











THE  
PROCEEDINGS  
OF THE  
LINNEAN SOCIETY  
OF  
NEW SOUTH WALES

FOR THE YEAR

1935

VOL. LX

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WITH NINETEEN PLATES  
and 417 Text-figures.

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## CORRIGENDA (1935).

- Page 92, line 2, for *australis* read *australe*  
for *Hampella* read *Hampeella*
- Page 111, lines 5, 6, for *uniseptum* read *uniseptatum*
- Page 228, line 6 from bottom, for *Bryopsis comosa* read *Bryopsis plumosa*
- Page 228, line 3 from bottom, for *crassinervius* read *crassinervia*
- Page 228, line 2 from bottom, for *Helminthocladia* read *Helminthora*
- Page 406, line 35, for *Erodium cygnodium* read *Erodium cygnorum*
- Page 406, line 36, and Page 423, line 8 from bottom, for *Tetragonia eremea* read *Tetragonia eremaea*
- Page 419, line 6, for *K. Georgeii* read *K. Georgei*

## ANNUAL GENERAL MEETING.

WEDNESDAY, 27th MARCH, 1935.

The Sixtieth Annual General Meeting was held in the Society's Rooms, Science House, Gloucester Street, Sydney, on Wednesday, 27th March, 1935.

Professor W. J. Dakin, D.Sc., President, in the Chair.

The minutes of the preceding Annual General Meeting (28th March, 1934) were read and confirmed.

### PRESIDENTIAL ADDRESS.

Another decade has passed in the history of the Society, which now enters its sixty-first year. Since the celebration of the Society's Jubilee ten years ago there have been many changes—the most outstanding in the way of achievement perhaps being the co-operation with the Royal Society of New South Wales and the Institution of Engineers, Australia, which resulted in the building of Science House, now regarded by a number of the scientific and professional institutions of Sydney as their permanent home. During the same decade there have been startling changes financially, but the Society, in spite of one or two misfortunes, appears to have safely negotiated the worst of the bad times—chiefly as a result of the conservation of most of its surplus income in the prosperous years before the depression. We may justly be proud of the amount and quality of the research work carried out by members, which is placed on permanent record in the PROCEEDINGS, of which the last ten volumes will compare favourably with those of any previous decade in the Society's history.

The concluding part of Volume lix of the Society's PROCEEDINGS was issued in December. The complete volume (447 plus lxiv pages, nineteen plates and 351 text-figures) contains thirty-six papers from twenty-seven authors, five papers being by Linnean Macleay Fellows and three by the Macleay Bacteriologist.

Exchanges from scientific societies and institutions totalled 1,795 receipts for the Session, as compared with 2,084, 1,866 and 1,703 for the three preceding years. During the year the following institutions were added to our exchange list: Imperial Fisheries Institute, Tokyo, Japan; New York Botanical Garden, New York, U.S.A.; University of Minnesota, Minneapolis, U.S.A.; Asociacion Sudamericana de Botanica, Montevideo, South America.

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

TANNATT WILLIAM EDGEWORTH DAVID, who died at Sydney on 28th August, 1934, was born at St. Fagan's Rectory, near Cardiff, Wales, on 28th January, 1858. He was educated at Magdalen College School, and New College, Oxford, where he was elected to the Senior Classical Scholarship in 1876. He graduated B.A. in 1880. Included in his studies was a course of Geology under Professor Prestwich, and he made his first acquaintance with glacial problems in South Wales, his

first paper, "Evidences of Glacial Action in the Neighbourhood of Cardiff", being published in 1881 by the Cardiff Naturalists' Society. He continued his geological studies under Professor Judd at the Royal School of Mines, and came to Australia in 1882 as Geological Surveyor on the staff of the Geological Survey of New South Wales, under the late C. S. Wilkinson. During the next decade he carried out many important geological investigations in New South Wales, including studies of the fossiliferous Silurian beds at Yass, the tinfields of New England, and the Coal Measures of the Hunter River district. The Hunter River Coalfield occupied much of his time and thought from this period until his death. During his survey of the field he discovered the occurrence of the Maitland Coalfield, and it is almost impossible to estimate the commercial value of the results of this work. Apart from the economic aspect, there arose many interesting problems concerned with the peculiar fauna and flora of the Permo-Carboniferous rocks, and with the occurrence of glacial phenomena.

In 1891 he was appointed Professor of Geology in the University of Sydney, where he remained until his retirement in 1924. His enthusiasm and inspiring personality quickly widened the influence of the Geological School of the University, and under him there grew up a band of geologists who have taken a prominent part in the development of geology and mining in Australia. He soon became recognized as a leader amongst Australian scientists; he was President of the Geological Section of the Australasian Association for the Advancement of Science in Hobart in 1892, and Brisbane, 1895; President of our Society, 1893-4 and 1894-5; President of the Royal Society of New South Wales, 1896 and 1909; President of the Australasian Association for the Advancement of Science, 1904, at Dunedin, and 1913, at Melbourne; President of the Australian National Research Council, 1921-22. He was a member of the Council of our Society from 1891 until his death, and was also for many years a member of the Council of the Royal Society of New South Wales.

His presidential addresses form a valuable series of summaries of knowledge in the Australian Region of volcanic action, structural features, evidences of glaciation, Mesozoic History, and tectonics.

In 1897 he was chosen as leader of the second expedition to the Atoll of Funafuti, where, in addition to obtaining a complete core from a bore sunk to a depth of 1,118 feet, he carried out a survey of the atoll and made investigations on the growth of corals. Soon after his return he studied the great thickness of Radiolarian rocks of Devonian age in New South Wales, showing that they were laid down in comparatively shallow water and not in abyssal depths. In 1906 he visited the glaciated districts of Southern India and attended the International Geological Congress in Mexico, where he presented an important paper summarizing the hypotheses put forward to explain past changes in climate. The year 1908 he spent in the Antarctic with the Shackleton Expedition, making the first ascent of Mount Erebus, and also made the first journey to the South Magnetic Polar area.

Much of his time for a few years after his return was occupied in arranging for the study of the geological material brought back by the Expedition, and also in securing funds for the publication of the scientific memoirs of the Expedition, this latter involving lecturing tours throughout the Commonwealth. Then came further Antarctic activities—organization of the Australasian Antarctic Expedition under Douglas Mawson, arrangements for Captain Scott's last Expedition, and securing support for Shackleton's Second Expedition—and the



visit of the British Association to Australia in 1914, in all of which he took a prominent part. On the outbreak of war he took an important part in the organization of a battalion of miners; he himself joined as Major, and arrived in France in May, 1916. He became geological adviser to the Controller of Mining in the First, Second, and Third Armies, and later to the Inspector of Mines of the British Expeditionary Forces, and in this capacity rendered very valuable service, since geological advice was of the greatest importance in tunnelling and mining operations in the very porous strata below ground water level. He was promoted to the rank of Lieutenant-Colonel, received the D.S.O., and was twice mentioned in dispatches.

In 1924 he retired from the Chair of Geology to devote himself to the preparation of a work on the Geology of Australia. He supplemented his previously unrivalled knowledge of the geology of the continent by travelling extensively and visiting or revisiting many critical areas. In 1933 he published a new Geological Map of Australia, accompanied by a volume of explanatory notes, but unfortunately he had not completed the major work at the time of his death. He spent much time during his last few years in studying the traces of the remains of organisms in the Pre-Cambrian rocks of South Australia. Though he had not yet succeeded in convincing all of his colleagues that the remains were truly organic, he himself believed that this piece of work was one of the most important contributions, perhaps the greatest, he had made to science.

As a geologist and as a leader in science his fame was world-wide, and he received many honours in recognition of his outstanding achievements: He was made C.M.G. in 1910, D.S.O. in 1918, and K.B.E. in 1920; he was awarded the Bigsby Medal (1899) and the Wollaston Medal (1915) of the Geological Society of London, the Conrad Malte-Brun Prize of the Geographical Society of France (1915), the Mueller Medal of the Australasian Association for the Advancement of Science (1908), and the Clarke Memorial Medal of the Royal Society of New South Wales (1919). He had conferred on him the honorary degree of Doctor of Science by the Universities of Oxford, Wales, Manchester, Cambridge and Sydney, and of Doctor of Laws by the University of St. Andrews. The Royal Society of London elected him a Fellow in 1900. On his retirement in 1924 he was made Professor Emeritus by the Senate of the University.

He was truly "a fine scholar, a great scientist, a gifted teacher, a distinguished explorer, an ardent patriot, a warm-hearted philanthropist, a gracious friend, and a humble-minded Christian gentleman".

WALTER H. BONE, who died at Killara on 15th July, 1934, had been a member of the Society since 1923. He was a great lover of the bush and a writer of animal and bush stories. As a naturalist he was a supporter of various scientific societies, but it was only on very rare occasions that he attended meetings of our Society.

THOMAS McDONNOUGH died at his home at Coogee on 26th June, 1934, at the age of sixty-seven. He entered the Public Service in 1891 and was engaged on the Sydney Detail Survey until he was transferred to Ballina in 1901. Here he spent several years in survey work in connection with water supply, drainage schemes, and harbour and river works; in 1908 he was transferred back to Sydney, and for many years was occupied in investigations for sewerage and water supply schemes for a number of the larger country towns of New South Wales, as well as for drainage and sewerage works in Sydney. He was a licensed surveyor and an Associate of the Sydney Technical College. Though he did not

take an active part, he was for many years a very regular attendant at the meetings of this Society, of which he had been a member since 1907.

WILLIAM SUTHERLAND DUN, who died at Mosman on 7th October, 1934, was born at Cheltenham, England, on 1st July, 1868. At the age of about twelve months he came to Australia on the ship '*Sobraon*'. He was educated at Newington College and the University of Sydney, and entered the Department of Mines in 1890. In the earlier years of his service in the Geological Survey he was assistant to the late Sir Edgeworth David in the survey of the Hunter River Coalfields. Later he became assistant to the late Robert Etheridge, Jr., under whom he obtained his training as a palaeontologist. In 1899 he became Palaeontologist and Librarian to the Geological Survey, a position he retained until his retirement from the Public Service in 1932. He was also Lecturer in Palaeontology in the University of Sydney from 1902 till his death, and was Honorary Palaeontologist to the Australian Museum. He was President of this Society for the two years 1913 and 1914, and a Member of Council from 1901 to 1919. He was an Ordinary Member of the Society from 1894 to 1922, and a Corresponding Member, 1932-1934. He was President of the Royal Society of New South Wales in 1916, and for many years a member of the Council of that Society. He was elected an associate member of the Australian National Research Council in 1922. He contributed only three papers to our PROCEEDINGS, one of them in conjunction with W. N. Benson and W. R. Browne, and one with W. H. Rands and T. W. E. David. The greater part of his published work was palaeontological, and much of it appeared in the publications of the Geological Survey of New South Wales. He had an extraordinarily wide knowledge of the fossil faunas and floras of Australia and of geological literature in general, and it was seldom that he was unable to assist any one of his fellow workers seeking information. His death was a very severe loss to Australian palaeontology, and, with the present-day tendency to specialization, it will probably be a very long time before another acquires such a wide knowledge of our fossils.

We offer our hearty congratulations to Mr. E. C. Andrews on his election as an Honorary Fellow of the Royal Society of New Zealand; Dr. R. J. Tillyard on the award of the Mueller Medal by the Australian and New Zealand Association for the Advancement of Science; Professor W. J. Dakin on the award of the R. M. Johnston Memorial Medal by the Royal Society of Tasmania; and Mr. John Andrews on the award of a Rockefeller Scholarship to enable him to continue his studies at Cambridge.

