85
Al_2O_3	26·53	24·41	25·35	24·91	18·13	14·66	13·89	12·71	8·75
Fe_2O_3	2·17	1·39	2·40	1·22	1·92	1·91	0·70	0·61	0·47
FeO	6·01	5·95	4·64	4·76	4·34	4·45	4·04	4·21	2·68
MgO	3·15	2·91	2·75	2·51	2·83	2·39	1·98	0·78	0·82
CaO	0·37	0·36	0·65	0·51	0·19	0·19	0·28	0·67	0·34
Na_2O	1·23	1·09	0·62	1·06	0·92	0·50	1·12	1·31	1·19
K_2O	5·90	5·45	6·28	6·12	4·58	3·92	2·88	3·29	2·54
H_2O+	3·79	2·64	1·25	1·23	1·60	0·89	0·42	1·29	0·96
H_2O-	0·31	0·28	0·26	0·22	0·26	0·18	0·07	0·17	0·24
TiO_2	1·03	0·85	0·86	0·86	0·69	0·71	0·63	0·63	0·25
P_2O_5	—	0·15	0·20	0·14	0·27	—	—	—	0·10
MnO	0·06	0·07	0·05	0·11	0·03	0·04	0·06	0·03	0·05
Etc.	—	—	0·15	0·09	—	—	—	—	—
	100·08	99·56	100·09	99·79	99·73	99·82	99·71	100·29	100·24

1. Spotted granulite. East end of Yaven Creek bridge, Por. 51, Par. of Dutzon, Co. Wynyard. Anal. T. G. Vallance.
2. Spotted granulite. Mt. Pleasant Creek, Por. 32, Par. of Wallace, Co. Wynyard. Anal. T. G. Vallance.
3. Spotted granulite. Cooma area. Anal. G. A. Joplin. PROC. LINN. SOC. N.S.W., 67, 1942: 181.
4. Mottled gneiss. Cooma area. Anal. G. A. Joplin. *Ibid.*, p. 181.
5. Granulite. Por. 32, Par. of Wallace, Co. Wynyard. Anal. T. G. Vallance.
6. Cordierite-rich granulite. East side of Por. 35, Par. of Dutzon, Co. Wynyard. Anal. T. G. Vallance.
7. Corduroy granulite. Cooma area. Anal. G. A. Joplin. PROC. LINN. SOC. N.S.W., 67, 1942: 168.
8. Quartz-rich granulite. Por. 66, Par. of Cunningdroo, Co. Wynyard. Anal. T. G. Vallance.
9. Granitized quartz-rich granulite. Near granite margin, east side of Por. 228, Par. of Tenandra, Co. Clarendon. Anal. T. G. Vallance.

Obviously potash has been concentrated and one explanation of this increase might be by the late addition of K_2O from the granite. Billings suggested that potash is derived by the hydrolysis of potash felspar in the plutonic rocks:

$$\underset{\text{orthoclase}}{6KAlSi_3O_8} + 2H_2O \rightarrow \underset{\text{muscovite}}{2H_2KAl_3Si_3O_{12}} + 2K_2O + 12SiO_2$$

Muscovite does occur in the granites but it would be a matter of difficulty to prove whether it is wholly or partly related to the release of potash to the nearby metasediments. The late glassy-quartz veins which cut the high-grade rocks in a few places may represent the destination of some of the silica freed by such a process as that postulated by Billings.

Holmes and Reynolds (1947) have suggested a similarity between Billings' New Hampshire occurrence of "muscovitization" of high-grade rocks and certain Dalradian rocks in Donegal in which quartzite is converted to mica schist. They disagree with Billings' explanation and state that "the migrations involved in the metasomatic metamorphism of the Malin Head Quartzite (and presumably that of the Loon

Mountain schists [Billings]) . . . were of the far-travelling type characteristic of migmatite fields and the surrounding zones of regional metamorphism".

In the present case the late muscovite-enrichment in the high-grade rocks is greatest around the margins of the plutonic masses and mainly occurs in proximity to them. The evidence we have concerning the alteration of the various minerals (sillimanite, cordierite, and felspar) leads to some interesting time relations. The porphyroblasts of the knotted schists must have been altered before the end of the metamorphism because of the variation in the mineralogy of the aggregates which replace them (brown biotite develops in the higher-grade knots whereas nearer the outer limit of the knotted schist zone fine sericite is characteristic). Permeation by alkali-bearing solutions must at some stage have extended out as far as the knotted schist zone. One would naturally expect that these solutions would have been most active in the deeper high-grade zone and the fact that cordierite porphyroblasts, for example, are only partly altered in the high-grade rocks (cf. knotted schists) suggests that they did not suffer this action. Development of brown biotite in the aggregates of the higher-grade rocks is perhaps correlable with the trend towards the sillimanite peak of metamorphism and following this may have come a final "muscovitization". The sillimanite, cordierite and pink andalusite may thus belong to a rather later generation than the porphyroblasts of the knotted schists. Of the two "muscovitizations" only the later one may have been directly related to the presence of the granite.

TABLE 7.

Examples of Potash-enrichment in High-grade Rocks.

	1	2	A	B	C
$\frac{K_2O}{Al_2O_3}$	0·18	0·27	0·19	0·17	0·31
$\frac{Na_2O}{Al_2O_3}$	0·05	0·03	0·09	0·07	0·04
$\frac{K_2O+Na_3O}{Al_2O_3}$ . .	0·23	0·27	0·28	0·24	0·36

1. Fine-grained psammopelite (Biotite Zone). This paper, Table 1, No. 1.
2. Cordierite-rich granulite. The cordierite is now extensively altered to mica. High-grade Zone. This paper, Table 1, No. 2.

A. Slate. Low-grade Zone.
B. Sillimanite Schist. High-grade Zone.
C. Muscovitized Schist. High-grade Zone.

Note.—A, B, and C belong to the Littleton Formation (New Hampshire) and are quoted from Billings (1938), Table 4.

Discrete veins and tongues of leucocratic quartzo-felspathic material occur in the high-grade zone in close proximity to the margin of the Green Hills granite (and to a smaller extent near the Wantabadgery granite). These mixed rocks (migmatites or injection rocks) are similar in many respects to the more extensive injection rocks found at Cooma. In the case of the pelites the metasedimentary host material may be mottled or spotted and granular like the granulites mentioned above. At times the host material becomes coarsely crystalline and there may be a concentration of biotite (a biotite selvedge) in the host near the vein margin. The vein material may carry subordinate muscovite and red-brown biotite in addition to the abundant quartz and felspar. Brown tourmaline may also occur in the veins.

It has been seen that the pelites in the high-grade zone tend, in general, to assume the appearance of spotted granulites but the transition to such rocks from the knotted schist stage is rather gradual. This transition suggests a possible development-stage in the history of these rocks which was not recorded at Cooma (Joplin, 1942). There the "spots" were regarded as pelitic fragments which had been disrupted by the formation of orthoclase porphyroblasts. In the present case the spots seem to represent altered porphyroblasts of andalusite and/or cordierite comparable with those that form the knots in the knotted schists. The micaceous spots occur in the granulites even where orthoclase is of minor importance and certainly could have had no extensive mechanical action. The best explanation seems to be that the spots of the granulites (in the outermost parts of the zone at least) are actually highly recrystallized mica-aggregates corresponding to the altered knots of the schists. It is interesting to note that green biotite may occur in the spots of the granulites whereas only the typical red-brown variety is developed in the base of such rocks. Comparison of analyses of pelites and of altered "nodules" from a Victorian knotted schist (see Tattam, 1929, Table I, no. 6; these are the only altered porphyroblasts from knotted schists in this metamorphic belt which have been analysed) will indicate a fairly close correspondence (except for magnesia and to some extent iron). Conceivably both pelite fragments and mica-replaced porphyroblasts could provide the material for the spots in the granulites in different cases. In the higher-grade parts of this zone the dark micaceous spots of the granulites are separated by felspar-rich leucocratic veins or patches and it may be that there the development of felspar has helped to break down the original pelite material. It seems not unreasonable to regard the early-stage spotted granulites as derived from knotted schists by recrystallization whereas with the development of more felspar (perhaps by addition due to metasomatism) internal disruption may accentuate the spotting of the granulites.

A summary of the probable history of these rocks might be: (1) production of knotted schists under (mainly) thermal influence, followed by (2) alkali metasomatism causing alteration of the porphyroblasts to mica aggregates, (3) increase in thermal intensity resulting in the recrystallization of the mica aggregates (with the development of biotite, etc.) and the granulitic appearance of the rocks with the micaceous patches remaining as relics. The generation of sillimanite, cordierite, potash felspar, and perhaps pink andalusite belongs to this period. Finally with waning temperature (4) potash-rich solutions caused the breakdown of the high-grade aluminous minerals (except andalusite) to muscovite. The high-grade environment may have been, in part, superimposed on the knotted schists as the metamorphism progressed to its peak (3). Such observations indicate that the metamorphism although in a general sense progressive must have taken place in a number of stages, just as was decided after examining the knotted schists.

(ii) *Psammopelites and Psammites.*

The general trend of mineral transformations in the pelitic rocks is also shown by the sandier types, though the metamorphic representatives of the latter in this zone are more quartz-rich and often more granular than the isogradal pelites. As a rule the banded psammopelites preserve their original sedimentary banding till a more advanced stage than the other metasediments. The mottled or spotted pelitic bands in these rocks behave exactly as do the normal pelites whilst the sandier bands are recrystallized to granoblastic aggregates of quartz, red-brown biotite, muscovite, and sometimes felspar. In appearance such banded rocks are similar to the corduroy granulites described from Cooma (Browne, 1914; Joplin, 1942).

Towards the granite contact it becomes apparent that the sandy rocks have been more easily permeated than the accompanying pelites. The increase in size of the K-felspar grains with approach to the granite suggests that part, at least, of the necessary material for their formation has come from the granite by some process such as metasomatism. The felspar porphyroblasts near the contact may grow to about half to one inch long and are commonly marked by fine perthitic intergrowths. Oligoclase is a frequent associate of the K-felspar and it exhibits a greater proportion of twinned grains near the granite than away from it. Where the bulk composition permits, cordierite, always more or less altered, may occur as rather regular idioblasts. Andalusite does not usually appear in these more homogeneous rocks but it does occur in the pelitic bands of the corduroy granulites. Regarding the development of cordierite rather than andalusite in this case, there may be some significance in the fact that the psammopelites when plotted on an ACF diagram (Text-fig. 8—points 8–12 represent psammopelites, the remainder are pelites) tend to fall farther away from the A (andalusite) pole and nearer the F pole than the normal pelites; the separation is, however, never very great.

As in the case of the pelites the sandy rocks near the granite may display the features of banded migmatites or injection rocks. The vein material is in general comparable with the leucocratic quartzo-felspathic material mentioned in connection with the pelites. Banded gneisses of mixed origin may thus occur locally along the edge of the Green Hills granite mass. Veins of coarse glassy quartz (later than the quartzo-felspathic veins) occur in such rocks near Hugel Trig. Station.

(iii) *Tourmalinization of High-grade Metasediments.*

Metasediments rich in tourmaline are scattered at intervals along the granite contacts and have been studied near Alfred Town, north of Bilda Trig. Station, and near the north-west end of the Green Hills mass. Tourmaline as an accessory is widespread in all the metasediments of this region and though variable in colour is most commonly of the blue-grey pleochroic type. The boron-rich rocks on the other hand are quite exceptional and are characterized by pleochroic brown tourmaline. These rocks occur only in close proximity to dykes and veins of the acid phases (aplites or pegmatites) of the granite.

All gradations may be seen from the extreme case of pure quartz-tourmaline rocks to little-affected types with only a few brown tourmaline grains associated with the usual minerals of the metasediments. The process of tourmalinization appears to involve the replacement of all the components of the metasediments (except quartz) by tourmaline. Biotite is usually the first mineral to disappear, followed by felspar and then muscovite. The replacing tourmaline is a strongly pleochroic (E = pale fawn; O = very dark brown) variety of schorlite occurring as ragged crystals, often rich in quartz inclusions. In the completely replaced rocks (i.e. the quartz-tourmaline rocks) there is often a marked dimensional orientation of the tourmaline grains. Late crystallization of quartz in veins is not an unusual feature of these rocks.

The field relations strongly suggest that these tourmaline-rich rocks are due to the addition of boron from the plutonic rocks. Tourmaline occurs in many of the pegmatites and aplites, though it is in general rather rare in the normal granites and granodiorites. It seems reasonable to regard the association of tourmaline-rich rocks with acid phases of the granite as being of genetic significance. The phenomenon of boron metasomatism is by no means rare and has been often invoked to explain the extensive development of tourmaline-rich rocks in proximity to plutonic masses (Turner, 1948, p. 127). As Turner pointed out, the process leads to a mineralogical convergence whereby a pelite, for example, of rather complex mineralogy is reduced to a quartz-tourmaline mixture. It is of interest to note here that Howitt, in 1888, described certain tourmaline-bearing rocks from Omeo, Victoria, in the same metamorphic belt as the present area; he ascribed the tourmaline to "volatile emanations" from plutonic magmas.

The evidence available in this area points to a rather restricted extent for the boron metasomatism. In every case where tourmaline becomes important it is near acid phases of the granite, whilst the accessory tourmaline (usually of different colour) of wide distribution in the metasediments may be quite reasonably regarded as being of detrital origin. Contrary to the opinions of some petrologists (see Hutton, 1939), the boron has apparently not travelled far from its source, certainly not as far as the alkali-rich solutions which caused the rather extensive production of late sericite or muscovite in the alumina-rich rocks.

REVIEW OF THE METAMORPHISM IN THE LIGHT OF THE FACIES CONCEPT.

Now that some picture of the metamorphic progression and of the rocks formed in the various stages has been given it will be useful to attempt briefly to relate the results to the appropriate metamorphic facies (see Turner, 1948).

The metasediments which we have considered belong, for the most part, to a group of rocks with excess silica and alumina and deficient potash (relative to alumina).

The remarkable uniformity in composition has been reflected in the rather constant mineral assemblages found in the rocks in a given metamorphic grade.

The low-grade rocks with the definitive association sericite (muscovite) and chlorite belong to the muscovite-chlorite subfacies of the Greenschist Facies (see Turner, 1948, p. 96). The antigorite-rich assemblage of the silicified serpentine also belongs here. With the development of brown biotite (characteristic of the biotite zone) the grade of metamorphism becomes equivalent to the biotite-chlorite subfacies of the same facies as the low-grade rocks.

Andalusite and/or cordierite associated with albitic felspar in the outer part (at least) of the knotted schist zone bespeaks a grade of metamorphism corresponding to the actinolite-epidote hornfels subfacies of the Albite–Epidote–Amphibolite Facies (Turner, 1948). When more calcic plagioclase (in this case oligoclase) is developed along with the andalusite and/or cordierite in the pelitic schists Amphibolite Facies conditions are indicated. Such conditions probably applied in the more metamorphosed part of the knotted schist zone and certainly applied over a large portion of the high-grade zone. The mineral assemblages suggest that a cordierite-anthophyllite subfacies environment prevailed here. Text-figure 8 shows the positions of various high-grade rocks on an ACF diagram as devised for this subfacies. It can be readily seen that these rocks might be expected to give such mineral assemblages as (*a*) muscovite-andalusite-cordierite-plagioclase-(quartz), (*b*) muscovite-biotite-cordierite-plagioclase-(quartz) (see Turner, 1948, p. 79). Such associations do occur here but, as the diagram suggests, plagioclase is subordinate. Potash felspar is unstable in this subfacies in association with andalusite or cordierite. It has been noted, however, that potash felspar does appear in some of the high-grade rocks and it becomes commoner as the granite contacts are approached. Sillimanite also occurs under these conditions. The assemblages in which such minerals occur are not in complete equilibrium but they do suggest a change from the cordierite-anthophyllite subfacies. The association potash felspar-sillimanite is a possible one in the sillimanite-almandine subfacies of the Amphibolite Facies, and it may also occur in the Pyroxene Hornfels Facies. Besides certain of the high-grade rocks of the country-rock metasediments this association may also appear in the pelitic inclusions in the Wantabadgery and Green Hills granites. If these high-grade types belonged to the sillimanite-almandine subfacies, then, if equilibrium were attained, almandine garnet should appear in rocks of this composition. Although ideal equilibrium conditions have not been realized there should be some tendency for garnet to appear if such an environment once prevailed here; almandine has not been recorded from these rocks. On the other hand there is equally no tendency for pyroxene to appear in any of the metasediments. No basic rocks which might develop pyroxene under Pyroxene Hornfels Facies conditions occur in close proximity to the high-grade zone. Pyroxene has been noted (associated with amphibole) in a large inclusion in the Wantabadgery granite at Mundarlo; it has also been seen in certain basic rocks from the "basic belt" between Adelong and Batlow. Discussion of the significance of pyroxene in the latter rocks must be deferred, but it may be noted that the mineral tends to develop in some of these rocks as they are followed southwards along the strike, suggesting a possible metamorphic relation to the Green Hills granite and the general metamorphism rather than to the Ellerslie-Wondalga granite with which the pyroxenic rocks may come in contact. Hornblende-pyroxene granulites also occur as xenoliths in the Cooma gneiss (Joplin, 1942, p. 171) which bears much the same metamorphic relations to the metasediments at Cooma as does the Green Hills granite to the metasediments here. All this suggests to me a transition from Amphibolite to Pyroxene Hornfels Facies and it is believed that the high-grade metasediments reflect the same tendency.

The introduction of potash and the production of mica in the higher-grade rocks have thrown all the mineral assemblages into disequilibrium. In developing this broad facies picture I have attempted to restore the mineralogy of the various metasediments to what it probably was before these disturbing influences caused the retrogression.

It is felt that despite this present disequilibrium the metamorphic facies progression is sufficiently clear to merit our attention.

In the Cooma study Dr. Joplin correlated her metamorphic zones with those devised by Barrow (see p. 98) for the Dalradian of Scotland and believed that Barrow's almandine, staurolite and kyanite zones were missing. She related the high-grade rocks (permeation and injection zones) to Barrow's sillimanite zone and referred to a "metamorphic unconformity" existing between the biotite and sillimanite zones. Actually there seems to be no need for postulating such a break and from a consideration of the various facies there is not much evidence for it. There was probably a waxing and waning of the temperature/stress ratio and various other complicatory events such as alkali-metasomatism during the metamorphic history of this area but, broadly speaking, the facies involved belong to a series indicating a general increase in grade with approach to the granite masses. Table 8 shows the suggested sequence of facies and subfacies encountered in this study (they also occur at Cooma) and the zonal correlation together with Barrow's zonal series and the appropriate facies and subfacies (mainly after Turner, 1948). In both cases the same facies are involved but, except in connection with the Greenschist Facies, rocks from the two areas (the Grampian Highlands of Scotland and the present area) belong to different subfacies. Barrow's subfacies equivalents are indicative of a more dynamothermal metamorphism than those referred to in this paper which bespeak a more thermal type (with less stress influence relative to the thermal effect) of metamorphism. This significant difference was noted by Joplin (1942). Fig. 9 (see p. 113) indicates that under the appropriate physical conditions the metasediments here described would have developed Barrow's index mineral staurolite (almandine might have been formed at a lower-grade stage) instead of the andalusite and cordierite. I do not believe that the high-grade zones at Cooma and in the Wantabadgery-Adelong-Tumbarumba area are strictly correlable with Barrow's sillimanite zone (Joplin, 1942, p. 194) which, according to Turner, represents the sillimanite-almandine subfacies of the Amphibolite Facies, but rather that the development of sillimanite represents an incomplete transition to a higher-grade facies. Turner (1948) quotes the work of Tattam (1929) in the north-eastern Victorian complex in connection with the mineral reaction biotite → sillimanite shown by some of the rocks of that area; a similar transition occurs in this area, especially in the pelitic inclusions in the granites but also to some extent in the

TABLE 8.

Metamorphic Zones and the Equivalent Facies and Subfacies (partly after Turner, 1948).

	Barrow's Zones.	Facies and Subfacies.		Zones Used in this Study.
		GREENSCHIST FACIES		
—Increasing Temperature— ↓	Chlorite Zone	Muscovite-chlorite subfacies	Muscovite-chlorite subfacies	Low-grade Zone
	Biotite Zone	Biotite-chlorite subfacies	Biotite-chlorite subfacies	Biotite Zone
		———*Temperature/Stress Increasing*———→		
		ALBITE-EPIDOTE AMPHIBOLITE FACIES		
	Garnet Zone (Almandine)	Chloritoid-almandine subfacies	Actinolite-epidote hornfels subfacies	
				Knotted schist Zone
		AMPHIBOLITE FACIES		
	Staurolite Zone	Staurolite-kyanite subfacies		
	Kyanite Zone			
			Cordierite-anthophyllite subfacies	High-grade Zone
	Sillimanite Zone	Sillimanite-almandine subfacies		
		PYROXENE HORNFELS FACIES		

country-rocks. Turner suggests that the reaction is typical of the sillimanite-almandine subfacies, but it seems probable that it is not confined to that particular environment.

The foregoing remarks serve to show that the metamorphic progression described in this paper runs, in a sense, parallel to the Dalradian metamorphic sequence of George Barrow; they also emphasize the fact that Barrow's zones represent but one type of metamorphic progression. In the present case the metamorphism was regional in extent but had an important thermal factor. Consideration of the problem of the relation between the granite masses and the metamorphism must be deferred until the granites themselves have been described.

EXPLANATION OF PLATES V AND VI.

Plate v.

Geological sketch map of the Wantabadgery-Adelong-Tumbarumba district.

Plate vi.

A. Banded low-grade siliceous metasediment from the western side of the jasper belt near Nangus. Note the contortions and rupture induced by the deformation after the development of the schistosity. Granular quartz has been deposited along the lines of fracture. Ordinary light.

B. Siliceous serpentine-bearing rock. Patches of fairly coarse fibrous antigorite occur in a matrix of finer antigorite, talc, chalcedony, and calcite. Note the chalcedony vein (dark) with faint marginal radiating growths. Crossed nicols.

C. A rather coarse sandy psammopelite (subgreywacke) from the knotted schist zone. There is a general orientation of the sand grains (quartz, felspar, and a few rock fragments) in a matrix now consisting of biotite and muscovite. Some of the sand grains show signs of granulation. It is clear that this rock has retained more detrital features than has the isogradal finer-grained type (no. D). Crossed nicols.

D. Psammopelite from the knotted schist zone. Mica flakes are distinctly recrystallized and show a preferred orientation along the obvious schistosity. Ordinary light.

E. Knotted schist (pelite) from near the high-grade zone outer limit. The photograph shows a lustrous schistosity-plane with large euhedral micaceous pseudomorphs after andalusite (?—most crystals are defaced but andalusite forms (001), (011), and (110) are visible in some cases). The scale is in inches.

F. Spotted granulite (pelite) from the high-grade zone. Note the fresh andalusite porphyroblast (right of centre) with a granular marginal zone; the irregular patch in the core is an aggregate of sillimanite needles. To the left of the big andalusite grain is a ragged porphyroblast of cordierite now completely replaced by a fine mica aggregate. The rock is distinctly more granular than the lower-grade schists. Ordinary light.

Magnification of nos. A, B, C, D, and F is × 13.

Photographs by G. E. McInnes.

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CYTOLOGY OF *SEPTORIA* AND *SELENOPHOMA* SPORES.

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(Plate vii; three Text-figures.)

[Read 29th July, 1953.]

Synopsis.

The Giemsa stain was used to demonstrate the nuclear condition in macrospores of species of *Septoria* and *Selenophoma*, and in species of *Ascochyta*, *Colletotrichum*, *Fusarium*, *Gloeosporium*, *Neurospora* and *Phyllosticta*. One nucleus per cell was recorded for all species except *Neurospora*. The nuclei in the immature, one-celled spores of *Septoria nodorum* consisted of 5-7 fragments. One nucleus, linear in form, was demonstrated in the micropycnidiospores of *Septoria tritici*. The nuclei in the germ tubes and hyphae of some of the species were also studied, and in many cases were found to be elongated. The small nuclei in hyphae and conidia of *Neurospora tetrasperma* were rounded.

Several other methods, involving different fixatives and stains, were used, and the results obtained with Giemsa were confirmed. No nuclei could be detected in living spores of *Septoria* and *Selenophoma* species with the phase contrast microscope.

Spores of species of *Septoria*, *Selenophoma* and *Ascochyta* from the field and from culture were stained to demonstrate the amount of fat present and its distribution in the spores.

1. The Nuclear Condition.

The nuclear condition of species of *Septoria* and *Selenophoma* (particularly of those occurring on Gramineae in Australia) was investigated.

There is very little information in the literature concerning the nuclear condition of either the spores or the mycelium of these genera. Sprague (1934), when describing the spores of *Septoria tritici* f. *avenae*, stated "the contents are homogeneous, with nuclei and nucleoli clearly evident". Moore (1940) cited the description of Ellis and Martin of *S. consimilis* on lettuce (held to be similar to *S. lactucae*) as "spores filiform, multinucleate". In their detailed study of the structure and germination of *Septoria* spores, McMillan and Plunkett (1942) noted, however, that "in no protoplast, stained or unstained, has there been any structure that could be construed as a nucleus". MacNeill (1950) published a preliminary note on a study of *S. lycopersici*, stating that "the Feulgen stain, modified to suit the type of material at hand, indicates a uninucleate condition of both spore and mycelial cells". Shaw (1951) found that nuclei were clearly visible in spores and sporophores of *S. pepli* in sectioned diseased leaves stained with gentian violet-orange G. In this case, however, the septations were not clear, so that the number of nuclei per cell could not be determined.

The nuclear condition of the micropycnidiospores in some species of *Septoria* has not previously been determined.

There appear to be only two references to the nuclear condition of species of *Selenophoma*. Allison (1945) reported that the spores of *S. bromigena* were slightly guttulate, non-septate and multinucleate. Vanterpool (1947) recorded that the spores of *S. linicola* on flax may be either uninucleate or multinucleate.

Methods.

A method was sought whereby spores and mycelium could be stained without embedding and sectioning. The aceto-orcein and aceto-carmine methods of McClintock (1945) and the aceto-carmine method of Cherewick (1944) were not successful. The Method 2 of Robinow (1944), of dipping unfixed, air-dried impression preparations for five seconds into boiling N/5 HCl, rinsing and mounting in 0·1% crystal violet in water, was also unsuccessful.

The following methods were found to give good results with the organisms tested. In all cases spores were allowed to exude from pycnidia into a drop of tap water on grease-free slides, or secondary conidia or mycelium were added to the water, direct from cultures. In most tests the water was allowed to evaporate at room temperature. When germinating spores were required, the slides were placed in petri dishes with moist cotton wool, taken out after the required length of time, and allowed to air-dry. The spores or mycelium adhered to the slides throughout all the subsequent treatments.

Method 1.

This method is a modification of one used by Knaysi, Hillier and Fabricant (1950), whose technique has been used successfully with bacteria by Mr. A. D. Rovira, of the Microbiology Department, Faculty of Agriculture, University of Sydney. The method as adapted for the fungal material is as follows: (i) fix air-dried spores in 95% alcohol for 12–15 minutes; (ii) hydrolyse in N HCl at 60°C. for 6–15 minutes; (iii) wash in tap water for one minute; (iv) stain with 10% Giemsa for approximately one hour; (v) wash in tap water for one minute, and either allow to dry and examine under oil immersion or dehydrate in the acetone/xylol mixtures of Robinow (1944), mount in euparal and examine under oil: or allow to dry, mount in euparal and examine under oil.

This method is quick and has given consistently good results. The nuclei stain vivid red-purple, and the cytoplasm stains very faint mauve.

Air-drying alone has been used for fixation, e.g., for the study of mitoses in peripheral embryonic blood and for yeast cells, followed by hardening in 95% alcohol (Darlington and La Cour, 1947, p. 67 and p. 61 respectively). Knaysi *et al.* (1950) considered that fixation with alcohol dissolved lipids and so increased the penetration of the dye into the cellular structures of *Mycobacterium tuberculosis.*

Air-drying was done at room temperature, or at higher temperatures over a microscope lamp. Alcohol was added to the slides while a thin film of moisture remained around the spores, and was then allowed to evaporate. There appeared to be no difference in the results.

The time of fixation by 95% alcohol was varied from 1 to 15 minutes without appreciably altering the results. The time of hydrolysis varied from 1 to 15 minutes: best results were obtained with hydrolysis of 6–15 minutes, depending on the species. Best results were obtained when tap water (pH just over 7) rather than distilled water was used for washing.

Shaw (1952) used the above method to show the nuclear condition of sporidia of *Tolyposporium restifaciens*, and it has been the main method used throughout this study. Barratt and Garnjobst (1949) also used an acid Giemsa stain to determine the number of nuclei in macro- and microspores of *Neurospora crassa.*

The other methods were used to determine whether the same picture of the nuclear condition was obtained (*a*) by using a different fixative and (*b*) by using another stain. No major differences were detected in the nuclear condition with the other methods.

Method 2.

(i) Treat the air-dried spores according to Robinow (1944) by fixing in the vapour of 5 ml. of 2% osmium tetroxide for three minutes and allow to dry; (ii) immerse in 70% alcohol for five minutes; (iii) hydrolyse in N HCl at 60°C. for ten minutes; (iv) stain with 10% Giemsa for one hour; (v) subsequent treatment as Method 1.

The nuclei stain red and the cytoplasm stains faintly mauve.

Method 3.

(i) Immerse the air-dried spores in water at 80°C. for 10–20 minutes. This procedure was used by Knaysi *et al.* (1950) in tests with desoxyribonuclease on *M. tuberculosis*; (ii) wash several times in water; (iii) stain with 10% Giemsa for one hour; (iv) subsequent treatment as Method 1.

The result obtained is not as clear as with Method 1, but proved particularly good for spores of *Selenophoma donacis* produced in culture. The nuclei stain red and the cytoplasm mauve.

Method 4.

As a further check on the nuclear picture, spores were stained by the Feulgen technique. The leuco-basic fuchsin was prepared according to the modified formula after de Tomasi (1936) and Coleman (1938), as given by Darlington and La Cour (1947). Subsequent treatment was mainly as recommended by the Botany Department, University of Sydney: (i) Fix in acetic alcohol (3:1) for ten minutes; (ii) take through the alcohols from absolute to water; (iii) hydrolyse in N HCl at 60°C. for six minutes; (iv) stain in leuco-basic fuchsin for 15–24 hours; (v) wash in sulphite water four times (ten minutes each); (vi) rinse in distilled water; (vii) take through 20%, 60%, 80% and absolute alcohol; (viii) mount in euparal.

This method is longer than the preceding ones, and great care has to be taken in preparing the leuco-basic fuchsin. The nuclei stain reddish-purple and the cytoplasm faint pink.

Method 5.

For an approximate picture of the nuclear condition, very dilute cotton-blue lactophenol can be used. The nuclei stain deep blue, the cytoplasm blue, and the guttulae remain unstained.

Live spores of species of *Selenophoma* and *Septoria* were also examined under the phase contrast microscope, both in phase and with dark field, but no nuclei could be detected.

Examination of stained material was made with a Zeiss microscope using a combination of 90X apochromatic objective (N.A. = 1·3) and 20X and 15X oculars. Photographs were taken using the same microscope and objective, and a 12X ocular with trichrome green filter and Process Pan film. A few photographs were taken by Mr. Woodward-Smith and these are so specified.

RESULTS.

Examination was made of spores of the following species of *Septoria* and *Selenophoma*, from the field (F) and from culture (C). Spores of species of *Ascochyta*, *Colletotrichum*, *Fusarium*, *Neurospora* and *Phyllosticta* were also included in the tests. Germinating spores and mycelium were studied in the species marked †.

Fungus.	Host.	Source.
Septoria avenae.	*Avena sterilis.*	F†
S. avenae f. *triticea.*	*Triticum vulgare.*	F†
S. bromi.	*Bromus molliformis.*	F & C
S. macropoda.	*Poa annua.*	F
S. nodorum.	*Triticum vulgare.*	F†
S. tritici (macro- and micro-pycnidiospores).	*T. vulgare.*	F & C†
S. tritici var. *lolicola.*	*Lolium multiflorum.*	F & C†
Septoria sp.	*Anthoxanthum odoratum.*	F
S. apii-graveolentis.	*Apium graveolens.*	F
S. dianthi.	*Dianthus barbatus.*	F
S. dianthi.	*D. caryophyllus.*	F
S. lactucae.	*Lactuca sativa.*	F
S. lactucae.	*L. scariola.*	F
S. lycopersici.	*Lycopersicon esculentum.*	F
S. pepli.	*Euphorbia peplus.*	F
Septoria sp.	*Erodium cygnorum.*	F
Septoria sp.	*Silene gallica*	F
Septoria sp.	*Stellaria media.*	F
Selenophoma donacis.	*Arundo donax* (?).	F & C†
S. donacis var. *stomaticola.*	*Agropyron scabrum.*	F & C†
S. donacis var. *stomaticola.*	*Triticum vulgare.*	F & C†
Ascochyta sp.	*Bromus unioloides.*	F†
Colletotrichum graminicolum.	*B. unioloides.*	F
Fusarium sp. (macro- and micro-spores).		C
Gloeosporium sp.		C
Neurospora tetrasperma.		C
Phyllosticta sp.	*Dichelachne sciurea.*	F

All the species of *Septoria* examined had one nucleus per cell, so that the number of nuclei per spore equalled the number of cells per spore (Plate vii, 1 and 4).

The scolecosporous or filiform-spored species of *Septoria* are generally recognized as typical of the genus. These species usually produce slow-growing yeasty colonies on P.D.A., with or without the production of secondary conidia, the cultures later becoming carbonaceous. The nuclei did not stain as easily or as vividly as the nuclei of that other type still designated by many workers as belonging to the genus *Septoria*, and typified by *S. avenae* and *S. nodorum*. This latter type has cylindrical spores which produce quickly-growing cottony cultures on P.D.A. The nuclei of the spores stained easily and vividly, and in conformity with the wider spore the nuclei were wider than the nuclei in the filiform spores.

In many preparations, under the most critical illumination, the nuclei of mature spores of *S. nodorum* could be resolved into 5–7 fairly circular fragments arranged in a circle. In immature one-celled spores pressed out of pycnidia these rounded fragments were distributed over a larger but still circular area in the centre of the spore, as in Text-figure 3. It is to be noted that in these one-celled spores there is only one area containing the nuclear fragments, so that the four nuclei in mature spores are probably all derived from a single nucleus.

The nuclear condition of micropycnidiospores of species of *Septoria* has not previously been determined. Microspores of *S. tritici* were stained by Method 1, preparations being chosen for study where macropycnidiospores were also present for comparison. One nuclear region occurred per microspore and was linear in shape, conforming to the morphology of the spore, measuring 4–5μ long × 0·8μ wide, the spores themselves being usually 8–10μ long × 0·8μ wide. The nuclear region was not homogeneous, as about five deeply-staining areas occurred close together in sequence (Plate vii, 3; Text-fig. 2).

In most cases the nuclei of spores allowed to remain in water for several hours lost some of their vividness as compared with the nuclei of freshly-exuded spores. In spores where germination had commenced from only one or two cells, the nuclei in these cells appeared more diffuse and less deeply stained than in the cells without germ tubes. In preparations showing spores after five hours in water, where more than 90% of the spores had germinated, the ungerminated spores were outstanding because of the vividness of the nuclei. In some germinating cells, however, the nuclei still stained sharply.

Nuclei appeared in the germ tubes after approximately four hours (Plate vii, 5). At that time germ tubes of *S. nodorum* and *S. avenae* were about 30μ long, and there was usually one arising from each end of the spore. The nuclei in the germ tubes in preparations obtained by the methods outlined were always longer than wide, and parallel to the direction of the hyphae. The only more or less circular nucleus detected in preparations of young germinating material was at the junction of two branches. In spores after 5–6 hours in water, two regions of chromatinic reaction, or two linear nuclei, were detected in the germ tubes. Under critical illumination many of these linear nuclei could be resolved into rounded fragments, usually about 5–7 in number, but sometimes more. In older material the nuclei were spaced rather regularly along the hyphae, and all had the linear form.

Spores were allowed to remain in water for 24 hours, by which time a weft of hyphae had been produced on the slide. This was allowed to air-dry and was treated as were the spores. The chromatinic areas were easily detected in the hyphae, were rather regularly spaced, and again had the linear form. Mycelium from one-week-old cultures of the cottony *Septoria* species (*S. nodorum*, *S. avenae*, and *S. avenae* f. *triticea*) was teased out in water on slides and treated as in Method 1. Linear nuclei were again observed, with others slightly more rounded in outline (Plate vii, 6).

Selenophoma Species.

Mature spores examined of *S. donacis* and *S. donacis* var. *stomaticola* had one nucleus per spore (Plate vii, 8).

Conidia of the variety are produced abundantly in culture, and more or less retain the falcate shape. In some spores a septum is laid down at the centre, and in these two nuclei—or one per cell—occurred. Conidia of the species are also produced abundantly in culture, but vary from falcate to linear to sausage-shaped, together with many other abnormal forms. In the falcate-shaped spores the nuclei stained vividly and were regularly rounded in outline, with the cytoplasm only faintly stained. In the abnormally-shaped spores the nuclei were more difficult to differentiate. In dividing spores two nuclei occurred, or one per cell (Text-fig. 1).

Text-figures 1-3.

1. Conidia of *Selenophoma donacis* from culture, stained with Giemsa, showing one nucleus per spore and two nuclei in dividing spores. Spore "s" is similar to pycnidiospores from the field. × 1000.

2. Micropycnidiospores of *Septoria tritici*, stained with Giemsa, showing one linear, slightly "beaded" nucleus per spore. × 2000.

3. Single-celled immature spores of *Septoria nodorum* pressed out of pycnidia, showing one region of nuclear activity per cell: three cells with 5-7 fragments and one cell with a nucleus of two parts. Some nuclei in the more mature 2- and 4-celled spores also showing fragments. Stained with Giemsa. × 2000.

Other Genera.

Spores of *Colletotrichum* sp., *Gloeosporium* sp. and *Phyllosticta* sp. showed one nucleus per cell, i.e., one nucleus per spore, when stained with Giemsa. Spores of *Ascochyta* sp. also had one nucleus per cell, or two per spore, and spores of *Fusarium* sp. had one nucleus per cell, so that the microspores had one per spore, and the macrospores had the same number of nuclei as the number of cells in the spores. Conidia of *Neurospora tetrasperma* had from several to many (exact number not determined) nuclei per cell, and the mycelium had many approximately round nuclei scattered throughout the cells (Plate vii, 7).

DISCUSSION.

The Feulgen reaction is specific for desoxyribonucleic acid, and Murray *et al.* (1950) and Tulasne and Vendreley (1947) stated that the Giemsa stain may also be considered to demonstrate the distribution of DNA (desoxyribonucleic acid). DNA is concentrated in the nucleus and there is little doubt, therefore, that the areas stained in these preparations with Giemsa do represent the nuclei.

Some workers have recorded that certain macroconidia contain more than one nucleus per cell, e.g., the conidia of *Neurospora crassa*, where 1–20 are common (Barratt and Garnjobst, 1949), and in *Helminthosporium carbonum*, where each cell of the 1- to 9-celled mature conidia contains from 1–8 nuclei (Roane, 1952).

The present study has shown, however, that the macro- and micropycnidiospores and conidia of the species of *Septoria* and *Selenophoma* examined have one nucleus per cell. From the evidence obtained from the one-celled immature spores of *Septoria nodorum*, where only one area of nuclear reaction was detected, it would seem that the nuclei in the mature spores are all derived from one nucleus.

The nuclei of the spores of *S. nodorum* can be resolved into 5–7 fragments. This might be an artefact produced by the methods used, or might truly represent 5–7 chromatinic areas carrying a heavier charge of desoxyribonucleic acid.

Darlington and La Cour (1940) pointed out that with *Trillium* the over-nucleated chromocentres of the resting stage are in fact the under-nucleated differential segments of metaphase—they are the heterochromatic parts of the chromosomes. Hillary (1939), in tests with the Feulgen reaction, using tissue of animals, plants, bacteria and fungi, recorded that with fungi (species of *Mucor*, *Geopyxis* and *Aleurodiscus*) there was in most cases a large nucleus with small chromocentres distributed around the nucleolus and the periphery of the nucleus.

As the actual division of the nucleus into two was not observed in *S. nodorum*, it is impossible to say whether the 5–7 fragments retain their identity in the actively dividing state, or whether they are of a heterochromatinic nature and are undercharged with DNA when the nucleus divides.

Elongated nuclei were usual in these preparations of germ tubes and hyphae. Smith (1923) noted "long torpedo-like" nuclei in some parts of the thallus of *Saprolegnia*, and Wilson (1937) stated that in the spongy framework of the sporophore of *Peziza rutilans* were "hyphae taking an unusual straight course with septa at infrequent intervals and long spindle-shaped nuclei pressed in single file against their walls. So peculiar did these nuclei appear that some doubt was felt as to their nature until the Feulgen reaction was carried out, when the chromatin threads were brightly coloured. The elongation of the nuclei does not appear to be caused by the narrowness of the hyphae as is the case in the paraphyses."

Smith (1923) considered that the constant upward streaming seemed to cause a tension or strain within the semi-liquid cytoplasm, and the nuclei responded to the strain by becoming elongated.

It is considered that the linearity of the nuclei of the microspores of *S. tritici* is due to the conformation of the microspore. The elongated nuclei in the hyphae and germ tubes might also be caused by the narrowness in relation to the size of the nuclei.

When the linear nuclei were first observed, it was thought that the linearity might have been caused by the methods of drying and fixing used, but the condition persisted when the speed of drying was altered by varying the temperature and when fixations were carried out without previous drying. It is also to be noted that rounded nuclei in spores occurred in the same preparations as linear nuclei in hyphae and microspores. Also, in the conidia and hyphae of *Neurospora tetrasperma*, the nuclei, which are small in relation to the cells containing them, are revealed by using Method 1 to be nearly circular, and are similar in appearance to those figured by Cutter (1946) using a completely different technique.

The linear nuclei in the microspores and in many of the hyphae have a "beaded" appearance. These "beads" might represent the fragments seen in some of the nuclei of the spores.

The difference in the intensity of stain in the nuclei in germinated and ungerminated spores probably indicates a change in the distribution of the desoxyribonucleic acid as the cell begins to germinate.

Stained spores were examined in every stage of germination, and it was noteworthy that no nucleus in the many germinating *Septoria* spores examined was detected in the act of dividing—the nuclei in young germ tubes all appeared at some little distance from the spore nuclei. The closest observed was in the spore shown in Plate vii, 5.

Details of mitosis in dividing spores of *Selenophoma* could not be determined. The nuclei had an amitotic appearance (Text-fig. 1), but as pointed out by Cutter (1946) for other fungal nuclei, this might be an artefact.

In an endeavour to observe the mitotic division, living spores of both *Septoria* spp. and *Selenophoma* sp. were kept under continuous observation under phase contrast, but, as already noted, no nucleus could be detected, either in phase or with dark field. This confirms the finding of McMillan and Plunkett (1942), who, using bright and dark field microscope, could find no structure that could be construed as a nucleus. Apparently the R.I. of the nucleus in these spores is so similar to the R.I. of the cytoplasm that it cannot be detected even with phase contrast, or else the cytoplasm is so dense that the nucleus is obscured.

2. Fat Reaction.

Spores of *Septoria*, *Selenophoma* and *Ascochyta* from the field and from culture were stained to demonstrate the amount of fat present and its distribution.

Spores were allowed to exude from pycnidia into water on clean slides, or secondary spores were added to the water from culture and allowed to air-dry. Spores adhered to the slides during all the subsequent treatments. Fat was stained according to the methods outlined below.

Methods.

Method 1. Sudan III.

A saturated solution of Sudan III in 70% alcohol and pure acetone (1:1) was prepared, and the spores on the slides treated as follows (after Conn, 1936): (i) Fix in the vapour of formaldehyde for 10 minutes; (ii) stain in Sudan III for 10 minutes (in a sealed dish); (iii) dip for an instant in 65% alcohol; (iv) wash in water; (v) mount in glycerine.

Method 2. Sudan IV.

A saturated solution was prepared in 70% alcohol and the material treated as in Method 1.

Both Sudan III and Sudan IV stained fat a vivid orange. Cotton-blue was sometimes used as a counter stain.

Spores were also treated with benzol or ether, either (*a*) before the above staining treatments, to remove the fat (no fat was detected after the subsequent staining treatments); or (*b*) after staining. In this case the stained fat disappeared very slowly.

Fat can also be demonstrated in spores by treating with cotton-blue without previous air-drying or staining. Fat globules remain unstained.

Results.

Filiform Septoria *Spores, as* Septoria tritici.

Usually no large guttulae are visible in unstained spores from the field, and, when viewed at high magnifications, only small guttulae in spores stained with cotton-blue.

After staining with Sudan, a fat reaction can be detected by a faint orange "speckled" condition over the spore, and very occasionally in very small globules, often near the septa.

In culture many of the species produce conidia directly on the mycelium. The conidia vary in shape from symmetrically filiform to asymmetrically bacillar, with a varying number of septa. When grown on P.D.A. an abundance of fatty material can be detected in most conidia, especially from old cultures. It occurs first as fatty globules strung along the spore, later forming patches or blocks, sometimes nearly occupying the whole spore, which loses its identity. It stains a vivid orange colour with Sudan.

When counterstained with cotton-blue lacto-phenol, the orange colour remains undisturbed, as if the whole interior of that portion of the cell were a block of fat.

Cylindrical Septoria *Spores, as in* S. nodorum, S. avenae.

In the unstained spores from the field, and in spores stained with cotton-blue lacto-phenol, large and small guttulae, sometimes nearly the width of the spore, can easily be detected. They are usually situated at both ends of the cells, i.e., clustered around the septa and at the ends of the spores.

Staining with Sudan colours the guttulae a deep red-orange. The rest of the cell remains unstained—no "speckling" occurs as in the filiform spores (Plate vii, 10).

These species do not, as far as is known, produce conidia in culture, but occasionally pycnidiospores are produced. When stained with Sudan the spores show fat accumulation in all stages, from those with guttulae of various sizes clustered at each end of the cells around the septa, to those where the numbers of guttulae have increased and spread from the ends towards the centre of the cells. At a later stage practically the whole spore, except for the septa and an area about the centre of each cell, is coloured a deep orange. At a high magnification this fat is revealed as masses of rather evenly-sized globules. The free area in the centre is probably that occupied by the nucleus.

Ascochyta *sp. from* Bromus unioloides.

Fat distribution in these spores is similar to that in the cylindrical type of *Septoria* spore, where guttulae are clearly visible in the unstained and cotton-blue stained spores from the field. After treatment with Sudan, the guttulae stain a deep orange, with the rest of the spore unstained (Plate vii, 9).

Selenophoma *sp.*

No guttulae were visible in the spores of most field collections of *Selenophoma*, either unstained or stained with cotton-blue. With these spores, either no fat, or a faint "speckling" towards the ends of the spore, was detected with Sudan.

As with the filiform type of *Septoria* species, secondary spores are produced directly on the mycelium in culture. When treated with Sudan, well-formed symmetrical young spores gave no fat reaction. Other spores, older and more asymmetrical, had faint pale orange "speckling", and some had a few circular globules which gave a deep orange colour. Old and knobbly mycelium from culture was packed with large globules and stained vividly with Sudan.

DISCUSSION.

These tests show that the amount of fat, judged qualitatively, and its distribution, is different in the two types of *Septoria* spores as they occur in the field. Spores of *Ascochyta* sp. from *Bromus unioloides* gave a reaction for fat similar to the cylindrical type of *Septoria* spores, and spores of *Selenophoma* gave a reaction similar to the filiform type of *Septoria* spores. Under cultural conditions favouring high fat synthesis, additional fatty material is stored in the cells to such an extent that very large globules or whole blocks of fat occur, particularly in the filiform spores.

Foster (1949) has pointed out that with fungi, while the major deposits of fat obviously are in vacuole globules, some lipide material undoubtedly does exist in the cytoplasm proper, and some fatty materials are laid down in the cell wall of fungi. In this latter case the fatty material is sometimes protected.

Slight differences were detected in the intensity of the stain in some of the spores, particularly in those of *Ascochyta* sp. The colour varied from bright orange to deep orange. Sudan is reputed to colour "true fats" intensely, and cholesterin esters and cholesterin-fatty acid mixtures less intensely. The slight differences in the intensity of the above preparations could be due to differences in the type of fat present, or to differences in the concentration of the fat in the globules.

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EXPLANATION OF PLATE VII.

1. Spores of *Septoria nodorum* stained with Giemsa. The nuclei (one per cell) are vividly stained, the septations clear, and guttulae are visible in the cells as unstained circular areas. × 1000.

2. Micropycnidiospores and portion of a macropycnidiospore of *Septoria tritici* stained with cotton-blue lacto-phenol. × 1000.

3. Micropycnidiospores and portions of small macropycnidiospores of *Septoria tritici* from summer material from the field, stained with Giemsa. Note the linear nucleus in each microspore, conforming to the shape of the spore, and the rounded nuclei in the macrospores. The cytoplasm in the ends of the microspores is only faintly stained. × 1000.

4. Filiform spores of *Septoria lactucae* stained with Giemsa, showing one nucleus per cell and faint septations. × 1000.

5. Germinating spore of *Septoria avenae* stained with Giemsa, showing germ tubes from three cells. The four nuclei in the spore are vividly stained, the linear nuclei in the germ tubes less intensely stained. Photograph by Woodward-Smith. × 900.

6. Hyphae of *Septoria* sp. from *Anthoxanthum odoratum* from culture, stained with Giemsa, showing linear nuclei. Photograph by Woodward-Smith. × 900.

7. Conidia of *Neurospora tetrasperma* stained with Giemsa, showing many small rounded nuclei per spore, the spore walls being out of focus. Photograph by Woodward-Smith. × 900.

8. Spores of *Selenophoma donacis* var. *stomaticola* from culture, stained with Giemsa, showing one nucleus per spore. × 1000.

9. Spores of *Ascochyta* sp. from the field, stained with Sudan, showing heavily stained fat globules clustered at each end of the cells. Photographed with a blue filter. × 1000.

10. Spore of *Septoria nodorum* from the field, stained with Sudan, showing heavily stained fat globules distributed as in the *Ascochyta spores*. Photographed with a blue filter. × 1000.

THE *CULEX PIPIENS* GROUP IN SOUTH–EASTERN AUSTRALIA. II.

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(Five Text-figures.)

[Read 29th July, 1953.]

Synopsis.

The *Culex pipiens* complex in Australia consists of three forms: *C. fatigans, C. pipiens* form *molestus* and *C. pipiens australicus,* n. subsp. An account is given of their morphological and biological characteristics, their distribution in Australia and their capacity for interbreeding. These observations provide the basis for a discussion of the taxonomic status of the three forms.

In its morphology and biology the Australian *molestus* conforms to *C. molestus* as described by Marshall and Staley. The status of this mosquito remains obscure and until its relationships to *C. pipiens* and *C. fatigans* are more definitely established, it should be called *C. pipiens* form *molestus*. It is recorded from Victoria and northern Tasmania.

C. fatigans is widely distributed in Australia but in southern Victoria it is found regularly only in late summer and autumn. It hybridizes freely with *C. pipiens* form *molestus* but no permanent populations of intermediates have been found in Victoria. Interbreeding between *C. fatigans* and other members of the *C. pipiens* complex has been recorded from various parts of the world but the available evidence does not seem to justify the reduction of *C. fatigans* to the status of a subspecies of *C. pipiens*.

C. pipiens australicus, n. subsp., is also widely distributed in Australia. Morphologically it is distinct from other members of the complex; biologically it is very similar to *C. pipiens*. It is a rural non-man-biting mosquito which is anautogenous, eurygamous and heterodynamic. It has a limited capacity for interbreeding with *C. fatigans* and *C. pipiens* form *molestus* in the laboratory but in nature is reproductively isolated from both these forms.

INTRODUCTION.

The problems presented by the *Culex pipiens* complex (Mattingly *et al.*, 1951) concern the relationships of *C. pipiens* L., *C. fatigans* Wied. and *C. molestus* Forskål.

Until recently the status of *C. pipiens* and *C. fatigans* as distinct species had not been seriously questioned, but there is now evidence from various parts of the world, and particularly from the United States, that where the two forms occur together, they interbreed with the production of permanent populations of intermediates. Hence it has been claimed that *fatigans* should be treated as a subspecies of *C. pipiens* L. It is however, not clear that the mosquito involved in these hybridizations is *C. pipiens*, s.s.; in some cases there is no doubt that it is actually *C. molestus*.

C. molestus was described by Forskål in 1778 but subsequently was included in the synonymy of *C. pipiens* L. In 1937 it was again recognized as a distinct species by Marshall and Staley (1937). Over a period of some years the observations of a number of workers had indicated the existence of two biological races of *C. pipiens* in Europe. One was a man-biting form which was autogenous, stenogamous and homodynamic; the other was anautogenous, eurygamous and heterodynamic and did not attack man. Marshall and Staley (1937) claimed that the two forms presented constant morphological differences and should be regarded as distinct species. For the autogenous form they revived Forskål's name *C. molestus*; the name *C. pipiens* L. they restricted to the anautogenous one.

This conclusion has not been universally accepted; some authors follow Marshall and Staley, but others regard *molestus* as a subspecies, or merely as a biotype, of *C. pipiens*. Thus the name *pipiens* as used by some authors, including nearly all the earlier ones, has a wide meaning, as used by others, a narrow one. In order to avoid confusion we shall use the terms *pipiens* and *molestus* in the sense in which they were defined by Marshall and Staley (1937).

The *C. pipiens* complex in Australia consists of three forms: *fatigans*, *molestus* and a third form which, as far as is known, is confined to this country. We regard this form as a new subspecies of *C. pipiens* L. Prior to its formal description, which cannot appropriately be given until its relationships to the other members of the complex have been discussed, we will refer to it as *australicus*.

A. MORPHOLOGICAL AND BIOLOGICAL CHARACTERISTICS OF THE MEMBERS OF THE COMPLEX.

a. fatigans.

The form *fatigans* has a world-wide distribution in the tropics and subtropics and is the common domestic *Culex* over the greater part of Australia. In southern Victoria, however, it seems unable to maintain itself permanently. Drummond (1951) stated that in some years it was rare or absent in Melbourne, but detailed observations during 1951–52 indicate that its disappearance is a seasonal phenomenon. During the autumn of 1951 it was abundant in Melbourne but in the following spring could not be found. It was present in small numbers in January, 1952, at which time the other members of the *pipiens* group were abundant. It increased steadily during February, and in March the larvae were very numerous in all kinds of artificial water containers. Oviposition continued freely until the end of May and on a small scale for another month. However, most of the larvae emerging from eggs laid late in May and in June died before the end of July. A few pupated during the winter and adults emerged from time to time—one emergence was recorded in late August—but apparently they did not establish themselves. Thus in two successive years *fatigans* was abundant during the autumn but rare or absent in the spring.

C. fatigans is homodynamic and is said to be incapable of hibernation. We have not found hibernating adults but this is not significant, as we have likewise failed to find hibernating *australicus*, a form which is certainly able to hibernate. In Melbourne, reproduction in *fatigans* is brought to an end by winter temperatures and even if the adults emerging in June were able to survive the winter they would not have been fertilized because the low night-temperatures of autumn and early winter would inhibit mating. In the laboratory mating will not occur at temperatures below 20°C. Males would not be expected to survive, since they do not do so even in species which are known to hibernate. Resumption of breeding in the spring would then depend upon the survival of adults emerging from the small winter population of pupae; *fatigans* would thus be rare or absent during early spring. This difference from *molestus*, which is also homodynamic, can be attributed to the higher temperature requirements of *fatigans*.

A morphological characteristic of *fatigans* which requires comment here is the siphon index of the larva. Woodhill and Pasfield (1941) gave the index for Australian *fatigans* as ranging from 3·4 to 6·5. It seems that their material included larvae of *australicus* which at that time had not been distinguished from *fatigans*.* In collections from several localities in Victoria the index for *fatigans* larvae never exceeded 4·8 (Table 1).

The number of branches on head-seta *f* varies from two to six with a mean of five. This is greater than the number given by Hopkins (1936). This seta is of no value in distinguishing *fatigans* from the other members of the *pipiens* group in Australia.

b. molestus.

The form *molestus* was first recorded from Australia by Drummond (1951). At that time it was known from southern Victoria up to sixty miles north of Melbourne but its range now extends to the northern border of the State (Mildura, Albury), and southwards to Tasmania. Although Mattingly (1951, 1952) has described *molestus* as an urban mosquito it is not restricted to urban situations in Victoria. Here it is common in rural areas in the vicinity of dwellings.

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* The larvae of *australicus* were first recognized as distinct from typical *fatigans* by Dr. E. N. Marks in 1942. In correspondence she referred to them as "long-siphoned *fatigans*".

Morphologically, Australian *molestus* is indistinguishable from the European as described by Marshall and Staley (1937). The general colour is pale, the basal tergal bands are not constricted at the sides, and the venter is clothed entirely with pale scales. Some specimens collected in the autumn were darker than usual and had the general colour of *pipiens*. However, the venter was without dark scales and apart from the darker colour these specimens retained all the characteristics of *molestus*.

In the female the first fork cell is long (Table 2); the ratio of cell to petiole varies from 4·4 to 8·5, with a mean of 5·2. In the male the combined length of the first four segments of the palps is less than the length of the proboscis. The dimensions of the palps correspond closely with those given by Christophers (1951) (Table 3). The hypopygium, which is identical with that of the European *molestus*, will be discussed later.

The larvae also agree with the descriptions given by Marshall and Staley (1935) and Jobling (1938). The siphon index varies from 3·3 to 4·9, with a mean of 4·3.

TABLE 1.

Siphon Index of fatigans *from Victoria. Measurements are Expressed in Microns.*

Locality.	No.	Siphonal Index.			Length of Siphon.		
		Max.	Min.	Mean.	Max.	Min.	Mean.
Merbein—horse trough ..	50	4·6	3·5	4·3	1350	1098	1224
Merbein—rain-water tank ..	48	4·8	4·0	4·4	1384	1206	1296
Merbein—goose pond ..	50	4·6	3·6	4·2	1332	1026	1206
Culgoa—pool	49	4·6	3·7	4·0	1546	1260	1368
Melbourne	53	4·8	4·0	4·3	1530	1260	1296
	250	4·8	3·5	4·2	1546	1026	1278

C. molestus is a stenogamous mosquito; mating will occur in a space of a few cubic inches. In larger cages males may mate with resting females, but more usually mating is initiated while both sexes are in flight and is completed on the floor of the cage. In nature, swarming of males was often observed. It occurs just after sunset, between buildings or above the surface of water in tanks or butts. The swarms consisted of ten to thirty males.

A characteristic which has been regarded as highly distinctive of *molestus* is its capacity for autogenous reproduction. It is now known that in crosses, autogeny behaves as a simple mendelian recessive and it seems that the gene in question is not limited to *molestus* (Laven, 1951); in some populations of *molestus* it may be rare: in Cairo, Knight and Malek (1951) found that only one to four per cent. of females in wild populations were autogenous. Our earlier observations had indicated that a high proportion of Australian *molestus* were autogenous but, as Mattingly has pointed out, such a conclusion could have been influenced by unconscious selection in a laboratory colony. However, in the course of a recent experiment a group of thirty-nine females reared from a natural population of pupae produced thirty-eight autogenous egg rafts. Further work on the frequency of autogeny is in progress.

Several workers have noted that with *molestus* the egg rafts laid after a blood meal are generally larger than those produced autogenously. The size of the raft is also influenced by the size of the mosquitoes. A group of females which, because of an unfavourable larval environment, were below normal size and which were fed on human blood, laid rafts containing 50–60 eggs. On the other hand, autogenous rafts from females of normal size may contain 120–130 eggs. In rafts collected at natural breeding places the number of eggs varied from 30 to 178; in the majority the number was 70–125. The rafts are variable in shape; they may be oval, triangular or elongate.

In the laboratory *molestus* will breed without interruption throughout the year. In colonies maintained in outdoor cages emergences of adults, and egg-laying, continued during June and into the early part of July. In natural breeding places also, egg rafts were plentiful until the end of June and during one mild spell (temperature 14°C.) dancing of males was observed. It was noted, however, that attacks on man ceased about the middle of May. This was perhaps due to low night temperatures; it suggests that during the late autumn *molestus* maintains itself largely by autogeny.

Larvae which hatched from eggs laid in outdoor cages in June passed the winter in the third or fourth stage. The majority of larvae hatching in July died; the survivors reached the third stage in August. Emergence of adults from these colonies and from exposed natural breeding sites commenced in September but in some sheltered places, such as drainage pits, pupae were present during the winter and emergence was complete by the end of August. There is therefore no hibernation; Australian *molestus*, like the European, is homodynamic.

It is a man-biting mosquito and in Melbourne is a troublesome pest. It enters houses and bites at night. In this respect it is active from October until May.

Larval Ecology.—Occasionally, and mainly in the autumn, larvae are found in large pools and swamps but the favoured breeding places throughout the year are artificial containers such as water butts and drainage pits. The larvae are tolerant of foul water.

TABLE 2.

Ratio of Length of the Upper Fork Cell to Its Petiole in the Female Wing. The Length of the Cell was taken as that of its Lower Branch.

	No.	Upper Fork Cell/Petiole.		
		Max.	Min.	Mean.
fatigans	50	3·7	2·5	3·2
molestus	50	8·5	4·4	5·2
australicus	50	4·1	2·6	3·2

c. *australicus*.

This is the mosquito referred to by Drummond (1951) as an undescribed member* of the *C. pipiens* complex in Australia. Previously it had been confused with *fatigans*, but, in fact, is more closely allied to *pipiens*.

It has a general dark colour, the basal tergal bands are constricted at the sides and the venter has prominent median and lateral patches of dark scales. It is, therefore, readily distinguished from *molestus* and, with typical specimens, from *fatigans* also. With material from any one locality *australicus* and *fatigans* can be separated by the differences in colour, but with specimens from different areas separation of females is sometimes impossible. The venational character, the ratio of the first fork cell to its petiole, which is useful for distinguishing *fatigans* from *molestus*, is of no value in separating *fatigans* and *australicus* (Table 2).

Males, however, can be reliably identified by the palps and the hypopygium. Characteristics of the palps of members of the *pipiens* complex are shown in Table 3.

In both the absolute and relative length of the palpal segments *australicus* is intermediate between *pipiens* and *fatigans* but is closer to *pipiens*. The distinctive feature of the palps of *australicus*, as is shown in the table, is the abundance of hairs on the shaft. The distal half is densely clothed with long hairs. In *fatigans* the hairs are sparse and disposed more towards the tip (Fig. 1). A further distinction, seen in

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* This is the mosquito which in correspondence has been called "*fatigans* type B" and "long-siphoned *fatigans*".

living specimens, is that in *fatigans* the fourth and fifth segments are held approximately at right angles to the shaft; in *australicus* the fifth segment is bent backwards (Text-fig. 1).

The male hypopygium is also intermediate between those of *pipiens* and *fatigans* but it is sharply distinct from both (Text-fig. 2). The dorsal processes of the mesosome are directed outwards, are thickened distally and are slightly excavated at the tip. In *fatigans* these processes are upright, i.e. are almost parallel and are pointed. The ventral processes in *australicus* are leaf-like distally and are thus unlike the narrow sickle-shaped processes of *pipiens* (and *molestus*).

With regard to North American *pipiens*, however, the position is not clear. The mesosome of the Baltimore *pipiens* studied by Sundararaman (1941) and Rozeboom (1951) is distinctly different from that of European *pipiens*. This is shown by Rozeboom's illustration (Mattingly *et al.*, 1951, p. 347) and by his statement that it "closely resembles" the mesosome of the type specimen of *C. comitatus* from California for, according to Edwards (1931) and Freeborn (1926), *comitatus* is identical with *C. pipiens pallens* from the Orient. Edwards recognized *pallens* as a separate subspecies because of its distinctive mesosome.

TABLE 3.

Characteristics of the Male Palps of Members of the pipiens *Complex. Measurements are expressed in Millimetres. Measurements of European* pipiens *and* molestus *are taken from Christophers* (1951).

	Number of Specimens.	Length of Proboscis.	Dimensions and Proportions of Palps.						Number of Hairs on Shaft of Palp.			
			Segments 1–3.	Segments 1–4.	Total.	Segs. 1–4/ Proboscis.	Segs. 1–3/ Seg. 4.	Segs. 1–3/ Seg 5.	Number of Specimens.	Minimum.	Maximum.	Mean.
pipiens (Europe) ..	20	2·54	1·90	2·60	3·42	1·02	2·71	2·32	8	19	27	24
australicus	100	2·40	1·80	2·43	3·13	1·01	2·86	2·57	50	29	50	35
fatigans (Victoria) ..	100	2·06	1·58	2·05	2·55	0·99	3·36	3·16	50	6	14	10
molestus (Europe) ..	20	2·40	1·80	2·36	2·95	0·98	3·21	3·05	7	11	18	16
molestus (Victoria) ..	100	2·50	1·79	2·37	3·00	0·94	3·14	2·78	50	12	21	15

Further evidence that the mesosome of Baltimore *pipiens* is different from that of the European is given by the data of Sundararaman (1949) and Barr (Rozeboom, 1951) on the DV/D ratio. Both these workers found that the ratio was zero or positive. Christophers (1951) pointed out that in his strains of *pipiens* and *molestus* the ratio was negative and this was generally true of the Cairo *molestus* studied by Knight and Malek (1951), where the ratio varied from minus 0·14 to plus 0·02. There is then reason to doubt Sundararaman's identification of his material as *C. pipiens pipiens*.*

In respect of the structure of the mesosome, *australicus* approaches *pipiens pallens* and the Baltimore *pipiens*, but it is distinct from both these forms. Little information is available on *pipiens pallens*, but the observations of Feng (1938) indicate that it is a typical domestic mosquito. In their biology and morphology *pallens* and *comitatus*, in contrast to *australicus*, are closer to *fatigans* than to *pipiens*. It is, indeed, not clear why *pallens* is not regarded as a subspecies of *fatigans* rather than of *pipiens*. *australicus* and Baltimore *pipiens* differ in their biology, e.g. Baltimore *pipiens* will

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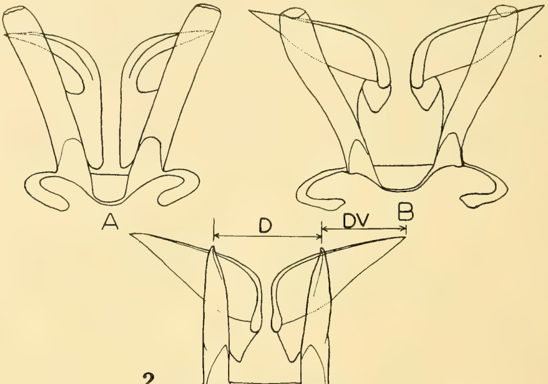
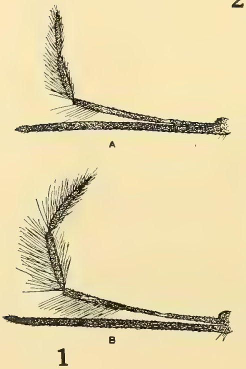
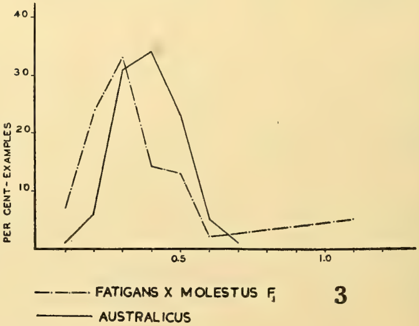
* The position is further complicated by the fact that in specimens of Baltimore *pipiens* sent to us by Professor Rozeboom the mesosome is identical with that of typical *pipiens*. The siphon index of larvae varied from 3·9 to 4·7, with a mean of 4·2; these values correspond to those of *molestus* and *fatigans*.

mate in a space of one cubic foot whereas *australicus* is eurygamous, and also in the structure of the mesosome. This is evident from a comparison of the published figures of the two forms and from the DV/D ratio. In *australicus* the ratio is higher and scarcely overlaps that of Baltimore *pipiens*.

As is shown below, *molestus* and *fatigans* will interbreed readily in the laboratory. The mesosome of the hybrids is intermediate between those of the parent forms; the ventral arms are long and broad; the dorsal arms are sometimes pointed but are usually of uniform thickness with a slight hollowing at the tip. The position of the dorsal arms is very variable; sometimes they are almost parallel, as in *fatigans*, but generally are directed more or less outwardly towards the tips of the ventral processes. Through the courtesy of Professor Rozeboom we have been able to examine specimens of the "Alabama *quinquefasciatus*". The range of morphological variation of the mesosome seems to be the same as in our *molestus* × *fatigans* hybrids. This observation supports the contention of Sundararaman (1949) and Rozeboom (1951) that the "Alabama *quinquefasciatus*" is a hybrid between *pipiens* (or *molestus*) and *fatigans*.







Text-fig. 1.—Structure of the male palp. A. *fatigans*; B. *australicus*.

Text-fig. 2.—Structure of the male mesosome. A. *molestus*; B. *australicus*; C. *fatigans*.

Text-fig. 3.—Distribution of DV/D in *australicus* and in *molestus* × *fatigans* hybrids.

The DV/D ratio of this American form, like that of our laboratory hybrids, is very similar to that of *australicus* (Text-fig. 3); the mesosome of *australicus*, however, is morphologically distinct.

In several morphological characters *australicus* approaches *fatigans*; biologically it is almost identical with *pipiens*.

It is anautogenous. It is not a man-biting mosquito; adults caught in houses were never freshly engorged and further, when fed, in the laboratory, on human blood, the egg rafts deposited were only about one-third the size of those found in nature (Table 4). Although chickens and canaries were not attacked in the laboratory, birds are evidently normal hosts. Many adults were caught in a chicken house (chickens and ducks) in Melbourne; ten freshly engorged ones had bird blood in the gut; others laid rafts of normal size (Table 4).

Unpublished observations of Mr. D. J. Lee show that *australicus* also attacks rabbits.

TABLE 4.

Size of Egg Rafts of australicus. *The Measurements were made along the Axes of Greatest Length and Greatest Breadth.*

	Number of Rafts.	Size in mm.			Number of Eggs.		
		Min.	Max.	Mean.	Min.	Max.	Mean.
From natural breeding places	51	2·9×1·4	5·6×2·1	4·7×1·4	136	503	256
From females caught in chicken house ..	18	3·0×1·0	6·5×1·3	4·9×1·4	113	380	247
From females fed on human blood ..	25	1·6×0·6	3·0×1·2	2·3×1·0	30	126	73

australicus is eurygamous and in the laboratory we have not been able to get it to mate regularly. Mating never occurred in cages of 2400 cubic inches and only rarely in cages of 40 cubic feet. It was no more frequent when several hundred adults were liberated in a room (500 cubic feet). The temperature was maintained at different levels between 20°C. and 25°C., the humidity and intensity of illumination (white and blue lighting) were varied, but over a period of a fortnight only three females out of a hundred examined were fertilized.

Judging from the results of cross breeding experiments between members of the *pipiens* group, the failure to obtain free mating of *australicus* is due to a disability of the males rather than of the females.

Swarming of males in the field has been observed on many occasions. It occurs shortly after sunset in the vicinity of breeding grounds. Swarms consist of 100–150 males which move rhythmically in a vertical direction some five to six feet above the ground.

australicus is heterodynamic. Oviposition seems to cease early in April. Adults collected later in this month refused to feed and could only be induced to do so by exposure to artificial lighting for about ten days. Feeding was followed by oviposition. In the field, neither adults nor larvae were found during the winter. A few advanced larvae were present late in August but the numbers were far too small to account for the abundance of adults in early spring. It appears that some females are active in August but that the majority remain in hibernation until late in September.

In Melbourne, *australicus* continues to breed throughout the summer, but some observations at Mildura suggest that in northern Victoria reproduction is interrupted during mid-summer. In early December *australicus* was found to be the dominant *Culex*; adults were abundant in chicken houses and larvae were numerous. In early February it was rare except for first stage larvae. Two months later, in mid-April, all the larvae were at the third and fourth stages; few adults were found in chicken houses;

presumably they had entered hibernation. These observations, though limited, suggest that in Mildura, *australicus* has a peak of abundance in spring and early summer and a second one in early autumn. On the other hand, *fatigans*, after starting rather later than *australicus*, breeds continuously throughout the summer and autumn.

TABLE 5.

Breeding Sites of fatigans *and* australicus *at Merbein.*

Breeding Sites.	Number of Males Examined.	*fatigans.*	*australicus.*
Goose pond (foul, muddy water)	70	97 per cent.	3 per cent.
Rain water tanks ..	56	94 ,,	6 ,,
Horse trough	50	100 ,,	0 ,,
Marsh	56	18 ,,	82 ,,
Flooded pasture ..	35	5 ,,	95 ,,

Larval Ecology.—Larvae of *australicus* are found in a variety of habitats both urban and rural. They may be present in artificial containers and occasionally in polluted water. The favoured breeding sites, however, are pools, swamps or channels characterized by stationary or slowly moving, clean water. The contrast between *australicus* and *fatigans* in relation to breeding sites is shown by observations made at Merbein (Table 5). Table 5 was compiled by counting males, identified by their hypopygia, which emerged from collections of larvae from the various sites. It will be seen that *fatigans* predominated in polluted water and artificial containers; *australicus* was predominant in natural ground water.

TABLE 6.

Siphon Index and Length of Siphon of Larvae of australicus *from Various Localities. Measurements are in Microns.*

	No.	Siphon Index.			Siphon Length.		
		Max.	Min.	Mean.	Max.	Min.	Mean.
Williamstown	37	6·4	5·2	5·6	1710	1386	1512
Gunbower	19	5·8	4·7	5·3	1854	1458	1620
Undera	25	6·3	5·2	5·7	1908	1476	1674
Inglewood	25	6·3	5·3	5·5	1710	1350	1530
Melbourne suburbs ..	100	6·3	4·4	5·3	1692	1260	1386
	206	6·4	4·4	5·5	1908	1260	1494

australicus is a rural or semi-rural mosquito; in this, as in other important biological characters, it is different from *fatigans* but similar to *pipiens*.

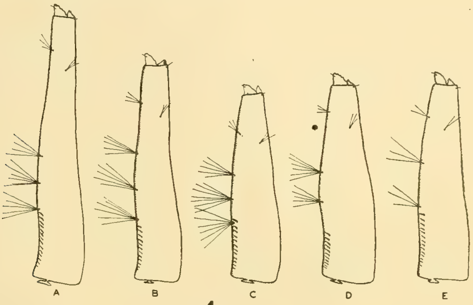
The larvae of *australicus* are morphologically similar to those of *fatigans* and *molestus* but can be distinguished by the siphon index (Table 6; Text-fig. 4). The average value of the index in the three forms is: *australicus*, 5·5; *fatigans*, 4·2; *molestus*, 4·3. As can be seen from Text-figure 4, there is only a small overlap between *australicus* and *fatigans*. The siphon is slightly curved while in *fatigans* it is straight (Text-fig. 5).

The pupa of *australicus* can be distinguished from those of *molestus* and *fatigans* by the trumpet, which in *australicus* is almost cylindrical and at least five times as long as its greatest width. The paddle is oval and more narrow than in *molestus* or *fatigans*.

B. CROSS-BREEDING WITHIN THE PIPIENS COMPLEX.

a. Laboratory Experiments.

For cross-breeding experiments we have used (1) *australicus* from natural populations in the suburbs of Melbourne; (2) *molestus* from a laboratory colony established from females caught in Melbourne and maintained autogenously; (3) *fatigans* from a laboratory colony derived from egg rafts collected at Albury. Examination of male genitalia showed that the laboratory colonies were pure strains. Some additional experiments were made with *C. globocoxitus* which were obtained from natural populations in Melbourne. All the adult mosquitoes used in these experiments had emerged from pupae reared singly in separate tubes.



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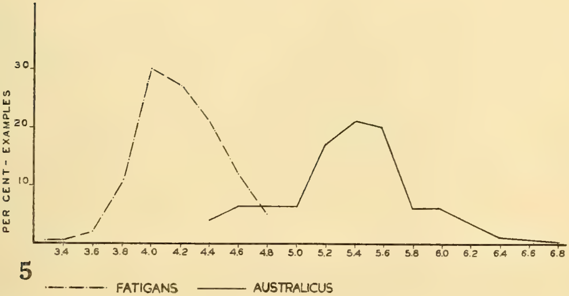

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Text-fig. 4.—Siphon of the fourth-stage larva. A, B. *australicus*; C, D. *fatigans*; E. *molestus*.

Text-fig. 5.—Distribution of the siphon index in fourth-stage larvae of *australicus* and *fatigans*.

The object of the first experiments was to test the mating preferences among the *pipiens* complex. Females of *molestus*, *fatigans* and *australicus* were caged together with either *molestus* or *fatigans* males and after twenty-four hours were dissected and their spermathecae examined. For *molestus* males the cage had a capacity of a thousand cubic inches; for *fatigans* males it was a cubic foot in size. The temperature was 23°–24°C.

These experiments showed that *molestus* and *fatigans* males did not distinguish between their respective females (Table 7). Mating with *australicus* was less frequent. In the two experiments only 20 per cent. of these were fertilized as against 80 per cent. of the other two forms.

In another experiment of this kind the *fatigans* females were replaced by *globocoxitus* females. A group of sixty females, twenty of each form, were caged with forty *molestus* males for four days at 18°–20°C. Fertilization occurred in twelve *molestus*, five *australicus* and four *globocoxitus*.

The infrequent mating of *australicus* females with *molestus* and *fatigans* males, and this was also observed in direct cross-breeding experiments, may possibly be due to the existence of some mechanical barrier to copulation. However, as will be shown later, *globocoxitus* males, whose distinctive genitalia might be expected to prove a bar to mating with members of the *pipiens* complex, mate freely with *molestus* and *fatigans*. A more probable explanation lies in the fact that *australicus* is eurygamous whereas the others are stenogamous.

TABLE 7.

Preferential Mating within the pipiens *Complex.*

Males.	No.	Number of Females Fertilized.		
		molestus.	*fatigans.*	*australicus.*
molestus ..	15	17/20	12/20	3/20
fatigans ..	15	16/20	18/20	5/20

In the laboratory, Melbourne *molestus* interbreeds readily with *fatigans* from Melbourne and Albury. Crossing is obtained with either sex and the F1 are vigorous and fertile.

australicus, however, does not readily interbreed with either *molestus* or *fatigans*. Experiments using *australicus* females were invariably unsuccessful. In one series, in which a total of 101 females were caged with *molestus* males, 18 egg rafts were obtained but no eggs hatched. In these experiments no check was made to see if the females laying the egg rafts had been fertilized. In a later experiment each female, after laying, or after death if no eggs were laid, was dissected and the spermatheca examined. Thirty-eight *australicus* females were caged with 60 *molestus* males for two days. After a blood meal the females were placed separately in tubes with water for oviposition. It will be seen from Table 8 that 11 of the 14 females which deposited eggs had been fertilized. None of the eggs hatched. Similar results were obtained in crosses between female *australicus* and male *fatigans* (Table 8). Four egg rafts were obtained from fertilized females, but again none hatched.

TABLE 8.

Results of Crossing australicus *Females with* molestus *and* fatigans *Males.*

	australicus (38) × *molestus* (60)		*australicus* (30) × *fatigans* (50)	
	Fertilized.	Not Fertilized.	Fertilized.	Not Fertilized.
Refused to feed ..	1	1	2	9
Fed :				
Eggs not laid ..	2	19	1	13
Rafts laid ..	11	3	4	1
Eggs hatched ..	0	0	0	0

Reciprocal matings were not often successful because, as pointed out above, *australicus* males rarely mate in the laboratory. Only a few *molestus* and *fatigans* females were fertilized even when caged with large numbers of *australicus* males for periods of two to three weeks. However, in contrast to the previous experiments, all the egg rafts deposited were fertile to some degree. In *molestus* × *australicus* crosses the hatch in different rafts varied from 21 per cent. to 95 per cent.; in *fatigans* × *australicus* crosses, hatching averaged about 80 per cent. In both crosses the F1 larvae appeared to develop normally but there was a heavy mortality in the pupal stage. The viability of the F2 eggs was low; there was never more than a 50 per cent. hatch.

Thus crosses between female *australicus* and male *molestus* or *fatigans* were sterile but the reciprocal crosses were fertile. This phenomenon has been observed in various species and subspecies of *Aëdes* (Woodhill, 1949, 1950; Perry, 1950; Downs and Baker, 1949) and also between different races of *molestus* (Laven, 1951*a*).

It is clear that in the laboratory the three Australian members of the *pipiens* complex can interbreed. As far as *australicus* is concerned this conclusion probably has little relevance to conditions in nature. In the laboratory, even when no choice was possible, *australicus* mated only infrequently with *molestus* and *fatigans*, and when these matings yielded fertile eggs there was a heavy mortality of the F1 pupae. These facts, coupled with the differences in larval ecology and mating behaviour between *australicus* on the one hand and *molestus* and *fatigans* on the other, suggest that interbreeding between these forms would occur rarely, if at all, under natural conditions and that no permanent population of intermediates would be established.

TABLE 9.

Composition of Natural Populations of the pipiens *Complex in Melbourne.*

	australicus.	*molestus.*	*fatigans.*	Hybrids.
February	62	19	17	2
May	8	20	42	30

With *molestus* and *fatigans* the situation is entirely different. These two forms exhibit no preferential mating, crosses between them are fully fertile, and the hybrids are vigorous and themselves fully fertile. The two forms have essentially the same larval ecology and mating habits. One would anticipate that *molestus* and *fatigans* would interbreed freely in nature.

b. Field Observations.

Drummond (1951) noted the occurrence of intermediate forms in Melbourne and suggested that *molestus* and *fatigans* were interbreeding. Supporting evidence has come from observations on the mosquito population of a water butt at the Zoology Department. Two large samples of late larvae and pupae were taken, one in February and one in May. From each sample 100 males were reared and classified on their hypopygia (Table 9).

Both *australicus* and *molestus* had been established in the water butt for several months prior to taking the first sample, but *fatigans* which, as stated earlier, is common in Melbourne only during late summer and autumn, was a recent arrival. Only two of the hundred males of the February sample were hybrids. By the end of May, however, the *australicus* population had declined, *fatigans* had become numerous and there were 30 hybrids.

Hybrids obtained in the laboratory between members of the *pipiens* complex are very similar morphologically and caution must be exercised when assigning the parentage of natural hybrids. However, of the 32 hybrids recorded above, 30 fell within the range of variation found in *molestus* × *fatigans* laboratory hybrids. The remaining two were different but were also different from any of the *australicus* × *molestus* or *australicus* × *fatigans* laboratory hybrids. Their origin remains in doubt.

Apart from these two specimens we have found no others which could be regarded as *australicus* × *molestus* hybrids, although the two forms are found breeding in close proximity to one another over a wide area in southern Victoria.

Melbourne does not provide adequate material for investigating natural hybridization between *australicus* and *fatigans*. *fatigans* does not become numerous until autumn, by which time *australicus* is declining. However, in northern Victoria the two forms are found together for a large part of the year. Of 300 males of the *pipiens* complex collected at several localities at Merbein, and classified on their hypopygia, 207 were definitely *fatigans* and 92 definitely *australicus*. The remaining specimen was possibly a hybrid.

Our general conclusion from these laboratory and field observations is that *australicus* is reproductively isolated from both *molestus* and *fatigans* but that the two latter forms interbreed where they come into contact. A permanent population of intermediates has not been found in Melbourne but may become established in the northern part of the State.

As already indicated, *C. globocoxitus*, the fourth member of the *pipiens* group in Australia, will interbreed freely in the laboratory with both *molestus* and *fatigans*. The crosses were fully fertile and the larvae developed normally to give a fertile F1. In crosses with *australicus* no adult hybrids were obtained. About 80 per cent. of the eggs hatched but the larvae failed to develop.

Crossing between *globocoxitus* and *molestus* occurs occasionally in nature. Three specimens have been collected in suburbs of Melbourne which are indistinguishable from laboratory hybrids between these forms.

C. TAXONOMIC STATUS OF THE MEMBERS OF THE C. PIPIENS COMPLEX.

a. molestus.

The discussion on the *C. pipiens* complex (Mattingly *et al.*, 1951) revealed a wide divergence of opinion on the status of *molestus*. Christophers and Shute believe that the morphological and biological differences between *pipiens* and *molestus* warrant both being regarded as distinct species. On the other hand, Laven and Mattingly were of the opinion that "in the *pipiens-molestus* complex we are faced with an assemblage of diverse genetical potentialities, the expression of which is conditioned by the selective action of the environment rather than by any limitation to cross breeding".

The gene concerned with autogeny is not restricted to *molestus* and is not necessarily of high frequency in all *molestus* populations. Similarly the other biological characteristics of *molestus* are not necessarily associated; there are forms known which are eurygamous and man-biting, stenogamous and non-man-biting. For these reasons Mattingly (1951, 1951*a*) concluded that the occurrence of "typical" *molestus* is a local phenomenon, and, since it had been recorded mainly in large cities, he suggested that it should be considered an urban biotype and called, if a name were necessary, form *molestus*.

In Australia the range of *molestus* extends from the south coast of Victoria and northern Tasmania to Mildura, some 400 miles to the north. Throughout this range the combination of characters which typify *molestus* are preserved. It appears, therefore, that either the environmental differences within this area are too small to have any appreciable selective action or we are dealing with a pure *molestus* stock. All our observations indicate that in south-eastern Australia we have a mosquito which presents constantly the morphological and biological characters of *molestus* as defined by Marshall and Staley.

We cannot accept Mattingly's contention that *molestus* is a strictly urban biotype. In Australia it is associated with dwellings, but it breeds in water butts, ditches and drainage pits, and in such situations larvae are found in rural areas.

Our conclusion is that *molestus* should be distinguished from *pipiens* and called *C. pipiens* L. form *molestus*, using the term "form" as it is used by Knight and Malek (1951) to indicate that its relationship to other members of the complex has yet to be determined. As Mattingly (1951*a*) has pointed out, future work may show that *molestus* has its closest affinities with *fatigans* rather than *pipiens*.

b. fatigans.

The status of *fatigans* as a species has been questioned because of its ability to interbreed with other members of the *pipiens* complex. However, the statement in several recent publications that it interbreeds with *pipiens* requires qualification.

In laboratory crosses Weyer (1936) found that *molestus* and *fatigans* were interfertile but that when *pipiens* and *fatigans* were crossed no eggs were produced. In similar experiments Roubaud (1941) obtained eggs from both crosses, but those resulting from *pipiens* × *fatigans* matings yielded no fertile hybrids. Farid (1949), Sundararaman (1949) and Rozeboom (1951) have reported complete interfertility in crosses between laboratory strains of *pipiens* and *fatigans* but, as pointed out above, their *pipiens* was not typical.