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

Mr. H. L. Jensen, Macleay Bacteriologist to the Society, completed his introductory work on the numbers of microorganisms in soils and the preliminary tests of the usefulness of the Rossi-Cholodny method. The results of this work appeared in two papers in the PROCEEDINGS for 1934. He then carried out preliminary experiments on the influence of varying temperature and moisture on the composition of the soil micro-flora in decomposition experiments with organic matter in soil. These experiments showed that, as a general rule, irrespective of the character of either the soil or the organic material in it, bacteria tended to multiply most strongly at low temperatures, whereas actinomycetes predominated under conditions of high temperature and low moisture. By means of an adaptation of the Rossi-Cholodny method he was able to obtain quantitative expressions for the density of vegetative fungal mycelium in the soil, a method for which had hitherto been wanting. These results have been incor-

porated in a paper which is ready for publication. He then commenced the main experiments on the decomposition of organic matter by soil organisms, the general aim of which was to determine over a period of ten to forty days, at temperatures varying from 3-5 to 37-38° C., the production of carbon dioxide from soil either with or without extra addition of organic matter, and to correlate the rate of carbon dioxide formation (which serves as an index of the intensity of decomposition) with the changes taking place in the numbers of the different groups of microorganisms. The results of these experiments have been consistent, and they account naturally for the rapid disappearance of "humus" in soils in hot climates as well as for the synthesis of proteid material which has been shown to take place during the decomposition of organic matter at low temperatures. They would also seem *in part* to account for the vigorous nitrate formation that is known to take place in Australian wheat soils, but more work in this direction is needed before any final conclusion can be reached.

Mr. F. A. Craft, Linnean Macleay Fellow of the Society in Geography, has completed two papers, one of which, "Regimes and Cyclical Volume Changes of the Upper Murray and Snowy Rivers, N.S.W.", appeared in the PROCEEDINGS for 1934. The second deals with the relationship between stream flow and modern erosion in the upper Murray Catchment. He has found that the work of the stream since white settlement has been directed towards the continuation of terrace cutting in valley alluvials. A cycle is indicated involving pebble formation from weathered channels and hillsides, followed by a period of decreasing supply of material and its more complete reduction in the passage of gorges and ending in clear streams flowing on unweathered rock. He also completed work for a further paper dealing with stream geography in south-eastern Australia. This has been mainly devoted to a preparation of a series of maps showing the relative annual flows of most of the principal rivers, the distribution and importance of effective catchments, the annual regimes, the variability of flow from year to year, and the importance of exceptional maximum and minimum flows in the output of streams.

Miss Lilian Fraser, Linnean Macleay Fellow of the Society in Botany, completed a study of the life-histories of *Aithaloderma ferruginea* and *A. viridis*, the results being included in a paper on the life-histories and the systematic positions of *Aithaloderma* and *Capnodium*. These two genera are shown to be closely related, and the affinities of the Capnodiaceae prove to lie with the Dothideales rather than with the Sphaeriales or Perisporiaceae. It is shown that there may be developed structures such as "ostiole", periphyses and stromatic wall, which are very similar to structures in unrelated genera, but are of different origin. The importance of this in the systematic determination of mature specimens without examination of the life-history is discussed. Systematic studies have been made of (i) the species of Eucapnodiaceae collected in New South Wales, of which five species and varieties are described as new and other species are described, several of them being recorded from Australia for the first time; (ii) the species of the Chaetothyriaceae collected in New South Wales, of which nine are described as new and one recorded for the first time in Australia; (iii) species of Meliolineae and Trichopeltaceae from various parts of New South Wales. Work in progress includes a survey of the host range, distribution, nomenclature and biology of *Asterella Hakeae*, and a microchemical study of the cell wall of *Dematium pullulans*. During the coming year Miss Fraser proposes to make a complete study of the cell membrane of the Capnodiaceae and related

fungi to determine, if possible, the reason for their powers of resistance to variations in temperature, humidity and light intensity. She also hopes to complete the study of the reactions of members of the Capnodiaceae to substances in the honey-dew of insects, with a view to discovering the reason for their restricted habitat. She also proposes to study the distribution of the epiphyllous flora of the rain forest areas and to collaborate with Dr. McLuckie in the description of new parasitic fungi.

Dr. I. V. Newman, Linnean Macleay Fellow of the Society in Botany, prepared for publication the later portion of the life-history of *Acacia Baileyana* (Cootamundra Wattle). He conducted extensive field work in a search for the natural habitat of this species, but was able to find it only in one small area near Cootamundra. Following on the phenomena of fertilization recorded in *Acacia Baileyana*, he collected material for a further study of those phenomena in *A. Baileyana* and *A. discolor*. He has studied *A. longifolia* and *A. suaveolens* in view of the theory of carpel polymorphism, enunciated by Miss E. R. Saunders of Cambridge, and has shown that these two species do not conform to that theory, as claimed by Miss Saunders. This study deals with the whole course of the ontogeny of the legume up to the time of fertilization, and will have some bearing on theories propounded by Professor J. McLean Thompson and Dr. H. Hamshaw Thomas. Dr. Newman has also begun a genetical study of the flower-colour forms of *A. discolor*, and has carried out a considerable amount of field and herbarium work for the future revision of the taxonomy of the genus *Acacia*. During the coming year he proposes to continue his investigation of the Australian Acacias with a view to working out a classification that will correspond with the phylogenetic relationships and will clarify the many difficulties existing in the taxonomy of the genus.

Mr. N. Alan Burges, Linnean Macleay Fellow of the Society in Botany, resigned his Fellowship as from 31st July, 1934, having been awarded the James King of Irrawang Travelling Scholarship by the University of Sydney, under which he proceeded to Cambridge. During the time he held the Fellowship he continued his study of *Uromycladium*, particularly that of *U. Tepperianum* on *Acacia stricta*. Material was collected in the field and some infection experiments were tried, but were unsuccessful. He continued the cytological examination of the teleutospore stage, paying particular attention to the origin of the binucleate stage. The results of his work have been embodied in papers which will be submitted to the Society during the coming year.

Three applications for Linnean Macleay Fellowships were received in response to the Council's invitation of 26th September, 1934. I have pleasure in reminding you that the Council reappointed Miss Lilian Fraser and Dr. I. V. Newman to Fellowships in Botany, and also appointed Mr. R. N. Robertson, B.Sc., to a Fellowship in Botany for one year from 1st March, 1935. We wish them a successful year's research. The small number of applications was due, partly, to the fact that at least two prospective applicants received appointments of a more permanent nature very shortly before the time for application for Fellowships.

Mr. Rutherford Ness Robertson graduated in Science at the University of Sydney with first class honours in Botany in March, 1934. He was then awarded a Science Research Scholarship in the University. He has been investigating the physiology of the movement of stomata in certain Australian plants, and has come to the conclusion that this movement is intimately bound up with the



general metabolism of the leaf and is not specially connected with water loss. He has designed a special apparatus for extracting the gas from the intercellular space system of leaves and for analysing this gas for its relative percentage of carbon dioxide and oxygen at different times during the day. By this he hopes to discover any correlation which may exist between stomatal movement and photosynthesis and respiration. In addition to this physiological work, he has taken part in two ecological surveys. For his year's work as a Fellow he proposes to continue the investigation of the physiological processes involved in the leaf, and particularly their bearing on stomatal movement. He also proposes, as opportunity offers, to continue his participation in the ecological survey of the Myall Lakes area and to elucidate some of the problems that arise there.

#### THE AQUATIC ANIMAL AND ITS ENVIRONMENT.

##### *From the Point of View of Salinity and Osmotic Pressure of the Internal Media.*

During the last ten years Zoological Science has made an altogether new valuation of the study known since 1869 as Animal Ecology. The intricacy of the relationships between an animal and its environment (whether inanimate or animate) has been better appreciated. As a result there has arisen a realization of the need for a thorough investigation of all the mechanisms which subserve this relationship. The new Ecology will certainly provide future zoologists with enough experimental work to satisfy the most ardent critic of purely descriptive work. It will entail not only laboratory experimentation, but the closest observation of the whole organism in its natural habitat and experimentation in this environment. And it will, no doubt, provide results of as much value in economic science as in pure science.

Tonight I propose to put together a story of the investigation of one aspect of this matter—the relationship existing between an *aquatic* animal and its environment on account of the fact that some, at least, of its bounding membranes must be permeable wholly or partially to the external medium (whether it be sea or fresh water).

Twenty-six years have actually elapsed since the publication of my first paper on this subject. At that time very few people indeed, in Great Britain, were interested in the matter. Earlier work had been carried out by several European scientists, a Canadian physiologist and a United States zoologist. Practically no further interest was shown in the British Empire until recent years. Perhaps the modern trend to make zoology a more experimental science is responsible for the new enthusiasm in this line of research which, one might add, has been almost newly discovered by zoologists. For this reason, I felt that it would be useful if, without entering into too much detail (surely quite an unnecessary feature of a Presidential Address), I set forth the position reached and something of the interesting tale of progress.

As far back as 1859, the great French physiologist, Claude Bernard, with that foresight so characteristic of him, realized the advantage of the term "Internal Medium" for those constituent fluids of the body (blood, coelomic fluid, etc.) as contrasted with what is outside. By the term *External Medium* I shall understand the fresh water, sea water, hot spring water or whatever may be the aqueous fluid in which aquatic animals live. The term "Internal Medium" or "Internal Media" is a particularly useful one, for it serves to include other fluids of the body as well as blood, and in many invertebrates these body fluids play a very important part in the constitution of the body.

Now it might appear to be obvious that the fluids in the vacuolated protoplasm of a single-celled organism like an Amoeba, a Paramecium, a marine Radiolarian, or a multi-cellular creature like a Jelly Fish, should be much more related in constitution to the external medium than those of a crab with its hard shell of impervious chitin, or a fish with its scaly exoskeleton. The facts show, however, that the real conditions are by no means so obvious and simple as one might conclude at first sight. The blood of a teleost fish is usually altogether different in its salinity from that of a lobster living side by side in the same sea-water. The thin protoplasmic membrane of an almost microscopic single cell may separate fluids astonishingly different in composition.

The most important difference between waters in which aquatic animals live lies in their salt content. We shall, therefore, be chiefly concerned with the effect of this saline composition of the external medium upon the creatures living within it. Fortunately the saline composition of ocean water is remarkably uniform. The degree of salinity varies in different places, and it may be very low in river estuaries, but even here one usually finds the different constituents in the same proportions. The only change has been a dilution. It will be desirable to give the constituents of a typical ocean water at the outset.

Chlorine	..	..	..	..	..	..	..	..	55.29
Bromine	..	..	..	..	..	..	..	..	0.19
SO <sub>4</sub>	..	..	..	..	..	..	..	..	7.69
CO <sub>2</sub>	..	..	..	..	..	..	..	..	0.21
Sodium	..	..	..	..	..	..	..	..	30.59
Potassium	..	..	..	..	..	..	..	..	1.11
Calcium	..	..	..	..	..	..	..	..	1.20
Magnesium	..	..	..	..	..	..	..	..	3.72

The total weight of the salts in grams per 1,000 grams of sea-water is known as the salinity, and the average salinity of typical ocean sea-water may be regarded as 35‰.

Chemical analyses of the internal fluids of the animal body date back to the 'fifties, but some of the early work was very inexact. Thus, in 1852, Thomas Williams stated that the bulk of the fluid of the visceral cavity of Tubularia consisted of sea-water, "for when the specimen dries and the fluid evaporates, cubic crystals of chloride of sodium are seen amidst the albuminous molecules". The same author also considered that the bulk of the fluid in the peritoneal space of the Gephyrea was salt water.

The first more detailed and accurate chemical analyses of the fluids of aquatic animals came in the years between 1870 and 1888. The salinity of several of these was set out by Boussingault in 1872. Leon Frédéricq examined Octopus blood in 1878, and L. Cuenot investigated the starfish in 1888 and claimed that the body fluids were practically sea-water with all its salts.

It is evident that, about the period between 1880 and 1885, the relations between the internal media and the external media were beginning to be understood, and this was undoubtedly due mainly to the work of Leon Frédéricq of Liège. In a paper in 1882, bearing the title "Influence du milieu extérieur sur la composition saline du sang chez quelques animaux aquatiques", he states definitely that the blood of crabs, lobsters and octopus of the North Sea is as salt as the sea-water, whilst that of the crayfish of the rivers contains very little salt. And he adds to this the comment: "It seems, therefore, to be established that by virtue of the simple laws of diffusion an equilibrium in salts is produced by a simple exchange." Then, however, comes the more interesting further state-

ment to the effect that in *fish* the conditions are not like this and that, despite the fact that oxygen and  $\text{CO}_2$  easily pass through the gills of these animals, the fish of the sea present a salinity *entirely different* from that of the water they live in.

Three years later, in 1885, Claude Bernard was fully acquainted with the consequences of these discoveries, and in his book "Introduction à l'étude de la médecine expérimentale" (p. 110) he proclaims: "Chez tous les êtres vivants le milieu intérieur, qui est un produit de l'organisme, conserve des rapports nécessaires d'échange et d'équilibre avec le milieu cosmique extérieur, mais à mesure que l'organisme devient plus parfait, le milieu organique se spécifie et s'isole en quelque sorte de plus en plus du milieu ambiant."

It was a remarkable generalization, seeing that the real facts were only divulged here and there and in no case in a really complete state. Claude Bernard had realized that in the vertebrate phylum there had been evolved a remarkably constant internal chemical environment culminating in the regulated temperature of the birds and mammals.

Frédéricq, in commenting on Bernard's generalization in the year of its publication, gives further details of his own work on the salinity of the blood of aquatic animals under different conditions, and now begins to try the experiment of putting a marine crustacean into a mixture of sea and fresh water. It is clear, however, that very little was known of the exact saline composition of the blood. It was the general concentration of salts that had aroused interest.

But already, from another side, facts were being obtained which were to have a very fundamental bearing on the question. For many years it had been customary for physiologists to use a solution of common salt ( $\text{NaCl}$ ) when making experiments in which blood had to be diluted without the corpuscles changing in volume, or for the examination of fresh animal tissues under the microscope. The solution used was about 0.75%, approximately isotonic with the blood. In 1882 Sydney Ringer, in a famous paper, showed that if he desired to keep a frog's heart beating the ordinary saline solution was disastrous. He then tried adding other substances to the normal saline in order to obviate the abnormal effects, and discovered that white of egg would do it. He traced this to the effect of potassium chloride, and eventually by a series of thoughtful experiments a solution was obtained which would maintain the heart beat satisfactorily. The solution has since been known as Ringer's Solution. It consists of  $\text{NaCl}$  0.65%,  $\text{KCl}$  0.03%,  $\text{CaCl}_2$  0.02% + a trace of sodium bicarbonate, and it is a curious fact that the relative proportions of sodium, calcium and potassium in this mixture are very close to the proportions of the same salts in sea-water.

In the year 1889 Bunge made the suggestion that the large amount of sodium chloride in human tissues might be the relic of some aquatic ancestor. A few years later, Quinon (1897), better versed now in the composition of the internal media of different animals, made the definite assertion that the internal medium was practically a marine medium and that even a highly developed creature, such as a bird or a mammal, should be able to withstand a considerable introduction of sea-water. Finally, he extended his thesis and stated definitely that the facts pointed to a theory that life originated in water and that there could be no doubt that such water was marine.

There were now two theses in the field arising from a study of the salinity of the internal fluids of aquatic and other animals, and either of these alone was of sufficient interest to make the matter worthy of general attention.

Singularly enough they were to remain practically unknown, except to the few specialists who had taken the subject up.

The idea that evolution had resulted in a progress from a condition in which the internal fluids of aquatic animals were entirely at the mercy of the external medium, to one in which the animal controlled its internal media and kept them independent of their surroundings, led naturally to a more detailed and accurate series of researches.

The questions to be answered were:

1. In what animal groups did the independence of the internal media first become obvious?

2. What was the mechanism involved in maintaining this independence?

In regard to this second question, which was to prove by far the more difficult of solution, several possibilities could be envisaged. The skin and outer bounding membranes of the body could be impermeable to water and salts (as in the whales which live in sea-water but come to the surface to breathe); the skin could be permeable or semi-permeable and the regulation of the composition of the internal blood, etc., could be maintained by the kidneys or other excretory organs; the outer membrane itself could play a part in regulation.

The collection of more observations was clearly the first need, and several authors now commenced to make observations by other methods and more careful chemical analyses.

Realizing that the skin and body wall of aquatic animals could act as a semi-permeable membrane with resultant osmotic conditions, Bottazzi of Naples commenced, in 1897, a series of investigations on the so-called osmotic pressure of the blood of fishes and the internal media of other aquatic animals. The principal method used was the determination of the freezing point of the fluids in question by use of the Beckmann Freezing Apparatus. This method was introduced about 1892 by Dreser for the investigation of human body fluids for medical purposes.

Its application to the new line of research was particularly appropriate, for, not only is it a very convenient method, but it had the advantage of throwing light from a different angle on the relationships of the internal and external media.

The phrase "osmotic pressure" implies, of course, the presence of two solutions separated by a semi-permeable membrane. To speak, then, of the osmotic pressure of a fluid apart from these conditions may seem strange. Actually no difficulty arises in practice. When salts are dissolved in water and the solution is separated from pure water by a membrane impermeable to the salts but permeable to the water, water passes through the membrane from the solution to the water and with a pressure which is dependent upon the concentration of molecules, ions or colloidal particles in the solution. When we speak of the osmotic pressure of a solution we refer, therefore, to the effect it would produce if it were separated by a semi-permeable membrane from the pure solvent. Now, since the freezing point of a solution is also lowered proportionately by the concentration of molecules, ions, etc., within it, we can use the freezing point as a direct measurement of osmotic pressure. Generally it suffices to give the lowering of the freezing point, thus salt water of 37.83% freezes at  $-2.29^{\circ}$  C. We express this as  $\Delta 2.29^{\circ}$ , meaning that the saline constituents are responsible for a depression of the freezing point of  $2.29^{\circ}$  C.



We may now give some of the results of Bottazzi's investigations in the 'nineties.

<i>Coelenterata.</i>										
<i>Alcyonium palmatum</i>	..	..	..	Vascular cavity fluid	..	..	..	..	..	Δ 2·195
<i>Echinoderms.</i>										
<i>Astropecten aurantiacus</i>	..	..	..	Water vascular system	..	..	..	..	..	Δ 2·312
<i>Asterias glacialis</i>	..	..	..	Visceral cavity fluid	..	..	..	..	..	Δ 2·295
<i>Gephyrea.</i>										
<i>Sipunculus nudus</i>	..	..	..	Fluid of visceral cavity	..	..	..	..	..	Δ 2·31
<i>Crustacea.</i>										
<i>Maja squinado</i>	..	..	..	Blood	..	..	..	..	..	Δ 2·36
<i>Homarus vulgaris</i>	..	..	..	Blood	..	..	..	..	..	Δ 2·292
<i>Gasteropoda.</i>										
<i>Aplysia limacina</i>	..	..	..	Body cavity fluid	..	..	..	..	..	Δ 2·31
<i>Cephalopoda.</i>										
<i>Octopus macropus</i>	..	..	..	Blood	..	..	..	..	..	Δ 2·24
<i>Elasmobranch fishes.</i>										
<i>Torpedo marmorata</i>	..	..	..	Blood	..	..	..	..	..	Δ 2·26
<i>Trygon violacea</i>	..	..	..	Blood	..	..	..	..	..	Δ 2·44
<i>Marine Teleost fishes.</i>										
<i>Charanz puntazzo</i>	..	..	..	Blood	..	..	..	..	..	Δ 1·04
<i>Cerna (Serranus) gijas</i>	..	..	..	Blood	..	..	..	..	..	Δ 1·034

The freezing point of the Naples sea-water from the Aquarium is given as having an average  $\Delta$  of 2·29. The freezing point for human blood is  $-0\cdot56$  to  $-0\cdot59$ , and it is interesting to note that Rodier (1899) obtained  $\Delta$  0·602 for the turtle *Chelonia caouana* and  $\Delta$  0·74 for the blood serum of a dolphin, *Delphinus phocaena*.

These figures bore out the analyses of Frédéricq (1884, 1885, 1891). The resemblance between the body fluids of the invertebrata and the sea-water in which they were living was clearly brought out. But a surprising feature was the low freezing point for elasmobranch blood, which indicated an apparently high salinity. It looked at first sight as if the sharks and rays resembled the invertebrates in the condition of their body fluids. Here was a really astonishing fact which was rendered more interesting still when Rodier, working at Arcachon, where the water was slightly less saline, found that the blood of six species of sharks and rays had a freezing point slightly different from those of Naples, but agreeing in that it was again nearly, if not the same as, that of the sea-water.

But Frédéricq (1891) had already shown that the marine elasmobranchs, like the teleosts, were relatively poor in salt. It seemed as if there were some curious discrepancy between freezing point determinations and analyses. The solution of the mystery was grasped by Quinton and Rodier (1899), both of whom realized that an extraordinary proportion of urea, already noted as a character of shark blood, was responsible for the unusual lowering of the freezing point.\* Unfortunately, up to this time, the methods of analysis had been only approximate and the full situation was still not realized.

\* The fact that sharks and rays were apparently different from all other animals in containing an enormous quantity of urea in the blood was discovered as early as 1858 by Staedeler. In 1888 Krukenberg confirmed this for a number of species.

In the meantime experiments were being conducted upon the effects of fresh-water or diluted sea-water on marine fish and other marine creatures, and vice versa, of sea-water on fresh-water forms. It was easily seen that an alteration in the sea-water by diluting with fresh-water produced a fall in the salinity of the internal media of many invertebrates, with a corresponding reduction in osmotic pressure.

A few of these experiments, combined with the results of the determinations made on animals from natural environments of different type, caused Bottazzi (1908) to put forward the argument that the body fluids of marine invertebrates, and also those of the elasmobranchs, had the same osmotic pressure (except for slight and unimportant differences) as the surrounding sea-water. The actual electrolytes present in the fluids of the different species varied, and might differ even in the same groups of animals. On the other hand, the internal media of marine teleosts differed entirely from the surrounding medium in osmotic pressure, and in this respect the teleosts resembled the higher land vertebrates.

But the invertebrates of fresh and brackish waters had to be regarded as entirely different from their marine relatives. The salt content of their blood was found to be higher than that of the surrounding water—in the case of the fresh-water crayfish *much* higher. We shall see that the conditions are altogether more complex here than was realized, and I shall return to the invertebrata after a consideration of the conditions in teleost fishes.

#### *The Osmotic Conditions Prevailing in Teleosts.*

There was considerable doubt at first as to the constancy and complete independence of the blood and internal media of the teleost fishes. Quinton, by putting fishes from sea-water into fresh-water, had indeed altered the concentration of the blood salts, but the fish were anything but normal under such conditions.