The position seems to be that *fatigans* will not interbreed with *pipiens* but will interbreed freely with *molestus* and with a North American form of *pipiens* which may itself be a hybrid. Until the status of these latter forms has been determined, it is premature to treat *C. fatigans* as a subspecies of *C. pipiens*.

c. australicus.

This is primarily a rural mosquito. It is widely distributed in Australia but, as far as is known, does not occur elsewhere. This suggests that it is a relatively ancient member of the Australian fauna. The other two members of the *pipiens* complex appear to be recent introductions. Mackerras (1950) suggests that *fatigans* was brought in by the early white settlers; *molestus* has been found here only during the last ten years.

australicus has thus been isolated for a long period from other members of the complex and, as shown by laboratory and field observations, is reproductively isolated from *molestus* and *fatigans*. In Victoria it exists side by side with *molestus* without the production of an intermediate population; in New South Wales, Queensland and Western Australia it is in contact with *fatigans* but the two forms remain distinct. Whether *australicus* and *pipiens* would be interfertile is not known; there would be no ethological barrier to mating.

If *fatigans* and *molestus* were definitely accepted as subspecies of *C. pipiens*, *australicus* could be regarded as a distinct species. As Mayr (1942, p. 179) has written, "owing to range expansion two formerly allopatric forms begin to overlap and to prove thereby to be good species. If no overlap existed and if we had to classify these forms merely on the basis of their morpohological distinctness, we would probably decide, in most cases, that they were subspecies. But overlap without interbreeding shows that they have attained species rank." The status of *molestus* and *fatigans*, however, is not settled, and to describe *australicus* as a distinct species would ignore its very close relationship to *pipiens*. The status of *australicus* should be determined by this relationship rather than by reference to *molestus* and *fatigans*.

Within the *pipiens* complex there seem to be two major evolutionary lines: one, represented by *molestus* and *fatigans*, leading to domestic, stenogamous, man-biting and homodynamic mosquitoes, the other, represented by *pipiens* and *australicus*, leading to rural, non-man-biting, eurygamous and heterodynamic mosquitoes. The two lines tend to be isolated ethologically; genetic isolation between them seems to have been largely achieved except as between *molestus* and *pipiens*.

For these reasons we propose to describe *australicus* as a new subspecies of *Culex pipiens* L. A formal description is given below.

CULEX PIPIENS AUSTRALICUS, n. subsp.

Adult.

The male differs from *C. pipiens* L. as follows. The general colour is darker, almost black. The upper surfaces of the proboscis, palps and legs, the tergites and the median and lateral patches on the sternites are black-scaled. The shaft of the palp is more hairy than in *C. pipiens* L. The pleurae, in addition to the usual patches of white scales, have a few post-spiracular scales. The dorsal processes of the mesosome are transparent and are directed outwards. They are thickened distally and slightly excavated at the tip. The ventral processes are long and leaf-like distally. Wing length: 4·0 mm.

Specimens from Victoria show little variation in colour, but those from New South Wales, Queensland and Western Australia are lighter. There are no significant variations in the structure of the mesosome. The setae on the ninth tergite vary in number from five to fifteen, with an average of eight. The post-spiracular scales are sometimes absent.

The female differs from the male as follows. The pale basal bands on the second to sixth tergites are constricted laterally and on the second to fifth tergites are separated from the white lateral spots. The eighth tergite is pale except for some black scales apically. As in the male, the venter is white scaled with conspicuous median and lateral patches of black scales. Wing length: 4·9 mm. The upper fork cell is 3·3 times the length of its stem.

Females show the following variations. A separation of the tergal bands from the lateral spots may be restricted to the second to fourth tergites or may be extended to the sixth. The black patches on the venter are sometimes reduced to a few black scales.

Specimens from New South Wales, Queensland and Western Australia, like the males from these areas, are lighter in colour and the patches on the sternites are often inconspicuous. These specimens may be indistinguishable from *C. fatigans*.

Types.—The holotype male and allotype female from Melbourne, a paratype series from the suburbs of Melbourne and from Merbein are in the collections of the National Museum, Melbourne.

Larva.

The fourth stage larva differs from that of *C. pipiens* L. as follows. The frontal hairs: the outer has 7–10 branches, the mid 4–5, the inner 4–7. The mental plate has a large central tooth and 8–9 lateral teeth. The siphonal tufts: the first has 4–8 hairs; the second, 3–8; the third, 3–6; the fourth, 2–3. Pecten teeth: 9–13. Comb scales: 31–40. The siphon index varies from 4·4 to 6·4 with a mean of 5·5.

Pupa.

The setae are similar to those of *C. pipiens* L. The paddle is oval; the ratio of breadth to length is about 0·65. The trumpet is almost cylindrical and is at least five times as long as its greatest breadth. The opening is one-third of the length of the trumpet.

Distribution.—In addition to the type series, specimens have been examined from various parts of Victoria and from Tasmania: Launceston, 2♂, 29.3.52; Bothell, 1♂, 30.3.52. N.S.W.: Coolatai, 1♂, 5.1.44; Terry Hie Hie, 1♂, 31.9.51 (A. L. Dyce). Western Australia: Marble Bar, 1♂, Aug. '44; Midland Junction, 1♂ and 1♀, 3.5.44. Queensland: Coolangatta, 1♂, 27.11.43; Bundaberg, 1♂ and 1♀, 3.10.45; Moolyamba, 2♂, 2.5.48, 2♀, 9.5.48; Gin Gin, 1♂ and 1♀, 4.10.45 (J. L. Wassell); Ashgrove, 1♂, 26.2.47 (E. V. Grable); Wowan, 1♂ and 1♀, 28.10.45 (M. P. Lawton); Cloy Field, 1♂ and 1♀, 14.7.48 (L. Angus); Samford, 4♂, 13.9.43, 1♀, 26.7.44 (E. Marks); Brible, 1♀, 24.9.44; Mitchell, 1♀, 2.11.44. South Australia: Upper South-east, 3♂ and 1♀, '52.

Key to the Culex pipiens *group in Australia.*

Males.

1. Coxites broad, swollen. Palpi short, longer than proboscis by only half the length of the last segment .... *globocoxitus*
   Coxite narrow 2
2. Length of first four segments of palp not exceeding length of proboscis. Shaft with 12-21 long hairs .... *molestus*
   First four segments exceed length of proboscis 3
3. Fifth segment of palp directed backwards. Shaft with dense long hairs. Venter with conspicuous median and lateral patches of black scales .... *australicus*
   Fifth segment directed upwards. Shaft with only 6-14 long hairs. Spots on venter inconspicuous or absent .... *fatigans*

Females.

1. Basal tergal bands not constricted 2
   Basal tergal bands constricted and separated from lateral spots at least on tergites 2-5 .. 3
2. Tergites almost black with broad creamy basal bands. Ventral side of proboscis with pale scales over entire length. Venter with or without median and lateral patches of dark scales .... *globocoxitus*
   Tergites brown, bands pale. Ventral surface of proboscis with dark scales at tip. Venter entirely pale .... *molestus*
3. Dark. Venter with median and lateral patches of dark scales .... *australicus*
   Lighter. Patches on venter usually absent, rarely conspicuous .... *fatigans*

CONCLUSIONS.

1. The *C. pipiens* complex in Australia consists of three forms: *C. fatigans*, *C. pipiens* form *molestus*, and *C. pipiens australicus*, n. subsp.

2. *C. fatigans* is widely distributed in Australia but is not permanently established in southern Victoria. Here it can be found regularly only during late summer and autumn. On the evidence available at present *C. fatigans* should be regarded as specifically distinct from *C. pipiens*.

3. In morphology and biology the Australian *molestus* conforms to *C. molestus* as described by Marshall and Staley. In view of its uncertain taxonomic position this mosquito should be called *C. pipiens* form *molestus*. It occurs in Victoria and Tasmania.

4. *C. pipiens australicus*, n. subsp., is widely distributed in Australia. Morphologically it is distinct from other members of the *pipiens* complex; biologically it is very similar to *C. pipiens pipiens*. It is a rural non-man-biting mosquito which is anautogenous, eurygamous and heterodynamic.

5. *C. fatigans* and *C. pipiens* form *molestus* interbreed freely in the laboratory and in the field, but no permanent population of intermediates has been found in Victoria.

6. *C. pipiens australicus*, n. subsp., has a limited capacity for interbreeding with *C. fatigans* and *C. pipiens* form *molestus* in the laboratory but in nature is reproductively isolated from both these forms.

Acknowledgements.

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AUSTRALIAN RUST STUDIES. XII.

SPECIALIZATION WITHIN UROMYCES STRIATUS SCHROET. ON TRIGONELLA SUAVISSIMA LINDL. AND MEDICAGO SATIVA L.

By W. L. WATERHOUSE, The University of Sydney.

(Plate viii.)

[Read 26th August, 1953.]

Synopsis.

Uromyces striatus Schroet. on *Trigonella suavissima* Lindl. in western New South Wales was found to attack lucerne (*Medicago sativa* L.). Comparisons of the reactions of several species of *Trigonella* from overseas with those of numerous species of *Medicago* show that the two rusts represent distinct physiologic races. There is evidence that they are also different from the U.S.A. rust. In many cases individual plant progenies of a species gave quite different results. All four groups of the possible combinations of resistance and susceptibility to the two races were found. No correlation was found between these groups and the recognized botanical groups of these species. A striking case of variegation in a plant of *M. hispida* Gaertn. occurred, and the progeny of one of the shoots yielded albinotic seedlings.

INTRODUCTION.

In 1939 a collection of *Trigonella suavissima* Lindl. at the flowering stage was forwarded from Lake Menindie, N.S.W., for examination because of heavy rust attack on leaves and stems. A similar submission was made in 1950.

Determinations showed that the rust conformed to the description of *Uromyces striatus* Schroet. A culture was maintained first on the original host plants which had been sent in the growing condition, and later on seedlings of *T. suavissima* in pots, in order that the host range might be studied.

SPECIALIZATION STUDIES.

Uredospores transferred to lucerne (*Medicago sativa* L.) growing in pots gave full infections, and from these, transfers back to the *Trigonella* were made.

The susceptibility of lucerne was unexpected. Because of the importance of lucerne as a crop and pasture plant, and of the medics in pastures, it is important to know the host ranges of pathogens that attack them.

For comparative studies, a culture of lucerne rust from an infected crop at Lismore, N.S.W., was maintained on lucerne in a different plant house.

For these preliminary studies, seed of *Trigonella* spp. from overseas was used, together with a quantity of host material of *Medicago* spp. that was kindly made available by Mr. F. W. Hely, of the C.S.I.R.O. Over a period of years he has studied an extensive collection obtained from world sources, sorting out variants, and making many single plant selections. All the seed used came from single plants he had saved. In no case was there any evidence of heterogeneity in the rust reactions shown.

Seed was scarified with sandpaper, germinated between blotting paper, and then transferred to pots, and kept in the plant house until the seedlings had reached the inoculation stage. The leaves were atomized with water, uredospores transferred to the wetted leaves, and the pots then kept in a saturated atmosphere for 36–48 hours, after which they were placed on the plant house benches. Rust development was at its best after about three weeks, but weather conditions caused variations in this time.

In both rusts there was a noticeable slowing-down of rust development in the winter, but comparisons between summer and winter readings showed no differences in the type of susceptible or resistant reactions that developed.

For recording the results it was not necessary to adopt any elaborate scheme, as for example that which is generally used for the cereal rusts (Stakman and Levine, 1922).* Nothing of the "mesothetic" type was found. Three types were recognized: (i) immunity, as shown by absence of any effect of inoculation; (ii) resistance, as shown by production of "flecks" or small pustules borne on necrotic areas; and (iii) susceptibility, as shown by production of normal pustules without any killing action upon the host (Plate viii). In the classifications that follow, (i) and (ii) are grouped together as "resistance".

In Table 1 are given the results when the two rusts were used to inoculate available species of *Trigonella*.

TABLE 1.

Comparison of Reactions shown on Seedlings of Trigonella *spp. by the Rusts from* T. suavissima *and* Medicago sativa.

Host.	Source.	Reaction to Rust from	
		T. suavissima.	*M. sativa.*
T. suavissima ..	Lake Menindie, N.S.W.	Susceptible.	Susceptible.
T. corniculata ..	Italy.	Resistant.	Resistant.
T. arabica	Israel.	Resistant.	Resistant.
T. spicata	Armenia, U.S.S.R.	Resistant.	Resistant.
T. noeana	Iran.	Resistant.	Susceptible and Resistant.

The material received direct from Iran in 1951 was in the pod. Seeds were shelled from selected pods so there is little likelihood that extraneous seed was included in the sowing. There has not been time to pure-line plants showing each rust reaction for further tests. This *Trigonella* result is not unlike that of many of the *Medicago* spp., where single plant progenies of a particular species give very diverse rust reactions, showing that genetic variation within the species is common. The other three overseas species were kindly supplied by Mr. W. Hartley, of C.S.I.R.O.

The results of inoculating the available species of *Medicago* with the two rusts are set out in Table 2.

These results may be grouped as follows, the number in the brackets representing the number of plant progenies involved:

Rust Group 1. Susceptible to Both Rusts.

M. arabica (1), *M. orbicularis* (3), *M. ciliaris* (1), *M. littoralis* (1), *M. gaetula* (1), *M. soleiroleii* (1), *M. rugosa* (1).

Rust Group 2. Susceptible to *Trigonella* but Resistant to Lucerne Rust.

M. tuberculata (2), *M. turbinata* (3), *M. minima* (2), *M. tribuloides* (2), *M. orbicularis* (1), *M. rigidula* (2), *M. scutellata* (2).

Rust Group 3. Resistant to *Trigonella* but Susceptible to Lucerne Rust.

M. arabica (1), *M. tribuloides* (1), *M. orbicularis* (1), *M. intertexta* (1), *M. rigidula* (1), *M. laciniata* (1), *M. coronata* (1), *M. littoralis* (1).

Rust Group 4. Resistant to Both Rusts.

M. tuberculata (2), *M. hispida* (8), *M. tribuloides* (1), *M. obscura* (1), *M. rigidula* (1), *M. lupulina* (1).

It is clear that the two rusts represent distinct physiologic races. A study of additional isolates from each of the original hosts might well bring to light the existence of further races.

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* STAKMAN, E. C., and LEVINE, M. N., 1922.—The determination of biologic forms of *Puccinia graminis* on *Triticum* spp. *Minn. Agr. Expt. Sta. Tech. Bull.* 8.

Whilst in some of the species of *Medicago* all the plant progenies tested gave the same reactions, individuals within other species commonly behaved quite differently. This emphasizes again the extreme importance of genetical control of the hosts to be used as differentials in specialization studies. It also indicates that a considerable amount of natural crossing takes place in *Medicago* spp.

The difficulty of comparing Australian results with those recorded elsewhere is apparent. Thus Chilton, Henson, and Johnson (1943)* report that *U. striatus* occurs in U.S.A. on 14 of the *Medicago* species set out in Table 2. Included are two, viz., *M. lupulina* and *M. hispida*, here found to be resistant. It is noteworthy that of *M. hispida* seven plant progenies were found to be resistant to both the rusts used. This might indicate that the Australian rusts represent different physiologic races from those that occur in U.S.A., but the final proof would be given by comparisons of results when the same plant progenies were tested side by side with the different rusts.

TABLE 2.

Comparison of Reactions shown on Seedlings of Medicago *spp. by the Rusts from* T. suavissima *and* M. sativa.

Host.	Number of Plant Progenies Tested.	Reaction to Rust from	
		T. suavissima.	*M. sativa.*
M. orbicularis All.	3	Susceptible.	Susceptible.
	1	Susceptible.	Resistant.
	1	Resistant.	Susceptible.
M. ciliaris Willd.	1	Susceptible.	Susceptible.
M. intertexta (Mill.) Urb. ..	1	Resistant.	Susceptible.
M. scutellata All.	2	Susceptible.	Resistant.
M. rugosa Desr.	1	Susceptible.	
M. blancheana Boiss.	1		Resistant.
M. tribuloides Desr.	2	Susceptible.	Resistant.
	1	Resistant.	Susceptible.
	1	Resistant.	Resistant.
M. littoralis Rhode	1	Susceptible.	Susceptible.
	1	Resistant.	Susceptible.
M. murex Willd.	1	Resistant.	
M. obscura Retz.	2	Resistant.	Resistant.
	1	Susceptible.	Resistant.
M. rigidula (L.) Desr.	2	Susceptible.	Resistant.
	1	Resistant.	Susceptible.
	3	Resistant.	Resistant.
M. tuberculata Willd.	2	Susceptible.	Resistant.
	1	Resistant.	Resistant.
M. turbinata Willd.	3	Susceptible.	Resistant.
M. arabica (L.) All.	1	Susceptible.	Susceptible.
	1	Resistant.	Susceptible.
M. hispida Gaertn.	7	Resistant.	Resistant.
M. praecox D.C.	1	Resistant.	
M. laciniata (L.) All.	3*	Resistant.	Susceptible.
M. minima (L.) Desr.	2	Susceptible.	Resistant.
M. lupulina L.	1	Resistant.	Resistant.
M. gaetula	1	Susceptible.	Susceptible.
M. coronata (L.) Desr.	1	Resistant.	Susceptible.
M. soleiroleii Durby.	1	Susceptible.	Susceptible.

* Includes one plant progeny from seed received in 1951 direct from Iran.

Thanks to the Director of the Royal Botanic Gardens at Kew and Miss Joy Garden, of the N.S.W. National Herbarium, a list of recognized species of *Medicago* and their

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* CHILTON, S. J. P., HENSON, L., and JOHNSON, H. W., 1943.—Fungi reported on species of *Medicago*, *Melilotus*, and *Trifolium*. *U.S.D.A. Misc. Pub.* 499.

grouping has been obtained recently (February, 1953), and makes possible a comparison of the botanical groupings of the species with those based upon their rust behaviour.

In rust group 1 the seven species fall into six different botanical groupings.

In rust group 2 the seven species fall into four different botanical groupings.

In rust group 3 the eight species fall into five different botanical groupings.

In rust group 4 the six species fall into three different botanical groupings.

On this evidence there is no relationship between the rust behaviour and the recognized botanical grouping of the species.

Occurrence of Abnormalities.

A plant of *M. hispida* in the early seedling stage showed a marked chlorophyll deficiency. As growth proceeded, one shoot grew strongly with full chlorophyll development, but on the other side of the plant parts of leaves or parts of leaflets produced no chlorophyll, leading to variegation of the foliage (Plate viii). Seeds from pods on the normal shoot gave rise to green seedlings, but from pods on the variegated shoot two albinotic seedlings were produced in addition to normal green plants: no variegated plants were found.

Acknowledgements.

Mr. F. H. Hely, of the C.S.I.R.O., kindly made available seed from his wide collection of medics for use in the work, together with all the information he had got regarding nomenclature. Miss Joy Garden, of the National Herbarium, assisted with the nomenclature of the plants. The technical staff, and particularly Miss E. Dumbrell, gave loyal and efficient service throughout. My daughter (E.R.W.) has given the greatest assistance in this as in other recent papers. To all, grateful thanks are tendered. Financial assistance is thankfully acknowledged from the Commonwealth Research Grant, the Commonwealth Bank of Australia, and the Rural Bank of N.S.W.

EXPLANATION OF PLATE VIII.

1. Leaves of *Medicago orbicularis* with (*a*) upper and (*b*) lower surfaces showing susceptible reactions of *Uromyces striatus*. Nat. size.

2. Leaves of *M. turbinata* with (*a*) upper and (*b*) lower surfaces showing resistant reactions of *U. striatus*. Nat. size.

3. Seedling plant of *M. hispida* showing a sectorial chimera. Nat. size × ½.

THE GENUS SELENOPHOMA ON GRAMINEAE IN AUSTRALIA.

By Dorothy E. Shaw, Faculty of Agriculture, University of Sydney.

(Plate ix.)

[Read 26th August, 1953.]

Synopsis.

Selenophoma donacis on *Arundo donax* is recorded for the first time in New South Wales and Queensland.

Selenophoma donacis var. *stomaticola* is also recorded for the first time, in New South Wales, Australian Capital Territory, Tasmania, South Australia and the Northern Territory, on introduced and native grasses. Many of the specimens were heavily diseased. Pure cultures were established from most collections, and varied considerably in texture, colour and pigmentation of the medium. Inoculation tests carried out to date show that the isolates are specific for the host from which they were obtained.

S. donacis var. *stomaticola* on wheat is recorded from South Australia. Certain commercial varieties of wheat, and other varieties used as sources of resistance to other diseases, were susceptible when inoculated in the glasshouse with spores from culture. Lesions with pycnidia and spores were obtained. Only a few varieties showed some resistance. The isolate did not attack the other cereals or the grasses tested.

The economic importance of the wheat and grass diseases is discussed.

Introduction.

Organisms now referred to the genus *Selenophoma* were at one time described as species of *Septoria*. The genus *Selenophoma* was erected by Maire (1906) and the name taken up by Sprague and Johnson (1940). The papers of these workers (1940, 1945, 1947, 1950) have clarified the position in many respects, particularly regarding the synonymy.

Information in scattered references in the literature on this genus, its distribution, morphology and hosts, is brought together in this paper.

History of the Genus on Gramineae.

Septoria donacis Pass. was described in 1878 and 1879 on *Arundo donax* and *Septoria oxyspora* Penz. and Sacc., with slightly different spore widths, in 1884, also on *Arundo donax* (Sprague and Johnson, 1950). Maire (1906) erected the genus *Selenophoma* to cover a pycnidial species, with hyaline, aseptate, curved spores with acute ends.

Grove is cited by McKay (1946) as being apparently the first to record *Septoria oxyspora* from the British Isles in 1910. Stapledon *et al.* (1922) recorded *Septoria culmifida* Karst. on *Alopecuris pratensis*, *Poa trivialis*, *Dactylis glomerata*, *Phleum pratense* and *Arrhenatherum avenaceum* in Britain.

Jørstad (1924, 1930) reported that in Norway *Septoria culmifida* attacked barley and caused severe infection of timothy. Grove (1935) described the symptoms of *Septoria oxyspora* on *Arundo donax* and gave *S. culmifida* Lind. as a synonym. At the same time he described *S. lunata* with smaller and narrower spores as occurring on a grass (? *Festuca*).

Allison (1939) published his studies on *Septoria bromigena* Sacc. isolated from *Bromus inermis*. *B. inermis* was the only susceptible species of 34 bromes tested. Later (Allison, 1945) he could not obtain infection of species of *Agropyron*, *Elymus*, *Hordeum*, *Sitanion*, *Avena*, *Secale* or *Triticum*.

Sprague and Johnson (1940, 1945) stated that they considered that "certain fungi with non-septate falcate spores borne in small globose pycnidia . . . were more logically assigned to *Selenophoma* Maire than to *Septoria* Fries.". Accordingly, *Septoria bromigena*, *S. donacis* and *S. everhartii* became *Selenophoma bromigena*, *S. donacis* and *S. everhartii*. These workers emended the genus to include species with somewhat obtusely pointed spores, and described a new species, *S. obtusa*. At the same time it was proposed that *Phyllosticta stomaticola* Bäuml. be included in *Selenophoma donacis* as *S. donacis* var. *stomaticola* (Bäuml.), comb. nov.

Sampson and Western (1941) described the lesions on various grasses caused by *Septoria oxyspora* in Britain, and noted that Lind, in 1907, suggested that *Metasphaeria culmifida* Sacc., which he found on dead leaves associated with the *Septoria*, was the perfect stage. Moesz (1941) recorded *Selenophoma calamagrostidis* as causing spotting on leaves of *Calamagrostis epigies* in Latvia.

Fischer *et al.* (1942) published a host and pathogen index to the diseases observed on grasses in certain Western States. Connors and Savile (1943) reported *S. donacis* var. *stomaticola* on barley in Canada.

Frandsen (1943) proposed to separate representatives of a group of *Septoria* species parasitizing grasses with non-septate half-moon or boomerang-shaped conidia, from the genus *Septoria* under the genus *Lunospora*, with *L. oxyspora* as the type species. Petrak (1947) commented that the new genus *Lunospora* of Frandsen was identical with *Selenophoma*. Sprague and Johnson (1950) also stated that they considered that the genus *Lunospora* was founded on essentially the same characteristics as *Selenophoma*, which has priority. They then gave the complete synonymy as they understood it.

McKay (1946) published a study of *Septoria oxyspora*, isolated from diseased barley in Ireland. No infection was obtained on cocksfoot, timothy, oats, rye or wheat. Sprague (1949) recorded *Selenophoma donacis* var. *stomaticola* as occurring on wheat in Washington and Idaho. The fungus was tentatively called Race 12 of the variety *stomaticola*, but was later (Sprague and Johnson, 1950) included in the species. Weiss (1950), in an index of the diseases of Gramineae in the United States, listed those grasses reputed to be hosts of species of *Selenophoma*. Sprague and Johnson (1950) published a study of the species occurring on North American grasses, dealing particularly with the taxonomy, cultural characters and recorded hosts.

Sprague (1950) published further notes on host range studies, which are summarized below.

S. bromigena.—*Bromus carinatus* had been found infected, and this increase in host range, it was stated, may be associated with the development of a new race. No cross-inoculation tests, however, had been carried out on *B. inermis*.

S. donacis.—No cross-inoculation tests were reported other than those for the isolate from wheat. It was stated, however, that on the basis of single spore cultures there appeared to be several distinct strains, groups or races.

S. donacis var. *stomaticola.*—Pure culture studies and examination of collections showed that the variety is divisible into ten major groups, on *Danthonia californica*, *Dactylis glomerata* and *Koeleria cristata*, *Festuca idahoensis*, *Poa pratensis*, *Arrhenatherum elatius*, *Phleum pratense*, *Sporobolus asper*, *Festuca kingii*, *Deschampsia* spp. and *Hordeum* spp. No cross-inoculations were reported other than for the group on *Danthonia*.

S. everhartii and *S. obtusa.*—Some of the collections approached the other species and variety. No inoculation tests were reported.

AUSTRALIAN RECORDS.

No species of *Septoria* which could be assigned to *Selenophoma* have been located in any reference of Australian fungi, except for a record of *S. nebulosa* Rost. by Brittlebank* on "Grass stems". The entry concludes with the note "N.S.W. 1895 Sci. Bull. Dept. Agr. No. 46, p. 39, 1934." and "C. C. B. [Brittlebank] Vict.". No record can be found, however, anywhere in the Science Bulletin of *S. nebulosa*.

Sprague (1950) noted that *Septoria nebulosa* Rostr. *non* Desm., a synonym of *Rhabdospora groenlandica* Lind, belongs to *Selenophoma*, and it is probable that Brittlebank recorded on "Grass stems" what would now be regarded as *S. donacis* var. *stomaticola*. On request, Mr. Fish, Biologist of the Victorian Department of Agriculture,

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* "Catalogue of Australian Fungi", compiled by C. C. Brittlebank between 1910 and 1937.

kindly checked through herbarium material, but no specimen of *Septoria nebulosa* has been retained.

Pollock (1945) published the results of an examination of five shiploads of Australian wheat at Plant Quarantine Station at San Pedro, California. Among the organisms listed on wheat stem and leaf fragments was *Selenophoma* sp. The report stated that wheat was apparently a new host for this fungus.

COLLECTIONS, CULTURAL CHARACTERISTICS AND INOCULATION TESTS.

Species of *Selenophoma* have been identified on many native and introduced grasses and one cereal, from New South Wales, Australian Capital Territory, Tasmania, South Australia, Queensland and the Northern Territory.

Collections examined were of two main types:

1. Those with spores falcate to straight, the horns usually of unequal thickness with sharp points, measuring 16–28 × 2–4μ. These were assigned to *S. donacis*.

2. Those with falcate spores, symmetrical to slightly irregular in width of the horns, measuring (8)–10–16–(20) × 2μ, with slightly smaller pycnidia than in type 1. These were assigned to *S. donacis* var. *stomaticola*.

None of the collections was assigned to *S. bromigena*, *S. obtusa*, *S. everhartii* or to var. *linearis*, although individual spores in some collections were similar to the published figures of those species.

TABLE 1.

Selenophoma donacis (*Pass.*) *Sprague and A. G. Johnson.*

S.U. Acc.	Date.	Collector.	Locality.	Pycnidia. μ	Pycnidiospores. μ
258	6.9.50	A. L. Dyce.	Wallalong, N.S.W.	50–120	(16)–20–26–(28) × 2–3
703	20.1.52	A. L. Dyce.	Texas, Queensland.	60–110	18–24 × 2–4
773	12.8.52	D.S.	Gunnedah, N.S.W.	70–110	20–23 × 3
774	12.8.52	D.S.	Mary's Mount, N.S.W.	85–120	20–24 × 2·5–3

Cultures were established from most collections, either from pycnidiospores exuded into water and streaked on agar, or from surface-sterilized eyespots, and were maintained on P.D.A. As noted by Sprague and Johnson (1950), cultures were very varied as to texture, colour and pigmentation of the medium. With all isolations the morphology of the conidia from newly established cultures was checked with the morphology of the pycnidiospores from the field. Conidia, particularly of the species, varied considerably in old cultures.

Selenophoma donacis (Pass.) Sprague and A. G. Johnson.

Collections of this species, as set out in Table 1, were from New South Wales and Queensland, and were heavily infected, showing on the leaves numerous lesions, up to 6 mm. long × 3 mm. wide, with abundant pycnidia in the centres of the spots. Lesions were less abundant on the sheaths but, when they did occur, were up to 10 mm. long × 5 mm. wide, with abundant pycnidia in the centres.

The hosts of all four accessions were called "bamboo" in their localities. Miss J. W. Vickery, of the National Herbarium, Botanic Gardens, Sydney, identified the hosts as probably *Arundo donax*, and this was reasonably confirmed when portion of an old head was subsequently found at Texas, Queensland.

Cultures on P.D.A. were slow-growing, at first mucous, pale cream, bearing masses of conidia which varied from 18 to 32 × 2 to 4μ. The spores were falcate to irregular in shape, and the ends were usually pointed. Cultures later turned black with a pale pink spore exudate and a pink tinge in the medium. Cultures from the four accessions were similar in texture, colour and pigmentation of the substrate.

Mature spores from the field were uninucleate. Two nuclei were detected only in dividing spores from culture (Shaw, 1953).

Sprague (1950) has recorded this species, mainly as the small-spored form, on other grasses besides *Arundo donax*, on which it was first described. Therefore as many as possible of these hosts were included in inoculation tests. No clonal material from the four accessions was available for inoculation.

Infection could not be obtained on the following in several tests, using both spores direct from the field, and from culture: *Avena sterilis algeriensis* "Algerian"; *Digitaria sanguinalis*; *Holcus lanatus*; *Hordeum distichon* "Kinver"; *Panicum antidotale*; *Phalaris tuberosa*; *Poa compressa*; *Secale cereale*; *Setaria italica*; *Triticum vulgare* "Federation".

Species of *Avena*, *Panicum*, *Phalaris*, *Poa*, *Secale* and *Triticum* have been recorded as hosts of *S. donacis*, but from these tests it appears that the organism from *Arundo donax* represents a distinct race. Sprague (1950) noted that there appeared to be several distinct strains, groups or races of *S. donacis*, on the basis of single spore cultures. No other inoculation tests have been reported for the organism from *Arundo donax*.

S. donacis on Wheat.—A *Selenophoma* on wheat was first reported for the U.S.A. in a preliminary note by Sprague (1949) as the var. *stomaticola*. Later it was placed in the species proper (Sprague, 1950).

An Australian isolate has now been studied, and while it is realized that the American isolate was transferred to the species proper only after much consideration, the writer feels that the local isolate is more readily assigned to the var. *stomaticola* than to the species. The collection is therefore considered in the following section.

Selenophoma donacis var. *stomaticola* (Bäuml.) Sprague and A. G. Johnson.

The variety was collected on native and introduced grasses and wheat from New South Wales, Australian Capital Territory, Tasmania, South Australia and the Northern Territory, as set out in Table 2. The hosts, grouped on a tribe basis, were as follows:

Festuceae: *Dactylis glomerata* L., *Festuca elatior* L., *†"*Poa caespitosa* Forst.", *Vulpia Myuros* (L.) Gmel.

Hordeae: *Agropyron*-wheat hybrid, **Agropyron scabrum* (Labill.) Beauv., *Triticum vulgare* Host.

Aveneae: **Amphibromus Neesii* Steud., **Anisopogon avenaceus* R. Br., **Danthonia caespitosa* Gaud., **D. pallida* R. Br., **D. penicillata* (Labill.) F. Muell., **D. racemosa* R. Br., *Danthonia* sp.

Agrostideae: **Aristida vagans* Cav., **Deyeuxia monticola* var. *valida* (Roem. & Schult.) J. Vickery, **Dichelachne rara* (R. Br.) J. Vickery, *Phleum pratense* L., *Sporobolus capensis* Kunth., **S. elongatus* R. Br., **Stipa aristiglumis* F. Muell., **S. variabilis* Hugh, *Stipa* sp.

Zoisieae: **Neurachne Muelleri* Hack.

Oryzeae: **Microlaena stipoides* (Labill.) (R. Br.).

Lesions were of the eye spot or "frog-eye" type, with pale buff to white interiors bounded by distinct reddish-brown to purple borders (Plate ix, 1). They occurred most commonly on the stems, sheaths and leaves, and sometimes on the glumes, as in the case of *Anisopogon avenaceum*. Pycnidia occurred in rows in the buff centres.

In some collections (those of *Microlaena stipoides*, *Deyeuxia monticola* var. *valida* and *Danthonia pallida*) a diffuse reddish tinge surrounded the eyespot. The lesions of *Microlaena stipoides* were of perfectly-formed eyespots, but each lesion was only about 1 mm. × ½ mm., so that to the naked eye heavily infected leaves looked as if they had large reddish-brown lesions, which were in reality made up of many small eyespots.

The lesions varied according to the host and the part of the plant infected, but were usually about 3–6 mm. long by 1–2 mm. wide. A few of the accessions (nos. 234, 681, 780, 787, and 802) were of old material, and no spots were evident.

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* Native species.

† "*Poa caespitosa* Forst." is regarded as a complex of Tussock grasses requiring further taxonomic study.

The widths of the spores, taken at the widest place, were approximately 2μ. Slight variations occurred in most cultures, the spores being, if anything, slightly wider than those from the field.

TABLE 2.

Selenophoma donacis *var.* stomaticola (*Bäuml.*) *Sprague and A. G. Johnson.*

S.U. Acc.	Date.	Collector.	Host.	Locality.	Pycnidia.	Pycnidiospores.	
						F.	C.
234	30. 8.50	D.S.	*Stipa aristiglumis.*	Piallaway, N.S.W.	—	12–20	12–20
456	29. 1.51	D.S.	*Phleum pratense.*	Kosciusko, N.S.W.	40–100	10–14	12–16
466	29. 1.51	D.S.	"*Poa caespitosa.*"	Kosciusko, N.S.W.	60– 90	12–16	—
467	29. 1.51	D.S.	*Agropyron scabrum.*	Kosciusko, N.S.W.	80–100	14–20	—
469	1. 2.51	D.S.	*Danthonia penicillata.*	Kosciusko, N.S.W.	50– 70	12–16	8–14
473	7. 2.51	G. Wade.	"*Poa caespitosa.*"	Cressy, Tas.	60– 80	16–18	—
497	20. 3.51	T. W. Atkinson.	*Festuca elatior.*	Glen Innes, N.S.W.	—	12–20	—
517	2. 3.47	A. B. Costin.	"*Poa caespitosa.*"	Kosciusko, N.S.W.	50– 90	10–20	—
532	7. 7.51	I. A. Watson.	*Stipa* sp.	Tichborne, N.S.W.	70– 90	10–14	12–16
595	17. 9.51	A. T. Pugsley.	*Triticum vulgare,* "Scimitar".	Adelaide, S.A.	—	12–18	9–16
626	17.10.51	I. A. Watson.	*Amphibromus Neesii.*	Tichborne, N.S.W.	50– 90	10–16	10–16
635	22.10.51	D.S.	*Vulpia Myuros.*	Temora, N.S.W.	60– 80	8–12	10–16
637	22.10.51	D.S.	*Danthonia caespitosa.*	Temora, N.S.W.	50– 80	12–18	10–18
651	11.12.51	J. Begg.	*Dactylis glomerata.*	Canberra, A.C.T.	60–100	12–16	10–20
670	19.11.51	E. J. Breakwell.	"*Poa caespitosa.*"	Canberra, A.C.T.	60–120	12–14	12–16
681	23.10.51	P. G. Valder.	*Stipa aristiglumis.*	Gunnedah, N.S.W.	—	14–20	—
696	27.12.51	D.S.	*Anisopogon avenaceus.*	Oatley Park, N.S.W.	50– 90	10–16	10–16
705	23. 1.52	D.S.	"*Poa caespitosa.*"	Mt. Ainslie, A.C.T.	60– 90	12–16	10–20
706	23. 1.52	D.S.	*Agropyron scabrum.*	Mt. Ainslie, A.C.T.	80–100	12–16	—
709	23. 1.52	D.S.	*Danthonia* sp.	Mt. Ainslie, A.C.T.	50–80	12–16	10–16
710	23. 1.52	D.S.	*Amphibromus Neesii.*	Sullivan's Ck., A.C.T.	60– 90	12–16	14–20
711	15. 6.48	R. A. Perry.	*Neurachne Muelleri.*	Gallipoli Station, N.Territ.	60– 90	10–14	—
733	27. 4.52	D.S.	*Phleum pratense.*	Kosciusko, N.S.W.	80–120	12–16	12–18
756	8. 6.52	D.S.	*Aristida vagans.*	National Park, N.S.W.	—	—	14–16
776	12. 8.52	D.S.	*Aristida vagans.*	Mary's Mount, N.S.W.	100–120	14–16	—
780	16. 8.52	D.S.	*Agropyron* - wheat hybrid.	Botanic Gardens, N.S.W.	75–120	10–14	10–18
787	26. 8.52	E. G. Wingrave.	*Dactylis glomerata.*	Huonville, Tas.	—	—	10–18
799	16. 9.52	F. Robertson.	*Microlaena stipoides.*	Sublime Point, N.S.W.	—	—	10–14
802	16. 9.52	F. Robertson.	*Dichelachne rara.*	Sublime Point, N.S.W.	70–100	10–16	10–16
819	24.10.52	D.S.	*Danthonia caespitosa.*	Temora, N.S.W.	60– 80	12–16	13–18
823	24.10.52	D.S.	*Amphibromus Neesii.*	Temora, N.S.W.	40– 90	14–16	10–16
826	24.10.52	D.S.	*Stipa variabilis.*	Temora, N.S.W.	60– 90	12–18	—
838	31.10.52	D.S.	*Anisopogon avenaceus.*	Kellyville, N.S.W.	60– 80	10–16	—
851	14.11.52	D.S.	*Microlaena stipoides.*	Mt. Tomah, N.S.W.	60–100	10–14	10–17
861	12.11.52	D.S.	*Dactylis glomerata.*	Orange, N.S.W.	70– 90	12–14	10–20
866	18.11.52	G. Sullivan.	*Microlaena stipoides.*	Bilpin, N.S.W.	75–100	10–14	10–20
867	18.11.52	G. Sullivan.	*Danthonia racemosa.*	Meadow Flat, N.S.W.	50– 90	14	—
874	8.12.52	G. Sullivan.	*Amphibromus Neesii.*	Sullivan's Ck., A.C.T.	50– 60	12–16	16–20
875	8.12.52	G. Sullivan.	*Agropyron scabrum.*	Mt. Ainslie, A.C.T.	60– 80	14–18	10–20
876	8.12.52	G. Sullivan.	"*Poa caespitosa.*"	Mt. Ainslie, A.C.T.	50– 60	12–16	10–15
877	8.12.52	G. Sullivan.	*Deyeuxia monticola* var. *valida.*	Mt. Ainslie, A.C.T.	50–100	14–20	16–23
884	17.12.52	G. Sullivan.	*Danthonia pallida.*	Gunning, N.S.W.	50– 95	13–20	14–20
894	4. 3.53	D.S.	*Sporobolus capensis.*	Cronulla, N.S.W.	50– 95	—	14–18
904	15. 5.53	D.S.	*Sporobolus elongatus.*	Camden Park, N.S.W.	50– 70	12–15	12–16

Spores were uninucleate (Plate ix, 4), or binucleate in dividing spores produced in culture (Shaw, 1953).

Cultures from all isolates were at first mucous, pale cream to faint pink, and produced masses of conidia directly on the mycelium. Old cultures became leathery or carbonaceous, and the texture varied considerably. They were variously coloured, but were mainly black with yellow or pink, with or without yellow or rose pigmentation of the medium. The colour of the colonies and the intensity of the medium pigmentation varied with the age of the colony and the amount of exposure to light.

Cultures were mainly of three types:

1. Coloured yellow or yellow and black, with bright yellow pigmentation of the medium. (Isolates from *Amphibromus Neesii* and *Agropyron scabrum*. The isolate from *Dactylis glomerata* was also of this type, but it had been isolated from old faded leaves.)

2. Cultures black, pink, or black and pink, with rosaceous pigmentation of the medium. (Isolates from *Triticum vulgare*, *Phleum pratense*, *Microlaena stipoides* and *Agropyron*-wheat hybrids.)

3. Cultures without medium pigmentation under the conditions during which the tests were carried out.

Isolate from Wheat.

In September, 1951, leaves of "Scimitar" wheat received from the Waite Institute, South Australia, were infected with *Septoria tritici*, and also with a few lesions of the eyespot type which were not typical of the speckled leaf blight. Upon examination it was found that the lesions were caused by a *Selenophoma* with small spores. Pure cultures of the organism were established.

As mentioned previously, the *Selenophoma* from wheat in the United States was first reported as the var. *stomaticola*, but was later placed in the species proper, mainly because of the shape of the spores which were reported as being 16–21 × 2·2–3·5μ (Sprague, 1950).

The spores in the collection from South Australia measured 12–18 × 2μ, and from culture measured 9–16 × 2μ. When produced on "Rhodesian" wheat in the glasshouse they measured 10–18 × 2–2·5μ. The measurements, which are all in the same range, are slightly smaller than those given by Sprague, but his drawings of spores on leaf fragments from Australia which were intercepted by Pollock, and of spores from Idaho (1950, his fig. 22, B and C) are very similar to those of the present collection, except that the latter are slightly narrower and slightly more pointed. The organism resembled the small spored variety on grasses rather than the large spored species on *Arundo donax*. While it is realized that the wheat *Selenophoma* in the U.S.A. was transferred to the species proper only after much consideration, it is felt that the South Australian organism is more accurately assigned to the var. *stomaticola* than to the species (Plate ix, 5–10).

Sprague (1949, 1950), in inoculation tests with the American organism, could obtain only sterile leaf spots. When inoculated in the glasshouse, the Australian isolate produced on wheat, leaf spots with abundant pycnidia and spores. It is, perhaps, a more virulent strain. The pycnidia produced after artificial inoculation, however, were not heavily pigmented and could not be discerned with the naked eye.

Inoculations were carried out on the following plants in several series of tests, using spores from culture: *Avena sterilis algeriensis* "Algerian", *Bromus inermis*, *Dactylis glomerata*, *Festuca elatior*, *Holcus lanatus*, *Hordeum distichon* "Kinver", *Phleum pratense*, "*Poa caespitosa*", *Secale cereale*, *Triticum vulgare* "Federation".

In every test, lesions with pycnidia and spores occurred on "Federation" wheat, but no infection could be obtained on the other grasses or cereals. This confirms Sprague's finding that the wheat isolate is confined to wheat.

Various species of wheat and those varieties either agronomically popular in Australia or being used as sources of resistance to other diseases, e.g., leaf and stem rust, were tested in the glasshouse for their reaction to the *Selenophoma* isolate.

Sprague (1949) noted that resistance varied in the field from the highly susceptible varieties "Rex" and "Orfed" to the highly resistant varieties "Kharkof", "Comanche" and "Hymar × Elgin 3 (F4 composite)".

Wheats tested were divided into the following categories:

Resistant.	Mod. Resistant.	Mod. Susceptible.	Susceptible.	Very Susceptible.
Triticum monococcum. *T. monococcum* var. *flavescens.*	*T. timococcum.* *T. vulgare ;* Democrat. Exchange. Hofed. M.D. 1303. Mentana.	*T. vulgare ;* Brolga. Celebration. Charter. Chinese × (Chinese × *Agropyron elongatum*). Eureka. Fedweb. Gular. Kendee. Marquillo. Mediterranean. R.A.C. 170. Thew. *Timopheevi* der. 1656. *Uruguay 1064.	*T. compactum ;* Little Club. *T. vulgare ;* Bordan. Egypt 1228. Federation. Resistant. Bencubbin.	*T. dicoccum ;* Khapli. *T. vulgare ;* Dundee. Festival. Kenya 744. *Rhodesian. Yalta.

* "Rhodesian" and "Uruguay" are shown in Plate ix, 2 and 3.

Organisms from Various Hosts.

The results of pathogenicity tests which it has been possible to make to date are as follows:

	Agropyron—Wheat hyb.	*Aristida vagans.*	*Dactylis glomerata.*	*Phleum pratense.*	*Triticum vulgare.*
Agropyron scabrum				—	
Amphibromus Neesii			—		
Aristida vagans		S			
Arrhenatherum elatius	—	—	—	—	—
Avena sterilis algeriensis	—	—	—	—	—
Bromus inermis				—	—
Dactylis glomerata	—	—	S	—	—
Danthonia caespitosa	—		—	—	
Dichelachne sciurea				—	
Festuca elatior	—	—	—	—	—
Holcus lanatus	—	—	—	—	—
Hordeum distichon	—	—	—	—	—
Phleum pratense	—	—	—	S	—
"*Poa caespitosa*"	—	—	—	—	—
Poa compressa	—		—	—	
Secale cereale	—	—	—	—	—
Triticum vulgare	L	—	—	—	S
Vulpia Myuros				—	

S = Susceptible ; L = Lesions only ; — = Immune.

All the grasses inoculated are recorded hosts of *Selenophoma* here or overseas. Each isolate tested was specific for its own host. Infection was easily obtained on timothy and wheat with the respective isolates, but difficult to obtain with the other isolates even on the hosts from which they were obtained. It is possible that the conditions favouring infection were not present or that there were genetic differences in clones of the same grass species. Tsiang (1944) found highly significant differences in reaction to *Selenophoma bromigena* between clones of *Bromus inermis*.

ECONOMIC IMPORTANCE.

Selenophoma donacis and *S. donacis* var. *stomaticola* have been identified on both native and introduced grasses throughout the eastern half of Australia. It is not known how long the organisms have been present in this country: whether they are indigenous on the native grasses or whether they were imported here from overseas on introduced grasses and have since spread to the native species.

Some of the grasses collected were heavily diseased, but, as the cross-inoculation tests to date indicate a great deal of specificity for the host, it is probable that the disease will be serious only on particular species in certain localities.

The first world record of a *Selenophoma* on wheat was on Australian wheat examined at Quarantine Station at California in 1944. It was not recorded elsewhere until 1948, at Pullman, Washington, but Sprague has since stated that it had been collected at Pullman in 1915, but not then determined (1950).

The only known field occurrence in Australia is that on "Scimitar" leaves from South Australia (S.U. Acc. 595). However, it is instructive to examine the proportions of the well-known pathogenic fungi in the five shiploads of wheat identified at the Californian Quarantine Station (Pollock, 1945), viz.:

Fungus.	Number of Lots.
Urocystis tritici	7
Puccinia rubigo-vera var. *tritici*	17
Puccinia graminis var. *tritici*	5
Tilletia caries	1
Tilletia foetida	1
Selenophoma sp.	5
Septoria tritici	17

The writer has not been able to determine the season in which this wheat was grown or from what parts of the wheat belt it came. It is evident, however, that the disease was present in the field somewhere prior to 1944.

It should be noted that many of the varieties of wheat which are grown commercially in Australia, or used as sources of resistance to other diseases, proved susceptible to the South Australian isolate in glasshouse tests. Thus the varietal composition of the wheat belt makes it a suitable medium for the organism, although environmental conditions in the field might be operating against high incidence and widespread distribution.

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DESCRIPTION OF PLATE IX.

1. *Phleum pratense* with "frog-eye" type lesions caused by *Selenophoma donacis* var. *stomaticola* after artificial inoculation. × 1.

2. "Rhodesian" wheat, a very susceptible variety, with lesions and yellowing caused by *S. donacis* var. *stomaticola* after artificial inoculation. × 1.

3. "Uruguay" wheat, a moderately susceptible variety, with lesions caused by *S. donacis* var. *stomaticola* after artificial inoculation. × 1.

4. Spores of *S. donacis* var. *stomaticola* from *Sporobolus elongatus* stained with Giemsa to show one nucleus per cell. × 900.

5. Spores from culture of *S. donacis* from *Arundo donax*, stained with cotton-blue. × 600.

6. Spores from field collection of *S. donacis* from *Arundo donax*, stained with cotton-blue. × 600.

7. Spores from culture of *S. donacis* var. *stomaticola* from wheat, stained with cotton-blue. × 600.

8. Spores from glasshouse collection of *S. donacis* var. *stomaticola* from wheat, stained with cotton-blue. × 600.

9. Spores from culture of *S. donacis* var. *stomaticola* from *Phleum pratense*. × 600.

10. Spores from field collection of *S. donacis* var. *stomaticola* from *Phleum pratense*. × 600.

Photos 4-10 by Woodward-Smith.

STUDY OF SOIL ALGAE.

II. THE VARIATION OF THE ALGAL POPULATION IN SANDY SOILS.

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(Plate x, figs. 1, 2; four Text-figures.)

[Read 26th August, 1953.]

INTRODUCTION.

The algal population in the soil has previously been studied mainly from a floristic point of view, but little information is available concerning the number and variation of algae in the soil, which is partly due to the lack of an adequate rapid technique. This difficulty has been overcome by fluorescent microscopy introduced by one of us (Tchan, 1952) and, using this new technique, the population of algae in the soil was studied in its natural conditions, and experiments were carried out to explain some of the direct observations obtained in studying the daily variation and vertical distribution of the algae in soil.

I. TECHNIQUE.

The technique has been fully described in a previous paper (Tchan, 1952) and no modification is introduced in the present work.

The sensitivity of the method may be tested as follows.

A counting chamber of 0·2 mm. depth and a surface area of 1·5 × 1·65 cm. has a volume of 0·05 c.c. Since the soil suspension can be concentrated by centrifuging to 1:5 (soil:water), then this volume represents 0·01 g. of soil. It is found with suitable replicates that the technique can estimate an algal population of the order of 1,000 cells per gramme. A reasonable estimation of a population of about 100 cells per gramme can be obtained by using McCrady's statistical table (Calmette *et al.*, 1948). In fact, estimations using the statistical table allow for a theoretical possibility of a population as low as 20 cells per gramme of soil. In practice, little interest or significance is attached to such a low algal population in the soil. The technique used is described as follows.

A suspension of algal cells was counted over the whole chamber. A series of dilutions (1 c.c. in 9 c.c. of water) was used (five replicate counts for each dilution) until the last dilution was free of algae, e.g., one suspension contained 80 cells per chamber. In the first dilution the replicates gave five positive countings; the second dilution gave three; and the third dilution was free of algae. According to the statistical table the above results give characteristic numbers of 553 or 530, which correspond respectively to 90 and 80 cells calculated to be present in the original suspension. This gives a good correlation with the initial count made on the undiluted suspension.

In another suspension which gave a theoretical number of 500 cells, the results were as follows:

Characteristic number	520	513	511	451	503
∴ Cells in suspension (calculated from table)	500	850	450	500	600

The use of the statistical technique was found to be necessary when the algal population was at a very low level. For higher numbers the direct count of the suspension was quite adequate.

In order to compare this direct microscopy technique with a culture method the following experiments were carried out.

A sandy soil was used to prepare a soil-water medium according to Pringsheim (1950). Potassium nitrate and potassium phosphate buffer adjusted to the same pH as that of the original soil were added to the medium.

The algal population in a suspension was first estimated by the direct microscopy technique. A series of dilutions of this original suspension was then inoculated into the soil-water medium, using five replicate tubes for each dilution prepared. The number of algae present after incubating at 25°C. with two fluorescent lamps for several weeks to three months, was calculated by using McCrady's table, and depended on the number of tubes in each dilution in which growth was evident when examined either by naked eye or microscopically. The results are summarized as follows.

Number obtained by direct microscopy	1,000	1,400	2,000	4,000	23,000	29,000	43,000	40,000
Number obtained by culture technique	600	1,500	1,500	4,500	13,000	30,000	30,000	45,000
Ratio $\frac{\text{culture}}{\text{microscopy}}$	0·6	1·07	0·75	1·12	0·56	1·03	0·70	1·12
Culture technique shows :								
Less	40%		25%		44%		30%	
More		7%		12%		3%		12%

The above table shows that significant differences between the two techniques occurred when the culture technique gave a lower number than obtained by direct microscopy. When the culture technique gave a higher number, the difference was only of the order of 12%. The rapidity of the direct microscopy is very appreciable, and for this reason the culture technique was not used in any of the other experiments carried out, except on rare occasions.

II. Daily Variations in the Algal Population of the Soil.

For the following experiments described a garden soil from Sydney University was used. The soil was apparently homogeneous as a result of previous cultivation. Samples were prepared by mixing five small amounts of soil taken at random from within a square metre.

The experiment was set up at 11 a.m. in May on a sunny day. The following variations in the algal population were recorded at intervals during the day:

Time	11 a.m.	2 p.m.	5 p.m.	7 p.m.	8 a.m.	12 noon
No. algae per gramme ..	4,750	2,100	5,300	4,500	1,300	2,500

Several factors account for these variations. Using the direct microscopy technique it was evident that some nematodes, displaying a white-green fluorescence, had eaten several algae, as seen by the red fluorescent areas within their bodies. Likewise, several protozoa contained algal inclusions. The number of nematodes and protozoa, however, was not high enough to have much effect on the number of algae.

Other factors must be taken into consideration. In winter, water condenses on the surface of the soil during the night; on the following morning the temperature of the surrounding soil rises with the increase in sunlight. Algae thus have a suitable condition in which to multiply; then during the day the soil may dry out, resulting in the death of some of the algae. To support this hypothesis the following experiments were carried out.

Firstly, an experiment was set up to determine the minimum water content of the soil in which the multiplication of algae was possible.

A sandy soil sample was air dried and five grammes placed in the lid of a Petri dish. Sufficient water was added to bring the moisture content of the soil to 12, 24, 30, 45, 60 and 100 per cent. of its water-holding capacity. The lids of the dishes were then covered by the base of the Petri dish so that the bottom of the dish rested on the soil in the lid. The space between the Petri dish and lid was thus reduced to a minimum. The apparatus was sealed to prevent the loss of water during incubation, and the Petri dishes were incubated at 25°C. for a few hours with two fluorescent tubular lamps, and then the algal cells were counted.

Examination showed that there was no growth of algae below 12% of the water-holding capacity of the soil. From 24% to 30% the number rose from 2,500 per gramme to 4,200 per gramme. At 45% the number was 4,700, and from 60% to 100% the number of algae was approximately constant at 6,000.

The following points are evident from the foregoing results, and apply at least to the sandy soil used in the experiment.

(1) When the soil is moistened to 60% of its water-holding capacity the optimum condition is reached for the growth of algae. Further addition of water does not increase their growth over the short period of our experiment.

(2) When the soil nears its air-dried condition the number of algae in the soil becomes constant.

(3) The minimum moisture needed for the growth of algae is between 12% and 24% of the water-holding capacity, which is indeed very low.

The object of the second experiment was to determine the effect of drought on the algal population.

A sandy garden soil rich in algae was used. Five replicates of 10 grammes of soil were placed in a Petri dish and allowed to dry in the open air and light. Every two hours samples were taken to make estimations of the algal population and the loss of water from the soil. The algal population was estimated by both direct microscopy and a culture technique using soil-water media described above. The loss of water was determined by change in weight of the soil sample. Graph I shows the correlation between the loss of water and the variation of the algal population.

The experiment was set up with soil moistened to 100% of its water-holding capacity. After two hours the number of algae rose from 23,000 to 44,000 (direct microscopy) or 12,500 to 30,000 (culture technique), and the soil moisture content had dropped by 58%. After four hours the count had dropped and risen respectively in the two techniques to 40,000 and 45,000, whilst the moisture content was as low as 12·3% of its original water-holding capacity. From this time both techniques showed a drop in the number of algae (28,000 by direct microscopy and 30,000 by culture technique) and the soil was practically air dried. After three days the soil contained a practically constant number of algae.

Two points are clear from these results: (1) At low moisture levels the growth of algae was not inhibited, but when the soil was almost air-dried (below 12% of its water-holding capacity) the number of algae diminished very quickly; (2) When conditions were suitable algal populations could be doubled in a few hours.

From these observations it is possible to assume that, at least for the sandy soil in question, the daily variation in the algal population is affected by the change in the moisture content of the soil. There is a critical quantity of water which controls the algal population in the soil. This was found to be 12% of the water-holding capacity of the sandy soil used. Below this level no growth could be detected and some algae may have died. Above this level growth recommenced.

III. THE VERTICAL DISTRIBUTION OF ALGAE IN THE SOIL.

For these observations soils from Kuring-gai Chase Reserve (Mount Colah, N.S.W.) and from Warrah Fauna and Flora Sanctuary (near Woy Woy, N.S.W.) were used. These sandy soils have never been subjected to agricultural treatment or interference.

During the winter and early spring of 1952 soils were sampled from different depths. Precautions were taken to avoid the possible mixture of surface soil with the subsoil. A block of soil was cut out and test tubes pushed horizontally into the block from different levels. On extracting the tube only the portions of the soil near the opening of the tube were used. This corresponded with the central portion of the soil in the block. The chance of mixing the soil was thus reduced to a minimum. If the soil was water-saturated, the block of soil was cut into slices, which were separated and suspended in water in order to count the algae present.

It is clear that in the water-saturated condition most of the algal population was confined to the top few millimetres. The number dropped very quickly and at a depth of 1 cm. it became insignificant compared with the large surface population.

In the soil which was not water saturated (Mount Colah) the surface soil contained more algae than the lower layers, but the difference was not so sharp. Also a reasonable quantity of algae could be found in a relatively deep part of the soil.

	0–0·4 cm.	0·4–0·6 cm.	0·6–0·8 cm.	1 cm.	1–3 cm.	3–5 cm.	5–10 cm.
Mt. Colah after rain	—	—	—	1,200	900	300	<150
Woy Woy I	800,000	10,000	5,000	<150	—	—	—
Woy Woy II	275,000	15,000	4,000	<150	—	—	—

Woy Woy I—water logged, with macroscopic growth of algae on surface.

Woy Woy II—water saturated, macroscopic growth of algae on surface.

Several questions arise from these observations: (1) Why is the algal population confined to the top layers of the soil when the soil is water-saturated? (2) Is light necessary for the growth of algae in water-saturated sandy soils, as indicated by the presence of algae in relatively larger numbers in the surface soils? (3) If light is necessary for the growth of algae in sandy soils, how far is it able to penetrate into the soils? (4) It is well known that algal growth occurs in the dark if a suitable energy source is provided (Bristol Roach, 1927, 1928). If this is so, can they grow anaerobically in a water-saturated soil?

Several experiments were set up in order to obtain information concerning these questions.

The first experiment aimed to determine the aerobic and anaerobic states in water-saturated sandy soil; the vertical distribution of algae under the experimental conditions; and the effect of light on their distribution. Use was made of the filter paper technique introduced by one of us (Tchan, 1945), in which dyes were used as rH_2 indicators. This technique was successfully used for the study of the aerobic-anaerobic relationship in the decomposition of cellulose in the soil (Pochon and Tchan, 1947).

Pieces of filter paper 4″ × 6″, which had been previously stained in vertical strips with four dyes of different rH_2 values, were moistened and pressed flat against the sides of seven one-litre beakers, so that the colour change of the dyes could be seen during the course of the experiment. The range of rH_2 values given by the different dyes is as follows: methylene blue $rH_2 = 14$, Nile blue $rH_2 = 9$, pheno-safranin $rH_2 = 5{\cdot}8$, neutral red $rH_2 = 3{\cdot}8$. A washed river-sand practically free of algal cells was added in a wet state to the beakers and shaken down well as it was added, in order to avoid air bubbles to a certain extent. The control was set up with tap water. To the second sample Derx's mineral solution was added (Derx, 1950) containing KNO_3 as a nitrogen source. The third sample contained Derx's mineral solution plus 1% glucose as organic matter. The fourth was a duplicate of the second and the fifth was a duplicate of the third, but the beakers were wrapped with black paper so that the light could only penetrate from the surface (surface light). The sixth and seventh were duplicates of the second and third respectively, except that they were kept entirely in the dark. All beakers were kept in a glasshouse.

The results obtained from the experiment are summarized below.

I. The control (No. 1).

After 3 days: The methylene blue strip was reduced throughout the lower 4 cm.

After 6 days: The methylene blue strip was reduced throughout the entire length except for the top 1·5 cm. The Nile blue strip was partially reduced in all but the top 1·5 cm. The neutral red strip was irregularly reduced at 3 cm., 5·5 cm., 10·5 cm. and 13 cm.

After 7 days: There was no appreciable change.

After 14 days: The soil was slightly dry and the subsequent entry of oxygen re-oxidized the dyes as far down as 4 cm. Some fungal growth was visible on the filter paper. There was a macroscopic growth of algae on the surface of the soil.

II. Soil and Derx's mineral solutions (Nos. 2, 4, 6).

After 3 days:

In the light: no reduction was evident.

Surface light: no reduction was evident.

In the dark: no reduction was evident.

After 6 days:

In the light: a thin green algal layer had appeared on the soil surface. Methylene blue was reduced from 2·5 cm. to 10 cm., Nile blue was reduced from 2·5 cm. to 10 cm. and neutral red was reduced from 5·5 cm. to 8·5 cm.

Surface light: a thin green algal layer had appeared on the soil surface and the reduction of the dyes was similar to that in the light.

In the dark: the soil was very moist; there was no macroscopic growth of algae on the surface and the reduction of the dyes was similar to the previous two cases.

After 7 days:

In the light: there was no change in the dyes; a heavy growth of algae was present on the surface of the soil and also in the air spaces throughout the soil in parts which were within the reduction zone and exposed to the light at the edge of the beaker.

Surface light: there was no further reduction in the dyes, the surface algal growth was greater.

In the dark: there was no further reduction in the dyes and no algal growth.

After 14 days:

In the light: the surface algal growth had increased and the large areas of algal growth which were made possible by the presence of air bubbles in contact with the light had regenerated sufficient oxygen by photosynthesis to re-oxidize completely the dyes in the immediate vicinity of the algal zone.

Surface light: a thick green mat of algae had further developed on the surface but, due to the absence of light below the surface, there was no re-oxidation in this case.

In the dark: no further change had occurred.

An entirely new experiment was set up in which the dye pheno-safranin, which had proved unsatisfactory in our case, was replaced by Janus green ($rH_2 = 5·2$), and in which the large air bubbles, so prominent in the former experiment, were avoided by careful shaking of the soil on addition to the beaker. It was then found that, in the absence of air bubbles, the algae grew only on the surface, below which the dyes remained permanently reduced.

III. Soil and Derx's mineral solution and glucose (Nos. 3, 5, 7).

After 3 days:

In the light: methylene blue was reduced from 0 cm. to 2·5 cm. and again from 7·5 cm. to 10 cm.

Surface light: methylene blue was reduced from 0 cm. to 7·5 cm.

In the dark: methylene blue was reduced from 0 cm. to 7·5 cm.

All beakers were completely swamped to the brim with water due to the raising of the water level by the gas formed as a result of fermentation. There was a very strong smell typical of an anaerobic fermentation and a heavy surface scum on the water.

After 6 days:

In the light: methylene blue was reduced completely from 4 cm. to 6·5 cm. and from 10 cm. to 15 cm. while partial reduction occurred at 0 cm. to 4 cm. and 6·5 cm. to 10 cm. The Nile blue was partially reduced at 1·5 cm. to 2·0 cm. and the neutral red was reduced at 7·5 cm. to 15 cm.

Surface light: methylene blue was reduced at 2·5 cm. to 7·5 cm. and partially reduced at 7·5 cm. to 15 cm. The Nile blue was reduced at 2·5 cm. to 12·5 cm. and partially reduced at 12·5 cm. to 15 cm.

In the dark: there was complete reduction of the methylene blue and Nile blue.

In the three beakers the odour of fermentation still persisted; there was a marked irregularity and pocking in the soil due to the liberation of gas from the soil and the subsequent lowering of the water level to replace the gas. Water was added where needed.

After 7 days: As at 6 days, but the odour of fermentation had disappeared in all cases. There was no sign of any algal growth.

After 10 days: No change in the reduction of dyes but the surface of the soil showed signs of the beginning of algal growth in the presence of light only.

After 14 days: There was a definite algal growth in the presence of light only.

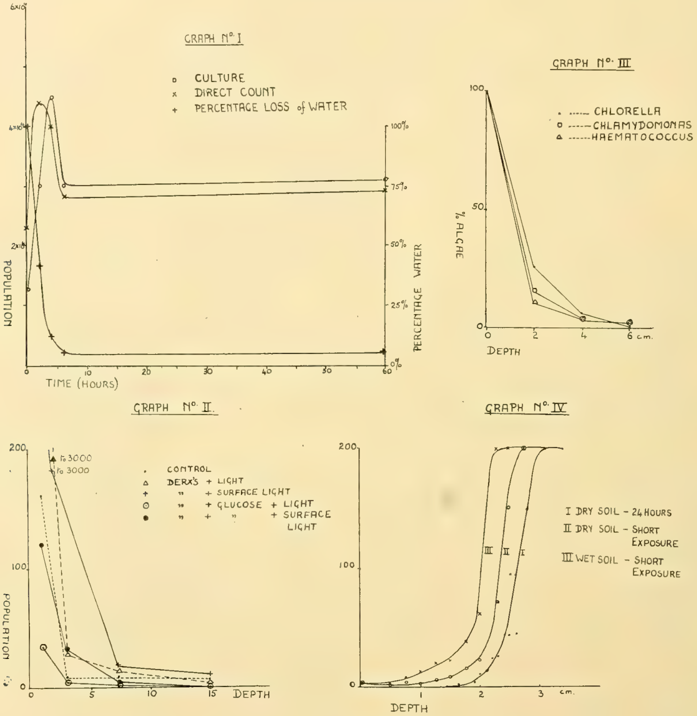
Soil samples were taken at this stage. The qualitative tests with Fehling's reagent did not show the presence of any reducing substances in the beakers to which glucose had originally been added. The algal populations were estimated by the direct fluorescence microscope technique for all samples. Results are summarized in the Graph II. Two beakers (Nos. 3 and 5) showed practically no growth of algae. When algae were present, most were confined to the top 5 mm. and yet algae could be found at 1·5 cm. depth, but in such low numbers that it was doubtful if this was not due to washing down with water when the samples were taken. Two days after this stage a growth of algae was noticed in beaker No. 5, which had been supplied with added glucose. A green surface layer was formed within five days. In the experiment kept completely in the dark there was no algal growth visible on the surface of the sand, even after 45 days.

It has already been shown that the growth of algae in the dark, even in the presence of organic matter, is most unlikely. Therefore, was the presence of algae at 1·5 cm. below the surface of the soil due to the penetration of air and light to this depth or to the effect of washing down by water or a combination of both factors?

PRECIPITATION OF ALGAE BY WATER.

A river sand was washed with water until it was practically free of algal cells. A large filter funnel was plugged with glass wool and filled with the sand. A complete water column was set up in the sand by allowing water to filter through until all air bubbles were excluded, leaving a surface layer of about 1 cm. head of water, and blocking the exit by means of a clamped rubber tube. A few c.c. of a suspension of a pure culture of algae, which had been examined to ensure that all the cells were well distributed throughout the water, was added to the water layer above the sand and well mixed with it. The funnel was opened for about five minutes and the water allowed to drain away slowly into a beaker until all the free water had filtered off. The centre of the sand was cut into a small block and the number of algal cells deposited at different levels was counted. In order to determine the distribution of different morphological types of algae through the soil three pure cultures were used, namely, *Chlorella* (9 × 8μ), *Chlamydomonas* (20 × 13μ), and *Haematococcus* (50μ diameter). The results may be seen in Graph III.

Algal cells were found throughout the top 6 cm. of the soil, but *Chlorella* cells were present in the water which had filtered through the 20 cm. column of the sand into the beaker. It may thus be seen that the smallest algal cells are more readily distributed into the deeper layers of the soil by the downward movement of water. This observation could account for the presence of algae at depths of 1·5 cm. below the main zone of distribution of algae at the surface of the soil.



Graphs I-IV.

Penetration of Light into the Soil.

Photographic plates (extra-rapid panchromatic) were buried into a large square container of dry sand at an angle of about 30°, and the soil left exposed in the open for 24 hours. The plates were subsequently developed and the penetration of light into the soil was estimated by measuring the intensity of light transmitted through the plate by means of a Weston-Master exposure meter. In a similar experiment using wet sand, the results were not significant owing to the injurious effect on the photographic plate of a 24-hour subjection to water-saturated soil. However, in order to obtain some kind of comparison, shorter term experiments were set up and the readings obtained were then extrapolated to obtain comparable results. In the dried sand it was found that the light could penetrate down to 1·5 cm. This is in agreement with the results obtained by directly counting the algae in the different layers of the soil. However, it is known that with very little light a plate becomes fully exposed within a day, and the light intensity measured at a depth of 1·5 cm. may be inadequate for the growth of algae. At 2·9 cm. it was found that there was no penetration of light at all. It can be seen by extrapolation from the short exposure of plates in wet and dried sand that the light penetration does not vary to any significant amount in the two conditions (see Graph IV). Thus it may be safely assumed that the penetration of light into the sandy soil in the water-saturated condition as used in the first experiment was limited to the top centimetre.

Discussion.

To the best of our knowledge the daily variation of the algal population of the soil has not been recorded in detail before. The cause of this variation is not completely understood, but it seems that the presence of nematodes and protozoa, and the changes in the water content of the soil may contribute. In the work presented here, nematodes and protozoa did not seem to play any significant role, since they were present in such low numbers. The important factor seemed to be the water content of the soil—an aspect which has been studied previously in some detail.

The remarkable resistance of algae to desiccation was demonstrated early in this century by Bristol Roach (1919). Further experiments by Petersen (1935) confirmed this observation. Petersen has shown that periods of very slow desiccation (of about one month's duration) of a soil may kill quite a considerable number of vegetative algal cells. However, this slow drying process is not of very common occurrence in sandy soils, and it is possible that any such slow-drying soils may induce the algae to produce resistant forms which would not be found in conditions where quick drying is possible. Bristol Roach (1919, 1920), using an intensive desiccation method, has shown that algae survived desiccation. The variation in the algal population in the present work occurred within a matter of hours, and the number of algae appeared to remain at a constant level of about 65% of the total algal population once the soil had reached the air-dried state.

Bristol Roach's results did show the presence of resistant forms of algal cells. However, such severe desiccation is not of very common occurrence in nature. Therefore the present results approximate more closely to the normal state of a soil system. This resistance to drought by algae is still far from being completely understood.

The minimum and maximum water levels needed for the growth of the algal flora in a sandy soil were examined and about 12% of the water-holding capacity (or 3% by weight) was required as the minimum amount needed for active growth. It may be possible that such a small amount of moisture, while inadequate for the growth of algae, could activate them into a state in which they could immediately start to grow and divide on the addition of extra water. This suggestion of activation is only hypothetical, since it is practically impossible during the experiment to keep the soil at a constant moisture level when such small amounts of water are involved. It may be presumed that under the experimental conditions the air immediately above the soil was 100% humid. Sometimes it was noted that a drop of water had condensed against the wall of the Petri dish, and if a soil particle had been in contact with it, the water content of the soil at this point would be much higher than the theoretical 3% of the experiment. It was observed by Schröder (1886) that diatoms died in soil containing 9·05% of water, but Petersen (1935) pointed out that the diatoms used by Schröder were hydrophilous species, and by using *Hantzschia amphioxys* and *Navicula mutica* he (1935) was able to show that full activity in the soil of these two species was possible at a moisture level of 5·2%. This is comparable with the results obtained above.

Thus the variation in the water content of the soil is an important factor in connection with the algal population of the soil. It was only when near the air-dried state that the algal population decreased remarkably, whilst above this point it increased quickly to a constant steady level, which was finally independent to a certain extent of the excess water added. Between these two limits the water content of the soil plays a part in controlling the rate of the algal growth.

Distribution of Algae in the Soil.

Direct observation showed that in water-saturated soil the algal population was confined to the top few millimetres of the soil. When in an unsaturated state more algae could be found in the few centimetres immediately below the surface. Our experiments have shown that when the sand was saturated with water an anaerobic condition was established just below the surface (as indicated by the reduction of the rH_2 indicators). The influence of mineral salts on the speed of reduction of the dyes will be published in a separate paper, for which work is in progress. Direct counting of the algae confirmed the accumulation of the algal population to the top few millimetres under natural conditions. It would be expected that the anaerobic conditions present just below the surface would prevent the growth of algae, but it was found that if a small air bubble had been originally included in the soil, it provided enough oxygen for algae to grow in the anaerobic zone below the top few millimetres, and since there was photosynthetic regeneration of oxygen by the algae, it became a centre of re-oxidation and provided a suitable condition for other aerobic organisms to grow. This micro-ecological condition could only be produced with the presence of light. (In the dark the presence of air bubbles was not sufficient to re-oxidize any of the dyes which had become reduced during the early part of the experiment.) Experiments with photographic plates showed that light only penetrated the top centimetre of the soil. The penetration of light of different wave lengths in sand as recorded by Hoffmann (1949) with a photoelectric cell is very suggestive, and results were similar to ours. Since photographic plates require very little light to be fully exposed with long exposure time (a complete sunny day), it is doubtful whether this light intensity would be sufficient to ensure the growth of algae at depths greater than 1 cm. from the surface. Since coarse sandy soil is the most transparent to light and permeable to air, the present observation may be extended to other types of soil without involving any significant errors. Nevertheless, it must be remembered that in certain conditions where the soil is covered with water, e.g. rice fields, the presence of air bubbles below the water would provide a suitable starting point for algae to regenerate the oxygen needed by the root system.

One of us has shown (Pochon and Tchan, 1947) that in an unsaturated soil the top few centimetres were not under anaerobic conditions. If light cannot penetrate to this depth it may be possible that algae can grow heterotrophically, using the available air and an external organic carbon supply. Bristol Roach (1927, 1928) used sugars, and Treboux (1905) used organic salts to grow pure cultures of algae in the dark. The natural occurrence of sugar in the soil has always been doubted, and the use of organic salts by algae in the dark and in the soil has not been confirmed by direct experiments under natural conditions (Moore and Karrer, 1919, and Pugmaly, 1924). Petersen (1935) has shown that in the dark the presence of 0·5% of glucose did not increase the algal population. His work was done with a pure culture and sterile soil. With fresh unsterilized soil Petersen showed that algae did not multiply in the dark. Generally speaking, algae in pure culture are able to grow in the dark when suitable organic matter is provided. As Winogradsky (1932) has pointed out, the pure culture experiments have no absolute value in soil studies if the results are not confirmed by direct observation in the soil. Work with the total flora of the soil in natural conditions and with pure cultures has not at all times produced similar results, and modifications of one or the other have been evident. One of us has shown (Pochon, Tchan, Wang, Augier, 1950) that the addition of fibrous cellulose into the soil induced the growth of the cellulose-decomposing bacterium, e.g. *Cytophaga*, but that with precipitated cellulose no growth occurred. Both forms of cellulose, however, were attacked by *Cytophaga* in pure culture. Therefore, if such a specific substance with only a slight modification of structure can induce two different microbiological reactions, then this conception may also be valid in the case of algae, as shown by results in both pure culture and our results in the natural conditions, when glucose was the added factor in both cases. Our experiments showed that in seminatural conditions the addition of glucose was not only unable to increase the algal population in the dark, but that even in the light the algae could not grow to any significant degree. In the deeper parts of the soil, where the anaerobic conditions were present, it was expected that no algal growth would occur, but even on the surface where the soil was in permanent contact with the air, the growth of algae was not noticeable. The microbial fermentation of glucose in these cases was indicated by a quick reduction of the rH_2 indicators and a characteristic smell. This fermentation seemed to be responsible for the inhibition of any algal growth, since once the fermentation had ceased (indicated by the absence of any smell and a negative test with Fehling's reagent for sugar) the growth of algae became noticeable in the soil kept in the light and formed a green cover on the surface within a few days. In the soil kept in the dark the growth was insignificant, which indicated that in the natural conditions, in the presence of the total flora of the soil, not only were the algae unable to compete with other micro-organisms for the sugar but there was an antagonistic effect produced by these organisms which seemed to prevent the algal growth. It may be that under special circumstances when available nitrogen is absent, only nitrogen-fixing organisms (bacteria or blue-green algae) would be able to grow, in which case the competition would be limited. After the fermentation of sugar had ceased and only organic salts remained, no evidence was produced to support the theory that growth of algae in the dark can proceed by utilizing organic salts, as was suggested by Treboux.

Thus all experiments have suggested that there was no growth of algae in the dark under natural conditions and that the subterranean algae are washed down from the surface. By filtering algae through sand it was obvious that the smaller sized algae can pass through 10 cm. of sand in a single filtration. Under natural conditions a heavy shower of rain could easily bring about such a condition. These results agree well with those of Petersen (1935) working with algae, and Burges (1950) with fungi.

CONCLUSION.

Using a method of fluorescent microscopy, the daily variation of the algal population in sandy soils was recorded. Hypotheses proposed to account for this variation were tested experimentally.

The quick growth and the physiological behaviour of the algae in a soil should benefit the soil in a number of ways: namely, by providing organic matter from photosynthetic activity; by a fast formation of a surface covering over the soil, thus diminishing erosion effects due to water and wind; and by the fixation by algae of soluble mineral nutrients which would otherwise be lost to the soil by drainage. This latter point has a bearing on the work done by Fuller and Rogers (1952), who found that algae in certain cases proved a favourable source of phosphate.

Experiments dealing with the vertical distribution of algae under natural conditions in the soil and their presence in the subterranean layers did not support the theory that the growth of algae in the dark is possible, even with the addition of an organic matter supply. Furthermore, it seems evident from the experimental data that the presence of glucose could create an antagonistic action which would inhibit the growth of algae in the soil. This hypothesis is a likely one, but is not yet fully understood.

The studies of algal physiological behaviour in the soil, using pure cultures, do not necessarily provide the complete solution to this problem. Algae must be studied, like other organisms, in the presence of the total flora of the soil to understand their role and behaviour in such a situation.

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EXPLANATION OF PLATE X, FIGS. 1, 2.

1. *Filter paper technique.*—The dyes from left to right are: neutral red, pheno-safranin, Nile blue, methylene blue.

Left beaker: When tap-water alone was added to the soil the reduction of the dyes was continuous within the anaerobic zone, and both methylene blue and Nile blue strips were reduced from within the top few centimetres to the bottom.

Centre beaker: When Derx's solution was added to the soil, the growth of algae took place more readily and was initiated by air bubbles in the soil. The products of algal growth in these areas oxygenated the soil to such an extent that re-oxidation of the dyes occurred in small areas which coincided exactly with these zones of growth. Such areas are visible in the Nile blue and methylene blue strips on the filter paper.

Right beaker: When a 1% glucose solution was added to the soil the reduction of the dyes was pronounced, due to the increase in anaerobic fermentation. Algal growth was inhibited and no re-oxidation areas were evident.

2. *Centre beaker, one week later.*

The re-oxidation of the dyes by algal growth was very pronounced in the methylene blue strip and was just evident in the Nile blue strip. The zone of algal growth exceeded the space occupied by the original air bubble, which initiated its growth, due to the production of oxygen from photosynthesis.

STUDIES OF N–FIXING BACTERIA. V.

Presence of Beijerinckia in Northern Australia and Geographic Distribution of Non-symbiotic N–Fixing Micro-organisms.

By Y. T. Tchan, Macleay Bacteriologist to the Society.

(Plate x, figs. 3, 4; one Text-figure.)

[Read 26th August, 1953.]

The distribution of aerobic N-fixing bacteria has been very intensively investigated in Australia except the northern part of this continent (Collins, 1952; Jensen, 1940; Jensen and Swaby, 1940; McKnight, 1949; Swaby, 1939). The species present are mostly *Azot. chroococcum*, occasionally *Azot. beijerinckii* and *Azot. vinelandii*. *Azot. beijerinckii* var. *acido-tolerans* has been isolated in the Sydney district (Tchan, 1953).

No *Beijerinckia* species have been reported. On the other hand, countries and islands near Northern Australia are inhabited by species of *Beijerinckia*. They have been isolated by Derx (1950) in recent years. The intensive movements of animals and human populations, and transport of dirt by wind could be a constant contaminating source of Australian soil by micro-organisms of the islands surrounding the country. The present paper is aimed to answer the following two questions:

(1) Are there any species of *Beijerinckia* in Northern Australia?
(2) What is their geographic distribution and their ecology?

Materials and Technique.

Soil samples: Samples were collected in a small sterile container at their natural moisture content. They were not a random sample. Most of them were collected along the roadside. Samples took two months to reach the laboratory. These consisted of 48 samples collected by the 1952 Australian Museum expedition; 15 samples around 19·5° latitude (Ayr, Queensland) collected by the Division of Plant Industry of C.S.I.R.O. were sent to me by air mail and immediately examined.

0·1 g. of each sample was inoculated into Derx's medium and Winogradsky's medium with sucrose as organic matter. After two months of incubation at 30°C., samples were considered as negative when no aerobic N-fixing bacterial colonies appeared. Positive samples were then analysed quantitatively by the liquid solid media technique described in an earlier paper (Tchan, 1952).

Chemical analyses were made for the C content by Walkley and Black's method. pH was determined by a glass electrode potentiometer with 1:10 soil water ratio. The P was estimated colorimetrically. Two extractions were used: (1) Burd's (Burd, 1948) contact equilibrium technique with water as solvent: (2) 3% citric acid at pH 3·5. As the *Beijerinckia* gave a final pH of 3·5 in their culture, this pH value was chosen for extraction.

Since samples were of small quantities (10–50 g.) it was impossible to make an extensive chemical analysis.

Discussion.

The results from this investigation showed for the first time that the soils of Northern Australia are inhabited by *Beijerinckia*. The number of positive samples is 17 over a total of 48 collected by the Australian Museum Expedition. It is very similar to the percentage of soils containing *Azotobacter* in the other parts of Australia.

The importance of these organisms in the N-economy of the soil cannot be discussed, since the 1952 drought and the long period between the time of collecting and analysis made the discussion very difficult. However, one sample gave 4,000 cells p.g. of soil.

TABLE 1.

Date, Localities, Soil.	Geological Formation of Soil.	*Azotobacter* p.g. of Soil.	*Beijerinckia* p.g. of Soil.	pH.	P. (1) Mg./kg.	P. (2) Mg./kg.	C. G./kg. of Soil.
Western Australia.							
(1) 20.5.52. 42 miles north of Hall's Creek on Wyndham Road, eastern Kimberleys. Residual red-brown soil. Flat savannah.	—	—	—	6·5	—	—	0·70
(2) 20.5.52. 18 miles south of Mabel Creek, eastern Kimberleys. Red-brown residual. Taken from about roots of Mitchell grass in open eucalypt country.	—	Sporadic	—	6·65	—	—	2·70
(3) 22.5.52. 20 miles south of Wyndham. Black sandy soil. From grass roots beneath eucalypt in open savannah.	—	—	—	6·5	—	—	2·0
(4) 26.5.52. Forrest River Mission, 15 miles south-east of Wyndham. Muddy soil from dry waterhole.	—	—	—	5·2	—	—	1·00
(5) 26.5.52. Forrest River Mission. Sandy loam. Collected from plain at base of quartzite hill.	—	—	—	6·25	—	—	0·90
(6) 12.6.52. Ivanhoe Station, northern Kimberleys. Black alluvium. Lightly timbered plain. Specimen from base of tree.	—	—	—	6·3	—	—	1·20
(7) 12.6.52. Ivanhoe Station. Black alluvium. Lightly timbered black soil plain. Specimen from base of grass clump.	Basalt	100	800	7·5	5	25	0·7
(8) 13.6.52. Newry Station between Ivanhoe and Auvergne. Brown soil from weathered quartzites and slates (Pre-Cambrian). Lightly timbered country. From amongst grass and tree roots.	—	—	—	8·1	—	—	0·40
(9) 13.6.52. Auvergne Station. Black residual. Sparsely timbered open country.	—	—	—	7·42	—	—	2·10
Northern Territory.							
(10) 13.6.52. Timber Creek near Victoria River Depot, Victoria River. Limy brown alluvium. Amongst grass roots ½–1″ below surface.	Basalt	500	Sporadic	6·08	—	—	0·40
(11) 14.6.52. 72 miles north of Victoria River Downs Station. Basaltic soil. Lightly timbered plain with moderate grass development. Sample from bank of small watercourse.	—	—	Sporadic	5·58	2·5	26	1·15
(12) 28.6.52. Port Keats Mission. Fine clay from bank of spring. Bank overhung by grass but clay collected did not appear to have been invaded by roots.	—	—	—	5·3	—	—	0·25
(13) 28.6.52. Port Keats Mission. Mangrove mud. Specimen from amongst mangrove roots exposed at low tide.	—	—	—	5·3	—	—	1·3
(14) 28.6.52. Port Keats Mission. Weathered ferruginous Permian sandstone soil. From amongst *Pandanus* roots near surface, in *Pandanus*-grassy hillside.	Sandstone	—	Sporadic	5·88	0·5	28	1·90

TABLE 1.—*Continued.*

Date, Localities, Soil.	Geological Formation of Soil.	*Azotobacter* p.g. of Soil.	*Beijerinckia* p.g. of Soil.	pH.	P.		C. G./kg. of Soil.
					(1) Mg./kg.	(2) Mg./kg.	
(15) 28.6.52. Port Keats Mission. Black silt from marsh. Tea-tree marsh adjoining mangroves.	—	—	—	5·3	—	—	2·25
(16) 28.6.52. Port Keats Mission garden. Black silt. From base of banana tree.	—	—	—	5·5	—	—	2·30
(17) 28.6.52. Port Keats Mission area. Black soil and mould of fallen leaves. Light rain forest adjoining mangrove-fringed stream. 2″ below surface.	Clay	—	4000	5·7	0·8	12·5	2·0
(18) 28.6.52. Port Keats Mission. Black soil and leaf mould. Light rain forest adjoining mangrove-fringed stream. Depth : 6″.	Clay	—	Sporadic	5·6	0·6	12·0	3·0
(19) 30.6.52. 60 miles south of Darwin on Rum Jungle road. Sandy ferruginous soil. Open forest with undercover of sorghum. Specimen from roots of gum sapling.	Granite	—	Sporadic	5·55	0·6	20·0	2·0
(20) 30.6.52. 60 miles south of Darwin on Rum Jungle road. Sandy ferruginous. Open forest with sorghum. From amongst roots of sorghum.	—	—	—	5·5	—	—	0·35
(21) 30.6.52. Stapleton Creek, 65 miles south of Darwin. Soil weathered from Pre-Cambrian metamorphosed sediments. Savannah. From foot of grass clump.	Schist	—	Sporadic	5·3	1·0	12·5	2·9
(22) 30.6.52. Stapleton Creek. As above. From roots of scrub (light rain forest) along creek. Depth : 2″.	—	—	—	5·5	—	—	1·9
(23) 30.6.52. 105 miles south of Darwin. Sandy soil. Dry sclerophyll. Amongst eucalypts of adjoining small creek.	Granite	Sporadic	500	7·62	—	—	1·65
(24) 30.6.52. Katherine. Limy soil. Open forest with drying grass. Sample from grass and tree roots.	—	—	—	5·1	—	—	2·25
(25) 30.6.52. Katherine. Limy sand. Dry sclerophyll (gum). Taken from soil amongst fallen leaves.	Limestone	Sporadic	Sporadic	6·2	—	—	2·25
(26) 30.6.52. 19 miles south of Katherine. Depth : 2″. Ferruginous soil. Gum saplings with thick grass. Taken at sapling base amongst eucalypt and grass roots.	—	—	—	5·42	—	—	0·90
(27) 30.6.52. Maranboy tinfield, 30 miles south-east of Katherine. Sandy soil (weathered porphyry). Lightly timbered eucalypt forest with grass.	—	—	—	5·4	—	—	1·4
(28) 30.6.52. Mataranka. Ferruginous sandy soil. Lightly timbered gum forest with grass.	—	—	—	4·65	—	—	2·1
(29) 30.6.52. 30 miles north of Daly Waters. Black sandy soil. Lightly timbered forest.	Sandstone	—	Sporadic	5·5	0·6	75	3·0
(30) 30.6.52. 30 miles north of Daly Waters. Dried mud from depression. Collected from amongst roots of dead grass.	—	—	—	5·15	—	—	0·45

TABLE 1.—*Continued.*

Date, Localities, Soil.	Geological Formation of Soil.	*Azotobacter* p.g. of Soil.	*Beijerinckia* p.g. of Soil.	pH.	P.		C. G./kg. of Soil.
					(1) Mg./kg.	(2) Mg./kg.	
(31) 1.7.52. Dunmara. Ferruginous sandy soil. Mallee thicket. Taken at tree base.	—	—	—	5·42	—	—	0·14
(32) 1.7.52. 110 miles south of Daly Waters. Red sandy soil. Semi-desert scrub. Taken amongst roots.	Sandstone	—	Sporadic	5·55	0·7	25	0·10
(33) 3.7.52. 50 miles east of Frewena on Barkley Highway. Ferruginous sandy soil (Cambrian). Semi-desert plain with moderate degree of shrubbery. Taken from grass roots.	—	—	—	6·65	—	—	0·5
(34) 3.7.52. 25 miles west of Soudan Station on Barkley Highway. Ferruginous sandy soil (weathered Cambrian). Semi-desert plain with rank grass and scattered shrubs. Taken from amongst roots.	—	—	—	6·25	—	—	0·4
Queensland.							
(35) 12.7.52. 25 miles south-east of Normanton. Red sandy soil. Lightly timbered open country.	—	—	—	6·28	—	—	1·0
(36) 12.7.52. Norman River, 16 miles west of Normanton. Damp river alluvium (water's edge). Riverside scrub.	—	—	—	5·0	—	—	—
(37) 12.7.52. Norman River, 16 miles west of Normanton. Dry river alluvium. Amongst riverside scrub 30 feet from water's edge.	—	—	—	5·4	—	—	0·25
(38) 13.7.52. 5 miles east of Gilbert River crossing, bank of tributary. River alluvium. River bank amongst light timber.	Alluvium	—	500	5·82	0·5	37·5	25·0
(39) 13.7.52. 20 miles west of Georgetown, Queensland, Granitic soil. Dry open forest.	Granite	150	500	7·25	2·0	76·0	26·0
(40) 14.7.52. Einasleigh River (near Einasleigh, Queensland). River alluvium. Amongst tea-tree roots on bank.	Granite ? Basalt ?	Sporadic	Sporadic	5·9	—	—	13·0
(41) 18.7.52. 35 miles W.N.W. of Innisfail, Atherton Tableland (2,500 feet). Basaltic soil. Rain-forest floor litter.	Basalt	Sporadic	Sporadic	5·1	2·5	37·5	28·0
(42) 19.7.52. 15 miles north of Cardwell. Litter of decaying leaves. Rain forest. Height probably about 500 feet.	—	—	—	5·7	—	—	21·0
(43) 19.7.52. 15 miles north of Cardwell. Grassy mud at streamside adjacent to rain forest. Alluvial soil.	—	—	—	5·0	—	—	6·5
(44) 21.7.52. 10 miles south of Ingham. Black alluvium. Grasslands adjoining canefields.	Granite	—	150	5·8	1·0	76·0	20·0
(45) 24.7.52. 50 miles south of Charters Towers. Brown sandy soil. Dry lightly-timbered open forest with grass (from base of grass clump).	—	—	—	5·8	—	—	2·0

TABLE 1.—*Continued.*

Date, Localities, Soil.	Geological Formation of Soil.	*Azotobacter* p.g. of Soil.	*Beijerinckia* p.g. of Soil.	pH.	P. (1) Mg./kg.	P. (2) Mg./kg.	C. G./kg. of Soil.
(46) 29.7.52. 20 miles south of Rockhampton. Alluvial soil adjoining dam. Open semi-cultivated land with light timber.	—	—	—	5·3	—	—	25·0
(47) 29.7.52. 20 miles north of Gladstone. Brown shale. Coastal open forest with grass.	—	—	—	5·7	—	—	20·0
(48) 27.7.52. 40 miles north of Claremont. Black (?) alluvial soil. Dry sclerophyll forest.	—	—	—	5·75	—	—	5·5

The soil samples were collected from that portion of the route from the eastern Kimberleys, north-west coast, sclerophyll woodlands southwards along the Stuart Highway and semi-desert terrain eastwards on the Barkley Highway, western Queensland, to the rain forests of north-east Queensland.

The geographic distribution of *Beijerinckia* in Australia seems to be limited at 17–18° latitude. Of the 15 samples collected around the 19·5° latitude only one gave positive growth of *Beijerinckia*. It is possible that no *Beijerinckia* was detected south of 20° latitude. It should be kept in mind that the soil samples examined were in limited number for such a big area. However, if McKnight's results are compiled with the present investigation, it seems that *Beijerinckia* does not occur south of the Tropic of Capricorn. It is important and very desirable to test more soil samples between 17° and 20° latitude in Australia before a definite conclusion can be made. The limit of 17–18° latitude may be used as a starting point for further investigations.

TABLE 2.

Authors.	Localities.	% Soil Containing *Azotobacter*.	% Soil Containing *Beijerinckia*.
Jensen	New South Wales ..	25	—
McKnight	Queensland..	43·15	—
Swaby	Victoria	26·15	—
Tchan	Sydney	22	—
Tchan	Northern Australia ..	15	35

The ecological conditions of *Beijerinckia* in Australia are not understood. The soil type and its parent material in positive cases are indeed very variable (see Table 1). The analysis of C, P content and pH of soil samples did not show any correlation between presence and absence or number of *Beijerinckia* per g. of soil. On the other hand, *Azotobacter* did not occur at pH less than 5·5 except in one case of sporadic presence of *Azotobacter* at pH = 5·1. The climatic environments have no apparent influence on the presence of *Beijerinckia*.

It is clear that *Beijerinckia* can survive in low rainfall countries. The drought of 1952 in Northern Australia provided an example. Also in high rainfall country outside the tropical zone (Brisbane, Sydney, etc.) *Beijerinckia* seems to be absent (see Text-figure 1). Temperature cannot be considered as an important ecological factor in its distribution, since the occurrence of *Beijerinckia* took place in certain places where the mean minimum temperature of 57·2°F. (14°C.) is lower than certain places outside the tropic zone, e.g. Brisbane 59·7°F. (15·4°C.).

Under the experimental conditions *Beijerinckia* (isolated from Northern Australia) inoculated into soil and kept in a refrigerator (+4°C.) survived after 36 days. As along certain parts of the east coast of Australia (Queensland, N.S.W.) the winter temperature never goes much below that limit, there is no apparent reason to believe that *Beijerinckia* could be killed during the winter.

Complete desiccation (with $CaCl_2$) in the laboratory did not destroy *Beijerinckia* in soil after 36 days, but such a severe desiccation is not likely to occur in the temperate places of the east coast of Australia. This may suggest that *Beijerinckia* may survive in air-dried soil at normal humidities.

TABLE 3.

(Data compiled from Meteorological data, C.S.I.R.O., Melbourne, 1933. Pamphlet 42.)

Soil Sample No.	Mean Temperature (°F.).		Humidity.	Rainfall. (Inches per Year.)
	+° max.	+° min.		
32	89·4	65·3	36	14·72
7	92	63·9	41	20·84
10, 14, 17, 18, 23, 25, 29 ..	94	66·7	51	26·48
38, 39, 40	89·9	64·8	52	31·97
41	78	57·2	74	51·84
19, 21	90	74·3	68	60·45
44	82·2	65·5	81	142·61
Bowen	82·6	67·2	69	39·88
Rockhampton	83·5	62·8	67	39·75
Brisbane	78·1	59·7	68	45·27
Sydney	70·2	56·2	70	47·50

If the chemical and meteorological factors could not explain the absence of *Beijerinckia* outside the tropical zone of Australia, the only remaining hypothesis will be that *Beijerinckia* is a young genus which may have been introduced to this country very recently and has not had enough time to reach the rest of the continent. This hypothesis may not be considered as a valid one, since the movement of animal and human transport in Queensland is so intensive that the contamination from Northern Queensland can be realized in a matter of months. Furthermore, information in the literature shows that *Beijerinckia* has been found only in tropical countries. Altson (1936) in Malaya was probably the first person to detect *Beijerinckia*; later it was found in Indian soils by Starkey and De (1939), in Indonesia and Pacific islands by Derx *et al.* (1950), in Africa (Käuffmann, 1953) and in South America (Derx, 1952). Outside the tropical zone the *Beijerinckia* has been sought but unsuccessfully (Northern Africa (Derx, 1952); Southern France (Derx, 1950); N.S.W. (Jensen and Swaby, 1940; Tchan, 1952)). From these data one may conclude that if *Beijerinckia* has spread so widely in the tropics, including very long distances separated by oceans, it is not likely that it needs more time to reach the Australian soils south of the tropics. It is likely that the hypothesis mentioned above has no important value.

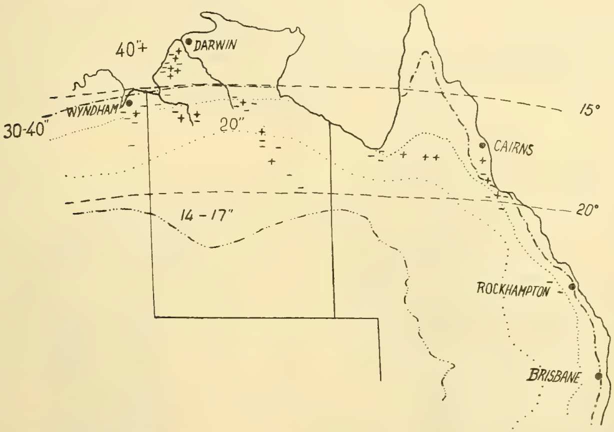
It is not clear why *Beijerinckia* is a genus confined to tropical countries.

This geographic limitation of *Beijerinckia* can be extended to the distribution of other N-fixing micro-organisms in the world. The distribution of *Rhizobium* is excluded in this paper because it is practically a question of distribution of legumes. The non-symbiotic N-fixing soil micro-organisms can be classified into four groups: blue-green algae (*Nostoc* and *Anabaena*), *Clostridium*, *Azotobacter* and *Beijerinckia*.

(1) In the tropical countries the four groups of organisms have been detected.

(2) In the temperate zone the absence of *Beijerinckia* reduces the number to three groups.

(3) In the arctic and antarctic zones the early workers have reported the presence of *Azotobacter*. Rountree (1939) reported the presence of *Azotobacter* in Macquarie Island soils, but more recently Bunt could not confirm this result with soil samples collected in most suitable conditions. Also he reported that on the N-free media the Macquarie Island soil samples gave some colonies similar in appearance to *Azotobacter*. The early positive results may be due to contamination of soil samples. On the other hand, in Greenland, the search for *Azotobacter* has been always negative (Barthel, 1922; Jensen, 1951).



Text-figure 1.—Map showing distribution of *Beijerinckia*, the latitudes and the rainfall.
+ . . . . . . positive soil; − . . . . . . negative soil.

The absence of *Azotobacter* in the very cold regions could be partly explained by the death of *Azotobacter* (including cysts) at a prolonged low temperature. Wang (1949) has reported that *Azotobacter* is killed if the culture is kept in a refrigerator for a prolonged period. So the very cold regions contain only two groups of non-symbiotic N-fixing micro-organisms (blue-green algae and *Clostridium*).

This division of the world, according to the distribution of non-symbiotic N-fixing micro-organisms, into three zones is still at a purely hypothetical stage. It could only be established with some certainty if a very extensive survey in different regions could be carried out. At the present stage this suggestion may provide a starting point for future research work.

CONCLUSION.

The present results have contributed to our knowledge by showing that:

(1) *Beijerinckia* is present in Northern Australia. To the best of my knowledge it is the first time that these organisms have been detected in this country.

(2) The distribution of *Beijerinckia* in Australia seems to be limited to the north of 17–18° latitude. It is likely to be absent south of the 20° latitude.

(3) The ecological factors of the distribution of *Beijerinckia* in Australia are still not understood. Some chemical, geological and climatic factors are discussed.

(4) A suggestion has been made to divide the world into three zones, according to the distribution of non-symbiotic N-fixing micro-organisms: (*a*) tropical zone with the presence of *Beijerinckia*, *Azotobacter*, *Clostridium* and blue-green algae; (*b*) temperate zone with *Azotobacter*, *Clostridium* and blue-green algae; (*c*) arctic and antarctic zone with *Clostridium* and blue-green algae.

This suggestion is purely hypothetical but may provide a starting point for future research.

Acknowledgements.

The author is indebted to Dr. H. S. McKee for his help and criticism; to Mr. H. Fletcher, leader of the Australian Museum Central and North-West Expedition, and particularly to Mr. J. A. Keast, who collected the soil samples; also to Mr. Lovett, of C.S.I.R.O., for sending 15 soil samples from Queensland. This work would have been impossible without their collaboration. His sincere thanks are extended to Dr. W. R. Browne for geological information, to Professor H. G. Derx for his private communications and to Dr. A. B. Walkom for his help.

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EXPLANATION OF PLATE X, FIGS. 3, 4.

Fig. 3.—Photomicrograph of *Beijerinckia* in mixed culture.

Fig. 4.—Top: Colonies of *Beijerinckia* on N-free medium three weeks old. Lower right: Colonies of *Azotobacter*, same age. Lower left: Colonies of other bacteria.

A NEW SPECIES OF *PSEUDOPHRYNE* FROM VICTORIA.

By JOHN A. MOORE, Fulbright Research Scholar, Sydney University.

(One Text-figure.)

[Read 29th July, 1953.]

The Australian Museum has in its collections an undescribed *Pseudophryne* of a most striking kind. It is represented by a single specimen. The basing of a new species on a single specimen is a hazardous procedure, but in this instance I think it is justified in view of the unusual characteristics shown by the specimen. There is no other *Pseudophryne* that has even a remote resemblance.

PSEUDOPHRYNE CORROBOREE, n. sp.

Type: R 13103, a male in the Australian Museum, Sydney. Collected by Ossie Rixon at Towong Hill Station, Corryong, Victoria. Donated by T. W. Mitchell. The type locality is near the Victoria–New South Wales border, about 25 miles north-west of Mount Kosciusko.

Pseudophryne corroboree in dorsal (left) and ventral (right) views. Approximately twice natural size.

Description: A *Pseudophryne* having the same general structural features as *P. australis* (Gray) and *P. bibroni* Günther. Body length 24 mm.; tibia 7·9 mm.; width of head at posterior end of jaws 7·0 mm.; tip of snout to centre of nares 1·1 mm.; centre of nares to anterior corner of eye 1·7 mm.; anterior-posterior dimension of eye 2·2 mm. The three dimensions last given were obtained by viewing the specimen laterally under a binocular microscope and the measurements made with an ocular scale. The fourth toe reaches the snout when the leg is extended along the side of the body. The shape of the head and the structure of the hand and foot are the same as in *P. australis* and

P. bibroni. A detailed description of these and other members of the genus will be found in Parker (1940).

This species differs from all others of the genus in its unusual dorsal pattern, which can be best appreciated by reference to the figure. In the type the dark bands are black and the light areas pale yellow. Dark and light areas of similar tones cover the entire body. The tubercles at the base of the fingers and on the metacarpals are light, contrasting strongly with the dark background. Many of the tubercles of the foot, including the inner metatarsal tubercle, are likewise light in colour against a dark background. The postfemoral glands cannot be distinguished externally, but the area where they occur in other species of *Pseudophryne* is light in colour.

Diagnosis: *Pseudophryne corroboree* can be distinguished from all other species of the genus and from all other Australian frogs by the boldly contrasting dark and light stripes on the dorsal surface.

The specific name was suggested by the resemblance of the dorsal pattern of *P. corroboree* to the body paintings used by some Australian aboriginal tribes in their corroborees.

When specimen R 13103 was received at the Australian Museum, Mr. Kinghorn realized that it was an undescribed species and attempted to secure more information and specimens. No additional specimens have been received, but this excerpt of a letter from Mr. Mitchell is of interest: "It was found at the foot of a fence post at the foot of the Round Mountain. After getting your letter asking for information I questioned the finder, one Ossie Rixon. He said that he has seen them before about the Round Mountain and also about the Fifteen Mile. He said 'they are rare but you do see them . . . generally about the cattle pads . . . they don't hop like a frog but sort of go along on all fours right up on their toes . . . they don't squat like a frog . . .'." This type of locomotion is common in other species of *Pseudophryne.*

I am indebted to Mr. Kinghorn for allowing me to describe this species.

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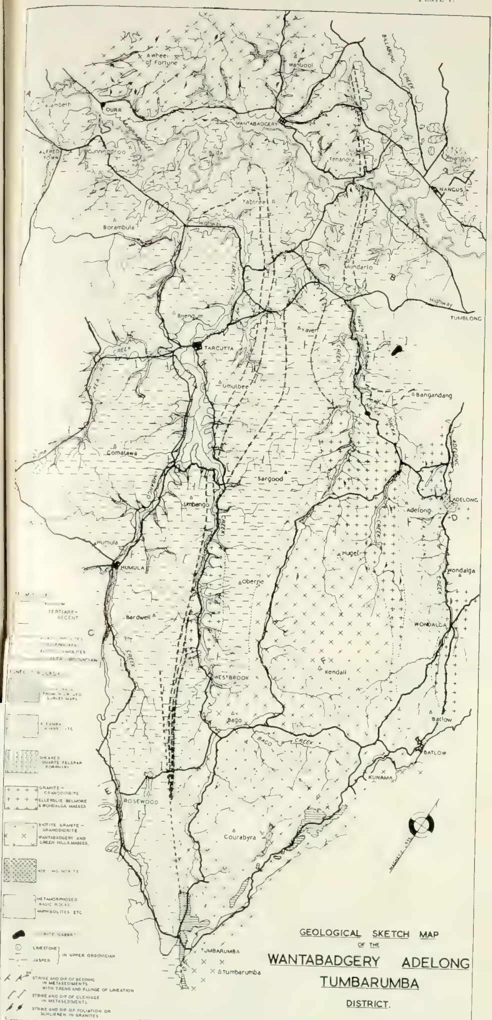
GEOLOGICAL SKETCH MAP
OF THE
WANTABADGERY ADELONG
TUMBARUMBA
DISTRICT.
SCALE
2 1 0 2 4 6 MILES
TERTIARY-RECENT
UPPER ORDOVICIAN
FROM N.S.W. GEO SURVEY MAPS
SHEARED QUARTZ FELSPAR PORPHYRY
GRANITE - GRANODIORITE
ELLERSLIE BELMORE & WONDALGA MASSES
BIOTITE GRANITE - GRANODIORITE
WANTABADGERY AND GREEN HILLS MASSES
METAMORPHOSED BASIC ROCKS
AMPHIBOLITES ETC
LIMESTONE
JASPER
IN UPPER ORDOVICIAN
STRIKE AND DIP OF BEDDING IN METASEDIMENTS
WITH TREND AND PLUNGE OF LINEATION
STRIKE AND DIP OF CLEAVAGE IN METASEDIMENTS
STRIKE AND DIP OF FOLIATION OR SCHLIEREN IN GRANITES
CRUSH BANDS IN GRANITE
FAULT INFERRED
OUTER LIMIT OF BIOTITE ZONE
KNOTTED SCHIST ZONE
HIGH GRADE ZONE
60°
A
B
C
D
E
F
Wheel of Fortune
Wantool
BILLABONG CREEK
Oura
WANTABADGERY
ALFRED TOWN
Cunningdroo
Zenandra
Nangus
NANGUS
MURRUMBIDGEE
RIVER
Yabtree
Borambula
Highway
TARCUTTA
Mundarlo
Highway
TUMBLONG
Billenbah
Yaven
YAVEN CREEK
TARCUTTA
Umutbee
Bangandang
NACKI NACKA
Comatawa
ADELONG
Sargood
UMBANGO
Umbango
ADELONG
Adelong
Humula
HUMULA
Hugel
Oberne
CREEK
Wondalga
WONDALGA
Bardwell
CREEK
Kendall
WESTBROOK
Bago
BAGO CREEK
Batlow
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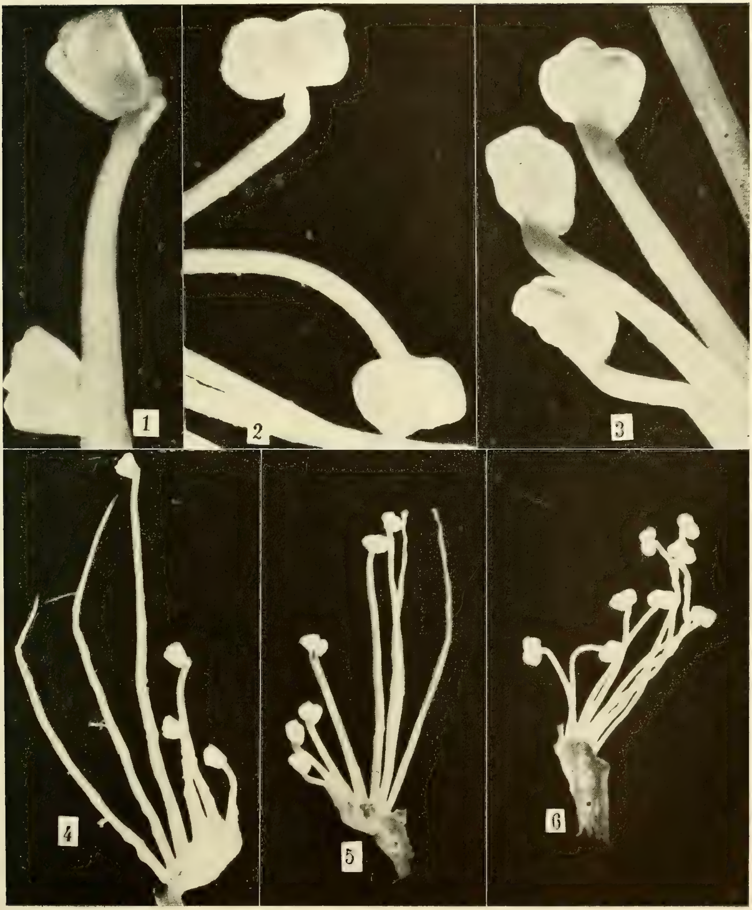
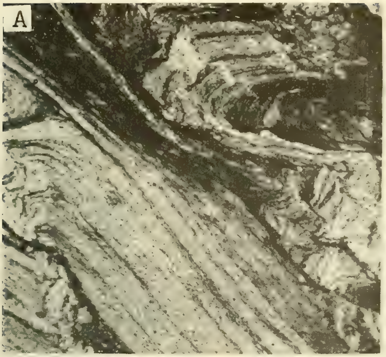
KUNAMA
ROSEWOOD
Courabyra
TUMBARUMBA
Tumbarumba

Eucalyptus sideroxylon and *E. albens*, and hybrids.



Anthers of *Eucalyptus sideroxylon* and *E. albens.*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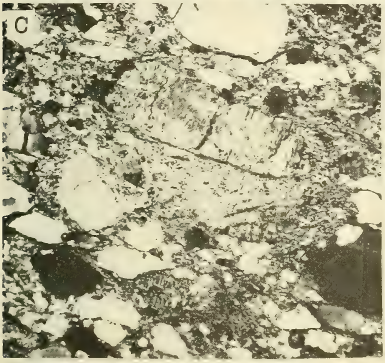
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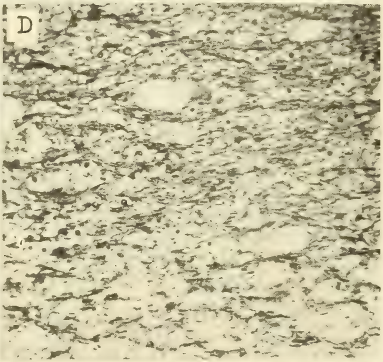
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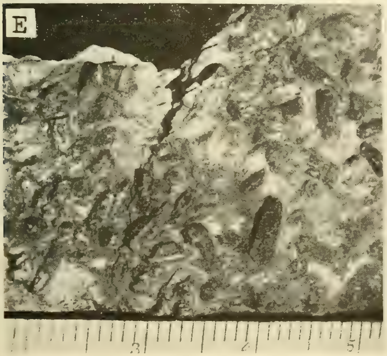
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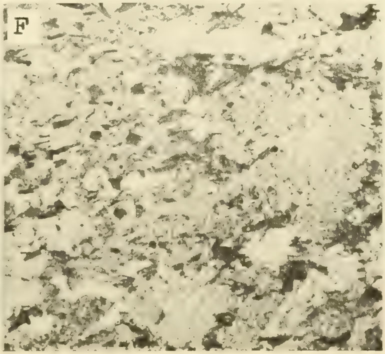
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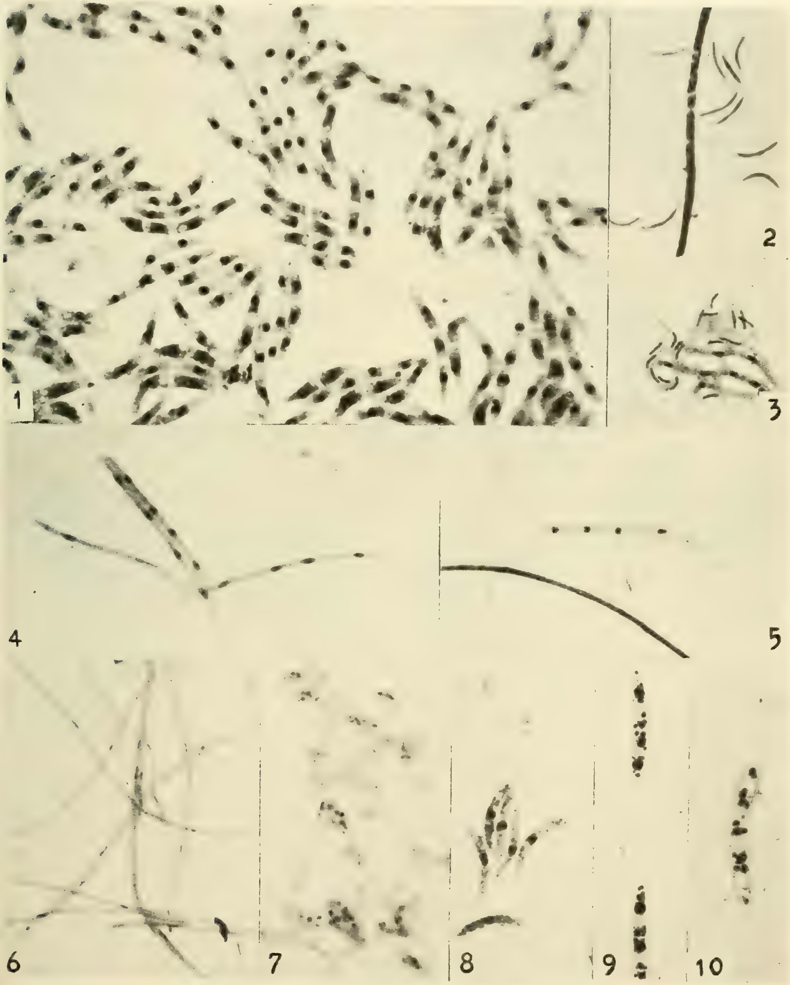
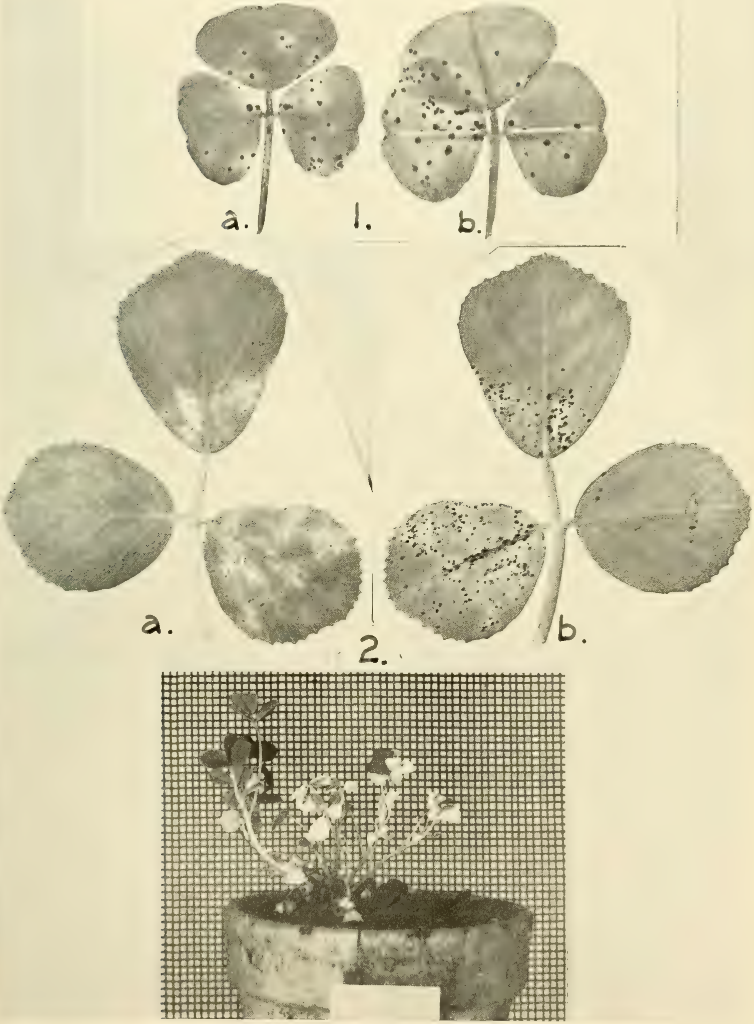
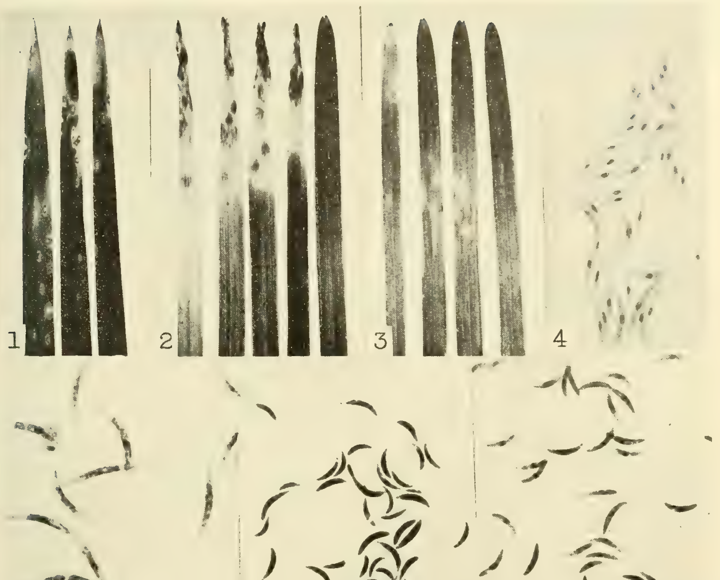


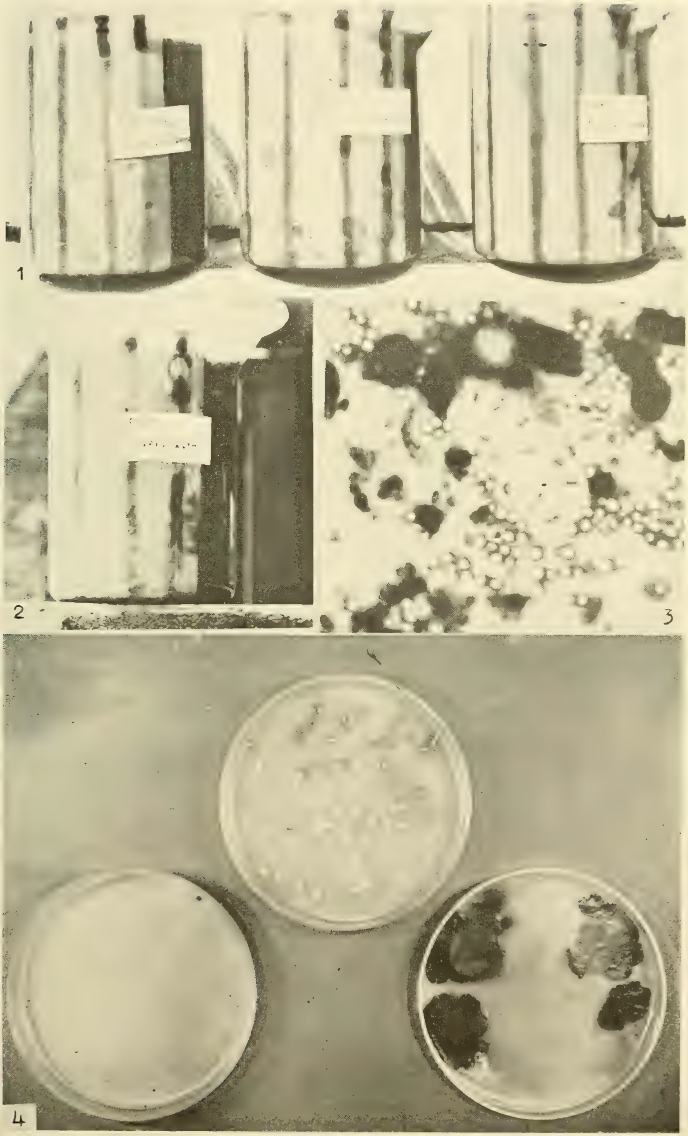
Spores of *Septoria* and *Selenophoma*.



Leaves and seedling plant of *Medicago*.



Selenophoma on Gramineae in Australia.



1, 2: Growth of soil algae.
3: *Beijerinckia* in mixed culture; 4: *Beijerinckia*, *Azotobacter*, and other bacteria.

STUDIES IN THE METAMORPHIC AND PLUTONIC GEOLOGY OF THE WANTABADGERY–ADELONG–TUMBARUMBA DISTRICT, N.S.W.

PART II. INTERMEDIATE–BASIC ROCKS.

By T. G. VALLANCE, Linnean Macleay Fellow in Geology.

(Plate xi; two Text-figures.)

[Read 30th September, 1953.]

Synopsis.

The intermediate to basic rocks of igneous origin in this area are confined to a relatively narrow belt running from near Nangus to south-east of Batlow. A metamorphic progression from low-grade Greenschist Facies rocks in the north to amphibolites and (locally) pyroxene granulites in the south is noted. This progression is more or less equivalent (as far as metamorphic grade is concerned) to that shown by the metasediments of this region (see Part I of these Studies). A number of the rocks of igneous origin do not fit into this progression and it is suggested that they post-date the metamorphism. Two other rocks, not in the "basic belt", viz., the "kersantites" and norite-gabbro at Adelong, are briefly discussed.

INTRODUCTION.

In Part I of these studies (Vallance, 1953) attention was mainly confined to the metasediments and the manner in which the metamorphism had affected them. Brief mention was, however, made of the fact that in the Adelong–Batlow area and to the north-west, near Nangus, rocks of igneous origin occurred in a more or less definite belt running parallel to the strike of the metasediments. The rocks of this belt form the subject of this paper. Although not so clearly demonstrated as with the metasediments the evidence of metamorphic variations in this case is still of some interest.

ROCKS OF THE "BASIC BELT".

In the northern part of the belt the rocks of igneous parentage are often rather fine-grained and mostly occur as small discontinuous lenses among the metasediments. Poor exposures often make it impossible to determine definitely whether the rocks are extrusive or intrusive; the restricted nature of the outcrops perhaps suggests that they are intrusive. Metasediments usually predominate in this part of the belt, the "igneous" rocks playing a minor rôle, but to the south-east this situation is reversed. South of Bangandang Trig. Station the rocks of igneous parentage are, as a rule, coarser, often less or non-schistose, and outcrop along a tract of country several miles wide separating the Ellerslie granite on its western side from the Wondalga granite to the east. Minor bands of sandy sediments are associated with the basic rocks in this part of the belt. Because of the predominance of basic rocks over metasediments in the southern part of the belt it alone has been marked distinctively on the map (see Plate v of Part I). The belt has not been traced to the south of Batlow, but about 34 miles away, at Tumut Pond, on roughly the same line of strike, basic to ultrabasic rocks (serpentines, etc.) have been mapped by the geologists of the Snowy Mountains Hydro-Electricity Authority.

Many of the rocks of this belt are more or less altered or metamorphosed. Low-grade rocks occur near Nangus, whilst, further south, the metamorphism becomes more intense, the metamorphic grade of many of the basic rocks increasing with it. At the upper extreme of the metamorphic series these rocks are represented by amphibolites and pyroxene-bearing types. The basic rocks with a metamorphic status in accord with that of the metasediments may be regarded, in general, whether extrusive or intrusive, as ante-dating the general metamorphism which affected this region. There is a possibility, however, that a few of the rocks considered may be post-metamorphic in age. Some of the types from the southern end of the belt still display features characteristic of igneous rocks (diorites-gabbros); these will be considered after the amphibolites.

In this study no attempt has been made to examine each metamorphosed igneous rock in terms of its parent material. Most of the rocks are sufficiently close chemically to be considered as a group, for it must be realized that relatively small differences in the mineralogy of the parent rocks will be obscured by the mineralogical convergence induced by the metamorphism. The lack of convenient index minerals or distinctive textural features precludes any detailed subdivision of these rocks into metamorphic zones, whilst the almost complete absence of pelitic metasediments from the southern part of the belt prevents any extension of the previously-used zonal system to include the basic rocks. A twofold metamorphic grouping will be adopted here. The lower grade rocks (from the northern part of the belt) are regarded as greenschists (they have Greenschist Facies assemblages, though not all are markedly schistose) and will be considered separately from the more southerly basic rocks which include more highly metamorphosed types representative of the Epidote-Albite Amphibolite and Amphibolite Facies (Turner, 1948). The greenschist group embraces the metamorphic equivalents of the low-grade and biotite zones as established for the metasediments. The second group includes types (not all of the second group rocks conform to this) which are correlable with the metasediments in the knotted schist and high-grade zones.

GREENSCHISTS.

In the vicinity of Nangus village masses of rocks grouped as greenschists occur along the regional strike and are associated with jaspers and low-grade siliceous metasediments. Mostly small, the masses may range up to about 30 feet in thickness; they are usually rather restricted laterally.

Typically the rocks are greenish-grey, dark green, or even black, fine-grained crystalline varieties characterized in almost every case by the rather abundant development of sodic felspar. Both massive and schistose types are found and, although their mineralogical constitutions may be, in general, comparable, the schistose rocks tend to have fibrous amphibole whilst the more massive varieties are often chlorite-rich. Deformative forces have frequently produced a "rolled-out" effect in the schists and traces of original phenocrysts (particularly pyroxene) may remain as relics. Signs of original sub-ophitic or intersertal textures are still evident in some of the more massive rocks.

Albite (Ab_{98-100}) usually occurs as laths or subhedral tabular grains and apparently replaces earlier, more calcic, plagioclase. There is no obvious tendency for large albite porphyroblasts to develop. The felspar is often somewhat dusted and included epidote granules are common. Associated with the albite may be found augite, hornblende, actinolite, epidote, chlorite, calcite, sphene, and iron oxides (mainly magnetite), though usually not all occur together.

Pyroxene and hornblende are unstable in this environment and occur here as relics from the original rocks. Colourless to grey subhedral or anhedral grains of pyroxene (+ve, $Z \wedge c$ up to 42°; augite) usually have patchy surfaces due to alteration to uralitic amphibole and epidote. Occasionally, as in the altered hornblende-augite porphyrite, about three-quarters of a mile south-west of Nangus village, subhedral pyroxene grains may show less alteration than the accompanying amphibole phenocrysts. Hornblende crystals up to half an inch long occur here, but these are not typical of the rocks in this area; in many cases they are absent. Alteration of this hornblende (2V very large; –ve; $Z \wedge c = 25°$; X = pale yellow-green, Y = yellow-brown, Z = yellow-brown) to sea-green chlorite and epidote is, in some cases, complete. The conversion of hornblende to fibrous actinolite occurs in many of the more completely reconstructed types, particularly in the schists. In fact, pale fibrous amphibole, with epidote and felspar, constitutes the major part of the base of such greenschists. Faint pleochroism from almost colourless to pale green or bluish-green is characteristic; $Z \wedge c$ varies up to about 19°. As a rule, where this amphibole is abundant chlorite is either reduced in importance or actually absent. A darker, more strongly pleochroic actinolite (X = pale yellow-green, Y = yellow-green, Z = deep leaf-green; Z∧c = 19°) is prominent in a few rocks where it takes the place of the paler variety.

Epidote, usually granular, is widespread both in the base and in the phenocrysts of these rocks. Aggregates of epidote grains at times give the impression of pseudomorphing earlier ferromagnesian minerals. In the schists the epidote granules are often grouped in bands. Both pleochroic (pale yellow-brown to colourless) common epidote and colourless clinozoisite occur in these rocks; the former is by far the more important. Coarse, brilliantly pleochroic (X = colourless, Y = greenish-yellow, Z = pale lemon-yellow) epidote sometimes occurs with quartz in veins in the more massive rocks.

TABLE 1.

	1	A	B
SiO_2	57·24	56·65	59·59
Al_2O_3	16·63	20·37	17·31
Fe_2O_3	2·46	1·24	3·33
FeO	4·21	3·28	3·13
MgO	3·06	3·20	2·75
CaO	4·50	4·31	5·80
Na_2O	5·83	5·65	3·58
K_2O	1·24	2·75	2·04
H_2O+	1·51	1·43	1·26
H_2O-	0·48	0·11	
TiO_2	0·95	0·67	0·77
P_2O_5	n.d.	0·29	0·26
MnO	0·04	0·08	0·18
CO_2	2·05	—	—
	100·20	100·03	100·00

1. Albite-epidote-chlorite-calcite rock (greenschist group). Por. 85, Par. of Nangus, Co. Wynyard. Anal. T. G. Vallance.

A. Augite-hornblende andesite. Wellington district, N.S.W. Anal. M. J. Colditz. *Jour. Proc. Roy. Soc. N.S.W.*, 81, 1948, p. 192.

B. Average of 87 rocks called andesites (calc. by Daly). Quoted from Johannsen (1937), vol. III, p. 168.

In the chloritic rocks the distinctive mineral is usually widely distributed through both base and phenocryst-relics whilst patches of it may fill interspaces between felspars. The colour is somewhat variable but most flakes are pleochroic in shades of pale yellow-green to darker green or brownish-green. Where determinable the optical sign is positive; birefringence weak (up to about 0·006); anomalous interference tints (blues, purples, and even browns) are typical; the chlorite is probably a variety of pennine. Although typical of the rather massive rocks, several examples of chlorite-bearing schists have been noted. The latter seem to have no regular distribution. Calcite may locally become important in the low-grade rocks but normally occurs only as an accessory. The analysed specimen (Table 1, no. 1) has about 2% CO_2 due to the presence of calcite. Accessories such as sphene and iron-ore have a wide distribution. Small quantities of quartz are present in some cases.

From their mineral constitution it is believed that these rocks were derived from igneous rocks of from intermediate to basic nature. Only one rock from the northern part of the belt has been analysed and its composition is quoted in Table 1. It is not far from an andesite in composition. Some of the types not analysed may be a little more basic than this.

Despite the apparently wide variety of rock types in this group, the essential mineral assemblages involved are relatively few and simple. Such accessories as quartz, iron oxides, and sericite (rather rare) are omitted from the following groups for the sake of simplicity. The main mineral assemblages are: (*a*) albite-epidote-chlorite; (*b*) albite-epidote-chlorite-actinolite (not as common as the others); (*c*) albite-actinolite-epidote (sphene); (*d*) albite-chlorite-epidote-calcite (sphene).

Such associations are quite well known from low-grade metamorphic terrains. All are, in fact, typical of the Greenschist Facies (see Turner, 1948; Billings and White, 1950). There is a tendency for the formation of simple assemblages such as albite-chlorite (and occasionally albite-actinolite) in some cases but they are rarely, if ever, extensively developed. Turner (1948, p. 97) has suggested that such an assemblage as albite-chlorite owes its origin to the existence of an open system whereby circulating solutions were able to influence the mineralogical arrangement in a rock which, in a closed system, would acquire a stable assemblage of the type albite-epidote-actinolite-sphene.

Although many of these rocks may be confidently assigned to the Greenschist Facies, division into subfacies is not readily attained. Assemblages such as those mentioned above are, in general, just as typical of the biotite-chlorite subfacies (Turner) as of the muscovite-chlorite subfacies. Thus it will be seen that no marked change should be expected where these rocks pass from a region characterized by muscovite-chlorite (in the rocks of appropriate composition) to the biotite zone (as defined by the pelites). Wiseman (1934) has shown that in the south-eastern Highlands of Scotland there is no marked difference between the epidiorites of the chlorite and biotite zones. Where the composition does permit, biotite may appear in relatively basic rocks in the biotite zone, but such conditions are more often satisfied by basic sediments than by rocks of igneous origin (see Phillips, 1930; Macdonald, 1944). The so-called kersantites at Adelong carry biotite due to their richness in K_2O, but biotite has not been found in any of the greenschists examined from the "basic belt".

An important matter arises in the interpretation of the genesis of the mineral assemblages of these rocks; it applies particularly to the massive types. Such minerals as albite, chlorite, epidote, and actinolitic amphibole are commonly found in Greenschist Facies rocks and may be produced by low-grade dynamic metamorphism; they may, however, result from late-magmatic or deuteric activity. Some of the massive rocks discussed here may post-date the general metamorphism and could well have been affected by deuteric action alone. The presence or absence of schistosity in the low-grade rocks is probably not a completely reliable guide upon which to base any relative age determination. Nevertheless it seems possible that all the rocks considered in this section may not be of the same age nor have had the same background. As far as mineral assemblages are concerned, the results of the two processes, low-grade dynamic metamorphism or deuteric alteration of later rocks, are roughly convergent, although there may be a tendency in the present suite of rocks for chlorite to appear rather than amphibole where the latter process has dominated. Although it might be argued that the deuterized rocks are non-metamorphic and therefore do not belong strictly to the Greenschist Facies, it is expected that not all Greenschist Facies mineral assemblages result exclusively from low-grade dynamic metamorphism.

ROCKS FROM THE SOUTHERN PART OF THE "BASIC BELT".

(*a*) *Amphibolites and Pyroxene Granulites.*

Passing southwards from Nangus along the strike it can be noticed that the common amphibole-bearing rocks become darker and more recrystallized. The effect is seen to advantage along the north-eastern contact of the Ellerslie granite and to the south the contrast may still be well marked. At the actual contact the basic rocks have been injected by granitic material on a small scale and locally hybrids are developed.

In the Greenbank area (the Monaro Highway crosses Nacka Nacka Creek at this locality) the basic rocks tend to become true amphibolites characterized by the assemblage green hornblende-plagioclase. These amphibolites are dark, compact rocks, some with granoblastic structure, sometimes variable in grain size, and occasionally veined by quartzo-felspathic material when near the granite. Typically they consist of abundant euhedral to subhedral green aluminous hornblende grains in a finely granular base of plagioclase (see Plate xi, B). The amphibole (X = pale yellow-brown, Y = brownish-green, Z = dark green; $Z\wedge c = 25°$; $\alpha = 1{\cdot}661$, $\gamma = 1{\cdot}678$) is distinctly different from the amphibole (actinolite) of the greenschists. Odd fragments of paler, more actinolitic amphibole may occur in the amphibolites but in at least some cases they are related to local retrogression. In the somewhat schistose amphibolites the amphibole porphyroblasts may be slightly rotated. Plagioclase in the amphibolites is granular, twinned, and is often remarkably clear. Large felspar areas (up to about 0·3 mm.) between the amphiboles resemble porphyroblasts but are usually aggregates of fine grains (smaller felspar porphyroblasts do, however, occur in a number of cases). The felspar is more calcic than that of the low-grade rocks and though oligoclase is the most usual type it may grade as far as andesine.

Quartz is of variable development; at times it is quite absent, whilst locally it may appear as an important accessory. Epidote-clinozoisite is not common in the amphibolites but rocks rich in this mineral do occur in this part of the belt. Frequently the epidote-rich rocks are obviously banded. The felspar associated with the epidote in such cases is usually very finely granular and untwinned but appears to be more calcic than albite. In general, there seems to be an inverse relation between the epidote minerals and hornblende in this locality (cf. Harker, 1939, p. 269). The reason for the appearance of epidote in the banded rocks is probably chemical, and chemical variations are also responsible, no doubt, for the rare occurrences of biotite (brown or green) and, even less commonly, of muscovite in a few of the rocks of the Greenbank area. The mica-bearing rocks must be richer in alkalis than are the normal amphibolites but this has not yet been confirmed by analysis. It is not clear whether these micaceous rocks are strictly of igneous parentage or whether they were derived from basic sediments intruded by or interbedded with the amphibolites.

One specimen of amphibolite has been analysed with the result given in Table 2 (no. 1). The most remarkable features are the rather low MgO and high CaO contents, whilst it is readily seen that in composition the rock approaches a basalt. It is a matter of no little interest to note that the rock is chemically close to certain amphibole-bearing granulites and amphibolites from the Cooma district. Joplin (1942) was struck by the distinctive composition of these latter rocks. Somewhat similar types have also been found at Albury. The Albury and Cooma examples were compared by Joplin (1947), but it can be seen that on an ACF diagram (Text-fig. 1) the former fall outside the field which Dr. Joplin drew to include the Cooma representatives of this group. On this diagram the analysed rock from the present area falls within the "Cooma" field. Other rocks plotted on this diagram include the "andesitic" type from Nangus (Table 1, no. 1). When calculated without regard for CO_2 it also appears within the enclosed field as does the "kersantite" from Adelong when treated in the same way.

Near the granite contact at George's Hill, about three miles west of Adelong, a few of the basic rocks are characterized by large (up to 6 mm.) crystals of amphibole, some of which, at least, are derived from pyroxene (+ve; $Z\wedge c = 44°$). The amphibole is usually a pale green, feebly pleochroic type with extinction angles up to 24°. On occasions it may be recrystallized to aggregates of more strongly pleochroic hornblende like that in the normal amphibolites. Epidote and sphene are common in these rocks and oligoclase normally is associated with granular amphibole in the base. As amphibole and not pyroxene characterizes the metamorphosed basic rocks in this part of the belt it seems probable that the latter mineral, now partly replaced, is primary.

Pyroxene does, however, become a constituent of certain metamorphosed rocks further to the south, near the village of Sharp's Creek (about three miles west of Wondalga). These rocks are typically dark grey, fine-grained, compact granulites consisting of rhombic pyroxene, plagioclase, quartz, biotite, and magnetite. The pyroxene is grey in colour, non-pleochroic, optically negative (hypersthene), and occurs as small, ragged, sometimes poikiloblastic grains which occasionally form narrow bands or strings through the rocks. Plagioclase is granular, of variable size, the larger grains (about 0·4 mm.) often being rich in tiny quartz inclusions; it is only occasionally twinned. Its composition is more calcic than that of the felspar of the amphibolites and ranges down to labradorite (Ab_{40}). Strongly pleochroic biotite (X = straw yellow, Y = red-brown, Z = dark red-brown) flakes are less common but still widespread.

This mineral association hypersthene-labradorite (probably indicative of Pyroxene Hornfels Facies metamorphism; evidence of Granulite Facies conditions is quite lacking in this area) in strongly recrystallized rocks has not been found extensively, in fact it seems to be represented only on the western side of the basic belt in this more southerly part of its outcrop and even there it is not very widespread. It is interesting to note that the apparent facies progression from Amphibolite Facies to Pyroxene Hornfels Facies takes place in rocks which are all roughly in equivalent positions relative to the Ellerslie granite. Normal pelites do not occur near this part of the belt, but the suggestion is made that these pyroxenic rocks and the amphibolites are more or less isogradal with the high-grade and knotted-schist-zone metasediments.

TABLE 2.

	1	A	B	C	D	E
SiO_2	48·41	49·50	48·23	48·76	49·07	47·24
Al_2O_3	16·78	16·47	16·67	14·96	21·76	18·55
Fe_2O_3 ..	2·90	0·72	2·60	1·91	3·44	6·02
FeO	9·03	9·10	6·09	6·75	8·74	4·06
MgO	5·35	7·47	7·65	7·34	3·65	5·24
CaO	13·33	14·79	9·22	10·00	10·32	11·72
Na_2O	1·89	0·47	1·67	1·03	1·03	2·42
K_2O	0·47	0·32	0·84	0·95	0·37	0·15
H_2O+	0·44	0·57	3·17	2·97	0·62	2·24
H_2O-	0·27	0·03	0·25	0·35	0·14	0·21
TiO_2	1·19	0·75	0·78	0·65	0·69	1·46
P_2O_5	n.d.	0·05	0·26	0·13	tr.	0·26
MnO	0·32	0·16	0·15	0·17	n.d.	0·31
CO_2	—	—	1·88	3·40	—	0·19
Etc.	—	—	—	1·09	—	0·05
	100·38	100·40	99·52	100·46	99·83	100·12

1. Amphibolite. Top of George's Hill, Por. 58, Par. of Ellerslie, Co. Wynyard. Anal. T. G. Vallance.

A. Hornblende granulite (with trace of pyroxene). Cooma area. Anal. G. A. Joplin. PROC. LINN. SOC. N.S.W., 67, 1942, p. 172.

B. Altered basic rock. Albury area. Anal. G. A. Joplin. *Ibid.*, 72, 1947, p. 90.

C. "Trachytic rock." Hume Reservoir (Albury area). Anal. W. A. Greig. *Ann. Rept. Dept. Mines N.S.W.*, 1924, p. 105.

D. "Amphibolite" xenolith. Murrumbucca Creek at Gap Road crossing (Cooma area). Anal. G. A. Joplin. Unpublished analysis by courtesy of the analyst.

E. Basalt (porphyritic central type). Mull, Scotland. Anal. E. G. Radley. *Mem. Geol. Surv. Scotland*, "Mull", 1924, p. 24. (Called porphyritic basic augite andesite lava in *Summ. Progress* for 1915, p. 26.)

(b) *Rocks of Doubtful Metamorphic Status.*

The greater part of the belt from near Adelong to Batlow consists of amphibole- and, in some cases, pyroxene-bearing rocks which are usually coarser (fine-medium grain size) than the types discussed in the preceding section and are of somewhat doubtful metamorphic status. Most of them probably ante-date the Ellerslie and Wondalga granites, but frequently their textural aspect is more like that of an igneous rock than one which has suffered much metamorphism. Amongst the members of this group a certain amount of diversity with regard to mineral content and texture exists.

Hypersthene-labradorite rocks (these are quite different from the pyroxene-granulites mentioned above) characterized by laths of twinned felspar and subhedral pleochroic (pink to grey-green) hypersthene have been found to the east of Adelong Creek in the southern part of the Parish of Adelong and further to the west near the Sharp's Creek road. Olivine has not been encountered in these rocks which otherwise are similar to certain finer-grained phases of the Adelong norite. A feature of these rocks is the presence of ragged grains of magnetite of apparently late crystallization. Pleochroic green hornblende is sometimes moulded on to the pyroxene. Brown biotite flakes are not uncommon. The relation of these rocks to the following has not been established, but as they all occur in the same belt they are considered together here.

Many of the intermediate to basic rocks display evidence of progressive mineralogical changes with the development of minerals such as green hornblende and, in places, actinolite at the expense of pyroxene and brown hornblende. All gradations are found from rocks typically carrying the former minerals to those with pyroxene and/or brown hornblende which may retain an "igneous" appearance. In addition to being directly derived from pre-existing pyroxene or amphibole the green hornblende also occurs as needles and blades in the base of such rocks. Rarely the amphibole of the base may be granular. Rocks particularly rich in fibrous tremolite-actinolite are locally found in shear-zones; a good example occurs near the southern boundary of the Parish of Adelong on the Adelong-Wondalga road.

Colourless pyroxene, somewhat granular or in prismatic crystals, is often less altered to green amphibole than is the accompanying brown hornblende. The pyroxene (+ve; $Z\wedge c = 43°$) is a diopsidic augite. Granular clinozoisite occurs with it in places. Most of the rocks of this group carry felspar, about andesine in composition. Twinning is common and irregular extinction features due to strain or even actual ruptures may occur, particularly in the larger grains. In general, the felspar of these basic dioritic rocks is quite fresh, but occasionally it may be replaced by albite—perhaps as a result of deuteric alteration. The albite-bearing rocks are not widespread. Of the accessories in the rocks of this whole group the most important are apatite, sphene, and magnetite; quartz rarely plays more than an accessory rôle.

Near the top of the ridge on the Sharp's Creek road a few rocks are marked by the presence of large (up to 10 mm.) euhedral pyroxene crystals, sometimes rendered patchy by partial alteration to amphibole, set in a granular matrix consisting essentially of pyroxene, green-brown hornblende, andesine-labradorite, brown biotite, and iron-ore. The pyroxene of the large crystals is augitic, whilst hypersthene is represented in the base. Rhombic pyroxene has, in places, grown on the margins of the augite (Plate xi, C), but elsewhere the clinopyroxene may have an amphibole-mantle. The reason for these apparent anomalies is not clear, but the presence of hypersthene mantles might suggest a metamorphic origin. Diopside grains fringed with granular hypersthene occur in certain basic charnockites in Sweden (Quensel, 1951) as well as in India and Uganda. In such cases the reaction diopside → hypersthene is almost certainly related to the deep-seated plutonic environment in which the charnockites were formed. It might be argued that the Sharp's Creek road rock has suffered a metamorphism of the type which affected the pyroxene granulite (see p. 185) about one and a half miles away, but there is not much evidence upon which to establish this. Late hypersthene associated with hornblende and biotite also occurs in the Adelong norite-gabbro (in the latter the hypersthene crystallized over a considerable period relative to the clinopyroxene), a rock which does not appear to have suffered much metamorphism. This introduces a doubt as to whether the rock under discussion owes its appearance today to metamorphic recrystallization or to an unusual type of primary igneous crystallization; at present no really satisfactory answer suggests itself. Wilson (1952) records hypersthene of metasomatic origin replacing and mantling clinopyroxene and associated with biotite, but there is little evidence to support the view that the hypersthene in the present case is metasomatic.

Two relatively small masses of dioritic-gabbroic rocks, in many respects similar to the aforementioned basic diorites, occur in the neighbourhood of Bangandang Trig. Station. One of these masses is enclosed by the Ellerslie granite, and the second, roughly in the line of strike of the belt, invades low-grade metasediments. Poor exposures are typical of the contacts of both of these masses; the second does not seem to have had much thermal effect on the metasediments.

The rocks of these two masses are more or less massive with a dark colour and medium grain size and consist mainly of amphibole and plagioclase. The zoned plagioclase crystals (andesine-labradorite) often have epidotized cores. The average grain size of the felspar in the more northerly mass is distinctly less than that of the large hornblende crystals (3-4 mm.). The grain size is more uniform in the mass enclosed by the granite. Interstitial quartz (sometimes in graphic intergrowth with felspar) is a rare accessory; other accessories are apatite, sphene, and iron-ore. Small relict patches of pyroxene (both rhombic and monoclinic, but mainly the latter) fringed by brown hornblende (pleochroic from pale straw to dark brown; $Z\wedge c = 26°$) occur in some cases. Brown hornblende also appears as well-formed crystals and grains mantled by green hornblende (X = pale yellow-green, Y = medium yellow-green, Z = bluish-green). Some of the brown hornblende patches have a subophitic aspect. Pale green fibrous actinolite is not uncommon; frequently it grows on the margins of the green hornblende. The series pyroxene → brown hornblende → green hornblende → actinolite (uralite) may be regarded (see Erdmannsdörffer, 1947; Nickel, 1952) as a normal scheme associated with the cooling of dioritic or gabbroic magmas, although similar mineral changes could conceivably be brought about by metamorphic agencies (cf. the concept of magmatic-metamorphic convergence; see Erdmannsdörffer, 1948). Brown hornblende may develop in certain metamorphosed basic rocks in proximity to plutonic masses (Egeler, 1947; Deer, 1953), but, as Eskola (1939) has said, "der braunen Hornblenden höherer Temperaturbereiche der Magmagesteine und der gemeinen grünen Hornblenden, wie sie charakterischerweise in den Gesteinen der Amphibolitfazies und noch in manchen Epidotamphiboliten". In the present case the brown hornblende occurs both near to and away from the Ellerslie granite mass and the area of true amphibolites; there can be little doubt that the mineral is primary and magmatic. Similar green hornblende also occurs in the two masses, one of which, as was said, is remote from the higher-grade part of the region, and it is reasonable to expect that it, too, may have been part of a magmatic reaction series associated with cooling (probably the same is true of the hornblendes in the basic diorites of the "basic belt"). When we come to the actinolitic amphibole there is not sufficient clear evidence to prove definitely whether it belongs strictly to this cooling series or whether it is related to some later low-grade metamorphism. Although the rocks are apparently massive, their felspar often shows signs of fracture which may have been related to some period of low-grade metamorphic activity.

The difficulty in assessing the extent of the metamorphism which affected these rocks, together with the rest of the members of this group, is the reason for their being discussed under the heading "of doubtful metamorphic status". In many cases it seems that the metamorphism (*sensu stricto*), if any, which affected them was not intense.

(*c*) *Concluding Remarks.*

To conclude, it is suggested that there are two main groups of basic rocks in the southern part of the belt. The first includes the granulitic green hornblende-plagioclase rocks (amphibolites) and hypersthene-plagioclase granulites. Associated with these, near Greenbank, are some epidote- and biotite-bearing banded rocks which may be of sedimentary origin. Rocks at Cooma, chemically similar to the amphibolites here, were thought by Joplin (1942, p. 173) to represent contemporaneous flows or small sills among the Ordovician metasediments. In the present case their real nature has not been established. The metamorphism which left its mark on these rocks was not strictly related to the Ellerslie granite because the metamorphic grade appears to increase to the south; it is clear from field evidence, however, that these basic rocks ante-dated this granite. The second group includes rocks of greater diversity. Texturally they are usually coarser than the above-mentioned types and often have an "igneous" appearance. The second-group rocks frequently display signs of the mineral series pyroxene–brown hornblende–green hornblende–actinolite; a sequence apparent in both massive and somewhat deformed types. In some cases the series seems to be due to progressive changes in the cooling environment of these rocks during their magmatic stage; there may, however, be an overlap between such a process and rather low-grade metamorphic activity. The second-group rocks in general also ante-date the Ellerslie-Wondalga granite but they have come later than the members of the first group. The relatively coarse nature of the later rocks, and the apparent scope for reaction of pyroxene with residual magmatic material to give hornblende, etc., rims suggest a rather long cooling period probably more in keeping with an intrusive environment than with the rocks being extrusive.

Two possibilities suggest themselves as reasons for the development of metamorphic pyroxene in the granulites and for the general increase in metamorphic grade in the greenschists and first-group rocks towards the south. They are that the effects are due largely (1) to the thermal influence of the second-group basic rocks on the earlier types or (2) to the metamorphism with which the Green Hills granite mass was associated (it will be remembered that this granite was linked with the highest-grade metamorphism of the metasediments—see Vallance, 1953). The increase in grade in the metamorphosed basic rocks occurs with approach to this granite but it is also in this part of the belt that the second-group basic rocks are most common. The patchy development of the pyroxene granulites might suggest local thermal action by the later basic rocks (pyroxenic rocks, in many respects similar to the granulites here, occur locally in Scotland as high-grade contact-metamorphosed products derived from Tertiary igneous rocks—see MacGregor, 1931). It should be noted, however, that such granulites are typically formed on the western side of the belt, i.e. nearest the Green Hills mass. As none of the basic rocks are found in contact with this granite no definite age-relations can be established with it. At Cooma (Joplin, 1942), the granulites, similar to the amphibolites here (see p. 185), occur as inclusions in the Cooma gneiss which is closely comparable with the Green Hills granite. No basic inclusions have been found in the latter, but if the lithological correlation with Cooma is valid and has age significance then the amphibolites here may ante-date the Green Hills granite. Whether the second-group basic rocks ante-date or post-date this granite is not really known. As these second-group basic rocks do not appear, as a rule, to have suffered the general metamorphism which affected certain greenschists as well as the amphibolites and metasediments, they may post-date the Green Hills, for that granite seems to be closely associated with the general metamorphism.

"KERSANTITES."

Of doubtful relation to the other basic rocks are the small bodies, regarded by Harper (1916) as dykes, in the granite at Adelong. They were called kersantites by Card, but the diagnosis must have been based primarily on chemical composition. No opportunity was available to examine these rocks in the field because they appear to be commonly recognized only in the underground workings of the old gold-mines. These mines are not being worked at the present day. However, a fairly representative collection of these rocks, assembled by Harper, is housed in the Mining Museum, Sydney, and was kindly made available for study.

In the following brief remarks mention will be made of the mineralogy of these rocks, although little can be added to Harper's statement on their field occurrence. Harper refers to dykes of different ages, only the earlier group of which has suffered dynamic action. Both schistose and massive varieties are in the Mining Museum collection, but all are alike in showing extensive recrystallization. Both types often have comparable mineralogical constitutions, most commonly consisting of muscovite, biotite, quartz, calcite, felspar, with chlorite, epidote, amphibole, sphene, and pyrite on occasions. The rocks display few lamprophyric characters.

The schistose types commonly carry two micas and calcite but variations in composition are reflected in the development of pale green or blue-green pleochroic amphibole (X = very pale yellow, Y = pale yellow-green, Z = mid-bluish-green; $Z \wedge c = 21°$) in a few cases. Most of the ferromagnesian minerals tend to form clots which, in the schistose rocks, are elongated along the schistosity. Biotite flakes (X = pale yellow-brown, Y = mid-greenish-brown, Z = very dark brown or greenish-brown) may grow either across or along the schistosity. Occasionally biotite becomes the major component in these rocks. Twinned calcite grains (up to 1 mm. in the coarser types) are widespread and their presence distinguishes the two-mica schists here from the pelitic schists described in Part I of these studies. The felspar, where determined, appears to be oligoclase or albite, more commonly the latter.

TABLE 3.

	1	A	B	C
SiO_2	49·66	53·04	47·79	50·76
Al_2O_3	17·44	15·68	18·23	12·20
Fe_2O_3	1·00	4·25	2·76	1·19
FeO	6·75	4·41	9·18	6·65
MgO	4·71	5·79	5·23	11·75
CaO	7·10	6·02	6·32	6·26
Na_2O	2·69	3·28	2·66	2·16
K_2O	3·85	3·10	4·10	4·79
H_2O+	1·53	2·49	2·15	0·66
H_2O-	0·09		0·08	0·22
TiO_2	1·22	0·73	1·35	0·76
P_2O_5	0·22	0·30	0·42	0·28
MnO	0·11	—	0·20	0·30
CO_2	3·00	0·88	0·0	1·39
Etc.	0·59	0·14	0·21	0·41
	99·96	100·11	100·68	99·78

1. Kersantite. Gibraltar Mine, Adelong. Anal. W. A. Greig. *Ann. Rept. Dept. Mines N.S.W.*, 1916, p. 225.

A. Average of 54 rocks called kersantites. Quoted from Johannsen (1937), vol. III, p. 190.

B. Biotitplagioklasschiefer. Seidenbuch (Odenwald). Anal. Hartwig. In Erdmannsdörffer, *Heidelberger Beit. Min. Pet.*, 1, 1947, p. 66.

C. Biotite-hornblende-schist (lamproschist). 1 mile S.E. of Glencalvie Lodge, Ross & Cromarty, Scotland. Anal. E. G. Radley. *Mem. Geol. Surv. Scotland*, 1912, " Ben Wyvis, Carn Chuinneag, Inchbae and the surrounding country ", p. 125.

As far as mineral assemblages indicate, both massive and schistose varieties seem to have suffered fairly comparable degrees of metamorphism, at least equal to the biotite-chlorite subfacies of the Greenschist Facies, although they might belong to the Epidote-Albite Amphibolite Facies (Turner, 1948). The presence of these assemblages in rocks which are supposed to intrude and thus post-date the granite (Wondalga granite) suggests that there was some post-granite metamorphism. Even the massive types show few signs of relict igneous textures although they have not suffered any dynamic action. In view of the present inaccessibility of these rocks the problem of why the massive types should have a mineralogy similar to that of the schistose varieties cannot be solved. Perhaps here again late-magmatic and dynamothermal metamorphic effects were convergent as far as the development of new mineral phases was concerned.

The chemical composition of the analysed rock (Table 3, no. 1) is comparable with that of a kersantite. The rock is plotted on an ACF diagram (Text-fig. 1, points no. 15) both with and without regard to CO_2. The two points obtained are joined in the diagram. From the diagram it can be seen that the "kersantite" is not far removed from the amphibolites (it should be noted, however, that the latter ante-date the Wondalga granite whilst, according to Harper, the "kersantites" post-date it). The remarkably high potash content of the "kersantite" is reflected in the large amounts of mica usually present. A schistose rock, from the Odenwald, with a somewhat similar composition and consisting essentially of biotite and plagioclase is quoted in Table 3 for comparison. Dynamothermally metamorphosed lamprophyres have been described from various parts of Scotland (Peach et al., 1912; Harker, 1939) and some of them have mineral assemblages comparable with the Adelong "kersantites".

THE ADELONG NORITE–GABBRO.

Practically confined to the town area at Adelong is a small mass (about 1 × ½ mile), elongated roughly north-west–south-east, composed of medium-grained basic rocks referred to as gabbros by Harper (1916). These rocks occupy a low area and their outcrop is variable. In places (particularly near the south-eastern margin of the mass) they appear as tors, but elsewhere isolated boulders and soil-type differences are the only clues available in delimiting the extent of the basic mass in the dominantly granitic terrain. Adelong Creek flows round the eastern side of the mass which has apparently controlled the course of the stream. At the south-eastern end of the mass a small quarry has been opened to exploit the rock for monumental purposes.

The rock is holocrystalline and, though obviously rich in plagioclase, where fresh has a distinctly dark colour. Altered patches are greenish; this alteration is in most cases related to zones of dislocation and is not merely due to atmospheric effects. In the fresh material long laths of clear plagioclase often display a preferred orientation; dark pyroxene crystals are usually also visible macroscopically. Coarse and irregular patches, with felspars up to one inch long, obvious brown hornblende and biotite in addition to pyroxene, are randomly distributed through the mass. Basic clots enriched in olivine and pyroxene, often to the exclusion of felspar, are also present in places. Mineralogically these latter clots appear to be closely related to their host rocks and may merely represent fragments of an early phase of the norite-gabbro.

The mode of a fairly typical specimen of the rock is given in Table 4. Plagioclase is abundant in all these rocks as twinned (albite, pericline, and carlsbad laws mainly) labradorite (Ab_{46}) laths remarkably free from inclusions. A few tiny olivine grains may be included, but equally often the felspar is included in the olivine. The laths display intricate undulose extinction patterns and often have small-scale ruptures. When bent, transverse cracks appear in the laths and these cracks may be filled by later felspar. Subhedral to anhedral olivine may be found in all stages of alteration to serpentine but in the fresh rocks it is largely unaltered. Magnetite inclusions, either as bands of fine granules or as larger skeletal aggregates, are a feature of much of the olivine. The olivine grains are sometimes mantled by brown hornblende or biotite but the mantles are irregular and rarely complete.

Two pyroxenes are typical but their relative proportions vary a good deal; as a result the rocks range in composition from olivine-augite norites to olivine-hypersthene gabbros. Rhombic pyroxene invariably occurs as pleochroic (X = bright pink, Y = straw, Z = pale yellow-green) subhedral or anhedral grains. Optically negative, the grains occasionally exhibit oblique extinction (up to 16°—cf. Johannsen, 1937, vol. III, p. 212). Fine schiller inclusions may occur in this mineral but they are never as abundant as in the clinopyroxene. The latter commonly is polysynthetically twinned and has typical pyroxene cleavages. The grains are greyish, non-pleochroic, optically positive, and have $Z\wedge c$ up to 49°, corresponding to augite. The schiller inclusions produce a dirty brown coloration whilst local alteration to amphibole gives rise to patchy extinction effects in the pyroxene.

The four minerals labradorite, hypersthene, augite, and olivine constitute the main part of the mass but locally, as was mentioned above, patches with more complex mineralogy occur. In column 2 of Table 4 it will be seen that practically all the members of Bowen's well-known reaction series may be present in such cases. Olivine is typically less abundant in these more acid phases and may actually be absent. Augite and hypersthene occur and are often partly mantled by hornblende; patches of brown amphibole may appear in the augite. Separate hornblende (Z^c up to 29°) grains at times have ophitic relations to the felspar laths. In general, there is a colour zoning from brown-green to green or blue-green from the interior to the margins of the hornblende grains. Large plates of brownish biotite (X = pale straw yellow, Y = dark brown or greenish-brown, Z = dark brown to greenish-brown) up to 3–4 mm. across may also occur with the hornblende. A distinctly different biotite (X = pale straw yellow, Y = bright leaf-green, X = dark leaf-green; –ve; 2V very small) occasionally mantles pyroxene grains but is much less important than the brown variety. The latter type may have inclusions of calcite along the cleavages. Sometimes biotite appears to grow on hornblende which has itself grown on pyroxene. Muscovite is a rare accessory. Quartz is also rare (the 0·7% of quartz in the mode quoted is rather exceptional).

TABLE 4.

Modes of Rocks in the Adelong Norite-Gabbro Mass.

	1	2
Quartz	—	0·7
Labradorite	58·3	41·0
Apatite	0·1	0·1
Biotite (brown)	0·1	8·5
(green)	—	0·6
Hornblende	0·2	15·5
Hypersthene	18·2	10·2
Augite	8·7	14·0
Olivine	12·1	2·1
Magnetite	2·1	1·0
Muscovite	—	tr.
Actinolite	—	5·5
Serpentine	tr.	0·4
	99·8	99·6

1. Olivine-augite norite.
2. Quartz- and olivine-bearing biotite-hornblende-hypersthene gabbro.

Pale green actinolitic amphibole may appear as an alteration product of the pyroxene or hornblende. Locally, in zones of dislocation, the reaction is carried to extremes. Even structurally unaltered rocks from the vicinity of the crush bands may show signs of this change. The actinolite (X = very pale yellow-green, Y = yellow-green, Z = mid-green or blue-green; Z^c = 18°) occurs both as needles and as uralitic patches directly replacing the earlier ferromagnesian minerals. Chlorite sometimes appears with the actinolite. In view of the field association there can be little doubt that the green actinolite-rich rocks developed from the norite-gabbro by localized low-grade dynamic metamorphism.

Whilst the actinolite may be explained away as being of metamorphic origin such was probably not the case with the green and brown hornblendes and biotites in the patches already described. These latter minerals may mantle the pyroxenes and olivine and appear to have formed later than these, though still probably during the magmatic period. Of the pyroxenes, hypersthene appears to have finished crystallizing last (it sometimes mantles augite, cf. p. 187), but as it also occurs as inclusions in the augite it probably had a lengthy crystallization period. Plagioclase must have separated at an early stage and it is interesting to note that whereas the plagioclase twins are often twisted and even ruptured, such features are very rarely displayed by the twins in the pyroxene grains. Perhaps the development of rhombic pyroxene in the norite and gabbro was related to the early crystallization of plagioclase. Olivine also was of early formation and was followed by the two pyroxenes, hornblende, and finally biotite. The most reasonable explanation for this sequence seems to be given in terms of the reaction series, with the hornblende and biotite mantling pyroxene and olivine being in the nature of reaction rims (Bowen, 1928). The presence of accessory quartz in the more acid, coarser patches adds plausibility to this explanation based on progressive changes in environment leading to differentiation during consolidation of the magma.

TABLE 5.

	1	A	B	C
SiO_2	52·54	50·04	55·05	57·18
Al_2O_3	16·94	18·68	14·15	14·13
Fe_2O_3	2·10	0·80	1·80	1·90
FeO	4·77	6·91	5·31	5·85
MgO	9·05	7·79	8·07	7·00
CaO	10·44	9·88	9·36	7·64
Na_2O	2·92	2·35	2·82	2·36
K_2O	0·44	0·12	0·72	2·30
H_2O+	0·45	1·74	1·46	0·45
H_2O-	0·07	0·28	0·22	0·07
TiO_2	0·40	0·80	0·57	0·60
P_2O_5	0·04	0·16	0·06	0·21
MnO	0·12	0·14	0·22	0·11
CO_2	0·11	0·27	0·02	abs.
Etc.	tr.	0·62	0·06	0·22
	100·39	100·58	99·89	100·02

1. Norite. Adelong village. Anal. H. P. White. *Ann. Rept. Dept. Mines N.S.W.*, 1916, p. 225.

A. Diorite. Murgatroyd's Tunnel, Hillgrove area, N.S.W. Anal. J. C. H. Mingaye. *Geol. Surv. N.S.W., Records*, 8, 1907, p. 216.

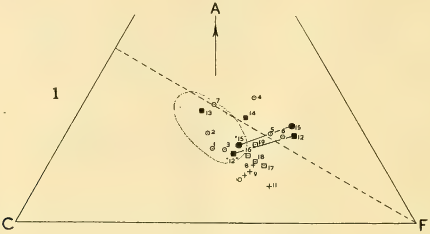
B. Diorite. Hillgrove area. Anal. J. C. H. Mingaye. *Ibid.*, p. 214.

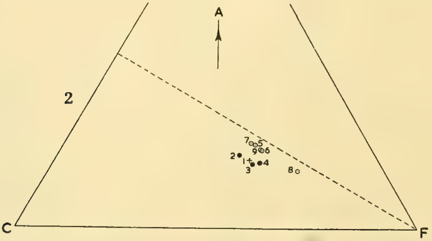
C. Quartz monzonite. Kiandra, N.S.W. Anal. W. A. Greig. *Jour. Proc. Roy. Soc. N.S.W.*, 56, 1923, p. 269.

In 1923 Browne and Greig described from Kiandra (about 45 miles south-east of Adelong) an olivine-bearing quartz monzonite which displays several features in common with the Adelong norite-gabbro. The sequence olivine, rhombic pyroxene, clinopyroxene, hornblende, and biotite is observed in both places. The clinohypersthene reported from Kiandra has not been found at Adelong, although hypersthene with apparent oblique extinction due to the chance orientation of thin sections has been noted in this study (p. 191). Potash felspar was not found in the Adelong basic rocks.

The Adelong norite-gabbro is surrounded by granite related to the Wondalga mass and the only age relations we have are with that granite. Harper (1916) stated that the basic rock "intrudes the granite, for round its edges wherever bedrock is exposed, tongues of gabbro, varying in width from a few feet up to many yards, are seen to be extending into the granite". In view of the freshness of the norite and the crumbly nature of much of the granite (due in large measure to cataclasis) this age relation might be expected but, in actual fact, as far as I have determined, the opposite state of affairs exists. Examination of the contacts (where exposed) west of the town suggests that the granite has actually invaded the norite and that the "tongues" of basic rock are really relics of the original mass. Fine granitic veins and very local felspathization of the norite indicate that the granite post-dates it. The granite seems merely to have proved more susceptible to the dynamic action than did the norite-gabbro. Little thermal effect on the basic rock appears to have been caused by the granite but, in view of the rather restricted contact features associated with this granite-type elsewhere, this is not really surprising.

It is interesting to note that Watt (1899), at Wyalong, found norite, somewhat similar to the Adelong rock, ante-dating a gneissic "granite" which, though more basic, is in many respects like the granite of the Ellerslie and Wondalga masses. Although Wyalong is about 100 miles north-west of Adelong, it lies on the same line of strike and the rock-associations in the two places may be more than accidental.





Text-fig. 1.—Point 1, This paper, Table 2, no. 1. 2, Joplin (1942), Table 6, no. II. 3, Joplin (1942), Table 6, no. I. 4, Joplin (1947), Table 4, No. I. 5, Joplin (1947), Table 4, no. II. 6, A.R.D.M. for 1924, p. 105, no. 1065/24. 7, This paper, Table 2, no. D. 8, 9, 10, 11, Cooma amphibolites, Joplin (1939). 12, This paper, Table 1, no. 1. 13, This paper, Table 1, no. B. 14, This paper, Table 1, no. A. 15, This paper, Table 3, no. 1. 16, This paper, Table V, no. 1. 17, This paper, Table I, no. C. 18, This paper, Table 5, no. A. 19, This paper, Table 5, no. B. (The enclosed field is taken from Joplin (1942), Fig. 5.)

Text-fig. 2.—Point 1, This paper, Table 5, no. 1. 2-4, Johannsen (1937), vol. III, Table 79 (average olivine gabbros). 5-9, Johannsen (1937), vol. III, Table 80 (average norites and olivine norites).

In Table 5 an analysis of the Adelong norite is quoted. The Hillgrove rocks noted for comparison are of interest because they are associated with gneissic granite chemically and lithologically similar to the granite at Adelong. Certain amphibolites at Cooma (Joplin, 1939) have the composition of gabbros or norites but any correlation between these and the Adelong norite-gabbro cannot be more than highly speculative. In Text-figure 1 it can be seen that the Adelong norite falls near the Cooma amphibolites. At Cooma these rocks ante-date the Cooma gneiss, which is, I believe, equivalent to the Green Hills granite in this area. It is thought that the Green Hills is itself older than the Ellerslie and Wondalga granites. However, if the basic rock ante-dated the Green Hills granite it should have suffered the general metamorphism; of this there is little indication. In David (1950) the norites of Adelong and Wyalong are tentatively referred to the late Silurian (Bowning) orogeny.

Chemically, the only analysed specimen from the Adelong basic mass is more closely allied to gabbros than to norites. In Text-figure 2 it will be seen that average norites and olivine norites tend to group themselves away from average olivine gabbros and that the Adelong rock falls with the gabbro group.

No definite statement is possible at present concerning the origin of the Adelong norite-gabbro. If the distinctive features are related to contamination of a basic magma by aluminous sediments (Bowen, 1928; Read, 1931) all trace of it has disappeared. There is thus no clear evidence upon which to decide whether the rocks were formed by the addition of aluminous material to a basic magma or by direct crystallization (without contamination) from a magma of the appropriate composition. Certain basic masses in various parts of the world have, in recent years, been regarded as representing "fronts" related to processes of granitization. However, in the present case insufficient evidence of large-scale and intense granitization which would have been necessary to produce the basic mass is available. Until this is definitely established, it seems preferable to continue to regard the norite-gabbro as having been magmatic and intrusive.

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EXPLANATION OF PLATE XI.

A.—Greenschist from Por. 157, Par. of Ellerslie. A fine-grained rock consisting mainly of actinolite, epidote, and albite. Much of the actinolite is arranged parallel to the obvious schistosity which is further accentuated by iron-staining. Ordinary light. × 13.

B.—A granular amphibolite from near the granite contact at George's Hill (Por. 58, Par. of Ellerslie). Obvious green hornblende is set in a base of clear plagioclase. A little epidote is present. Note the vague traces of banding and the occasional hornblende porphyroblasts in this specimen. Ordinary light. × 13.

C.—Granular basic rock from the western side of the "basic belt" on the Sharp's Creek road (Por. 67, Par. of Nacka Nacka). Large clinopyroxene grains (sometimes patchy due to partial alteration to amphibole) may have discontinuous rims of rhombic pyroxene. Granular rhombic pyroxene and plagioclase occur in the base with some clinopyroxene, hornblende and biotite. Ordinary light. × 13.

All photomicrographs by Mr. G. E. McInnes.

STUDIES IN THE METAMORPHIC AND PLUTONIC GEOLOGY OF THE WANTABADGERY–ADELONG–TUMBARUMBA DISTRICT, N.S.W.

PART III. THE GRANITIC ROCKS.

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(Plate xii; ten Text-figures.)

[Read 30th September, 1953.]

Synopsis.

The plutonic rocks of this area are divided into three main groups. Representatives of two of these groups are here discussed in some detail. The earlier of the two is related to the period during which the essentially miogeosynclinal sediments were metamorphosed (see Vallance, 1953*a*). It is suggested that these granites were not formed in their present environment but have been derived (whether by anatexis or syntexis) from a deeper level, not yet exposed, of the metamorphic complex. Sedimentary material seems to have contributed a good deal to their formation. The second-group granites post-date the metamorphism but show interesting local reaction features with basic rocks. The rocks of these two groups are correlated with similar types at Cooma and elsewhere in New South Wales.

INTRODUCTION.

Granitic rocks of various types occupy a considerable part of the area examined and display many interesting relations to the rocks amongst which they occur. It is the purpose of this paper to describe these plutonic rocks and to discuss their relations to the metamorphism which affected the region.