Garrey (1904) believed that the body membranes of teleost fishes were definitely impermeable. He examined a species of eel in both fresh and salt water and also the small fish so commonly used for experiments in the United States, *Fundulus heteroclitus*. He stated: "From these experiments we may conclude that in all probability the blood of *Fundulus* does not suffer much, if any, change in concentration when the fish is transferred from salt-water into fresh-water or vice versa, provided the membranes are uninjured. If these experiments admit of general application to migratory teleosts they would indicate that these animals also are in some way protected from changes in the osmotic pressure of the blood and tissues and that the principal protective factor probably lies in a lack of permeability of their membranes."

Griffiths (1892), who had made chemical analyses of the body fluids and tissues of many species of invertebrates, stated also that the blood of a marine haddock did not contain more soluble salts than that from fresh-water fishes.

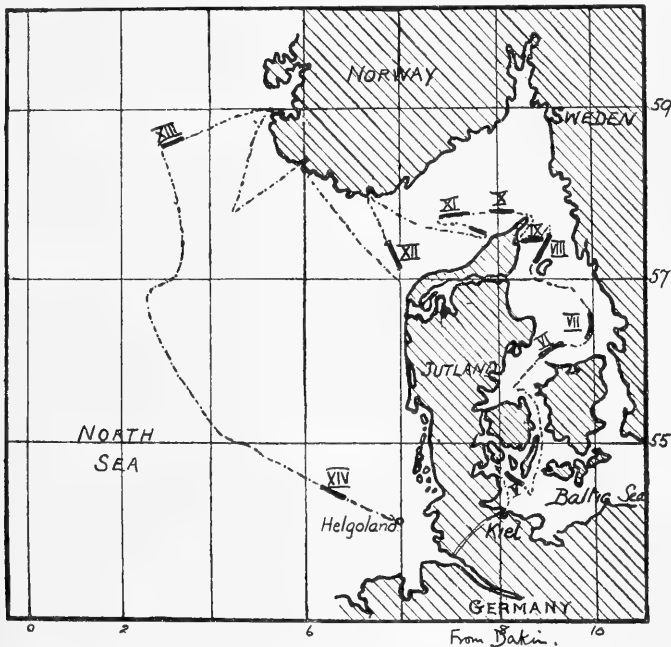
Naturally interest was directed to such fish as could pass normally from sea-water to fresh-water and safely withstand extensive changes in the constitution of the external medium. In this regard Greene (1904) investigated the Chinook Salmon for the United States Bureau of Fisheries, remarking that it might be considered an ideal subject for the study of the osmotic balance which existed between the outside medium and the living tissues.

Greene examined eighteen salmon from the sea and found that the mean freezing point of the blood was  $-0.762^{\circ}$  C. He then examined salmon from tidal waters which were practically fresh and, finally, others from the spawning

beds in fresh waters. The figure for the tidal waters was  $-0.737$  and for the spawning beds  $-0.613$ . Notwithstanding his determinations, Greene was averse to putting these results down as a proof of the effect of the surrounding water. He affirms that "the absence of food and the important metabolism occurring during the eight to twelve weeks' sojourn in fresh-water are to be considered in this connection and possibly are sufficient to account for the change".

I am giving rather full attention to the matter of the fresh-water teleostei because it seemed that this was the lowest group of vertebrate animals which had achieved a full measure of control over the composition of their blood. It was essential to determine whether complete independence had been attained.

Some evidence was already accumulating against the view set out above, Dekhuyzen (1905) in particular having examined different teleost species from sea-water of a wide range of salinity. I was rather against any further attempt at aquarium experiments since the more or less rapid changes of water seemed extremely likely to upset the normal condition of the fish. And if the teleosts performed work in sustaining a blood salinity and osmotic pressure very different from the external media, it would be most likely that any unhealthy conditions would completely overshadow normal changes, especially if such were small.



Cruise of "Poseidon", Feb.-March, 1908.—The stretches in black connected by the dotted line indicate the places where the trawl was used, and the numbers the series of determinations referred to in the text.

The method which I adopted in order to investigate the matter more fully was to obtain permission to travel on one of the scientific voyages of the German research ship "Poseidon" from Kiel in the Baltic to Helgoland in the North Sea. In this way it was thought possible (provided that trawling was carried out at

regular intervals) to obtain fish of the same species—Plaice (*Pleuronectes platessa*) and the Cod (*Gadus morrhua*) in particular, as well as others—from water of a range of salinities, to obtain them in the living state, and to do all this within a few weeks, so that conditions might remain as uniform as possible during the entire experiment.

Since the account of this expedition was printed in the first numbers of a journal which is now somewhat rare, I have taken this opportunity to redraw the map of the voyage, which shows where the otter trawl was used and the actual determinations were made.

The results which concern us here may be tabulated as follows:

Date.	Series No.	Position.	$\Delta$ of Sea Water.	Salinity. %	Species of Fish.	$\Delta$ of Blood.
Feb. 5	I	Kiel Harbour.	-1.093‰	2.033	<i>Gadus morrhua</i> .	-0.720
" 6	II	" "	"	"	" "	-0.75 -0.751
" 10	III	" "	"	"	<i>Pleuronectes platessa</i> . (3 species.)	-0.66
" 12	IV	" "	"	"	<i>Pleuronectes platessa</i> . (3 species.)	-0.65
" 16	V	On S.S. " <i>Poseidon</i> " in Baltic just outside Kiel Forde.	-1.3	2.6%	<i>G. morrhua</i>	-0.758 -0.710 -0.730
" 16	V	"	"	"	<i>P. platessa</i> . (3 species for each det.)	-0.718 -0.720
" 17	VI	Kattegat. "	-1.665 "	2.97 "	<i>G. morrhua</i> . <i>P. platessa</i> . <i>Raja radiata</i> .	-0.715 -0.73 -1.51
" 17	VII	Kattegat, near Coast of Sweden.	-1.71	3.15	<i>G. morrhua</i> . <i>R. batis</i> .	-0.8 -0.77 -1.82
March 5	XIV	North Sea.	-1.90	3.485	<i>G. morrhua</i> .	-0.73 -0.79 -0.75 -0.77
	XV	Helgoland.	-1.90	"	<i>P. platessa</i> .	-0.78 -0.84 -0.75 -0.77
	XVI	Helgoland.	-1.90	"	<i>G. morrhua</i> .	-0.778 -0.748

The "*Poseidon*" was fitted with a special laboratory for the examination of the wet and live fish as they came from the trawl. The specimens used for the investigation were all in excellent and uninjured condition. The freezing point determinations were made at once, irrespective of whether it was daytime or

2 a.m. Since the expedition left Kiel in February, it may well be imagined that the voyage was not particularly comfortable.

As the "*Poseidon*" was engaged in making a complete series of scientific determinations of the oceanographical conditions prevailing, it was possible to obtain the results of chemical analyses of the sea-water at the place where the fish were captured (and within a few hours of the trawling). The freezing point of the bottom water was also taken by myself whilst the trawl was being dragged along the bottom.

A very considerable number of *Pleuronectes platessa* were examined and the figures show a continuous but *slight* change from Kiel ( $\Delta$  0.655) to Helgoland (average  $\Delta$  0.787) the water having changed from  $\Delta$  1.093 to  $\Delta$  1.90. But in the case of the cod fish the variation between individuals at one place is often greater than the difference between specimens from two such different waters as that in the Baltic and that at Helgoland.

Other species of teleosts inhabiting sea-water and brackish estuarine water, including the eel from fresh-water and from sea-water, were examined later and shown to possess a slightly higher osmotic pressure in sea-water than in fresh-water.

These results have been generally confirmed. I think we can say quite definitely today that the teleost fishes have practically achieved independence of the external medium although not completely freed from its influence. It is also clear that each different species of teleost fish has its own mean osmotic pressure, or, to put it another way, its own characteristic chemical composition (even those species living together in water of the same salinity differ slightly), which is quite in accordance with modern physiological discovery.

*Modern Views on the Internal Media and their Regulation in Elasmobranch Fishes.*

More exact determinations of the composition of the blood of these animals, whose strange physiological condition separates them as far from other fishes as their morphology, have revealed the following facts:

Under normal conditions in the open sea the blood of elasmobranch fishes has approximately the same osmotic pressure as that of the water in which they are living. Duval has pointed out, however, that there is not complete isotonicity. The freezing point of the blood of these fishes examined during his experiments and also, he notes, as indicated in results of some earlier workers, was more frequently a little lower than that of the surrounding sea-water.

Thus:

	$\Delta$ of blood.	$\Delta$ of local sea-water
<i>Scyllium catulus</i> .. ..	2.18	Sea-water, 2.13 (Frédéricq, 1901).
Rays at Arcachon .. ..	1.89	Sea-water, 1.84 (Duval).
<i>Scyllium catulus</i> .. ..	2.17	Sea-water, 2.08 (Duval, Monaco).

The difference is small and was not considered worthy of note by the earlier workers.

The low freezing point of elasmobranch blood is due to salts plus an unusual amount of urea. Actually less than half of the osmotic pressure is due to salts. Duval gives the NaCl of the serum as only sufficient to produce a  $\Delta$  of 0.97° where the blood freezes at -2.17. In other words the urea is responsible for a depression of the freezing point of 1.20° C. Urea may be present up to a proportion as great as 3%. This is extraordinary when one remembers that only 0.03%

is usually found in mammalian blood plasma.\* But this is not the only startling feature. It is not difficult to demonstrate (Dakin and Edmonds, 1931) that urea in solution diffuses very easily through living bounding membranes of aquatic animals, and urea is one of the most diffusible substances through artificial membranes. But the gill membranes of the elasmobranchs must be impermeable to urea. And then, notwithstanding this, one finds (Duval, 1925) that the red corpuscles are totally unaffected osmotically by the urea in the blood. The corpuscular wall would appear to be easily permeable. Truly a paradoxical state of affairs.

It is no wonder that considerable interest has been paid to the effect on the elasmobranchs of altering the constitution of the sea-water in which they are held. Unfortunately sharks and rays are almost entirely confined to sea-water, and it was a long time before any from natural fresh-waters were examined. It was quite easy to see that in experimental tanks the osmotic pressure of the blood of elasmobranchs was very easily affected by changes in the salinity of the water and thus they were entirely different from teleosts in this respect.

My own figures for these fish from sea-water in the Baltic and North Seas showed that:

*Raia radiata*, in the Kattegat, with  $\Delta$  of sea-water 1.66, gave blood  $\Delta$  1.5, whilst *Raia valonia*, in the North Sea, with  $\Delta$  of sea-water 1.98, gave blood  $\Delta$  2.0.

Duval showed that when a dogfish was put without gradual change into a sea-water diluted so that its freezing point was only  $-1.07$  (the normal was  $-2.08^{\circ}$  C. where he was working), the freezing point of the blood changed from  $-2.17^{\circ}$  C. to  $-1.76^{\circ}$  in 3 hours 30 minutes.

Other experiments have shown that the normal close agreement between the osmotic pressure of elasmobranch blood and that of the sea-water is only found within certain restricted limits. It would appear then that the elasmobranch is not entirely without control over its internal media after all. All these experimental changes of salinity result, however, in serious damage to the fish, and it seems peculiarly important in this work that conclusions are not drawn from unhealthy specimens. Certainly Duval's experiments lasted for too short a time and were accompanied by too abrupt and deleterious a change of medium to indicate whether a real and new equilibrium had been arrived at between the fish and its environment.†

In 1931, H. W. and C. G. Smith solved the problem of the conditions prevailing in elasmobranchs by making a journey to Siam and Malaya where certain species were to be obtained swimming in perfectly fresh water.