On a lithological basis, the rocks have been separated into three groups. We shall be concerned with only two of these. Not much attention has been given to the third, designated here the Kyeamba adamellite; it occurs on the western side of the area and only a very small part of the mass has been mapped. More of it has been covered by Whiting (1950). Where examined, the rock is a massive, medium-grained, hornblende-free type which appears to be in a different metamorphic environment from the members of the other two plutonic groups; it is thought to be younger than these.

Of the other granitic groups, the members of the first are characterized by a medium grainsize, fairly massive appearance (some are slightly gneissic), roughly euhedral biotite flakes and a general absence of hornblende. Rocks of the second group also contain biotite as the chief melanocratic mineral but may, at times, carry amphibole as well. They may be somewhat coarser grained than the first group rocks and are often rather gneissic, sometimes markedly so. In general, the areas of highest grade metamorphism are associated with the first-group granites rather than with the second. Although both groups include types ranging from granite to granodiorite, it is usually not very difficult to separate them in the field. At Cooma, where metamorphism similar to that observed here has also left its mark, two main types of plutonic rocks occur and they are similar to those distinguished in this paper.

GRANITES OF THE FIRST GROUP.

By way of introduction it should be made clear that the term granite will often be used here in a broad sense to include granodiorite. To the first group have been assigned the rocks of two large plutonic bodies, the Wantabadgery and the Green Hills (named after the Green Hills State Forest, which is largely situated on this rock type) masses.

The Wantabadgery granite occupies the south-eastern end of a large batholith which, according to the Geological Map of the State, extends to the north-west to near Methul West (about 16 miles south-east of Ardlethan). The batholith is depicted as having an irregular outline, yet with a distinct elongation parallel to the strike of the metasediments. The dimensions of the mass as marked on this map are about 60 × 25 miles. Whether the mass is uniform throughout is not known, but in the area examined by the author the granite has a remarkable overall sameness (ignoring purely local features such as variations in biotite content). Specimens from Junee and Wagga Wagga can be readily matched with others from Wantabadgery. Lithologically similar material was recorded by Raggatt (1933) from Junee Reefs and Sebastopol.

Plate v of Part I of these Studies (Vallance, 1953*a*) indicates that the Wantabadgery granite covers a large area north of the Murrumbidgee River in the Oura–Wantabadgery district and passes across the river near Tenandra. South of Tenandra it forms a prolongation parallel to the strike of the country rocks and occupies the valley of lower Yaven (or Hillas) Creek. South-west of Oura the granite again crosses the river and forms the low ridge on which Kiambeth Trig. Station is situated. Similar granite occurs on the eastern side of Willan's Hill near the city of Wagga Wagga. Although a large part of the granite-metasediment contact appears to transgress the regional strike, detailed work has shown that, in the vicinity of the contact, the strike of the metasediments is deflected sympathetically with the granite. Near its margin the granite tends to have a more gneissic appearance than elsewhere and the foliation typically follows the trend of the margin.

The metasediments near the Wantabadgery granite belong, as a rule, to the knotted schist zone (Vallance, 1953*a*). High-grade rocks are normally confined to within a few feet of the contact; they are, however, more extensive just north of Yaven Trig. Station. Contrasted with this is the wide high-grade zone near the other member of this group, the Green Hills granite.

Like the Wantabadgery granite, the lithologically similar Green Hills granite mapped during the course of this work occupies only a portion (the northern portion) of a large batholith of rather uncertain dimensions. The Green Hills mass has an interesting prolongation to the north-west (cf. the south-east end of the Wantabadgery mass) and has been traced along the upper Yaven Creek and upper Oberne Creek valleys and through the Green Hills Forest to the main Batlow–Tumbarumba road, where it appears just south of Batlow. Except where interrupted by Tertiary basalt near Laurel Hill, the granite can be followed to Tumbarumba. During a hasty reconnaissance south of Tumbarumba, what appeared to be the same granite was followed as far as Tooma and Welaregang and was seen to occur across the Murray River in Victoria. From observations made on the Victorian side of the river it would seem that this granite is at least partly responsible for the large bulk of the Corryong batholith (Edwards and Easton, 1937). To the west of Tumbarumba there is reason to believe that the granite margin is faulted. The granite seems to be identical with, and may be continuous with, the rock called by Mr. L. Hall, of the N.S.W. Geological Survey, the New Maragle granite, which occurs to the east of Tumbarumba. North of Batlow the Green Hills granite is apparently separated from the "basic belt" (Vallance, 1953*b*) by a somewhat gneissic granite belonging to our second group.

This large mass has thus been traced for nearly 50 miles along the regional strike of the country rocks but lack of data on the location of the eastern margin south of Batlow precludes any reliable estimate of its maximum width. Mr. K. R. Sharp has found similar granite on and east of the Tumut River near the S.M.H.E.A.'s Tumut Pond Power Station site. This occurrence is conceivably continuous with the Green Hills or New Maragle granites but the intervening country has not been examined because of its inaccessibility.

In addition to the lithologically comparable Cooma gneiss (Browne, 1914; Joplin, 1942) at Cooma, similar granites have been found on the Murray River, south-west of Mt. Kosciusko (Browne et al., 1946), at Albury (Joplin, 1947), and in parts of north-eastern Victoria (Howitt, 1888; Tattam, 1929).

At Hugel Trig. Station a patch of high-grade metasediments occurs on top of the granite. A similar, and larger, patch is to be found in the Nurenmerenmong Range, east of Tumbarumba. The elevation of these patches above the surrounding granite country suggests that they are remnants of the original roof now isolated by erosion. By way of contrast it might be mentioned that no such remnants have been found in the Wantabadgery mass, although it, like the Green Hills granite, contains many included fragments of the country rocks. The boundary between the granite and the highly metamorphosed sediments of the roof patches is usually rather vague. Similar gradational contacts occur betwen the Green Hills granite and the high-grade country rocks along its western margin; this is particularly true of the contact north of Bago Trig. Station. In contrast to this, the contacts around the Wantabadgery granite are less diffuse (except near Yaven Trig. Station), although here, too, it is difficult to locate exactly the granite-metasediment junction.

The granites of both masses may display a slight, steeply dipping, foliation but they are often fairly massive (cf. Joplin's (1942, p. 186) remarks on the Cooma gneiss). As at Cooma, the foliation in these rocks is usually indicated by trails of biotitic schlieren or by the rarer sub-parallelism of included rock fragments. The foliation, in general, follows the regional trend of the country rocks except where the granite contacts cut across this direction; there the foliation is locally parallel to the margins of the mass. Away from the margins the foliation resumes its regional trend.

Aplitic, pegmatitic, and milky quartz dykes and veins are often associated with these granites, particularly near their margins. A remarkably large quartz dyke forms the Rocky Knob at Oura. Dykes of doleritic and bostonitic rocks have also been found in the granites.

Pegmatites and Aplites.

The pegmatites, often with graphic texture, show few unusual features. In addition to the abundant quartz and K-felspar (orthoclase or microperthite) they usually carry tourmaline, muscovite, and a little acid oligoclase. The tourmaline crystals (up to two inches long) are often fractured across their length and the breaks are typically healed by granular quartz. The pegmatite dykes sometimes have a marginal graphic zone bordering an inner zone, rich in felspar, itself flanking a central region composed largely of quartz and tourmaline (cf. Joplin, 1942, p. 187).

The aplites are fine- to medium-grained rocks with obvious quartz, felspar, and muscovite. Acid oligoclase may be important in addition to the K-felspar. Myrmekitic intergrowths have been observed and small flakes of colourless mica may also replace the felspar. Tourmaline is not as abundant as in the pegmatites. The formation of tourmaline here seems in many cases to have post-dated the crushing which some of these aplites suffered. Pinkish garnet has been found in a few dykes near Oura. The grains (up to 2 mm. across and often rich in quartz inclusions) display rough crystal outlines with slight alteration to chlorite along cracks. There are few signs of much reaction between the aplite material and the garnets, and the origin of the latter is somewhat puzzling. At Albury, oligoclase granites, rather similar to the rocks here grouped with the aplites, also contain garnet (Joplin, 1947); it is believed to be pyrogenic. The garnet in the Oura district has not been analysed but one garnet-bearing rock so studied contains little manganese (Table 2, no. 6). This suggests, though it does not prove, that the garnet is not spessartine-rich. In general, garnets occurring as stable phases in such acid rocks tend to be manganiferous because Mn^{++} does not replace Fe^{++} or Mg^{++} in biotite from granites and pegmatites (Ramberg, 1945) and thus the expected reaction

$$\underset{\text{garnet}}{(FeMg)_3Al_2Si_3O_{12}} + \underset{\text{K-felspar}}{2KAlSi_3O_8} + 2H_2O \longrightarrow \underset{\text{biotite}}{K(FeMg)_3AlSi_3O_{10}(OH)_2} + \underset{\text{muscovite}}{KAl_3Si_3O_{10}(OH)_2} + 3SiO_2$$

may not take place if the garnet is rich in manganese. Where almandine occurs in aplitic rocks with sufficient K_2O (e.g. see Sugi, 1930) it often shows some signs of conversion to biotite. Spessartine-rich garnets may in many cases be pyrogenic but almandines occurring in similar acid rocks are perhaps more often xenocrystal. In view of the low MnO in the rock, which had sufficient K_2O to form free K-felspar, it seems somewhat doubtful whether the garnet is pyrogenic in this case. There is, however, no apparent source for the mineral if it is to be regarded as xenocrystal and no clear reason why it should not have reacted more extensively with its environment.

Granite-Granodiorite.

The largest parts of the Wantabadgery and Green Hills masses are composed of rocks which fall into this category. In both masses the rocks outcrop as large boulders and tors which, despite their resistant appearance, are typically very extensively weathered. When fresh the rock is distinctly greyish. In places it may be porphyritic, as a rule the most porphyritic parts being associated with patchy, biotite-rich phases of the granite. Often, however, the rocks have a fairly even, medium-grain size.

TABLE 1

Modes of Plutonic Rocks and of a Basic Patch.

	1	2	3
Quartz	34·6	33·3	22·2
K-felspar	30·4	5·5	1·6
Plagioclase	12·6	38·7	24·4
Biotite	8·9	20·4	42·3
Hornblende	abs.	abs.	abs.
Muscovite (+sericite)	13·3	1·6	8·4
Accessories	0·2	0·4	1·0

1. Biotite granite (sericite-rich). Por. 235, Par. of Oura, Co. Clarendon. (For analysis see Table 2, no. 1.)
2. Granodiorite. Quarry, north-eastern side of Willan's Hill, Wagga Wagga. (For analysis see Table 2, no. 3.)
3. Biotite-rich patch in the Wantabadgery mass near Tenandra Trig. Station. (For analysis see Table 2, no. 5.)

Modes of two of these rocks are given in Table 1. Quartz, felspar, and biotite, with some muscovite, are the chief constituents. Quartz is abundant and normally occurs as irregular grains often faintly dusted with small inclusions. Minute needles of rutile and sillimanite have been noted in the quartz, the sillimanite occurring most commonly near the remnants of metasediment inclusions. Locally, the quartz may show intense strain features.

K-felspar appears mainly as orthoclase or microperthite and may or may not exceed plagioclase in abundance (cf. columns 1 and 2 in Table 1). Some of the felspar has microclinic gridiron-twinning, a feature commonest in the granite near biotite-rich broken-down metasediment relics. The K-felspar may form either euhedral phenocrysts or anhedral grains. Phenocrysts up to one inch long often have good Carlsbad twinning and, sometimes, marginal zones of biotite inclusions. The large felspars are commonly microperthitic with needles and rods of intergrown albite. Similar large felspars may also be developed in the metasediment inclusions. Some of the K-felspar in the granite is myrmekitized; this is another feature which tends to become more obvious near the disrupted inclusions (see Plate xii, A). Muscovite often is abundant near the myrmekite indicating, perhaps, the destination of some of the released potash.

Plagioclase may also occur as phenocrysts or smaller anhedral grains. As at Cooma (Joplin, 1942), it has been found impracticable to distinguish between the relatively plagioclase-rich and plagioclase-poor types in the field. The plagioclase is usually an oligoclase or acid andesine (Ab_{65-70}) and even in the most basic (biotite-rich) phases of the rocks it does not become much more calcic. Some of the plagioclase is roughly zoned and where the mineral has been fractured and healed by later crystallization the zones have an irregular distribution. Parts of certain zoned grains have been completely separated before the final consolidation. Twinning is typical and among the twin-varieties recorded is a rather large group of laws included by Gorai

(1950, 1951) in his C-twins. Albite and pericline laws (Gorai's A-twins) are also represented.

Biotite is the most important melanocratic constituent in these rocks. The black, lustrous, almost euhedral flakes are obvious in hand specimen. The dark mica is of the strongly pleochroic red-brown variety ($\gamma = 1{\cdot}643$, X = very pale yellow-brown, Y = dark red-brown, Z = dark red-brown) and typically has haloes round certain small inclusions. Some of these appear to be zircon; others may be monazite. Rutile, iron-ore, and apatite are also included; the latter has not had much effect on the host (cf. Hutton, 1947). The biotite usually resists weathering processes but occasionally it is altered to muscovite and chlorite, excess TiO_2 being released as rutile to form sagenite webs (this alteration is probably more often related to late hydrothermal activity than to normal weathering). Bundles of sillimanite needles are common in biotite near strewn metasediment relics.

Muscovite is found as large blades and also sericitic aggregates. The larger muscovite flakes have 2V about 38° and $\beta = 1{\cdot}597$. The aggregates are usually associated with myrmekite and altered felspar; they seem to be of late origin. Muscovite-quartz and biotite-quartz symplektites, associated with myrmekite, occur in certain metasediment inclusions as well as in the nearby granite itself. The association of the three types of intergrowth is always close and cases have been noted where the vermicular quartz of one passes, without interruption, into an adjacent intergrowth. Crushing is rarely observed near these features. Hills (1933) noted the association of myrmekite and biotite-quartz symplektite at Marysville (Victoria) and, following Väyrynen, suggested that it was related to the "crystalloblastic development of biotite from potash felspar, in which change plagioclase and quartz are liberated". This explanation is different from Sederholm's well-known hypothesis (see, for example, Drescher-Kaden, 1948; Seitsaari, 1951). Du Rietz (1938) attributed muscovite-quartz symplektites at Muruhatten (Sweden) to the "muscovitization" of microcline. Rest solutions attacked the microcline and the change to mica released SiO_2 to crystallize as quartz. The extensive development of sericitic mica from cordierite, sillimanite, and felspar in the high-grade metasediments of the country rocks (see Vallance, 1953*a*) may be related to the alteration to mica of felspar in the granites.

Apatite, zircon, rutile, iron-ore, tourmaline, and sillimanite may all occur as accessories in these rocks. A few grains of colourless andalusite have also been noticed (cf. the pink variety in the Cooma gneiss). Joplin (1942, p. 188) believes the colourless andalusite to be xenocrystal. Card (1895) recorded pieces of colourless to brown-red or blue andalusite, up to one pound weight, in Burra Creek, south of Tumbarumba. These may have come from a contaminated phase of the granite or pegmatite. Detrital monazite reported from Batlow and Tumbarumba (Card, 1920) may have been shed from the Green Hills granite. Curran (1896) mentioned topaz, garnet, and kyanite from Tumberumba [*sic*] as well as sapphire, ruby, and spinel (the last three are probably derived from the Tertiary basalts). Kyanite has not been found in any of the rocks of this district but apparently blue-grey tourmaline has been mistaken for this mineral (old slides in the Mining Museum, Sydney, labelled kyanite contain tourmaline). Curran's description of his "kyanite" does not tally with tourmaline, but his find has not been confirmed.

Chemical Data.

Six representatives of this group of rocks have been analysed—a granite, an adamellite, two granodiorites, a garnet-bearing aplitic rock, and a basic patch (inclusion) with the mineralogy of a quartz-mica diorite. These are all given in Table 2 together with comparable rocks from other parts of the great metamorphic belt and from Cooma. The granites from Oura, Cooma, and Albury all have SiO_2 in the range 70–73% and most of them have low lime contents. Where plagioclase becomes more important the lime content increases. The granodiorite from Willan's Hill, Wagga Wagga, is compared with the Woomargama gneiss (Joplin, 1947) near Albury. The Woomargama gneiss is believed to be related to the Albury gneiss, its higher lime content being regarded by Joplin as due to contamination by lime-bearing material. The specimen from the Corryong batholith (no. E) is chemically not unlike the Woomargama gneiss and the granodiorite from Willan's Hill. The garnet-bearing aplite is similar in composition to the oligoclase granites of Joplin (1947, Table 6). The biotite-rich patch (no. 5) represents a greatly altered sedimentary inclusion occurring in the granodiorite (no. 4); its composition will be discussed later (p. 204).

TABLE 2.

First-Group Plutonic Rocks and Similar Types.

	1	A	B	C	2	3	D	E	4	5	6	F
SiO_2 ..	72·53	71·93	70·65	70·44	71·33	66·98	66·43	67·67	67·74	54·86	75·53	76·10
Al_2O_3 ..	14·57	14·62	15·25	15·84	14·82	16·83	17·53	14·50	14·77	18·32	15·88	15·95
Fe_2O_3 ..	0·74	0·83	0·83	0·53	1·99	1·18	0·15	0·87	1·31	2·01	0·46	tr.
FeO ..	2·02	2·25	3·45	3·35	2·31	3·58	3·76	3·78	4·52	8·01	0·40	
MgO ..	1·04	1·18	1·63	1·24	0·99	1·84	1·91	2·21	1·62	4·16	0·29	0·11
CaO ..	0·70	0·91	0·94	0·73	1·60	2·88	2·55	2·18	1·58	1·95	0·65	0·23
Na_2O ..	2·25	1·98	1·77	1·70	2·61	2·12	2·37	2·38	1·97	2·46	2·80	2·90
K_2O ..	4·96	5·03	4·63	4·09	3·39	3·22	3·22	3·42	4·44	5·22	3·19	3·27
H_2O+ ..	0·72	0·75	0·60	0·62	0·89	0·80	0·61	1·81	0·89	1·30	1·01	1·16
H_2O- ..	0·11	0·34	0·09	0·09	0·12	0·14	0·21	0·11	0·26	0·22	0·09	
TiO_2 ..	0·42	0·33	0·65	0·66	0·52	0·67	1·10	0·61	0·70	1·18	abs.	—
P_2O_5 ..	0·09	0·22	0·12	0·22	tr.	—	0·07	tr.	—	—	0·15	—
MnO ..	0·04	0·03	0·05	tr.	0·04	0·05	—	tr.	0·05	0·14	0·04	—
Etc. ..	—	0·02	—	—	—	—	—	tr.	—	—	—	—
	100·19	100·42	100·66	99·51	100·61	100·29	99·91	99·54	99·85	99·83	100·49	99·72

1. Biotite granite. Por. 235, Par. of Oura, Co. Clarendon. Anal. T. G. Vallance.
A. Granite. Mt. Wagra (Victoria). Anal. C. M. Tattam. *Bull. Geol. Surv. Vict.*, 52 : 38.
B. Cooma gneiss (with plagioclase phenocrysts). Cooma. Anal. G. A. Joplin. PROC. LINN. SOC. N.S.W., 67, 1942 : 188.
C. Albury gneiss. Albury. Anal. G. A. Joplin. *Ibid.*, 72, 1947 : 117.
2. Biotite-adamellite. Creek bed, Por. 224, Par. of Oura, Co. Clarendon. Anal. T. G. Vallance.
3. Granodiorite. Quarry, north-east side of Willan's Hill, Wagga Wagga. Anal. T. G. Vallance.
D. Two-mica gneiss. Woomargama (Albury district). Anal. G. A. Joplin. PROC. LINN. SOC. N.S.W., 72, 1947 : 118.
E. Grey biotite-granite. Par. of Cudgewa, Victoria. Corryong batholith. Anal. F. F. Field. *Proc. Roy. Soc. Vict.*, 50, 1937 : 82.
4. Granodiorite. Near Tenandra Trig. Station, Por. 218, Par. of Tenandra, Co. Clarendon. Anal. T. G. Vallance.
5. Biotite-rich patch in the granodiorite near Tenandra Trig. Station (no. 4). Anal. T. G. Vallance.
6. Garnet-bearing aplite. Por. 168, Parish of Bilda, Co. Clarendon. Anal. T. G. Vallance.
F. Muscovite granite. Omeo, Victoria. *Trans. Roy. Soc. Vict.*, 24, 1888 : 110.

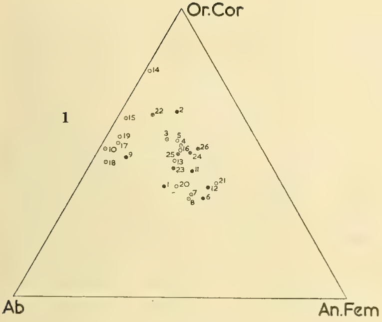
On the Or.Cor:Ab:An.Fem diagram (Text-fig. 1) the plutonic rocks of the first group (Wantabadgery–Green Hills type) are somewhat widely spaced. They fall roughly into three classes, the acid phases (near the Or.Cor:Ab edge), the potash felspar-rich granites, and the more plagioclase-rich adamellites and granodiorites. Point no. 21 in this figure represents a hypothetical rock with two parts of granite with one part of a lime-bearing psammite (cf. Joplin, 1947, Tables 11 and 13). The rocks have also been plotted on an ACF diagram (Text-fig. 2) and, for comparison, the diagrams for the second-group plutonic rock and similar types have been placed below.

To summarize, the chief chemical features of these granitic rocks of the first group are the excess of potash over soda and the fairly general low lime content. Even when the CaO content is relatively high, most of it must be held in plagioclase because hornblende and other lime-bearing ferromagnesian minerals are absent.

Inclusions in the First-Group Granites.

Inclusions, ranging in size from tens of feet or more to a few inches across, are common in both the Wantabadgery and Green Hills masses. Most of the inclusions

1



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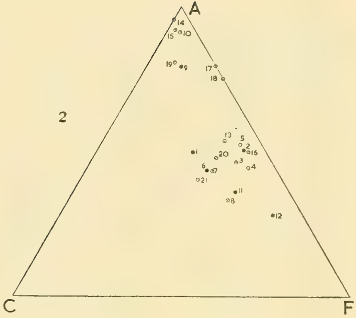

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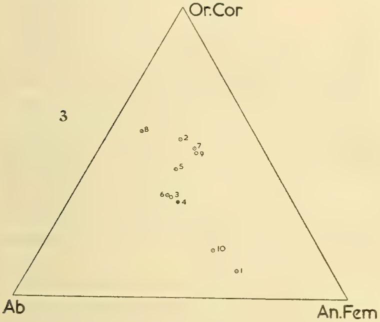

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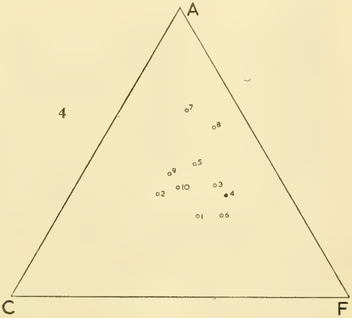

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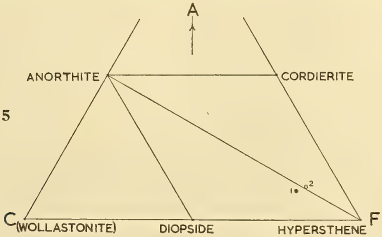


Text-figures 1-5.

Text-figures 1, 2.—Point no. 1, This paper, Table 2, no. 2. 2, This paper, Table 2, no. 1. 3, This paper, Table 2, no. A. 4, This paper, Table 2, no. B. 5, This paper, Table 2, no. C. 6, This paper, Table 2, no. 3. 7, This paper, Table 2, no. D. 8, This paper, Table 2, no. E. 9, This paper, Table 2, no. 6. 10, This paper, Table 2, no. F. 11, This paper, Table 2, no. 4. 12, This paper, Table 2, no. 5. 13, Joplin, 1942, Table 8, no. II. 14, Joplin, 1942, Table 8, no. III. 15, Joplin, 1942, Table 8, no. IV. 16, Joplin, 1947, Table 12, no. III. 17, Joplin, 1947, Table 6, no. I. 18, Joplin, 1947, Table 6, no. II. 19, Joplin, 1947, Table 6, no. III. 20, Joplin, 1947, Table 11, no. III. 21, Two parts of rock (point 2) with one part of limy metasediment (Joplin, 1942, Table 4, no. II). 22, Vallance, 1953*a*, Table 1, no. 5. 23, Vallance, 1953*a*, Table 1, no. 6. 24, Vallance, 1953*a*, Table 6, no. 8. 25, Vallance, 1953*a*, Table 6, no. 9. 26, Joplin, 1942, Table 5, no. IV. The metasediments (nos. 22-26) indicate the close relationship between certain psammopelites and the granitic rocks.

Text-figures 3, 4.—Point no. 1, This paper, Table 5, no. A. 2, This paper, Table 5, no. B. 3, This paper, Table 5, no. C. 4, This paper, Table 5, no. 1. 5, This paper, Table 5, no. D. 6, This paper, Table 5, no. E. 7, This paper, Table 5, no. F. 8, This paper, Table 5, no. H. 9, Joplin, 1943, p. 171, no. V. 10, Tattam, 1929, Table III, no. 21.

Text-figure 5.—ACF diagram showing certain possible Pyroxene Hornfels Facies assemblages. Where silica is deficient spinel may appear as an extra phase. Point 1 (plotted without correction for spinel) corresponds to the analysis no. 1 in Table 3. Point 2 represents the Cooma ultrabasic rock (Table 3, no. A).

can be readily related to metasediment types occurring among the country rocks. In general, sillimanite is commoner in the inclusions in the Wantabadgery granite than in the metasediments around it. A fairly large mass of ultrabasic rock is included in the granite at Mundarlo. Quartz nodules are not uncommon as inclusions and may exhibit a tendency to have narrow marginal felspar-rich zones developed.

The great bulk of the inclusions belong to the series pelite-psammopelite-psammite. Alumina-rich rocks are characterized in this environment by the presence, often in abundance, of sillimanite. These inclusions do not appear to acquire a hornfels texture; in general, they resemble the high-grade zone rocks (Vallance, 1953*a*). The usual mineral assemblage in these inclusions is biotite, sillimanite, muscovite, quartz, and felspar, in varying proportions dependent upon the original composition. Tourmaline occurs in places. The felspar is often untwinned and may be intergrown with vermicular quartz. Complete equilibrium has rarely been attained in these rocks. A few inclusions, rich in muscovite and having patches of greenish biotite and chlorite, probably once contained cordierite. Dark biotitic selvedges are often seen around the metasediment inclusions.

Sillimanite occurs here as felted masses or, less frequently, as clear, colourless porphyroblasts (see Plate xii, B). Sometimes it is concentrated in quartz giving the well-known *faserkiesel*. Andalusite does not often appear in the inclusions. The characteristic mineral reaction in the pelitic inclusions is biotite $\rightarrow$ sillimanite (fibrolitization). As the first stage, sillimanite fibres and needles develop at the margins of the red-brown biotite and finally mats of sillimanite cover the whole flake. Even when the reaction has gone to completion it is sometimes possible to see the outlines of the original biotite. The displaced potash probably gives rise to K-felspar and perhaps, ultimately, muscovite. In some inclusions muscovite is also converted to sillimanite. At a later stage in the history of these inclusions the sillimanite becomes unstable and may be converted to micas.

The sillimanite development may be largely a metamorphic effect but perhaps volatile constituents related to the granite had some influence. Williams (1934) suggested that in Stewart Island (N.Z.) the formation of sillimanite in a sillimanite-tourmaline paragenesis was related to boron-bearing solutions. Tourmaline is associated with sillimanite in some of the inclusions here; occasionally, however, it appears to replace the sillimanite. It is interesting to note that recently Michel-Lévy (1950) has synthesized sillimanite from Al_2O_3 + SiO_2 mixtures with borax solutions at 400–450°C. and water vapour pressure of 50 kg/cm^2.

The exact amount of material added to these inclusions is difficult to assess, but that such action has taken place in many cases is indicated by the increase in felspar content near the margins of the inclusions and by the obvious quartzo-felspathic veins, sometimes arranged *lit-par-lit* fashion, in certain examples. As in the high-grade zone rocks, some of the felspar here may have been derived by purely metamorphic means but clearly a large part of it came from an external source. Increase in felspar content (both K-felspar and oligoclase occur in these metasomatized inclusions) usually is accompanied by a decrease in sillimanite; the latter often passes back to mica. Mechanical breakdown of the inclusions is assisted by the development of felspar porphyroblasts. The gradation from normal metasediment inclusion through felspathized inclusion to contaminated granite and granite is complete. Field evidence suggests that the psammopelite inclusions are more readily granitized than are the highly aluminous pelites. However, with increasing intensity of granitization it becomes more difficult to determine the original nature of the inclusions.

Only one metasediment inclusion has been analysed (Table 2, no. 5), but this gives us some interesting information. In hand specimen the rock has the appearance of a mica diorite but in the field it is obviously an inclusion and seems to be derived from a sediment. Its composition, however, shows that it has undergone considerable chemical re-organization. When plotted on a von Wolff diagram (Text-fig. 10, point no. 5) it can be seen that this rock is displaced, relative to the metasediments, away from the Q pole due to the abundance of L and M (as a result of the biotite present). Reynolds (1946) has shown that pelitic rock fragments in granite tend to become basified as part of a geochemical sequence leading to granitization. It is difficult to generalize from one analysis, but it seems evident that here the basic patch displays a marked excess of Fe, Mg, and Ti over that characteristic of either the metasediments or the granites. Reynolds suggests that in the conversion of pelites to granitic rocks two processes are important, basification, followed by granitization. Psammitic rocks may be converted to granitic material by granitization without much basification. Thus in the present case the rocks of sandy nature are readily made over into granitic types by the process of felspathization. With these changes in mind it is interesting to look back for a moment to the country rock metasediments. They, too, are plotted on Text-figure 10, but in them we do not see any clearly-defined geochemical culminations of the type noted above. Certain of the high-grade rocks are displaced away from Q relative to the lower-grade types but the displacement is not very great (cf. p. 214). There is no evidence of an important basic culmination (basic front) in the country rocks near the granite margins.

In addition to the numerous representatives of the aluminous pelite-psammopelite-psammite series discussed above, a few psammitic rocks with calcareous matrices occur as inclusions. Comparable types are not common among the country rocks. These inclusions are typically pale-coloured, often with green or yellow-green spots, and although traces of bedding or schistosity may be visible the rocks are often granulitic. The essential minerals of these limy inclusions are quartz and xenoblastic patches of clinozoisite-epidote. Green amphibole, garnet, felspar, iron-ore and, rarely, white mica may also be developed.

The clinozoisite-epidote has a dirty-brown colour and displays either normal epidote interference colours or anomalous blues. Amphibole may occur as ragged green porphyroblasts and is apparently actinolitic ($Z \wedge c = 20°$). Felspar is not abundant but both plagioclase (andesine-labradorite) and K-felspar have been noted in a few cases. Where felspar is developed, clinozoisite-epidote tends to disappear. Part, at last, of the Na and K required for the felspars must have been derived from the granite. Some of the inclusions carry ragged colourless garnets which, from their environment, are believed to be grossular-rich.

The metamorphic grade of these calcareous rocks does not seem to be as high as that indicated by the other metasediment inclusions. In Scotland, zoisite normally gives place to anorthitic plagioclase in the almandine zone but the reaction does not seem to have proceeded far here in rocks associated with others showing at least Amphibolite Facies assemblages. Epidote-quartz-actinolite-bearing inclusions in a granodiorite at Kozárovice (Hejtman, 1951) typically show marginal alteration to diopsidic pyroxene and hornblende in reaction rims. Such a scheme might be expected here but it has not been recognized.

An unusual mass of ultrabasic material, about 50 feet or more across, has been found in the Wantabadgery granite about half a mile east of Mundarlo homestead. In hand specimen the inclusion is a fine-grained, dark, dense granulitic rock. It consists essentially of amphibole, pyroxene, and green spinel, with a little talc, sphene, and iron-ore (see Plate xii, C).

The pyroxene is a hypersthene (colourless; –ve; apparent oblique extinction to 15°, but mostly straight) and occurs as ragged grains, not infrequently penetrated by amphibole blades. The amphibole is a pale, feebly pleochroic (X = colourless, Y = very pale yellow-brown, Z = pale yellow-brown; $\gamma = 1{\cdot}646$; $Z \wedge c$ up to 19°) variety occurring as aggregates of small blades or as individuals up to about 0·5 mm. long. Both positive and negative signs have been obtained (sections with two cleavages are often positive, with one they may be negative). Apart from differences in sign the amphiboles seem to be indistinguishable. The positive sign suggests that the mineral is cummingtonite, although γ is rather low (Simpson, 1932, has a cummingtonite with low refractive index; see also Winchell, 1951). The negative sign suggests a tremolite-actinolite which, from the paragenesis, must be a magnesian type. A fine flaky mineral (talc ?) occurs in patches. Small bright-green translucent grains of spinel are a common feature of these rocks.

The high magnesia content of this rock marks it as typically ultrabasic. No other ultrabasic rocks have been found in this area and as the only possibly related types are the silicified serpentines south of Nangus (Vallance, 1953*a*) the origin of this large inclusion is unknown. From what can be seen in the field the rock has been recrystallized without much reaction with the granite or much internal change in composition.

Rocks of similar chemical composition occur at Cooma (Joplin, 1942) as masses of chlorite amphibolite (see Table 3) within the zones of granitized schists. Ultrabasic types also occur as inclusions in the gneiss at Cooma; these are recorded as having what may be amphibole pseudomorphs after pyroxene. Mikkola and Sahama (1936) have described a metamorphosed ultrabasic rock (see Table 3) from Lapland consisting of rhombic pyroxene, amphibole (intermediate between hornblende and magnesia-rich tremolite-actinolite), green spinel, and a carbonate mineral.

TABLE 3.

	1	A	B
SiO_2	46·44	46·36	43·97
Al_2O_3	10·12	10·38	10·43
Fe_2O_3	3·98	5·68	1·47
FeO	8·30	3·24	7·14
MgO	21·32	24·69	23·44
CaO	6·54	5·08	6·84
Na_2O	0·78	0·46	0·30
K_2O	0·28	0·05	0·19
H_2O+	1·41	3·39	0·77
H_2O-	0·08	0·19	0·05
TiO_2	0·20	0·22	0·22
P_2O_5	—	0·03	0·09
MnO	0·12	0·42	0·20
CO_2	abs.	—	4·74
	99·57	100·19	99·85

1. Ultrabasic inclusion in the Wantabadgery granite. Por. 52, Par. of Mundarlo, Co. Wynyard. Anal. T. G. Vallance.

A. Chlorite-amphibolite. Pine Valley, Por. 70, Par. of Binjura. Cooma area. Anal. G. A. Joplin. PROC. LINN. SOC. N.S.W., 67, 1942 : 191.

B. Spinel-bearing pyroxene-amphibole-calcite rock. Kussuolinkivaara, Sodankylä (Finnish Lappland). Anal. L. Lokka. *Bull. Comm. Géol. Finlande*, no. 115, 1936 : 366.

It seems clear from the rocks themselves that their present mineral assemblage is not in complete equilibrium. Hypersthene and spinel may be relics of the highest grade reached in the metamorphism. In the Pyroxene Hornfels Facies the rock should acquire a stable association of the type hypersthene-diopside-plagioclase-spinel. It will be seen from Text-figure 5 that diopside and plagioclase are not likely to be important here; neither has been definitely recognized. (In rocks of this composition similar mineral assemblages might be formed under either Pyroxene Hornfels or Granulite Facies conditions. The absence of garnet in the metasediments suggests the former here.) If hypersthene-spinel represents the metamorphic "peak", the assemblage shows some relation to that of Tilley's (1924) Class I Mg ii b hornfelses. Sedimentary hornfelses belonging to this class have been noted by Stewart (1946). The development of amphibole and talc may be related to a later retrogressive effect. These minerals are, in places, obviously derived from pyroxene and the reactions may be parallel to the late-stage conversion of the anhydrous high-grade mineral sillimanite to mica in some of the pelitic inclusions.

Dynamically-altered Granite.

Although signs of a fairly weak stress environment are not uncommon in the granite masses it is somewhat rare to find indications of intense dynamic action. Crush bands up to about 200 yards wide have, however, been found in the Oura–Wantabadgery district. They commonly trend about 15° east of north and may be traced for considerable distances in almost straight lines. Superficially they resemble long slate inclusions. The crushing is a wholly post-consolidation effect.

A complete gradation exists from normal granite to rocks with good cleavages (phyllonites—Knopf, 1931) or even to mylonites. Micaceous minerals in the granite yield to the stress by slipping and often develop intricate contortions across the cleavages. Biotite is converted to stretched-out patches of chlorite and sericite, often iron-stained. Any sillimanite present is converted to sericite. Quartz and felspar are more resistant and with intensification of the crushing may stand out as porphyroclasts. Usually, however, they develop cracks which lead to disruption of the grains. The felspar becomes sericitized whilst the quartz typically has undulose extinction. Narrow granular crush-bands may be set diagonally across the larger quartz grains and these lead to complete disintegration. Plate xii, D, shows the result of progressive crushing. Many of the rocks acquire an obvious slaty cleavage whilst a diagonal slip cleavage may also appear. The final product may have the assemblage sericite, finely-granular quartz, and some chlorite; this is a typical Greenschist Facies association. In some cases the frictional heat developed during the crushing has been sufficient to weld together completely the crushed material. This is in marked contrast to the crumbly nature of the crush-rocks in the Ellerslie granite.

GRANITES OF THE SECOND GROUP.

The chief representative of this plutonic group forms the Ellerslie granite mass which occupies the floor of the open valley accommodating both Nacka Nacka and Yaven Creeks. Within the Parish of Ellerslie this granite is widespread. The mass has a somewhat irregular outline and comes into contact with a variety of rock types. As a rule the granite is more easily eroded than are the surrounding rocks. With a broad, rounded north-western end (near the locality known as Clearmont), the mass gradually tapers to the south-east, becoming quite narrow near Sharp's Creek village (west of Wondalga). It apparently persists, however, as far as Peel's Creek (west of Batlow) and Batlow. The maximum length is more than 20 miles and the width about 5 miles.

There is quite a variation in the appearance of the rocks of the Ellerslie mass. Often they are markedly gneissic biotite-bearing granites and granodiorites but more massive (usually still with traces of foliation) phases are not rare. The distribution of the two types is irregular and they have not been mapped separately.

Similar to the Ellerslie granite are the rocks outcropping along Adelong Creek north of Adelong and, to the south, near Wondalga. This mass is traversed by the Tumbarumba road from near Adelong to within three miles of Batlow, where it passes off into unmapped country to the east. It is proposed to refer to this mass as the Wondalga granite mass. Although it is separated from the Ellerslie granite by the "basic belt" (Vallance, 1953*b*) the two rocks are so similar that they are believed to be of roughly the same age and to have had the same petrogenetic background. A small mass, named the Belmore mass (after the Parish of Belmore), occurs between Tarcutta and Westbrook. It is composed of rocks of the Ellerslie type but has not been studied in detail.

Lithologically similar granitic rocks occur near Tumut Pond, whilst there are many interesting analogies with the gneissic granites of the Kosciusko plateau, with the Murrumbidgee batholith rocks north of Cooma, and with certain granites in central-western New South Wales.

Aplites and Pegmatites.

Fine- to medium-grained aplites and acid granites occur as dykes and veins in these granites. They are quite abundant near Adelong; elsewhere they may be more dispersed.

Sometimes acid veins are given off into the country rocks. In the basic rocks, especially, such veins may be ptygmatically folded. The acid dyke rocks are more resistant to erosion than is the host granite. Some of the dykes show post-consolidation crushing.

Mineralogically, the acid rocks consist of quartz, K-felspar, and some acid oligoclase, with small amounts of muscovite, biotite, chlorite, and pyrite. The quartz is often strained and occurs both as irregular grains (0·5 to 1 mm. across) or as aggregates of tiny grains arranged in interstitial patches or in bands around the larger grains (e.g. felspar) in the rocks. There is a slight, but not a general, tendency for the quartz to be intergrown graphically with felspar. Felspar is often altered to sericite or kaolin. The K-felspar is commonly microperthitic, the intergrown albite being of the patch- or stringer-type. The plagioclase grains may be zoned; signs of fracturing and later healing are not uncommon. Muscovite, excluding sericite, is not common, whilst the little biotite present is often partly or wholly altered to chlorite. In a few cases the dark mica is merely recrystallized to finer aggregates of itself. Pyrite occurs in these rocks near Adelong.

Coarser-grained pegmatites also occur in the granites. The K-felspar of these is often microperthitic and some of the dykes have graphic margins with quartz-rich central zones. Tourmaline crystals about two inches long may be present. Compared with the aplites these rocks are not very abundant. There seems to be little or no mineralization associated with them and, in places, they have escaped the crushing which affected the granites and aplites.

Granite-Granodiorite.

As in the first-group rocks, a complete gradation exists here between granite and granodiorite; local, more basic, phases occur and will be mentioned later. The rocks are fairly even, medium-grained types, although sometimes small felspar phenocrysts appear. Normally the rocks are greyish but near Peel's Creek school (three miles west of Batlow) a reddish phase occurs. The gneissic foliation in the Ellerslie and Wondalga masses is generally arranged north-west–south-east; dips are usually steep. In places the granites have been crushed to cleaved, crumbly material along bands traversing the masses. Crushed granites are extensive along Adelong Creek near Wondalga.

Whether they be gneissic or almost massive, the rocks have a fairly uniform mineral association, consisting of quartz, plagioclase, K-felspar, and biotite together with some muscovite and accessories (see mode in Table 4). Hornblende occurs near the contact with the basic rocks.

The quartz may have a faintly bluish colour and usually forms irregular grains with sutured margins against felspar. Strain features are to be seen even in the quartz of the fairly massive rocks. In some of the foliated granites the quartz grains may be recrystallized to aggregates of smaller granules. These granules are at times arranged in bands strung out along the foliation; such bands may be wrapped around felspar crystals which, although sometimes fractured, are never granulated in the same way as the quartz. The feature suggests that the quartz has undergone plastic flow and recrystallization. Such bands and lenses of quartz stand out on the weathered surfaces. Watt (1899) recorded similar quartz in the "granite" at Wyalong, an area which has many analogies with Adelong. Watt believed this quartz deformation to be a post-consolidation effect and it seems difficult to explain it in another way. Vermicular quartz in myrmekitic intergrowths hardly ever occurs in these rocks (cf. p. 201).

Subhedral to euhedral crystals of plagioclase (oligoclase-andesine, up to Ab_{70}) are common, often exceeding K-felspar in abundance. Albite, carlsbad, and pericline twin-laws are represented. Zoning is common and the more calcic cores are typically more altered than the margins. The felspar may be somewhat strained and, if fractured, is often healed by later felspar or granular quartz. Both untwinned and twinned (microclinic) types of K-felspar may appear as ragged grains, sometimes moulded onto plagioclase. Microperthitic intergrowths are common. With a decrease in K-felspar content the rocks grade towards quartz-mica diorites.

The chief mica is a strongly pleochroic biotite (X = pale yellow- or greenish-brown, Y = very dark brown, Z = very dark brown, almost black; 2V very small; $\beta = 1{\cdot}648$). More rarely the biotites are of the reddish-brown type. Inclusions with pleochroic haloes are commoner in the latter variety. In some rocks the biotite is clotted and recrystallized to aggregates of smaller flakes. The mica may wrap round felspar crystals in the rocks with abundant granular quartz (p. 208); the biotite here often projects across the grain boundaries into the felspar. Epidote and sphene are often associated with biotite.

Fine sericite as an alteration product is more extensive than primary muscovite. Bright green chlorite often occurs after biotite but, in addition, well-formed, pleochroic (pale yellow to bright green) chlorite flakes with anomalous blue or purple interference colours exist independently of the biotite. Apatite, sphene, zircon, calcite, epidote, and iron-ore are accessories. The sphene may be reddish-brown, feebly pleochroic, and optically positive with a small 2V. Allanite, a rare accessory, is represented by one zoned, pleochroic brown crystal found in the granite at Gadara (east of Adelong but still of the Wondalga type). Allanite also occurs in the Murrumbidgee batholith.

TABLE 4.

Mode of Specimen of Ellerslie Granite.

Quartz	16·8
Orthoclase	22·1
Plagioclase	39·1
Biotite	21·4
Hornblende	nil
Muscovite	0·3
Accessories	0·3

Granodiorite. Por. 62, Par. of Wallace, Co. Wynyard. (For analysis, see Table 5, no. 1.)

Chemical Data.

Only one representative of this plutonic group has been analysed (see Table 5) so little can be said about the chemistry of this group. For comparison, however, a compilation of analyses of more or less similar rocks from analogous environments has been made. All of these rocks are regarded by Dr. W. R. Browne (see David, 1950) as being related to his Bowning orogeny.

These analyses have been plotted on Or.Cor:Ab:An.Fem and ACF diagrams (Text-figs. 3 and 4) which are placed, for comparative purposes, below the corresponding diagrams for the first-group rocks. The more calcic members of the first group fall near many of the types included here with the second group. If the rocks plotted on Text-figure 3 do, in fact, belong to one plutonic series they show little variation in Ab over a considerable range of Or.Cor. The most basic member (from Wyalong) probably owes its present composition to reaction with basic igneous material; similar hybrid rocks are formed here along the contacts between the "basic belt" and the Ellerslie and Wondalga granites. These basified rocks are in marked contrast to the biotitic inclusion (Text-fig. 1, point no. 12) which would be roughly equivalent to the most basified phase of the first-group granites.

Marginal Features of the Second-Group Granites.

Brief mention has already been made of the fact that the Ellerslie and Wondalga granites come into contact with a variety of country rocks.

On its western side the Ellerslie granite abuts high-grade metasediments some of which are migmatitic. Remarkably shallow (25°–30°) westerly dips occur in Turner's Creek near the granite but these rapidly steepen away from the granite. To the north-west in Mt. Pleasant Creek the granite has a clear-cut contact against migmatites and does not appear to have been responsible for the veining. The granite is fairly massive here and shows no important grain size or compositional changes near the contact. Some of the contact rocks show gentle folds sympathetic with the granite margin;

these may be related to plastic flow associated with the relatively active period of the granite's invasion. The independence of the high-grade rocks and the Ellerslie granite is emphasized to the north-east where the same granite comes into contact with knotted schists or even lower-grade pelites without knots. Such rocks, together with isogradal sandier metasediments, outcrop in Nacka Nacka Creek along the northern part of the Ellerslie mass. Further east and along its eastern margin the granite occurs alongside the "basic belt". The increase in metamorphic grade to the south-east along this belt has already been described (Vallance, 1953*b*). On the eastern side of this belt, the Wondalga granite appears. Tongues of granite and acid granite, ranging from large prolongations down to veinlets, are given off into the basic rocks. Ptygmatic folds in some of these veins may indicate a certain plasticity in the host rocks during injection (Wilson, 1952).

TABLE 5.

	A	B	C	1	D	E	F	G	H
SiO_2	58·93	63·35	67·64	67·67	68·92	69·55	70·31	74·99	76·08
Al_2O_3	17·48	16·92	15·66	16·02	16·21	14·16	18·68	10·44	12·93
Fe_2O_3	1·73	1·23	1·12	0·56	0·57	0·60	0·63	5·58	0·70
FeO	5·01	4·58	3·31	3·79	2·42	3·33	1·83	n.d.	0·90
MgO	4·33	3·03	1·55	2·20	1·04	1·45	1·10	0·09	0·53
CaO	7·08	4·45	2·14	2·12	2·31	2·20	2·22	0·50	0·52
Na_2O	2·91	1·90	3·03	2·86	2·43	3·14	1·37	2·66	2·31
K_2O	1·34	2·28	3·58	3·41	4·36	4·09	3·32	4·82	5·26
H_2O+	0·73	0·86	0·90	0·57	0·93	0·30	0·65	0·52	0·33
H_2O-	0·13	0·09	0·30	0·18	0·08	0·20	0·09	0·17	0·19
TiO_2	0·52	0·84	0·62	0·71	0·52	0·54	0·35	tr.	0·35
P_2O_5	0·14	tr.	0·13	—	0·30	0·12	0·06	—	0·12
MnO	tr.	—	0·12	0·03	0·03	0·23	—	tr.	0·06
Etc.	tr.	—	0·20	—	0·04	0·22	—	—	—
	100·33	99·53	100·30	100·12	100·16	100·13	100·61	99·77	100·28

A. Quartz-mica diorite. Klondyke Mine, Wyalong. *Geol. Surv. N.S.W.*, *Min. Res.* no. 5, 1899 : 14.

B. Quartz-mica diorite (hornblende-free). Cooma area. Anal. G. A. Joplin. Proc. Linn. Soc. N.S.W., 68, 1943 : 171.

C. Granite. Hillgrove area. Anal. J. C. H. Mingaye. *Rec. Geol. Surv. N.S.W.*, 8, 1907 : 217.

1. Granodiorite. Creek bed, Por. 62, Par. of Wallace, Co. Wynyard. Anal. T. G. Vallance.

D. Granite. Koetong mass (north-east Victoria). Anal. C. M. Tattam. *Bull. Geol. Surv. Vict.*, 52, 1929 : 38.

E. Granite. Hillgrove township. Anal. W. A. Greig. *Rec. Geol. Surv. N.S.W.*, 8, 1907 : 215.

F. Coarse biotite-granite. A phase of the "Blue gneiss"-Murrumbidgee batholith. Shannon's Flat, W.N.W. of Cooma. Anal. G. A. Joplin. Unpublished analysis by courtesy of the analyst.

G. White gneiss. Bunyan. Anal. G. A. Joplin. Proc. Linn. Soc. N.S.W., 68, 1943 : 172.

H. Granite. Wyangala Dam, Lachlan River, 19 miles south of Woodstock. Anal. W. A. Greig. *Dept. Mines N.S.W.*, *Ann. Rept. for* 1932: 96.

Local reaction is typical of the contact between the granites and basic rocks. As far as the granite is concerned, the most obvious result is a basification with the development of hornblende. In extreme cases hornblende completely displaces biotite as the chief melanocratic mineral; the resultant rocks tend to become dioritic in composition. The basic rocks become somewhat recrystallized and large amphiboles may be developed. Felspar also increases in these rocks near the contact and probably contributes to their mechanical breakdown. Biotite, too, may appear in the acidified basic rocks. The whole process appears to be one of hybridization, involving reciprocal reaction between the two parents. Some splendid examples of the results of this process are to be seen in the quarry near the swimming pool at Batlow, where granite veins invade the amphibolite. Plate xii, E, illustrates one of the reaction rocks carrying a good deal more hornblende than biotite. The amphibole of these rocks is variable in colour, grey, greenish, and brownish-green types being common; as a rule the strongly greenish type mantles the others. All the amphiboles are negative and have $Z \wedge c$ greater than 20° (up to 28°). Some of the large hornblende grains enclose rounded felspars or have sutured margins against felspar. Occasionally these big amphiboles are rifted apart along the cleavages and granular quartz fills the resulting wedge-shaped cavities. Felspars, too, may be cracked and healed. Some of the larger felspars have granular quartz and ferromagnesian minerals wrapped round them. A complete gradation exists from granite through basified granite and acidified amphibolite to normal amphibolite. In many cases, however, the modified "granitic" veins may be readily distinguished from the essentially basic host material.

The Ellerslie granite comes into contact with the Green Hills granite along a front extending from near Batlow to Yaven Creek. Sharp junctions have not been found and the usual occurrence is a gradation over a couple of hundred yards between the two types. Each granite shows signs of foliation roughly parallel to the direction of the contact in the vicinity of the contact but, away from it, it resumes its normal parallelism to the strike of the country rocks. Directional structures are more obvious in the Green Hills mass along this contact than elsewhere within that mass.

The gradational rocks are variable even in hand specimen, but they commonly display a roughly gneissic appearance. They are frequently biotite-rich and have an uneven yet medium grain size. As both granites are broadly comparable in mineralogy no marked mineral change is to be expected in the gradational rocks. Felspar, biotite, and quartz remain the chief constituents. Andesine (about Ab_{65}) occurs as euhedral or subhedral grains up to 5 mm. across. These grains are twinned and may be zoned; they are often fractured and healed by later felspar (note the patchy appearance of the felspar in Plate xii, F). The felspars are roughly oriented in the plane of the foliation and may have biotite wrapped round them. A little K-felspar has been found and, rarely, myrmekitic intergrowths; the latter are typical of the Green Hills granite but not of the Ellerslie granite. The abundant mica is a strongly pleochroic red-brown biotite, often concentrated in clots. Muscovite is not common. Quartz is usually much strained and cracked but may not be as extensively granulated as some of the quartz in the Ellerslie mass itself. The evidence of fractured and healed felspar suggests dynamic action at some stage before the final consolidation of these rocks.

Similar gradational contacts have been found between the analogous granite-types in the area north of Cooma.

THE PROBLEM OF THE AGES OF THE GRANITES.

The relative ages of the two granite groups appear to be the same here as in the Cooma area where the Cooma gneiss ante-dates the Murrumbidgee batholith rocks. The second-group Ellerslie granite, along its north-western margin, cuts across high-grade rocks and metamorphic zones which are related to the Green Hills and Wantabadgery granites. It seems reasonable to believe, therefore, that the Ellerslie granite is younger than these first-group rocks. The Ellerslie granite is more extensively crushed than the first-group types, but this feature may have resulted merely from the greater resistance of the latter. Little information on relative ages is obtainable from the gradational contact between the Green Hills and Ellerslie granites. That the gradation was due to reaction related to the advent of the Ellerslie granite before the Green Hills mass was quite cold and consolidated is considered unlikely because the former obviously post-dates the metamorphism (and its thermal environment) with which the latter was closely associated. There may not, however, have been a very great time-interval between the emplacement of the two granites. Perhaps a stress environment existing during the introduction of the Ellerslie granite weakened the Green Hills type along its margins and thus facilitated reaction with the later granitic material. The local foliation parallel to the contact in the Green Hills mass may be related to this postulated stress environment.

As the Wantabadgery and Green Hills granites bear roughly the same relations to the metamorphic zones it is assumed that they are not greatly different in age.

The general similarity of the so-called second-group masses suggests that they, too, may be fairly closely related in time.

Of the absolute ages of the granite we know nothing definite. Harper (1916) believed that the granite at Adelong (second-group type) was Carboniferous and claimed that it could be traced for 25 miles to the south-east, where it intruded fossiliferous Devonian rocks. This does not seem to have been adequately confirmed. Dr. W. R. Browne (in David, 1950) suggested that the granite between Batlow and Tumbarumba (here regarded as part of the Green Hills mass) should be "very tentatively grouped as late middle Devonian but may be Carboniferous". Edwards and Easton (1937) believed the Corryong batholith to be either post lower or post middle Devonian in age. The Cooma and Albury gneisses which are almost identical with the first-group rocks here both in appearance and environment are regarded (see Joplin, 1947) as epi-Ordovician in age. The Murrumbidgee batholith rocks, similar to the second-group types, are considered to be of epi-Silurian age (Joplin, 1943).

No fossils have been recorded from the area studied, but at two localities not far away, Moorong Trig. Station near Wagga Wagga, and Carboona Gap on the Tumbarumba-Jingellic road, upper Ordovician (Eastonian ?) graptolitic remains have been found. Both occurrences are in rocks affected by granite. The writer has not been to Moorong Trig. Station, but at Carboona the granite is lithologically identical with the Green Hills type granite. A little to the west of the black (carbonaceous) graptolitic sediments at Carboona normal pelites show metamorphic features typical of the high grade of metamorphism as described here (Vallance, 1953*a*). These Carboona rocks were placed by Joplin (1947) in her zone of sills. The granite is thus in much the same metamorphic setting as the Green Hills mass and as both occur in the same belt they are regarded as probably being related in age. If the graptolites are of Eastonian age there surely could not have been a great deal of cover if the granite were of late Ordovician and pre-Silurian age. The presence of extensive metamorphic zones suggests that the first-group granites, associated with them, belong to a fairly deep zone (cf. Joplin, 1948).

If the heat flow, conductivity of the roof rocks, and the temperature difference between the granite and the surface at the time of emplacement were known, the thickness of the cover above the granite might be obtained from the equation (Birch *et al.*, 1942)

$$dQ = K.\frac{dT}{dn}.dS$$

(where dQ is the quantity of heat conducted in unit time across an area dS; K is the conductivity; and dT/dn is the temperature gradient normal to the surface dS). These values are not available here, but a rough estimate may be obtained by substituting hypothetical data. Birch (1950), in a granitic terrain, obtained heat-flow values ranging from $1{\cdot}6 \times 10^{-6}$ to $1{\cdot}9 \times 10^{-6}$ cal/cm^2.sec; in active orogenic regions the values would conceivably be higher. Studies on sillimanite (Michel-Lévy, 1950) and granitic felspars (Barth, 1951) indicate that these minerals can form at about 450–500°C. It is not unreasonable to expect that the granite would have been at about that temperature. Assuming a temperature difference of the order of 400°C., heat-flow about twice Birch's values, and a roof with the conductivity of slate, a depth-of-cover value of about 10,000 feet is obtained. Raguin (1946) quotes values of from 1500 to 3000 metres for the depth of burial of migmatites in the Pyrenees region. A cover of the order of that noted above seems to be thicker than could reasonably be expected of the Bolindian (uppermost Ordovician) rocks alone.

To overcome the depth problem it seems necessary to postulate sedimentation continuing, without break at the end of the Ordovician, into the Silurian in the metamorphic belt. Just how far into Silurian times this progressed is not known. There is no definite evidence of an orogeny at the close of the upper Ordovician in this region. The closest limit we have is to be found in the Wombat Creek area of north-eastern Victoria where sediments variously called upper Silurian or lower to middle

Devonian (David, 1950; Crohn, 1950) unconformably overlie upper Ordovician rocks. If the unconformity was related to an epi-Ordovician Benambran orogeny (David, 1950) this folding could well have occurred in lower or middle Silurian times. As it seems clear that the first-group granites were related to the metamorphism which, in a broad sense, accompanied the folding they, too, may belong to the early or middle Silurian.

At the southern end of the metamorphic belt the analogues of both granitic groups here described ante-date middle Devonian rocks (Crohn, 1950, p. 25) and perhaps the same time-relations exist here. The second-group rocks may thus post-date the middle Silurian and ante-date the middle Devonian. They are perhaps to be referred to the epi-Silurian Bowning orogeny (cf. the Murrumbidgee batholith rocks—see Joplin, 1943).

REMARKS ON THE ORIGIN AND SIGNIFICANCE OF THE GRANITES.

The First-Group Granites.

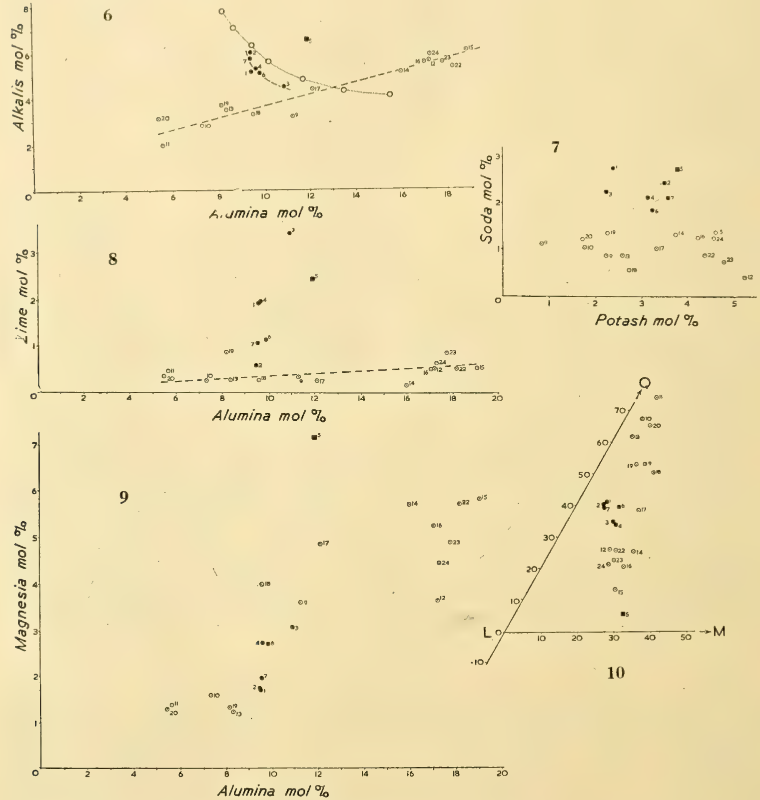
Because of the close relationship in the field between the extensive metamorphic zones and the rocks of this group the question of the genesis of the latter is of considerable interest. Like the same question asked of so many other granitic masses, however, it has as yet no completely satisfying answer.

It seems reasonable to believe that pre-granitic basic rocks may have occurred in this region, but whether or not they were related genetically to the granites has not been established (at Cooma, Joplin (1942) suggested that the chlorite amphibolite, for example, was related to the Cooma gneiss). The absence of plutonic rocks of intermediate type (apart from purely local biotite-rich patches) associated with the first-group granites rather suggests that the latter were not immediately derived from basic magma by differentiation.

If we compare the compositions of the granitic rocks and the metasediments we find several interesting points. Of the metasediments, the psammopelites come nearest to the granites in composition (cf. Text-fig. 1). Psammopelites predominate among the metasediments and the approximate proportions, obtained from a section near Alfred Town, pelites (20%), psammopelites (60%), and psammites (20%), are roughly representative of the metasediments as a whole. An average rock calculated on this proportional basis would be still like a psammopelite because the excess of Al_2O_3 and K_2O of the normal pelites would be offset by the excess SiO_2 in the psammites. Compared with the plutonic types such a rock would be deficient in alkalis (particularly Na_2O) and CaO, whilst having rather more Al_2O_3 and ferromagnesian constituents than the granites. The actual differences are, however, not very great; addition of soda alone to the metasediments would give a composition not unlike a granite. Formation of granitic rocks from sediments by metamorphic-metasomatic processes (often involving addition of soda) is nowadays a commonly invoked petrogenetic scheme. We must enquire whether there is any evidence of its action here. If metasomatism were applicable on a regional scale one would expect progressive changes in composition to accompany changes in grade in the metasediments. That such changes may take place in some cases has been elegantly established by Lapadu-Hargues (1945). Using mole percentages of various constituents he demonstrated several interesting progressions in rocks ranging from slates to granites.

The granitic rocks from this area as well as metasediments have been plotted on mole percentage variation diagrams (Text-figs. 6, 7, 8, and 9). In the alkali/alumina diagram it is clear that the metasediments, irrespective of metamorphic grade (they range up to spotted granulites and mottled gneisses), roughly fall along a straight line. The granitic rocks form a series running in opposition to the sedimentary variation. The granite curve, if extended, would meet the other curve in the region of the psammopelites. Lapadu-Hargues' curve is parallel to the granite curve. Somewhat similar features are also exhibited in the soda/potash (Text-fig. 7), lime/alumina (Text-fig. 8), and magnesia/alumina (Text-fig. 9) diagrams. The variation pattern for iron is similar to that for magnesia. Although the arrangement is rather irregular in the soda/potash diagram the plutonic rocks all have high Na_2O relative to the metasediments.

These results suggest that the present compositions of the metasediments are, in the main, directly related to their original compositions and that there has been little *apport chimique.* Actually, there may be a slight tendency for the highest-grade rocks



Text-figures 6-10.

Point no. 1, This paper, Table 2, no. 2. 2, This paper, Table 2, no. 1. 3, This paper, Table 2, no. 3. 4, This paper, Table 2, no. 4. 5, This paper, Table 2, no. 5. 6, Joplin, 1942, Table 8, no. I. 7, Tattam, 1929, Table III, no. 19. 9, Vallance, 1953*a*, Table 1, no. 1. 10, Vallance, 1953*a*, Table 1, no. 5. 11, Vallance, 1953*a*, Table 1, no. 6. 12, Vallance, 1953*a*, Table 3, no. 1. 13, Vallance, 1953*a*, Table 1, no. 4. 14, Vallance, 1953*a*, Table 2, no. 1. 15, Vallance, 1953*a*, Table 6, no. 1. 16, Vallance, 1953*a*, Table 6, no. 2. 17, Vallance, 1953*a*, Table 6, no. 5. 18, Vallance, 1953*a*, Table 6, no. 6. 19, Vallance, 1953*a*, Table 6, no. 8. 20, Vallance, 1953*a*, Table 6, no. 9. 22, Joplin, 1942, Table 7, no. I. 23, Joplin, 1942, Table 7, no. IV. 24, Joplin, 1942, Table 7, no. V.

The dotted circles represent metasediments and the black circles granitic rocks. The dotted curve in Text-fig. 6 is from Lapadu-Hargues (1945).

to have alkali/alumina and soda/potash ratios a little higher than those of the low-grade types. The increase is never great and is certainly not on the scale of Lapadu-Hargues' variation. The inclusions in the granites show more advanced stages in this series than do the marginal country rocks (see p. 205). Joplin (1942, p. 181) concluded that there was a small addition of soda in the formation of the highest-grade rocks at Cooma. Detrital albite in some of the lower-grade rocks introduces an element of doubt when assessing the amount of Na_2O added to the higher-grade metasediments. The increase in K_2O content due to the muscovitization in certain high-grade rocks near the granites is a further complication.

The evidence available in the present case suggests to me that, if the granites were derived from the metasediments, then the critical granitization stages are not clearly represented in the variation curves. This may be because actual granitization took place at deeper levels not yet exposed. There certainly seems to be more reason to believe that the granites of the Green Hills and Wantabadgery masses were introduced into their present position than that they were formed *in situ*. The small amount of *apport chimique* even in the high-grade rocks suggests a break in the granitization series. The differences in the metamorphic environments associated with the Wantabadgery granite (mainly knotted schists, localized high-grade rocks) and the Green Hills granite (extensive high-grade zone) suggest that the lithologically identical granites did not form in their present positions. Displacement seems to have been of some importance in the emplacement of the Wantabadgery granite; the deflection of the strike of the country rocks in the Oura-Wantabadgery district (see p. 198) may have been due to displacement. The plagioclase twins represented in the granites of this group include Gorai's (1950, 1951) C-twins (see p. 200). Gorai believes that granitic rocks with plagioclase in which his C-twins are important (his I-granites) are of igneous origin, having passed through a mobile stage.

From the abundance of metasediment inclusions in the granites it seems clear that a good deal of sedimentary material has been added to them even if the granites were not largely derived from the metasediments at a lower level. Whether the granites were formed by extensive contamination of a magma or by extensive granitization (anatexis essentially) of the metasediments, the final products would tend to be similar and to approach the bulk composition of the sediments. Joplin (1948) believes that both processes were active in the similar environments at Cooma and Albury. Oligoclase granite magma, derived from the base of the Sial is regarded as an active agent and Dr. Joplin considers that orthoclase-bearing gneisses are formed as a first-stage granitization of the metasediments, ahead of the advancing granite; ultimately a potash-enriched syntectic granite is produced. At Cooma and Albury representatives of the oligoclase granite and syntectic granite are found. In this area some aplitic dyke rocks have compositions similar to the oligoclase granite type (see p. 201), the main varieties in the first-group plutonic masses are akin to Joplin's syntectic or contaminated granites. The postulated primary oligoclase granite magma would be a convenient source of soda required in the making-over of the sedimentary material.

An important control in determining the metamorphic and plutonic history of this metamorphic belt must have been the miogeosyncline in which the sediments were deposited. Sinking of the geosynclinal belt must have led to folding of the sediments and, as the action progressed, the rocks doubtless acquired cleavage and schistosity. Associated with the sinking was a relative rise in the geothermal surfaces with a great increase in thermal activity at the base of the geosyncline. The thermal activity might have been related to the sinking of the geosyncline, to igneous activity at its base, or to a combination of both. Although the initial thermal gradient may have been rather steep, it is suggested that a primary thermal zoning was established in the geosynclinal sediments (cf. Kennedy, 1948). The deepest and highest-grade zone was in the region of greatest activity where, according to Joplin's (1948, 1952) theory, oligoclase-granite magma was able to react extensively with the metasediments. Looked at from the sediments' angle, an important feature of this zone was probably the addition of soda. Above this postulated granitization zone was the highest-grade zone at present visible (characterized by spotted granulites, etc.). With the steep thermal gradient this zone was probably overlain by more restricted knotted schist and biotite zones. At Cooma we may have exposed a deeper level than that represented by the high-grade zone in this area. The extensive migmatites in what is known as the injection zone at Cooma have only restricted equivalents here. Although it has been assumed that these Cooma rocks are arterites (due to magmatic injection) it may be that they are in part venitic. Locally produced (contact) migmatites at higher levels are probably more arteritic than are those of a granitization zone proper. The explanation given at Cooma (Joplin, 1943) that on low-grade metamorphic rocks a later contact thermal metamorphism was imposed is only roughly followed here in the idea of an advancing thermal front as the metamorphism progressed. The complete metamorphic series demonstrated (Vallance, 1953*a*) in these rocks stresses the essential unity of the whole process.

The suggested primary thermal zoning was probably modified when the granitic material produced in the deeper levels was rendered capable of movement and was able to escape upwards in the "thermal envelope". Although it is believed that the Green Hills granite is not in its place of origin, it may not have travelled far and still had sufficient energy available to migmatize locally the metasediments amongst which it came to rest. Such a granite might be called parautochthonous (Read, 1951). The high-grade zone rocks present evidence of a stage-wise metamorphism with signs of a thermal "peak" superimposed on somewhat less metamorphosed rocks. The Wantabadgery granite was able to escape further from the postulated granitization zone and its final roof must have been above the level of the high-grade zone and within the knotted schist zone. With the initial steep thermal gradient the knotted schist and biotite zones may have been narrower than they are now; their limits were perhaps extended by the thermal "front" associated with the intruding granite. Locally, along its margins, the Wantabadgery granite effected migmatization on a small scale. Tourmalinization of the contact rocks was also related to the presence of granitic material (see Vallance, 1953*a*).

The variations in the state of the country rocks near these identical granites have led to the latter being regarded not as the cause of the metamorphism (i.e., that the metamorphism is not purely a contact effect due to the presence of the granites), but that both metamorphism and granites were related to the same ultimate causes, bound up with the history of the geosyncline. At the levels we now see, the results of this action were mainly metamorphic but the more intense conditions of the deeper zones were probably conducive to extensive metasomatic reaction and granitization. The granites, whether broadly syntectic or anatectic, belong to the deeper level and it is only as a result of their mobility that they are now visible. The granites were, however, probably able to exert some contact thermal influence on the rocks which they invaded. Variations in the width of the knotted schist zone and, to a less extent, the biotite zone near the Wantabadgery granite may be partly related to differences in the slope of the granite contacts.

The lack of strong foliation in many of these first-group granites suggests that no very great stress influence was involved during their crystallization. That a stress environment of a rather weaker nature did exist, however, is indicated by the rough orientation of some inclusions and schlieren, and by the fact that with the Wantabadgery granite, at least, the thermal effect was not sufficiently great to overcome the schistosity of the metasediments. Schistose contact rocks are, of course, quite well known (Grout, 1933). The first-group granites probably came to rest soon after a tectonic maximum; they are in this sense late synkinematic. The Wantabadgery and Green Hills masses show features characteristic of Browne's (1931) synchronous batholiths.

That plutonic activity has occurred in a miogeosynclinal environment is itself quite interesting, though not exceptional; Marshall Kay (1951) mentions several examples of this association. Compared with the eugeosynclines there is, however, a general lack of plutonic activity in miogeosynclinal regions. The sediments of this miogeosyncline are characterized by appreciable potash and, in general, fairly low lime contents. It is probable that such features do not typify all similar geosynclines, but there is reason to expect that they are more characteristic of miogeosynclinal than of eugeosynclinal sediments. In Part I of these Studies (Vallance, 1953*a*, Text-fig. 2) the restricted chemical composition of the pelites of this metamorphic belt relative to pelites from other parts of the world, and presumably from various geosynclinal environments, was clearly demonstrated. The potassic granites of the type found in this area and which probably derived a good deal of their source material from the metasediments could only be the "most universal" (Joplin, 1948, p. 38) where there is an overall sedimentary uniformity of the type found here.

The Second-Group Granites.

These rocks have not received as much attention as the other types because they lack the close relations to the general metamorphism shown by the first-group granites. It seems clear that the second-group rocks were emplaced later than those already discussed, but how much later it is not possible to say. They may have followed fairly soon after the earlier group but it is possible that some of the rocks of the "basic belt" (Vallance, 1953*b*) were intruded during the time between the emplacement of the first- and second-group granites. In any case, the latter definitely post-date the metamorphism. Field evidence suggests that the Ellerslie granite invaded to a higher level in the crust than did the neighbouring Green Hills granite (the latter still has roof remnants, the former is quite unroofed). According to Joplin (1948) the second-group granite equivalent at Cooma also belongs to a higher level than the Cooma gneiss. The Murrumbidgee batholith does not display typical synchronous batholith features nor yet those characteristic of a subsequent batholith (Browne, 1931); Joplin (1948) refers to it as a quasi-synchronous batholith.

The lack of extensive metamorphic-metasomatic features at the margins of such large bodies as the Ellerslie and Wondalga masses surely suggests that, in general, the granites were not very active when they crystallized and that they were not formed in place. They seem to be hardly in the right setting for wholesale granitization *in situ*. The most outstanding marginal effect of these granites is their reaction on a local scale with the basic rocks (p. 210). Joplin (1948) has drawn attention to the evidence of reaction between the Murrumbidgee batholith rocks and amphibolite inclusions in the area north of Cooma. The theory was advanced that the reaction is a reciprocal effect and this is contrasted with basic inclusions being recrystallized without much reaction in the Cooma gneiss. Dr. Joplin believed that strong compression prevented reaction in the latter case but that, as the Murrumbidgee batholith was "emplaced during waning compression", hybridization was possible there and was, in fact, of considerable importance. Whether this theory be true or not there is nevertheless a marked contrast between the attitudes of members of the two granite groups in the present area to basic inclusions (and basic country rocks). Joplin considered that hybridization of the primary oligoclase-granite magma by reaction with the pre-existing basic rocks was responsible for the more basic phases of the Murrumbidgee batholith. Hybridization has occurred locally with the Ellerslie and Wondalga granites and the "basic belt" rocks, but as the hornblendic phases are largely confined to the contacts it is difficult to say how important this reaction has been in determining the nature of the second-group rocks. At Cooma, the White gneiss (Joplin, 1943) is regarded as representing the relatively "pure" (i.e. unhybridized) oligoclase-granite-magma type; a similar rock has not been found in this area unless it occur among the types classed as aplites, none of which have been analysed. In the case of the second-group granites there are few instances of much reaction with metasediments although inclusions of such rocks occur in the granites.

The second-group granites often display gneissic features indicative of a stress influence. The fact that non-gneissic acid pegmatite veins may be associated with the gneissic granite suggests stress waning before complete consolidation. Many crush-bands, however, bear witness to post-consolidation shearing. Parts of the Ellerslie mass are relatively massive, indicating, no doubt, that directed pressure was not exerted uniformly through the mass. If the granites of this group were associated with a separate epi-Silurian orogeny (see p. 213) there are not many signs of its effect on the earlier-metamorphosed rocks. This later folding must have closely followed the trends of the earlier folding if the gneissic foliation in the second-group granites is any indicator of the contemporary stress pattern. However, although the granites often have a distinct foliation, this is no real reason for postulating an intense folding associated with them.

If these granites were derived from primary oligoclase-granite magma by reaction with the country rocks this must have largely taken place at a lower level. In view of the chemical similarity between certain first- and second-group granitic rocks (cf. Text-figs. 1-4) it is possible that the earlier granites may have contributed to the development of the second-group types. A renewal of activity in the deeper levels may have resulted in this contribution not being a purely passive one based on assimilation of solid granite by a later, active magma. A certain "rejuvenation" of the earlier granitic material may have been one phase in the development of the later type. The dominance of biotite in many of the second-group granites, for example, might be related to the contribution of the earlier plutonic types and/or to deep-level granitization of sedimentary material. It is clear, however, that any postulated renewal of deep-level activity was unable to affect greatly the metamorphic picture, related to the earlier activity, which we can trace at the present level of exposure. The distinctly calcic phases of the second-group granites are perhaps most reasonably to be connected with addition of hornblendic rocks. The association and hybridization of similar gneissic granites with analogous basic rocks at Cooma, Adelong, Wyalong, and Hillgrove, amongst other places, are probably of more than casual significance in determining the nature of the gneissic granites.

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EXPLANATION OF PLATE XII.

A.—Granitized metasediment relic in the Wantabadgery granite showing myrmekitic intergrowths and traces of biotite-quartz symplektite (near centre). Crossed nicols. × 45.

B.—Pelitic inclusion in the Wantabadgery granite showing sillimanite needles and euhedral crystals developed at the expense of biotite. Ordinary light. × 13.

C.—Ultrabasic inclusion in the Wantabadgery granite showing blades and aggregates of amphibole surrounding ragged hypersthene grains (higher relief). The dark granules are green spinel. Ordinary light. × 13.

D.—Dynamically-altered Wantabadgery granite. From top right to bottom left there is a gradation from crushed granite with ruptured quartz and felspar grains to completely rolled-out quartz-mica-chlorite aggregates. Note the development of schistosity and the disappearance of large quartz-grains with increase in intensity of dynamic action. Ordinary light. × 13.

E.—Basified second-group granite from Batlow. Note the development of hornblende with a definite reduction in the biotite content. The reaction occurs where the granite comes into contact with the basic rocks. Ordinary light. × 13.

F.—Granite-granite hybrid rock from the zone between the Ellerslie and Green Hills masses. Note the irregularities in the felspar grain, and the strained appearance of the quartz. A small biotite-clot can be seen at the top (right). Crossed nicols. × 13.

All photomicrographs by Mr. G. E. McInnes.

THE OCCURRENCE OF VARVED CLAYS IN THE KOSCIUSKO DISTRICT, N.S.W.

By T. G. VALLANCE, Linnean Macleay Fellow in Geology.

Plate xiii; one Text-figure.)

[Read 30th September, 1953.]

Synopsis.

Varved clays occurring in the valley of Trapyard Creek in the Kosciusko district are described. The clays were deposited in a small, short-lived lake formed behind a moraine bar deposited by the Trapyard glacier during the Pleistocene glaciation. These sediments are remarkable for their content of unaltered minerals, particularly micas, derived from the local granite country rocks. The banded clays represent the first Pleistocene varved glacial deposits found on the mainland of Australia and are probably the most recent yet discovered in the Commonwealth.

INTRODUCTION AND GENERAL REMARKS.

The discovery of banded clays in the floor of the Trapyard Creek Valley was made in January, 1951, by Dr. W. R. Browne and Mr. D. G. Moye (chief geologist, S.M.H.E.A.) during a natural history survey of the Kosciusko region by a party of which the author was a member. Further exposures were found during the next summer.

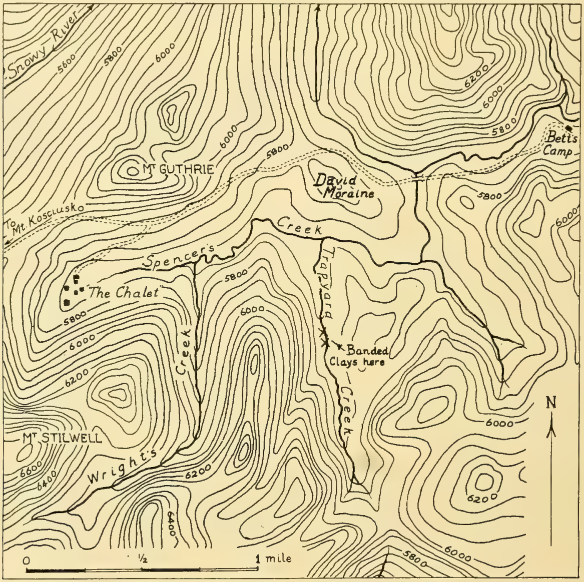
The waters of Trapyard Creek flow through a straight, open U-shaped valley about one mile long to join Spencer's Creek at a point about one mile east of the Chalet at Charlotte's Pass (see Text-fig. 1). The combined stream passes round the eastern end of the David moraine (Taylor, Browne and Jardine, 1925), a great mound partially blocking the glacial valley system, and flows down the Lower Spencer's Creek valley to meet the Snowy River.

The literature on the glacial features at Kosciusko is, as yet, not extensive, although the district shares with Tasmania the only definite evidence of Pleistocene glaciation so far found in the Commonwealth. The most recent account of glaciological studies at Kosciusko is given by Browne (1952) in which passing mention is made of the varved clays.

Differential movement due to what is known as the Kosciusko Uplift at the end of Pliocene times caused the elevation of much of eastern Australia. The effect was particularly marked in the Kosciusko district, where the highest country in Australia (Mt. Kosciusko, 7316 feet) bears witness to this uplift. It is probable that this area was essentially an isolated uplifted plateau at the beginning of Pleistocene times, a feature characteristic of it at the present day. During part of Pleistocene times glacial conditions prevailed at Kosciusko and these have left their mark on the physiography of the region. From the physiographic record Dr. W. R. Browne (1952) has pieced together a sequence of three stages during the glaciation.

During the earliest stage Dr. Browne believes that much of the area down to at least 4800 feet was covered by an ice-sheet or ice-cap of variable thickness in which there was movement of ice for the most part in an easterly direction from the vicinity of the Main Divide. Occasionally erratics which indicate such movement have been found but, because most of the region is occupied by granite, such evidence is somewhat rare. Dr. H. Rutledge and the present writer tend to regard the early-stage glacial features as related to an extensive névé-field environment rather than to an ice-cap, but all workers are agreed on the widespread effect of the earliest glaciation. The extensive ground moraine deposited over the area is largely related to this phase.

Following this stage, and separated from it by an unknown time-interval, came a period in which valley glaciers flourished. These valley glaciers in certain cases must have followed the trends of the pre-glacial streams which survived the first phase. The glaciers deepened existing open valleys and in many ways modified the landscape already smoothed by the earlier glaciation. Some of the valley glaciers headed in steep-walled cirque-hollows whilst others, like the Trapyard Creek glacier, headed in low cols (called ice-divides by Dr. W. R. Browne) with the ice supply augmented by hanging tributary glaciers. Evidence of the work of the valley glaciers is clear in the U-shaped profiles of the valleys today and in the moraine material left by the ice as it retreated to the heads of the valleys.



Text-fig. 1.—Map of the Upper Spencer's Creek basin area showing Trapyard Creek and the banded clay locality.

During the third stage the ice was much more restricted in extent and its erosive action was largely confined to cirque-cutting. This final glacial stage modified the heads of the "valley-glacial" valleys in the higher parts of the region but otherwise did not greatly affect the previously-glaciated landscape.

Trapyard Creek valley, in which the banded clays have been found, remains as a relic of the second phase of the glaciation. Towards the end of this stage, as the ice retreated up the valleys of Spencer's Creek and its tributaries (including Trapyard Creek), moraine barriers were deposited across them. The great mass of the David moraine is the largest of these recessional moraines; smaller examples occur at intervals further up the valleys. Water ponded by the moraine barriers formed small lakes which, following the breaching of the moraines, were drained and now appear as flat, boggy areas through which the modern streams meander. Lines of erratic blocks may now indicate the former moraine bars from which the finer material has been washed. Lake Süssmilch (David, 1908) came into existence immediately behind the David moraine and apparently extended across the junction of the Trapyard Creek and Spencer's Creek valleys. In the Upper Spencer's Creek valley above Lake Süssmilch recessional moraines were responsible for the damming of Lake Mackie and Lake Lendenfeld (David, 1908). Traces of clays have been found in these lake-floors but, in general, the fine material is mixed with gritty granite detritus which constitutes the greatest proportion of the material underlying the peaty bogs on the old lake floors. Above Lake Süssmilch in the Trapyard Creek valley a small lake was apparently formed behind a now much-dissected moraine bar and it was upon the floor of this that the banded clays here discussed were laid down. The absence of a distinct clay horizon in many of the test holes sunk by the S.M.H.E.A. in the Trapyard Creek valley indicates that the lake was quite restricted in extent.

THE CLAYS.

The clays are best seen in sections where the meandering Trapyard Creek has cut down through the sediments in the floor of the valley. They are apparently not extensive and only two important exposures, about 100 yards apart, have thus far been discovered. Typically the clays are associated with decomposed granite and gritty granite-rubble derived from the country rocks by mechanical breakdown. Such granite detritus occurs both above and below the clay band in the exposures examined. Occasionally small erratic blocks may be encountered in the creek banks. As a rule the clays are confined to a single horizon although locally it may be divided by discontinuous, narrow gritty bands. Where the floor upon which the clays were deposited was irregular, small-scale slump folds are common at the base of the clay band (see Plate xiii, D). Sharply-defined fault dislocations are sometimes associated with the slump folds.

Typically the clays have an overall greyish colour but they may appear buff-coloured due to iron-staining. Alternating bands of fine and coarser (silty) material are found in many cases, though not all of the Trapyard Creek clays show this feature clearly. As a rule, in the banded clay a coarser band is broader than its finer-grained partner. Normally the total thickness of the clay deposit does not exceed 1–1½ feet. The banding of the clays suggests a seasonal deposition such as is often found in varved glacial sediments. In view of the evidence of Pleistocene glaciation in the Kosciusko region it seems natural to associate these clays with a glacial origin.

A feature of the clays is their richness in micaceous minerals and chlorite. Both biotite (green or green-brown) and muscovite occur, and these were no doubt derived, without much chemical alteration, from the granite, in the first instance by the mechanical action of the ice. The high mica content is particularly striking in thin section where it can be seen that both fine and coarser bands contain micas. In fact, the mineralogy of the bands is fairly consistent, the variation chiefly producing the characteristic banding being that of grain size. Quartz and felspar occur as well as the micas and chlorite, and crystalline kaolinite has also been noted. A few "heavy" mineral grains, including tourmaline and zircon, have also been derived from the granite. The richness in micaceous minerals has led to the development of a distinctive fabric due to the preferred orientation of many flakes in the plane of deposition. In the silt bands the larger mica flakes and quartz and felspar grains settled before the finer silt so producing graded bedding (see Plate xiii, C). Graded bedding is often also present in the fine clay bands. Kuenen and Migliorini (1950) recently showed that many cases of graded bedding are due to the action of turbidity currents. Since then Kuenen (1951) has applied turbidity currents to explain the origin of glacial varves. The graded bands in the Trapyard Creek varves, however, with their depositional fabric due to micas laid parallel to the surface of deposition, do not show many signs of the action of turbidity currents. These currents would surely produce a more haphazard arrangement of the mineral grains in such sediments.

Compared with the parent granitic material there seems to be an enhanced content of mica minerals relative to quartz and felspar in these sediments. Perhaps there has been some concentration of the flaky minerals by virtue of their being more easily transported than the quartz and felspar grains of equivalent size. The exposed clay sections are all rather near to what is regarded as the remains of the old moraine dam and may be relatively remote from the point where the sediment-bearing meltwater entered the lake. Thus there may have been opportunity for some differentiation (i.e. concentration of micas relative to quartz and felspar) in the detrital material as it was transported in suspension across the small body of water. All evidence available points to a rather local origin for the material in the clays, even though there may have been some sorting before deposition; deposition so near the source would effectively prevent much chemical breakdown of the mica minerals.

The total amount of clay and silt deposited in this lake was not great. Important factors in determining this were the restricted source area and the apparently short life of the lake. Even if only the major alternating fine and coarser bands are related to seasonal variations it is clear that not much sediment was added to the lake in most years. A total of 112 pairs of bands has been counted in the best-exposed creek-section, but as many of the pairs are very narrow (the maximum thickness of the silt bands is about 6 mm.; most bands are much thinner than this, often being less than 1 mm.) they may be related to fluctuations in the environment within a single season. A period of 112 years should be regarded as no more than the maximum possible duration of the conditions under which the clays were deposited. As many of the narrow bands may be sub-seasonal the actual number of years is probably less than 112.

The increased amount of meltwater produced as a result of the gradual amelioration of the glacial conditions led to the extinction of the lake by breaching the moraine dam, thus causing the lake to be drained. Locally-derived granite sand and gravel washed down on top of the clays helped to preserve them, but the erosive effect of Trapyard Creek in cutting back to a base level has now again exposed these banded sediments.

Age of the Banded Clays.

These varved clays of the Kosciusko area obviously post-date the glaciers which carved such valleys as that of Trapyard Creek. They are most reasonably associated with the retreat of the valley glaciers and thus may ante-date the local, late cirque-cutting glaciation. By correlation with Tasmania (see David, 1950, p. 629) the clays might belong to the period following the Yolande glacial stage. (Three Pleistocene glacial stages, the Malannan (oldest), Yolande, and Margaret (youngest) stages, each separated by interglacial periods, have been recognized in Tasmania—see A. N. Lewis, 1945.) The only other recorded occurrence of Pleistocene glacial clays is in western Tasmania. The Tasmanian varves belong to the period of waning of the ice sheet related to the Malannan or first-stage glaciation. Thus the Trapyard Creek varved clays are probably the most recent so far recorded in the Commonwealth of Australia.

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EXPLANATION OF PLATE XIII.

A.—Part of the upstream exposure of banded clay in Trapyard Creek. 10 cm. intervals are marked on the stick.

B.—The downstream clay exposure showing the irregular base of the clay horizon at this locality. Sand and grit derived from granite and occasional rock fragments constitute the section above and below the clay. A discontinuous sandy band occurs in the clay horizon. Banding is not as regular here as in the upstream exposure.

C.—Banded clay from the upstream locality (see A) showing alternations of fine and coarser bands. Note the graded bedding.

D.—A fragment from the base of the clay horizon at the downstream locality (see B) showing folds (outlined) due to slumping of the basal bands after deposition on an irregular surface. The material upon which the clays and silts were deposited has been caught up into the arches of the slump folds. The troughs of the folds are infilled with coarse quartz and felspar sand and mica flakes mixed with clay. Coarse silt, followed by finer silt and clay, deposited on a more level surface (marked by dashes) above the slumped horizon creates a local intraformational unconformity.

AUSTRALIAN RUST STUDIES. XIII.

SPECIALIZATION OF UROMYCES PHASEOLI (PERS.) WINT. IN AUSTRALIA.

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(Plate xiv.)

[Read 28th October, 1953.]

Synopsis.

Use has been made of a set of differentials from U.S.A. over a period of 12 years to determine physiologic races of *Uromyces phaseoli* (Pers.) Wint. in Australia. For many years races 2 and 17 as described by Harter and Zaumeyer were the only races found, but in recent years another race styled race 17A has become most important. It attacks the widely grown dwarf varieties which were resistant to the former races, and has almost completely superseded these latter.

Numerous varieties from many sources have been classified on the basis of their resistance to the 3 races. Most show susceptibility to all 3 races. Amongst those showing full resistance, the Western Australian variety "Westralia" is outstanding, and has been used as a parent in crosses designed mainly to give resistant dwarf types.

Several morphological aberrations are described.

INTRODUCTION.

Bean rust, caused by *Uromyces phaseoli* (Pers.) Wint., was first recorded in New South Wales in 1894 (Noble, Hynes, McCleery and Birmingham). Until recent years its damage was done to runner types like "Epicure", which were often ruined late in the season. Now dwarf varieties are heavily attacked as well, and this attack may come early in the season.

Control of the disease by spraying or dusting is probably uneconomic on a commercial scale: the use of resistant varieties offers the best method of control. In such breeding work it is essential that the life history, and especially details of the specialization of the pathogen, should be worked out if a sound programme is to be followed. Harter and Zaumeyer (1941) described 20 physiologic races in U.S.A., and Fisher (1952) has added 10 more races, using 2 additional varieties as differentials.

LIFE HISTORY.

To date the aecidial stage has not been recorded in Australia, although it has been sought. Efforts have been made to germinate teleutospores, but without success. These are formed freely, replacing uredospores, late in the season, and in nature may have germinated and produced the small aecidia which escaped detection on the early growth of the bean plants. Along the coastal area from Queensland to Victoria beans are grown all the year round, and it is probable that the uredospore stage persists all the time in one region or other. During the short time that these studies have been in progress, there has been no month of the year in which uredospore material has not been submitted for determination. Air-borne uredospores are probably responsible for initiating the epiphytotics that develop in commercial areas when weather conditions become favourable.

PHYSIOLOGIC SPECIALIZATION.

In 1925 a series of determinations of rust reactions was made on the group of bean varieties brought from Cornell University and then in use for sorting out physiologic races of *Colletotrichum lindemuthianum*. The rust was collected on "Epicure" runner beans growing in a suburb of Sydney. At that time only runner beans showed rust attack.

The results obtained can now be compared with those given on the same set of varieties when inoculated with a race of the rust known to be r.17. In all cases there is agreement in respect of the resistance or susceptibility shown. It appears probable, therefore, that r.17 was present as far back as 1925.

Following upon the publication of the extensive studies on specialization of the rust in U.S.A. by Harter and Zaumeyer (1941), seed of the differentials they used was kindly supplied in 1941 by Dr. Zaumeyer, and at the commencement of 1942 a beginning was made with studies of Australian material.

Materials and Methods.

In general the procedure set out by Harter and Zaumeyer (1941) was followed. Marked differences were found in some cases between the reactions shown in the plant house in the summer as compared with the winter, although Wei (1937) reports that temperature variations between 16° and 28° C. did not change the type of reaction. A change from "4" to "7" reaction has not been uncommon here.

The notation used by Harter and Zaumeyer (1941) was adopted. In this, Grade 0 denotes immunity, and Grade 10 complete susceptibility, with the intervening grades linking these two extremes. Sometimes, and particularly in the work with commercial bean varieties, difficulty was experienced in determining with accuracy many of these intervening grades which vary with temperature fluctuations.

Collections of rusted material in the uredospore stage were dealt with in the plant house without delay: storage in the refrigerator seldom exceeded two weeks. Dundas (1949) reported that new races were produced by mutation in cold storage. Stock cultures from race determinations were stored on leaves dried out at room temperatures before going into the refrigerator. At a temperature of approximately 3° C. the spores remained viable for periods of 6 months. It was noted in some cases that spores after storage showed no germinations in hanging drop cultures, but nevertheless produced satisfactory infections when used to inoculate leaves of susceptible varieties.

Seedlings in 4-inch pots were used for inoculation at the stage when the primary leaves were fully expanded. After atomising with water, the spores were lightly rubbed over the surfaces, and the pots incubated for a period of 24 hours before being placed on the plant house benches. Two to three weeks were necessary for the reactions to develop.

Purity of Differential Varieties.

From the outset, the need for maintaining genetic purity of the differential varieties became apparent. Sowings of the original seed sent from U.S.A. led to the production of seedlings which showed marked differences between the pigmentation of the hypocotyl and cotyledons, as well as differences in the green colour of the first foliage leaves. This was especially noted in two of the differentials.

In the variety "White-seeded Kentucky Wonder Hybrid, No. 780", colour differences were noted and led to comparative work being done on single plant progenies. From sowings of typical seed of the variety, four typical single plants were taken, and from each family several single plants were grown on for progeny tests.

One family gave resistance ("1" or "2" reactions) throughout when tested with races 2 and 17. Homozygosity for green pigmentation was shown.

Two families showed the same double resistance throughout. In one of them, 2 of the 8 progenies were homozygous for the green and one homozygous for the purple pigmentation, while the remaining 5 progenies were heterozygous. In the second family, 5 of 11 progenies were homozygous for green and 2 for purple pigmentation, whilst the remaining 4 progenies were heterozygous.

The fourth family was susceptible ("8" or "9" reactions) to race 2 and resistant (reactions "1" or "2") to race 17 throughout. Two of the 7 progenies were homozygous for green and 2 for purple pigmentation, whilst the remaining 3 progenies were heterozygous.

In a second variety, "Bountiful No. 181", even stronger evidence of wide variability was found.

Again, sowings of typical U.S.A. seeds of the variety were made, and from this 7 typical single plants were taken and grown on. Progenies from each were tested as seedlings with the following results:

- 2 of them gave 7 progenies each, all showing susceptibility ("8" reaction) to each of the races 2 and 17.
- 2 of them gave 7 progenies each, all showing resistance ("1" or "2" reactions) to races 2 and 17.
- 3 were heterozygous:
  - 1 gave 5 progenies, 2 giving r.2 = "9" and r.17 = "1" reactions, 3 giving r.2 = "3" and r.17 = "9" reactions.
  - 1 gave 7 progenies, 2 giving r.2 = "9" and r.17 = "8" reactions, 2 giving r.2 = "8" and r.17 = "3" reactions, 3 giving r.2 = "2" and r.17 = "2" reactions.
  - 1 gave 6 progenies, 4 giving r.2 = "8" and r.17 = "8" reactions, 1 giving r.2 = "8" and r.17 = "1" reactions, 1 giving r.2 = "1" and r.17 = "1" reactions.

Pigmentation, as well as rust reaction, was recorded throughout. Only one of the 7 families was homozygous for the green pigmentation: it was one of the 2 which were resistant throughout to races 2 and 17. The remaining 6 were heterozygous for the colour production. There was no correlation between the rust reactions and pigmentation.

In this same variety, still further proof of variability was found after race 17A was recorded.

An isolate giving the reactions of r.2 produced resistant ("2") reactions on one of the plants in a pot. It gave the same reaction to r.17. This and a typical susceptible plant in the pot were grown to maturity. They conformed to the morphological characteristics of the variety. The progeny were tested with all 3 races. Those of the resistant plant were resistant to r.2 and r.17 but susceptible to r.17A, whilst those of the susceptible parent showed susceptibility to all 3 races. The tests were carried on another generation in each of the families, and similar results obtained.

At the same time three other random single plants were taken and the progeny tested in the same way. Two of them gave the resistant reactions to r.2 and r.17 and susceptible reactions to r.17A, whilst the other plant gave susceptibility to all 3 races.

In these cases there was no evidence of morphological heterozygosity, and the origin of the variants is unknown.

No information was available as to where the seed had been grown in U.S.A., and nothing is therefore known about the likelihood of natural crossing taking place. But it is clear that this phenomenon must always be taken into account in work of this sort, and the strictest control of the parentage of varieties maintained.

RESULTS OF RACE DETERMINATIONS.

To date 3 races have been determined, two of them conforming to races 2 and 17 of Harter and Zaumeyer. The third differs markedly from r.17 in its capacity to attack dwarf "Wonder" varieties like "Canadian Wonder", "Wellington Wonder", "Tweed Wonder", "Hawkesbury Wonder", "Clarendon Wonder", "Richmond Wonder", and "Brown Beauty", and is designated r.17A. This follows the procedure used in the cereal rusts.

Typical reactions are set out in Table 1.

The results of the survey are set out in Tables 2 and 3.

It is seen that during the first part of the period—up till 1948—r.17 was present in 70% of the collections, r.2 accounting for the remaining 30%.

Of the 14 isolates of r.2, 10 came from Western Australia. In 8 of them, r.17 was also present. Similar mixing of races has occurred in N.S.W. collections. The other 4 were found in the Sydney metropolitan area on dwarf varieties producing tiny "3" reactions (Plate xiv).

TABLE 1.

Typical Reactions of Three Physiologic Races of Bean Rust on Varieties of Phaseolus vulgaris.*

Race No.	Differential Varieties.							
	U.S. No. 3.	No. 181.	No. 643.	No. 650.	No. 765.	No. 780.	No. 814.	"Wonder" Variety.
2	8	7	8	9	2	1	1	2
17	8	7	1	9	3	1	1	2
17A	8	7	1	9	3	1	1	9

* The first seven differentials are those used by Harter and Zaumeyer (1941). The additional one is essential for Australian determinations.

In 1948 a serious outbreak of rust in dwarf varieties like "Brown Beauty" and "Hawkesbury Wonder" was observed by the late Mr. R. D. Wilson of the N.S.W. Department of Agriculture: previously only tiny "3" grade pustules had been noted on these beans. The occurrence of the two races together on "Hawkesbury Wonder" beans growing in the Sydney metropolitan area is shown in Plate xiv.

TABLE 2.

Summary of the Number of Isolations of Physiologic Races of Uromyces phaseoli *Grouped according to Time of Collection*

Race No.	Year of Collection.												Totals.
	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	
2	—	1	11	1	1	—	3	3	—	—	—	—	20
17	4	2	13	8	3	3	11	7	4	3	1	—	59
17A	—	—	—	—	—	—	1	9	15	19	13	2	59
	4	3	24	9	4	3	15	19	19	22	14	2	138

The rust on the dwarf beans proved to be a "new" physiologic race. Of the isolates examined since its appearance, r.17A has been present in 64%, r.17 in 29%, and r.2

TABLE 3.

Frequency of Occurrence of Races of Uromyces phaseoli *Grouped according to Source of the Collections Studied.*

Race No.	Source of Material Examined.				Totals.
	A.C.T.	N.S.W.	Q.	W.A.	
2	—	9	1	10	20
17	—	29	4	26	59
17A	1	31	6	21	59
	1	69	11	57	138

in 7% of the cases. It has almost completely superseded the other two races that were formerly present. Whilst able still to attack the runner types, the rust has extended its host range to the dwarf varieties which are so widely grown, hence its rapid spread.

Following upon its first determination in the coastal bean-growing areas of N.S.W. in April 1948, it appeared in collections from N.S.W. in 1949, and in late April 1949 was present, mixed with r.2, on canning beans sent from Warwick, Queensland. In February, March, and the beginning of April, collections from Queensland had yielded only r.17, and all later submissions have shown the presence of only r.17A.

The Western Australian position is also of interest. From this State Mr. W. P. Cass Smith has forwarded many collections for examination over the years. In 1944, 1945 and 1946 only races 2 and 17 were found. No further material came to hand until 1948 when only r.17 was determined. The next submission was in 1950, and this collection, as well as all the others received in 1951, show the presence of only r.17A. As a check, Mr. Cass Smith arranged for sowings to be made of dwarf varieties like "Brown Beauty" which are not usually grown in Western Australia. These became heavily rusted. Samples of this material were found to give the usual reactions for r.17A.

Changes in the physiologic races present in a particular area are well known and are a continuing problem for the plant breeder.

Specialization studies had been in progress covering the eastern and western parts of Australia over a sufficiently long period prior to the finding of r.17A to show that it appeared suddenly. The extensive cultivation of the dwarf varieties and their continued resistance until 1948 provide further evidence of this fact. Now they build up r.17A whilst screening out the other two.

It seems unlikely that uredospores of the "new" race were transported to Australia in air currents. No near source of such material is known.

There are many known cases in which hybridization in the aecidial stage has been responsible for the production of new races. It is for this reason that special efforts have been made to induce teleutospore germination of the bean rust. When this is accomplished it will be possible to determine the homozygosity or otherwise of the three races referred to herein, and to make crosses between pairs of them. It may then be found that a cross between r.2 and r.17 yields r.17A, or that it is a segregate from one of them.

Apart from hybridization of the fungi, there is evidence in the cereal rusts of mutation giving rise to new races. Some of the best examples have been found in work on the cereal rusts, Australian studies having given several instances (Waterhouse, 1952). It is possible that r.17A arose in this manner.

MORPHOLOGICAL ABERRATIONS.

In one plant of "Hawkesbury Wonder" and in two of "Epicure" beans, the production of three cotyledons and three primary leaves was noted (Plate xiv). Later growth was normal in each case, and the progeny were also normal.

In the last-named variety one completely albinotic plant was found (Plate xiv). After production of fully expanded primary leaves, growth slowed down, and the plant soon died.

A further unusual happening was the production of a side branch at the axil of the cotyledons in "Kentucky Wonder Hybrid 780" (Plate xiv). Inoculations with known races of rust led to the production of the same reactions on it as on the leaves of the main stem and no differences were found in the flowers and pods it produced.

DETERMINATIONS OF VARIETAL RESISTANCE.

Varieties of beans from many sources were used in tests to determine their reactions to the three races of rust in the plant house. Wherever possible these results have been checked with field behaviour in the Sydney district.

Nomenclature has given considerable trouble. Varieties have been accessioned under the name given by the sender. In many instances the varietal name from different sources has been the same and no differences between them have been found.

But in other cases clear differences have been found, not only in regard to morphology, but also in the rust reactions given: the particular one which has been correct has often been difficult to determine. There have been many evidences of the existence of different strains of the same variety. In yet other instances there has been obvious admixture of different seeds in the one packet. Every effort has been made to check on the varietal characteristics, but there may well be cases in which the true variety was not actually represented.

The varieties have been classified on the basis of the reactions given into the following groups:

Group 1.—Susceptible to races 2, 17 and 17A.

B1225, Black Wonder, Blue Lake Hybrid 65, Blue Lake Stringless, Boston Marrow, Bountiful (Ferry Morse), Bountiful, Burbank, Burpee's Stringless Green Pod, Cecic's Epicure, Coast Pink, Corvette, Cromer, Doppelite, Drought Resistant, Dwarf Haricot (Comptesse de Chambourd), Early Pink (2 strains), Early White, Epicure (a strain), Feijao rayado, Frijol guarzo rayado, Frigoli Nigros, Fullgreen No. 1, Fullgreen, Full Measure, Great Northern (3 strains), Granda (2 strains), H4981-H1, Habilla, Harter's 181 Bountiful, Harter's 650 Pinto, Hidatsa Red, Hungarian Medal Pea, Hungarian White Hay Pea, Hungarian White Pea, Idaho Brown, Ideal Market, Katenoshi, Kentucky Wonder, Klein Weisse, Landreth, Longfellow, Masterpiece, Michelite (2 strains), Michigan, Native Bean, Navy Ottawa, Norida (2 strains), Northern Star, Norwegian, Otenashi, Pearl Sugar, Pilot (4 strains), Pink, Pinto, Poroto C.P.I. 11439, Poroto criollo, Poroto cuarenton, Poroto enana, Poroto topero, Princess of Artois, Prolific, Red Mexican (2 strains), Red Valentine (2 strains), Roger's Sensation Wonder, Roumanian White, Roumanian White Pea, Russia (3 strains), Scotia, Scott's Bluff Pinto (2 strains), Shravni Ghendi, Sixty Day, St. Fiacre, Standard Pink (2 strains), Stringless Green Pod French Bean, Stringless Green Pod (Rumsey's), Striped Bountiful, Strider, Supergreen (2 strains), Sutter Pink (2 strains), Tennessee Green Pod, Tiger, Unrivalled Wax, U.S. No. 3, Verespoor, White Imperial, Wiggins's Prolific, Yellow Eye Improved.

Group 2.—Resistant to race 2, susceptible to races 17 and 17A.

Ashley Wax, Little Navy, Michigan Robust, Morse's No. 191.

Group 3.—Resistant to races 2 and 17, susceptible to race 17A.

Ace, Alabama No. 1, Asgrow's Plentiful, B2675, Black Valentine (3 strains), Blue Lake Stringless, Brittlewax, Brown Beauty, Brown Beauty (Pugsley's Resistant), Burbank, Canadian Wonder, Clarendon Wonder (2 strains), Clarendon Wonder × Wellington Wonder, Dwarf Pencil Pod Wax, Dwarf Stringless Kidney Wax, Early Pale Dun, Early White, Ferry's Plentiful, Florida Belle (Asgrow's), Frijol Pico de Oro, Fullgreen No. 2, H49, Hawkesbury Wonder (2 strains), Idaho, Idaho Refugee, Keystonian, Low's Champion (4 strains), Logan, Long Green Stringless, Long White Marrow, Medal (4 strains), Morse's No. 65, Negro Long Pod, New York State Refugee 5, Pacer, Pencil Pod Black Wax, Pencil Pod Wax (Ferry Morse), Plentiful (Asgrow's), Poroto C.P.I. 11440, Poroto C.P.I. 11443, Pure Gold Wax Bean, Red Kidney (3 strains), Red Kidney (Geneva), Richmond Wonder, Roger's Refugee 1071 (3 strains), Roger's Sensation Refugee, Roger's Stringless Greenpod Refugee, Round Pod Kidney Wax, Staley's Surprise (2 strains), Startler Wax, Stringless Black Valentine, Stringless Green Pod (Asgrow's), Stringless Green Pod Refugee, Stringless Kidney Wax, Stringless Refugee, Tendergreen (2 strains), The Wonder (3 strains), Top Crop, Top Notch Golden Wax, Tweed Wonder (3 strains), U.S. Refugee No. 5, Wardwell Kidney Wax, Wellington Wonder (2 strains), Well's Red Kidney (2 strains), Yellow Eye, 847.

Group 4.—Susceptible to races 2 and 17, resistant to race 17A.

Corbett's Refugee, Epicure (a strain), Giant Stringless Greenpod, Rice (2 strains), Robust (2 strains), Yellow Eye Improved.

Group 5.—Susceptible to race 2, resistant to races 17 and 17A.

C.P.I. 11272, Californian Small White, Harter's 643, Meyer, Plentiful.

Group 6.—Resistant to races 2, 17 and 17A.

Cherokee Wax, Cooper Wax, Feijao, Florida Belle (3 strains), Harter's 765, Harter's 780, Harter's 814, Kentucky Wonder Brown Seeded, Lazy Wife, Little Navy, Native Bean (2 strains), Pacer, Purple Pod, Rainy River (3 strains), Resistant W.A. Kentucky Wonder, Small White, Stringless (Asgrow's), Weston, Westralia.

It is clear that the majority of the varieties tested show susceptibility to all three races. Included are all types, runner as well as dwarf types.

There are quite a number of the tested varieties which show resistance to races 2 and 17, but are susceptible to race 17A. Notable amongst these are the dwarf series of "Wonder" beans.

Most important is the group showing resistance to all three races. Outstanding is the Western Australian runner variety known as "Westralia" which has become so important as a commercial variety, not only because of its resistance, but also because of its high yield and high quality beans. It has been used most frequently as the parent in crosses with dwarf types like "Hawkesbury Wonder", from which it is expected to derive dwarf varieties resistant to rust. In a forthcoming paper it will be recorded that extensive tests have shown that "Westralia" also has resistance to all available strains of *Colletotrichum lindemuthianum.* (Sacc. and Magn.) Briosi and Cav. Thus from the crossbred material, types with the combined resistance to rust and anthracnose should become available.

ACKNOWLEDGEMENTS.

Collections of seed for testing have been received from Mr. N. S. Shirlow and other members of the N.S.W. Department of Agriculture, from Mr. P. I. Pryke of the Victorian Department of Agriculture, from Mr. N. Hartley of the C.S.I.R.O., and from Messrs. A. Yates and Co. Pty. Ltd. Samples of rust for determinations have been forwarded by workers in many areas: especial mention should be made of Mr. W. P. Cass Smith of W.A. in this regard. Loyal and efficient service has always been given by the technical staff, and particularly by Miss E. M. Dumbrell. Again my daughter (E.R.W.) has given invaluable help throughout. To all, grateful thanks are tendered. Financial assistance is gratefully acknowledged from the Commonwealth Research Grant, the Science and Industry Endowment Fund, the Commonwealth Bank, and the Rural Bank of N.S.W.

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EXPLANATION OF PLATE XIV.

A, Under-surface of leaf of seedling "Tweed Wonder" bean inoculated on the left with race 17 which gives a "3" reaction and on the right with race 17A giving a "9" reaction. Nat. size.

B, Under-surface of leaf of mature plant of "Hawkesbury Wonder" bean showing natural field infection by race 17 (tiny "2" reactions) and by race 17A (large "8" reactions). Nat. size.

C, Young inoculated bean pods of "Tweed Wonder" showing heavy rust attack by race 17A and minute pustules produced by race 17. Nat. size.

D, Seedling "Epicure" bean showing 3 cotyledons and 3 primary leaves. × ⅔.

E, Seedling "Epicure" beans showing albinotic seedling with normal green types. Nat. size.

F, "Kentucky Wonder Hybrid 780" seedling showing unusual production of branch from cotyledon node. × ⅓.

A NEW SUB-FAMILY AND NEW GENERA AND SPECIES OF AUSTRALIAN HEMIPTERA-HETEROPTERA.

By N. C. E. Miller, F.R.E.S., F.Z.S., F.E.S.S.A., Commonwealth Institute of Entomology, London.

(*Communicated by T. G. Campbell.*)

(Eight Text-figures.)

[Read 28th October, 1953.]

Synopsis.

A subfamily, three genera and eight species of Australian micropterous Hemiptera belonging to the families Coreidae and Reduviidae are described as new.

In the family Coreidae the subfamily Agriopocorinae has been defined, it being related to, although distinct from, the Coreinae. The genus *Agriopocoris* has been erected to accommodate *A. froggatti*, *A. chadwicki*, *A. porcellus* and *A. macilentus*. A key is given to the species.

In the family Reduviidae, subfamily Harpactorinae, the monotypic genus *Austrocoranus* has been erected to accommodate *A. mundus*, and the genus *Dicranurocoris* to include three species, *D. victoriae*, *D. canberrae* and *D. tasmaniae*.

In collections received from the Division of Entomology, Commonwealth Scientific and Industrial Research Organisation, Canberra, from the South Australian Museum, Adelaide, and also from the Department of Agriculture, New South Wales, through the agency of Mr. C. E. Chadwick, were several micropterous Heteroptera belonging to the families Coreidae and Reduviidae.

Material included four new species of Coreidae and four of Reduviidae, all of which are described in this paper.

The most remarkable of these are certain species of Aradid-like Coreids found among leaf-debris on the floor of forests and under bark. Unfortunately, some of these are represented by females only, and in these cases it has been considered desirable not to name them at present; later, perhaps, more material of both sexes will be collected and then it will be possible to continue the study further. Two species of these Coreids, however, are represented by a male and a female each, another species by two males and a fourth by one male. From a detailed study of these four species, it is clear that they cannot be placed in any of the subfamilies at present recognized, and therefore a new subfamily is described below for their reception.

I am greatly indebted to Dr. W. E. China of the British Museum (Natural History), London, for his kind assistance in the genitalia preparations.

Family COREIDAE.

*Agriopocorinae, subfam. nov.

Micropterous. Antennal tubercles together about as wide as head. Orifices of metapleural glands distinct. Posterior acetabula not excised. Bucculae long, extending beyond insertion of antennae. Pro- and mesosternum sulcate. Spiracles adjacent to margin of abdomen; spiracles on segments 2 and 3 marginal; visible from above.

This new subfamily is related to the Coreinae on account of the length and position of the bucculae and distinct gland orifices. It cannot be placed therein, however, since the tibiae are not sulcate and the posterior acetabula are not excised. The shape and sculpture of the abdomen are also characters which preclude its being placed in the Coreinae or in any other subfamily. The micropterous condition of the wings unfortunately allows no comparison to be made with the venation of the Coreinae, a character which is important in diagnosis.

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* *αγριωπός* = wild-looking; *κοριs* = bug.

AGRIOPOCORIS, gen. nov.

Size small. Tuberculate. Antennae thick; basal segment shorter than head. Head about as wide as long. Rostrum extending to median coxae. Ocelli present or absent. Abdomen dorsally with rounded arcuate carinae and circular depressions. Legs short, thick; basal segment of tarsi sub-equal in length to segments 2 and 3 together. Setae short, thick, truncate apically.

Key to Agriopocoris *Species.*

1. Lateral margin of 7th abdominal segment produced; harpagones with apical portion angulate and apex long and slender 3
2. Lateral margin of 7th abdominal segment not produced; harpagones with apical portion almost straight and apex short, conical .... *porcellus* (Fig. 3)
   Harpagones with apical portion regularly curved and apex sub-acute .. *macilentus* (Fig. 4)
3. Lateral margin of 7th abdominal segment rectangularly produced .... *froggatti* (Fig. 1)
   Lateral margin of 7th abdominal segment tuberculately produced .... *chadwicki* (Fig. 2)

Type species, *Agriopocoris froggatti*.

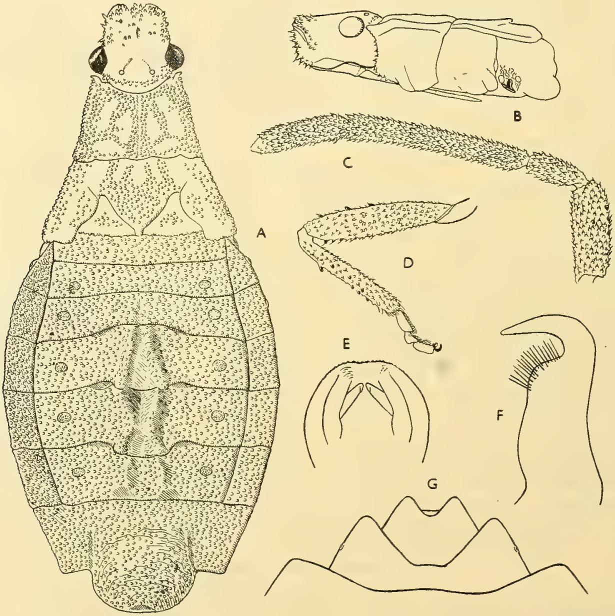


Fig. 1.—*Agriopocoris froggatti*, gen. et sp. n. A, Whole insect, dorsal view (antennae and legs omitted); B, Head and thorax, lateral view; C, Antenna; D, Anterior leg; E, Pygophore, dorsal view; F, Harpago; G, Apex of abdomen, ♀, dorsal view.

AGRIOPOCORIS FROGGATTI, sp. nov. (Fig. 1)

Colour.—Pale ferruginous. Bucculae, rostrum, apical margin of acetabula pale stramineous; acetabula also with transverse blackish stripe adjacent to pale area. Vertex with some piceous tubercles. Apex of carinae on abdominal segments 4 and 5 blackish.

Structure.—Segment 2 of antennae half as long as segment 1; segment 3 about three times as long as 2; segment 4 twice as long as 1. Tubercles on head mainly on lateral and basal areas. Vertex with a narrow, median, longitudinal sulcus and an oblique depression in front of each ocellus. Tylus anteriorly with moderately long tubercles. Ocellar interspace equal to width between an ocellus and an eye. Tubercles on nota conforming more or less to a pattern. Pro- and mesonotum with a median, longitudinal sulcus extending to base of produced portion of scutellum. Metanotum with projecting marginal tubercles posteriorly. Acetabula punctate. Rudimentary hemelytra concavely excised apically, extending just beyond posterior margin of metanotum. Segment 7 of abdomen rounded apically, longitudinally broadly sulcate sublaterally. Anterior and median femora with some moderately long setigerous tubercles among the low, rounded tubercles.

Total length: ♂, 10·50 mm. ♀, 12·50 mm.

1 ♂ (type), 1 ♀ (paratype), Australia; Sydney, 1895, W. W. Froggatt, in the Division of Entomology, C.S.I.R.O., Canberra, A.C.T.

The ♀ paratype is much darker in coloration than the type and in structure differs mainly in the shape of the terminal segments of the abdomen.

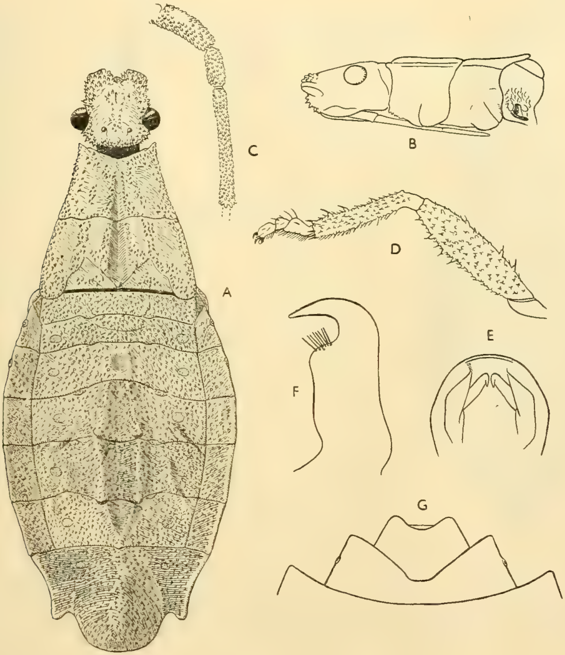


Fig. 2.—*Agriopocoris chadwicki*, sp. n. A, Whole insect, dorsal view (antennae and legs omitted); B, Head and thorax, lateral view; C, Antenna (apical segment missing); D, Anterior leg; E, Pygophore, dorsal view; F, Harpago; G, Apex of abdomen, ♀, dorsal view.

AGRIOPOCORIS CHADWICKI, sp. nov. (Fig. 2)

Colour.—Dull ferruginous. Tibiae, segment 7 of abdomen suffused with stramineous. Rostrum, bucculae, apical margin of acetabula stramineous; acetabula also with dark brown suffusion adjacent to stramineous area. Lobes of gland orifices whitish. Femora, apex of carinae on segments 4 and 5 of abdomen blackish.

Structure.—Resembles preceding species, but differs mainly in smaller size and narrower habitus, more strongly elevated carinae on segments 4 and 5 of abdomen, more strongly elevated external apical angles of connexival segments, tuberculately produced lateral margin of segment 7 of abdomen and in genitalia of both sexes.

Total length: ♂, 10·00 mm. ♀, 11·00 mm.

1 ♂ (type), 1 ♀ (paratype), Australia; Mt. Wanyambilli, N.S.W., 14.8.1948, C. E. Chadwick, in the Entomological Branch, Department of Agriculture, New South Wales.

The ♀ paratype is much darker in coloration.

AGRIOPOCORIS PORCELLUS, sp. nov. (Fig. 3)

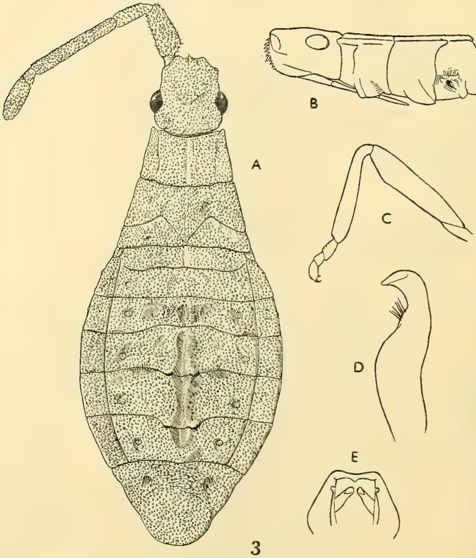
Colour.—Dull ferruginous. Abdomen ventrally testaceous. Tibiae with stramineous suffusion.

Structure.—Smaller than *A. chadwicki* and differs mainly in the lateral margin of the 7th abdominal segment being almost straight and in the genitalia. The rudimentary hemelytra extend to the middle of the metanotum. Differs from *A. chadwicki* and *A. froggatti* in regular external margin of connexivum, the external apical angles of the segments of which are not at all elevated, and in the femora not having long tubercles.

The ocelli are lacking in this species, a condition not uncommon in entirely apterous species.

Total length: ♂, 8·30 mm.

1 ♂ (type), Australia; Southport, Queensland, 16.10.1901, W. W. Froggatt, in the Entomological Branch, Department of Agriculture, New South Wales; 1 ♂ (paratype), Southport, Queensland, 16.10.1901, W. W. Froggatt, in the British Museum (Natural History), London.



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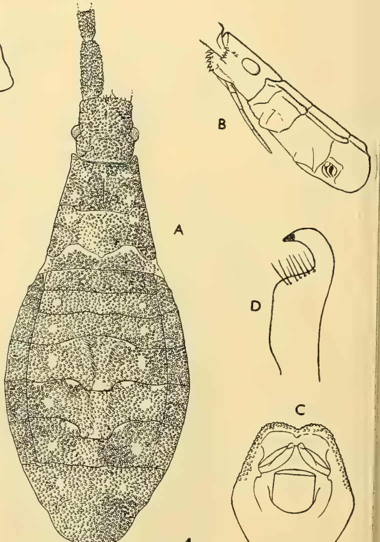

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Fig. 3.—*Agriopocoris porcellus*, sp. n. A, Whole insect, dorsal view (legs omitted); B, Head and thorax, lateral view; C, Anterior leg; D, Harpago; E, Pygophore, dorsal view.

Fig. 4.—*Agriopocoris macilentus*, sp. n. A, Whole insect, dorsal view (legs omitted); B, Head and thorax, lateral view; C, Pygophore, dorsal view; D, Harpago.

AGRIOPOCORIS MACILENTUS, sp. nov. (Fig. 4)

Colour.—Pale ferruginous. Bucculae dark stramineous. Segments 2 and 3 of abdomen apically mid-dorsally with a small elevated spot, femora and tibiae with suffused spots, pale stramineous. Apex of carinae on segments 4 and 5 of abdomen dorsally, blackish; segment 7 with pale yellow suffused areas.

Structure.—Segment 2 of antennae half as long as segment 1; remaining segments missing. Vertex with a median, sub-ovate depression anteriorly; epicranium with a shallow, oblique sulcus in front of ocelli and a short, transverse sulcus joining a short, longitudinal sulcus behind eyes. Tylus anteriorly with moderately long tubercles. Ocellar interspace a little less wide than distance from an ocellus to an eye. Pronotum with a median, longitudinal sulcus not reaching anterior margin. Rudimentary hemelytra broadly rounded apically, extended to middle of metanotum. Segment 7 of abdomen with lateral margins sinuate; segment broadly rounded apically. Anterior femora with four or five setigerous tubercles, more erect and longer than remaining tubercles.

Total length: ♂, 9·00 mm.

1 ♂ (type) New Mecklenburg (New Ireland), Bismarck Archipelago, 31.10.1887 (name of collector illegible), (under bark). Type in the South Australian Museum, Adelaide, South Australia.

Similar to *A. porcellus*, but differs in the more slender form, the sculpture of the dorsal surface of the abdomen (in this new species the carinae on segments 4 and 5 are less prominent), the shape and sculpture of the pygophore and the shape of the harpagones, which are regularly curved with the extreme apex sub-acute.

Family REDUVIIDAE.

Subfamily HARPACTORINAE.

AUSTROCORANUS, gen. nov.

Micropterous. Basal segment of antennae longer than head. Postocular longer than anteocular. Antennal tubercles remote from eyes. Anteocular and postocular tuberculate. Basal segment of rostrum shorter than segment 2. Anterior lobe of pronotum longer than posterior lobe. Scutellum produced apically. Segments 1 and 2 of abdomen dorso-laterally with an oblique carina; apical margins medially of segments 3–6 elevated. Anterior and median femora incrassate; all femora nodulose. Apical segment of tarsi longer than segments 1 and 2 together. ·Head, thorax and legs with sub-erect setae; head and body also with abundant adpressed setae.

Type species, *Austrocoranus mundus.*

AUSTROCORANUS MUNDUS, sp. nov. (Fig. 5)

Colour.—Black. Antennae brown: basal segment dark brown basally. Tibiae brown, darker basally and apically and with a sub-basal yellowish annulation. Segments 2–6 of connexivum with a sub-apical, marginal dark yellow spot. Setae greyish and piceous. Abdomen ventrally light brown with a median, longitudinal, narrow, dark brown stripe.

Structure.—Basal segment of antennae longer than segments 2 and 3 together. Transverse sulcus on vertex arcuate; median sulcus very short and narrow. Basal segment of rostrum extending to middle of eyes. Ocelli small, elevated, directed forwardly and laterally. Anterior lobe of pronotum rugose, except sulcate areas smooth; posterior lobe strongly rugose with an oblique carina sub-dorsally anteriorly and some tubercles. Scutellar spine rounded apically, oblique, concave on lower surface basally. Hemelytra extending to base of abdomen. Apical margin of segments 3–6 of abdomen dorsally thickened; segment 7 medially with a large, rounded, circular elevation.

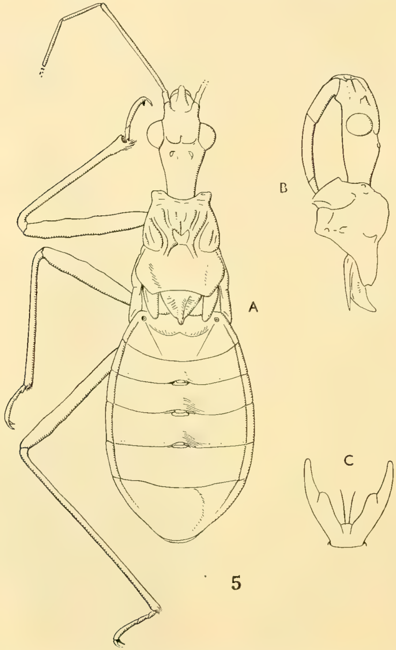
Total length: ♂, 12·50 mm. ♀, 11–13·00 mm.

Greatest pronotal width: ♂, 2·20 mm. ♀, 2·00–2·20 mm.

1 ♂ (type), Australia; Armadale, Western Australia, 12.5.1934, K. R. Norris; 1 ♀, Beverley, Western Australia, 9.5.1913, F. H. du Boulay; 2 ♀♀, Beverley, Western Australia, 1913, W. W. Froggatt, (paratypes) in the Division of Entomology, C.S.I.R.O.,

Canberra, Australian Capital Territory; 1 ♂ (paratype), Armadale, Western Australia, 12.5.1934, K. R. Norris, in the British Museum (Natural History), London.

This new genus appears to be closely allied to *Coranus* Curtis (1833, Ent. 10), from which it differs in the slender segments 2 and 3 of the antennae, in the head being longer than pronotum and having tubercles on anteocular and postocular, in the relatively shorter basal segment of rostrum and in the position of the antennal tubercles which are remote from and not close to the eyes.



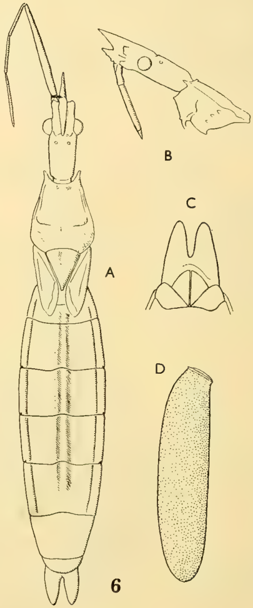


Fig. 5.—*Austrocoranus mundus*, gen. et sp. n. A, Whole insect, dorsal view; B, Head, pronotum and scutellum, lateral view; C, Claw of anterior tarsus.

Fig. 6.—*Dicranurocoris victoriae*, gen. et sp. n. A, Whole insect, dorsal view (legs omitted); B, Head and pronotum, lateral view; C, Apex of abdomen; D, Ovum.

*DICRANUROCORIS, gen. nov.

Elongate. Micropterous. Basal segment of antennae sub-equal in length to head. Tylus and vertex acutely produced. Antennal tubercles with a lateral tubercle. Head with low, rounded tubercles and with longer tubercles sub-basally. Ocelli small. Eyes moderately prominent. Rostrum straight; basal segment a little more than half as long as segment 2. Anterior margin of pronotum laterally produced; anterior lobe of pronotum longer than posterior lobe and with a low tubercle anteriorly on each side of mid-dorsum; posterior lobe with a low carina anteriorly on each side of mid-dorsum. Scutellum triangular, longer than wide, produced apically. Hemelytra extending to 2nd abdominal segment. Prosternum laterally anteriorly with a short projection. Anterior femora moderately incrassate and with a spine on lower surface near apex. Segment 8 of abdomen bilobate.

Type species, *Dicranurocoris victoriae*.

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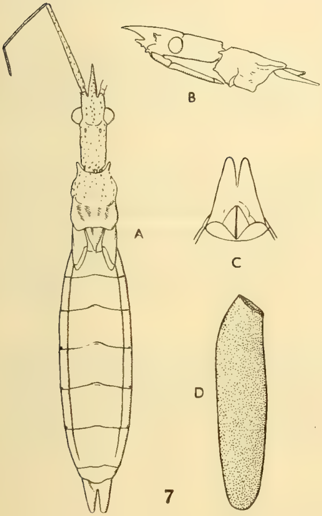
* *δίκρανος* = forked. *οὐρα* = tail. *κορίς* = bug.

DICRANUROCORIS VICTORIAE, sp. nov. (Fig. 6)

Colour.—Stramineous, except head, brown. Vertex with two sub-parallel, longitudinal piceous stripes. Basal segment of antennae suffused with brown; remaining segment yellowish. Apical segment of rostrum piceous. Segments 2–5 of connexivum apically laterally with a small brownish spot.

Structure.—Basal segment of antennae thick in basal half, narrower towards apex; shorter than remaining segments together. Ocellar interspace equal to width between an ocellus and an eye. Lateral projections on collar directed forwards, feebly curved apically. Disc of scutellum with a shallow, irregular depression; produced portion feebly elevated, rounded. Connexivum narrowly sulcate laterally.

Total length: ♀, 13·00 mm.



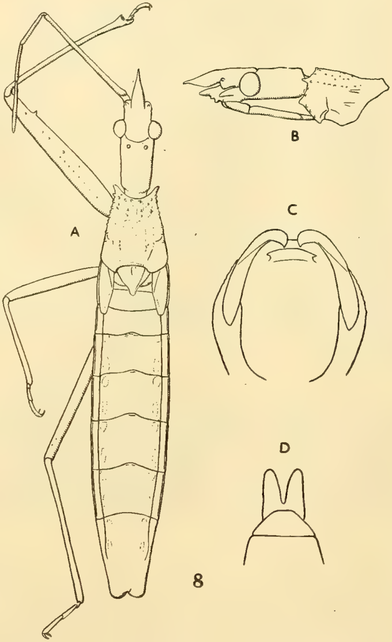


Fig. 7.—*Dicranurocoris canberrae*, sp. n. A, Whole insect, dorsal view (legs omitted); B, Head, pronotum, elytron and scutellum, lateral view; C, Apex of abdomen; D, Ovum.

Fig. 8.—*Dicranurocoris tasmaniae*, sp. n. A, Whole insect, dorsal view; B, Head and pronotum, lateral view; C, Pygophore, dorsal view; D, Apex of abdomen, ♂, dorsal view.

1 ♀ (type), 3 ♀♀ (paratypes), Australia; Toora, Victoria, 16.12.1937, R. V. Fyfe, in the Division of Entomology, C.S.I.R.O., Canberra, Australian Capital Territory; 1 ♀ (paratype), Toora, Victoria, 16.12.1937, R. V. Fyfe, in the British Museum (Natural History), London.

The nearest ally of this new genus is *Dicrotelus* Er. (1842, *Arch. Naturgesch.* 8 [1], p. 284), which it resembles in that the head has projections anteriorly and in the bilobate 8th segment of the abdomen. *Dicrotelus*, however, has strongly tuberculate legs and head, spinose anterior lobe and postero-lateral angles of posterior lobe of pronotum, tuberculate scutellum and connexivum.

Mature ova dissected from the abdomen of the type are cylindrical, feebly curved at opercular end, and smooth with minute reticulation. The colour dark yellow. For a small insect, the ova are relatively large, being approximately 2·50 mm. in length.

DICRANUROCORIS CANBERRAE, sp. nov. (Fig. 7)

Closely resembles the preceding species, but differs in smaller size and in coloration, being generally darker. In structure it differs in the more acute projection on the vertex, the more strongly tuberculate legs, basal segment of antennae and postocular, and the lenticular shape of the ocelli; projections on anterior lobe of pronotum distinctly tuberculate and posterior lobe with median and lateral depressions, disc of scutellum more deeply impressed; lobes of segment 8 of abdomen narrower.

Total length: ♀, 11·50 mm.

1 ♀ (type), Australia, Canberra, A.C.T., Dec. 1929, H. J. Willings, in the Division of Entomology, C.S.I.R.O., Canberra, A.C.T.

An ovum dissected from this specimen resembles that of *D. victoriae*, but is a little longer.

DICRANUROCORIS TASMANIAE, sp. nov. (Fig. 8)

Colour.—Testaceous. Head and basal segment of antennae in basal half suffused with brown. Pleura paler. Posterior femora piceous. Abdomen ventro-laterally with suffused piceous spots. Apical segment of rostrum piceous. Abdomen dorsally with brownish elevated spots on segments 3 and 4. Tubercles and spine on anterior and median femora brown. Pubescence pale greyish.

Structure.—Basal segment of antennae with low tubercles mainly on upper surface. Produced portion of vertex acute and curved downwards feebly; produced portion of tylus trilobate, the upper lobe moderately long and sub-acute. Anterior lobe of pronotum with scattered tubercles; posterior lobe with a low, rounded oblique carina sub-dorsally and with lateral area somewhat strongly depressed. Head with low rounded tubercles particularly on postocular. Prosternum laterally and propleural episternum with some tubercles.

Total length: ♂, 11·00 mm. ♀, 12·50 mm.

1 ♂ (type), 1 ♀ (paratype), Tasmania; New Norfolk, Lea (in tussocks), in the South Australian Museum, Adelaide, South Australia; 1 ♀ (paratype), New Norfolk, Tasmania, Lea (in tussocks), in the British Museum (Natural History), London.

Allied to both the preceding species, but perhaps more particularly to *D. canberrae* as regards structure and sculpture of head and legs.

A NEW GENUS OF THE PLECTASCALES.

By LILIAN FRASER, Department of Agriculture, New South Wales.

(Plate xv; twenty-nine Text-figures.)

[Read 28th October, 1953.]

Synopsis.

An Ascomycetous fungus of a reduced or primitive type, obtained in culture from mouldy stick licorice, is described. It is placed in the Plectascales as the type of a new genus, and the name *Xeromyces bisporus* is proposed for it.

It forms abundant cleistocarps in culture, which originate as lateral three-celled branches on the mycelial threads. Two-spored asci are produced directly from cells resulting from the division of the central cell of the branch, and the wall is formed by the growth of branches from the basal cell of the branch. Stages in the development of the fructification are described.

In 1946, Mr. W. J. Scott of the C.S.I.R.O. Food Preservation Laboratory, Homebush, obtained in culture a fungus from mouldy stick licorice. This fungus was unusual in that it grew with moderate luxuriance on partly dried out media, on media rich in carbohydrates and at comparatively low relative humidity, but was unable to grow on ordinary laboratory media at high humidity.

Preliminary examination showed it to be an ascomycete of a primitive or reduced type and of some interest phylogenetically as well as physiologically. A more detailed investigation was therefore undertaken.

An elucidation of the main outline of its life cycle revealed no relationship with already described ascomycetes sufficiently close to justify its inclusion in a defined genus. It is therefore described as the type of a new genus and placed tentatively in the Plectascales.

METHODS OF EXAMINATION.

1. The fungus grew fairly rapidly and produced ascocarps very abundantly on a malt extract medium,* and Petri dishes poured with 20 ml. of this medium were inoculated and incubated at 25°C. Fragments of No. 0 microscope cover glass flamed and placed on the agar surface allowed the growth of the fungus somewhat sparsely over them. This growth adhered fairly well to the glass and could thus be fixed and stained with the minimum of disturbance.

2. The fungus also grew well in drop culture of liquid medium** on glass slides over saturated solution of potassium bromide.

The fixative most generally used was Craf 1 (Sass, 1940). Stains used were aceto-carmine, Harris' haematoxylin and Heidenhain's iron alum haematoxylin. Feulgen's fixative and stain as modified by Jones (1947) were also used to confirm nuclear detail. Cotton blue in lacto-phenol was useful for gross morphology.

THE FUNGUS.

Mycelial Characters.

The mycelium in a carbohydrate-rich medium is rather coarse, septate, the cells multinucleate, the nuclei very minute and scattered. The young hyphae are densely granular, becoming vacuolate with age. Occasional inflated beaded densely protoplasmic cells are present. The colony in culture is radiating, at first white, closely adherent to the agar surface and not growing much above it, later becoming creamy because of the maturation of the ascocarps which are densely crowded on the surface of older colonies, giving them a finely granular appearance.

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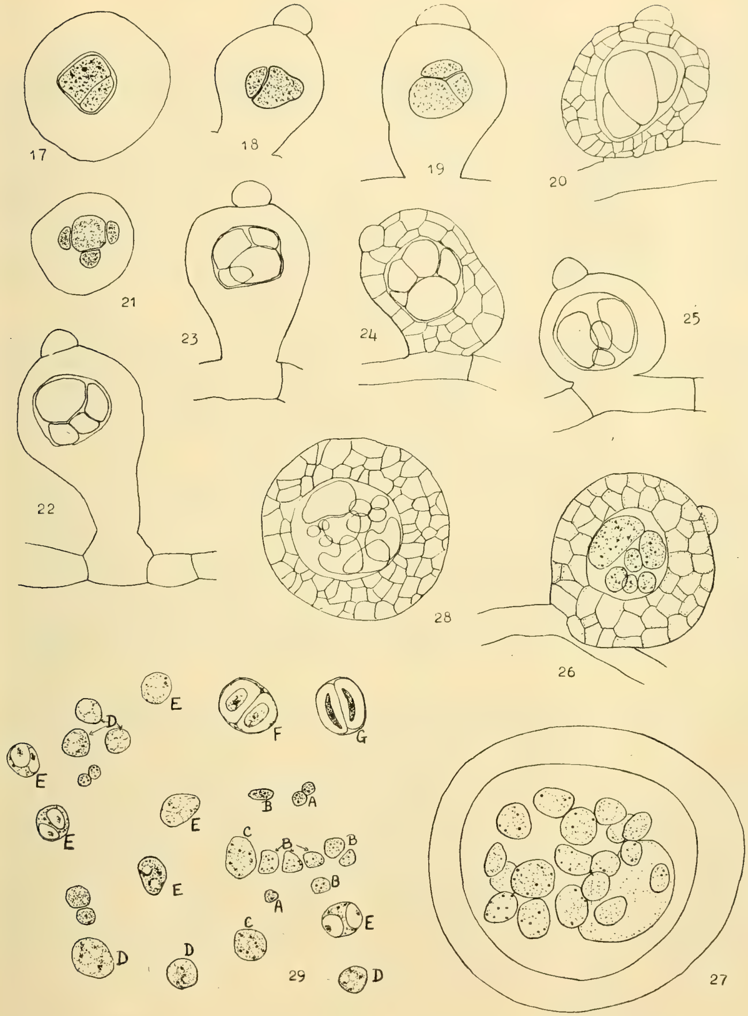
* Malt extract 50 gm.; Powdered agar 10 gm.; Water 50 ml..

** Dextrose 50 gm.; Malt extract 10 gm.; Water 50 ml.

Text-figures 1-16.

1, A-F, Aleuriospores showing variation in size and shape. × 900. 2, Hypha showing initial stage of development of ascocarp branch (A), and later stage (B), in which terminal and central cells have been cut off. × 1,080. 3, Young ascocarp branch prior to cell wall formation. × 900. 4, Young ascocarp branches, at the stage of the first division. × 1,080. 5, Young ascocarp branch showing initiation of first branch from basal cell. × 900. 6-7, A slightly later stage than that shown in fig. 5, three branch initials visible. × 1,080. 8-13, Stages in development of branches from the basal cell, to form a wall around the central cell (C), one branch pushing between it and the terminal cell (A). × 1,080. 14-15, Ascocarp branch, optical section showing wall structure, central cell (C) and terminal cell (A). × 1,320. 16, Vertical view of ascocarp branch showing wall structure and central cell. × 1,080.



Text-figures 17-29.

17-24, Stages in division of central cell: 17, Vertical view of ascocarp showing first division of central cell. × 1,080. 18, Lateral view of ascocarp showing first division of central cell. Shape of central cell suggests immanence of second division. × 900. 19, Second division of central cell. × 900. 20, Second division of central cell, subsidiaries cut off from opposite sides. × 1,080. 21, Vertical view showing 3 subsidiary cells cut off from different faces of central cell. × 900. 23-24, Division of central cell showing three to four subsidiaries of varying size. × 1,080. 25-28, Further division of central cell with production of subsidiaries and small ascus initials, rounded off and lying free within ascocarp wall. 25, 26, 28 × 1,080; 27 × 1,320. 29, A-G, Stages in development of asci and ascospores. × 1,080. A, Binucleate ascus initials; B, Later stage in growth of ascus, showing increased size and 4 to 6 nuclei; C, Developing asci with 8 nuclei; D, Developing ascus, showing non-staining circular areas associated with deeply staining granules (probably nuclei) which may be ascospore initials; E, Developing ascus, two ascospores in process of growth, other granular material, possibly disintegrating spore initials, crushed against wall; F, Ascus with young ascospores; G, Mature thick-walled fusiform ascospores still held together by ascus wall.

Accessory Spores.

Conidium-like spores which appear to be aleuriospores (Mason, 1933) are produced in culture at relative humidities below about 85%. They are borne terminally on lateral branches of the mycelium and are usually one-celled and more or less globose to pyriform, but occasionally two- or three-celled (Plate xv, fig. 1; Text-fig. 1, A–F). The spore wall is somewhat thicker than the wall of the mycelial cells and is highly refractive. The spores are not abstricted from the hyphae on which they develop and usually remain attached. However, spores which have become detached by the breaking of the hypha immediately below them are occasionally seen.

When a fragment of mycelium bearing aleuriospores is transferred to fresh medium the spores germinate by the production of a germ tube.

Development of the Ascocarp.

Ascocarps arise as short stout lateral branches on the young hyphae. The branch is at first a non-septate projection (Text-figs. 2A, 3). A terminal and a central cell are cut off from a basal section which remains part of the subtending mycelial cell (Text-figs. 4, 2B). The cells are densely protoplasmic, multinucleate and the nuclei are minute and scattered. Four rather stout branches then grow out from the basal cell just below the wall separating it from the central cell (Text-figs. 5, 6, 7). One or two of these branches usually develop more quickly than the others (Text-figs. 8, 9, 10, 11). They grow up and enclose the central cell, one pushing between it and the terminal cell (Text-figs. 8–13). They are at first continuous with the basal cell, but as they grow, cell walls appear (Text-figs. 11, 12, 13). Stout blunt branches are produced (Text-fig. 13) which finally form a complete pseudo-parenchymatous wall several cells thick around the central cell, which, at this stage, stains very deeply (Text-figs. 14–16). Throughout the subsequent growth of the ascocarp the terminal cell remains attached to the wall and stains faintly. No evidence of fusion between any of the wall cells and the central cell has been seen, so that if one of them is an antheridium its function has evidently become lost.

The central cell becomes somewhat enlarged and flattened, and cuts off one and then several somewhat smaller cells (Text-figs. 17–25). In some aspects these have the appearance of a compressed spiral (Text-figs. 22–24) as though they were cut off successively from the same part of the central cell. Other preparations (Text-fig. 21), however, show clearly that these cells are cut off from different faces of the central cell, probably successively but in rapid succession, since few stages intermediate between ascocarps containing a solitary central cell and those containing a central cell and several subsidiaries in addition are seen in any preparation. These cells separate from each other and lie free within the ascocarp wall. Further cells of smaller size are then produced, evidently as outgrowths cut off, either from the subsidiaries or from these and the original central cell as well. These small cells do not remain attached to each other, but round off and lie free (Text-figs. 25–28). Smeared ascocarps at this stage of development disgorge a mass of small cells which are mostly quite separate, occasional paired cells or small cells attached to the larger subsidiaries indicating their probable method of formation.

It could not be determined with certainty whether, after the formation of the subsidiaries, all subsequent growth took place by the cutting off of cells from them, whether the original central cell contributed directly to the production of the small cells also, or whether the small cells themselves divided. The central cell and its subsidiaries are multinucleate and the nuclei are scattered.

The ascocarp wall continues to grow to accommodate its increasing contents, apparently by intercalary division of the wall cells. When nearly mature the ascocarp contains free within this wall the mass of small cells and a number of larger cells, distorted and fainty staining, which are the central cell and its first formed subsidiaries. The number of these varies from 1 or 2 in small ascocarps to about 6 in larger fructifications.

The small cells which develop in great quantity appear at first to be bi-nucleate (Text-fig. 29, A). These small cells function directly as asci. They enlarge and the number of nuclei increases (Text-fig. 29, B). A maximum of 8 very densely staining small bodies which are interpreted as nuclei have been seen in these cells (Text-fig. 29, C).

The appearance of the developing asci just prior to spore formation suggests that at least four, and possibly eight, spores start to form, but almost at once all but two cease further development and are crushed against the ascus wall (Text-fig. 29, D, E). The earliest sign interpreted as the beginning of ascospore formation is the appearance of non-staining circular areas associated with densely staining small granules, probably nuclei (Text-fig. 29, D). The spores elongate, becoming fusiform (Text-fig. 29, G) with thick refractive walls at maturity.

By the time all spores are mature, the ascocarp wall has become very thin and fragile and appears to disintegrate without any special line of dehiscence, leaving the mass of spores free (Pl. xv, fig. 2). In media rich in carbohydrates, ascocarps are large and produce numerous spores. Smaller ascocarps, containing only a few spores, are produced under starvation conditions.

Relationships.

The very reduced and simplified nature of the reproductive system makes purely speculative any interpretation of the structure and any suggestion of possible relationships. The terminal cell of the ascocarp initial may be regarded as a vestigial trichogyne. The central cell clearly functions as an ascogonium, and the subsidiary cells cut off from it and the subsequently developed mass of cells which function as asci may be regarded as components of ascogenous hyphae which, instead of remaining attached, separate from each other as soon as they are formed. Direct functioning of cells of the ascogenous hyphae as asci has been described by Emmons (1935) in a number of species of *Penicillium*. In these, chains of 5–6 asci develop directly from cells of the ascogenous hyphae.

A more precise picture of nuclear behaviour in the developing ascogonium and asci is required to throw further light on the relationships of this fungus.

Acknowledgements.

The fungus was obtained in culture by Mr. W. J. Scott, and to him I wish to express my grateful thanks for permitting this study to be made.

The development of the aleuriospores was first observed by Mr. P. R. Maguire, technologist of the C.S.I.R.O. Food Preservation Laboratory, in the course of studies on the growth of the fungus at different relative humidities. I wish to express my grateful thanks to him for drawing them to my attention and for providing a number of photographs illustrating their development. I also wish to thank Miss E. M. Wakefield for her advice and suggestions.

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Xeromyces bisporus, gen. et sp. nov.

Mycelium in culture white, radiate; hyphae 4–10μ wide, average 5–6μ, septate, multinucleate; nuclei minute. Aleuriospores terminal on lateral branches 20–40μ long, occasionally longer; usually 1-celled, but occasionally 2–3 celled; unicellular spores globose to pyriform, smooth with moderately thick wall, 15–18 × 11–14μ. Multicellular spores 17–35 × 11–15μ.

Ascocarps pale yellow, 55–150μ (average 110μ) in diameter, the wall fragile at maturity, disintegrating without definite line of dehiscence. Asci 8–12μ in diameter at maturity, spherical. Ascospores 2 per ascus, fusiform, 9–11 × 4 × 5μ (average 10 × 4 × 5μ), smooth with moderately thick walls (average 1·5μ), pale yellow in mass. Ascocarp arising as a short lateral branch of 3 cells, a cap cell, a central cell and a stalk cell. The stalk cell producing 4 branches which enfold and form a wall around the central cell. Asci produced by division of the central cell, few to many per ascocarp. Antheridium absent.

Mycelium in cultura album, radiatum; hyphae 4–10μ, latae, septatae, multinucleatae; nuclei minute. Aleuriosporae in ramis lateralibus terminales, 20–40μ longa, plerumque unicellulares sed aliquando 2–3-cellulares; sporae unicellulares globulares vel pyriformes, 15–18 × 11–14μ, laeves parietibus crassiusculis, sporae multicellulares 17–35 × 11–15μ.

Ascomata pallido-flava, 55–150μ diametro, parietibus in maturitate fragilibus, sine linea distincta dehiscentiae disrumpentia; asci in maturitate 8–12μ diametro, globosi; ascosporae in quoque asco duae, fusiformes, 10 × 4 × 5μ, in cumulo pallido-flavae, laeves, parietibus crassiusculis.

Ascoma ut ramus brevis lateralis natum, cellarum trium compositum nempe pilei-cellulae, cellulae mediae et pediculi-cellulae; cellula basalis ramos quattuor ferens, cellulam mediam amplectentes et circa eadem parietem formantes; asci divisione cellulae mediae producti, in quoque ascomati pauci vel multi; antheridium nullum.

EXPLANATION OF PLATE XV.

Fig. 1.—Mycelium and aleuriospores. × 200.

Fig. 2.—Mature ascocarps in process of disintegration and liberation of spores. × 400.

ABNORMALITIES IN LINUM USITATISSIMUM L.

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(Plates xvi–xvii; twenty-two Text-figures.)

[Read 25th November, 1953.]

Synopsis.

Abnormalities noted in *Linum usitatissimum* during genetical investigations of rust resistance at Sydney University are briefly described and illustrated with text figures and photographs. These include polyembryos, leaf and cotyledon abnormalities, abnormalities of the stem and chlorophyll deficiencies, etc.

All but the leaf abnormalities appear to be more common in hybrids than varieties. It is suggested that this reflects genetic imbalance in the hybrids.

Introduction.

Abnormalities were noted during genetical investigations at Sydney University of rust resistance in *Linum usitatissimum* L. Busse and Burnham (1930), Shibuya (1939), and Millikan (1951) have reported stem abnormalities, and Crooks (1933) described compound leaves in this species.

Other abnormalities have been reported frequently in other species (White, 1945, the biology of fasciation, and Waterhouse, 1953, polyembryony in cereals).

The abnormalities observed in double cross, F_2 and varietal material during 1952 are dealt with below.

POLYEMBRYONY.

Twin embryo seeds were detected, soon after germination on blotting paper, by the emergence of two roots (Plate xvi, fig. 14.). The twins were always separate and gave identical rust reactions when tested with races to which the source material was segregating in ratios of 1:1 or 3:1 resistant:susceptible (Table 1). One was sometimes sturdier than the other, and neither was as sturdy as normal seedlings for the first few weeks.

They may be due to single fertilization followed by splitting of the young zygote, or result from double fertilization of two female by two male gametes. The identical rust reactions indicate genetic identity of the female gametes if more than one is involved, but gives no indication of single or double fertilization, since the pollen parent of the double cross seed was non-segregating F257. But single fertilization followed by twinning is the more probable process in *Linum* (Eames, personal communication). The one occurrence in F2 material which could have refuted this process, rather confirmed it. Waterhouse (1953) has attributed polyembryos in the cereals to the same process.

COTYLEDON ABNORMALITIES.

There were two types of abnormalities: (1) Those with three (Plate xvii, figs. 15*a*, 15*b*, 16*a*) and (2) those with four cotyledons (Plate xvii, figs. 3, 4; Text-figs. 11–14) completely separated from each other or fused together in pairs for varying lengths from the base (Plate xvii, 16*a*).

Each cotyledon had its own vascular system and an axillary bud. One type 2 seedling with two pairs of cotyledons united at the base had an interesting arrangement of two pairs of axillary buds (Text-fig. 14) vertically opposed to each other in the two axils.

Effect of Cotyledon Complex on Phyllotaxy.

This effect, as distinct from the usual environmentally induced deviations from the norm, could be assessed in those sowings in which all seedlings with normal cotyledons had a normal decussate arrangement at the lower nodes. There was no significant deviation from the norm in seedlings with fused cotyledons (Plate xvii, fig. 16*a*; Text-fig. 1). In those with complete separation of the cotyledons the phyllotaxy varied from normal decussate (Plate xvii, fig. 15*b*) to whorls of three leaves (Plate xvii, fig. 15*a*), with intermediate types alternating single or whorls of three leaves with the usual opposite pairs (Text-figs. 2 to 10). In others the arrangement was spiral, and sometimes quite irregular.

Formation of Cotyledon Abnormalities.

Type 1 abnormal seedlings with three equal sized cotyledons evenly disposed about the stem, and successive whorls of three leaves, probably commenced as tripartite embryos. The others must have commenced as bipartite embryos, laying down two primary cotyledon primordia and establishing the tendency to a decussate phyllotaxy. One cotyledon primordium has then over-differentiated. The complex has usually separated along the mid-line giving rise to two cotyledons of equal size, often closely appressed to each other. Lateral separation has occurred at least once, and possibly accounts for the small cotyledons sometimes observed (Plate xvii, fig. 18).

In a Walsh hybrid seedling one of the three cotyledons was separated from the other two by a distinct internode (Plate xvii, fig. 7). Since it lay in the same radius as one above it, it could scarcely have derived from the bifurcation of one of two original primordia, but must rather have been a premature and unrelated primordium.

TABLE 1.

Details of Polyembryos.

Pedigree of Polyembryos.	Race of Rust.	Reaction of Seedlings.	Expected Ratio of Resistant to Susceptible Plants.
(Ottawa 770B × Bison) × F257[1]	2	Both immune.	1 : 1
(Bison × Ottawa 770B) × F257	2	Both immune.	1 : 1
(Bison × Ottawa 770B) × F257	Not	tested.	Two sets of twins.
(Argentine F11 × Bison) × F257	2	Both immune.	3 : 1
(Italia Roma × JWS) × F257	6	Both susceptible.	1 : 1
(Bolley Golden × Bison) × F257	6	Both immune.	1 : 1
(Argentine F11 × Ottawa 770B) × F257 ..	Not	tested.	
(Argentine F11 × Newland) × F257	Not	tested.	
Punjab × Concurrent	6	Both susceptible.	3 : 1
Ottawa 770B	Not	tested.	
F257	Not	tested.	

[1] F257 susceptible to all Australian races of rust.

Pedigree of affected seedlings.

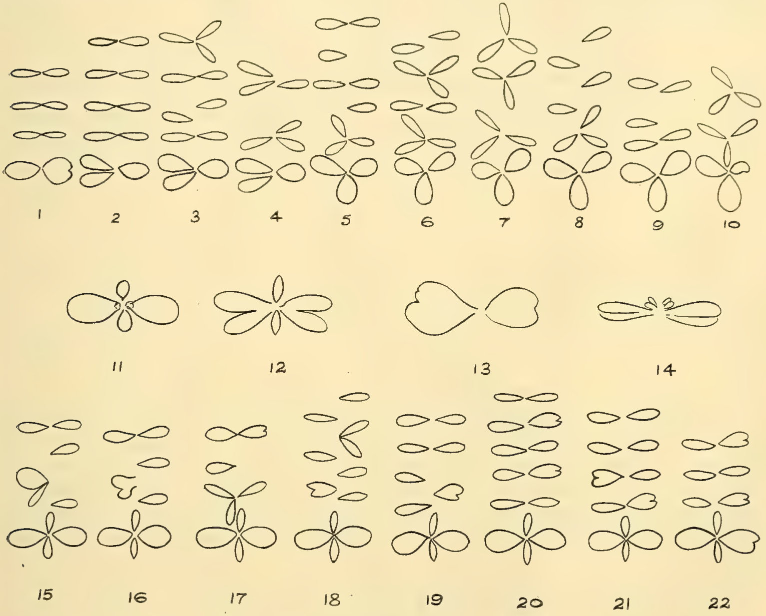
Type 1.—(Koto × Punjab) × F257, (Argentine F11 × F257) × F257, (Morye × Abyssinian) × F257, (Bolley Golden × Koto) × F257, 2 (Italia Roma × Bison) × F257, (Abyssinian × Tammes' Pale Blue) × F257, (Ottawa 770B × Argentine F11) × F257, (F257 × Ottawa 770B) × F257, (J. W. S. × Newland) × F257, (Argentine F11 × Bison) × F257, Williston Golden × Bison, Very Pale Blue Crimped × Koto, Very Pale Blue Crimped × Bison, F257 × Williston Golden, Very Pale Blue Crimped × F257, Punjab × Very Pale Blue Crimped, Walsh × F257, Leona × F257, Morye × F257.

Type 2.—(Argentine F11 × Concurrent) × F257, (Morye × Abyssinian) × F257, Ottawa 770B × Morye.

LEAF ABNORMALITIES.

Three types of leaf abnormalities were noted: Compound leaves, Whorls of three or more leaves, Cone- and fan-shaped abnormalities. The first two have received a brief mention (Crook, 1933); reference to the last group is made by Forsyth and Schuster (1943).

Compound leaves showed varying degrees of differentiation into component subleaves, from slight terminal indentation (Plate xvi, fig. 10) to almost complete separation to the base (Plate xvi, fig. 12). Each subleaf had its own vascular system. There were usually two or three subleaves and rarely more than four. Compound leaves were often associated with another compound leaf or one or two normal leaves at the same node. But the number of subleaves and leaves together rarely exceeded four and never exceeded six.



Text-figures 1-22.

1 to 10. Varying effects of cotyledon complex on phyllotaxy.

1 and 2, Normal decussate; 3, Irregular; 4, Three-leaf whorls with leaves slightly displaced along the vertical axis; 5, Alternation of 3-leaf whorls, single leaves and opposite pairs; 6, Alternating 3-leaf whorls and opposite pairs (up to the thirteenth node); 7, Even 3-leaf whorls; 8, Basal 3-leaf whorl, spiral above; 9, Irregular; 10, Whorl of three cotyledons, one very small. Even 3-leaf whorls above.

11. Whorl of four cotyledons, two large and two small, and two growing points.

12. Two pairs of partially united cotyledons with two basal leaves.

13. Two pairs of almost completely united cotyledons, showing lateral separation of one pair.

14. Two pairs of partially united cotyledons and two pairs of vertically opposed axillary buds.

15–19. Skewed phyllotaxy resulting from apparent fusion or incomplete separation of contiguous leaf primordia.

20, 21. Apparent bifurcation of a single leaf primordium with no appreciable effect on phyllotaxy.

22. Walsh seedling showing terminal bifurcation of one cotyledon and the two leaves immediately above in the same radius.

Text-figures 11–14, × 1; others × 0·8 approx.

Whorls of three or four leaves and rarely five, were often associated with bifurcated and fasciated stems, but were common on normal seedlings.

Cones consisted of a complete whorl of four undeveloped leaves (Plate xvi, figs. 6*a*, 6*b*) with only the slightest terminal separation. The tissue sometimes seemed to have been under strain, resulting in rupture from the base to varying degrees (Plate xvi, fig. 5), culminating in an everted cone (Plate xvi, fig. 11). The shoot continued to grow up through the cone without any marked distortion (Plate xvi, fig. 1).

Cone and fan abnormalities were noted by Forsyth and Schuster (1943) among seedlings seed-treated with spergon at a frequency regulated by the dose of the fungicide. The seedlings dealt with in the present paper were not treated with spergon, and the abnormalities could not be attributed to the action of any chemical.

Seedlings with abnormalities at two nodes (Plate xvi, fig. 10) were not uncommon. Those with three were rare. One plant had six affected nodes.

TABLE 2.

Internode Length of Normal and Abnormal Seedlings in $\frac{1}{64}$", Noted 10.8.51. F257.

	Normal Seedlings.		Seedlings with Fan Type Abnormalities Above First Internode.		Seedlings with Cone Abnormalities Above First Internode.	
	First.	Second.	First.	Second.	First.	Second.
Average internode length ..	1·4	15·1	4·0	14·7	4·5	20·3
Number of seedlings.. ..	18		10		6	
Range of length	1–3	8–22	2–6	9–23	3–6	15–25

Localization of Leaf Abnormalities.

Whorls of leaves and compound leaves occasionally occurred on secondary, particularly fasciated, side shoots. Cones were always restricted to the primary shoot.

The three groups were mostly confined to the first five nodes and seldom found above the seventh (Table 5), but compound leaves with slight terminal indentations have been found at higher levels, e.g., single plants in hybrid lines of Very Pale Blue Crimped × Punjab and Morye × Newland; at node 9 in the former and 8" up the stem in the latter.

TABLE 3.

Length of Internodes in Centimetres of Eleven Normal and Six Abnormal Seedlings[1] of an F6 Line of Walsh Parentage, Sown 22.7.52.

	Second Internode.	Third Internode.	Fourth Internode.
Average and range of length of internodes contiguous with abnormality.	2·8 2·8	2·11 1·9 to 2·5	1·9 1·7 to 2·4
Average and range of length of internodes non-contiguous with abnormality.	2·17 1·6 to 2·8	1·65 1·4 to 2·1	1·39 1·2 to 1·8

[1] Several with abnormalities at more than one node.

Associated Features.

Internodes contiguous with cone and fan type abnormalities were generally longer than usual (Plate xvi, figs. 7, 8). The internode between the cotyledons and first leaf pair in F257 was usually hardly visible. But all F257 seedlings with cone- and fan-shaped abnormalities at the first node in 1951 had a distinct internode (Plate xvi, fig. 2) below, and a markedly longer than normal internode above the affected nodes with cones (Plate xvi, fig. 4*a*, *c*; Table 2).

The internodes contiguous to cone and fan abnormalities in an F6 line of Walsh parentage were again longer than normal (Table 3).

Varietal Differences.

a. Frequency.—Compound leaves and whorls (Plate xvi, fig. 8) occurred in all hybrids and varieties. But there was a distinct difference in frequency between varieties, clearly borne out by the rust increase varieties Punjab, Walsh, F257 and Ottawa 770B, sown at about fortnightly intervals from March to September, 1952. The seedlings were checked when 2½″ to 3½″ high. Ottawa 770B, with an average of 40%, was consistently more affected than the others; Punjab with fewer off types, 12%, was always more affected than F257 and Walsh averaging 2% and 3% respectively (Table 4).

TABLE 4.

Difference Between Varieties in the Frequency of Plants with Leaf Abnormalities.

	Number of Affected Seedlings Among Total Examined.			
	Ottawa 770B.	Punjab.	Walsh.	F257.
1.2.52	—	—	—	0/300
14.3.52	20/76	6/120	0/150	1/215
8.4.52	10/47	1/34	0/58	0/154
April, 1952	43/81	16/220	1/86	11/337
May, 1952	22/63	29/171	0/17	9/74
June, 1952	40/76	24/209	0/39	10/97
July, 1952	34/66	53/202	8/95	23/225
August, 1952	12/24	13/43	—	1/54
September, 1952	6/19	1/63	0/32	0/67
October, 1952	20/51	10/103	2/30	3/106
1952 total	207/503	153/1165	11/507	58/1629
1.4.53	19/126	5/190	4/140	1/136

Cones were generally restricted to one or two varieties. The three varieties, Punjab, Walsh and Concurrent, sown in 1950, were severely affected, but only two of twenty varieties, F257 and Very Pale Blue Crimped, developed cones in 1951. Several plants of Rust Resistant Norfolk Earl and an F6 line of Walsh parentage were affected in 1952. Other varieties sown at the same time and grown in the same position showed only a low percentage of compound leaves.

TABLE 5.

Number of Seedlings with First Abnormality at the Following Nodes.

Date Sown, 1952.	Ottawa 770B.								Punjab.							Walsh.				F257.						
	1	2	3	4	5	6	7	8	2	3	4	5	6	7	8	2	3	4	8	2	3	4	5	6	7	8
March ..		19	1						3		1									1						
April ..		39	7	1	4	1		1	16	1						1				3			4	3		
May ..		14	3		3				16	3		3		1	1					1	1	2	2	3		
June ..		31	6		3				10	2	1	8	2	1							1		4	3		1
July ..	1	17	5	2	2	2	4	1	32	7	1	13	1			2	4	1	1	6	3	3	8	2	1	
August ..		10	2						12	1														1		
September		5	1						1																	
October		14	5	1					10								2			3						
Total ..	1	149	30	4	12	3	4	2	100	14	3	24	3	2	1	3	6	1	1	14	5	5	18	12	1	1

b. Node at which the first abnormality appeared.—Varieties showed a slight difference in the node at which the first compound leaf or whorl appeared. It was usually the second node in Ottawa 770B and Punjab, the third node in Walsh, and the second, fifth and sixth nodes in F257 (Table 5).

There was no marked difference between varieties in the ratio of seedlings affected at one and more than one node. The latter constituted 22%, 15%, 18% and 9% of the total number of affected seedlings in Ottawa 770B, Punjab, Walsh and F257 respectively. The low figure for F257 is scarcely significant considering the few plants affected (Table 6).

Multiple leaves occurred in all lines. There was no significant difference in the ratio of multiple to compound leaves between the varieties.

TABLE 6.

Number of Seedlings with Abnormalities at More than One Node.

	Ottawa 770B.	Punjab.	Walsh.	F257.
Number of seedlings with abnormalities	207	153	11	58
Number of seedlings with two affected nodes	40	20	2	5
Number of seedlings with three affected nodes	6	3	—	—
Percentage of seedlings with more than one affected node among abnormal seedlings	22	15	18	9

Abnormalities in Hybrid Populations.

The frequency of abnormalities in hybrids was no greater than in varieties, and was often surprisingly low, e.g. Williston Golden and Very Pale Blue Crimped hybrids. There were more in Ottawa 770B hybrids (Table 7), but even in the most affected cross, Ottawa 770B × Argentine F11, the number was well below the frequency in Ottawa 770B. The very low frequency in Ottawa 770B × Walsh may be the result of the dominance of the latter variety. The first abnormality tended to appear over a wider range of nodes in the Ottawa hybrids than in Ottawa itself, in which it usually appeared at the second node.

Effect of Abnormalities on Rust Reaction.

There was no detectable effect on the rust reaction. Ottawa 770B always gave normal reactions despite its high frequency of abnormalities. In Plate xvi, fig. 13, the reaction of a normal and compound leaf on the same seedling is seen to be identical.

TABLE 7.

Number of Seedlings with Abnormal Leaves in Hybrid Populations.

Date Sown.	Pedigree.	Total.	Number of Seedlings with First Abnormality at the Following Nodes.							
			2	3	4	5	6	7	8	9
16.5.52	(Ottawa × Argentine F11)	85/244	8	8	8	14	1		2	
	(Ottawa × Walsh) ..	29/234	6	2	6	10	5			
	(Ottawa × Morye) ..	48/249	4	8	15	16	1	3	1	1
	(Ottawa × Italia Roma) ..	46/251	8	15	3	11	3	4	1	1
	Total	.. ..	26	33	32	51	10	7	4	2

Effect of the Environment.

Compound leaves and whorls occurred at most times of the year, but were less common in sowings made in the warmer months. A trial sowing of Ottawa 770B kept in the fluorescent-light rooms, with a moderately high and fairly constant temperature, was remarkably free from abnormalities, although growth was otherwise rather abnormal. Only one in 669 F257 seedlings had a compound leaf in sowings made between 1st February and 8th April, 1952. There was a marked increase in later sowings. Thirty of 123 Ottawa 770B seedlings sown 14th March and 8th April, 1952, and only 19 in 126 sown 1st April, 1953, had abnormal leaves. The frequency doubled in later sowings (Table 4).

Cones and typical fan off types, with two exceptions, appeared during midwinter, after periods of prolonged, and consistently low temperatures. Since they appeared simultaneously in the varieties affected, usually at the same node, in the open, under cold frames and in unheated glasshouses, temperature, rather than light intensity, degree of hardiness of the seedling, etc., seems to be the responsible factor.

The Nature of the Cone Abnormalities.

Cones were always quadrate. The absence of the expected leaf pair at the next node, clearly demonstrated in affected F257 seedlings (Plate xvi, figs. 2, 4), confirmed the fact that two pairs of leaf primordia had become fused at the one node. There must therefore be a strong tendency for leaf primordia to associate in groups of two pairs prior to their separation by an internode. This is a fluid association which must readjust itself each time one of the pairs is removed from the primitive growing point by elongation of the internode. It is not an association of successive groups of four primordia, since this would preclude any association of the second and third, or fourth and fifth leaf pairs, realized at least once. It can also be inferred from the association of the first and second leaf pairs in the F257 cone abnormalities that no internode develops prior to germination.

Formation of the Leaf Abnormalities.

These abnormalities seem to be the product of a complex interaction between the variety, stage of seedling development and temperature, resulting finally in suppressed differentiation of primordia. In the cones, four leaf primordia have failed to separate, and developed as a solid crown of tissue with slight terminal separation of the primordia. Since the basic quadrate association of primordia is not disturbed, subsequent phyllotaxy is usually normal. The internode has been completely suppressed, but this has been compensated by longer internodes contiguous with the affected node.

In the leaf whorls the primordia have separated completely, but an internode has been suppressed.

Most of the compound leaves seem to be due to fusion or inadequate separation of contiguous primordia. The distortion of the quadrate association is reflected in the subsequently skewed phyllotaxy (Plate xvi, fig. 9; Text-figs. 15–19).

But some compound leaves must be due to over-differentiation. In a Walsh seedling with slight terminal bifurcation of one cotyledon, the two leaves immediately above in the same radius were similarly affected and must have resulted from the same process of over-differentiation (Text-fig. 22). The normal decussate phyllotaxy of the Ottawa 770B and Punjab seedlings (Text-figs. 20, 21) typical of many others is difficult to explain if the compound leaves are fused contiguous primordia. It is quite natural if they are bifurcated primordia, which would not affect the quadrate association of the original primordia.

STEM ABNORMALITIES.

At least 5% of out-of-season field-sown Concurrent F2 hybrids, Concurrent × Ottawa 770B, Concurrent × Tammes' Pale Blue and their reciprocals, were abnormal. The stems were fasciated, flat and ribbony, for lengths upwards of a foot. The symptoms persisted into the inflorescence, usually reduced to a small club head, and produced bifurcated flowers, fused anthers, filaments, styles and capsules. None of the F2 seedlings in crosses Punjab × Koto, Punjab × Ottawa, Punjab × Tammes' Pale Blue and reciprocals, were abnormal.

There were three types of abnormalities among pot sown seedlings: (1) Fasciated epicotyl elongating without branching (Plate xvii, fig. 11); (2) Fasciated epicotyl branching into (*a*) a normal and fasciated shoot (Plate xvii, fig. 8), (*b*) two fasciated shoots (Plate xvii, fig. 13*a*), (*c*) two normal shoots (Plate xvii, fig. 12); and (3) Shoot branching into two normal shoots without any obvious prior fasciation (Plate xvii, figs. 9, 14).