The osmotic pressure of the blood of these typically marine fish in fresh-water corresponded to a  $\Delta$  of  $1.0^{\circ}$  C. It is obvious, therefore, at a glance, that the elasmobranchs are no more incapable of upholding the osmotic pressure of their internal media than are the teleosts or fresh-water crustacea. *Their degree of independence may be different, the physiological mechanisms involved may be different, but it is a clear fact that in fresh-water the highest aquatic invertebrates, and the aquatic vertebrates all sustain internal media* (the blood is

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\* Baglioni found about 2.61% in elasmobranchs at Naples and showed that to sustain the normal beat of the heart of a shark an artificial saline solution had to contain 2 grammes urea and 2 grammes of NaCl for every 100 c.c. of water.

† I gather that R. Margaria still considered in 1931 that the elasmobranchs were unable to sustain a difference between the body fluids and the environment. This was again the result of experimental methods on a few animals.



that particularly dealt with) *whose salinity is controlled and which is in most cases actually higher than that in the blood plasma of terrestrial mammals.*

Smith's results indicated the probable solution of another problem which has interested me for many years. The fall in osmotic pressure in the fresh-water elasmobranchs could conceivably be due to the mere absorption of water by the fish—the gills or other bounding membranes acting as an impermeable membrane to salts and urea but permeable to water. By analysis of both the urea and the chloride contents, Smith has shown, however, that the concentration of these substances is not reduced equally during the passage to fresh-water. There is a big fall in the urea concentration (a fall of 70%), but a fall of only 25% in the chlorides.

This would indicate that the regulation is much less simple than might be supposed, and that in regard to the salinity of the blood the elasmobranch is not acting very differently (if it is different at all) from the teleost fish. The part played by the urea in the physiology of the elasmobranch is the peculiar feature—in fact it is unique in the animal kingdom.

Before we turn to the significance of these facts concerning the aquatic vertebrates of the two groups, elasmobranchs and teleosts, let us consider in greater detail the results of modern researches on the aquatic invertebrates.

*The Relation between the External Medium and the Internal Medium of Marine and Fresh-water Invertebrates.*

The earlier researches showed, as I have already pointed out, that both the salinity and osmotic pressure of marine invertebrates were very like those of their surroundings. But it was very soon observed that some species of aquatic invertebrates, which lived in fresh-water and belonged to the same animal groups as the typical marine forms, managed to conserve a high salinity for the blood and a high osmotic pressure, although immersed in fresh-water. This resulted in a tendency to divide the aquatic invertebrates into two sub-divisions, the marine and the fresh-water forms, and to assume that a very different physiological function had been evolved in the latter. Bottazzi himself (1908) introduced the term "poikilomotocity" for the marine invertebrates, assuming that their salinities fluctuated (and with an isotonicity) with that of the surroundings, like the temperature of "cold blooded" or poikilothermic animals. The fact, known at that time, that the blood of a marine crab placed in almost fresh-water, or even in a mixture 50% sea-water and 50% fresh-water, never reached isotonicity with its surrounding medium, was regarded as due to the inability of the crab to live long enough in the diluted sea-water for the state to be attained.

The facts are as follows: In most marine invertebrates, when living under ocean or open sea conditions such that the sea-water is of a salinity between 33‰ and 35‰, the osmotic pressure of the body fluids is approximately the same as that of the sea-water. (There are, however, some interesting discrepancies even here.) When, however, the salinity is considerably reduced, either by the addition of water in experimental tanks or where estuarine and river conditions arise, the osmotic pressure and salinity of the blood and other fluids both fall until a new equilibrium is reached, but whether this results in a new isotonicity depends entirely upon the amount of dilution of the sea-water and upon the species of animal concerned. In no case does the internal fluid become isotonic with the external if the sea-water is very considerably diluted. The closest approach to this condition is seen in animals such as worms and molluscs with

extensive unarmoured body walls. (I always assume that the creatures remain alive and reasonably healthy.)

The crab, *Heloeccius cordiformis*, which is found in certain estuaries of New South Wales, presents a freezing point for the blood a little below that of the sea-water at  $\Delta$  1.9, in which the animal is living. When, however, the animal is placed in fresh-water, the salinity of the blood changes as indicated in the following table (Dakin and Edmonds, 1931).

*Reaction of the Crab, Heloeccius cordiformis, to fresh-water.*

Duration of Experiment.	Medium.	$\Delta$ of Medium. (° C.)	$\Delta$ of Blood. (° C.)
2 hours	Fresh-water.	0.0	1.9
6 "	" "	0.0	1.83
8 "	" "	0.0	1.7
24 "	" "	0.0	1.56
30 "	Diluted sea-water.	0.1	1.3
8 weeks.	" " "	0.72	1.38
Controls in sea-water.		1.98	1.89

But the rate of change indicated here varies for different invertebrate species and many marine invertebrates cannot withstand the conditions of the above series of experiments at all, but could only be tested in less diluted sea-water.

Schlieper (1930) has recorded that the crab, *Carcinus maenas*, which also lives under a wide range of conditions on the European Coast, presents at Helgoland a freezing point for the blood approximately the same as that of the sea-water there ( $\Delta$  1.9 or thereabouts), but in the Baltic Sea, where the freezing point is only 0.75° C. lower than that of fresh-water, the  $\Delta$  for the blood is retained at 1.48° C. to 1.55° C. So *Carcinus maenas* is evidently very similar in its reactions to our *Heloeccius*.

Contrasted, however, with the above types are other exclusively marine crabs, such as *Portunus puber*, *Herbstia condyliata*, and *Maja verrucosa*, whose blood freezing points are normally exactly the same as the sea-water in which they are living. Schwabe's experiments (1933) show that when *Maja verrucosa* is placed in diluted sea-water  $\Delta$  1.33, the blood has exactly the same  $\Delta$  after 36 hours as the diluted sea-water.

One of the most surprising examples is that of the two species of *Nereis*, *Nereis pelagica* and *Nereis diversicolor*. Schlieper's experiments (1929) showed that the latter species, when placed out of sea-water of 32‰ into that of 15‰, seemed quite normal after 24 hours, whilst the former swelled up through osmotic intake of water and died. *N. diversicolor* is apparently able to sustain an osmotic pressure for its body fluids greater than that of the environment when the latter is brackish water ( $\Delta$  0.21° C.), the other species is not.

The marine worm, *Arenicola marina*, whose internal medium has a  $\Delta$  1.70 in a sea-water of  $\Delta$  1.72 (in the North Sea), has a  $\Delta$  of as low as 0.75 for its internal medium in the Baltic Sea water at 0.77. This  $\Delta$  is lower than that of many aquatic crustacea in the perfectly fresh water of rivers and lakes. For example, the  $\Delta$  for the blood of the fresh-water crayfish is 0.8 to 1.0° C., and for the fresh-water crab, *Telphusa fluviatilis*, 1.16° C. We (Dakin and Edmonds (1931)

and Edmonds (unpublished) have shown that in a salt-water mollusc (*Onchidium*) and in five other species of Crustacea, the osmotic pressure of the blood in diluted sea-water is sustained in defiance of the external medium (*i.e.*, the creatures are homoiosmotic).

This practically sums up the whole position so far as a change towards lowered salinity is concerned. The invertebrates in fresh-water represent then the species which can withstand an outer medium which is deficient in salts. Of these, the higher crustacea, like the crayfish, present a freezing point for the blood of  $-0.8^{\circ}$  C. to  $-1.0^{\circ}$  C., and so are not unlike the marine crab, *Heloeccius cordiformis*, referred to above, and to other homoiosmotic forms, except that the modification of the external environment has been greater. In contrast with these are the fresh-water lamellibranchs, which present the lowest osmotic pressure for their blood and internal media. Thus the pond mussel, *Anodonta*, gives  $\Delta$  0.1 in fresh-water. Even here, however, after thousands of generations of fresh-water existence, the animal sustains an internal fluid with a higher salinity than that of the surrounding medium.

#### *Poikilosmoticity in Marine Invertebrates.*

We have taken for granted that within some limits, which vary for different species, the osmotic pressure of the internal media of marine invertebrates is almost identical with that of the surrounding sea-water. More accurate experiments in which a large number of individual species are used may show that even this is not so general as has been supposed.

Schlieper consistently obtained a  $\Delta$  for the blood of *Carcinus maenas* which averaged  $1.96^{\circ}$  C. when the external sea-water was  $-1.91^{\circ}$  C. Duval also noticed a frequent slight hypertonicity. Other workers have observed the same thing. In *Pachygrapsus crassipes*, however, the blood only freezes at  $-1.327^{\circ}$  where the sea-water freezes at  $-1.975^{\circ}$  C. (Baumberger and Olmstedt, 1928).

Miss Edmonds has made a special study of these conditions in the New South Wales crab, *Heloeccius cordiformis*, and here there seems to be a regular *hypo-tonicity*, the difference in the freezing points of sea-water and blood being about  $0.25^{\circ}$  C. She also found similar conditions for *Leptograpsus variegatus*.

It is a curious and important fact that, for certain marine invertebrates which have been the subject of experiment (not so many have been used in this way), an *increase* in the concentration of the salinity of the external medium produces a greater and more speedy effect upon the internal media than does a dilution. Thus, according to Frédéricq and Duval, when *Carcinus maenas* is immersed in sea-water which has been concentrated, the salinity of the blood rises after a few hours in apparent exact correspondence with that of the external medium. Schwabe (1933) found that the three marine crabs, *Dromia vulgaris*, *Herbstia condyliata* and *Portunus corrugatus*, attained almost isotonicity in 51% sea-water after only 48 hours.

Our experiments with the brackish-water crabs of New South Wales are interesting in this respect. In an early paper (Dakin and Edmonds, 1931) we found that whilst an increase in salinity in the blood of *Heloeccius cordiformis* took place in concentrated water, the freezing point of blood was only  $-2.92$  in water of freezing point  $-3.28$  after 28 days. Further experiments of Edmonds showed that in salt solutions of  $\Delta$  3.24, crabs, after a duration of 36 days, presented a freezing point for the blood which was only  $0.14^{\circ}$  C. different from that of the sea-water. *Heloeccius* agrees, therefore, with *Carcinus* and other species in its

reaction to the highly concentrated saline medium, except that it certainly "gives way" more slowly to the influence of the environment.

I am not altogether in agreement with Schlieper when he says that in contrast to all fresh-water animals and marine teleosts which have mechanisms for controlling their water content, most marine invertebrates are poikilosmotic and have an osmotic pressure which is the same as that of the external medium. The latter may be the case, though only within certain limits, but is it correct to say that the fresh-water species have a mechanism not possessed by their marine relatives? Is it correct to assume that there is some new mechanism at work in *Nereis diversicolor* which is not present in its related species, *N. pelagica*?

The real poikilosmotic condition often only exists (if it does show itself) between narrow limits. It may be quite true to say that a certain species of marine crab is poikilosmotic in sea-water between certain limits of salinity, but the use of the term is unfortunate if it means that aquatic invertebrates are to be divided into two sharply-marked classes, poikilosmotic and homoiosmotic. The differences between distinct zoological groups like the echinoderms, with their vast coelomic cavity, and crustacea, with a haemocoel, is another matter. The important difference between species which can invade and live in brackish or fresh waters and their relations limited to the sea, is that the former are capable of tolerating a change in the constitution of their internal fluids and of keeping in action a series of processes which sustain new equilibrium and a "steady state". The problem may be wholly quantitative, if I can put it this way, rather than qualitative.

This is a convenient place to refer to a lesser known field, to the conditions which obtain in typically aquatic invertebrates, such as the crabs (and some other crustacea), which have invaded the land and which live a more or less terrestrial existence.

Observations of A. S. Pearse (1932) show that there is quite a range of types. In *Gecarcinus littoralis* which lives in burrows, often at considerable distances from the sea, the  $\Delta$  of the blood is only 1.65, whereas the nearby ocean water has a  $\Delta$  of 2.04. *Cardisoma guanhuni*, another very large crab, often found far from the sea, has a similar freezing point for the blood.

Pearse concludes that land crabs have blood of lower osmotic pressure than those of marine crustaceans and that the attainment of land life (possibly through the acquirement of air-breathing habits) is associated with a reduction in the salinity of the blood.

So far we have considered the osmotic pressure of the internal media and assumed, perhaps more particularly in the case of the marine invertebrata, that it was largely due to sodium chloride, together with the other salts found in sea-water. This was the thesis of Quinton (1897), referred to at the beginning of this address. And it is true that in the relative amounts of the inorganic constituents of the body fluids even of the higher animals—land animals and also fresh-water animals—the general resemblance to the composition of sea-water is most striking.

In the case of the marine invertebrates, an absolute identity of the saline constituents of the body fluids with the proportions of the salts in the surrounding water has been too often assumed just as an exact isotonicity and a complete dependence was taken almost as universal after the early work on this subject. Such is, however, not by any means the case, although the divergences may be small.

The following table from Pantin will serve to set the matter out. I have added the last lines giving the figures for the teleosts and for human serum.

	Date Taken or Calculated from.	Na.	K.	Ca.	Mg.	Cl.	SO <sub>4</sub> .	Δ° C.
Sea-water .. ..	Dittmar (1884) ..	100	3·6	3·9	12·1	181	20·9	—
” ” .. ..	—	—	—	—	—	—	—	-2·0-2·4
<i>Aurelia flavidula</i> ( <i>mesogloea</i> ) ..	Macallum (1926)	100	5·2	4·1	11·4	186	13·2	—
<i>Limulus polyphemus</i>	” ”	100	5·6	4·1	11·2	187	13·4	-2·04
<i>Aplysia limacina</i> ..	Bethe (1929) ..	100	4·0	4·4	11	180	—	—
” ” .. ..	Quagliariello (1925)	—	—	—	—	—	—	-2·32
<i>Homarus americanus</i>	Macallum (1926)	100	3·7	4·9	1·7	171	6·7	—
<i>Acanthias vulgaris</i>	” ”	100	4·6	2·7	2·5	166	—	-2·04
<i>Carcinus maenas</i> ..	Bethe (1929) ..	100	4·8	4·5	4·8	180	—	Variable.
Frog .. ..	Macallum (1926)	100	11·8	3·17	0·79	135·6	—	-0·4
Dog .. ..	” ”	100	6·6	2·8	0·76	139·5	—	-0·6
“ Hard ” fresh-water (Wembury) ..	Pantin (1931a) ..	100	74	299	66	190	95	—
(Cod) <i>Gadus callarius</i> (Pollock) <i>Pollachius</i> <i>virens</i> .. ..	Macallum (1926)	100	9·5	3·93	1·41	149·7	—	—
Human serum ..	” ”	100	4·33	3·10	1·46	137·8	—	—
Human serum ..	Kramer and Tisdall (1922) .. ..	100	5·97	2·99	0·896	106·46	5·73	—
Human serum ..	(Another analysis)	100	6·75	3·10	0·69	128·8	—	—

It is clearly evident from an examination of the few cases in this table that there is a range of dependence upon the saline composition of the sea-water in marine invertebrates, just as there is in osmotic pressure. Thus, the body fluids of the molluscs, as exemplified by *Aplysia*, are in close agreement with sea-water, whilst the higher crustacea, as exemplified by the lobster (*Homarus americanus*) and the crab (*Carcinus maenas*), agree pretty closely in the relative proportions of sodium, potassium, calcium and chlorine, but are very different on the score of magnesium. Unfortunately, there are too few complete analyses available of the media of invertebrates. The vertebrate animals are still more different but agree very closely amongst themselves.

These facts are very significant because, as will be pointed out later, there is evidence now to show that the bounding membranes are not impermeable to ions, although they are probably more permeable to water.

It is extremely probable, indeed one might say certain, that any control of the salinity and osmotic pressure of the internal media of aquatic animals is not effected merely by changes in water content. The body fluids are not merely a diluted or concentrated external medium. Their ionic composition is a function of the phenomena of protoplasm itself and of the body as a whole. The factors behind these phenomena are very elusive and the interpretations of the facts may well involve not only a physiological investigation but a palaeontological study.

*The Evolutionary Origin of the Independence of the Body Fluids of the Vertebrates.*

Before proceeding to the final stage in this subject, which is at the same time the most puzzling and the most interesting—I mean the search for the

mechanism and sources of energy which enable a creature to sustain internal media of a certain salinity in defiance of the composition of that which bathes its delicate bounding membranes—it is desirable to return to that historical problem raised 46 years ago by Bunge (1889) and then again by Quinton in 1897.

Quinton, I may remind you, stated that, so far as salinity was concerned, the blood of most animals was an altered sea-water. In 1903 the Canadian physiologist Macallum, apparently unaware of the suggestions of Bunge or Quinton, advanced the view that the blood plasma of vertebrates and invertebrates with a closed circulatory system is, in its inorganic salts, *but a reproduction of the sea-water of the remote geological period in which the prototypic representatives of such animal forms first made their appearance.*

This fascinating theory, as is often the case, caught the imagination, and today we find medical textbooks devoting some pages to the matter. In 1912, when I first criticized Macallum's theory, I pointed out that it might be a very reasonable assumption to regard the saline composition of the body fluids of animals as a relic of early biological history. In fact, I was prepared to accept one of his statements as it stood, viz.: "the inorganic composition of the blood plasma is an heirloom of life in the primeval ocean". But that was on the understanding that the heirloom could be modified as it was passed on in the course of evolution and not handed on unaltered like a piece of family plate. I refused, however, to accept Macallum's main thesis—that the blood plasma in any animals represented, so far as its inorganic composition was concerned, the composition of the sea-water of some remote geological epoch. For example, I saw no reason why because the  $\Delta$  for teleost blood was approximately  $-0.6$  one had to assume that the bony fishes (and, indeed, the ancestors of the higher vertebrates) had evolved in brackish water which had a salinity corresponding to this.

The work of recent years has confirmed my belief in this matter.

Take, for example, the fresh-water crabs of certain coastal creeks flowing into the Hawkesbury River near Sydney. These crabs (still an undescribed species) present every indication of a migration into the waters where they are now found from the brackish waters of the estuary, and from the geological evidence alone one may reasonably assume that the migration has been relatively recent. The crabs are thoroughly adapted to fresh-water and the osmotic pressure of the blood corresponds to  $\Delta$  1.23, a figure which is also approximately that of some fresh-water crayfish.

It is difficult to see how, in either or both cases, the blood salinity represents that of the ocean sea-water from which they or their ancestors came, nor can it represent the salinity of any particular stage on the way.

The purely marine crab, *Pachygrapsus crassipes*, has been found to have a  $\Delta$  for the blood as low as 1.327 where the sea-water was  $\Delta$  1.975° C. There is no reason to assume that this species of *Pachygrapsus* has evolved some new mechanism for regulating its body fluids, or that it did so in water of low salinity. The fact that a marine crab is able to sustain such a difference of composition as this between its body fluids and the external medium is additional evidence against the necessity for assuming that the ancestors of the vertebrates had their origin in an ocean of only half the present salinity or less, because the body fluids of the vertebrates of today present salinities of that order.

Take again, for example, the New South Wales estuarine crab, *Heloeciis cordiformis*. We have found this crab particularly common where the  $\Delta$  of the sea-water was 1.98° C. (That is to say, on flats where the sea-water is not

diluted to any great extent except during the rains.) It also extends into regions where the water is much less saline, but not into fresh-water. (Edmonds, unpublished paper, found it in water with a salinity corresponding to a  $\Delta$  of 0.8 to 0.58° C.) Yet in water of the lowest salinity the  $\Delta$  for the blood is 1.43° C., and at every point between its most saline and its least saline habitat the blood  $\Delta$  is a function of its environment. Edmonds has placed *Heloeccius cordiformis* taken from water of high natural salinity ( $\Delta$  1.98) into water with a freezing point of -0.72 and kept them in aquaria for two months. During the early part of this period the  $\Delta$  of the blood fell to 1.38° C., but then remained definitely constant. It was clearly evident that a new equilibrium had been reached and sustained with a very striking difference between the body fluids and the external medium, and the experimental result is practically identical with discoveries in the field. I see no reason to assume that *Heloeccius cordiformis* evolved this brackish water homosmoticity at some particular period in the remote past when the water in which it was living was of some special salinity. The salinity of the blood of fresh-water crustacea tells nothing definite about the exact concentration of early ocean waters, although I am not prepared to argue that the duration of evolutionary existence in fresh-waters is not without effect on the saline composition of the body fluids. At the same time, even in this respect it is necessary to remember that there is no reason why the particular salinity should not be just as much a reflection of the particular physiology of the species as a reflection of anything else. Where a large number of determinations are made it will be found that there are considerable differences between the osmotic pressures of one crab and another even under the same conditions and in the same locality (Edmonds).

It might be urged that the cases utilized above for this discussion are estuarine invertebrates. I would answer that I see no evidence why real marine species should not be capable of migrating into brackish waters and fresh waters today, and in such cases the salinity of the body fluids would no more represent the present day salinity of the ocean than does that of *Heloeccius cordiformis*. But suppose we turn to the aquatic vertebrates—both the teleost fishes and the elasmobranchs (although so different physiologically) exercise a regulation over the salinity of the blood. In both cases it is almost independent of the water bathing their bodies. Actually the salinity of elasmobranch blood is somewhat greater than that of teleost blood. It might be inferred from this that the elasmobranchs evolved in ocean water of a later date (Macallum utilizes very largely the calculations of Joly on the age of the earth by estimating the increasing salinity of the ocean). This, however, would be rather contrary to the usual views on the evolution of the vertebrates. Macallum's view is that the elasmobranchs evolved their fixed salinity at an earlier epoch than the teleosts and that it is now higher in the former because they have been exposed to the ocean's increasing salinity for a few more million years than the teleosts. To my mind this argument, which can be used either way, weakens his thesis still further.

The aquatic vertebrates—the teleosts and elasmobranchs—which have evolved an independence of their body fluids may:

- (1) Have evolved this independence in and when the ocean water had a salinity corresponding to a  $\Delta$  of say 0.6° C. (a long time ago), and then whilst the ocean water has slowly increased its salinity to 35‰, the original or nearly original salinity of the ocean has been retained in these vertebrates. (Macallum's view.)

- (2) Have evolved in ocean water of higher or lower salinity (to any degree) and for some reason gradually fixed their salinity at the present prevailing figures.
- (3) Have evolved from proto-vertebrates or early vertebrates which migrated from the sea into fresh or nearly fresh water and in which species, exactly as with the higher invertebrates which do this today, the salinity of the body fluids fell to a new equilibrium but was sustained at this, and by the consumption of energy was kept nearly independent of the vagaries of the external media.