The phyllotaxy, particularly in type 1 and 2 abnormalities, was most irregular. The leaves of the first two groups were often unusual compound forms. Multiple leaf clusters were common just below the point of bifurcation of type 3 seedlings. Primary shoots were usually affected, but each type also occurred on side shoots.

Mechanical Induction of Fasciation and Bifurcation.

The growing point and all the lateral buds of eight seedlings were damaged or destroyed by a grub. These, without exception, after a period of suppressed growth under optimal growing conditions, gave rise to very abnormal fasciated and bifurcated shoots with unusual compound leaves. Only one abnormal shoot was detected on twelve partially damaged seedlings, with several buds left intact.

Bifurcation and fasciation may thus result from suturing, or mechanical injury of meristematic tissue. In the absence of a normal, undamaged bud, the sutured tissue yields to the growth pressure and develops abnormal shoots. These conditions may well obtain in young seedlings, in which the growing point must be rather exposed to damage. If damaged by internal or external forces, growth continues along the only active axis then available and an abnormal shoot develops. At a later stage the growing point should be better protected, while other growing points could resume growth if the main shoot were damaged.

Pedigree of abnormal seedlings.

Type 1.—F391 × Newland.

Type 2.—(Ottawa 770B × Walsh) × F257, (Ottawa 770B × Kenya) × F257, (Ottawa 770B × Bison) × F257, (Argentine F11 × Abyssinian) × F257, (Bison × Kenya) × F257, (Bolley Golden × Newland) × F257, (Bolley Golden × Koto) × F257, (Argentine F11 × Newland) × F257, (Tammes' Pale Blue × Abyssinian) × F257, Newland × Akmolinsk, Ottawa 770B, Akmolinsk.

Type 3.—(Ottawa 770B × Bison) × F257, (Argentine F11 × Ottawa 770B) × F257, Akmolinsk × Abyssinian, Kenya × Abyssinian, Punjab × Concurrent, Very Pale Blue Crimped.

CHLOROPHYLL DEFICIENCIES.

(*Ottawa 770B* × *Walsh*) × *F257* (Plate xvii, fig. 6; Plate xvi, fig. 3).—The first symptoms appeared in a leaf at the third node of the primary shoot. Most of the subsequent leaves were affected, and the shoot finally died. The deficient tissue radiated from the leaf base in broken and unbroken lines of varying width. None of the secondary shoots were affected.

(*Walsh* × *Bison*) × *F257* (Plate xvii, fig. 5).—The symptoms commenced about 12″ up the stem of a secondary shoot. The chlorotic sectors were more clearly defined than the above specimen, and generally radiated from the base in a single strip. Fewer leaves were affected, and the symptoms persisted into the inflorescence. They were finally restricted to a small branch of the inflorescence, which failed to set seed. None of the other shoots were affected.

(*Bison* × *Kenya*) × *F257* (Plate xvii, fig. 1).—A cotyledon deficiency, which did not persist into the shoot. The deficient sectors were confined to two thin lateral strips identically placed on both cotyledons.

A specimen of unknown pedigree (Plate xvii, fig. 2) showed an interesting medial band of deficient tissue on both cotyledons and the first leaf pair. The other leaves were normal.

Miscellaneous Abnormalities.

Divided Hypocotyl.

(*Argentine F11* × *Bison*) × *F257* (Plate xvii, fig. 17).—The hypocotyl had split medially along an axis at right angles to the cotyledons. The two leaves at the cotyledon node were missing. There seemed to be a minute epicotyl at the base of the cleft but it failed to develop. The root was also bifurcated.

An Aquatic Bud.

(*Ottawa 770B* × *Bison*) × *F257* (Plate xvii, fig. 14).—This seedling developed a type 3 bifurcated shoot, which was excised, and left in an almost full, ¼-pint cream-jar in a moderately lighted section of a glasshouse. After about three weeks, a very unusual bud was noticed below the surface, just beneath the point of bifurcation. It had thick, very closely appressed, bract-like green leaves, and was much larger than normal. Despite careful efforts to maintain it, the bud failed to develop further.

Young buds, and occasionally young shoots grow aquatically, if left in well aerated vessels. But nothing like the above bud has ever developed.

Table 8.

Approximate Frequency of Abnormalities in F2, Double Cross and Varieties.

Type of Abnormality.	F2.	Double Crosses.	Varieties.
Polyembryos	1/3,000	9/6,000[1]	2/3,000
Cotyledon abnormalities	21/5,000	11/5,000	3/6,000
Fasciation and bifurcation of the stem	8/5,000	10/5,000	3/6,000
Chlorophyll deficiencies	0/5,000	3/5,000	0/6,000
Compound leaves, etc.	No more frequent in hybrids than varieties.		

[1] Three of these were found in the crosses (Ottawa 770B × Bison) × F257 and reciprocal, among about 150 seeds. This very high frequency was the only indication of specific genetic control of the abnormality. But 200 seeds from one pair were quite normal.

Bifurcated Basal Leaves and Growing Point.

(*Akmolinsk* × *Abyssinian*) × *F257* (Plate xvii, figs. 9, 10).—A single anticlinal suture seemed to have completely split the first two leaves medially, partially split the internode along the same axis, and produced two normal shoots, each carrying one of the two leaves normally expected at the second node. The medial splitting of the growing point is reflected in the spiral single leaf phyllotaxy of the derived shoots.

Fusion of Leaves at Different Nodes.

Two leaves at contiguous nodes were fused together medially, along their lateral margins (Plate xvi, fig. 15).

Bifurcation of a Leaf in Two Planes.

(*Walsh* × *Koto*) × *F257.*—The compound leaf consisted of two identical units fused together along the midrib. Each unit was slightly bifurcated distally.

Leaf-like sectors of tissue were appressed to the outer surface of some of the cone and fan type abnormalities noted in F257 seedlings in 1951, but this was the only occurrence of such a kind.

Discussion.

With the exception of the leaf abnormalities, all the aberrant types have either been confined to or been more frequent in hybrid lines than varieties (Table 8). There must, therefore, be some genetic factor operating with other external or internal forces initiating these abnormalities. They are either the product of some genetic complex occasionally realized in hybrid populations, or result from genetic imbalance.

There is not much evidence for the former. No one variety seemed to have a greater frequency of hybrid abnormalities than any other (but see footnote, Table 8), and progeny of several abnormalities, carried on to maturity, were normal.

The theory of genetic imbalance is more probable. The hybrids were derived from Flor's series of rust differential varieties, selected for their morphological and physiological diversity. Three of the major types of abnormality, polyembryony, cotyledon abnormalities, and fasciated epicotyls, and at least some of the fourth major group, leaf abnormalities, are probably produced by a common process, rather than unrelated processes. There seems to have been a proliferation of meristematic tissue, resulting in an enlarged growing face. The tissue has bifurcated and produced a double primordial complex, which has either continued development as a single fused unit, or separated into two normal and distinct primordia. This separation may occur early or late in development, and probably depends upon prior suturing of the complex. Several abnormalities have resulted from suturing without prior over-differentiation.

This process of over-differentiation, bifurcation and separation occurs from the earliest embryonic period to the late seedling stage, producing successively, polyembryos, split hypocotyledon, bifurcated cotyledons, fasciated and bifurcated epicotyls, and some bifurcated leaves.

The effect is generally localized to a single primordial segment, but may be more extensive, affecting simultaneously cotyledon and leaf type or phyllotaxy, leaf, internode and growing point, etc.

The compound leaves, cones, and whorls are a different phenomenon, resulting from suppressed separation of leaf primordia, and, by contrast with the other abnormalities, are as frequent in varieties as hybrids.

CONCLUSION.

Linum usitatissimum L. seems prone to a wide range of abnormalities. The major types seem to be an expression of genetic imbalance in hybrid populations, with internal stresses resulting in over-differentiation and bifurcation of meristematic tissue. Some of the most common abnormalities, compound leaves, seem to derive from this process. But many compound leaves are the end-product of a distinctly different process, suppressed separation of leaf primordia.

Acknowledgements.

This work was done during tenure of a Thomas Lawrance Pawlett Scholarship at Sydney University. I am deeply indebted to Professor W. L. Waterhouse for his unfailing encouragement and advice, particularly in compiling the photographic records.

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EXPLANATION OF PLATES XVI–XVII.

Plate xvi.

1. Seedling with fan and cone type abnormalities. × 1·3.

2. *a, b,* Seedlings with cones at the first node and short internode below; second leaf pair at right angles to cotyledons. *c,* Normal F257 seedling with second leaf pair in same radius as cotyledons. × 1.

3. Chlorophyll deficient primary shoot. × 0·7.

4. *a, c,* Seedlings (F257) with cones at node 1. Note longer internode above and obvious lack of a leaf pair. *b,* Normal seedling. × 0·6.

5. A cone slightly sutured from the base. × 1·8.

6. *a,* Undeveloped cone at node 1. *b,* Expanded cone showing quadrate structure. *c,* Normal seedling. × 1

7. Seedling with fan showing rather long contiguous internodes. × 0·5

8. Seedling with cone showing rather long contiguous internodes. × 0·5

9. Abnormal seedling showing skewed phyllotaxy following fusion of contiguous leaf primordia. × 1·7

10. Compound leaf with slight terminal differentiation at same node with a normal leaf. Note bifurcated leaf at next node. × 1·4

11. An everted cone. × 1·6

12. Compound and normal leaf at same node, showing varying degrees of separation of subleaves. × 1·4

13. Identical susceptible rust reactions on normal and compound leaves. × 1·7

14. Polyembryo with two roots emerging from germinating seed. × 1

15. Fusion of two leaves at contiguous nodes. × 1·6

Plate xvii.

1. Chlorophyll deficient cotyledons with lateral strips of completely deficient tissue. × 2·1

2. Chlorophyll deficient cotyledons and first leaf pair with medial and distal deficient sectors. × 1·3

3. Type 2 cotyledon abnormality with four subcotyledons. × 1·6.

4. A side view of the same abnormality. × 1·4.

5. Chlorophyll-deficient leaves from a side shoot, showing clearly defined radial deficient sectors. × 1·1

6. Chlorophyll-deficient leaves with radial sectors of varying intensity and size (see also Plate xvi, fig. 3). × 0·8.

7. A seedling with an extra cotyledon separated from the two normal cotyledons by a short internode. × 1·2

8. A fasciated shoot bifurcating into a normal and fasciated shoot. Note the abnormal leaves. × 1·1

9. A seedling, in which the epicotyl has been split medially without prior fasciation. The bottom internode has been partially sutured separating the two leaves at the second node, which now appear separately at the same level, still oppositely placed on the derived shoots. × 0·7.

10. The same seedling with the two basal leaves split medially. × 1·6.

11. A type 1 fasciated shoot, elongating without bifurcation. × 0·7.

12. Two fasciated side shoots from the same seedling with one branching into two normal shoots. × 0·5.

13. A fasciated seedling showing various types of branching, (*a*) into two fasciated shoots, (*b*) into a normal and fasciated shoot. × 0·6.

14. An aquatic bud, with large, bract-like leaves, observed just below the point of bifurcation of the primary shoot. Note the small normal bud at the base of the shoot. × 1·2.

15. *a*, An abnormal seedling with a whorl of three cotyledons and three leaves. *b*, An abnormal seedling with three cotyledons, two of which are closely appressed together and seem to have been derived by suturing of one of the two original cotyledon primordia. Note only two leaves at the bottom node. × 1·1.

16. *a*, Slight terminal bifurcation of a cotyledon. *b*, A normal pair of cotyledons. × 1·1.

17. An abnormal seedling with a split hypocotyledon. × 1·8.

18. A seedling with three cotyledons, and three basal leaves. One cotyledon is much smaller than the other two. × 1·4.

NOTES ON AUSTRALIAN THYNNINAE.

I. ARIPHRON BICOLOR ERICHSON.

By B. B. GIVEN,
Entomological Research Station, Nelson, New Zealand.

(*Communicated by Dr. A. J. Nicholson.*)

(Fifteen Text-figures.)

[Read 25th November, 1953.]

Synopsis.

Basic references to the species and its synonymy are given, followed by a concise description of both sexes, with the distribution range and flight period. The life-cycle is outlined as far as known, and the second instar larva and cocoon are described. The first instar larval characters are also described as far as possible from the exuvium. The more important adult and pre-adult features are illustrated by line drawings.

This paper will introduce a series of short descriptive notes on the Thynninae of Australia, with particular emphasis on the figuring of species concerned. The keys of Turner (1907, 1908, 1910) cannot be interpreted, and the bulk of his specific and generic descriptions are extremely difficult to follow, largely on account of lack of illustration of characters described. Consequently it is felt that emphasis should now be placed on clear figuring of the more important characters, with a minimum of word description.

Only species of certain identity will be described in this series of papers and, where possible, information on host records, flight periods, general habits and distribution will be included.

ARIPHRON BICOLOR ERICHSON, 1842.

Arch. f. Naturgesch. Berlin, 8:264 (♀).—*rigidulus* Turner, 1907, PROC. LINN. SOC. N.S.W., 32:274 (♀); 1913, PROC. LINN SOC. N.S.W., 38:610 (synonymy).

♂.—Colour remarkably constant in the four specimens examined, and very distinctive for the species. Black; antennae, palpi, legs except for coxae and trochanters, abdomen except for segments 5, 4 and posterior portion of 3, and tegulae, rufo-testaceous. Wings very slightly fumose, with darker areas below and distad of stigma.

Gross structure as in Text-figures 1, 3, 4, and 10. Note particularly area "a" in Text-figure 4, which is smooth and without vestiture. The presence of this area is characteristic of Australian members of the tribe Thynnini, and its shape is in many cases highly diagnostic of genera and species.

Coarse rugose puncturing on most of vertex and frons including supra-antennal prominence, much finer on clypeus and genae. Vestiture of head sparse except for clypeus which is clothed with decumbent grey hairs. Thorax rather sparsely and irregularly punctured; abdomen almost impunctate.

♀.—Head, thorax, legs and terminal abdominal segments ferruginous; remainder of abdomen and eyes darker red-brown to black.

Gross structure as in Text-figures 2, and 5–9. Note particularly basal prominence on head, pronotal depressions, form of mesopleurae, and flange-structures of abdominal terminalia.

Coarse puncturing on frons and anterior part of vertex, fine, sparse puncturing on thorax, obsolete sculpture on abdomen. No rugosity or carinae on abdominal segments.

Material examined.—2 males, 1 female from Cavendish, Victoria; 2 males, 1 female from East Warburton, Victoria, Coll. F. E. Wilson.

Flight period.—January, February.

Distribution.—Tasmania and Southern Victoria.

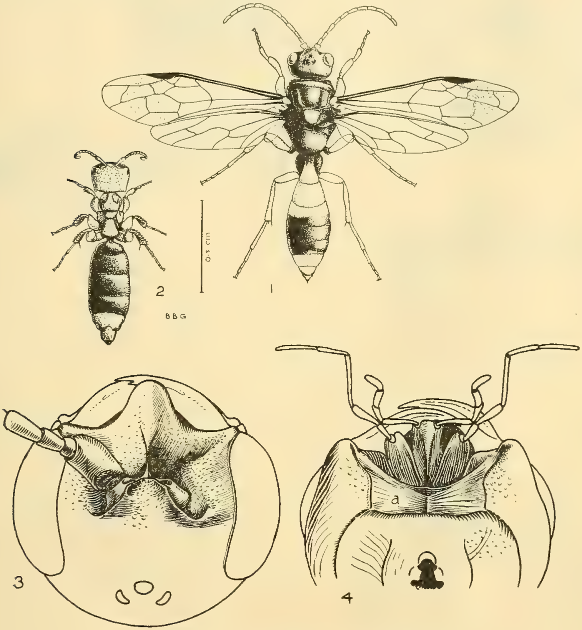
Note.—The subspecies *propodealis* Rohwer has not been seen by the writer.

Life cycle of Ariphron bicolor *Erichs.*

The entire life-cycle of this thynnid is not known, but the following remarks summarize information so far obtained.

Turner (1913, p. 610) makes the following remarks: "I took several males at Eaglehawk Neck in Tasmania, flying round and settling on a fallen Eucalyptus log, which contained a nest of *Myrmecia* ants. I searched the ants' nest as far as possible hoping to find the female, but was not successful."

Early in 1952, Mr. F. E. Wilson of Melbourne noted parallel occurrences at East Warburton, and succeeded in taking one male and a copulating pair.



Text-figs. 1-4.—*Ariphron bicolor* Erichs.
1, entire ♂; 2, entire ♀; 3, head, anterodorsal, ♂; 4, head, ventral, ♂.

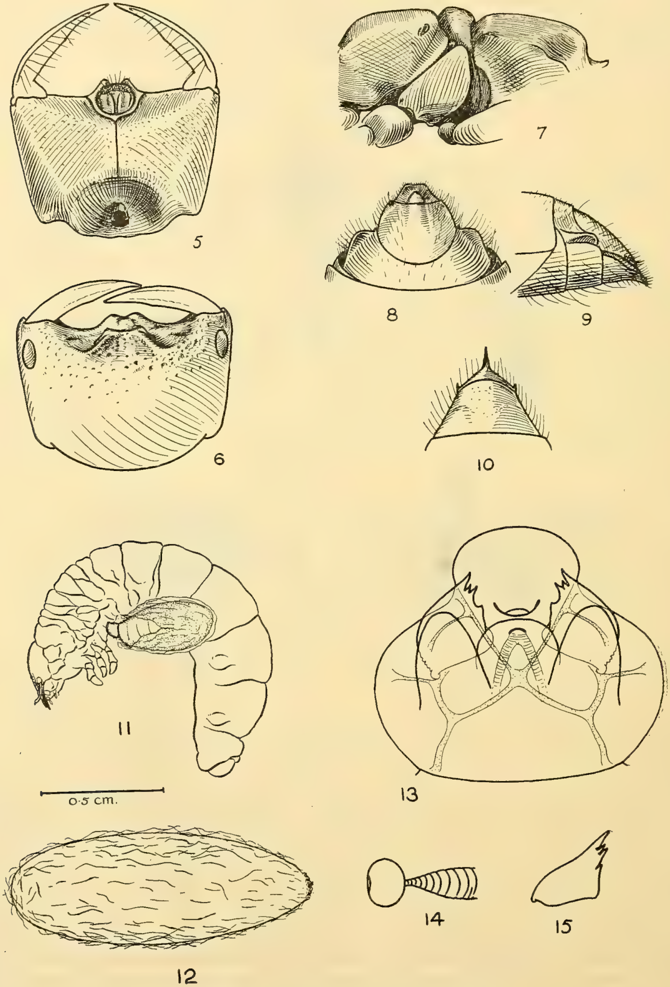
In January 1947, the writer made similar observations at Cavendish in Western Victoria, and on visiting the same log in January 1948, found males again ranging over it. On this occasion the log was split with an axe, and larvae and adults of a lucanid beetle were taken. The adults were identified by Mr. F. E. Wilson as *Syndesus cornutus* Fabr. One larva was found to have a second instar hymenopterous larva attached to its ventral surface, and a hymenopterous cocoon was taken, with the head-capsule of a lucanid larva loosely attached to its outer fibres. In another section of the log, an *Ariphron bicolor* female was found in a tunnel also containing a *Syndesus* larva, on the ventral surface of which was a typical thynnid egg. On this evidence it is assumed that the larva and cocoon herein described and figured, are those of *Ariphron bicolor*, and that a host of this thynnid is the lucanid *Syndesus cornutus* Fabr.

It is unfortunate that no final instar larvae of the parasite were collected, the only larva taken being in its second instar.

Description of second instar larva and cocoon of Ariphron bicolor.

The second instar larva is illustrated feeding on its host in Text-figure 11. The loose envelope covering the larva is the first instar cast skin.

The head capsule is well formed and sub-spherical, with powerful, toothed mandibles. No traces of antennae or palpi were detectable in slide mounts of the stained capsule.



Text-figs. 5-15.—*Ariphron bicolor* Erichs.

5, head, ventral, ♀; 6, head, dorsal, ♀; 7, thorax, lateral, ♀; 8, abdominal terminalia, dorsal, ♀; 9, abdominal terminalia, lateral, ♀; 10, abdominal terminalia, dorsal, ♂; 11, larval instar 2 on host; 12, cocoon; 13, larval instar 2, head, ventral; 14, larval instar 2, spiracle; 15, larval instar 1, mandible.

and no traces of vestiture or sculpture were noted on any portion of the body. The tentorium is of somewhat complex structure, and is illustrated by stippling in Text-figure 13. Oral lobes possibly representing labrum, labium and maxillae are well developed, and buccal and salivary openings are well defined.

Spiracles are all similar, and as illustrated in Text-figure 14.

The cocoon (Text-figure 12) is typical of the subfamily, consisting of a thin inner envelope, a compact, extremely tough, fine-textured main envelope, and an outer layer of fine, loose fibres. At the narrower (posterior) end is a small somewhat absorbent pad, which was in close contact with the tunnel wall. This pad, which evidently consists partly of larval faeces and is the only markedly water-absorbent part of the cocoon, appears to play a part in the moisture-conditioning of the cocoon interior.

The first instar larva.

The first instar skin was mounted and a mandible is illustrated in Text-figure 15. First instar spiracles are identical with those of second instar, except for size.

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TURNER, R. E., 1907.—PROC. LINN. SOC. N.S.W., 32 : 206-290 (*Ariphron bicolor*, pp. 271-4).
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———— 1910.—*Gen. Ins.*, 105 : 3, 5, 10-16.
———— 1913.—PROC. LINN. SOC. N.S.W., 38 : 610.

A NOTE ON THE GEOLOGY OF PANUARA AND ANGULLONG, SOUTH OF ORANGE, N.S.W.*

By N. C. Stevens,
Geological and Mining Museum, Sydney.

(Three Text-figures.)

[Read 25th November, 1953.]

Synopsis.

Mapping of this area links the Ordovician, Silurian and Devonian formations of Four Mile Creek and Cliefden Caves. Further details are given of the Ordovician Malongulli Formation and Angullong Tuff. Silurian strata ranging from Lower Llandovery to Wenlock, overlain by unfossiliferous shale and rhyolite, rest unconformably on Angullong Tuff. Upper Devonian Black Rock Sandstone overlies the rhyolite with unconformity. Monzonitic and syenitic rocks have invaded Ordovician strata south of Cadia, and flows of Tertiary trachyte and basalt are found at altitudes above 2000 feet.

1. Introduction.

Panuara and Angullong Estates are situted about 20 miles south-south-west of Orange and 15 miles west-north-west of Carcoar, between Panuara Rivulet and Cadiangullong Creek, south-flowing tributaries of the Belubula River. Panuara Estate has recently been subdivided for closer settlement, and the new roads and portions are shown on a map issued by the N.S.W. Department of Lands (1950).

The only reference to the geology of the district is a brief report by Booker (1950) on the Angullong Deep Lead. The map accompanying the report also shows Silurian sediments (including limestone near Cobbler's Creek) and Upper Devonian rocks to the west.

To the north, the geology of Four Mile Creek has been described by Stevens and Packham (1953), and a small area near the Cadia mines has been reported upon by Raggatt (1939). To the south and west, the country around Cliefden Caves and Cargo has been studied by the writer (Stevens, 1952; 1950). The present work clarifies the relations between Palaeozoic formations defined in papers on Cliefden Caves and Four Mile Creek.

2. Stratigraphy.

Ordovician.

Of the four Ordovician formations of the Cliefden Caves district, only two, the Malongulli Formation and the Angullong Tuff, can be definitely recognized in the area shown on the map (Text-fig. 1). The limestone bed marked with a question mark in the south-western corner of the map may possibly represent the northernmost extension of the Cliefden Caves Limestone, but it adjoins Silurian limestone on the west and until more fossils are collected its age must remain in doubt.

Malongulli Formation.—This formation, originally defined in the Cliefden Caves paper (Stevens, 1952), was later recognized at Four Mile Creek (Stevens and Packham, 1953). It is now known to extend south to the Belubula River, and graptolites have been collected at five new localities.

The lithology of the formation is much the same as in the areas to the north and south, consisting mainly of thinly-bedded siltstone, black and often calcareous when fresh, and grey and slaty when weathered.

In the northern part of the area the following graptolites have been found: Locality g_1, *Mesograptus foliaceus*, *Glyptograptus teretiusculus* (?) var. *euglyphus*; Locality g_2, *G. teretiusculus*; Locality g_3, *Diplograptus apiculatus* or *M. foliaceus*.

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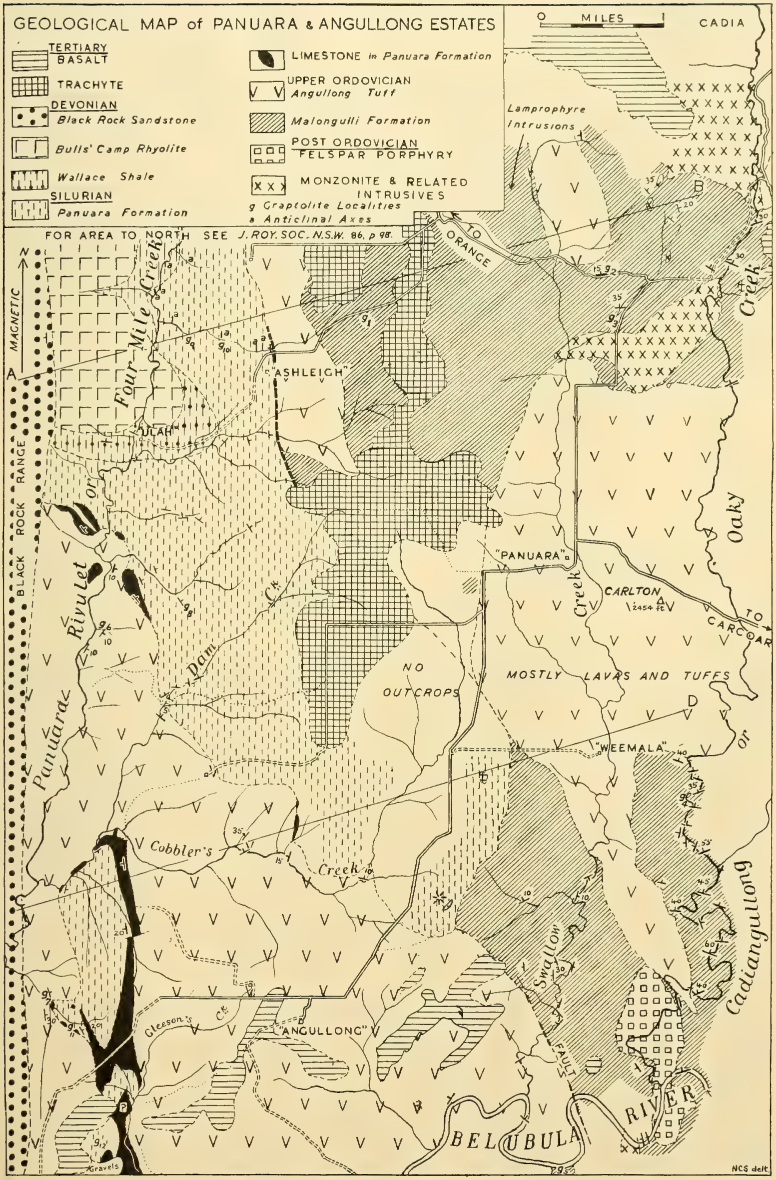


Text-fig. 1.—Geological Map of Panuara and Angullong Estates.

M. foliaceus (*sensu stricto*) is confined to zone 8 of the Ordovician (zone of *G. teretiusculus*), so that the strata at g_1 are one zone lower than the graptolite beds in the Malongulli Formation near Cliefden Caves. At g_3 structural evidence indicates a higher zone than zone 8, so that the graptolite is more likely to be *D. apiculatus.*

South-west of Cadia, cherts and some andesitic tuffs are interbedded with the siltstones near the top of the formation on either side of the belt of Angullong Tuff. To the west near "Ashleigh" (Text-fig. 1), the country is gently undulating with few outcrops, but good exposures of banded siltstones are to be seen to the south in Cadiangullong and Swallow Creeks.

The banded siltstones which outcrop in Swallow Creek east of Angullong are interbedded with andesitic tuffs and felspathic sandstones. The boundaries between fine and coarse sediments are irregular, and lenticular shale fragments are notable in some of the sandstones. These features are probably due to contemporaneous slumping and erosion of shaly beds. Some andesitic rocks are present in this area, but it is not clear whether they are part of the Malongulli Formation or the Angullong Tuff, as the strata are highly folded and faulted.

Fig. 2

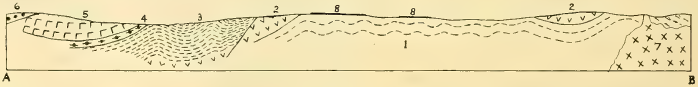
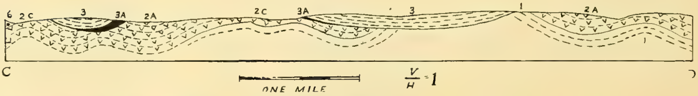


Fig. 3



Text-fig. 2.—Geological Section A B across map.

Text-fig. 3.—Geological Section C D. 1, Malongulli Formation; 2, Angullong Tuff; 2A, Andesite; 2C, Conglomerate and breccia; 3, Panuara Formation; 3A, Bridge Creek Limestone; 4, Wallace Shale; 5, Bulls' Camp Rhyolite; 6, Black Rock Sandstone; 7, Monzonite; 8, Tertiary trachyte.

In Cadiangullong Creek most of the formation is made up of dark calcareous siltstones with occasional beds of felspathic sandstone and impure limestone. The siltstones exhibit regular bedding of dark fine-grained and coarser felspathic sediment. Near the top of the formation (at g_4) diplograptid graptolites, including a possible *Cryptograptus*, are associated with ostracods and fragments of trilobites and brachiopods. This part of the formation is probably not younger than Caradocian (zone of *Dicranograptus clingani*). To the south, near the confluence of Merrimalong Creek and the Belubula River (at g_5), *Glyptograptus* cf. *teretiusculus* has been found in dark grey siltstones which probably belong to the Malongulli Formation, although they are a little to the west of the main outcrop. This area is rather complex and has not yet been fully investigated.

Angullong Tuff.—The Angullong Tuff, which overlies the Malongulli Formation, outcrops over most of the southern part of the Panuara-Angullong area, as well as between "Ashleigh" and Cadia. The main rock types are andesitic tuffs, andesites, conglomerates, breccias and siltstones.

In the type area near Cliefden Caves the formation consists mainly of tuffs with some andesite flows, overlain by banded siltstones. At Four Mile Creek, where a sequence is difficult to establish, andesites are more prominent, and conglomerates and pebbly tuffs appear near the base of the formation. Between these two localities all these rock types are present.

On Panuara Rivulet and Cobbler's Creek, andesitic conglomerates and breccias with beds of dark siltstone and tuff underlie andesites. Similar rocks outcrop one mile north of "Panuara" and along the Belubula River south-east of Angullong, but their distribution is irregular.

Graptolites found in the siltstone beds at g_6 and g_7 include species of *Climacograptus* with thecae showing mesial flanges, indicating a zone near the top of the Ordovician. The siltstones are probably of the same zone as the graptolite-bearing siltstones on the Belubula River south of "Carlton" (Stevens, 1952).

Andesites, which apparently overlie the conglomerates, are found east and north of the Silurian limestone on Cobbler's Creek, and similar lavas, interbedded with tuffs and breccias, make up most of the formation around "Panuara" and "Ashleigh". Both augite- and hornblende-andesites have been noted.

In the Panuara-Angullong area and to the east, there are difficulties in distinguishing between andesites of the Angullong Tuff and the older Walli Andesite, and between siltstones of the Malongulli Formation and the siltstones in the Angullong Tuff.

Silurian.

Panuara Formation.—All the fossiliferous Silurian sediments of Four Mile Creek, ranging from Lower Llandovery to Upper Wenlock, are included in this formation. It extends south and south-east towards the upper part of Cobbler's Creek, and also occurs in an isolated basin resting uncomfortably on Angullong Tuff west of Angullong.

In the north-western part of the map, immediately south of the area mapped by Stevens and Packham (1953), the Panuara Formation is faulted against the Angullong Tuff and the basal limestone does not appear, but it outcrops two miles further south on either side of Panuara Rivulet. The limestone is more massive and not as fossiliferous as the Bridge Creek Limestone Member to the north, but *Favosites* and *Halysites* have been collected from the south-eastern outcrop. Another lens of limestone is found at the base of the Panuara Formation 1½ miles north of Angullong. Nearer Panuara Rivulet, red, brown and green shales with some siltstones and fine-grained tuffs overlie the limestone.

Graptolites found in the shales at g_8 include *Monograptus flemingi* var. *primus*, *M. priodon* or *M. marri*, and (?)*Retiolites* sp. This association suggests a zone in the Lower Wenlock (g_3 of Four Mile Creek). In a west-flowing tributary of Panuara Rivulet near "Ashleigh", dark grey calcareous shales contain poorly-preserved graptolites at two localities (g_9 and g_{10}), probably the same horizon repeated by folding. The graptolites are *Monograptus* cf. *variabilis* or *nudus*, indicating an Upper Llandovery age, but structure and lithology suggest a higher zone.

South-east of Dam Creek, outcrops of the Panuara Formation are infrequent, and the lithology changes from shales to micaceous sandstones and siltstones. East of the Angullong Road these resemble sediments of the adjoining Malongulli Formation.

In the basin of Silurian sediments west of Angullong, limestone again occurs at the base of the Panuara Formation and outcrops along the eastern, southern and northern sides of the basin. On the south-western side, two limestone beds are separated by about 250 feet of brown and grey shales and siltstones. A bed of conglomerate, eight to 10 feet thick, with andesite boulders, underlies the upper limestone.

The lower limestone bed is similar to the Bridge Creek Limestone. Fossils found in it include *Halysites* (two species), *Heliolites*, *Favosites*, Mycophyllids, Streptelasmids, Pentamerids and bryozoa. Colonies of *Eofletcheria* "very like *subparallela*" (according to Dr. Hill) are notable. This coral has been described from the zone of *Dicranograptus clingani* in Norway (Hill, 1953), but in this district there is evidence that it is of Lower Llandovery age.

Graptolites have been found at three localities in the overlying shales. From the lowest locality (g_{11}) Mrs. Sherrard identified *Monograptus intermedius*, *M. triangulatus* and (?) *Rastrites longispinus*. Later a more comprehensive collection was obtained, from which Mr. G. Packham has identified the following (zone ranges are given in brackets): *Glyptograptus* sp., *G. tamariscus* (18–21), *G. sinuatus* (19), *Mesograptus* sp., *Petalograptus* sp. (19–22), *Orthograptus insectiformis* (19–20), *Rastrites* aff. *approximatus* (19–21) and *Climacograptus hughesi* (16–21). The forms belong to the zone of *Monograptus gregarius*, zone 19 of the British succession (Lower Llandovery, equivalent to g_1 of Four Mile Creek).

The upper limestone contains, besides corals, *Conchidium* sp., which is found in abundance in Cobbler's Creek, on the north-western side of the basin. Overlying strata are shales and siltstones with some fine-grained sandstones.

At the southern end of the basin the limestones join and diverge again to the south, where possible Ordovician limestone appears. Between Gleeson's Creek and the basalt to the west, at g_{12}, fossiliferous Silurian limestone adjoins shales with *Climacograptus* sp. and *Monograptus* cf. *gregarius*, suggesting an extension of the Lower Llandovery strata.

Upper Silurian or Devonian.

Wallace Shale.—Red and green shales of this formation overlie the Panuara Formation along Panuara Rivulet north-west of "Ashleigh". Beds of coarse micaceous arkose with irregular lenses of black shale are prominent in this area, and the base of the formation is marked on the southern side by a grey tuff with angular fragments of quartz and felspar.

Bulls' Camp Rhyolite.—The uppermost beds of the Wallace Shale grade into tuffs with pebbles and boulders of andesite which dip north under the rhyolite north of "Ulah". The rhyolite disappears to the west under Upper Devonian sandstones.

Upper Devonian.

Black Rock Sandstone.—The lithology of this formation has been noted in previous papers (Stevens, 1950; Stevens and Packham, 1953). Ripple marks and current bedding are shown in the excellent exposures on Panuara Rivulet, but no fossils have been found in this area.

Tertiary.

Trachyte.—A flow of trachyte extends south towards Angullong from the foothills of Mt. Canobolas. It is confined to the higher country between Panuara Rivulet and Cadiangullong Creek, and the base of the flow slopes southwards to an elevation of 2100 feet at the southern end. East of "Ashleigh", hills of Malongulli Formation rise to about 100 feet above the present upper surface of the flow. The maximum thickness is about 100 feet.

The trachytes are dark blue-grey and resinous when fresh, and pale grey and platy when weathered. Phenocrysts are of sanidine and the ferromagnesian mineral is probably aegirine-augite.

Basalt.—Tertiary basalt caps the ridge west of Cadia at an altitude of 2800 feet, and several outliers are present at a lower level at Angullong (2000 feet). Some basalt and trachyte also occur in the valley of Cadiangullong Creek south of Cadia, several hundred feet below the basalt and trachyte on the ridge.

Tertiary gravels beneath the basalt at Angullong have been worked for gold (Booker, 1950). A flat-topped hill west of Gleeson's Creek represents an area formerly covered by basalt.

3. INTRUSIVE ROCKS.

Monzonite and Related Intrusives.

Monzonite, associated with syenite-aplite, has been noted at Cadia (Raggatt, 1939). In mapping the district to the south, smaller intrusions of monzonite porphyry and syenite and a larger intrusion of syenitic rock have been found. The monzonite porphyries are related to the main mass of monzonite, and are similar to types collected by Raggatt from Cadia.

The western part of the larger syenitic intrusion is made up of a pink syenite consisting mainly of orthoclase and sodic plagioclase with chlorite from original amphibole or possibly biotite. East of the Angullong Road, the intrusive is a grey-green monzonite porphyry or porphyrite with phenocrysts of albitized and epidotized plagioclase and some augite in a deuterically altered felspathic groundmass.

A small intrusion of augite-syenite with a notable amount of zeolite outcrops among Silurian sediments north-east of Angullong, and an epidotized diorite has invaded the Malongulli Formation on the Belubula River south of Cadiangullong Creek.

Other Intrusions.

An intrusion of felspar-porphyry forms a gorge in the lower part of Cadiangullong Creek. The rock is conspicuous in the gravels of the Belubula River because of the large pink felspar phenocrysts. Quartz and hornblende are present in the groundmass.

Several small dykes of lamprophyre and uralitic dolerite have invaded the Malongulli Formation north of the Orange-Angullong Road (see Text-fig. 1). Some of these intrusions, associated with porphyrite, are shown in the south-eastern corner of the Four Mile Creek map.

The age of these intrusions cannot be placed more precisely than post-Ordovician, pre-Tertiary, except for the syenite which has invaded the Silurian sediments north-east of Angullong. Raggatt (1939) suggested a Kanimblan age for the Cadia monzonite.

4. STRUCTURE.

Where Ordovician sediments are well-exposed (as in Swallow and Cadiangullong Creeks), the structure is seen to be complex, with numerous minor folds and faults. Three major folds have been recognized between Panuara Rivulet and Cadiangullong Creek, with axes trending west-north-west. Many smaller folds are probably present, but they cannot be proved because of lack of outcrops or bedding.

In the western part of the area, angles of dip are gentle in both Ordovician and Silurian rocks, and there appears to be a conformity, but in other places the unconformity is evident.

At Four Mile Creek, the Panuara Formation, the Wallace Shale and the Bulls' Camp Rhyolite dip to the west, but further south, a number of close folds appears in the lower formations. Still further south the angles of dip become more gentle and the structure is seen to be a syncline with minor undulations, plunging north-west. The three formations disappear west under the Upper Devonian sandstones, and the disposition of these rocks indicates that the Panuara Formation, the Wallace Shale and the Bulls' Camp Rhyolite are all conformable. The unconformity between them and the Black Rock Sandstone is quite obvious.

The two most important faults are those between the Panuara Formation and the Angullong Tuff at "Ashleigh", and the fault separating the Angullong Tuff and the Malongulli Formation on Swallow Creek, with its possible extension on the Belubula River. At "Ashleigh" the basal limestones of the Panuara Formation are missing and the Silurian rocks are heavily sheared at the contact with the Angullong Tuff. To the south, beds of the Panuara Formation appear to dip east under the tuff. The fault on Swallow Creek has overfolded siltstones, and on the Belubula River there is a wide zone of sheared rocks south of this point.

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Palaeontological assistance has been given by Mrs. K. Sherrard and Mr. G. Packham, who determined the graptolites, and by Dr. D. Hill.

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GUSTAVUS ATHOL WATERHOUSE, 1877–1950.

(*Memorial Series, No. 14.*)

(With Portrait,* Plate xviii.)

Gustavus Athol Waterhouse was born at Waverley, Sydney, on 21st May, 1877. The old home in which he spent his early years is now portion of the War Memorial Hospital, Waverley. His first school was the Waverley Public School where he received from the Headmaster (Mr. Harrison) a thorough grounding in mathematics. He went on to the Sydney Grammar School in 1890 and had there a distinguished scholastic record, gaining the Medal for Trigonometry at the Senior examination in 1895.

He was brought up in an atmosphere of natural history. His father, Gustavus John Waterhouse, was an enthusiastic collector of Pacific Island weapons and implements, and his mother was a noted collector of shells from the beaches in the neighbourhood of Sydney. He, with his two younger brothers, took part in this shell collecting and paid many visits to such localities as Watsons Bay, Bottle and Glass Rocks, Little Manly, Balmoral and Botany Bay. During one of these excursions in search of cowries, he levered up a large slab of rock and was in such a position that, had he relinquished his hold on the rock, he would have been caught under it and probably severely injured. The effort of holding the rock until assistance was forthcoming resulted in such a strain on his heart that he later had to give up his participation in active sport on account of it. He had taken a keen interest in cricket and in tennis, and for a time his love of sport overshadowed his passion for natural history field work and collecting. During his years at Sydney Grammar School he spent many lunch hours in the galleries of the Australian Museum, which adjoins the school.

In the list of exhibits at the Third Annual Exhibition of the Field Naturalists' Society of New South Wales, held in 1893, there is an entry "Master Athol Waterhouse—collection of Australian Shells". The Council of the Society about that time included a group of naturalists that must have been a wonderful inspiration to a boy such as Waterhouse with a keen interest in collecting the local fauna. This group included A. H. S. Lucas, Charles Hedley, W. W. Froggatt, J. P. Hill, W. J. Rainbow, Thomas Steel and T. Whitelegge, each a noted name in the annals of natural history in Australia.

Waterhouse went on to the University of Sydney in 1896, and graduated Bachelor of Science in 1899 with First Class Honours in Geology and Palaeontology, and Bachelor of Engineering in 1900. Under the guidance of Professor Edgeworth David he made a special study of the volcanic dykes intruding the Triassic Rocks of the Sydney district and prepared a detailed map of the distribution of the dykes. In 1924 he obtained the degree of Doctor of Science, with University Medal, for a thesis based on his extensive work on hybridization in butterflies of the genus *Tisiphone*.

In 1900 he was appointed to the assay staff of the Sydney branch of the Royal Mint, and he remained on that staff until the branch was closed in 1926 when he retired. In 1928 he joined the newly-formed Division of Economic Entomology of the Council for Scientific and Industrial Research as one of its first officers—with the title of Curator and Administrative Officer. He played a very important part in all phases of the early organization of this Division. With characteristic enthusiasm and vigour he hunted for staff, with considerable success, and he arranged temporary accommodation until the permanent building was erected on the slopes of Black Mountain, Canberra. He was largely responsible for the planning of this building and for the provision of scientific equipment. He also helped in the design of several large glasshouse insectaries which

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* Portrait taken 1924.

are still in use. After occupying a truly key position during this early formative period he resigned when the Division became fully established in Canberra in 1930.

After graduation he commenced active participation in the affairs of scientific societies—an interest which he expanded and maintained for nearly forty years, when indifferent health compelled him to relinquish the last of his honorary offices. The Field Naturalists' Society of N.S.W. had ceased active existence in 1893, and Waterhouse took an active part in its revival as the Field Naturalists' Club in 1900. He was Honorary Secretary of this Club from 1900 to 1905, Vice President and Honorary Librarian in 1905–06, and President 1906–07. While he was President he offered a prize, for the best collection of insects, to Junior Members of the Club; collections submitted by Sydney Members to be from the County of Cumberland, and by country Members from their own districts. The Club later became the Naturalists' Society of New South Wales and Waterhouse was elected President for 1914–15.

He joined the Linnean Society of New South Wales in 1897, and was a member of the Council from 1912 to 1943. He was President for two years, 1921–23, Acting Secretary in 1927, and Honorary Treasurer 1926–28 and 1930–43. During his term as President he made one of the first public suggestions of a central home for the scientific societies in Sydney. Replying to the toast of the Visitors at the annual dinner of the Royal Society of New South Wales he reminded the assemblage that Burlington House in London was a building which housed a number of kindred societies, and drew attention to the coincidence that the function at which he was speaking was taking place in the Burlington Cafe. Might that, he said, be an omen that the time was ripe for some move to be made in Sydney to bring together the scientific societies in a suitable building. It may be that this speech crystallized ideas which had been mentioned informally from time to time. Whether or not that was so, discussions were held during the next few years, the Government was approached and asked to make available a suitable piece of land, and ultimately an Act was passed by Parliament granting to the Royal Society of New South Wales, the Linnean Society of New South Wales, and the Institution of Engineers, Australia, jointly the piece of land in Gloucester Street on which Science House was built. Waterhouse took an active part in these preliminary negotiations and he was a member of the Management Committee of Science House in its earlier years.

He took also an active part in the administration of the Royal Zoological Society of New South Wales, of which he was a Member of Council for many years and President in 1924–25. Of the Australian and New Zealand Association for the Advancement of Science he was Hon. General Treasurer from 1934 to 1946, and was President of Section D (Zoology) at the Auckland meeting in 1937. He was a member of the Australian National Research Council from 1926 till his death, and a member of the Executive Committee for some years. He joined the Royal Society of New South Wales in 1921 and for two years (1923–25) acted as Honorary Secretary in order to free Mr. R. H. Cambage for work connected with the Second Pacific Science Congress which was held in Australia in 1923.

He was Honorary Entomologist to the Australian Museum from 1919, an Elective Trustee from 1926 to 1947, and President of the Board of Trustees in 1930.

This is an outstanding record of voluntary service in the cause of science in Australia and there are few who can claim to have made such a continuous and successful contribution.

The Royal Entomological Society of London conferred on him the unusual distinction of Honorary Life Fellowship—an honour of which he was justifiably very proud.

His lifelong interest in zoology was mostly concentrated in collection and study of the Butterflies of Australia. His collection which ultimately became the finest existing collection of Australian species was commenced in 1893 while he was still at school. It is now preserved in the Australian Museum, to which he presented it about 1935. Of nearly 350 known Australian species, only four species are not represented in this collection. The Australian Museum collection contains all except 16 of the 888 specimens used as illustrations in "The Butterflies of Australia". The collection also contains all of Waterhouse's own types except one which is in the Macleay Museum, University of Sydney, and a few described with G. Lyell which are in the National Museum, Melbourne.

In addition to specimens collected by himself during trips to every State, his collection contains valuable specimens from many well-known collectors such as H. Elgner (Cape York), F. P. Dodd (Kuranda), R. E. Turner (Mackay, Kuranda and Cape York), L. Franzen and R. Illidge (Brisbane), G. M. Goldfinch (Sydney), and F. L. Whitlock (Western Australia).

There are five drawers of the magnificent species of *Ogyris*, most of the species being represented by long series of bred material. This genus, with the exception of a few New Guinea species, is confined to Australia. The collection also includes some thousands of specimens of Indo-Malayan species as well as specimens from Ceylon, Japan and the Pacific Islands.

Other unique features include the 300 specimens of the first, second and third generations of the crosses of *Tisiphone abeona* referred to below, a considerable number of colour aberrations, mosaic gynandromorphs, and other abnormal specimens, as well as a large amount of larval and pupal material. Waterhouse prepared extensive notes on this material and on the details of life histories, but unfortunately little of this information has been published.

Waterhouse began collecting butterflies at the age of 16, and 10 years later (1903) had amassed sufficient data to publish a catalogue of Australian butterflies containing 329 species, of which 283 species were represented in his own collection. This published list contained 79 species more than in Miskin's 1891 catalogue. The comprehensive nature of this work is illustrated by the fact that, by 1914, the number of species had been increased by only four, and by 1942 by only a further eight species. Only one new species has been described since 1942. Thus, in the last 50 years, only about a dozen new species have been added to a fauna of nearly 350 species. During the same time well over 100 new subspecies were described by Waterhouse from a vast amount of material collected from many parts of Australia.

Waterhouse's extraordinary thoroughness as a taxonomist may be illustrated by the fact that he examined in detail and made careful notes on about 480 types of Australian butterflies, including species and subspecies. Of the 134 remaining it is definitely known that 51 are lost and it is highly probable that a further 40 no longer exist. His determinations were made, therefore, with a vast background of knowledge, which extended beyond the Australian species to include the Pacific, Malayan and Indo-Malayan butterfly faunas. He described about 16 species of Australian butterflies and well over 100 geographical subspecies. It is probable that very few new species of butterflies remain to be found in Australia, except perhaps in the relatively uncollected far north-west. Few groups, therefore, of the Australian insect fauna are as thoroughly described as butterflies.

Waterhouse's Presidential Addresses to the Linnean Society of New South Wales in 1922–23 detailed the results of breeding experiments in respect of hybridization of certain species of butterfly. These experiments were mainly with the satyrid genus *Tisiphone* and were carried out in the grounds of his own home where he built special cages to which he transplanted specimens of the food plant of the species. His notebook and card catalogue with details of these experiments are preserved in the library at the Australian Museum. This work is an excellent example of his very broad taxonomic interests. Between 1914 and 1928 he made extensive collections of the geographical subspecies of *T. abeona* and in 1921 was able to cross the subspecies *abeona* and *morrisi*. These crosses were carried to the third generation and the offspring approached closely the extremely variable suspecies *joanna* which occurs around Port Macquarie. Later by studying the progeny of single female *joanna* he demonstrated that this variability was due to the hybrid nature of this subspecies. In addition, the results of crosses between the subspecies *abeona* and *rawnsleyi* suggested that the latter (the more northern subspecies) was derived from *morrisi*.

This study (summarized in *Aust. Zool.*, 5:217, 1928) was a pioneer work in experimental taxonomy and even today there are few examples of the "laboratory" synthesis of a naturally-occurring hybrid subspecies. It is unfortunate that these important studies have not become better known.

Almost all of Waterhouse's published scientific work deals with butterflies and includes, besides papers in the publications of scientific societies, the Catalogue of Rhopalocera of Australia (1903), The Butterflies of Australia (1914, with G. Lyell), and What Butterfly is That? (1932). His own first-printed interleaved copy of "What Butterfly is That?" in which his subsequent notes and annotations are written, together with his scientific books are preserved in the library of the Australian Museum.

His Presidential address to Section D, delivered at the 1937 meeting of the Australian and New Zealand Association for the Advancement of Science, gave a comprehensive account of the biology and taxonomy of Australasian butterflies. This address contained many of the results of his observations on type specimens and early literature made during a visit to England in 1936.

During this visit to England he worked almost daily at the British Museum (Natural History) examining types and other material, including the Banks Collection. The Museum had asked him to come to London to classify its collection, which began with specimens collected by Sir Joseph Banks and Captain Matthew Flinders. He also spent some time examining Lord Rothschild's Collection at Tring and Meyrick's Collection of Lepidoptera at Marlborough.

For any ordinary man it might be expected that an absorbing interest in Lepidoptera and intense activity in scientific societies would occupy all the leisure time available. But Waterhouse was remarkably active, both physically and mentally, and always had some interests in addition to those mentioned. About 1900 he was interested in the distribution of basic volcanic dykes in the Triassic Hawkesbury Sandstone Series in the Sydney district; for many years he collected Mollusca, of which his mother presented a fine collection to the Australian Museum; and he was a keen philatelist. He was a director of E. Vickery & Sons Pty. Ltd. for about fifteen years, and also took an active part in the management of The Coal Cliff Collieries Ltd., of which he was a director for many years and Chairman of Directors 1938–1943.

From 1943 onwards his health compelled him to relinquish gradually his scientific activities and this was a source of great disappointment to him. He did rally for a period in 1946–47 when it became known that butterfly collections in a number of Australian museums had been subject to a series of ingenious thefts. The collections affected included that which he had presented to the Australian Museum. Most of the specimens were recovered and from his personal knowledge of the specimens in his collection and the localities from which they came he was able to remedy much of the confusion resulting from changed locality labels and thus render a final important contribution to his own special subject. This task would have proved impossible were it not for the excellence of the Register of the collection, in which details of every specimen in the collection were meticulously recorded.

In 1914 he was rejected for military service, but for a period during World War I he put aside his entomological work and devoted his spare time to war service in his own district. He was instrumental in organizing the Roseville Rifle Club and as Captain of the Club drilled and marched over hill and road, exchanging his butterfly net and other collecting paraphernalia for a rifle.

Waterhouse was in the widest and truest sense a very learned man. Apart from science the breadth of his learning was amazing and his brain a storehouse of knowledge which was encyclopaedic. In his younger days he was deeply interested, among other things, in ancient history and always kept within easy reach his favourite volumes—the works of Bryce, Gibbon and Macaulay. Throughout his life he answered a continuous stream of questions coming from old and young alike. His questioners never failed to receive full and satisfying answers, except on those rare occasions when, if he did not know, he said so with conviction. It was axiomatic within his family and outside it that the information he gave would be precise and complete. He was a master of detail and his mental energy was tireless in seeking the truth. His knowledge, though profound, was unobtrusive, and his great learning intensified his natural humility.

His contributions to Science, and particularly to Australian Science, extend far beyond the tangible results of his published work and his unsurpassed collection of Australian Lepidoptera. His membership of many scientific societies and the very active part he played in their affairs has already been mentioned. Quite exceptional and outstanding has been his influence on amateur collectors. He had an amazing capacity for instilling enthusiasm, as well as a knowledge of sound taxonomic methods and of collecting techniques, into many of those with whom he came in contact. It was seldom that he went on collecting trips unaccompanied by one or more enthusiasts, some youthful, some elderly, many of whom, because of his inspiration and early training, have themselves made important contributions to Australian entomology. He himself was gratified by the additions to his own butterfly collection donated by many of those whose interest in the subject had been stimulated by him. Till the last he encouraged their enthusiasm by keeping up a prolific correspondence with naturalists—both young and old—throughout Australia and in the United Kingdom. His letters reveal the painstaking care and exactitude with which he replied to all their questions and he never failed to enrich his replies by adding something of scientific value which he had alighted upon from his own observation and experiment.

Although primarily interested in butterflies he collected vast numbers of insects of other groups. He possessed a seemingly innate discrimination of what was new or rare, and a large number of new species have been described by other workers using his material. He, as much as any other person in his time, was responsible for the maintenance of a high standard among amateur collectors and for a very great increase in their ranks.

His kindly personality and the high esteem in which his colleagues held him made it possible for him to influence other collectors to leave their valuable collections of insects to various museums. Notable examples are the Turner collection of Lepidoptera which is now housed in the Division of Entomology, C.S.I.R.O., Canberra, and the Barnard collection of moths which went to the Queensland Museum.

He died on 29th July, 1950, after a period of about seven years of continuous ill health. He is survived by his widow, two sons and two daughters; one son was killed on active service in New Guinea during World War II.

A.B.W.
A.J.N.

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Descriptions and Notes of Australian Hesperidae, chiefly Victorian. *Vict. Nat.*, xx : 52-57.
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* For this list we are indebted to Mr. A. Musgrave, of the Australian Museum, Sydney.

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Descriptions of and Notes on some Australian Hesperidae. *Vict. Nat.*, xxviii: 223-228 (with G. Lyell).

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Preliminary Notes on Myrmecophilus Lycaenid Larvae. *Austr. Nat.*, ii: 177-178.
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Notes on Australian Lycaenidae. Part VI. Proc. Linn. Soc. N.S.W., liii, pt. 4: 401-412.

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New Genera of Australian Hesperiidae and a New Subspecies. *Austr. Zool.*, vii, pt. 3: 198-201.
What Butterfly is That? A Guide to the Butterflies of Australia. Illustrated by Neville W. Cayley, F.R.Z.S. Angus & Robertson, Sydney.
Australian Hesperiidae. Part III. Proc. Linn. Soc. N.S.W., lvii, pts. 5-6: 409-410.

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Australian Hesperiidae. Part IV. Notes and Descriptions of New Forms. Proc. Linn. Soc. N.S.W., lviii, pts. 5-6: 461-466.

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Notes on Australian Lycaenidae. Part VII. Descriptions of New Races. Proc. Linn. Soc. N.S.W., lix, pts. 5-6: 416-420.

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Australian Hesperiidae. Part VII. Notes on the Types and Type Localities. Proc. Linn. Soc. N.S.W., lxii, pts. 3-4: 107-125.
On the Identity of the Butterfly known in Australia as *Heteronympha philerope* Boisd., 1832. Proc. Linn. Soc. N.S.W., 1937, lxii, pts. 5-6: 253-258.

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The Rothschild Collections. *Aust. J. Sci.*, i, pt. 3 : 99-100.
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Australian Hesperiidae. Part VIII. Descriptions of New Forms. PROC. LINN. SOC. N.S.W., lxiii, pts. 5-6 : 451-452.
Notes on Australian Butterflies in the Australian Museum. No. 1. *Rec. Aust. Mus.*, xx, pt. 3 : 217-222.

1940. Australian Hesperiidae, Part IX. PROC. LINN. SOC. N.S.W., lxv, pts. 5-6 : 568.

1941. The Small Cabbage White Butterfly. *Austr. Mus. Mag.*, vii, pt. 8 : 255-256.
Butterflies attracted by Brilliant Colours. *Austr. Mus. Mag.*, vii, pt. 9 : 323-324.
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Notes on Australian Lycaenidae. Part VIII. On *Ogyris zosine* Hew. and *O. genoveva* Hew. PROC. LINN. SOC. N.S.W., lxvi, pts. 3-4 : 234-238.

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STUDIES ON AUSTRALIAN THYNNIDAE. I.

A Check List of the Australian and Austro-Malayan Thynnidae.

By K. E. W. Salter, Department of Zoology, The University of Sydney.

[Read 25th November, 1953.]

Synopsis.

All systematic references to the Australian and Austro-Malayan Thynnids are listed; synonymy is based on the conclusions made by Rowland E. Turner in his numerous publications. He recognized 39 genera and approximately 480 species from this region.

Introduction.

Rowland E. Turner published his revision of this family in two parts during 1907 and 1908. This was followed in 1910 by his attempt to devise a suitable classification of the many species into subfamilies and genera. He then recognized three subfamilies, gave descriptions with keys of thirty-eight genera from Australia and listed the species in each genus. From 1910 to 1940 one new genus and more than a hundred new species were added by R. E. Turner and there were also notable contributions made by S. A. Rohwer (1910, 1925) and by Montet (1922). The authorship of the family Thynnidae was attributed to Erichson (1842) by Louis Agassiz (1842–1846); however, in the present paper, Shuckard (1840, 1841) is acknowledged as being the first to use the title "Family Thynnidae", thus priority is credited here to Shuckard.

The relationship of the Thynnid Wasps to their immediate allies, viz., the Bradynobaenids, Myrmosids, Anthoboscids, Tiphiids, Myzinids and Methocids, was discussed by V. S. L. Pate in 1947. He considered that all such groups, together with the Thynnids, should rank as subfamilies of the Family Tiphiidae, hence on this basis Thynninae Pate is synonymous with Thynnidae Shuckard. The taxonomic category of family is retained in the present check list. Turner appears to recognize four hundred and eighty species, though it is doubtful whether all are valid. His authority is acknowledged here for the synonymy of the species listed and for their grouping into genera.

This check list should be regarded as the first step towards a general monographic revision of the family Thynnidae and such a work is in preparation by the author.

Family THYNNIDAE Shuckard, 1840.

Family Thynnidae Shuckard, 1840, Lardner's Cabinet Cyclopaedia, 176–7: 405; Shuckard, 1841, Grey's Journal of Expeditions: 470; Erichson, 1842, Fam. Spheges, Trib. Thynnidae, *Arch. f. Naturgeschichte*: 253, 254; Erichson's Bericht, 1842: 64, 1843: 86, 1844: 98; Louis Agassiz, 1842/1846 (F. Thynnidae Erichson), Nomenclator Zoologicus: 34; Lepeletier, 1845: Pl. 35; Ashmead, 1903: 95; Schulz, 1908: 451; Turner, 1910, Gen. Insectorum; Subfamily Thynninae, Pate, 1947: 118.

Subfamily Diamminae.

Genus 1. *Diamma* Westwood.

Subfamily Rhagigasterinae Ashmead.

1. *Dimorphothynnus* Turner. 2. *Rhagigaster* Guérin. 3. *Eirone* Westwood.

Subfamily Thynninae.

1. *Ariphron* Erichson. 2. *Tachynomyia* Guérin. 3. *Megalothynnus* Turner. 4. *Oncorhinothynnus*, n.n. 5. *Psammothynnus* Ashmead. 6. *Phymatothynnus* Turner. 7. *Glaphyrothynnus* Turner. 8. *Aulacothynnus* Turner. 9. *Neozeleboria* Rohwer. 10. *Agriomyia* Guérin. 11. *Asthenothynnus* Turner. 12. *Leiothynnus* Turner. 13. *Aspido-*

thynnus Turner. 14. *Gymnothynnus* Turner. 15. *Epactiothynnus* Turner. 16. *Timesothynnus* Turner. 17. *Thynnoturneria* Rohwer, 1910. 18. *Acanthothynnus* Turner. 19. *Doratithynnus* Turner. 20. *Encopothynnus* Turner. 21. *Catocheilus* Guérin. 22. *Hemithynnus* Ashmead. 23. *Lophocheilus* Guérin. 24. *Macrothynnus* Turner. 25. *Thynnoides* Guérin. 26. *Elidothynnus* Turner. 27. *Campylothynnus* Turner. 28. *Lestricothynnus* Turner. 29. *Belothynnus* Turner. 30. *Leptothynnus* Turner. 31. *Guérinius* Ashmead. 32. *Pogonothynnus* Turner. 33. *Zaspilothynnus* Ashmead. 34. *Thynnus* Fabricius. 35. *Iswaroides* Ashmead.

Subfamily 1. DIAMMINAE Turner, 1907.

Turner, 1907: 212.

Genus 1. DIAMMA Westwood, 1835.

Westwood, 1835: 53. *Psamatha*, Shuckard, 1837: 68. *Tachypterus*, Guérin, 1830/39: 217. *Diamma*, Guérin, 1830/39: 234. *Psammatha*, Westwood, 1844: 103. *Tachypterus*, Smith, 1859: 64. *Diamma*, Smith, 1859: 65. *Trachypterus*, D.T., 1897: 119. *Diamma*, Ashmead, 1903: 157; Turner, 1907: 212.

1. DIAMMA BICOLOR Westwood, 1835.

Westwood, 1835: 53 (♀) New Holland. *Psamatha*, Shuckard, 1837: 68 (♂). *P. chalybea*, Shuckard, 1837: 69 (♂), Pl. 8, f. 1. *Diamma bicolor*, Guérin, 1838/9: 235 (♀). *Tachypterus fasciatus*, Guérin, 1830/9: 217 (♂); Guérin, 1842: 3, Pl. 99, figs. 7–13 (♂). *Psammatha chalybea*, Westwood, 1844: 19–20, 102, Pl. 54, fig. 5 (♂). *Tachypterus fasciatus*, Smith, 1859: 64 (♂). *T. australis*, Saussure, 1867: 109 (♂), T. 2, f. 27. *T. albopictus*, Smith, 1868: 237 (♂). *T. bicolor*, D.T., 1897: 119 (♂). *Diamma bicolor*, Ashmead, 1903: 157 (♂ and ♀). *T. bicolor*, Schulz, 1906: 162 (♂, ♀). *Diamma bicolor*, Turner, 1907: 212 (♂, ♀). *T. fasciatus*, Bequaert, 1926: 188.

Sydney, N.S.W.; Melbourne, Vict.; Adelaide, S.A.; Tasmania.

Subfamily 2. RHAGIGASTERINAE Ashmead, 1903.

Ashmead, 1903: 156 and 97.

Genus 1. DIMORPHOTHYNNUS Turner, 1910.

Enteles, Westwood, 1844: 143. *Dimorphothynnus*, Turner, 1910c: 5.

Type species, *Dimorphothynnus haemorrhoidalis* (Guér.) (= *Dimorphothynnus bicolor* Westwood).

1. DIMORPHOTHYNNUS BARNARDI (Turner), 1907.

Enteles barnardi, Turner, 1907: 246 (♂). Duaringa, Queensland.

Type Species 2. DIMORPHOTHYNNUS BICOLOR (Westwood), 1844.

Rhagigaster haemorrhoidalis, Guérin, 1842: Pl. 99, f. 1 and 2. *Enteles bicolor*, Westwood, 1844: 144 (♀). *Rhagigaster haemorrhoidalis*, Westwood, 1844: 102, 105 (♂); Guérin, 1845: 431. *Thynnus zingerlei*, D.T., 1897: 119 (♂). *T. lecheri*, D.T., 1897: 110 (♂). *Enteles bicolor*, Ashmead, 1903: 104. *E. haemorrhoidalis*, Turner, 1907: 242 (♂, ♀). *Dimorphothynnus bicolor*, Turner, 1916: 120. *Rhagigaster haemorrhoidalis*, Guiglia, 1948: 177. Perth, W. Aust.

3. DIMORPHOTHYNNUS CONJUGATUS (Turner), 1907.

Enteles conjugatus, Turner, 1907: 243 (♂). Queensland. Type in Oxford Museum.

4. DIMORPHOTHYNNUS DECEPTOR (Smith), 1879.

Thynnus deceptor, Smith, 1879: 169 (♂); D.T., 1897: 104 (♂). *Enteles deceptor*, Turner, 1907: 245 (♂). N.W. Australia.

5. DIMORPHOTHYNNUS DIMIDIATUS (Smith), 1859.

Rhagigaster dimidiatus, Smith, 1859: 62 (♂, ♀). *Thynnus ottenthalii*, D.T., 1897: 112 (♂, ♀), *nec* Halliday. *Enteles dimidiatus*, Turner, 1907: 244 (♂, ♀). Sydney.

6. DIMORPHOTHYNNUS FIMBRIATUS (Smith), 1859.

Thynnus fimbriatus, Smith, 1859: 42 (♀). *Rhagigaster apicalis*, Smith, 1859: 63 (♂) (*nec* Guérin). *Thynnus fimbriatus*, D.T., 1897: 106 (♀). *T. ottonis*, D.T., 1897: 112 (♂). *Enteles haemorrhoidalis*, Turner, 1907: 242 (♂, ♀). *Dimorphothynnus fimbriatus*, Turner, 1916: 120. Perth, W.A.; Adelaide, S.A.

7. DIMORPHOTHYNNUS INTEGER (Fabricius), 1775.

Thynnus integer, Fabricius, 1775, *Syst. Entom.*: 360; Fabricius, 1781, *Spec. Insect.*: 457; Fabricius, 1787, *Mantissa Ins.*: 284; Gmelin Lin. 1799: 2739. *Vespa integra*, Christ, 1791: 228. *T. integer*, Fabricius, 1793, *Entom. Syst.*: 245; Fabricius, 1804, *Syst. Piez.*: 231; Donovan, 1805: Plate 41; Guérin, Duperrey, 1830/39, ii, 2: 229. *Rhagigaster integer*, Westwood, 1844: 105; Smith, 1859: 60. *T. integer*, D.T., 1897: 109. *Enteles integer*, Turner, 1907: p. 245.

(♂) Probably Cooktown, Q.

8. DIMORPHOTHYNNUS MORIO (Westwood), 1844.

Rhagigaster morio, Westwood, 1844: 105 (♂); Smith, 1859: 61 (♂). *Thynnus serripes*, Smith, 1859: 44 (♀). *Rhagigaster morio*, Saussure, 1867: 114, Taf. 4, f. 67 (♂); Saussure, 1869: 58 (♀). *Thynnus morio*, D.T., 1897: 111 (♂, ♀). *T. serripes*, D.T., 1897: 115 (♀). *Enteles morio*, Turner, 1907: 246 (♂, ♀). *Dimorphothynnus morio*, Turner, 1910*c*: 6, Pl. 1, f. 8–11. Sydney.

9. DIMORPHOTHYNNUS SIMILLIMUS (Smith), 1865.

Rhagigaster simillimus, Smith, 1865*b*: 390 (*nec* Smith, 1859) (♂). *Thynnus wolframii*, D.T., 1897: 119 (♂). *Enteles simillimus*, Turner, 1907: 244 (♂). *Dimorphothynnus simillimus*, Turner, 1910*c*: 6 (♂). North-west Australia.

10. DIMORPHOTHYNNUS TESTACEIPES (Turner), 1907.

Enteles testaceipes, Turner, 1907: 244 (♂). *Dimorphothynnus testaceipes*, Turner, 1910*c*: 6 (♂). Australia. Type in Oxford Museum.

11. DIMORPHOTHYNNUS TRUNCISCUTIS Turner, 1916.

Turner, 1916: 121 (♂). Brisbane.

Genus. 2. RHAGIGASTER Guérin, 1842.

Guérin, 1830/39, *Duperrey*: 214 (*R. unicolor*, Port Jackson); Westwood, 1844, *Arc. Ent.*, ii, 2: 104; Saussure, 1867, *Reise d. Nov. Zool.*, ii, 1, Hym.: 110; Ashmead, 1903, *Canad. Ent.*, xxxv, June: 157. Turner, 1907, PROC. LINN. SOC. N.S.W., 1907: 214. *Rhytidogaster*, Turner, 1907, ibid.: 229; Guérin, 1842: 2, Pl. 99, f. 2.

Type species, *Rhagigaster unicolor* Guérin.

1. RHAGIGASTER ACULEATUS Saussure, 1867.

Saussure, 1867: 113 (♂). *Thynnus aculeatus*, D.T., 1897: 101 (♂). *Rhagigaster aculeatus*, Turner, 1907: 235 (♂). Sydney, Mittagong, N.S.W.; Victoria. *R.* st. *acutangulus*, Turner, 1907: 235 (♂, ♀). South Australia. *R. aculeatus*, Turner, 1910*b*: 264 (♀). Woodford, N.S.W.

2. RHAGIGASTER ALEXIUS Turner, 1907.

Turner, 1907: 230 (♂, ♀). Cape York.

3. RHAGIGASTER ANALIS Westwood, 1844.

Westwood, 1844: 106 (♀). *R. tristis*, Smith, 1859: 61 (♀). *R. nitidus*, Smith, 1859: 63 (♀). *Thynnus demattioi*, D.T., 1897: 104 (♀). *T. exneri*, D.T., 1897: 106 (♀). *Rhagigaster analis*, Turner, 1907: 225 (♀); Turner, 1910*b*: 260 (♂ and ♀ in cop.).

Western Australia.

4. RHAGIGASTER APPROXIMATUS Turner, 1907.

Turner, 1907: 219 (♂, ♀). Cairns, Queensland.

5. RHAGIGASTER ARUENSIS Turner, 1912.

Turner, 1912: 533 (♂, ♀). Aru Island. Type in B.M.

6. RHAGIGASTER AURICEPS Turner, 1907.

Turner, 1907: 220 (♂, ♀). Cairns, Q'ld.

7. RHAGIGASTER BIDENS Saussure, 1867.

Saussure, 1867: 112 (♂). *Thynnus semperi*, D.T., 1897: 115 (♂). *T. bidens*, Schulz, 1906: 160 (♂). *Rhytidogaster bidens*, Turner, 1907: 233 (♂, ♀). *T. bidens*, Turner, 1909: 140. Sydney (Coll. Froggatt).

8. RHAGIGASTER BREVIUSCULUS Turner, 1907.

Turner, 1907: 236 (♂, ♀). Mackay, Q'ld.

9. RHAGIGASTER CASTANEUS Smith, 1859.

Smith, 1859: 63 (♀); D.T., 1897: 103 (♀); Turner, 1907: 234 (♀); Turner, 1910*b*: 263 (♂), (♂, ♀ in cop.). South Perth, W. Aust.

10. RHAGIGASTER CINERELLUS Turner, 1910.

Turner, 1910*b*: 260 (♂). Cape York, Q'land. Type in Berlin Museum.

11. RHAGIGASTER COMPARATUS Smith, 1859.

Smith, 1859: 69 (♂, ♀). *Rhagigaster rugosus*, Smith, 1879: 176 (♂, *nec* ♀). *Thynnus comparatus*, D.T., 1897: 104. *T. rugosus*, D.T., 1897: 115. *Rhagigaster comparatus*, Turner, 1907: 238 (♂, ♀). Adelaide; Melbourne.

12. RHAGIGASTER CONSANGUINEUS Turner, 1907.

Turner, 1907: 240 (♂, ♀). Albany, Western Australia. Types in Oxford Museum.

13. RHAGIGASTER CORNUTUS Turner, 1907.

Turner, 1907: 233 (♂). Australia.

14. RHAGIGASTER CORRUGATUS Turner, 1910.

Turner, 1910*b*: 262 (♂, ♀). Woodford, N.S.W.

15. RHAGIGASTER CRASSIPUNCTATUS Turner, 1907.

Turner, 1907: 222 (♂, ♀). Mackay, Q'land.

16. RHAGIGASTER DECEMBRIS Montet, 1922.

Montet, 1922: 177 (♂). South Australia.

17. RHAGIGASTER DENTICULATUS Turner, 1907.

Turner, 1907: 232 (♂, ♀). Mackay, Q'land.

18. RHAGIGASTER DISCREPANS (Turner), 1908.

Rhytidogaster discrepans, Turner, 1908: 254 (♂, ♀). Fremantle, W.A.

19. RHAGIGASTER DISSOCIATUS Turner, 1940.

Turner, 1940: 102 (♂). Southern Cross, W. Aust.

20. RHAGIGASTER ELONGATUS Turner, 1907.

Turner, 1907: 225 (♂). Queensland. Type in Oxford Museum.

21. RHAGIGASTER FULVIPENNIS Turner, 1907.

Turner, 1907: 224 (♂, ♀). Cape York.

22. RHAGIGASTER FUSCIPENNIS Smith, 1879.

Smith, 1879: 175 (♂). *Thynnus fuscipennis*, D.T., 1897: 107 (♂). *Rhagigaster gracilior*, Turner, 1907: 223 (♂, ♀). Mackay, Q. *R. fuscipennis*, Turner, 1910*b*: 260.

23. RHAGIGASTER IRACUNDUS Turner, 1907.

Turner, 1907: 237 (♂). Melbourne.

24. RHAGIGASTER INTERSTITIALIS Turner, 1910.

Turner, 1910*b*: 261 (♂). Hermannsburg, Central Australia.

25. RHAGIGASTER JUBILANS Turner, 1913.

Turner, 1913: 608 (♂). Borroloola, Northern Territory. Type in Victorian National Museum.

26. RHAGIGASTER LAEVIGATUS Smith, 1879.

Smith, 1879: 176 (♂, ♀). N.W. Aust. *Thynnus levigatus*, D.T., 1897: 110 (♀, ♂). *Rhagigaster laevigatus* Turner, 1907: 226 (♂, ♀); Turner, 1910*c*: Pl. 3, f. 59 and 60. Townsville, Q'land.

27. RHAGIGASTER LATISULCATUS Turner, 1911.

Turner, 1911: 602 (♂, ♀). Kuranda, Q'land.

28. RHAGIGASTER MANDIBULARIS Westwood, 1844.

Westwood, 1844: 105 (♂, ♀), Pl. 74, 1 and 2; Smith, 1859: 61 (♂). *Thynnus mandibularis*, D.T., 1897: 110 (♂, ♀). *Rhagigaster mandibularis*, Turner, 1909: 131; Turner, 1910*a*: 7; Saussure, 1868: 112. Australia.

29. RHAGIGASTER NEPTUNUS Turner, 1907.

Turner, 1907: 227 (♂). Port Essington, Victoria. Type in Oxford Museum.

30. RHAGIGASTER NIGRITULUS Turner, 1907.

Rhagigaster fuscipennis, Turner, 1907: 218 (♀, ♂) (*nec* Smith). *Rhagigaster nigritulus*, Turner, 1910*b*: 260.

Mackay, Queensland.

31. RHAGIGASTER NOVARAE Saussure, 1867.

Saussure, 1867: 112 (♂); Hutton, 1881: 110 (♂). *Thynnus heideri*, D.T., 1897: 108 (♂). *T. novarae*, Schulz, 1906: 160 (♂). *Rhagigaster novarae*, Turner, 1907: 228 (♂).

New Zealand.

32. RHAGIGASTER OBTUSUS Smith, 1859.

Smith, 1859: 62 (♂). Adelaide; Turner, 1907: 226 (♂). Adelaide.

33. RHAGIGASTER PINGUICULUS Turner, 1908.

Turner, 1907: 238 (♂). Mackay, Q'land.

34. RHAGIGASTER PROTHORACICUS Turner, 1907.

Turner, 1907: 239 (♂, ♀). Mackay, Q'land.

35. RHAGIGASTER PUGIONATUS Saussure, 1867.

Saussure, 1867: 113 (♂). Cumberland. *Thynnus scalae*, D.T., 1897: 115 (*nec* Guérin). *Rhagigaster pugionatus*, Turner, 1907: 234 (♀). Tasmania; Turner, 1915*b*: 538. Cumberland, N.S.W.

36. RHAGIGASTER REFLEXUS Smith, 1859.

Smith, 1859: 62 (♂); D.T., 1897: 114 (♂); Turner, 1907: 226 (♂). Swan River, W.A.

37. RHAGIGASTER RUGIFER Turner, 1937.

Turner, 1937: 150 (♂, ♀). Dongarra, W.A.

38. RHAGIGASTER THYMETES Montet, 1922.

Montet, 1922: 179. Australia.

39. RHAGIGASTER TRISTIS Smith, 1859.

Smith, 1859: 63 (♂). *Thynnus hammerlei*, D.T., 1897: 108 (♂). *Rhagigaster tristis*, Turner, 1907: 232 (♂). Western Australia.

40. RHAGIGASTER TUMIDUS Turner, 1908.

Turner, 1907: 236 (♂, ♀). Melbourne; Swan River; Tempe, N.S.W.

41. Type Species. RHAGIGASTER UNICOLOR Guérin, 1838.

Guérin, 1838: 214 (♂). *Diamma ephippiger*, Guérin, 1838: 235 (♀); Guérin, 1842: 11 (synonymy), Pl. 103, f. 1–6. *Thynnus unicolor*, Klug, 1842: 23. *Rhagigaster unicolor*, Westwood, 1844: 105 (♂). *Diamma ephippiger*, Westwood, 1844: 105 (♀). *Rhagigaster mandibularis*, Westwood, 1844: 105, Pl. 74, f. 1 = ♂, f. 2 = ♀. *R. binotatus*, Westwood, 1844: 105 (♀). *R. unicolor*, Smith, 1859: 61 (♂). *R. mandibularis*, Smith, 1859: 61 (♂). *R. binotatus*, Smith, 1859: 61 (♀); Saussure, 1867: 111 (♂, ♀). *R. mandibularis*, Saussure, 1867: 111 (♂). *R. unicolor*, Saussure, 1867: 111 (♂, ♀), T. 4, f. 66. *R. aethiops*, Smith, 1879: 175 (♂), *nec* Klug. *R. uberhorstii*, D.T., 1897: 117 (♂). *R. binotatus*, D.T., 1897: 102 (♀). *R. mandibularis*, D.T., 1897: 110 (♀, ♂). *R. unicolor*, D.T., 1897: 117 (♀, ♂); Ashmead, 1903: 157 (♀, ♂); Turner, 1907: 217 (synonymy); subspec. *mandibularis*, Turner, 1907: 217; subspec. *ephippiger*, Turner, 1907: 218; subspec. *lyelli*, Turner, 1910*b*: 260. *R. unicolor*, Turner, 1910*c*: 6, Pl. 1, f. 20; Guiglia, 1948: 177.

N.S.W.; Victoria; South Australia; Western Australia.

42. RHAGIGASTER (?) PYXIDATUS (Turner), 1908.

Rhytidogaster pyxidatus, Turner, 1908: 255 (♂). Western Australia.

43. RHAGIGASTER DEPRAEDATOR Turner, 1910.

Turner, 1910*a*: 107 (♀). Cooktown, Q. Type in Hungarian National Museum.

Genus 3. EIRONE Westwood, 1844.

Aelurus, Klug, 1840/2: 42 (*nec Aelurus* Smith). *Eirone*, Westwood, 1844: 144. *Aelurus* (pars) Turner, 1907: 247; Saussure, 1868: 163. *Aelurus* (*Lepteirone*), Turner, 1907: 249; *Aelurus* (*Eirone*), Turner, 1907: 258. *Eirone*, Ashmead, 1903: 157; Turner, 1910*c*: 8.

Type species, *Eirone dispar* Westwood.

1. EIRONE ARENARIA (Turner), 1907.

Lepteirone arenaria, Turner, 1907: 253 (♂). Victoria.

2. EIRONE ALBOCLYPEATA Turner, 1915.

Turner, 1915*a*: 63 (♂, ♀). Yallingup, W.A.

3. EIRONE ALICIAE Turner, 1937.

Turner, 1937: 148 (♂, ♀). Tambourine Mt., Queensland.

4. EIRONE BASIMACULATA Turner, 1919.

Turner, 1919: 170 (♂). Hobart, Tas. Type, S.A. Museum, No. 10′ 10800.

5. EIRONE BRUMALIS Montet, 1922.

Montet, 1922: 182 (♂). *Eirone brumalis*, subspec. *denticulatus*, Montet, 1922: 184 (♂).

6. EIRONE CAROLI (Turner), 1907.

Lepteirone caroli, Turner, 1907: 252 (♂). Victoria. *Eirone caroli*, Turner, 1910*c*: 9 (♂).

7. EIRONE CASTANEICEPS Turner, 1907.

Turner, 1907: 269 (♂); Turner, 1910*c*: Pl. 3, f. 61 (♂). Mackay, Q.

8. EIRONE CELSISSIMA Turner, 1913.

Turner, 1913: 609 (♂, ♀); Turner, 1915*b*: 540 (♂). Mt. Wellington, Tasmania.

9. EIRONE COMES (Turner), 1907.

Lepteirone comes, Turner, 1907: 255 (♂). Victoria. *Eirone comes*, Turner, 1910*c*: 9.

10. EIRONE CRASSICEPS Turner, 1907.

Turner, 1907: 267 (♂). Cape York, Q.

11. EIRONE CUBITALIS (Turner), 1907.

Lepteirone cubitalis, Turner, 1907: 257 (♂, ♀). Victoria. Type in Coll. Froggatt.

12. Type Species. EIRONE DISPAR Westwood, 1844.

Westwood, 1844: 144, Pl. 82, (♂) f. 5, (♀) f. 6. *Thynnus* (*Eirone*) *dispar*, Smith, 1859: 41 (♂, ♀). (?) *T.* (*Agriomyia*) *brevicornis*, Smith, 1859: 39 (♂). *T. dispar*, D.T., 1897: 105 (♂). *T. brevicornis*, D.T., 1897: 103 (♂). *Eirone dispar*, Turner, 1907: 260 (synonymy); Ashmead, 1903: 157; Turner, 1915*b*: 540. Adelaide, S. Aust.

13. EIRONE EXILIS Turner, 1915.

Turner, 1915*b*: 539 (♂). Eaglehawk Neck, Tasmania.

14. EIRONE FALLAX (Smith), 1859.

Thynnus (*Agriomyia*) *fallax*, Smith, 1859: 35 (♂). *T. fallax*, D.T., 1897: 106 (♂). *Lepteirone fallax*, Turner, 1907: 256 (♀). Adelaide, S. Aust.

15. EIRONE FERRUGINEICEPS Turner, 1907.

Turner, 1907: 268 (♂). Sydney.

16. EIRONE FERRUGINEICORNIS Turner, 1910.

Turner, 1910*b*: 265 (♂), Pl. xxxi, fig. 3; Hermannsburg, Central Australia. Turner, 1915*a*: 64 (♂).

17. EIRONE FULVICOSTALIS Turner, 1907.

Turner, 1907: 263 (♂, ♀). Mackay, Q.

18. EIRONE GRANDICEPS (Turner), 1907.

Aelurus, Klug, 1840/1842: 42, *nec Aelurus* Smith. *Aelurus grandiceps*, Turner, 1907: 248 (♂, ♀). Sydney. *Eirone grandiceps*, Turner, 1910*c*: Pl. 1, fig. 15.

19. EIRONE ICHNEUMONIFORMIS (Smith), 1859.

Thynnus (*Agriomyia*) *ichneumoniformis*, Smith, 1859: 39 (♂). *T. ichneumoniformis*, D.T., 1897: 108. *Lepteirone ichneumoniformis*, Turner, 1907: 252 (♂, ♀). *E. ichneumoniformis*, Turner, 1915*b*: 540. Melbourne.

20. EIRONE INCONSPICUA Turner, 1907.

Turner, 1907: 262 (♂). Cairns, Q.

21. EIRONE LEAI Turner, 1915.

Turner, 1915*b*: 540 (♂). Waratah, Tas.

22. EIRONE LUCIDA (Smith), 1859.

Thynnus (*Agriomyia*) *lucidus*, Smith, 1859: 36 (♂). *T. lucidus*, D.T., 1897: 110. *Eirone lucida*, Turner, 1907: 266 (♂); Turner, 1915*b*: 540 (♂).

Eagle Hawk Neck, Tasmania.

23. EIRONE LUCIDULA Turner, 1907.

Turner, 1907: 266 (♂, ♀); Turner, 1910*c*: Pl. 3, figs. 62 and 63. Wagga, N.S.W.; Victoria; South Aust.; Mackay, Q.

24. EIRONE MAJOR Turner, 1919.

Turner, 1919: 171 (♂). Forest Reefs, between Bathurst and Orange, N.S.W.

Type in South Australian Mus., No. I. 10801.

25. EIRONE MARGINICOLLIS Turner, 1911.

Turner, 1911*b*: 604 (♂, ♀). Port Darwin.

26. EIRONE MONTIVAGA Turner, 1910.

Turner, 1910*b*: 266 (♂, ♀). Woodford, N.S.W.

27. EIRONE MUTABILIS Turner, 1908.

Turner, 1908*b*: 80 (♂). Adelaide River, Northern Territory.

28. EIRONE OPACA (Turner), 1907.

Lepteirone opaca, Turner, 1907: 255 (♂). Victoria.

29. EIRONE OSCULANS Turner, 1907.

Turner, 1907: 264 (♂). Mackay, Queensland.