The experimental evidence all seems to point to the latter, and it is interesting to note that many modern palaeontologists favour the view that the vertebrates were evolved in fresh-waters. (Chamberlain 1920, Grabau 1913, and O'Connell 1916, and others. Marshall and Smith (1930) affirm that the vertebrate glomerular kidney must have evolved in fresh-water.)

*The Mechanism whereby the Steady State is Maintained.*

It may be well to point out that recent researches have shown only too clearly that the mechanism whereby aquatic creatures sustain body fluids markedly independent of the external watery environment is by no means as simple as was once supposed.

The early workers spoke of "closed" blood systems and impervious body walls. Macallum regarded the kidneys as the essential regulators, and even in his paper of 1926 holds to this view. Thus: "The low concentration of salts in the blood, as compared with the concentration of salts in sea-water, and the maintenance of the palaeo-ratios in Selachians, after very many millions, possibly hundreds of millions of years of life in the sea, indicate unmistakably how inflexibly constant, practically, is the action of the organ concerned, the kidney in the vertebrates." On another page he says: "There are in Invertebrates no structure or structures having a function or functions quite similar to those of the vertebrate kidney. . . ." "In the long ages the kidney has ever thus performed functions which, for constancy and regularity, are unrivalled in the world of life, except by those of the cell nucleus, which, of course, is of vastly more remote origin. This constancy contrasts with the variations in functions which the other organs in vertebrates have undergone. It has made the vertebrates, with all their ranges of development, possible. Without such a constancy there could be no change in habitat from sea to land and fresh-water and back again to sea, for with such a change there would be a variation in the inorganic composition of the internal medium, an impossible handicap in the struggle for existence, which would greatly affect the development of the organs after the Eo-vertebrate stage was passed." But Macallum believed that the live bounding membranes of aquatic animals are impermeable to salts. Apart from this, his views do not conform to the facts.

So far back as 1910 it was shown by me that the osmotic pressure and salinity of the contents of certain marine teleost fish eggs were quite unlike that of the sea-water in which the eggs were floating, but only so long as the egg membranes remained alive. At the same time the egg of the elasmobranch was shown to have a low freezing point (1.80° C.) similar to the blood of the adult fishes of the same group, and in 1928 Needham and Needham recorded 888 mg. of urea in such eggs. There was distinct evidence in both cases of the action of the bounding membranes. And again, when discussing Macallum's views (Dakin, 1912) it was stated that "The bounding membranes of the body and the fluids



bathing them are the prime factors in the regulation of the blood constitution so far as salinity is concerned". "It may be said that for the substances for which it is permeable it (the bounding membrane) does not behave as a dead parchment membrane; on the other hand it exerts a direct and powerful influence."

Modern research has fully borne out these conclusions. The researches of Smith (1930), confirmed by Keys (1931) and Bateman and Keys (1932), have shown for example that the teleosts swallow sea-water and actually secrete chloride by the gills. Keys (1933) regards the facts at present as proving that in teleosts the kidneys conserve the saline constituents and eliminate water, whilst excess salt is eliminated by the gills, water being conserved by the bounding membranes of the latter organs.

If the regulation of the blood of the teleost fishes be controlled by the two sets of organs, we are still left very much in the dark as to how the separating membranes carry on the work. Are we to conclude that the fresh-water teleosts are different structurally from their marine relatives in so far as their kidneys are concerned? It has been suggested that these organs in fresh-water fishes are capable of very efficient water filtration combined with salt conservating powers.

It is not at all easy to devise experiments which will enable one to discover how the bounding membranes of *invertebrates* are functioning, but Adolph (1926) has found that frog's skin is more amenable. Adolph's important work has shown that whilst the frog regulates the general water content of its body by the kidneys, the inflow through its skin when immersed in fresh-water is quite definitely under control. He has shown that this inflow is due in large part to forces *other* than osmotic pressure. It is striking in this respect that if the skin be removed, the body wall is no longer able to function in this way. "The skinless frog is an ideal osmometer." The real forces at work in determining and controlling the inflow are, however, stated by Adolph to be still unknown, but they are wholly in the skin.

In passing, reference should be made to a very interesting point mentioned by Adolph, which seems to me to be well worthy of attention in connection with our invertebrate findings. After showing that the exchanges of water are caused in large part by forces other than osmotic pressure, he adds that "only in the higher concentrations, where the medium is more highly concentrated than the frog's blood and lymph, do the rates of exchange of water give any appearance of being proportional to concentration". Is it mere coincidence that in the crabs, *Carcinus*, *Heloecius*, and the other species previously mentioned, the unknown regulating processes do not seem to function when the animals are placed in concentrated sea-water?

The work of Bethe (1929) has already been referred to. It will be remembered that the early workers believed the bounding membranes of aquatic animals to be semi-permeable (permeable to water but impermeable to salts). Bottazzi and Enriques (1901) supported this view and many others have since then taken this position (including Macallum).

In favour of this attitude is the fact that many marine invertebrates, when placed in diluted sea-water, swell up and increase in weight. The bounding membranes act like the semi-permeable membrane of an osmometer. A starfish shows this particularly well. But it can be seen equally well at first in worms and other types. If, however, the experiment can be withstood by the animal concerned and the duration is not just that of a few hours, it will be found that in many cases the initial increase in weight disappears. The explanation

is that the membranes were more readily permeable to water than to salts, not that they were impermeable to the latter.

As Schlieper points out, however, there is room for further experiments along these lines.

Our own work (Dakin and Edmonds, 1931) confirms that of Bethe and others in showing that in many aquatic invertebrates (including the Crustacea) the bounding membranes are permeable to both water and salts. Yet the body fluids remain constant in a particular environment. This applies not only for species like the Crustacea, in which a protective impermeable body wall has been evolved except for areas like gills, but for types such as Oligochaete worms, with their soft dermo-muscular body walls.

If the external environment is changed, the body fluids change too—but not to the same extent—a new equilibrium is reached and once again a steady state is attained.

But how is the steady state sustained?

Schlieper has shown that, in some cases at least, an extra consumption of oxygen is required to provide the energy, and that this can be experimentally demonstrated. Thus in the crab *Carcinus* the need for oxygen increases with any diminution in salts in the external medium. Curiously enough, however, another crab (*Eriocheir*) presents no such increase in its energy requirements on passing from salt- into fresh-water.

Schlieper concludes that the excretory organs are not concerned in the osmotic control of the blood of *Eriocheir* and the crab *Telphusa* because the urine is isotonic with the blood. The same thing applies to the crab *Carcinus maenas*.

But the urine of the fresh-water crayfish (*Potamobius*) has extremely low salinity, and the  $\Delta$  is only  $0.16^\circ$  when the blood  $\Delta$  is  $0.8$  (Schlieper).

We are indeed far from the last word in connection with the aquatic invertebrates. There seem to be the most unexpected differences between them. If *Carcinus* and *Helociscus* are taken from sea-water and placed in fresh-water, there is no increase in weight which would result from the passage of water into the animals and yet, as we have seen, their salt content changes—Cl ions migrate outwards. But if exactly the same experiment is tried with the crab *Maja verrucosa* the weight increases—water is absorbed. Is it possible that in the same group of animals the organs are different in structure and function, or are the observed effects due to experimental conditions, to lack of acclimatization, etc? More than one investigator has discovered that damaged or dying gill and other membranes are permeable, whereas normally they are not so.

Pantin (1931) has investigated experimentally a peculiarly interesting example amongst aquatic invertebrates—the estuarine flatworm, *Gunda ulvae*. The body wall of this worm is permeable to both water and salts, yet the internal fluids are under some control and the animal will withstand considerable change in salinity. In fact, for some reason, it seems to prefer a changing medium such as one meets in a tidal estuary. If placed in fresh-water completely minus salts (i.e., distilled water), the worm swells greatly and dies; but if a small quantity of calcium be added the animal can survive much longer.

It has long been known, of course, that calcium ions have very definite effects upon the permeability of protoplasmic membranes,\* and it is very well

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\* R. K. S. Lim showed in 1917 that *Carcinus maenas*, the crab so often referred to in this paper, lived longest in fresh-water when calcium was added, and stated that this was due to altered permeability of the membranes.

known that a solution of common salt of the concentration of sea-water is likely to be as poisonous to marine animals as fresh-water. The addition of calcium ions seems to antagonize the sodium ions. The exact proportion of the different ions is indeed a matter of considerable importance in setting up aquaria with different salt solutions. And it needs only a few experiments to realize that marine animals which are never found in brackish water will live for a time in highly diluted sea-water when fresh-water proves almost immediately fatal.

Finally, it is a most important fact that the saline independence of the body fluids of the aquatic metazoa is not dissimilar from the conditions found in the cell itself.

The study of the live bounding membranes of the aquatic animals is really only just beginning. Two recent discoveries may serve to illustrate this point. Schwabe (1933), for example, has shown that in the crabs *Carcinus* and *Eriocheir*, when ecdysis is taking place, there is a fall in the concentration of the blood and the crabs swell up owing to intake of water. It seems clear that this is due to changes in the body wall.

Again the famous French physiologist Paul Bert made the discovery that eels which had been carelessly handled so that the mucus (so characteristic of the skin) had been removed, were no longer able to withstand a sudden change from fresh-water to sea-water. Duval took the matter up again and conducted a very interesting series of tests to see if it were true, and if it were due to partial loss of control over the salinity of the blood. He found that, whereas the  $\Delta$  of the blood of a fresh-water eel placed in sea-water of  $\Delta$  2·13° C. was only 0·79° C., that of an eel deprived of its mucous covering was as great as 1·15° C. Now the secretion of mucus is very characteristic of aquatic animals, but I am not aware of any researches as to its function.

The evidence collected in this paper shows clearly how aquatic animals are varyingly dependent upon their environment. We, with our impervious skins, may easily fail to realize the sensitivity to a changed medium which may be experienced by a marine fish. It is certain that many of the migrations of aquatic animals are due to but slight changes in saline composition. In this connection the New South Wales coast provides us with excellent examples. The Peneid prawns, as you know, enter our coastal lakes as tiny larvae; they feed and grow in these enclosed waters (which have a salinity much less than the sea-water) until they reach sexual maturity. Then they pass out to sea. It has already been shown that the freezing point of the blood of the crab *Eriocheir* rises after egg production. Probably this may be due to a special need for Cl during the breeding season. Schwabe (1933) believes that it is for this reason that breeding *Eriocheir* are never found in fresh-water. This might also be the explanation for the Peneid migration to the ocean.

It would take me too far here to enter upon this subject of migration so far as teleost fish are concerned—so many other factors enter the field.

I should like to point out, in concluding, that the investigations to which I have devoted some considerable time in this Address do not by any means constitute a purely academic problem. Their completion may have far reaching results in physiological research. I shall be content if I have shown what a wide field is presented by the subject, and how diverse are its ramifications.

I have always been particularly interested in these problems of the internal media of aquatic animals, because they involved such a happy combination of

experimental laboratory and aquarium studies with the investigation of the creatures in their natural haunts.

But they have always served to make me humble—to remind me of how little we know about the functioning of living organisms. We have now collected a mass of information on this subject of osmotic pressures of body fluids. Enough to show that emancipation from the external environment was an essential preliminary to the evolutionary height realized by the birds and mammals. But the *modus operandi* of the regulating “mechanism” still eludes us.

Professor A. V. Hill (1931), in referring to it, summed up the position excellently when he said: “Throughout we are involved, not with general equilibrium, but with conditions maintained constant by delicate governors and by a continual expenditure of energy. How that energy is supplied, how it is utilized to maintain the structure and the organization, is, I think, the major problem of Bio-physics today.”

APPENDIX I.

Freezing Points of Body Fluids °C.