30. EIRONE PARCA Turner, 1907.

Turner, 1907: 262 (♂, ♀). Mackay, Queensland.

31. EIRONE PSEUDOSEDULA (Turner), 1907.

Lepteirone pseudosedula, Turner, 1907: 251 (♂). Adelaide.

32. EIRONE RUFICORNIS (Smith), 1859.

Thynnus (*Agriomyia*) *ruficornis*, Smith, 1859: 34 (♂), *nec* Guérin. *T. haerdtlii*, D.T., 1897: 108. *Eirone ruficornis*, Turner, 1907: 265 (♂). Swan River, W.A.; Turner, 1910*b*: 265 (♀). Claremont, W.A.

33. EIRONE RUFICRUS (Turner), 1907.

Aelurus ruficrus, Turner, 1907: 249 (♂). Kenthurst, N.S.W.

Type in Coll. Froggatt.

34. EIRONE RUFOPICTA (Smith), 1879.

Thynnus rufopictus, Smith, 1879: 159 (♂); D.T., 1897: 115 (♂). *Lepteirone rufopicta*, Turner, 1907: 251 (♂). Adelaide; Melbourne.

35. EIRONE RUFODORSATA Turner, 1915.

Turner, 1915*a*: 64 (♂). Herberton, N. Queensland.

36. EIRONE SCHIZORHINA Turner, 1910.

Turner, 1910*b*: 264 (♂). N.S.W. Type in Berlin Mus.

37. EIRONE SCUTELLATA Turner, 1907.

Turner, 1907: 265 (♂, ♀). Mackay, Q., Cape York, Queensland.

38. EIRONE SUBACTA Turner, 1907.

Turner, 1907: 254 (♂, ♀). Adelaide. Types in Oxford Univ. Museum.

39. EIRONE SUBPETIOLATA Turner, 1916.

Turner, 1916: 122 (♂). Brisbane, Q'land.

40. EIRONE TENEBROSA Turner, 1907.

Turner, 1907: 261 (♂, ♀). Melbourne. Types in Oxford Museum.

41. EIRONE TENUIPALPA Turner, 1907.

Turner, 1907: 260 (♂, ♀). Mackay, Q.

42. EIRONE TRISTIS (Smith), 1859.

Thynnus (*Agriomyia*) *tristis*, Smith, 1859: 34 (♂). *T. tristis*, D.T., 1897: 117. *Lepteirone tristis*, Turner, 1907: 256. Australia.

43. EIRONE TUBERCULATA (Smith), 1859.

Thynnus (*Eirone*) *tuberculatus*, Smith, 1859: 41 (♂, ♀). *T. tuberculatus*, D.T., 1897: 117 (♀, ♂). *Eirone tuberculata*, Turner, 1907: 265 (♂, ♀). Lower Plenty, Victoria.

44. EIRONE VITRIPENNIS (Smith), 1859.

Thynnus (*Eirone*) *vitripennis*, Smith, 1859: 41 (♂, ♀). *T. vitripennis*, D.T., 1897: 118 (♀, ♂); Turner, 1907: 264 (♂). Lower Plenty, Victoria. (Type appears lost.)

Subfamily THYNNINAE Ashmead.

Subfamily Thynninae, Ashmead, 1903: 96, 97; Turner, 1907: 213 (part); (*nec* Pate, 1947: 116).

Genus 1. ARIPHRON Erichson, 1842.

Erichson, 1842: 264 (♀); Smith, 1859: 58; Ashmead, 1903: 157 (♀); Turner, 1907: 269 (♂, ♀); Turner, 1910*c*: 26 (♂, ♀).

Type species, *Ariphron bicolor* Erichson, 1842.

1. Type Species. ARIPHRON BICOLOR Erichson, 1842.

Erichson, 1842: 266, T. 5, fig. 8, 8*a*. (♀); Westwood, 1844: 146 (♀); Smith, 1859: 58 (♀), Pl. 3, fig. 13. *Thynnus bicolor*, D.T., 1897: 102 (♀). *Ariphron bicolor*, Turner, 1907: 271 (♀). *A. rigidulus*, Turner, 1907: 274 (♂). *A. rigidulus* and *bicolor*, Turner, 1910: 26, Pl. 3, figs. 64 and 65. *A. bicolor*, Turner, 1913: 610 (♂, ♀ in cop.); Turner, 1915*b*: 541; Rohwer, 1925: 415. *A. bicolor* subspec. *propodealis*, Rohwer, 1925: 415 (♂). *A. bicolor*, Erichson, 1844: 99; Ashmead, 1903: 157.

2. ARIPHRON BLANDULUS Turner, 1907.

Turner, 1907: 273 (♂, ♀). Berwick, Vic. Types in Coll. Froggatt.

3. ARIPHRON EXCISUS Turner, 1909.

Turner, 1909: 135 (♀). South Australia.

4. ARIPHRON HOSPES Turner, 1907.

Turner, 1907: 272 (♂). Australia. Type in Oxford Museum.

5. ARIPHRON NUDULUS Turner, 1907.

Turner, 1907: 274 (♂, ♀). Tweed River, N.S.W. Type in Coll. Froggatt.

6. ARIPHRON PALLIDULUS Turner, 1907.

Turner, 1907: 276 (♂). Cairns, Queensland.

7. ARIPHRON PAUSERIS Montet, 1922.

Montet, 1922: 197 (♂). Sydney.

8. ARIPHRON PETIOLATUS (Smith), 1859.

Thynnus (*Agriomyia*) *petiolatus*, Smith, 1859: 36 (♂). *T. petiolatus*, D.T., 1897: 113 (♂). *Ariphron petiolatus*, Turner, 1907: 271 (♂); Turner, 1910*c*: 26, Pl. 1, f. 19; Turner, 1913: 610 (♂); Hacker, 1913: 98 (♂).

Cairns, Queensland; Hunter River, N.S.W.; Melbourne, Victoria.

9. ARIPHRON RIXOSUS (Smith), 1879.

Thynnus rixosus, Smith, 1879: 168 (♂); D.T., 1897: 114 (♂). *Ariphron rixosus*, Turner, 1907: 274 (♂). Champion Bay, W. Aust.

10. ARIPHRON TRYPHONOIDES (Smith), 1859.

Thynnus (*Agriomyia*) *tryphonoides*, Smith, 1859: 34 (♂), 68 (♀). *T. tryphonoides*, D.T., 1897: 117 (♂, ♀). *Ariphron tryphonoides*, Turner, 1907: 275 (♂, ♀). Adelaide, S. Aust.; Victoria.

11. ARIPHRON VAGULUS (Turner), 1907.

Thynnus vagulus, Turner, 1907: 271 (♂). Victoria.

Genus 2. TACHYNOMYIA Guérin, 1842.

Guérin, 1842: 6 (*nec* Ashmead). *Aelurus*, Westwood, 1844: 122 (*nec* Klug); Smith, 1859: 53. *Pseudaelurus*, Ashmead, 1903: 99. *Tachynomyia*, Turner, 1907: 276; Turner, 1910*c*: 27; Rohwer, 1910*a*: 346; Saussure, 1868: 124.

Type species, *Tachynomyia abdominalis* Guérin.

1. Type species. TACHYNOMYIA ABDOMINALIS (Guérin), 1842.

Agriomyia (*Tachynomyia*) *abdominalis*, Guér., 1842: 5 (♂). *A.* (*Tachynomyia*) *spinolae*, Guér., 1842: 6 (♂). *Thynnus fervidus*, Erichson, 1842: 263 (♂). *Aelurus abdominalis*, Westwood, 1844: 122 (♂); Smith, 1859: 53 (♂). *Thynnus abdominalis*, D.T., 1897: 100 (♂). *Tachynomyia spinolae*, Ashmead, 1903: 99 (♂). *Tachynomyia abdominalis*, Turner, 1907: 279 (♀); Turner, 1910*c*: 27, Pl. 1, f. 16 (♂, ♀). *T. spinolae*, Rohwer, 1910*a*: 346. *T. abdominalis*, Turner, 1915*b*: 541. *Agriomyia abdominalis*, Guiglia, 1948: 176. *A. spinolae*, Guiglia, 1948: 176; Guérin, Duperrey, 1838: 229.

Victoria; Tasmania.

2. TACHYNOMYIA ABSTINENS Turner, 1907.

Turner, 1907: 284 (♂). Victoria.

3. TACHYNOMYIA ADUSTA (Smith), 1859.

Thynnus adustus, Smith, 1859: 43. *Aelurus pilosulus*, Smith, 1859: 56. *T. adustus*, D.T., 1897: 101. *Thynnus pilosulus*, D.T., 1897: 113. *Tachynomyia adusta*, Turner, 1907: 286. *Tachynomyia pilosula*, Turner, 1907: 285. *T. adusta*, Turner, 1909: 136; Turner, 1910*c*: 27 (♀). Victoria and New South Wales.

4. TACHYNOMYIA AGILIS (Smith), 1865.

Aelurus agilis, Smith, 1865*b*: 390 (♂). *Thynnus wildaueri*, D.T., 1897: 118 (♂) (*nec* Smith). *Tachynomyia agilis*, Turner, 1907: 284 (♂). Swan River, W. Aust.

5. TACHYNOMYIA ANTHRACINA (Smith), 1879.

Aelurus anthracinus, Smith, 1879: 174 (♂, ♀). *Thynnus mulleri*, D.T., 1897: 111 (♀, ♂). *Tachynomyia anthracina*, Turner, 1907: 287 (♂, ♀); Turner, 1910*c*: Pl. 3, figs. 66 and 67.

6. TACHYNOMYIA AURICOMATA Turner, 1910.

Turner, 1910*b*: 268 (♂). Endeavour River, Queensland (?) or Victoria. Type in Berlin Museum.

7. TACHYNOMYIA AURIFRONS (Smith), 1859.

Aelurus aurifrons, Smith, 1859: 54 (♂). *Thynnus aurifrons*, D.T., 1897: 102 (♂); *Tachynomyia aurifrons*, Turner, 1907: 285 (♂); Turner, 1913: 611 (♀) (♂, ♀ in cop.). Albany, W. Aust.

8. TACHYNOMYIA BARBATA (Smith), 1859.

Aelurus barbatus, Smith, 1859: 57 (♂, ♀). *Thynnus barbatus*, D.T., 1897: 102 (♀, ♂). *Tachynomyia barbata*, Turner, 1907: 290 (♂, ♀). Australia. The type appears to be lost.

9. TACHYNOMYIA BASALIS (Smith), 1859.

Aelurus basalis, Smith, 1859: 55, T. 3, f. 6 (♂). *Thynnus sennhoferi*, D.T., 1897: 115 (♂). *Tachynomyia basalis*, Turner, 1907: 281 (♂). Australia.

10. TACHYNOMYIA COMATA (Smith), 1864.

Aelurus comatus, Smith, 1864: 27 (♂). *Thynnus comatus*, D.T., 1897: 103 (♂). *Tachynomyia comata*, Turner, 1910*a*: 122. Waigiou, Malaya.

11. TACHYNOMYIA COMBUSTA (Smith), 1859.

Thynnus (*Agriomyia*) *combustus*, Smith, 1859: 32 (♂). *Thynnus combustus*, D.T., 1897: 104 (♂). *Tachynomyia combusta*, Turner, 1907: 285 (♂). Moreton Bay, Queensland.

12. TACHYNOMYIA CONCOLOR Turner, 1907.

Turner, 1907: 280 (♂), (♀ unknown). Berwick, Victoria. Type in Coll. Froggatt.

13. TACHYNOMYIA DISJUNCTA Turner, 1910.

Turner, 1910*b*: 267 (♂, ♀). Perth, W.A. (♂, ♀ in cop.).

14. TACHYNOMYIA EVELINAE Turner, 1940.

Turner, 1940: 95 (♂). Mondo, Papua.

15. TACHYNOMYIA FASCIPENNIS Turner, 1907.

Turner, 1907: 288 (♂, ♀). Cairns, Q'ld.

16. TACHYNOMYIA FERVENS Smith, 1859.

Aelurus fervens, Smith, 1859: 58 (♂). *Thynnus pernteri*, D.T., 1897: 113 (♂). *Tachynomyia fervens*, Turner, 1907: 284; Turner, 1912: 534 (♀). Woodford, N.S.W.; Brisbane, Queensland; Victoria; South Australia.

17. TACHYNOMYIA FLAVOPICTA (Ritsema), 1876.

Aelurus flavopictus, Ritsema, 1876: 185 (♂). Aru. *Thynnus seemulleri*, D.T., 1897: 115. *Tachynomyia flavopicta*, Turner, 1907: 289 (♂, ♀). Mackay, Q'land (♂, ♀ in cop.); Cairns, Cape York, Q'land; Turner, 1940: 92. Cyclops Mt., Dutch New Guinea.

18. TACHYNOMYIA FRAGILIS (Smith), 1865.

Aelurus fragilis, Smith, 1865*a*: 78 (♂). *Thynnus fragilis*, D.T., 1897: 106 (♂). *Tachynomyia fragilis*, Turner, 1907: 290 (♂). Morty Island.

19. TACHYNOMYIA IMBELLIS Turner, 1908.

Turner, 1908: 254 (♂). Perth, W.A.

20. TACHYNOMYIA INSULARIS (Smith), 1864.

Thynnus insularis, Smith, 1864: 26 (♀). Mysol, Malaya. D.T., 1897: 109 (♀). Turner, 1907: 290 (♀).

21. TACHYNOMYIA MACULIVENTRIS Turner, 1915.

Turner, 1915*a*: 63 (♂). Cunderdin, W.A.

22. TACHYNOMYIA MEGACEPHALA Turner, 1909.

Turner, 1909: 137 (♂). Cape York, Q'land.

TACHYNOMYIA MOCSARYI (see below, No. 33).

23. TACHYNOMYIA MOERENS (Westwood), 1844.

Aelurus moerens, Westwood, 1844: 124 (♂). *A. incanus*, Smith, 1859: 53 (♂). *A. moerens*, Smith, 1859: 53. *T. moerens*, Turner, 1908: 286 (♂). Shoalhaven, N.S.W.; Victoria.

24. TACHYNOMYIA OBLITERATA Turner, 1907.

Turner, 1907: 282 (♂). S. Aust. Type in Coll. Froggatt.

25. TACHYNOMYIA PARADELPHA Turner, 1907.

Turner, 1907: 281 (♂). Victoria.

26. TACHYNOMYIA PUNCTATA (Smith), 1859.

Thynnus punctatus, Smith, 1859: 44 (♀). *Aelurus dentatus*, Smith, 1859: 57 (♂, ♀) (*nec* Fab.). *A. incanus*, Smith, 1859: 69 (♀ *nec* ♂). *Thynnus kaltenbrunneri*, D.T., 1897: 109. *Tachynomyia punctata*, Turner, 1907: 283 (♂, ♀). Adelaide, S.A.

27. TACHYNOMYIA RUBELLA (Smith), 1859.

Aelurus rubellus, Smith, 1859: 56 (♂). *Thynnus friedrichii*, D.T., 1897: 107 (♂). *Tachynomyia rubella*, Turner, 1907: 281 (♂). Lower Plenty, Victoria.

28. TACHYNOMYIA SEDULOIDES Turner, 1907.

Turner, 1907: 283 (♂). Berwick, Victoria. Type in Coll. Froggatt.

29. TACHYNOMYIA SENEX (Smith), 1859.

Aelurus senex, Smith, 1859: 54 (♂). *Thynnus schroederi*, D.T., 1897: 115 (♂). *Tachynomyia senex*, Turner, 1907: 282 (♂); Turner, 1910*c*: 28, Pl. 1, fig. 18. Wagga, N.S.W.; Melbourne, Vic.

30. TACHYNOMYIA SUBFRAGILIS Turner, 1940.

Turner, 1940*a*: 95 (♂). Kokoda, Papua.

31. TACHYNOMYIA VOLATILIS (Smith), 1868.

Aelurus volatilis, Smith, 1868: 237 (♂) (*nec* 1859). *Thynnus mayri*, D.T., 1897: 111 (♂). *Tachynomyia volatilis*, Turner, 1907: 284. South Australia.

32. TACHYNOMYIA VULPINA (Smith), 1859.

Aelurus vulpinus, Smith, 1859: 54 (♂) (*nec* Klug, 1842). *T. vulpina*, Turner, 1909; 136 (♂) (*nec T. moerens*, Turner, 1907: 286). N.S.W. and Victoria.

33. TACHYNOMYIA MOCSARYI Turner, 1910.

Turner, 1910*a*: 108 (♂). Mt. Victoria, N.S.W. Type in Hung. Nat. Mus.

Genus 3. MEGALOTHYNNUS Turner, 1910.

Thynnus, Auctorum. *Megalothynnus*, Turner, 1910*c*: 28.

Type species, *Megalothynnus klugii* (Westwood).

1. Type Species. MEGALOTHYNNUS KLUGII (Westwood), 1844.

Thynnus kluggii, Westwood, 1844: 140, Pl. 82, f. 1 (♂). *T. gravidus*, Westwood, 1844: 141 (♀); D.T., 1897: 107 (♀, ♂). *T. friedrichii*, D.T., 1897: 107 (♂, ♀). *T.* (*Macrothynnus*) *friederici*, Turner, 1908: 196 (♂, ♀). *Megalothynnus klugii*, Turner, 1910*c*: 28 (♂, ♀). *T. gravidus* Turner, 1909: 140 (♀). Swan River, W. Aust.

2. MEGALOTHYNNUS POULTONI (Turner), 1908.

Thynnus (*Macrothynnus*) *poultoni*, Turner, 1908: 197 (♂). *Megalothynnus poultoni*, Turner, 1910*c*: Pl. 2, fig. 46. Champion Bay, W. Aust.

Genus 4. ONCORHINOTHYNNUS, nom. nov.

Oncorhinus, Shuckard, 1841: 470; Erichson, 1843: Bericht, 86; Westwood, 1844: 103; Smith, 1859: 65; Ashmead, 1903: 157; Turner, 1907: 213; Turner, 1910*c*: 29.

As the generic name *Oncorhinus* of Shuckard is preoccupied by the generic name *Oncorhinus* of Schonherr (1833), Family Curculionidae, *Oncorhinus xanthospilus* is left without a valid generic name, consequently the new name *Oncorhinothynnus* is proposed.

Type species, *Oncorhinothynnus xanthospilus* (Shuckard).

See further, Hagen, 1862–3, and Horn and Schenkling, 1928–1929.

Type species. ONCORHINOTHYNNUS XANTHOSPILUS (Shuckard), 1841.

Oncorhinus xanthospilus, Shuckard, 1841: 471 (♂); Westwood, 1844: 103 (♂); Smith, 1859: 65 (♂), Pl. 3, fig. 15. *Thynnus xanthospilus*, D.T., 1897: 119 (♂). *Oncorhinus xanthospilus*, Turner, 1907: 214 (♂); Turner, 1910*b*: 283 (♂, ♀ in cop.), Pl. 31, f. 7 (♀); Turner, 1910*c*: Pl. 3, fig. 74 (♂); Erichson, 1843: Bericht, 86. South Perth, W. Aust.

Genus 5. PSAMMOTHYNNUS Ashmead, 1903.

Ashmead, 1903, xxxv, April: 102; Turner, 1908, xxxiii, March: 96; Turner, 1910*c*, Fasc. 105: 29.

Type species, *Psammothynnus depressus* (Westwood).

1. Type Species. PSAMMOTHYNNUS DEPRESSUS (Westwood), 1844.

Thynnus (*Agriomyia*) *depressus*, Westwood, 1844: 107 (♂, ♀), Pl. 74, fig. 5 (♂), 6 (♀). King George Sound; Smith, 1859: 23. (?) *Thynnus trisulcatus*, Smith, 1859: 45 (♀). *Zeleboria depressa*, Saussure, 1867: 131. *Thynnus depressus*, D.T., 1897: 105 (♀, ♂). *Psammothynnus depressus*, Ashmead, 1903: 102 (♂), 106 (♀). *Thynnus* (*Psammothynnus*) *depressus*, Turner, 1908: 97 (synonymy). *Psammothynnus depressus*, Turner, 1910*c*: 29; Turner, 1915*b*: 543. Albany, W. Aust.; Hobart, Tasmania.

2. PSAMMOTHYNNUS FULVOPILOSUS (Smith), 1879.

Thynnus fulvopilosus, Smith, 1879: 160 (♂, ♀). *Rhagigaster rugosus*, Smith, 1879: 176 (♀, *nec* ♂). *T. fulvopilosus*, D.T., 1897: 107. *T. rugosus*, D.T., 1897: 115. *T.* (*Psammothynnus*) *fulvopilosus*, Turner, 1908: 97 (♂, ♀) (synonymy). Adelaide, S. Aust.

3. PSAMMOTHYNNUS KERSHAWI Turner, 1913.

Turner, 1913: 613 (♂). King Island, Bass St. Type in Victorian National Mus.

4. PSAMMOTHYNNUS RUBRICANS Turner, 1915.

Turner, 1915*a*: 60 (♂). Yallingup, South-west Australia.

5. PSAMMOTHYNNUS (?) TRISULCATUS (Smith), 1859.

Thynnus trisulcatus, Smith, 1859: 45 (♀). South Australia.

Genus 6. PHYMATOTHYNNUS Turner, 1908.

Thynnus, subgenus *Phymatothynnus*, Turner, 1908: 93. *Phymatothynnus*, Turner, 1910*c*: 30.

Type species, *Phymatothynnus monilicornis* (Smith).

1. PHYMATOTHYNNUS ARATUS (Turner), 1908.

Thynnus (*Phymatothynnus*) *aratus*, Turner, 1908: 94 (♂, ♀). *Phymatothynnus aratus*, Turner, 1940*b*: 99 (♂, ♀). Mittagong, N.S.W.; Tambourine Mt., S.E. Queensland.

2. PHYMATOTHYNNUS DERELICTUS Turner, 1915.

Turner, 1915*b*: 542 (♂, ♀). Eaglehawk Neck; Mt. Wellington, Tas.

3. Type Species. PHYMATOTHYNNUS MONILICORNIS (Smith), 1859.

Thynnus (*Agriomyia*) *monilicornis*, Smith, 1859: 39 (♂, ♀). *T. monilicornis*, D.T., 1897: 111 (♀, ♂). *Phymatothynnus monilicornis*, Turner, 1908: 93 (♂, ♀ in cop.); Turner, 1915*b*: 542. Melbourne, Vic.; Tas.; Bombala, N.S.W.

4. PHYMATOTHYNNUS PYGIDIALIS Turner, 1913.

Turner, 1913: 611 (♂, ♀). Melbourne. Type in Vict. Nat. Mus.

5. PHYMATOTHYNNUS PYGIDIOPHORUS Turner, 1915.

Turner, 1915*a*: 62, Pl. 1, figs. 13–14. (♂, ♀ in cop.).

6. PHYMATOTHYNNUS TONSORIUS Turner, 1915.

Turner, 1915*a*: 61 (♂, ♀ in cop.). Yallingup, S.W. Australia.

7. PHYMATOTHYNNUS VICTOR Turner, 1940.

Turner, 1940: 100 (♂, ♀ in cop.). Dongarra, W. Aust.

8. PHYMATOTHYNNUS ZENIS Montet, 1922.

Montet, 1922: 200 (♂). Australia.

9. PHYMATOTHYNNUS (?) DISTINCTUS (Guérin), 1842.

Lophocheilus distinctus, Guérin, 1842: 12, Pl. 103, figs. 14–15 (♂). *Thynnus* (*Lophocheilus*) *distinctus*, Smith, 1859: 40 (♂). *T.* (*Phymatothynnus*) *distinctus*, Turner, 1908: 95. *Lophonocheilus distinctus*, Guiglia, 1948: 176. Australia.

10. PHYMATOTHYNNUS (?) NITIDUS Smith, 1859.

Thynnus (*Agriomyia*) *nitidus*, Smith, 1859: 30 (♂). *T. nitidus*, D.T., 1897: 112. *Phymatothynnus nitidus*, Turner, 1908: 96 (♂). Adelaide and Perth. *P.* (?) *nitidus*, Turner, 1910: 269 (♀). Claremont, W.A.

Genus 7. GLAPHYROTHYNNUS Turner, 1908.

Zeleboria, Saussure (pars), 1867: 131; Ashmead, 1903: 102. *Thynnus*, subgenus *Glaphyrothynnus*, Turner, 1908: 108. *Glaphyrothynnus*, Turner, 1910*c*: 31. *Zeleboria* Saussure, Rohwer, 1910*a*: 347.

Rohwer, 1910: "*Thynnus carinatus* Smith and *Thynnus xanthorrhoei* Smith, the genotypes of *Zeleboria* and *Glaphyrothynnus* respectively, are congeneric so *Glaphyrothynnus* Turner is a synonym of *Zeleboria* Saussure."

Type species as designated by Turner, *Glaphyrothynnus xanthorrhoei* (Smith).

1. GLAPHYROTHYNNUS CARINATUS (Smith), 1859.

Thynnus carinatus, Smith, 1859: 29 (♂). *Zeleboria carinata*, Saussure, 1867: 131 (♂, ♀). *Thynnus carinatus*, D.T., 1897: 103 (♂, ♀). *T.* (*Glaphyrothynnus*) *carinatus*, Turner, 1908: 111 (♂, ♀). *Glaphyrothynnus carinatus*, Turner, 1910*b*: 272. *T.* (*Zeleboria*) *carinatus*, Ashmead, 1903: 102, 106; Rohwer, 1910*a*: 347. Queensland; N.S.W.; South Aust.; W. Aust.

2. GLAPHYROTHYNNUS CONTIGUUS Turner, 1908.

Thynnus (*Glaphyrothynnus*) *contiguus*, Turner, 1908: 109 (♂). Shoalhaven, N.S.W. Type in Coll. Froggatt.

3. GLAPHYROTHYNNUS FLAVESCENS (Smith), 1859.

Thynnus (*Agriomyia*) *flavescens*, Smith, 1859: 68 (♂, ♀). *T. flavescens*, D.T., 1897: 106 (♀, ♂). *T.* (*Glaphyrothynnus*) *flavescens*, Turner, 1908: 111 (♂, ♀). Adelaide, S. Aust. *Glaphyrothynnus flavescens*, Turner, 1910*c*: Pl. 2, figs. 38–39.

4. GLAPHYROTHYNNUS FUSIFORMIS (Saussure), 1867.

Zeleboria fusiformis, Saussure, 1867: 132 (♂). *Thynnus fusiformis*, D.T., 1897: 107 (♂). *Glaphyrothynnus fusiformis*, Turner, 1910*b*: 272 (♂). South Perth, W. Aust.

5. GLAPHYROTHYNNUS MARGINALIS (Westwood), 1844.

Thynnus (*Agriomyia*) *marginalis*, Westwood, 1844: 120, Pl. 76, fig. 3 (♂). *T. marginalis*, D.T., 1897: 110 (♂). *T.* (*Glaphyrothynnus*) *marginalis*, Turner, 1908: 110 (♂, ♀). Albany, Perth, W. Aust.

6. GLAPHYROTHYNNUS SEDULUS (Smith), 1859.

Thynnus (*Agriomyia*) *sedulus*, Smith, 1859: 35 (♂). *T. sedulus*, D.T., 1897: 115. *T.* (*Glaphyrothynnus* ?) *sedulus*, Turner, 1908: 112 (♂). Swan River.

7. GLAPHYROTHYNNUS SITIENS (Turner), 1908.

Thynnus (*Glaphyrothynnus*) *sitiens*, Turner, 1908: 112 (♂). *Glaphyrothynnus sitiens*, Turner, 1910*b*: 270 (♂, ♀). South Perth, W. Aust.

8. GLAPHYROTHYNNUS TRIFIDUS (Westwood), 1844.

Thynnus (*Agriomyia*) *trifidus*, Westwood, 1844: 119, Pl. 77, fig. 4 (♂); Smith, 1859: 24. *Zeleboria imitatrix*, Saussure, 1867: 132 (♂), T. 4, f. 72. *T. imitatrix*, D.T., 1897: 108 (♂). *T. imitator*, Schulz, 1906: 161 (♂). *T.* (*Glaphyrothynnus*) *trifidus*, Turner, 1908: 110. *Glaphyrothynnus trifidus*, Turner, 1910*b*: 271 (♂, ♀ in cop.). South Perth, Albany, W. Aust.

9. Type Species. GLAPHYROTHYNNUS XANTHORRHOEI (Smith), 1859.

Thynnus xanthorrhoei, Smith, 1859: 28; D.T., 1897: 119 (♂). *T. planifrons*, Smith, 1859: 46; D.T., 1897: 113 (♀). ? *T. plebejus*, Saussure, 1867: 123; D.T., 1897: 113 (♀). *Zeleboria xanthorrhoei*, Saussure, 1869: 60 (♂, ♀). *Thynnus* (*Glaphyrothynnus*) *xanthorrhoei*, Turner, 1908: 109 (♂, ♀). *Glaphyrothynnus xanthorrhoei*, Turner, 1910*c*: Pl. 4, figs. 77–78; Rohwer, 1910*a*: 347. Sydney, N.S.W.

Genus 8. AULACOTHYNNUS Turner, 1910.

Thynnus (pars), Smith, 1859: 40. *Thynnus*, subgenus *Zeleboria* (pars), Turner, 1908: 105. *Aulacothynnus*, Turner, 1910*c*: 32.

Type species, *Aulacothynnus femoratus* (Turner).

1. AULACOTHYNNUS CALCARATUS (Smith), 1859.

Thynnus (*Agriomyia*) *calcaratus*, Smith, 1859: 40 (♂). *Thynnus calcaratus*, D.T., 1897: 103 (♂). *T.* (*Zeleboria*) *calcaratus*, Turner, 1908: 105 (♂). *Aulacothynnus calcaratus*, Turner, 1910*c*: 32. Lower Plenty, Victoria.

2. Type Species. AULACOTHYNNUS FEMORATUS (Turner), 1908.

Thynnus (*Zeleboria*) *femoratus*, Turner, 1908: 105 (♂, ♀). *Aulacothynnus femoratus*, Turner, 1910*c*: 32. Bombala, N.S.W. Type in Coll. Froggatt.

Genus 9. NEOZELEBORIA Rohwer, 1910.

Zeleboria (Section 1), Saussure, 1867: 131; Turner, 1908: 98; Turner, 1910*c*: 32. *Neozeleboria*, Rohwer, 1910*a*: 347.

Type species, *Neozeleboria sexmaculata* (Smith).

1. NEOZELEBORIA ADA (Turner), 1908.

Thynnus (*Zeleboria*) *ada*, Turner, 1908: 102 (♂). Roebourne, N.W. Australia.

2. NEOZELEBORIA ADELPHA Turner, 1940.

Turner, 1940*a*: 94 (♂). Kokoda, New Guinea.

3. **Neozeleboria alexandri** Turner, 1915.

Turner, 1915*a*: 59 (♀, ♂). Cunderdin, W. Aust.

4. **Neozeleboria carinicollis** Turner, 1915.

Turner, 1915*b*: 545 (♂, ♀). Hobart, Tasmania.

Neozeleboria compar (see below, No. 19).

5. **Neozeleboria cryptoides** (Smith), 1859.

Thynnus (*Agriomyia*) *cryptoides*, Smith, 1859: 33 (♂). *T. cryptoides*, D.T., 1897: 104 (♀, ♂). *T.* (*Zeleboria*) *cryptoides*, Turner, 1908: 102 (♂, ♀). River Plenty; Melbourne; Gosford. Type in Oxford University Museum.

6. **Neozeleboria lacteimaculata** Turner, 1913.

Turner, 1913: 614 (♂, ♀). Queensland.

7. **Neozeleboria laevifrons** (Smith), 1859.

Thynnus laevifrons, Smith, 1859: 45 (♀); D.T., 1897: 110 (♀). *T.* (*Agriomyia*) *laevifrons*, Turner, 1908: 166 (♀). *T.* (*Zeleboria*) *laevifrons*, Turner, 1909: 138 (♀). South-east Australia.

8. **Neozeleboria longicornis** (Turner), 1908.

Thynnus (*Zeleboria* (?)) *longicornis*, Turner, 1908: 108 (♂). North-west Australia.

9. **Neozeleboria monticola** (Turner), 1909.

Thynnus (*Zeleboria*) *monticolus*, Turner, 1909: 138 (♂). Australian Alps, Victoria.

10. **Neozeleboria nitidula** (Turner), 1908.

Thynnus (*Zeleboria*) *nitidulus*, Turner, 1908: 101 (♂, ♀). *Zeleboria nitidula*, Turner, 1910*c*: 33, Pl. 4, figs. 75–76. Melbourne.

11. **Neozeleboria olivei** (Turner), 1910.

Zeleboria olivei, Turner, 1910*b*: 269 (♂). Cooktown, Queensland.

12. **Neozeleboria polita** (Turner), 1908.

Thynnus (*Zeleboria*) *politus*, Turner, 1908: 104 (♂, ♀). Cowra, N.S.W. Types in Coll. Froggatt.

13. **Neozeleboria proxima** (Turner), 1908.

Thynnus (*Zeleboria*) *proximus*, Turner, 1908: 99 (♂, ♀). *Neozeleboria proxima*, Turner, 1915*b*: 546. Leura, N.S.W.; Eaglehawk Neck, Tasmania. Types in Coll. Froggatt.

14. Type Species. **Neozeleboria sexmaculata** (Smith), 1859.

Thynnus (*Agriomyia*) *sexmaculatus*, Smith, 1859: 32 (♂). *Zeleboria sexmaculata*, Saussure, 1867: 131 (♂). *Thynnus sexmaculatus*, D.T., 1897: 116 (♂). *T.* (*Zeleboria*) *sexmaculatus*, Turner, 1908: 98 (♂). *Zeleboria sexmaculata*, Turner, 1910*c*: 33 (♂). *Neozeleboria sexmaculata*, Rohwer, 1910*a*: 347. Sydney.

15. **Neozeleboria trivialis** (Smith), 1859.

Thynnus (*Agriomyia*) *trivialis*, Smith, 1859: 38 (♂, ♀). *Aelurus fulvifrons*, Smith, 1859: 56 (♂, ♀). *Thynnus impatiens*, Smith, 1879: 168 (♂). *T. trivialis*, D.T., 1897: 117 (♀, ♂). *T. fulvifrons*, D.T., 1897: 107 (♀, ♂). *T. impatiens*, D.T., 1897: 108 (♂). *T.* (*Zeleboria*) *trivialis*, Turner, 1908: 100 (♀). Lower Plenty, Victoria; Champion Bay, W. Aust.

16. **Neozeleboria volatilis** (Smith), 1859.

Thynnus (*Agriomyia*) *volatilis*, Smith, 1859: 33 (♂). *T. volatilis*, D.T., 1897: 118 (♂). *T.* (*Zeleboria*) *volatilis*, Turner, 1908: 107 (♂). Australia (Smith), Adelaide (?).

17. **Neozeleboria** (?) **agnata** (Turner), 1908.

Thynnus (*Zeleboria*) *agnatus*, Turner, 1908: 103 (♂); Turner, 1910*c*: 56 (♀). Kuranda (Cairns), Queensland.

18. NEOZELEBORIA (?) SODALIS (Turner), 1908.

Thynnus (*Aeolothynnus*) *sodalis*, Turner, 1908: 122 (♂). Adelaide, S. Aust.

19. NEOZELEBORIA COMPAR (Turner), 1910.

Thynnus (*Zeleboria*) *compar*, Turner, 1910*a*: (♂, ♀). N.S.W. Type in Hung. Nat. Mus.

Genus. 10. AGRIOMYIA Guérin, 1838.

Guérin-Meneville, 1830/39, Duperrey, Vol. 2: 218; Saussure, 1868: 116; Ashmead, 1903: 105. *Cephalothynnus*, Ashmead, 1903: 100. *Agriomyia*, Turner, 1908: 155; Turner, 1910*c*: 33.

Type species, *Agriomyia maculata* Guérin.

1. AGRIOMYIA ADELAIDAE (Turner), 1908.

Thynnus (*Agriomyia*) *adelaidae*, Turner, 1908: 164 (♂, ♀). South Australia.

2. AGRIOMYIA ALBOMACULATA (Smith), 1859.

Thynnus (*Agriomyia*) *albomaculatus*, Smith, 1859: 27 (♂). *T. conspicuus*, Smith, 1868: 233 (♂). *T. albomaculatus*, D.T., 1897: 101 (♂). *T. conspicuus*, D.T., 1897: 104 (♂). *T.* (*Agriomyia*) *albomaculatus*, Turner, 1908: 163 (♂). Adelaide .

3. AGRIOMYIA ALBOPICTA (Smith), 1859.

Thynnus (*Agriomyia*) *albopictus*, Smith, 1859: 26 (♂). *T. albopictus*, D.T., 1897: 101 (♂). *T.* (*Agriomyia*) *albopictus*, Turner, 1908: 164 (♂). Swan River, W.A.

AGRIOMYIA BISECTA (see below, No. 20).

4. AGRIOMYIA CINGULATA (Turner), 1908.

Thynnus (*Agriomyia*) *cingulatus*, Turner, 1908: 160 (♂). Swan River, W.A. Type in Oxford Museum.

5. AGRIOMYIA CORNUTICOLLIS Turner, 1912.

Turner, 1912*a*: 48 (♀). Hermannsburg, Central Australia.

6. AGRIOMYIA IRREGULARIS (Smith), 1879.

Thynnus irregularis, Smith, 1879: 162 (♂); D.T., 1897: 109 (♂). *T.* (*Agriomyia*) *irregularis*, Turner, 1908: 166 (♂). Swan River, W. Aust.

7. AGRIOMYIA JUCUNDA (Smith), 1859.

Thynnus (*Agriomyia*) *jucundus*, Smith, 1859: 25 (♂). *T. jucundus*, D.T., 1897: 109 (♂). *T.* (*Agriomyia*) *jucundus*, Turner, 1908: 157 (♂). North-west Coast.

8. AGRIOMYIA LUCTUOSA (Smith), 1859.

Thynnus (*Agriomyia*) *luctuosus*, Smith, 1859: 26 (♂). *T. compressus*, Smith, 1859: 43 (♀); D.T., 1897: 104 (♀). *T. luctuosus*, D.T., 1897: 110 (♂). *T.* (*Agriomyia*) *luctuosus*, Turner, 1908: 162 (♂, ♀). *Agriomyia luctuosa*, Turner, 1910*c*: 34, Pl. 4, figs. 84–85. Cumberland, N.S.W.

9. Type Species. AGRIOMYIA MACULATA Guérin, 1838.

Guérin, Duperrey, ii, 1830/39: 218 (♂). *Thynnus maculatus*, Klug, 1840/42: 20 (♂). *T. variegatus*, Klug, 1840/42: 20 (♂), Pl. 1, fig. 3. *Agriomyia maculata*, Guérin, 1842: 3, Pl. 100, figs. 1–4. *Thynnus* (*Agriomyia*) *odyneroides*, Westwood, 1844: 109, Pl. 75, fig. 3 (♂), 4 (♀). *Sphex* (*Thynnus*) *variegatus*, Blanchard, 1849: T. 119, f. 6. *T.* (*Agriomyia*) *odyneroides*, Smith, 1859: 24. *T.* (*Agriomyia*) *maculatus*, Smith, 1859: 24. *T.* (*Agriomyia*) *variegatus*, Smith, 1859: 24. *T.* (*Agriomyia*) *maculatus*, Saussure, 1867: 116. *Zeleboria odyneroides*, Saussure, 1867: 131. *Thynnus odyneroides*, D.T., 1897: 112. *T. maculatus*, D.T., 1897: 110. *T. variegatus*, D.T., 1897: 117. *Agriomyia maculata*, Ashmead, 1903: 100. *Cephalothynnus odyneroides*, Ashmead, 1903: 100, 105. *Thynnus* (*Agriomyia*) *maculatus*, Turner, 1908: 156 (synonymy). *Agriomyia maculata*, Turner, 1910*c*: 34, Pl. 1, figs. 21, 22. *A. odyneroides* Turner, 1915*b*: 547; Bequaert, 1926: 188. *A. maculata*, Guiglia, 1948: 176. Cairns, Q'land, to Adelaide, South Australia.

10. AGRIOMYIA MARGINILABRIS Guérin, 1842.

Guér., 1842: 3, Pl. 100, figs. 5–7 (♂). *Agriomyia affinis*, Guér., 1842: 4 (♂). *Thynnus* (*Agriomyia*) *marginilabris*, Smith, 1859: 24 (♂). *T.* (*Agriomyia*) *consanguineus*, Smith, 1859: 24. *T.* (*Agriomyia*) *moestus*, Smith, 1859: 36 (♂, *nec* ♀). *T. marginilabris*, D.T., 1897: 110 (♂). *T. consanguineus*, D.T., 1897: 104 (♂). (*Agriomyia affinis*, Guérin, 1842: 4, *nec Thynnus affinis*, Guérin, 1830/39:* 226.) *Thynnus* (*Agriomyia*) *marginilabris*, Turner, 1908: 161 (♂, ♀). *A. marginilabris*, Guiglia, 1948: 176.

11. AGRIOMYIA MEDIA (Smith), 1879.

Thynnus medius, Smith, 1879: 170 (♂); D.T., 1897: 111 (♂). *T.* (*Agriomyia*) *medius*, Turner, 1908: 157 (♂). South Australia; subspec. *breweri*, Turner, 1908: 158 (♂, ♀). Albany, W. Aust. Types in Oxford Museum.

12. AGRIOMYIA MOLESTA (Smith), 1879.

Thynnus molestus, Smith, 1879: 166 (♂); D.T., 1897: 111 (♂). *T.* (*Agriomyia*) *molestus*, Turner, 1908: 163 (♂). South Australia.

13. AGRIOMYIA ROTUNDICEPS (Smith), 1859.

Thynnus rotundiceps, Smith, 1859: 46 (♀). (?) *T. propinquus*, Smith, 1879: 160 (♂). *T. rotundiceps*, D.T., 1897: 114 (♀). *T. propinquus*, D.T., 1897: 113 (♂). *T.* (*Agriomyia*) *rotundiceps*, Turner, 1908: 159 (♂, ♀). *Agriomyia rotundiceps*, Turner, 1910*c*: 34, Pl. 2, fig. 40. Cooktown, Mackay; Adelaide.

14. AGRIOMYIA RUBELLA (Smith), 1859.

Thynnus (*Agriomyia*) *rubellus*, Smith, 1859: 25 (♂). *T. rubellus*, D.T., 1897: 114 (♂). *T.* (*Agriomyia*) *rubellus*, Turner, 1908: 163 (♂). South-east Australia.

15. AGRIOMYIA SUSPICIOSA (Smith), 1879.

Thynnus suspiciosus, Smith, 1879: 161 (♂). *T. taeniolatus*, Froggatt, 1893: 71 (♂). *T. suspiciosus*, D.T., 1897: 116 (♂). *T. taeniolatus*, D.T., 1897: 116 (♂). *T.* (*Agriomyia*) *suspiciosus*, Turner, 1908: 164 (♂). *T.* (*Agriomyia*) *taeniolatus*, Turner, 1908: 168 (♂). *Agriomyia suspiciosa*, Turner, 1915*a*: 59 (♂). Central Australia; Adelaide, S.A.

16. AGRIOMYIA SCYLLIAS Montet, 1922.

Montet, 1922: 202 (♂). Oberon, Blue Mts., N.S.W.

17. AGRIOMYIA TROCHANTERINA (Westwood), 1844.

Thynnus trochanterinus, Westwood, 1844: 116, Pl. 77, fig. 3 (♂); Smith, 1859: 23 (♂); D.T., 1897: 117 (♂). *T.* (*Agriomyia*) *trochanterinus*, Turner, 1908: 165 (♂). Albany, W. Aust.; Victoria; N.S.W.; Queensland.

18. AGRIOMYIA VIVIDA (Smith), 1879.

Thynnus vividus, Smith, 1879: 161 (♂); D.T., 1897: 118 (♂). *T.* (*Agriomyia*) *vividus*, Turner, 1908: 157 (♂). Swan River, W. Aust.

19. AGRIOMYIA (?) ATTENUATA (Smith), 1859.

Thynnus attenuatus, Smith, 1859: 42 (♀); D.T., 1897: 102 (♀). *T.* (*Agriomyia*) *attenuatus*, Turner, 1908: 167 (♀). Australia.

20. AGRIOMYIA BISECTA Turner, 1910.

Turner, 1910*a*: 109 (♀). Cooktown, Q. Type in Hung. Nat. Mus.

Genus 11. ASTHENOTHYNNUS Turner, 1910.

Thynnus, Auctorum (pars). *Thynnus*, subgenus *Aeolothynnus*, Turner (pars), 1908: 113. *Asthenothynnus*, Turner, 1910*c*: 34.

Type species, *Asthenothynnus pulchellus* (Klug).

1. ASTHENOTHYNNUS BEATRIX (Turner), 1908.

Thynnus (*Aeolothynnus*) *beatrix*, Turner, 1908: 120 (♂, ♀). Leura, Mittagong, N.S.W.

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* See *Hemithynnus affinis* (Guérin) (p. 299).

2. ASTHENOTHYNNUS DECORATUS (Smith), 1879.

Thynnus decoratus, Smith, 1879: 159 (♂); D.T., 1897: 104 (♂). *T.* (*Aeolothynnus*) *decoratus*, Turner, 1908: 122 (♂). Adelaide, S. Aust.

3. ASTHENOTHYNNUS DEDUCTOR Turner, 1910.

Turner, 1910*b*: 273 (♂). Claremont, W. Aust.

ASTHENOTHYNNUS EXIGUUS (see below, No. 22).

4. ASTHENOTHYNNUS GENEROSUS (Turner), 1908.

Thynnus (*Aeolothynnus*) *generosus*, Turner, 1908: 119 (♂, ♀). Adelaide, S. Aust.

5. ASTHENOTHYNNUS INNOCUUS (Turner), 1908.

Thynnus (*Aeolothynnus*) *innocuus*, Turner, 1908: 118 (♂). Perth, W. Aust.

6. ASTHENOTHYNNUS LILLIPUTIANUS Turner, 1915.

Turner, 1915*a*: 57 (♂, ♀). Yallingup, South-west Aust.

7. ASTHENOTHYNNUS MARITIMUS Turner, 1915.

Turner, 1915*b*: 544 (♂, ♀). Eaglehawk Neck, Swansea, Tasm.

8. ASTHENOTHYNNUS MINUTUS (Smith), 1859.

Thynnus (*Agriomyia*) *minutus*, Smith, 1859; 35 (♂). *T. minutus*, D.T., 1897: 111 (♂). *T.* (*Aeolothynnus*) *minutus*, Turner, 1908: 116 (♂). North-west Coast of Australia.

9. ASTHENOTHYNNUS PENETRATUS (Smith), 1879.

Thynnus penetratus, Smith, 1879: 158 (♂); D.T., 1897: 113 (♂). *T.* (*Aeolothynnus*) *penetratus*, Turner, 1908: 120 (♂). Swan River, W. Aust.

10. ASTHENOTHYNNUS PLEURALIS Turner, 1915.

Turner, 1915*a*: 58 (♂, ♀). Yallingup, Kalamunda, South-west Australia.

11. Type Species. ASTHENOTHYNNUS PULCHELLUS (Klug), 1842.

Thynnus pulchellus, Klug, 1840/42: 20 (♂). *T.* (*Agriomyia*) *pulchellus*, Smith, 1859: 25 (♂). *T. multipictus*, Smith, 1879: 160 (♂). *T. pulchellus*, D.T., 1897: 114 (♂). *T. multipictus*, D.T., 1897: 111 (♂). *T.* (*Aeolothynnus*) *pulchellus*, Turner, 1908: 114 (♂, ♀ in cop.). *Asthenothynnus pulchellus*, Turner, 1910*c*: 34. N.S.W. and Victoria.

12. ASTHENOTHYNNUS PULCHERRIMUS (Turner), 1908.

Thynnus (*Aeolothynnus*) *pulcherrimus*, Turner, 1908: 115 (♂, ♀). Wattle Flat, N.S.W. Type in Coll. Froggatt.

13. ASTHENOTHYNNUS PYGMAEUS (Turner), 1908.

Thynnus (*Aeolothynnus*) *pygmaeus*, Turner, 1908: 117 (♂). Victoria.

14. ASTHENOTHYNNUS RUBROMACULATUS (Turner), 1908.

Thynnus (*Aeolothynnus*) *rubromaculatus*, Turner, 1908: 118 (♂). Wattle Flat, N.S.W., and Victoria.

15. ASTHENOTHYNNUS TENUIS (Turner), 1908.

Thynnus (*Aeolothynnus*) *tenuis*, Turner, 1908: 117 (♂). Mackay, Queensland.

16. ASTHENOTHYNNUS VICARIUS Turner, 1915.

Turner, 1915*a*: 56 (♂, ♀). Yallingup, South-west Aust.

17. ASTHENOTHYNNUS WESTWOODI (Guérin), 1842.

Agriomyia westwoodii, Guérin, 1842: 4, Pl. 99–105 (♂). *Thynnus westwoodii*, Smith, 1859: 24. *T. intricatus*, Smith, 1859: 30 (♂). *T. longiceps*, Smith, 1859: 46 (♀). *T. nanus*, Smith, 1879: 171 (♂). *T. intricatus*, D.T., 1897: 110. *T. nanus*, D.T., 1897: 111. *T. westwoodi*, D.T., 1897: 118. *T.* (*Aeolothynnus*) *westwoodi*, Turner, 1908: 113 (♂, ♀). *Asthenothynnus westwoodi*, Turner, 1915*b*: 544; Guiglia, 1948: 176. Tasmania; Victoria; Mittagong, N.S.W.

18. ASTHENOTHYNNUS (?) INCENSUS (Smith), 1868.

Thynnus (*Agriomyia*) *incensus*, Smith, 1868: 236 (♂). *T. incensus*, D.T., 1897: 108 (♂). *T.* (*Agriomyia*) *incensus*, Turner, 1908: 167 (♂). Champion Bay, W. Aust.

19. ASTHENOTHYNNUS (?) LEUCOSTICUS (Turner), 1908.

Thynnus (*Zeleboria*) *leucosticus*, Turner, 1908: 107 (♂). *Asthenothynnus leucosticus*, Turner, 1910*c*: 35 (♀, ?). Yass, N.S.W. Type in Coll. Froggatt.

20. ASTHENOTHYNNUS (?) PLANIVENTRIS (Turner), 1908.

Thynnus (*Aeolothynnus*) *planiventris*, Turner, 1908: 121 (♂). Western Australia.

21. ASTHENOTHYNNUS (?) QUADRICARINATUS (Saussure), 1867.

Thynnus quadricarinatus, Saussure, 1868: 124 (♀); D.T., 1897: 114 (♀). *T.* (*Aeolothynnus*) *quadricarinatus*, Turner, 1908: 116 (♀). Sydney.

22. ASTHENOTHYNNUS EXIGUUS (Turner), 1910.

Thynnus (*Aeolothynnus*) *exiguus*, Turner, 1910*a*: 111 (♂). Sydney.

23. ASTHENOTHYNNUS LACTARIUS (Turner), 1910.

Thynnus (*Aeolothynnus*) *lactarius*, Turner, 1910*a*: 112 (♂, ♀). Blue Mts., N.S.W. Type in Hung. Nat. Mus.

Genus 12. LEIOTHYNNUS Turner, 1910.

Thynnus, subgenus *Aeolothynnus* (pars), Turner. *Leiothynnus*, Turner, 1910*c*: 35. Type species, *Leiothynnus mackayensis* (Turner).

1. Type Species. LEIOTHYNNUS MACKAYENSIS Turner, 1908.

Thynnus (*Aeolothynnus*) *mackayensis*, Turner, 1908: 123 (♂, ♀). Mackay, Q'land.

2. LEIOTHYNNUS SPINIGERUS Turner, 1912.

Turner, 1912*b*: 534 (♂, ♀). Stradbroke Is., Moreton Bay, Q'land.

Genus 13. ASPIDOTHYNNUS Turner, 1910.

Turner, 1910*c*: 36.

Type species, *Aspidothynnus combustus* (Smith), 1859.

1. Type Species. ASPIDOTHYNNUS COMBUSTUS (Smith), 1859.

Thynnus (*Agriomyia*) *combustus*, Smith, 1859: 32 (♂). *T. combustus*, D.T., 1897: 104. *T.* (*Aeolothynnus*) *combustus*, Turner, 1908: 135 (♂). Adelaide, S. Aust.

2. ASPIDOTHYNNUS FOSSULATUS Turner, 1915.

Turner, 1915*a*: 55 (♂, ♀). Yallingup, South-west Australia.

3. ASPIDOTHYNNUS POLYBIOIDES (Turner), 1908.

Thynnus (*Aeolothynnus*) *polybioides*, Turner, 1908: 124 (♂). South Australia; Wimmera, Victoria.

4. ASPIDOTHYNNUS ROSTRATUS (Turner), 1908.

Thynnus (*Aeolothynnus*) *rostratus*, Turner, 1908: 134 (♂). Victoria.

Genus 14. GYMNOTHYNNUS Turner, 1910.

Turner, 1910: 36.

Type species, *Gymnothynnus gilberti* (Turner).

1. GYMNOTHYNNUS CARISSIMUS Turner, 1915.

Turner, 1915*a*: 53 (♂, ♀). Kalamunda, S.W. Aust.

2. Type Species. GYMNOTHYNNUS GILBERTI Turner, 1908.

Thynnus (*Aelothynnus*) *gilberti*, Turner, 1908: 153 (♂, ♀). Port Darwin. *Gymnothynnus gilberti*, Turner, 1910: 37, Pl. 2, fig. 43.

3. GYMNOTHYNNUS (?) LESOEUFI Turner, 1910.

Turner, 1910*b*: 280 (♂, ♀). South Perth, W. Aust.

4. GYMNOTHYNNUS (?) MUCRONATUS Turner, 1915.

Turner, 1915*a*: 54, Pl. I, figs. 15, 16. Cunderdin, W. Aust.

5. GYMNOTHYNNUS (?) TRIANGULICEPS Turner, 1910.

Turner, 1910*b*: 281, Pl. 31, fig. 4 (♀).

Genus 15. EPACTIOTHYNNUS Turner, 1910.

Turner, 1910*c*: 37.

Type species, *Epactiothynnus opaciventris* (Turner) = *Epactiothynnus crabroniformis* (Smith).

1. EPACTIOTHYNNUS ABDUCTOR (Smith), 1865.

Thynnus abductor, Smith, 1865*a*: 78 (♂). *T.* (?) *laevissimus*, Smith, 1865*a*: 77 (♀). *T. candidus*, Smith, 1879: 171 (♂); D.T., 1897: 103 (♂). Morty Is. Archipelagus. *T. levissimus*, D.T., 1897: 110 (♀). New Guinea. *T. abductor*, D.T., 1897: 100 (♂). Salwatty; New Guinea. *T.* (*Aeolothynnus*) *abductor*, Turner, 1908: 252 (♂). *T.* (*Aeolothynnus*) *laevissimus*, Turner, 1908: 252 (♀). New Guinea. *T. papuanus*, Cameron, 1911: 187 (♂). *Epactiothynnus abductor* Turner, 1940*a*: 93 (♂, ♀). Dutch New Guinea, Cyclops Mts.

2. EPACTIOTHYNNUS BEMBECULUS (Turner), 1908.

Thynnus (*Aeolothynnus*) *bembeculus* Turner, 1908: 126 (♂). Cooktown, Queensland.

3. EPACTIOTHYNNUS BIPARTITUS (Turner), 1908.

Thynnus (*Aeolothynnus*) *bipartitus*, Turner, 1908: 139 (♂, ♀). Cairns and Mackay, Queensland.

4. EPACTIOTHYNNUS COLORATUS (Turner), 1908.

Thynnus (*Aeolothynnus*) *coloratus*, Turner, 1908: 128 (♂, ♀). Mackay, Queensland.

5. EPACTIOTHYNNUS CONJUNGENS (Turner), 1908.

Thynnus (*Aeolothynnus*) *conjungens*, Turner, 1908: 130 (♂, ♀). Mackay, Queensland.

6. Type Species. EPACTIOTHYNNUS CRABRONIFORMIS (Smith), 1859.

Thynnus (*Agriomyia*) *crabroniformis*, Smith, 1859: 37 (♂). *T. crabroniformis*, D.T., 1897: 104 (♂). *T.* (*Agriomyia*) *crabroniformis*, Turner, 1908: 138 (♂); subspecies *opaciventris*, Turner, 1908: 138–9 (♂, ♀). *Epactothynnus opaciventris*, Turner, 1910*c*: 37, Pl. 1, figs. 23–24, Pl. 4, figs. 79–80; Williams, 1919: 160–2. Cairns, Queensland.

7. EPACTIOTHYNNUS CYGNORUM (Turner), 1908.

Thynnus (*Aeolothynnus*) *cygnorum*, Turner, 1908: 141 (♂). *Epactiothynnus cygnorum*, Turner, 1910*b*: 276 (♀). Champion Bay, Claremont, W. Aust.

8. EPACTIOTHYNNUS DAHLI Turner, 1910.

Turner, 1910*b*: 278 (♂, ♀). Ralum, New Britain. Type in Berlin Museum.

9. EPACTIOTHYNNUS EXCELLENS (Smith), 1879.

Thynnus excellens, Smith, 1879: 163 (♂). Swan Rv., W.A.; D.T., 1897: 106 (♂). *T.* (*Aeolothynnus*) *excellens*, Turner, 1908: 136 (♂). Swan River, W.A.

10. EPACTIOTHYNNUS EXCELSUS (Turner), 1908.

Thynnus (*Aeolothynnus*) *excelsus* Turner, 1908: 136 (♂). Port Darwin.

11. EPACTIOTHYNNUS JARDINEI (Turner), 1908.

Thynnus (*Aeolothynnus*) *jardinei*, Turner, 1908: 126 (♂). Cape York, Queensland.

12. EPACTIOTHYNNUS LABORIOSUS Turner, 1910.

Turner, 1910: 277 (♂, ♀). Claremont, W. Aust.

13. EPACTIOTHYNNUS MULTICOLOR Turner, 1916.

Turner, 1916: 119 (♂). Oxley, near Brisbane, Queensland.

14. EPACTIOTHYNNUS NITIDICEPS Turner, 1912.

Turner, 1912*a*: 535 (♂, ♀). Aru Island.

15. EPACTIOTHYNNUS PRODUCTUS (Turner), 1908.

Thynnus (*Aeolothynnus*) *productus*, Turner, 1908: 127 (♂). North-west Australia.

16. EPACTIOTHYNNUS QUADRATUS (Smith), 1859.

Thynnus quadratus, Smith, 1859: 42 (♀); D.T., 1897: 114 (♀). *T.* (*Aeolothynnus*) *quadratus*, Turner, 1908: 141 (♀). N.W. Australia.

17. EPACTIOTHYNNUS TASMANIENSIS (Saussure), 1867.

Thynnus (*Agriomyia*) *tasmaniensis*, Sauss., 1867: 119 (♂). *T. tasmaniensis*, D.T., 1897: 116 (♂). Tasmania. *T.* (*Aeolothynnus*) *tasmaniensis*, Turner, 1908: 129 (♂, ♀). Type of ♀ in Oxford Museum.

18. EPACTIOTHYNNUS VAGANS (Smith), 1862.

Thynnus (*Agriomyia*) *vagans*, Smith, 1862: 51 (♂). Celebes; Smith, 1877: 83 (♀). Celebes; D.T., 1897: 117 (♀, ♂); Schulz, 1906: 161. *T.* (*Aeolothynnus*) *vagans*, Turner, 1908: 252. Celebes.

19. EPACTIOTHYNNUS (?) ARENICOLUS (Turner), 1908.

Thynnus (*Aeolothynnus*) *arenicolus*, Turner, 1908: 134 (♂). Killalpanima, S.A., east of Lake Eyre.

20. EPACTIOTHYNNUS (?) PAVIDUS (Smith), 1879.

Thynnus pavidus, Smith, 1879: 166 (♂, ♀); D.T., 1897: 112 (♂, ♀). *T.* (*Aeolothynnus*) *pavidus*, Turner, 1908: 135 (♂, ♀). South Australia.

21. EPACTIOTHYNNUS (?) TENUICORNIS (Smith), 1859.

Myzine tenuicornis, Smith, 1859*b*: 151 (♂). Aru.

Genus 16. TMESOTHYNNUS Turner, 1910.

Turner, 1910*c*: 38.

Type species, *Tmesothynnus zelebori* (Saussure), 1867.

1. TMESOTHYNNUS COLLARIS (Guérin), 1842.

Lophocheilus (?) *collaris*, Guérin, 1842: 13 (♂). *Lophocheilus collaris*, Westwood, 1844: 103 (♂). *Thynnus* (*Lophocheilus*) *collaris*, Smith, 1859: 40 (♂). (?) *Tachynomyia nitens*, Saussure, 1867: 125, Pl. 4, fig. 65 (♂). *Thynnus collaris*, D.T., 1897: 103 (♂). *Thynnus nitens*, D.T., 1897: 112 (♂). *Thynnus* (*Aeolothynnus*) *collaris*, Turner, 1908: 133 (♂). *Lophonocheilus collaris*, Guiglia, 1948: 177. Victoria and N.S.W.

2. TMESOTHYNNUS DISPERSUS (Turner), 1908.

Thynnus (*Aeolothynnus*) *dispersus*, Turner, 1908: 133 (♂).

3. TMESOTHYNNUS HUMILIS (Erichson), 1842.

Thynnus humilis, Erichson, 1842: 264 (♀); Westwood, 1844: 146 (♀); Smith, 1859: 19 (♀); D.T., 1897: 108 (♀); Turner, 1908: 250 (♀); Turner, 1910*c*: 56 (♀). *Tmesothynnus humilis*, Turner, 1915*b*: 547 (♂, ♀).

4. TMESOTHYNNUS INGREDIENS Turner, 1916.

Turner, 1916: 118 (♂, ♀). Brisbane.

5. TMESOTHYNNUS IRIDIPENNIS (Smith), 1859.

Thynnus (*Agriomyia*) *iridipennis*, Smith, 1859: 38 (♂, ♀). *T. strangulatus*, Smith, 1879: 166 (♂, ♀). *T. iridipennis*, D.T., 1897: 109 (♀, ♂). *T. strangulatus*, D.T., 1897: 116 (♀, ♂). *T.* (*Aeolothynnus*) *iridipennis*, Turner, 1908: 132 (♂, ♀). Adelaide, S.A.; Lower Plenty, Victoria.

6. TMESOTHYNNUS PLATYCEPHALUS Turner, 1910.

Turner, 1910*b*: 275 (♂, ♀). South Perth, W.A.

7. TMESOTHYNNUS TRUNCATUS (Smith), 1859.

Thynnus (*Agriomyia*) *truncatus*, Smith, 1859: 38 (♂). *T. truncatus*, D.T., 1897: 117. *T.* (*Aeolothynnus*) *truncatus*, Turner, 1908: 131 (♂). Lower Plenty, Victoria (Type lost).

8. Type Species. TMESOTHYNNUS ZELEBORI (Saussure), 1867.

Thynnus (*Agriomyia*) *zelebori*, Saussure, 1867: 117 (♂). *T. zelebori*, D.T., 1897: 119 (♂). *T.* (*Aeolothynnus*) *zelebori*, Turner, 1908: 130 (♀). Sydney; Blue Mts.

Genus 17. THYNNOTURNERIA Rohwer, 1910.

Aeolothynnus, Ashmead, 1903: 101 (*Aeolothynnus multiguttatus* Ashmead). *Thynnus*, subgenus *Aeolothynnus*, Turner, 1908: 113. *Aeolothynnus*, Turner, 1910*c*: 39. *Turnerella*, Rohwer, 1910*a*: 349. *Thynnoturneria*, Rohwer, 1910*b*: 474. *Eurohweria*, Turner, 1911*b*: 608. *Thynnoturneria*, Turner, 1912*a*: 49.

Type species, *Thynnoturneria cerceroides* (Smith).

1. THYNNOTURNERIA ABLATA (Turner), 1908.

Thynnus (*Aeolothynnus*) *ablatus*, Turner, 1908: 148 (♂, ♀). South Australia.

2. THYNNOTURNERIA ARMIGER (Turner), 1908.

Thynnus (*Aeolothynnus*) *armiger*, Turner, 1908: 152 (♂, ♀). Mittagong, N.S.W. Types in Coll. Froggatt.

3. THYNNOTURNERIA ATERRIMA (Smith), 1879.

Thynnus aterrimus, Smith, 1879: 164 (♂); D.T., 1897: 102 (♂). *T.* (*Aeolothynnus*) *aterrimus*, Turner, 1908: 154 (♂). Swan River, W. Aust.

4. THYNNOTURNERIA BACCATA (Smith), 1868.

Thynnus (*Agriomyia*) *baccatus*, Smith, 1868: 236 (♂). *T. baccatus*, D.T., 1897: 102 (♂). *T.* (*Aeolothynnus*) *baccatus*, Turner, 1908: 147 (♂). Champion Bay, W. Aust.

5. THYNNOTURNERIA CENTRALIS Turner, 1912.

Turner, 1912*a*: 50 (♂). Hermannsburg, Central Australia.

6. Type Species. THYNNOTURNERIA CERCEROIDES (Smith), 1859.

Thynnus (*Agriomyia*) *cerceroides*, Smith, 1859: 34 (♂). *T. perelegans*, Smith, 1879: 167 (♂). *T. cerceroides*, D.T., 1897: 103 (♂). *T. perelegans*, D.T., 1897: 113 (♂). *T.* (*Aeolothynnus*) *cerceroides* Turner, 1908: 149 (♂, ♀). *Aeolothynnus cerceroides*, Turner, 1910*c*: 39.

Turnerella, n.n. for *Aeolothynnus*, Rohwer, 1910*a*: 349. *Thynnoturneria*, n.n. for *Aeolothynnus*, Rohwer, 1910*b*: 474. *Eurohweria*, n.n. for *Aeolothynnus*, Turner, 1911: 608. Sydney, Mackay, Cairns, Cape York.

7. THYNNOTURNERIA COMPRESSICEPS (Turner), 1911.

Eurohweria compressiceps, Turner, 1911: 611 (♂, ♀). Kuranda, Q'land.

8. THYNNOTURNERIA CRENULATA (Turner), 1910.

Aeolothynnus crenulatus, Turner, 1910*b*: 274 (♂), Pl. 31, fig. 8. Hermannsburg, Central Australia.

9. THYNNOTURNERIA DECIPIENS (Westwood), 1844.

Thynnus decipiens, Westwood, 1844: 105, 124 (♂); Smith, 1859: 18 (♂). *Thynnus* (*Aeolothynnus*) *decipiens*, Turner, 1908: 150 (♂). *Aeolothynnus decipiens*, Turner, 1910*c*: 39 (♂). *Thynnoturneria decipiens*, Turner, 1915*b*: 547 (♂). Tasmania.

10. THYNNOTURNERIA DIMIDIATUS (Westwood), 1844.

Thynnus (*Thynnoides*) *dimidiatus*, Westwood, 1844: 121, Pl. 76, f. 5. *T. dimidiatus*, Smith, 1859: 17 (♂). *T. heinricheri*, D.T., 1897: 108 (♂). *T.* (*Aeolothynnus*) *dimidiatus*, Turner, 1908: 137 (♂). Albany, W. Aust.

11. THYNNOTURNERIA HALOPHILA (Turner), 1909.

Thynnus (*Aeolothynnus*) *halophilus*, Turner, 1909: 139 (♂). Cape York, Queensland.

12. THYNNOTURNERIA ILLUSTRIS (Kirby), 1898.

Rhagigaster illustris, Kirby, 1898: 207 (♂). *Thynnus* (*Aeolothynnus*) *illustris*, Turner, 1908: 148 (♂). *Aeolothynnus illustris*, Turner, 1910*c*: Pl. 4, fig. 81 (♂).

13. THYNNOTURNERIA IMMITIS (Turner), 1911.

Eurohweria immitis, Turner, 1911: 612 (♂, ♀). Kuranda, Queensland.

14. THYNNOTURNERIA MYOLA (Turner), 1911.

Eurohweria myola, Turner, 1911: 609 (♂, ♀). Kuranda, Queensland.

15. THYNNOTURNERIA PENTADONTA (Turner), 1911.

Eurohweria pentadonta, Turner, 1911: 608 (♂, ♀). Kuranda, Queensland.

16. THYNNOTURNERIA PERTURBATA (Turner), 1910.

Aeolothynnus perturbatus, Turner, 1910*b*: 274 (♂). Hermannsburg, Central Australia.

17. THYNNOTURNERIA SANGUINOLENTA (Turner), 1908.

Thynnus (*Aeolothynnus*) *sanguinolentus*, Turner, 1908: 151 (♂, ♀). Liverpool, N.S.W. Types in Coll. Froggatt.

18. THYNNOTURNERIA SAUNDERSI (Turner), 1908.

Thynnus (*Aeolothynnus*) *saundersi*, Turner, 1908: 155 (♂). Adelaide (?). Type in Oxford Museum.

19. THYNNOTURNERIA TRIMACULATA Turner, 1912.

Turner, 1912*a*: 49 (♂). Hermannsburg, Central Australia.

20. THYNNOTURNERIA UMBRIPENNIS (Smith), 1859.

Thynnus (*Agriomyia*) *umbripennis*, Smith, 1859: 31 (♂). *T. umbripennis*, D.T., 1897: 117 (♂). *T.* (*Aeolothynnus*) *umbripennis*, Turner, 1908: 153 (♂). Wimmera, Victoria.

21. THYNNOTURNERIA XEROPHILA Turner, 1940.

Turner, 1940*b*: 101 (♂, ♀). Dedari (Coolgardie), W. Aust.

22. THYNNOTURNERIA (?) EYRENSIS (Turner), 1908.

Thynnus (*Aeolothynnus*) *eyrensis*, Turner, 1908: 146 (♂). Killalpanima, S. Aust., 100 miles east of Lake Eyre.

Genus 18. ACANTHOTHYNNUS Turner, 1910.

Thynnus (*Aeolothynnus*) pars, Turner. *Acanthothynnus*, Turner, 1910: 40.

Type species, *Acanthothynnus sannae* Turner.

1. ACANTHOTHYNNUS CLEMENTI (Turner), 1908.

Thynnus (*Aeolothynnus*) *clementi*, Turner, 1908: 145 (♂). Nickol Bay, W. Aust.

2. Type Species. ACANTHOTHYNNUS SANNAE (Turner), 1908.

Thynnus (*Aeolothynnus*) *sannae*, Turner, 1908: 142 (♂, ♀). *Acanthothynnus sannae*, Turner, 1910: 40, Pl. 1, f. 25–26, Pl. 2, f. 44. Cape York, Queensland (♂, ♀ in cop.).

Genus 19. DORATITHYNNUS Turner, 1910.

Thynnus (*Agriomyia*) pars, Smith, 1859. *Thynnus* (*Aeolothynnus*) pars, Turner, 1908. *Doratithynnus*, Turner, 1910*c*: 41.

Type species, *Doratithynnus doddii* Turner.

1. DORATITHYNNUS BIDENTATUS (Smith), 1859.

Thynnus (*Agriomyia*) *bidentatus*, Smith, 1859: 32 (♂). *T. bidentatus*, D.T., 1897: 102 (♂). *T.* (*Aeolothynnus*) *bidentatus*, Turner, 1908: 143 (♂); subspec. *orientalis*, Turner, 1908: 144 (♂). Wimmera, Victoria.

2. Type Species. DORATITHYNNUS DODDII (Turner), 1908.

Thynnus (*Aeolothynnus*) *doddii*, Turner, 1908: 144 (♂, ♀). Townsville, Queensland.

3. DORATITHYNNUS SPRAYI Turner, 1913.

Turner, 1913: 615 (♂). Kychering Soak. S. Aust.

Genus 20. ENCOPOTHYNNUS Turner, 1915.

Turner, 1915*a*: 52.

Type species, *Encopothynnus spinulosus* Turner.

1. ENCOPOTHYNNUS ATRIFACIES Turner, 1937.

Turner, 1937: 147 (♂, ♀). Merredin, W. Aust.

2. Type Species. ENCOPOTHYNNUS SPINULOSUS Turner, 1915.

Turner, 1915*a*: 52 (♂, ♀), Pl. 1, figs. 9, 10. Kalamunda, Darling Ranges, South-west Aust.

Genus 21. CATOCHEILUS Guérin, 1842.

Guérin, 1842: 8, Pl. 102, figs. 1–14; Westwood, 1844: 103; Ashmead, 1903: 100; Turner, 1908: 168; Turner, 1910*c*: 41.

Type species, *Catocheilus klugii* Guérin.

1. CATOCHEILUS IMMODESTUS (Turner), 1908.

Thynnus (*Lophocheilus*) *immodestus*, Turner, 1908: 187 (♂, ♀). Swan River, W.A.

2. Type Species. CATOCHEILUS KLUGII Guérin.

Guér., 1842: 8 (♂, ♀), Pl. 102, f. 1–14; Westwood, 1844: 140. *Thynnus* (*Catocheilus*) *diversus*, Smith, 1859: 41. *T. perplexus*, Smith, 1879: 164 (♂, ♀). *T. klugii*, D.T., 1897: 109 (♀, ♂). *T. perplexus*, D.T., 1897: 113 (♀, ♂). *T.* (*Catocheilus*) *klugii*, Turner, 1908: 168; Ashmead, 1903: 100 (♂), 104 (♀). *Catocheilus perplexus*, Turner, 1910: 42 (♂, ♀), Pl. 2, f. 45. *C. klugii*, Guiglia, 1948: 176. Swan River, W. Aust.

Genus 22. HEMITHYNNUS Ashmead, 1903.

Ashmead, 1903: 101. *Myrmecodes*, Ashmead, 1903: 100 (*nec* Latreille). *Thynnus*, Auctorum (pars). *Hemithynnus*, Turner, 1910*c*: 42.

Type species, *Hemithynnus apterus* (Olivier). Synonym for *H. hyalinatus* (Westwood).

1. HEMITHYNNUS AFFINIS (Guérin), 1838.

Thynnus affinis, Guér., 1830 (1839): 226 (♂). Port du Roi Georges; Klug, 1842: 18 (♂); Westwood, 1844: 102 (♂); Smith, 1859: 12 (♂); D.T., 1897: 101 (♂). *T.* (*Lophocheilus*) *affinis*, Turner, 1908: 193. *Hemithynnus affinis*, Bequaert, 1926: 189. *Agriomyia affinis*, Guiglia, 1948: 176. *Thynnus affinis*, Guiglia, 1948: 177. Albany, W. Aust.

2. HEMITHYNNUS ANNULATUS (Kirby), 1818.

Thynnus annulatus, Kirby, 1818: 476 (♂). *T. brownii*, Leach, 1819: 178 (♂). *Myrmecodes australis*, Griffith, Pidgeon and Gray, 1832: 516 (♀). *Thynnus annulatus*, Guérin, 1838: 228 (♂). *T. grayi*, Guérin, 1838: 231 (♀). *T. annulatus*, Klug, 1840/2: 17 (♂). *T. australis*, Klug, 1840/2: 18 (♀). *T. annulatus*, Westwood, 1844: 102. *T. brownii*, Westwood, 1844: 113, Pl. 76, fig. 1 (♂). *T. annulatus*, Smith, 1859: 14 (♂). *T. brownii*, D.T., 1897: 103 (♂). *T. annulatus*, D.T., 1897: 101 (♂). *T.* (*Lophocheilus*) *annulatus*, Turner, 1908: 193 (♂, ♀). *Hemithynnus annulatus*, Turner, 1910*c*: 43; Bequaert, 1926: 189. South-west Australia.

3. Type Species. HEMITHYNNUS APTERUS (Olivier), 1811.

Myzine aptera, Olivier, 1811: 137 (♀). *Thynnus dentatus*, Jurine, 1807: 179 (♂). *T. variabilis*, Kirby, 1818: 476 (♂); Leach, 1819: 178 (♂). *Myrmecodes flavoguttatus*, Latreille, 1819: 143 (♀). *Thynnus variabilis*, MacLeay, 1826: 127 (♂). *T. apterus*, Guérin, 1830/39: 230 (♀). *T. variabilis*, Guérin, 1830/39: 223 (♂). *T. flavoguttatus*, Guérin, 1830/39: 230 (♂). *T. variabilis*, Klug, 1840/42: 16 (♂, ♀). *T. olivieri*, Erichson, 1842: 262 (♂, ♀). *T. variabilis*, Guérin, 1842: 6 (♂, ♀), Pl. 101; Westwood, 1844: 102 (♂). *Myrmecodes flavoguttatus*, Westwood, 1844: 102 (♀ of above). *Thynnus apterus*, Westwood, 1844: 102 (♀ of above). *T. hyalinatus*, Westwood, 1844: 106, Pl. 74, f. 3–4. *T. olivieri*, Westwood, 1844: 146 (♂, ♀). *T. westwoodi*, Lepeletier, 1845, 568, Pl. 35, f. 6 (♂). *Myrmecodes olivieri*, Lepeletier, 1845: 588 (♀). *Mutilla* (*Myrmecodes*) *olivieri*, Blanchard, 1849: T. 118, f. 9. *Thynnus hyalinatus*, Smith, 1859: 16 (♂, ♀). *T. variabilis*, Smith, 1859: 12 (♂, ♀). *T. olivieri*, Smith, 1859: 18 (♂, ♀). *T. variabilis*, Macleay, 1863: vi; Hinds, 1863: vii (♂). *T. audax*, Smith, 1868: 234 (♂). *T. apterus*, D.T., 1897: 101 (♀, ♂). *T. audax*, D.T., 1897: 102 (♂). *T. hyalinatus*, D.T., 1897: 108 (♀, ♂). *T. olivieri*, D.T., 1897: 112 (♀, ♂). *T. graffii*, D.T., 1897: 107 (♂). *Hemithynnus hyalinatus*, Ashmead, 1903: 101 (♂), 107 (♀). *Thynnus* (*Lophocheilus*) *apterus*, Turner, 1908: 191. *T.* (*Lophocheilus*) *hyalinatus*, Turner, 1908: 192. *Hemithynnus hyalinatus*, Turner, 1910*c*: 42. *H. olivieri*, Turner, 1915*b*: 548. Southern Australia, from Albany to Southern Queensland.

4. HEMITHYNNUS AUSTRALIS (Boisduval), 1833.

Thynnus australis, Boisduval, 1833: 655, Pl. 12, fig. 2 (♂); Guérin, 1830 (1839): 228; Westw., 1844: 102. *T.* (*Lophocheilus*) *australis*, Turner, 1908: 187. Port Western.

5. HEMITHYNNUS CAELEBS (Saussure), 1867.

Tachynomyia caelebs, Saussure, 1867: 125 (♂). *Thynnus wieseri*, D.T., 1897: 118 (♂). *T.* (*Lophocheilus*) *wieseri*, Turner, 1908: 178 (♂). *Hemithynnus caelebs*, Turner, 1910*c*: 43 (♂). Australia.

6. HEMITHYNNUS CONNECTENS (Smith), 1859.

Thynnus connectens, Smith, 1859: 45 (♀); D.T., 1897: 104 (♀). *T.* (*Lophocheilus*) *connectens*, Turner, 1908: 188 (♀). Perth, W.A. *T. oppositus*, Smith, 1879: 162 (♂); D.T., 1897: 112 (♂). *T.* (*Lophocheilus* ?) *oppositus*, Turner, 1908: 191 (♂). *Hemithynnus connectens*, Turner, 1940*b*: 99. Yallingup, S.W. Aust.

7. HEMITHYNNUS CRINITUS (Turner), 1908.

Thynnus (*Lophocheilus*) *crinitus*, Turner, 1908: 184 (♂, ♀). Melbourne, Victoria.

8. HEMITHYNNUS EXCORIATUS (Turner), 1908.

Thynnus (*Lophocheilus*) *excoriatus*, Turner, 1908: 177 (♂, ♀). Australia; N.S.W. and Victoria. Types in Coll. Froggatt.

9. HEMITHYNNUS FLAVIFRONS (Smith), 1865.

Rhagigaster flavifrons, Smith, 1865*b*: 390 (♀). *Thynnus flavifrons*, D.T., 1897: 106 (♀). *T.* (*Lophocheilus*) *flavifrons*, Turner, 1908: 180 (♀). Swan River, W.A.

10. HEMITHYNNUS FLAVIPENNIS (Smith), 1859.

Thynnus flavipennis, Smith, 1859: 21 (♂); D.T., 1897: 106 (♂). *T.* (*Lophocheilus*) *flavipennis*, Turner, 1908: 190 (♂, ♀). New South Wales.

11. HEMITHYNNUS HAMLYN–HARRISI Turner, 1912.

Turner, 1912: 538. Brisbane, Q'land.

12. HEMITHYNNUS INCONSTANS (Smith), 1859.

Thynnus (*Agriomyia*) *inconstans*, Smith, 1859: 26 (♂); D.T., 1897: 108. *T. signatus*, Smith, 1859: 44 (♀); D.T., 1897: 116; Saussure, 1867: 121 (♀). *T.* (*Lophocheilus*) *inconstans*, Turner, 1908: 189 (♂, ♀). South-east Australia.

13. HEMITHYNNUS KIRBYI (Turner), 1908.

Thynnus (*Lophocheilus*) *kirbyi*, Turner, 1908: 182 (♂, ♀). Cumberland County, N.S.W.

14. HEMITHYNNUS LIBES Montet, 1922.

Montet, 1922: 205 (♂). Australia.

15. HEMITHYNNUS MACULOSUS (Smith), 1859.

Thynnus maculosus, Smith, 1859: 16 (♂); D.T., 1897: 110 (♂). *T.* (*Lophocheilus*) *maculosus*, Turner, 1908: 192. Australia.

16. HEMITHYNNUS OPPOSITUS (Smith), 1879.

Thynnus oppositus, Smith, 1879: 162 (♂); D.T., 1897: 112 (♂). *T.* (*Lophocheilus* ?) *oppositus*, Turner, 1908: 191 (♂). Swan River, W. Aust.

17. HEMITHYNNUS PETULANS (Smith), 1879.

Thynnus petulans, Smith, 1879: 164 (♂); D.T., 1897: 113 (♂). *T.* (*Lophocheilus*) *petulans*, Turner, 1908: 178 (♂). *Hemithynnus petulans*, Turner, 1910*b*: 282, Pl. XXXI, figs. 5 and 6 (♀). Swan River, W. Aust.

18. HEMITHYNNUS PRAESTABILIS Turner, 1910.

Hemithynnus praestabilis, Turner, 1910*b*: 281 (♂). West Australia.

19. HEMITHYNNUS PROTERVUS (Smith), 1879.

Thynnus protervus, Smith, 1879: 159 (♂, ♀); D.T., 1897: 114 (♂, ♀). *T.* (*Lophocheilus*) *protervus*, Turner, 1908: 178. Australia.

20. HEMITHYNNUS RUFIVENTRIS (Guérin), 1838.

Thynnus rufiventris, Guérin, 1830/39: 227 (♂); Klug, 1840/42: 19 (♂); Westwood, 1844: 102 (♂); Smith, 1859: 13 (♂, ♀); D.T., 1897: 115 (♂, ♀). *T.* (*Lophocheilus*) *rufiventris*, Turner, 1908: 185 (♂, ♀). *Hemithynnus rufiventris*, Bequaert, 1926: 188 (date, Guérin in Duperrey). *Thynnus rufiventris*, Guiglia, 1948: 177. Sydney, Goulburn, N.S.W.

21. HEMITHYNNUS SENEX (Smith), 1859.

Thynnus senex, Smith, 1859: 19 (♂). W. Australia; D.T., 1897: 115 (♂). *T.* (*Lophocheilus*) *senex*, Turner, 1908: 188 (♂). Western Australia.

22. HEMITHYNNUS TILLYARDI Turner, 1912.

Turner, 1912: 536 (♀, ♂). Dorrigo, N.S.W.

23. HEMITHYNNUS TUBERCULIVENTRIS (Westwood), 1844.

Thynnus tuberculiventris, Westwood, 1844: 118, Pl. 76, f. 2 (♂); Smith, 1859: 17 (♂); D.T., 1897: 117 (♂). *T.* (*Lophocheilus*) *tuberculiventris*, Turner, 1908: 184 (♂). Albany, W. Aust.; Victoria.

24. HEMITHYNNUS WALLISII (Smith), 1859.

Thynnus wallisii, Smith, 1859: 14 (♂, ♀); D.T., 1897: 118 (♂, ♀). *T.* (*Lophocheilus*) *wallisii*, Turner, 1908: 186 (♀). *Hemithynnus wallisii*, Turner, 1910*b*: 283. Sydney and Melbourne.

Genus 23. LOPHOCHEILUS Guérin, 1842.

Guérin, 1842: 11, Pl. 103, figs. 7–13; Westwood, 1844: 103; Ashmead, 1903: 158; Turner, 1908: 168; Turner, 1910*c*: 44.

Type species, *Lophocheilus villosus* Guérin.

1. LOPHOCHEILUS ANILITATIS (Smith), 1859.

Thynnus (*Agriomyia*) *anilitatis*, Smith, 1859: 37 (♂, ♀). *T. anilitatis*, D.T., 1897: 101 (♂, ♀). *T.* (*Lophocheilus*) *anilitatis*, Turner, 1908: 171 (♀). Melbourne.

2. LOPHOCHEILUS FERVENS (Smith), 1859.

Thynnus (*Agriomyia*) *fervens*, Smith, 1859: 31 (♂). *T. fervens*, D.T., 1897: 106 (♂). *T.* (*Lophocheilus*) *fervens*, Turner, 1908: 170 (♂). Australia.

3. LOPHOCHEILUS FROGGATTI (Turner), 1908.

Thynnus (*Lophocheilus*) *froggatti*, Turner, 1908: 181 (♂, ♀).

4. Lophocheilus laeviceps (Smith), 1859.

Thynnus laeviceps, Smith, 1859: 44 (♀). Australia; D.T., 1897: 110 (♀). *T. (Lophocheilus) laeviceps*, Turner, 1908: 181 (♀). *Lophocheilus laeviceps*, Turner, 1915*a*: 50 (♂, ♀). Yallingup, S.W. Aust.

5. Lophocheilus mamillatus (Turner), 1908.

Thynnus (Lophocheilus) mamillatus, Turner, 1908: 171 (♂). *Lophocheilus mamillatus*, Turner, 1915: 49 (♀). Fremantle, Yallingup, S.W. Aust.

6. Lophocheilus obscurus (Klug), 1842.

Thynnus obscurus, Klug, 1842: 22, Tab., f. 4 (♂). *T. (Thynnoides) obscurus*, Westwood, 1844: 138, Pl. 82, f. 2 (♀). *T. obscurus*, Saussure, 1867: 122 (♀); D.T., 1897: 112 (♀, ♂). *T. (Lophocheilus) obscurus*, Turner, 1908: 180 (♂, ♀); Kirby, 1898: 207. Victoria; Blue Mts., N.S.W.

7. Lophocheilus rubrocaudatus Turner, 1915.

Turner, 1915*a*: 51 (♂, ♀), Pl. 1, figs. 7 and 8. Yallingup, S.W. Aust.

8. Lophocheilus ruficeps Rohwer, 1925.

Rohwer, 1925: 415 (♀). Illawarra, N.S.W. Type in U.S. Nat. Mus.

9. Lophocheilus sylvanus Montet, 1922.

Montet, 1922: 209 (♂). Australia.

10. Type Species. Lophocheilus villosus Guérin, 1842.

Guérin, 1842: 12, Pl. 103 (♂); Westwood, 1844: 103. *Thynnus (Lophocheilus) villosus*, Smith, 1859: 40. *T. niger*, Smith, 1859: 30. *T. villosus*, D.T., 1897: 118. *T. niger*, D.T., 1897: 111. *Lophocheilus villosus*, Ashmead, 1903: 158 (♂). *Thynnus (Lophocheilus) villosus*, Turner, 1908: 169 (♂, ♀). *L. niger*, Turner, 1915*b*: 548. *Lophonocheilus villosus*, Guiglia, 1948: 177. Tasmania.

11. Lophocheilus (?) ambiguus (Turner), 1908.

Thynnus (Lophocheilus) ambiguus, Turner, 1908: 172 (♂, ♀). Australia (W. Macleay). Type in Oxford Museum.

12. Lophocheilus (?) saguineiventris Schulz, 1908.

Enteles sanguineiventris, Schulz, 1908: 455 (♂, ♀); Turner, 1910*c*: 44. Western Australia.

Genus 24. Macrothynnus Turner, 1908.

Thynnus, subgenus *Macrothynnus*, Turner, 1908: 72, 194. *Thynnus* Smith, partim. *Macrothynnus*, Turner, 1910*c*: 44.

Type species, *Macrothynnus simillimus* (Smith).

1. Macrothynnus insignis (Smith), 1859.

Thynnus insignis, Smith, 1859: 15 (♂); D.T., 1897: 109 (♂). *T. (Macrothynnus) insignis*, Turner, 1908: 195 (♂, ♀). Swan Rv. (Smith).

2. Macrothynnus iolieus Montet, 1922.

Montet, 1922: 212 (♀). Australia, occidentale.

3. Type Species. Macrothynnus simillimus (Smith), 1859.

Thynnus simillimus, Smith, 1859: 15 (♂); D.T., 1897: 116. *T. molitor*, Smith, 1859: 43 (♀); D.T., 1897: 111. *T. (Macrothynnus) simillimus*, Turner, 1908: 194 (♂, ♀). Sydney to Brisbane. *Macrothynnus simillimus*, Turner, 1910*b*: 283 (♂). South Perth.

Genus 25. Thynnoides Guérin, 1838.

Guérin, 1838: 214 and 232. *Thynnus (Thynnoides)*, Westwood, 1844: 102. *Thynnoides*, Ashmead, 1903: 99; Turner, 1910*c*: 45. *Thynnidea*, Rohwer, 1910*a*: 347.

Type species, *Thynnoides fulvipes* Guérin.

1. Thynnoides berthoudi Turner.

Turner, 1912*b*: 540 (♂).

2. Type Species. THYNNOIDES FULVIPES Guérin, 1838.

Thynnus (?) *rubripes*, Guérin's Atlas, 15/11/1831: Pl. 8, fig. 9. *Thynnoides fulvipes*, Guérin, 1838: 233 (♂). *Thynnoides rubripes*, Guérin, 1830/1839: 233 (♂). *Thynnus rubripes*, Klug, 1840/1842: 22 (♂). *Thynnus fulvipes*, Klug, 1840 (1842): 22 (♂). *Thynnus labiatus*, Klug, 1840 (1842): 23 (♂). *Thynnoides rubripes*, Guérin, 1842: 10, Pl. 102, f. 18. *Thynnoides fulvipes*, Guérin, 1842: 10, Pl. 102, figs. 15, 17 (♂). *Thynnoides rubripes*, Westwood, 1844: 102. *Thynnoides fulvipes*, Westwood, 1844: 102–3 (♂). *Thynnus* (*Thynnoides*) *fulvipes*, Smith, 1859: 22 (♂). *Thynnus* (*Agriomyia*) *moestus*, Smith, 1859: 36 (♂). *Thynnus labiatus*, D.T., 1897: 109. *Thynnus maestus*, D.T., 1897: 110. *Thynnoides fulvipes*, Ashmead, 1903: 99; Turner, 1908: 247 (♂, ♀); Turner, 1910: 45, 46; Rohwer, 1910*a*: 347; Guiglia, 1948: 177. *T. rubripes*, Guiglia, 1948: 177. Blue Mountains, N.S.W.

3. THYNNOIDES FUMIPENNIS (Westwood), 1844.

Thynnus (*Thynnoides*) *fumipennis*, Westwood, 1844: 108 (♂, ♀). *Thynnus fumipennis*, Smith, 1859: 22 (♂, ♀); D.T., 1897: 107 (♂, ♀). *Thynnoides fumipennis*, Ashmead, 1903: 98 (♂); Turner, 1908: 248 (♂); Rohwer, 1910*a*: 347. Melbourne to Sydney.

4. THYNNOIDES FUSCOCOSTALIS Turner, 1912.

Turner, 1912*b*: 540 (♂, ♀); Turner, 1915*a*: 48 (♂, ♀). Brisbane.

5. THYNNOIDES GRACILIS (Westwood), 1844.

Thynnus (*Thynnoides*) *gracilis*, Westwood, 1844: 139, Pl. 83, f. 2–3 (♂, ♀); Smith, 1859: 22. *T.* (*Thynnoides*) *bidens*, Saussure, 1867: 118, T. 4, f. 68 (♂, ♀). *T. viduus*, Saussure, 1867: 123, T. 4, f. 70 (♂, ♀). *T. bidens*, D.T., 1897: 102 (♂). *T. gracilis*, D.T., 1897: 107 (♀, ♂). *T. viduus*, D.T., 1897: 118 (♀). *T. dallatorrei*, Schulz, 1906: 160. *T. gracilis*, Turner, 1908: 249. *T. bidens*, Turner, 1909: 140. *Thynnoides gracilis*, Turner, 1910*c*: 46, Pl. 2, f. 52. Adelaide (River Murray).

6. THYNNOIDES LANIO Turner, 1910.

Turner, 1910*b*: 286 (♂, ♀). South Perth, W.A.

7. THYNNOIDES MESOPLEURALIS Turner, 1912.

Turner, 1912*b*: 539 (♂, ♀). Brisbane, Q'land.

8. THYNNOIDES NEPHELOPTERUS Turner, 1910.

Turner, 1910*b*: 285 (♂, ♀). South Perth, W.A.

9. THYNNOIDES PREISSII Turner, 1910.

Turner, 1910*b*: 284 (♂). Western Australia.

10. THYNNOIDES PUGIONATUS Guérin, 1838.

Guérin, 1830/39: 234 (♂). Nouvelle Hollande. *Thynnus pugionatus*, Klug, 1840/42: 23 (♂). *Thynnoides pugionatus*, Westwood, 1844: 102 (♂). *Thynnus* (*Thynnoides*) *pugionatus*, Smith, 1859: 22 (♂). *Thynnus pugionatus*, D.T., 1897: 114 (♂); Turner, 1908: 249 (♂, ♀). *Thynnoides pugionatus*, Bequaert, 1926: 189 (date Duperrey); Guiglia, 1948: 177. Sydney.

11. THYNNOIDES RUFI–ABDOMINALIS Rayment, 1935.

Rayment, 1935: 741, 193, Pl. 25*c*.

12. THYNNOIDES RUFITHORAX Turner, 1910.

Turner, 1910*b*: 284 (♀). Ararat, Victoria.

13. THYNNOIDES SENILIS (Erichson), 1842.

Thynnus (*Rhagigaster*) *senilis*, Erichson, 1842: 263 (♂). *T.* (*Agriomyia*) *senilis*, Smith, 1859: 25 (♂). *T. senilis*, D.T., 1897: 115 (♂); Turner, 1908: 248 (♂). *Thynnoides senilis*, Burrell, 1935: 20 (♂); Turner, 1915*b*: 549. Tasmania and Vict.

14. THYNNOIDES WATERHOUSEI (Turner), 1908.

Thynnus waterhousei, Turner, 1908: 244 (♂, ♀). Woodford, Blue Mts., N.S.W.

Genus 26. ELIDOTHYNNUS Turner, 1910.

Turner, 1910: 46.
Type species, *Elidothynnus melleus* (Westwood).

1. ELIDOTHYNNUS AGILIS (Smith), 1859.

Thynnus agilis, Smith, 1859: 20 (♂); D.T., 1897: 101 (♂); Turner, 1908: 225 (♂); Turner, 1910*b*: 288. Swan River (Smith); Sydney, N.S.W. (Froggatt).

2. ELIDOTHYNNUS BASALIS (Smith), 1859.

Thynnus (*Thynnoides*) *basalis*, Smith, 1859: 23 (♂). *T. vastator*, Smith, 1879: 158 (♀, ♂). *T. basalis*, D.T., 1897: 102 (♂). *T. vastator*, D.T., 1897: 118 (♀, ♂). *T. basalis*, Turner, 1908: 230 (♂, ♀). *Elidothynnus basalis*, Turner, 1910*b*: 290 (♂); Turner, 1910*c*: 46, Pl. 4, figs. 88–89. N.S.W.; Victoria; South Australia; Western Australia.

3. ELIDOTHYNNUS CRUCIS Turner, 1937.

Turner, 1937: 146 (♂, ♀). Southern Cross, W. Aust.

4. ELIDOTHYNNUS FRENCHI (Turner), 1908.

Thynnus frenchi, Turner, 1908: 226 (♂). Melbourne, Victoria.

5. ELIDOTHYNNUS FUMATIPENNIS Turner, 1915.

Turner, 1915*a*: 47 (♂, ♀). Cunderdin, W.A.

6. ELIDOTHYNNUS INSIDIATOR (Smith), 1879.

Thynnus insidiator, Smith, 1879: 163 (♂, ♀); D.T., 1897: 108 (♂, ♀); Turner, 1908: 227 (♂, ♀). Swan Rv., W.A.

7. ELIDOTHYNNUS IRRITANS (Smith), 1868.

Thynnus (*Agriomyia*) *irritans*, Smith, 1868: 235 (♂). *T. irritans*, D.T., 1897: 109 (♂); Turner, 1908: 228 (♂). Champion Bay.

8. Type Species. ELIDOTHYNNUS MELLEUS (Westwood), 1844.

Thynnus (*Agriomyia*) *melleus*, Westwood, 1844: 118 (♂), Pl. 76, fig. 4. *T. melleus*, Smith, 1859: 67 (♀), 24 (♂); D.T., 1897: 111 (♀); Turner, 1908: 227 (♂, ♀). *Elidothynnus melleus*, Turner, 1910*c*: 47, Pl. 2, fig. 42. Champion Bay, W. Aust., to Duaringa, Queensland.

9. ELIDOTHYNNUS MOBILIS (Turner), 1910.

Turner, 1910*b*: 288 (♂, ♀). Guildford, W.A.

10. ELIDOTHYNNUS PSEUDOMELLEUS (Turner), 1909.

Thynnus pseudomelleus, Turner, 1909: 140. Glen Innes, N.S.W. Type in Coll. Froggatt.

11. ELIDOTHYNNUS SUBINTERRUPTUS (Smith), 1868.

Thynnus subinterruptus, Smith, 1868: 235 (♂). *T. frater*, D.T., 1897: 106 (♂). *T. subinterruptus*, Turner, 1908: 229 (♂). Champion Bay, N.W. Coast, W.A.

12. ELIDOTHYNNUS TUBERCULIFRONS (Smith), 1879.

Thynnus tuberculifrons, Smith, 1879: 161 (♂); D.T., 1897: 117 (♂); Turner, 1908: 231. Swan Rv., W.A.

13. ELIDOTHYNNUS (?) ULTIMUS (Turner), 1908.

Thynnus ultimus, Turner, 1908: 246 (♂, ♀). Mackay, Queensland.

14. ELIDOTHYNNUS (?) MULTIGUTTATUS (Ashmead), 1903.

Aeolothynnus multiguttatus, Ashmead, 1903: 101; Rohwer, 1910*a*: 348. Type in U.S. Nat. Mus.

Genus 27. CAMPYLOTHYNNUS Turner, 1910.

Thynnus (pars), Smith.

Type species, *Campylothynnus flavopictus* (Smith).

1. CAMPYLOTHYNNUS ASSIMILIS (Smith), 1859.

Thynnus assimilis, Smith, 1859: 20 (♂). *T. flavofasciatus*, Smith, 1859: 45 (♀); D.T., 1897: 106 (♀). *T. assimilis*, D.T., 1897: 102 (♂); Turner, 1908: 225 (♂). *T. flavofasciatus*, Turner, 1908: 224 (♀). *Campylothynnus assimilis*, Turner, 1910*b*: 287 (♂, ♀). South Perth, W.A.

2. Type Species. CAMPYLOTHYNNUS FLAVOPICTUS (Smith), 1859.

Thynnus flavopictus, Smith, 1859: 21 (♂); D.T., 1897: 106 (♂); Turner, 1908: 223 (♂, ♀). *Campylothynnus flavopictus*, Turner, 1910*c*: 47, Pl. 2, fig. 51. S.W. Australia.

3. CAMPYLOTHYNNUS LUNDYAE Turner, 1915.

Turner, 1915*a*: 46 (♂, ♀), Pl. 1, f. 17–18. Cunderdin, W. Aust.

Genus 28. LESTRICOTHYNNUS Turner, 1910.

Turner, 1910*c*: 48.

Type species, *Lestricothynnus nubilipennis* Smith.

1. LESTRICOTHYNNUS DROSILLUS Montet, 1922.

Montet, 1922: 217 (♀). Rockhampton, Queensland.

2. LESTRICOTHYNNUS EXTRANEUS Turner, 1919.

Turner, 1919: 169 (♂, ♀). Port Lincoln, South Australia.

3. LESTRICOTHYNNUS FRAUENFELDIANUS (Saussure), 1867.

Thynnus (*Agriomyia*) *frauenfeldianus*, Sauss., 1867: 120 (♂). *T. frauenfeldianus*, D.T., 1897: 107 (♂); Turner, 1908: 240 (♀ noted but undescribed). Sydney.

4. LESTRICOTHYNNUS HEGIAS Montet, 1922.

Montet, 1922: 213 (♂). Sydney.

5. LESTRICOTHYNNUS ILLIDGEI Turner, 1910.

Turner, 1910*b*: 291 (♂, ♀). Mooraree, Brisbane, Queensland.

6. Type Species. LESTRICOTHYNNUS NUBILIPENNIS (Smith), 1879.

Thynnus nubilipennis, Smith, 1879: 167 (♂, ♀); D.T., 1897: 112 (♀, ♂); Turner, 1908: 239 (♂, ♀). Mackay, Q. *Lestricothynnus nubilipennis*, Turner, 1910*c*: 48, Pl. 2, f. 50.

7. LESTRICOTHYNNUS OPTIMUS (Smith), 1859.

Thynnus optimus, Smith, 1859: 29 (♂). *T. sulcatus*, Smith, 1859: 42 (♀). *T. optimus*, D.T., 1897: 112 (♂). *T. sulcatus*, D.T., 1897: 116 (♀). *T.* (*Aeolothynnus*) *optimus*, Turner, 1908: 125 (♂). *T.* (*Aeolothynnus*) *sulcatus*, Turner, 1908: 125 (♀). *Lestricothynnus optimus*, Turner, 1910*b*: 291; Turner, 1912*b*: 542 (♂, ♀ in cop.). Dorre Island, W.A.

8. LESTRICOTHYNNUS SUBTILIS Turner, 1910.

Turner, 1910*b*: 293 (♂, ♀). Claremont, W. Aust.

9. LESTRICOTHYNNUS TENUATUS (Smith), 1859.

Thynnus (*Agriomyia*) *tenuatus*, Smith, 1859: 31 (♂). *T. tenuatus*, D.T., 1897: 116 (♂). *T.* (*Lophocheilus*) *tenuatus*, Turner, 1908: 173 (♂). *Lestricothynnus* (?) *tenuatus*, Turner, 1910*b*: 294 (♀); 1910*c*: 56. South Perth, W.A. (♂, ♀ in cop.)

10. LESTRICOTHYNNUS THOE Montet, 1922.

Montet, 1922: 216 (♀). Australia.

11. LESTRICOTHYNNUS (?) COGNATUS (Smith), 1859.

Thynnus cognatus, Smith, 1859: 28 (♂); D.T., 1897: 103 (♂). *T.* (*Lophocheilus*) *cognatus*, Turner, 1908: 174 (♂). South-eastern Australia; Sydney–Brisbane.

12. LESTRICOTHYNNUS (?) CONSTRICTUS (Smith), 1859.

Thynnus constrictus, Smith, 1859: 19 (♂). Swan River, W.A.; D.T., 1897: 104 (♂); Turner, 1908: 241 (♂). *Lestricothynnus constrictus*, Turner, 1910*b*: 290 (♀). South Perth, W.A. (♂, ♀ in cop.)

13. LESTRICOTHYNNUS (?) LUBRICUS (Turner), 1908.

Thynnus (*Lophocheilus*) *lubricus*, Turner, 1908: 175 (♂, ♀). Cairns, Queensland.

14. LESTRICOTHYNNUS (?) MODESTUS (Smith), 1859.

Thynnus modestus, Smith, 1859: 19 (♂); D.T., 1897: 111 (♂); Turner, 1908: 240 (♂, ♀). Swan Rv., W.A.

15. LESTRICOTHYNNUS (?) MOECHUS (Turner), 1908.

Thynnus moechus, Turner, 1908: 234 (♂, ♀). Sydney. Types in Coll. Froggatt.

16. LESTRICOTHYNNUS (?) VIGILANS (Smith), 1859.

Thynnus (*Agriomyia*) *vigilans*, Smith, 1859: 28 (♂). *T. vigilans*, D.T., 1897: 118 (♂). *T.* (*Lophocheilus*) *vigilans*, Turner, 1908: 173 (♂, ♀). Melbourne, Victoria. (Type in Oxford Mus.)

Genus 29. BELOTHYNNUS Turner, 1910.

Turner, 1910*c*: 49.

Type species, *Belothynnus unifasciatus* Smith.

1. BELOTHYNNUS BINGHAMI (Turner), 1908.

Thynnus binghami, Turner, 1908: 244 (♂). Australia.

2. BELOTHYNNUS IMPETUOSUS (Smith), 1868.

Thynnus impetuosus, Smith, 1868: 233 (♂); D.T., 1897: 108 (♂); Turner, 1908: 242 (♂). South Australia.

3. BELOTHYNNUS MELANOTUS (Turner), 1908.

Thynnus melanotus, Turner, 1908: 243 (♂). Type in Oxford Museum.

4. BELOTHYNNUS NOVELLUS Turner, 1915.

Turner, 1915*a*: 48 (♂, ♀). Brisbane.

5. Type Species. BELOTHYNNUS UNIFASCIATUS (Smith), 1873.

Thynnus unifasciatus, Smith, 1873: 458, Pl. xliii, fig. 1 (♂), 2 (♀); Turner, 1908: 242 (♂). *Belothynnus unifasciatus*, subspec. *niger*, Montet, 1922: 220. Mackay, Queensland.

Genus 30. LEPTOTHYNNUS Turner, 1910.

Thynnus (pars), Westwood, 1844: 143. *Thynnus*, subgenus *Lophocheilus* (pars), Turner, 1908: 176. *Leptothynnus*, Turner, 1910*c*: 49.

Type species, *Leptothynnus purpureipennis* (Westwood).

1. Type Species. LEPTOTHYNNUS PURPUREIPENNIS (Westwood), 1844.

Thynnus purpureipennis, Westwood, 1844: 143, T. 83, f. 10 (♂); Smith, 1859: 18 (♂); Saussure, 1869: 58 (♂); D.T., 1897: 114 (♂). *T.* (*Agriomyia*) *maurus*, Smith, 1859: 37 (♂). *T. maurus*, D.T., 1897: 110 (♂). *T.* (*Lophocheilus*) *purpureipennis*, Turner, 1908: 176 (♂, ♀). N.S.W.

2. LEPTOTHYNNUS (?) PELTASTES Turner, 1912.

Turner, 1912: 542 (♂, ♀). Dorrigo, N.S.W.

Genus 31. GUERINIUS Ashmead, 1903.

Ashmead, 1903: 100. Type, *Thynnus flavilabris* Guérin (original designation). *Tachynothynnus*, Turner, 1910*c*: 50 (*Thynnus shuckardi* Guérin). *Guérinius*, Rohwer, 1910*a*: 349 (synonymy).

Type species, *Guérinius flavilabris* (Guérin).

1. GUERINIUS CONFUSUS (Smith), 1859.

Thynnus confusus, Smith, 1859: 13 (♂). *T. sulcifrons*, Smith, 1859: 43 (♀). *T. confusus*, D.T., 1897: 104 (♂). *T. sulcifrons*, D.T., 1897: 116 (♀). *T. confusus*, Turner, 1908: 214 (♂). *T. sulcifrons*, Turner, 1908: 214 (♀). *Tachynothynnus confusus*, Turner, 1910*c*: 50 (♂). *Tachynothynnus sulcifrons*, Turner, 1910*c*: 51 (♀). *Guérinius confusus*, Turner, 1913: 616 (♂, ♀ in cop.). Albany, Swan River, W. Aust.

2. Type Species. GUERINIUS FLAVILABRIS (Guérin), 1842.

Thynnus flavilabris, Guérin, 1842: 8 (♂); Westwood, 1844: 103 (♂); Smith, 1859: 18; D.T., 1897: 106. *Guérinius flavilabris*, Ashmead, 1903: 100 (♂). *Thynnus flavilabris*, Turner, 1908: 219 (♂). *Tachynothynnus flavilabris*, Turner, 1910*c*: 50 (♂). *Guérinius flavilabris*, Rohwer, 1910*a*: 349. (*Guérinius* Ash. = *Tachynothynnus* Tur.). Sydney.

3. GUERINIUS FLAVIVENTRIS (Guérin), 1838.

Thynnus flaviventris, Guérin, 1830/39: 229 (♂); Klug, 1840/42: 19 (♂); Guérin, 1842: 7, Pl. 101, f. 1–23; Westwood, 1844: 102 (♂); Smith, 1859: 16 (♂); D.T., 1897: 106 (♂); Turner, 1908: 222 (♂). *Guérinius flaviventris*, Bequaert, 1926: 189 (date of Duperrey). Swan River, W. Aust.

4. GUERINIUS GUERINII (Westwood), 1844.

Thynnus guérinii, Westwood, 1844: 137 (♂); Smith, 1859: 17 (♂); D.T., 1897: 107; Turner, 1908: 221 (♀). Melbourne; Albany, W. Aust.

5. GUERINIUS MAMMEUS (Montet), 1922.

Tachynothynnus mammeus, Montet, 1922: 221 (♀). Aust. mér. Gowlertown.

6. GUERINIUS OBSCURIPENNIS (Guérin), 1838.

Thynnus obscuripennis, Guérin, 1830/9: 227 (♂); Klug, 1840/2: 18 (♂); Westwood, 1844: 102 (♂); Smith, 1859: 13 (♂) D.T., 1897: 112 (♂); Turner, 1908: 220. *Guérinius obscuripennis*, Bequaert, 1926: 189 (date of Duperrey). Australia.

7. GUERINIUS PICIPES (Westwood), 1844.

Thynnus picipes, Westwood, 1844: 114 (♂), Pl. 77, f. 2. *T. pubescens*, Lepelet., 1845: 569 (♂). *T. picipes*, Smith, 1859: 17 (♂). *T. oblongus*, Smith, 1868: 232 (♂). *T. blasii*, D.T., 1897: 103 (♂). *T. picipes*, D.T., 1897: 113 (♂); Turner, 1908: 220 (♂). *Tachynothynnus picipes*, Turner, 1910*b*: 295 (♂, ♀ in cop.). Melbourne; Albany, Cottesloe, W. Aust.

8. GUERINIUS SHUCKARDI (Guérin), 1842.

Thynnus shuckardi, Guérin, 1842: 7, Pl. 100, f. 13; Westwood, 1844: 103, 136, Pl. 83, f. 5 (♀) (= *T. ferrugineus* Leach MSS.); Smith, 1859: 17 (♂, ♀); D.T., 1897: 116 (♀, ♂); Turner, 1908: 221 (♂, ♀). *Tachynothynnus shuckardi*, Turner, 1910*c*: 50 (♂, ♀), Pl. 2, fig. 53. *Thynnus shuckardii*, Guiglia, 1948: 177. Sydney, N.S.W.

9. GUERINIUS VARIPES (Smith), 1859.

Thynnus varipes, Smith, 1859: 67 (♂). *T. vespoides*, Smith, 1879: 165 (♂). *T. indistinctus*, Smith, 1879: 169 (♂). *T. varipes*, D.T., 1897: 118 (♂). *T. indistinctus*, D.T., 1897: 108 (♂). *T. vespoides*, D.T., 1897: 118 (♂). *T. substitutus*, Schulz, 1906: 160 (♂). *T. varipes*, Turner, 1908: 222 (♂). Adelaide, S.A.; Western Australia.

10. GUERINIUS (?) ANCHORITES (Turner), 1908.

Thynnus anchorites, Turner, 1908: 212 (♂). Killalpanima, South Aust. (100 miles east of Lake Eyre).

Genus 32. Pogonothynnus Turner, 1910.

Thynnus, Auctorum. *Pogonothynnus*, Turner, 1910*c*: 51.

Type species, *Pogonothynnus fenestratus* (Smith).

1. Type Species. Pogonothynnus fenestratus (Smith), 1859.

Thynnus fenestratus, Smith, 1859: 18 (♂). Swan Rv. (Smith). *T. crassipes*, Smith, 1859: 44 (♀). *T. fenestratus*, D.T., 1897: 106 (♂). *T. crassipes*, D.T., 1897: 104 (♀). *T. fenestratus*, Turner, 1908: 218 (♂, ♀). Champion Bay, W.A.

2. Pogonothynnus fulvohirtus Turner, 1915.

Turner, 1915*a*: 45 (♂, ♀), Pl. 1, figs. 5, 6. Yallingup, S.W. Aust.

3. Pogonothynnus morosus (Smith), 1879.

Thynnus morosus, Smith, 1879: 168 (♂); D.T., 1897: 111 (♂); Turner, 1908: 219 (♂). Champion Bay, W.A. *Pogonothynnus morosus*, Turner, 1940*b*: 99 (♀). Mingenew, W.A. (♂, ♀ in cop.).

4. Pogonothynnus vestitus (Smith), 1859.

Thynnus vestitus, Smith, 1859: 15 (♂); D.T., 1897: 118 (♂); Turner, 1908: 209 (♂). *Pogonothynnus vestitus*, Turner, 1910*b*: 296 (♂, ♀). South Perth.

5. Pogonothynnus (?) walkeri (Turner), 1908.

Thynnus walkeri, Turner, 1908: 236 (♂). Fremantle. *Pogonothynnus* (?) *walkeri*, Turner, 1910*b*: 295 (♀). South Perth. (♂, ♀ in cop.)

Genus 33. Zaspilothynnus Ashmead, 1903.

Thynnus, Auctorum. *Zaspilothynnus*, Ashmead, 1903: 99; Turner, 1910*c*: 52.

Type species, *Zaspilothynnus interruptus* (Westwood) (= *Z. leachiellus* Westwood).

1. Zaspilothynnus andreanus (Turner), 1908.

Thynnus andreanus, Turner, 1908: 231 (♂, ♀). N.S.W.

2. Zaspilothynnus atrocior (Turner), 1909.

Thynnus atrocior, Turner, 1909: 142 (♂). Gippsland, Victoria.

3. Zaspilothynnus biroi (Turner), 1910.

Thynnus biroi, Turner, 1910*a*: 117 (♂). *Zaspilothynnus biroi* subspecies *pratti*, Turner, 1911*a*, Vol. vii: 302; Turner, 1912*a*: 51 (♂). Facfac, S.W. New Guinea.

4. Zaspilothynnus campanularis (Smith), 1868.

Thynnus campanularis, Smith, 1868: 232 (♂); D.T., 1897: 103 (♂). *T. leachiellus*, Olliff, 1889: 98 (wrongly identified by Olliff), (*nec* Westwood). *T. campanularis*, Turner, 1908: 213 (♂). *Zaspilothynnus campanularis*, Turner, 1913: 616 (♂). Sydney; Lord Howe Island.

5. Zaspilothynnus carbonarius (Smith), 1859.

Thynnus (*Thynnoides*) *carbonarius*, Smith, 1859: 23 (♂). *T. caelebs*, Saussure, 1867: 122 (♀). *T. clypearis*, Saussure, 1869: 59 (♀?, ♂). *Rhagigaster clypeatus*, Smith, 1879: 177 (♂) (*nec* Klug). *T. hirnii*, D.T., 1897: 108 (♂). *T. caelebs*, D.T., 1897: 103 (♀). *T. clypearis*, D.T., 1897: 103 (♂, ♀); Schulz, 1906: 161 (♂, ♀). *T. carbonarius*, Turner, 1908: 233 (♂, ♀ in cop.) (synonymy). Sydney; Adelaide.

6. Zaspilothynnus cheesmanae Turner, 1940.

Turner, 1940: 92 (♂). Cyclops Mts., Dutch New Guinea.

7. Zaspilothynnus clelandi Turner, 1910.

Turner, 1910*b*: 305, Pl. XXXI, fig. 14 (♂), 15 (♀). Strelley River, N.W. Australia.

8. Zaspilothynnus conator (Turner), 1910.

Thynnus conator, Turner, 1910*a*: 115; Turner, 1911*a*: 302.

9. ZASPILOTHYNNUS CRUDELIS (Turner), 1908.

Thynnus crudelis, Turner, 1908: 238 (♂). Swan Rv., W.A. (?) *Enteles wagneri*, Schulz, 1908: 452 (♂). *Zaspilothynnus crudelis*, Turner, 1910*b*: 298 (♀). Perth, W.A. (♂, ♀ in cop.)

10. ZASPILOTHYNNUS CYANEIVENTRIS Rohwer, 1925.

Rohwer, 1925: 416, Pl. 1, f. 2–3. New Guinea. Types in U.S. Nat. Mus.

11. ZASPILOTHYNNUS DILATATUS (Smith), 1859.

Thynnus dilatatus, Smith, 1859: 43 (♀); D.T., 1897: 105 (♀). *T.* (*Macrothynnus*) *dilatatus*, Turner, 1908: 197 (♀). *T. atrox*, Turner, 1908: 237 (♂). *Zaspilothynnus dilatatus*, Turner, 1910*b*: 300 (♂, ♀ in cop.). South Perth, W.A. *Zaspilothynnus dilatatus* subspecies *spiculifer*, Turner, 1915*a*: 43 (♂, ♀). Southern Cross, W.A.

12. ZASPILOTHYNNUS EXCAVATUS (Turner), 1908.

Thynnus excavatus, Turner, 1908: 216 (♂, ♀). *Zaspilothynnus excavatus*, Turner, 1910*c*: Pl. 4, figs. 91, 92; Turner, 1916: 117. Kuranda, Cairns and Cooktown, North Queensland.

13. ZASPILOTHYNNUS GILESI Turner, 1910.

Turner, 1910*b*: 303, Pl. XXXI, figs. 12, 13 (♂, ♀). South Perth, W.A.

14. ZASPILOTHYNNUS HACKERI Turner, 1912.

Turner, 1912*b*: 543 (♂, ♀). Brisbane.

15. ZASPILOTHYNNUS LASIUS Montet, 1922.

Montet, 1922: 223 (♂). N.S.W.

16. Type Species. ZASPILOTHYNNUS LEACHIELLUS (Westwood), 1844.

Thynnus leachiellus, Westwood, 1844: 135, Pl. 83, f. 4 (♀). *T. interruptus*, Westwood, 1844: 115, Pl. 77, f. 1 (♂). *T. leachiellus*, Smith, 1859: 17 (♂, ♀); D.T., 1897: 109 (♀, ♂). *Zaspilothynnus leachiellus*, Ashmead, 1903: 99 (♂). *Thynnus leachiellis*, Turner, 1908: 210 (♂, ♀). *Zaspilothynnus interruptus*, Turner, 1910*c*: 52 (♂, ♀). Sydney; Moreton, Bay, Queensland.

17. ZASPILOTHYNNUS LIGNATUS Turner, 1910.

Turner, 1910*b*: 299 (♂, ♀). South Perth, W.A.

18. ZASPILOTHYNNUS MATURUS Turner, 1910.

Turner, 1910*b*: 304 (♀). South Perth, W.A.

19. ZASPILOTHYNNUS MULTISTRIGATUS (Turner), 1909.

Thynnus multistrigatus, Turner, 1909: 143 (♀). Richmond, N.S.W. Type in Coll. Froggatt.

20. ZASPILOTHYNNUS NEGLECTUS Turner, 1910.

Turner, 1910*b*: 300 (♂, ♀). N.S.W.

21. ZASPILOTHYNNUS NIGRIPES (Guérin), 1842.

Thynnoides nigripes, Guérin, 1842: 10 (♂); Westwood, 1844: 103 (♂). *Thynnus* (*Thynnoides*) *nigripes*, Smith, 1859: 22 (♂). *Thynnus nigripes*, D.T., 1897: 111; Turner, 1908: 238 (♂). *Zaspilothynnus nigripes*, Turner, 1910*b*: 301 (♂, ♀ in cop.). *T. nigripes*, Guiglia, 1948: 177. Swan River, W. Aust.

22. ZASPILOTHYNNUS NOVARAE (Saussure), 1867.

Thynnus (*Thynnoides*) *novarae*, Saussure, 1867: 119 (♂, ♀). *T. novarae*, D.T., 1897: 112 (♀, ♂). *T. remissus*, Schulz, 1906: 161 (♀, ♂). *T. novarae*, Turner, 1908: 235. Sydney, N.S.W.

23. ZASPILOTHYNNUS OBLIQUESTRIATUS Turner, 1911.

Turner, 1911*b*: 613 (♂, ♀). Kuranda, Queensland.

24. ZASPILOTHYNNUS OCHROCEPHALUS (Smith), 1868.

Thynnus ochrocephalus, Smith, 1868: 231 (♂); D.T., 1897: 112 (♂); Turner, 1908: 205 (♂); Kirby, 1896: 207. Champion Bay, W.A.

25. Zaspilothynnus picticollis (Turner), 1908.

Thynnus picticollis, Turner, 1908: 216 (♀); Turner, 1909: 144 (♀); Turner, 1910*c*: 53, Pl. 4, fig. 90 (♀). Swan Rv., W.A.

26. Zaspilothynnus pseustes (Turner), 1908.

Thynnus pseustes, Turner, 1908: 235 (♂, ♀). Sydney. Types in Oxford Museum.

27. Zaspilothynnus radialis Turner, 1910.

Turner, 1910*b*: 302, Pl. XXXI, fig. 11 (♂). Hermannsburg, Central Aust.

28. Zaspilothynnus rhynchioides Turner, 1913.

Turner, 1913: 616. Borroloola, Northern Territory. Type in Victorian Nat. Mus.

29. Zaspilothynnus rubropictus Turner, 1937.

Turner, 1937: 144 (♂, ♀). Dongarra, W. Aust.

30. Zaspilothynnus rugicollis Turner, 1915.

Turner, 1915*a*: 43 (♂, ♀). Yallingup, S.W. Aust.

31. Zaspilothynnus seductor (Smith), 1868.

Thynnus seductor, Smith, 1868: 234 (♂); D.T., 1897: 115 (♂); Turner, 1908: 215 (♂, ♀). Champion Bay, W.A.

32. Zaspilothynnus siccus (Turner), 1908.

Thynnus siccus, Turner, 1908*b*: 66 (♂). Central Australia.

33. Zaspilothynnus simplex (Smith), 1879.

Thynnus simplex, Smith, 1879: 167 (♂); D.T., 1897: 116 (♂); Turner, 1908: 238 (♂). Champion Bay, W.A.

34. Zaspilothynnus stratifrons Turner, 1917.

Turner, 1917: 58 (♂, ♀). Stradbroke Island, Moreton Bay.

35. Zaspilothynnus trilobatus Turner, 1910.

Turner, 1910*b*: 297 (♂, ♀). South Perth, W. Aust.

36. Zaspilothynnus unipunctatus Turner, 1915.

Turner, 1915*a*: 41 (♂, ♀), Pl. 1, figs. 1, 2. Yallingup, South-west Aust.

37. Zaspilothynnus vernalis (Turner), 1908.

Thynnus vernalis, Turner, 1908: 210 (♂, ♀); 1910*c*: 53, Pl. 2, figs. 31, 32. Mackay, Q.

38. Zaspilothynnus rufoluteus (Turner), 1910.

Thynnus rufoluteus, Turner, 1910*a*: 114; Turner, 1911*a*: 302 (♀). Cooktown, Queensland.

Genus 34. Thynnus Fabricius, 1775.

Thynnus, Fabricius, 1775. *Myrmecodes*, Latreille, 1809. *Homalothynnus*, Enderlein, 1904. Type species, *Thynnus dentatus* Fab.

1. Thynnus albopilosellus Cameron, 1906.

Cameron, 1906: 215 (♂). New Guinea.

2. Thynnus atratus Smith, 1862.

Smith, 1862: 51 (♂); Smith, 1865: 77 (♀); D.T., 1897: 102 (♂, ♀); Turner, 1908: 250. Halmaheira; Gilolo.

3. Thynnus bakeri Rohwer, 1925.

Rohwer, 1925: 418, Pl. 1, f. 4–5. Philippine Islands (Luzon ?).

4. Thynnus brenchleyi Smith, 1873.

Smith, 1873: 456, T. 43, f. 2 (♂); D.T., 1897: 103 (♂); Turner, 1908: 204 (♂, ♀); Turner, 1910*a*: 117. Cooktown, Q.; Champion Bay, W.A. (Smith); Narrabri, N.S.W.; Mackay, Q.

5. THYNNUS BRISBANENSIS Turner, 1909.

Turner, 1909: 145 (♂). Stradbroke Is., Moreton Bay. Type in Coll. Froggatt.

6. THYNNUS DARWINIENSIS Turner, 1908.

Turner, 1908: 206 (♂). Port Darwin.

7. Type Species. THYNNUS DENTATUS Fabricius, 1775.

Fabricius, 1775: 360 (♂); Fabricius, 1781: 475 (♂); Fabricius, 1787: 284 (♂); Roemer, 1789: 59 (♂); Gmelin, 1790: 2739 (♂). *Vespa dentata*, Christ, 1791: 228 (♂). *T. dentatus*, Fabricius, 1793: 244 (♂); Fabricius, 1804: 231 (♂); Donovan, 1805: Pl. 41, f. 1 (♂); Latreille, 1805: 278 (♂); Latreille, 1806: Pl. 13, f. 2–4 (♂); Jurine, 1807: 179 (♂); Latreille, 1809: 111 (♂); Lamarck, 1817: 109; Latreille, 1818: 77 (♂); Lepeletier, 1825: 645, Pl. 106, f. 17; Lamarck, 1835: 324; Guérin, 1838: 222 (♂); Blanchard, 1840: 375 (♂); Klug, 1840/2; 15 (♂); Westwood, 1844: 102 (♂); Lepeletier, 1845: 570 (♂); Smith, 1859: 11 (♂); D.T., 1897: 105 (♂); Ashmead, 1903: 98 (♂); Turner, 1908: 199 (♂, ♀); Turner, 1910*c*: 54 (♂, ♀), Pl. 2, figs. 35, 36, Pl. 4, figs. 93, 94. Cooktown, Cairns, Lizard Island.

8. THYNNUS ELGNERI Turner, 1908.

Turner, 1908: 207 (♂). Cape York. Type in Coll. Froggatt.

9. THYNNUS EMARGINATUS Fabricius, 1775.

Fabricius (♀ in error) see references quoted for *Thynnus dentatus* from 1775 to 1805; Guérin, 1838: 229 (♂); Westwood, 1844: 102 (♂); Smith, 1859: 16 (♂); D.T., 1897: 105 (♀ in error); Turner, 1908: 202 (♂). Cooktown, North Queensland.

10. THYNNUS ERRATICUS Smith, 1860.

Smith, 1860: 114 (♂); D.T., 1897: 105 (♂); Turner, 1908: 251 (♂). Batchian.

11. THYNNUS LUGUBRIS Smith, 1864.

Smith, 1864; 25 (♂); D.T., 1897: 110 (♂); Turner, 1908: 250 (♂); Turner, 1910*a*: 118 (♀). Ceram.

12. THYNNUS LUZONICUS Turner, 1908.

Turner, 1908*b*: 65 (♂, ♀); Rohwer, 1925: 419, Pl. 1, fig. 6. Polillo Island (off coast of Luzon).

13. THYNNUS MUTANDUS Turner, 1912.

Turner, 1912: 544 (♀, ♂). Aru Island.

14. THYNNUS OLIVACEUS Turner, 1908.

Turner, 1908: 251 (♂, ♀); Turner, 1940: 91 (♀). Kokoda, New Guinea.

15. THYNNUS PEDESTRIS (Fabricius), 1775.

Tiphia pedestris, Fabricius, 1775: 354; Fabricius, 1781: 452; Fabricius, 1787: 280; Gmelin, 1790: 2742. *Sphex pedestris*, Christ, 1791: 267. *Tiphia pedestris*, Fabricius, 1793: 228; Fabricius, 1804: 235. *Myrmecodes pedestris*, Latreille, 1809: 118. *Mutilla myrmecodes*, Lamarck, 1817: 100. *Myrmecodes pedestris*, Lepeletier, 1825: 654. *Thynnus pedestris*, Guérin, 1838: 231 (♀). *Mutilla myrmecodes*, Lamarck, 1835: 316. *Thynnus pedestris*, Klug, 1840/2: 16 (♀). *Myrmecodes pedestris*, Lepeletier, 1845: 587 (♀). *Thynnus pedestris*, Westwood, 1844: 102; Smith, 1859: 16; D.T., 1897: 113 (♀); Turner, 1908: 203 (♀); Ashmead, 1903: 100, 107. Australia (Banks).

16. THYNNUS PLACIDUS Smith, 1864.

Smith, 1864: 26 (♂); D.T., 1897: 113 (♂); Turner, 1908: 251 (♂). Waigiou.

17. THYNNUS PULCHRALIS Smith, 1859.

Smith, 1859: 68 (♂); Smith, 1873: 4, T. 43, f. 4 (♂); D.T., 1897: 114 (♂); Turner, 1908: 200. Adelaide to Cooktown.

18. THYNNUS PULLATUS Smith, 1864.

Smith, 1864: 26 (♂); D.T., 1897: 114 (♂); Turner, 1908: 251. Bouru.

19. THYNNUS SABULOSUS Turner, 1908.

Turner, 1908: 208 (♀); Turner, 1909: 144 (♀). Adelaide River, Northern Territory.

20. THYNNUS SERRIGER Sharp, 1900.

Sharp, 1900; 388 (iv), Pl. xxxv, fig. 13 (♀); Turner, 1908: 251; Turner, 1910*a*: 119. New Britain.

21. THYNNUS VENTRALIS Smith, 1865.

Smith, 1865: 389 (♀). *T. conspicuus*, Smith, 1873: 457, Pl. 43, fig. 3 (♂) (*nec T. conspicuus*, Smith, 1868). *T. smithii*, Froggatt, 1891: 16 (♂); D.T., 1897: 118 (♂). *T. ventralis*, D.T., 1897: 118. *T. wackernellii*, D.T., 1897: 118. *Homalothynnus eburneus*, Enderlein, 1904: 468. *T. ventralis*, Turner, 1908: 201 (♂, ♀); Turner, 1909: 146; Turner, 1910*c*, Pl. 2, figs. 33, 34. King George Sound, Roebourne, North-west Aust.

22. THYNNUS ZONATUS Guérin, 1838.

Guérin, 1838: 222 (♂); Klug, 1840: 15 (♂); Guérin, 1842: 7, Pl. 100, figs. 8–12 (♂); Westwood, 1844: 102 (♂); Smith, 1859: 12 (♂). *T. nigropectus*, Smith, 1879: 165 (♂). *T. zonatus*, D.T., 1897: 119 (♂). *T. nigropectus*, D.T., 1897: 112 (♂). *T. zonatus*, Turner, 1908: 207 (♂). Swan River, Roebourne. North-west Aust.

23. THYNNUS COOKII Turner, 1910.

Turner, 1910*a*: 116 (♀). Cooktown, Q.

Genus 35. ISWAROIDES Ashmead, 1899.

Ashmead, 1899: 50–51; Ashmead, 1903: 98; Turner, 1908: 253.
Type species, *Iswaroides koebelei* Ashmead.

1. ISWAROIDES KOEBELEI Ashmead, 1899.

Ashmead, 1899: 50 (♂, ♀); Ashmead, 1903: 98; Turner, 1908: 253; Turner, 1910*c*: 55; Rohwer, 1910*a*: 349–51. Australia.

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ABSTRACT OF PROCEEDINGS

ORDINARY MONTHLY MEETING.

25th March, 1953.

Mr. J. M. Vincent, President, in the chair.

Library accessions amounting to 59 volumes, 360 parts or numbers, 18 bulletins, 11 reports and 10 pamphlets, total 458, had been received since the last meeting.

PAPERS READ (by title only).

1. Australian Rust Studies. XI. Experiments in Crossing Wheat and Rye. By W. L. Waterhouse.

2. Genetic Control in *Eucalyptus* Distribution. By L. D. Pryor.

3. A New Subspecies of *Cermatulus nasalis* (Westwood) (Hemiptera-Heteroptera: Pentatomidae). By T. E. Woodward. (*Communicated by F. A. Perkins.*)

ORDINARY MONTHLY MEETING.

29th April, 1953.

Mr. J. M. Vincent, President, occupied the Chair.

The President announced that the Council had elected the following office-bearers for the 1953-54 session: Vice-Presidents: Dr. A. R. Woodhill, Mr. D. J. Lee, Mr. A. N. Colefax and Mr. S. J. Copland; Honorary Treasurer: Dr. A. B. Walkom; Honorary Secretaries: Dr. W. R. Browne and Dr. A. B. Walkom.

The following were elected Ordinary Members of the Society: Mr. D. E. Edwards, B.Sc.Agr., Division of Wood Technology, Sydney; Dr. A. T. Hotchkiss, Sydney University; Dr. E. J. Reye, M.B., B.S. (Univ. Qld.), Yeerongpilly, Queensland; Miss Hilda R. Simons, B.Sc., Killara, N.S.W.; and Miss Jill A. Whitehouse, B.Sc., Strathfield, N.S.W.

Congratulations were offered to Mr. P. H. Durie, Mr. J. A. Keast, Miss Elizabeth N. Marks, Miss Alison A. Millerd, Miss Dorothy E. Shaw and Dr. D. F. Waterhouse on obtaining the degrees of M.Sc., M.Sc., Ph.D., Ph.D. (Syd.), M.Sc.Agr., and D.Sc. respectively.

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The papers taken as read at the March Ordinary Monthly Meeting were discussed.

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1. A New Species of *Austroasca* Lower (Cicadellidae, Homoptera). By Harry F. Lower.

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3. Factors worth considering when making Measurements of Trombiculid Larvae. By Carl E. M. Gunther.

4. On Australian Helodidae. Part I. Descriptions of New Genera and Species. By J. W. T. Armstrong.

LECTURETTE.

A lecturette was given by Professor John A. Moore, Fulbright Professor, from Columbia University, N.Y., on Experimental Studies on the Evolution of Australian Frogs.

ORDINARY MONTHLY MEETING.

27th May, 1953.

Dr. A. B. Walkom occupied the Chair.

Mrs. Beatrice Mary Errey, N.S.W. University of Technology, Sydney, was elected an Ordinary Member of the Society.

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2. Studies of Nitrogen-fixing Bacteria. III. *Azotobacter beijerinckii* (Lipman, 1903) var. *acido-tolerans* (Tchan, 1952). By Y. T. Tchan, Macleay Bacteriologist to the Society.
3. An Undescribed Species of *Grevillea* from the Rylstone District. By H. S. McKee.

NOTES AND EXHIBITS.

Dr. Y. T. Tchan gave a short account of the life of S. N. Winogradsky (1856–1953), whose outstanding contributions to science opened new fields, not only in microbiology but also in physiology, biochemistry, agronomy and soil science.

Mr. John Bunt exhibited some specimens of the Ascomycete *Lachnea scutellata*, identified from material collected at Macquarie Island during 1951. The fungus forms small bright red ascomae on the soil surface. The same species has also been recorded from Tasmania and Tierra del Fuego, and a closely related species occurs in New Zealand and Kerguelen Island. The Macquarie Island representatives have probably had their origin in New Zealand.

Rev. R. G. Palmer exhibited three female specimens of filariae, probably *Diplotriaena clelandi* Johnston, from the right auricle of the heart of a magpie, *Gymnorhina tibicen*, from Glen Davis, 21st March, 1953. The specimens had been submitted to Dr. M. J. Mackerras, who made the following comment: "The specimens which you have discovered in the heart are the only female worms found so far." Filarial worms occur in very odd places and are notoriously hard to find. The commonest site is in the peritoneal cavity in the walls of the air sacs. They have been found in the pericardium, heart, under the skin of the neck, behind the eye, and in the thigh muscles.

Mr. T. G. Vallance exhibited a number of colour slides illustrating the Barrier Ranges region, N.S.W. The main rock types of the Willyama complex (Archaean), the Proterozoic Torrowangee Series and the Mootwingee Series were illustrated, as well as certain siliceous mesa cappings near Fowler's Gap.

Dr. W. R. Browne exhibited a Kodachrome slide of the Snowy Mts. area, illustrating its character of a highly dissected elevated peneplain with residuals.

ORDINARY MONTHLY MEETING.

24th June, 1953.

Mr. J. M. Vincent, President, occupied the Chair.

Messrs. D. S. Simonett, M.Sc., Artarmon, N.S.W., and E. T. Smith, Sunshine, Melbourne, Victoria, were elected Ordinary Members of the Society.

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3. Studies of Nitrogen-fixing Bacteria. IV. Taxonomy of Genus *Azotobacter* (Beijerinck, 1901). By Y. T. Tchan, Macleay Bacteriologist to the Society.

NOTES AND EXHIBITS.

Miss K. English exhibited two larvae of Tabanidae collected in a garden at Roseville. One was a very large stout larva, mottled brown in colour, collected under decaying weeds and leaves; from a similar larva the Pangonine *Scaptia vicina* Taylor was obtained. The other was a smaller larva found when digging up part of a neglected lawn; this has not yet been bred through so it is not known to which species of Tabanid it belongs.

LECTURETTE.

A lecturette was given by Mr. F. A. McNeill, of the Australian Museum—"A Search for Rarities along the Great Barrier Reef from Gladstone to Cairns".

ORDINARY MONTHLY MEETING.

29th July, 1953.

Mr. J. M. Vincent, President, occupied the Chair.

Mr. W. R. Frame, Port Moresby, Papua–New Guinea, was elected an Ordinary Member of the Society.

Library accessions amounting to 12 volumes, 82 parts or numbers, 3 bulletins, 3 reports and 2 pamphlets, total 102, had been received since the last meeting.

PAPERS READ.

1. The *Culex pipiens* Group in South-eastern Australia. II. By N. V. Dobrotworsky and F. H. Drummond. (*Communicated by D. J. Lee.*)

2. A New Species of *Pseudophryne* from Victoria. By John A. Moore, Fulbright Research Scholar, Sydney University. (*Communicated by L. C. Birch.*)

3. Cytology of *Septoria* and *Selenophoma* Spores. By Dorothy E. Shaw.

LECTURETTE.

A lecturette was given by Dr. L. C. Birch, entitled "The Importance of Light in Animal Ecology".

ORDINARY MONTHLY MEETING.

26th August, 1953.

Mr. J. M. Vincent, President, occupied the Chair.

Mr. N. V. Dobrotworsky, M.Sc., University of Melbourne, Carlton, Victoria, was elected an Ordinary Member of the Society.

Library accessions amounting to 63 volumes, 141 parts or numbers, 57 bulletins, 3 reports and 8 pamphlets, total 272, had been received since the last meeting.

PAPERS READ.

1. Australian Rust Studies. XII. Specialization within *Uromyces striatus* Schroet. on *Trigonella suavissima* Lindl. and *Medicago sativa* L. By W. L. Waterhouse.

2. Studies of N-fixing Bacteria. V. Presence of *Beijerinckia* in Northern Australia and Geographic Distribution of Non-symbiotic N-fixing Microorganisms. By Y. T. Tchan, Macleay Bacteriologist to the Society.

3. Study of Soil Algae. II. The Variation of the Algal Population in Sandy Soils. By Y. T. Tchan, Macleay Bacteriologist to the Society, and Jill A. Whitehouse.

4. The Genus *Selenophoma* on Gramineae in Australia. By Dorothy E. Shaw.

NOTES AND EXHIBITS.

Dr. Y. T. Tchan demonstrated a simple arrangement for a suitable lamp to provide uniform illumination for routine microscope work. It passes light through a cuvette containing very dilute suspension of milk in water, the size of the light source being controlled by a cardboard diaphragm.

LECTURETTE.

A lecturette was given by Dr. B. J. Ralph, entitled "Oxidative Mechanisms in the Wood-rotting Fungi".

ORDINARY MONTHLY MEETING.

30th September, 1953.

Mr. J. M. Vincent, President, occupied the Chair.

The President announced that the Council is prepared to receive applications for Linnean Macleay Fellowships tenable for one year from 1st January, 1954, 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, 4th November, 1953.

The President announced that Dr. Julian Huxley, who will be visiting Sydney in November next, will give an address to biologists at the University of Sydney at 8 p.m. on 11th November on "Evolution and Polymorphism".

The President also announced that an invitation to members had been received to attend the Annual Meeting of the Wild Life Preservation Society of Australia to be held in the Men's Lounge, Fifth Floor, Federation House, 166 Phillip Street, Sydney, on Thursday, 22nd October, 1953, at 8 p.m. The business meeting will be followed by the screening of two films: "Australia's Coral Wonderland" and "The Loon's Necklace".

Library accessions amounting to 1 volume, 16 parts or numbers, and 50 bulletins, total 67, had been received since the last meeting.

PAPERS READ.

1. Studies in the Metamorphic and Plutonic Geology of the Wantabadgery-Adelong-Tumbarumba District, N.S.W. Part II. Intermediate-Basic Rocks. By T. G. Vallance, Linnean Macleay Fellow in Geology.

2. Studies in the Metamorphic and Plutonic Geology of the Wantabadgery-Adelong-Tumbarumba District, N.S.W. Part III. The Granitic Rocks. By T. G. Vallance, Linnean Macleay Fellow in Geology.

3. The Occurrence of Varved Clays in the Kosciusko District, N.S.W. By T. G. Vallance, Linnean Macleay Fellow in Geology.

LECTURETTE.

Dr. N. C. W. Beadle gave a lecturette on "Death of the Mulga, and Decline in Soil Fertility in the West Darling Country".

ORDINARY MONTHLY MEETING.

28th October, 1953.

Mr. J. M. Vincent, President, occupied the Chair.

The President announced that the Council is prepared to receive applications for Linnean Macleay Fellowships tenable for one year from 1st January, 1954, 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, 4th November, 1953.

2. Studies in the Metamorphic and Plutonic Geology of the Wantabadgery–Adelong–Tumbarumba District, N.S.W. I. Introduction and Metamorphism of the Sedimentary Rocks. By T. G. Vallance, Linnean Macleay Fellow in Geology.

3. Studies of Nitrogen-fixing Bacteria. IV. Taxonomy of Genus *Azotobacter* (Beijerinck, 1901). By Y. T. Tchan, Macleay Bacteriologist to the Society.

NOTES AND EXHIBITS.

Miss K. English exhibited two larvae of Tabanidae collected in a garden at Roseville. One was a very large stout larva, mottled brown in colour, collected under decaying weeds and leaves; from a similar larva the Pangonine *Scaptia vicina* Taylor was obtained. The other was a smaller larva found when digging up part of a neglected lawn; this has not yet been bred through so it is not known to which species of Tabanid it belongs.

LECTURETTE.

A lecturette was given by Mr. F. A. McNeill, of the Australian Museum—"A Search for Rarities along the Great Barrier Reef from Gladstone to Cairns".

ORDINARY MONTHLY MEETING.

29th JULY, 1953.

Mr. J. M. Vincent, President, occupied the Chair.

Mr. W. R. Frame, Port Moresby, Papua–New Guinea, was elected an Ordinary Member of the Society.

Library accessions amounting to 12 volumes, 82 parts or numbers, 3 bulletins, 3 reports and 2 pamphlets, total 102, had been received since the last meeting.

PAPERS READ.

1. The *Culex pipiens* Group in South-eastern Australia. II. By N. V. Dobrotworsky and F. H. Drummond. (*Communicated by D. J. Lee.*)

2. A New Species of *Pseudophryne* from Victoria. By John A. Moore, Fulbright Research Scholar, Sydney University. (*Communicated by L. C. Birch.*)

3. Cytology of *Septoria* and *Selenophoma* Spores. By Dorothy E. Shaw.

LECTURETTE.

A lecturette was given by Dr. L. C. Birch, entitled "The Importance of Light in Animal Ecology".

ORDINARY MONTHLY MEETING.

26th AUGUST, 1953.

Mr. J. M. Vincent, President, occupied the Chair.

Mr. N. V. Dobrotworsky, M.Sc., University of Melbourne, Carlton, Victoria, was elected an Ordinary Member of the Society.

Library accessions amounting to 63 volumes, 141 parts or numbers, 57 bulletins, 3 reports and 8 pamphlets, total 272, had been received since the last meeting.

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NOTES AND EXHIBITS.

Dr. Y. T. Tchan demonstrated a simple arrangement for a suitable lamp to provide uniform illumination for routine microscope work. It passes light through a cuvette containing very dilute suspension of milk in water, the size of the light source being controlled by a cardboard diaphragm.

LECTURETTE.

A lecturette was given by Dr. B. J. Ralph, entitled "Oxidative Mechanisms in the Wood-rotting Fungi".

ORDINARY MONTHLY MEETING.

30th SEPTEMBER, 1953.

Mr. J. M. Vincent, President, occupied the Chair.

The President announced that the Council is prepared to receive applications for Linnean Macleay Fellowships tenable for one year from 1st January, 1954, 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, 4th November, 1953.

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ORDINARY MONTHLY MEETING.

28th OCTOBER, 1953.

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The President announced that the Council is prepared to receive applications for Linnean Macleay Fellowships tenable for one year from 1st January, 1954, 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, 4th November, 1953.

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3. A New Genus of the Plectascales. By Lilian Fraser.

NOTES AND EXHIBITS.

Mr. J. M. Vincent presented an exhibit showing the action of bacteriophage on a *Rhizobium trifolii.* The phage is one of several isolated by Mr. K. C. Marshall from soil at the University of Sydney. This appears to be the first record of the isolation of *Rhizobium* bacteriophage from an Australian soil.

LECTURE.

A lecture entitled "Journeyings in North Australia", illustrated by kodachrome slides, was given by Professor J. Macdonald Holmes.

ORDINARY MONTHLY MEETING.

25th November, 1953.

Mr. J. M. Vincent, President, occupied the chair.

Miss Patricia M. McDonald, B.Sc., Dip.Ed., Dee Why, N.S.W., and Mr. A. W. Parrott, Nelson, New Zealand, were elected Ordinary Members of the Society.

The President announced that Miss Nola J. Hannon, B.Sc., and Miss Ruth Simons, B.Sc., had been appointed to Linnean Macleay Fellowships in Botany for the year 1954.

The President informed members that the Society has for a number of years made a donation to the Zoological Society of London towards the cost of production of the Zoological Record.

Library accessions amounting to 12 volumes, 104 parts or numbers, 6 bulletins, 7 reports and 1 pamphlet, total 130, had been received since the last meeting.

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3. A Note on the Geology of Panuara and Angullong, south of Orange, N.S.W. By N. C. Stevens.

4. Studies on Australian Thynnidae. I. A Check List of the Australian and Austro-Malayan Thynnidae. By K. E. W. Salter.

NOTES AND EXHIBITS.

Misses Isobel Bennett and Elizabeth Pope exhibited two specimens of the seastar, *Astrostole insularis,* from the New South Wales coast and showed Kodachrome records of their colour patterns in life. This species was first described from Lord Howe Island in 1938 by H. Lyman Clark, who subsequently also stated in his "Echinoderm Fauna of Australia" (1946), 'Although it has not yet been reported from the Australian coast, it is possible that specimens have been taken and confused with the following species [*Coscinasterias calamaria*], which it resembles superficially.'

The two present specimens were collected between tidemarks. The first, Australian Museum registered number J.6832, was taken at Wellington Rocks, near the mouth of the Nambucca River in the northern part of the State, 1.11.1947, and the second, J.6833, was collected at Long Reef, near Collaroy, New South Wales, in August, 1953. Several additional specimens have now also been seen, so that it seems likely that the species has been overlooked in the past, as suggested by Clark.

LECTURETTE.

A lecturette entitled "The Role of Henri Derx in Tropical Biology" was given by Professor L. G. Baas-Becking.

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LIST OF MEMBERS.

(15th December, 1953.)

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., c.o. Mr. G. H. Aurousseau, 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.
1948 Baddams, Miss Greta, B.A., B.Sc., New England University College, Armidale, N.S.W.
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.
1948 Barrett, Mrs. Judith Hope, M.Sc. (*née* Balmain), 31 Holt Avenue, Mosman, N.S.W.
1935 *Beadle, Noel Charles William, D.Sc., Botany School, Sydney University.
1946 Bearup, Arthur Joseph, 66 Pacific Avenue, Penshurst, N.S.W.
1940 Beattie, Joan Marion, D.Sc. (*née* Crockford), c.o. Lake George Mine, Captain's Flat, N.S.W.
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.
1948 Birch, Louis Charles, D.Ag.Sc., M.Sc., Department of Zoology, 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.
1950 Brown, Kenneth George, 6 Dolphin Street, Randwick, N.S.W.
1924 Browne, Ida Alison, D.Sc. (*née* Brown), Department of Geology, Sydney University.
1949 Browne, Lindsay Blakeston Barton, Department of Zoology, Sydney University.
1911 Browne, William Rowan, D.Sc., Department of Geology, Sydney University.
1952 Bunt, John Stuart, B.Sc.Agr., Faculty of Agriculture, Sydney University.
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.

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.), 7 Thames Street, Sunbury-on-Thames, Middlesex, England.
1936 *Chadwick, Clarence Earl, B.Sc., Entomological Branch, Department of Agriculture, Farrer Place, Sydney.
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., 1 Hunter Street, Woolwich, 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.
1942 Cleland, Kenneth Wollaston, M.B., Department of Anatomy, Sydney University.
1931 Colefax, Allen Neville, B.Sc., Department of Zoology, Sydney University.
1946 Colless, Donald Henry, 9 Eng Neo Avenue, Singapore 21, Malaya.
1942 Copland, Stephen John, M.Sc., Chilton Parade, Warrawee, N.S.W.
1947 Costin, Alec Baillie, 12 Barambah Road, Roseville, 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.

1945 Davis, Mrs. Gwenda Louise, Ph.D., B.Sc., New England University College, Armidale, N.S.W.
1936 Day, Maxwell Frank, Ph.D., B.Sc., C.S.I.R.O., Box 109, Canberra, A.C.T.
1934 Day, William Eric, 23 Gelling Avenue, Strathfield, N.S.W.
1925 de Beuzeville, Wilfred Alexander Watt, J.P., "Melamere", Welham Street, Beecroft, N.S.W.
1937 Deuquet, Camille, B.Com., 126 Hurstville Road, Oatley, N.S.W.
1953 Dobrotworsky, Nikolai V., M.Sc., Department of Zoology, University of Melbourne, Carlton, N.3, Victoria.
1948 Drover, Donald P., Institute of Agriculture, University of Western Australia, Nedlands, W.A.
1946 Durie, Peter Harold, M.Sc., C.S.I.R.O., Veterinary Parasitology Laboratory, Yeerongpilly, Brisbane, Queensland.
1952 Dyce, Alan Lindsay, B.Sc.Agr., C.S.I.R.O., Division of Entomology, P.O. Box 109, City, Canberra, A.C.T.

1948 Ealey, Eric H. M., Girrawheen, Duffy Avenue, Thornleigh, N.S.W.
1953 Edwards, Dare William, B.Sc.Agr. (Hons.), Forestry Commission of N.S.W., Division of Wood Technology, 96 Harrington Street, Sydney.
1949 Elliott, John Henry, "Greengates", Pennant Hills Road, Beecroft, N.S.W.
1947 Endean, Robert, M.Sc., Department of Zoology, University of Queensland, Brisbane, Queensland.
1930 English, Miss Kathleen Mary Isabel, B.Sc., 2 Shirley Road, Roseville, N.S.W.
1953 Errey, Mrs. Beatrice Mary, Department of Biological Sciences, N.S.W. University of Technology, Broadway, Sydney.

1953 Frame, William Robert, c/- G. G. Smith & Co. Ltd., P.O. Box 17, Port Moresby, Papua-New Guinea.
1948 Fraser, Ian McLennan, Ph.D. (Cambridge), 8 Kiogle Street, Wahroonga, N.S.W.
1930 Fraser, Miss Lilian Ross, D.Sc., "Hopetoun", 25 Bellamy Street, Pennant Hills, N.S.W.

1950 Garden, Miss Joy Gardiner, B.Sc.Agr., Botanic Gardens, Sydney.
1935 *Garretty, Michael Duhan, D.Sc., "Surrey Lodge", Mitcham Road, Mitcham, Victoria.
1944 Greenwood, William Frederick Neville, 11 Wentworth Avenue, Waitara, N.S.W.
1946 *Griffiths, Mrs. Mabel, B.Sc. (*née* Crust), 2 Carden Avenue, Wahroonga, N.S.W.
1936 Griffiths, Mervyn Edward, M.Sc., Australian Institute of Anatomy, Canberra, A.C.T.
1939 *Gunther, Carl Ernest Mitchelmore, M.B., B.S., D.T.M., D.T.M. & H. (England), Bulolo Gold Dredging Limited, Bulolo, Territory of Papua–New Guinea.

1928 Hamilton, Edgar Alexander, 16 Hercules Street, Chatswood, N.S.W.
1952 Hannon, Miss Nola Jean, B.Sc., 22 Leeder Avenue, Penshurst, N.S.W.
1952 *Hansford, Clifford Gerald, M.A., Sc.D. (Cantab.), D.Sc. (Adel.), F.L.S., Waite Agricultural Research Institute, Private Bag, G.P.O., Adelaide, South Australia.
1917 Hardy, George Huddleston Hurlstone, "Karambi", Letitia Street, Katoomba, N.S.W.
1947 Harker, Miss Janet Elspeth, M.Sc., Ph.D., F.R.E.S., Girton College, Cambridge, England.
1951 Hewitt, Bernard Robert, c.o. Box 177, Kempsey, 2C, N.S.W.
1930 Heydon, George Aloysius Makinson, M.B., Ch.M., Flat 5, 79 O'Sullivan Road, Rose Bay, N.S.W.
1938 Hill, Miss Dorothy, M.Sc., Ph.D., Department of Geology, University of Queensland, Brisbane, Queensland.
1943 Hindmarsh, Miss Mary Maclean, B.Sc., 79 Onslow Street, Rose Bay, N.S.W.
1930 Holmes, Professor James Macdonald, Ph.D., B.Sc., F.R.G.S., F.R.S.G.S., Department of Geography, Sydney University.
1943 Horowitz, Benzoin, Eng.Agr.S., Dr.Agr.Sc. (Cracow, Poland), C.S.I.R.O., c.o. Waite Institute, Private Mail Bag, Adelaide, South Australia.
1932 Hossfeld, Paul Samuel, M.Sc., 132 Fisher Street, Fullarton, South Australia.
1953 Hotchkiss, Arland Tillotson, M.S., Ph.D. (Cornell), Department of Botany, Sydney University.
1942 Humphrey, George Frederick, M.Sc., Ph.D., Department of Biochemistry, Sydney University.

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1935 *Beadle, Noel Charles William, D.Sc., Botany School, Sydney University.
1946 Bearup, Arthur Joseph, 66 Pacific Avenue, Penshurst, N.S.W.
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1950 *Sharp, Kenneth Raeburn, B.Sc., Eng. Geology, S.M.H.E.A., Cooma, 4S, N.S.W.
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1953 Simonett, David Stanley, M.Sc., Department of Geography, University of Maryland, College Park, Maryland, U.S.A.

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1952 Slade, Milton John, B.Sc., 10 Bent Street, Wingham, N.S.W.
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1945 Southcott, Ronald Vernon, M.B., B.S., 13 Jasper Street, Hyde Park, South Australia.
1937 Spencer, Mrs. Dora Margaret, M.Sc. (*née* Cumpston), Moorabinda, Tenterfield, N.S.W.
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1898 Stead, David G., "Boongarre", 14 Pacific Street, Watson's Bay, N.S.W.
1932 Stead, Mrs. Thistle Yolette, B.Sc. (*née* Harris), 14 Pacific Street, Watson's Bay, N.S.W.
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1947 Ward, Mrs. Judith, B.Sc., Lilac Cottage, Invergarry, Inverness-shire, Scotland.
1930 Ward, Melbourne, Gallery of Natural History and Native Art, Medlow Bath, N.S.W.
1911 Wardlaw, Henry Sloane Halcro, D.Sc., F.R.A.C.I., 71 McIntosh Street, Gordon, N.S.W.
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1927 Waterhouse, Professor Walter Lawry, D.Sc.Agr., M.C., D.I.C., 30 Chelmsford Avenue, Lindfield, N.S.W.
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1949 Whaite, Mrs. Joy Lilian, c/- Department of Main Roads, Deniliquin 6S, N.S.W.
1946 Wharton, Ronald Harry, B.Sc., Institute for Medical Research, Branch Laboratory, Kuantan, Pahang, Federation of Malaya.
1953 Whitehouse, Miss Jill Armson, B.Sc., 83 The Boulevarde, Strathfield, N.S.W.
1926 *Whitley, Gilbert Percy, Australian Museum, College Street, Sydney.
1946 Wilkins, Miss Marjorie Jessie, M.Sc., 33 Muston Street, Mosman, N.S.W.
1952 Williams, Owen Benson, M.Agr.Sc. (Melbourne), 47 George Street, Deniliquin, N.S.W.
1950 Willis, Jack Lehane, M.Sc., A.A.C.I., 26 Inverallan Avenue, Pymble, N.S.W.
1947 Winkworth, Robert Ernest, Botany Department, University of Melbourne, Carlton, N.3, Victoria.
1934 Womersley, Herbert, F.R.E.S., A.L.S., South Australian Museum, Adelaide, South Australia.
1949 Wood, Edward James Ferguson, C.S.I.R.O., Marine Biological Laboratory, P.O. Box 21, Cronulla, N.S.W.
1932 Woodhill, Anthony Reeve, D.Sc.Agr., Department of Zoology, Sydney University.

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1949 Zeck, Mrs. Nance (Anne), 694 Victoria Road, Ryde, N.S.W.

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1923 Hill, Professor James Peter, D.Sc., F.R.S.Z., F.Z.S., F.R.S., "Kanimbla", Dollis Avenue, Finchley, London, N.3, England.

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HONORARY MEMBER.

1923 Hill, Professor James Peter, D.Sc., F.R.S.Z., F.Z.S., F.R.S., "Kanimbla", Dollis Avenue, Finchley, London, N.3, England.

CORRESPONDING MEMBERS.

1949 Jensen, Hans Laurits, D.Sc.Agr. (Copenhagen), State Laboratory of Plant Culture, Department of Bacteriology, Lyngby, Denmark.

1942 Rupp, Rev. Herman Montague Rucker, B.A., 32 Neville Street, Willoughby, N.S.W.

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LISTS OF NEW SUB-FAMILY, GENERA, SPECIES AND SUBSPECIES.

Vol. 78.

Sub-family.

Genera.

Species and Subspecies.

LIST OF PLATES.

Proceedings, 1953.

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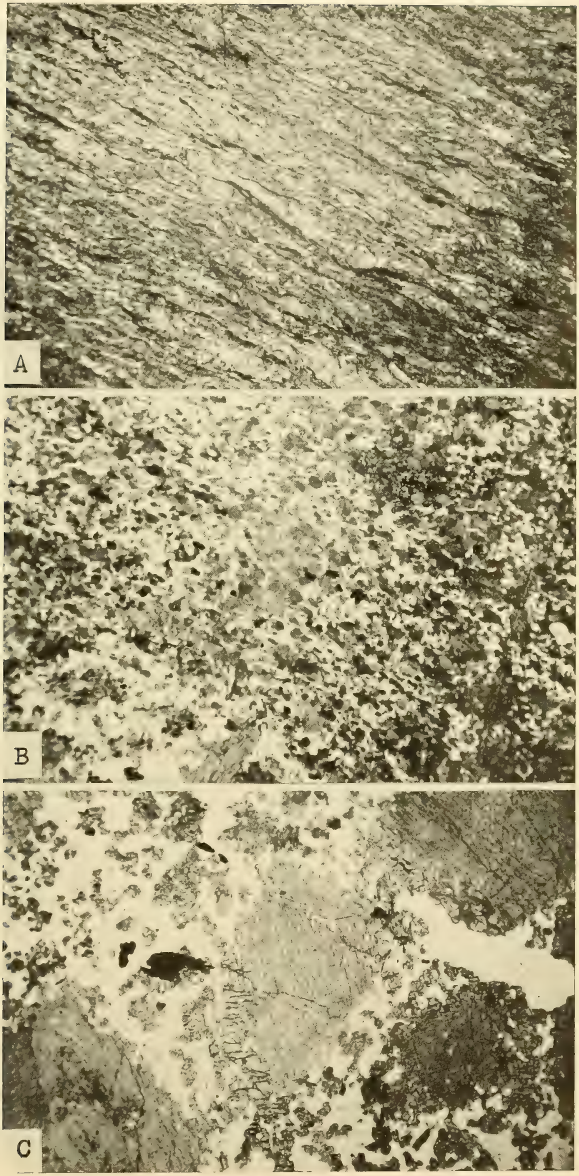
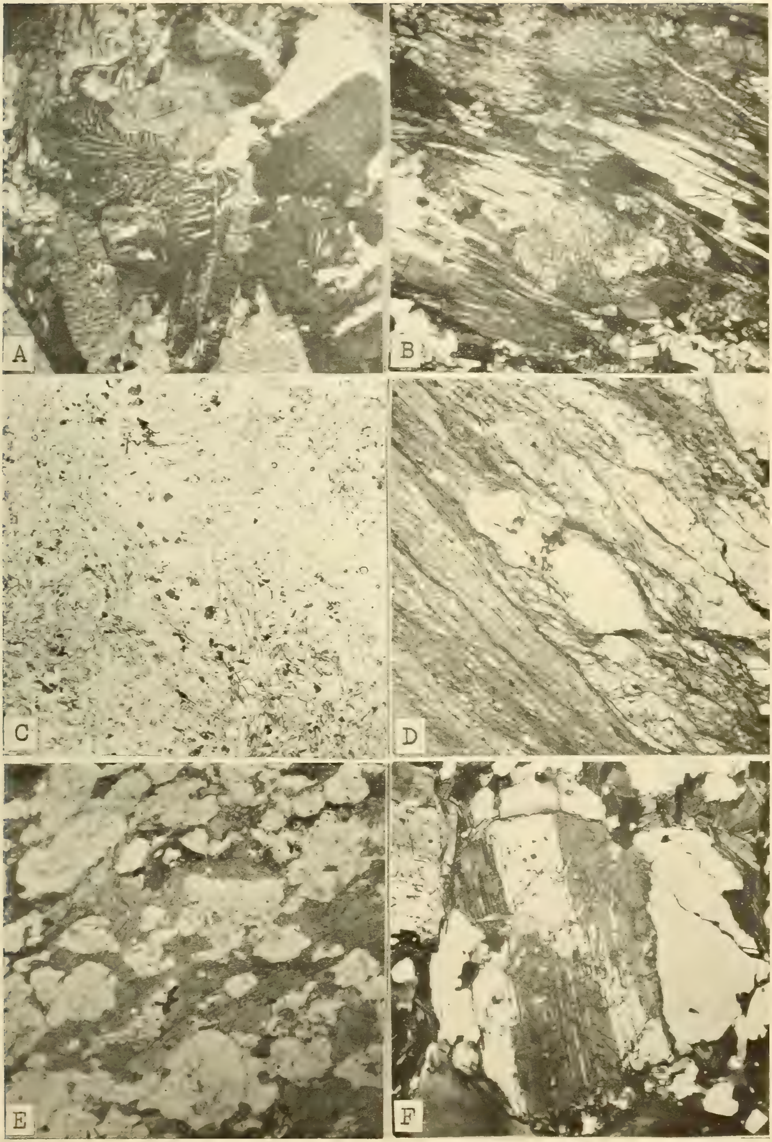
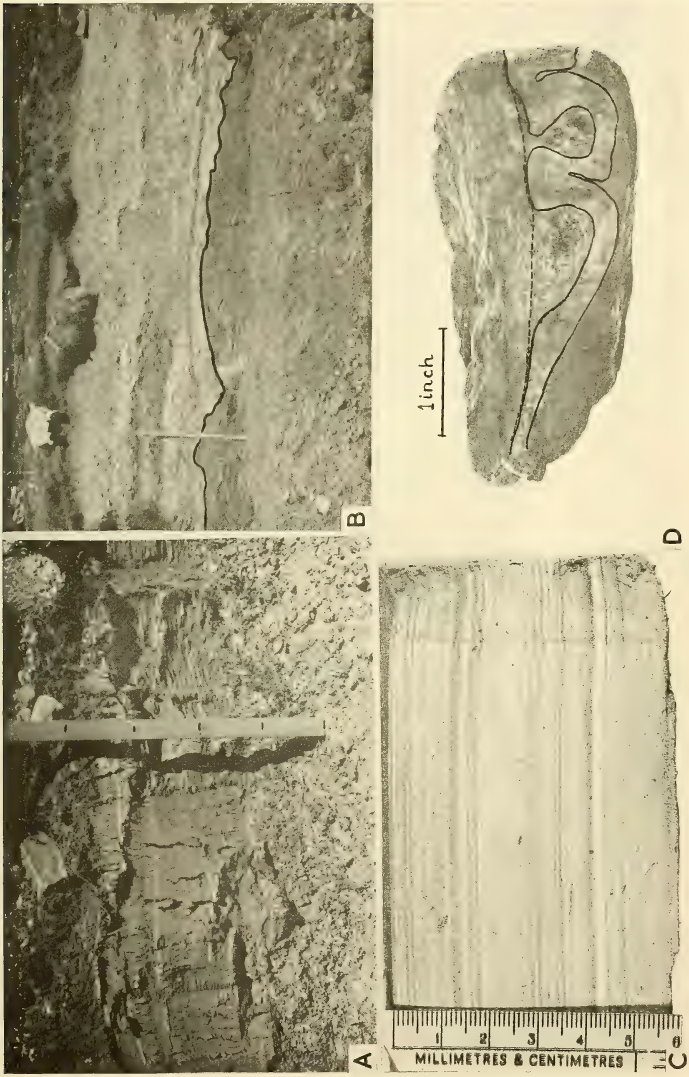
(1953.)



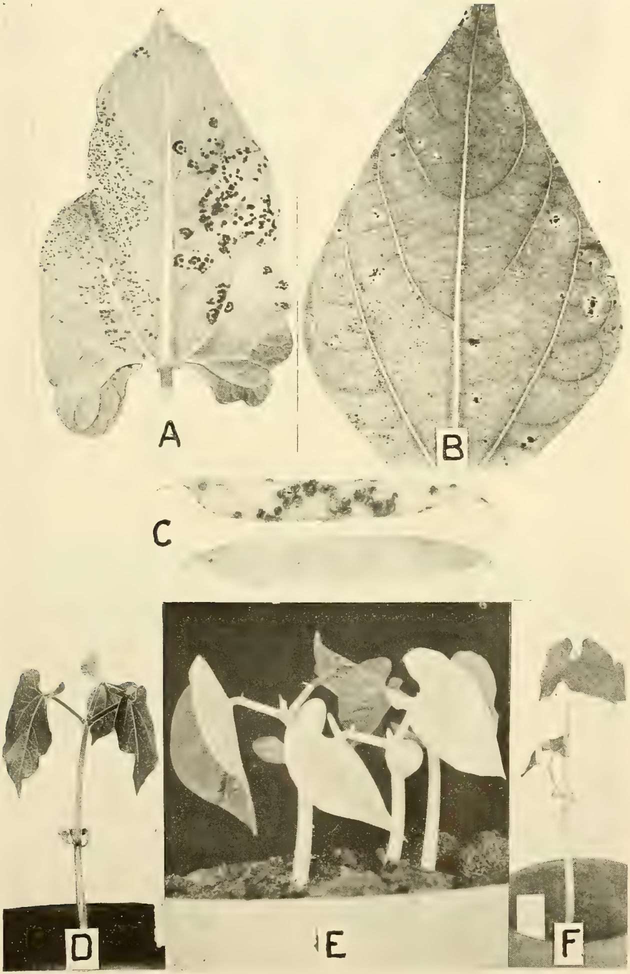
Rocks of the Wantabadgery-Adelong-Tumbarumba region.



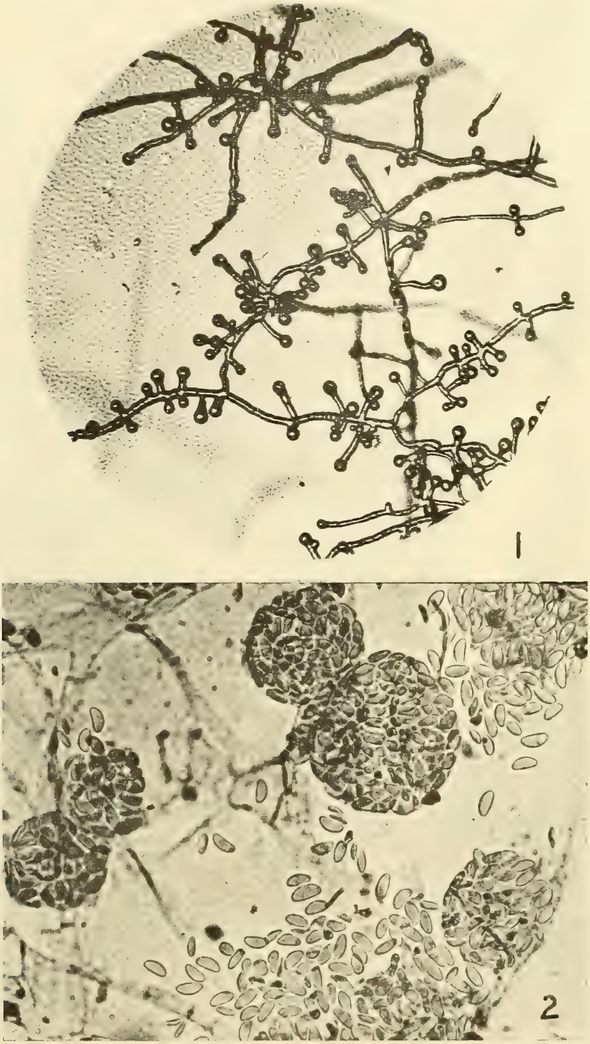
Rocks of the Wantabadgery-Adelong-Tumbarumba region.



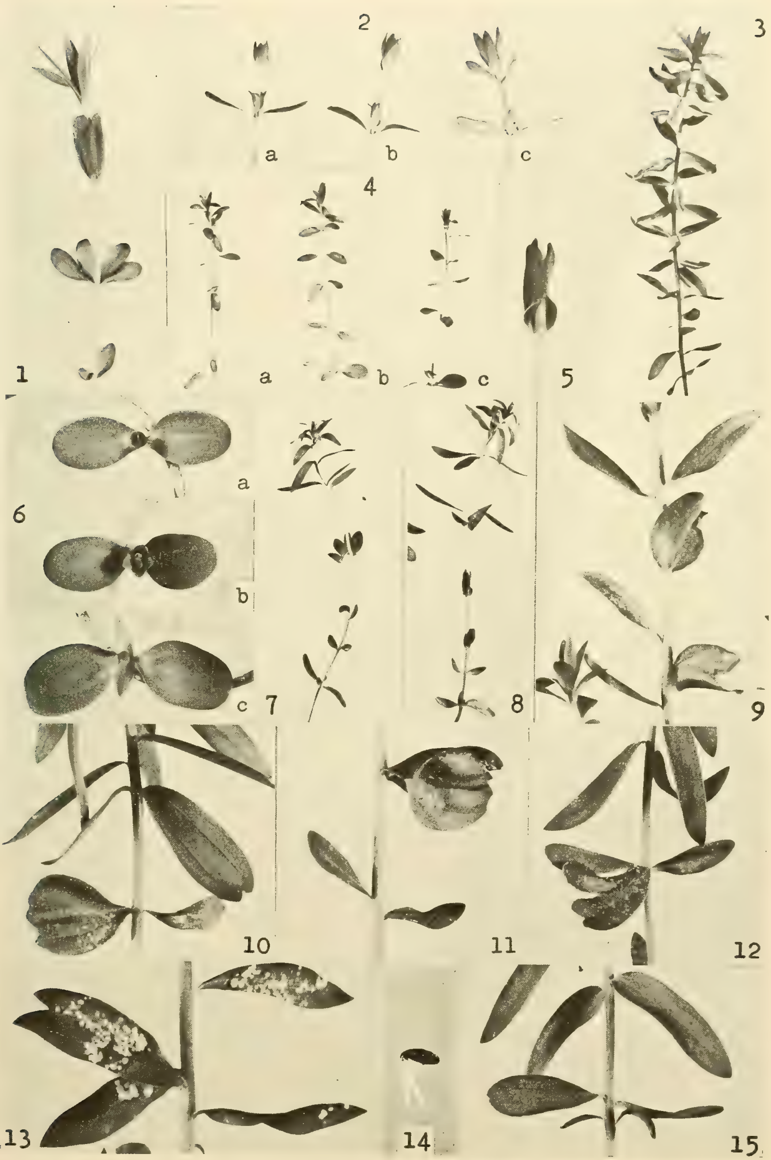
Varved clays in the Kosciusko district.



Bean leaves and seedlings affected by rust.



Xeromyces bisporus, gen. et sp. nov.



Abnormalities in *Linum usitatissimum* L.

Abnormalities in *Linum usitatissimum* L.

G. A. Waterhouse