Δ = depression of freezing point below 0° C.

Species.	Internal Medium. Δ °C.	Urine. Δ °C.	External Medium. Δ °C.	Author.
<i>Marine Animals.</i>				
Coelenterata— <i>Acyonium palmatum</i> .. ..	2.195–2.196		2.2	Bottazzi.
Echinodermata— <i>Asterias glacialis</i> .. .. .	2.295		2.195–2.36	”
<i>Holothuria poli</i> .. .. .	2.299		2.195–2.36	”
Annelida— <i>Sipunculus nudus</i> .. .. .	2.27–2.31		2.29	”
<i>Aphrodite aculeata</i> .. .. .	2.259		2.29	”
<i>Arenicola marina</i> (Helgoland) ..	1.7		1.72	Schlieper.
” ” (Baltic Sea) .. .. .	0.75		0.77	”
Mollusca— <i>Aplysia limacina</i> .. .. .	2.32		2.195–2.360	Bottazzi.
<i>Cassia sulcosa</i> .. .. .	2.36		2.22	Monti.
<i>Ostrea edulis</i> .. .. .	2.23		2.11–2.14	”
<i>Mytilus edulis</i> .. .. .	2.26		2.11–2.14	”
<i>Octopus vulgaris</i> .. .. .	2.16		2.11–2.14	”
Arthropoda— <i>Limulus polyphemus</i> .. .. .	1.90		1.82	N. Rogers.
<i>Homarus vulgaris</i> .. .. .	2.29		2.269–2.278	Bottazzi.
<i>Homarus americanus</i> .. .. .	1.82		1.80	N. Rogers.
<i>Hyas aranea</i> .. .. .	1.83		1.80	Schlieper.
<i>Carcinus maenas</i> .. .. .	2.17		1.96–1.99	Monti.
” ” .. .. .	1.97		1.92	Schlieper.
” ” .. .. .	1.95	1.95	1.92	”
<i>Maja verrucosa</i> .. .. .	2.13		2.17	Frédéricq.
<i>Cancer pagurus</i> .. .. .	1.84–1.91		1.91	Dakin.
<i>Helocercus cordiformis</i> .. .. .	1.95		2.17	Edmonds (unpublished)
” ” .. .. .	1.38		0.72	” ”
<i>Pachygrapsus crassipes</i> .. .. .	1.32		1.97	Baumberger and Olmstedt.
<i>Leptograpsus variegatus</i> (Sydney) ..	1.95		2.13	Edmonds (unpublished).
Tunicata— <i>Ascidia mentula</i> .. .. .	2.08		1.98	Duval and Prenant.

APPENDIX I.—Continued.

Freezing Points of Body Fluids °C.

Δ = depression of freezing point below 0° C.

Species.	Internal Medium. Δ °C.	Urine. Δ °C.	External Medium. Δ °C.	Author.
<b>Elasmobranchiata—</b>				
<i>Scyllium canicula</i> .. .. .	2·22		2·15	Duval.
<i>Mustellus vulgaris</i> .. .. .	2·36		2·29	Bottazzi.
<i>Carcharias littorina</i> .. .. .	2·03		1·83	N. Rogers.
<i>Trygon violacea</i> .. .. .	2·43		2·29	Bottazzi.
<i>Raja undulata</i> .. .. .	1·89		1·84	Duval.
"    "    "    "    "    "    "	1·96		1·88	"
<i>Scyllium stellare</i> .. .. .	2·23	2·40	2·0 ?	Bottazzi.
<i>Raja radiata</i> .. .. .	1·51		1·66	Dakin.
"    "    "    "    "    "    "	2·0		1·9	"
"    "    "    "    "    "    "	1·9		1·9	"
<b>Holocephali—</b>				
<i>Callorhynchus Millii</i> .. .. .	1·76	Concentration of sea-water between	1·5-1·85	"
<b>Teleostei—</b>				
<i>Pleuronectes platessa</i> .. .. .	0·787		1·9	"
"    "    "    "    "    "    "	0·650		1·093	"
"    "    "    "    "    "    "	0·88-0·9		1·91	"
"    "    "    "    "    "    "	0·68	(Almost fresh-water. Δ not taken.)		"
<i>Gadus morrhua</i> .. .. .	0·75		1·9	Dakin.
"    "    "    "    "    "    "	0·65	0·64	2·0	Bottazzi.
"    "    "    "    "    "    "	0·74		1·92	Dakin.
<i>Lophius piscatorius</i> .. .. .	0·63		1·92	"
<i>Conger vulgaris</i> .. .. .	0·77		2·14	Duval.
<i>Charanx puntacco</i> .. .. .	1·04		2·29	Bottazzi.
<i>Cerna gigas</i> .. .. .	1·034		2·29	"
	<i>Animals from Salt-water Lakes.</i>		<i>Salt-water.</i>	
<i>Artemia salina</i> .. .. .	Osmotic pressure of 1·2% NaCl Sol. of 1·3% NaCl Sol.	= to that Sol. Sol.	4·5% NaCl. 8·0% NaCl.	Medwedewa. "
	<i>Fresh-water Animals.</i>			
	Δ of Internal Medium.	Urine.	Δ of External Medium.	
<b>Mollusca—</b>				
<i>Anodonta cygnea</i> .. .. .	0·09		—	W. Koch.
<i>Unio pictorum</i> .. .. .	0·15		—	N. Monti.
<i>Limnaea stagnalis</i> .. .. .	0·22-0·23		0·02-0·03	Frédéricq.
<b>Crustacea—</b>				
<i>Daphnia magna</i> .. .. .	0·20-0·67		—	Fritzsche.
<i>Potamobius astacus</i> .. .. .	0·80		—	Frédéricq.
<i>Telphusa fluviatile</i> .. .. .	1·17		—	Duval.
<i>Eriocheir sinensis</i> .. .. .	1·09		—	Schlieper.
<i>Potamobius astacus</i> .. .. .	0·8-1·0	0·2	—	Herrmann.
<i>Astacopsis</i> (Australian Crayfish)	1·1		—	Dakin.
<i>Telphusa fluviatilis</i> .. .. .	1·18	1·2	—	Schlieper.
Unnamed species of crab from tributary of Hawkesbury River, N.S.W. .. .. .	1·4		—	Dakin.

## APPENDIX I.—Continued.

## Freezing Points of Body Fluids °C.

Δ = depression of freezing point below 0° C.

Species.	Internal Medium. Δ °C.	Urine. Δ °C.	External Medium. Δ °C.	Author.
Teleostei—				
<i>Barbus fluviatilis</i> .. .. .	0.50	—	—	Frédéricq.
<i>Leuciscus dobula</i> .. .. .	0.45	—	—	„
<i>Cyprinus carpio</i> .. .. .	0.50	—	—	Duval.
<i>Salmo fario</i> .. .. .	0.57	—	—	Dekhuyzen.
<i>Anguilla anguilla</i> .. .. .	0.62	—	—	Duval.
„ .. .. .	0.57-0.58	—	—	Dakin.
„ .. .. .	0.61	—	—	Keys.
„ (in sea-water) .. .. .	0.73	—	1.87	„
<i>Ariabas testudineus*</i> .. .. .	0.64	—	—	Pearse.
<i>Ophiocephalus striatus*</i> .. .. .	0.57	—	—	„
Dipnoi—				
<i>Epiceratodus (Neoceratodus) forsteri</i>	0.42	—	—	Dakin.
<i>Semi-terrestrial (Littoral or Sea Coast).</i>				
Crustacea—				
<i>Ocypoda albicans</i> .. .. .	1.70	—	2.04	Pearse.
<i>Coenobita clypeatus</i> (land hermit crab) .. .. .	2.09	—	2.04	„
<i>Gecarcinus littoralis</i> (lives some distance away from sea, on land)	1.65	—	2.04	„

\* Air-breathing fishes from Siam.

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## APPENDIX I.—Continued.

## Freezing Points of Body Fluids °C.

△ = depression of freezing point below 0° C.

Species.	Internal Medium. △ °C.	Urine. △ °C.	External Medium. △ °C.	Author.
Teleostei—				
<i>Barbus fluviatilis</i> .. .. .	0.50	—	—	Frédéricq.
<i>Leuciscus dobula</i> .. .. .	0.45	—	—	„
<i>Cyprinus carpio</i> .. .. .	0.50	—	—	Duval.
<i>Salmo fario</i> .. .. .	0.57	—	—	Dekhuyzen.
<i>Anguilla anguilla</i> .. .. .	0.62	—	—	Duval.
„ „ .. .. .	0.57-0.58	—	—	Dakin.
„ „ .. .. .	0.61	—	—	Keys.
„ (in sea-water) .. .. .	0.73	—	1.87	„
<i>Ariabas testudineus</i> * .. .. .	0.64	—	—	Pearse.
<i>Ophiocephalus striatus</i> * .. .. .	0.57	—	—	„
Dipnoi—				
<i>Epiceratodus (Neoceratodus) forsteri</i>	0.42	—	—	Dakin.
<i>Semi-terrestrial (Littoral or Sea Coast).</i>				
Crustacea—				
<i>Ocypoda albicans</i> .. .. .	1.70	—	2.04	Pearse.
<i>Coenobita clypeatus</i> (land hermit crab) .. .. .	2.09	—	2.04	„
<i>Gecarcinus littoralis</i> (lives some distance away from sea, on land)	1.65	—	2.04	„

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The Secretary (for Dr. G. A. Waterhouse, Honorary Treasurer) presented the balance-sheets for the year ended 28th February, 1935, duly signed by the Auditor, Mr. F. H. Rayment, F.C.A. (Aust.); and he moved that they be received and adopted, which was carried unanimously.

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

*President:* W. L. Waterhouse, M.C., D.Sc.Agr., D.I.C. (Lond.).

*Members of Council:* E. C. Andrews, B.A., W. R. Browne, D.Sc., E. Cheel, A. G. Hamilton, Professor T. G. B. Osborn, D.Sc., and T. C. Roughley, B.Sc., F.R.Z.S.

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

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

# Linnæan Society of New South Wales.

GENERAL ACCOUNT. Balance Sheet at 28th February, 1935.

LIABILITIES.		ASSETS.	
	£	s.	d.
Capital: Amount received from Sir William Macleay during his life-time	14,000	0	0
Further sum bequeathed by his Will	6,000	0	0
Contingencies Reserve	20,000	0	0
Fletcher Memorial Fund at 28th February, 1935	9,720	0	7
Commercial Banking Co. of Sydney, Ltd.	23	17	0
	505	0	3
	£30,248 17 10		
	11,000	0	0
	1,000	0	0
	3,600	0	0
	14,540	0	0
	10	0	0
	98	17	10
	£30,248 17 10		

## INCOME ACCOUNT. Year Ended 28th February, 1935.

	£	s.	d.		£	s.	d.
To Salaries	1,010	0	0	By Balance from 1933-1934	..	..	..
" Printing Publications	422	4	9	" Subscriptions: 1934-35	..	..	138 12 0
" Illustrations	72	11	9	Arrears	..	..	14 14 0
" Rates and Insurance	494	16	6	In Advance	..	..	9 9 0
" Library	192	13	11	Associates	..	..	1 10 0
" Postage	27	13	10	Entrance Fees	..	..	164 5 0
" Petty Cash	13	7	1	Interest	..	..	9 9 0
" Audit	55	7	9	" Sales (including 60 copies of PROCEEDINGS purchased by Government of New South Wales)	..	..	346 17 4
" Printing	7	7	0	" Fellowships Account (surplus income at 28th February, 1935, transferred)	..	..	182 9 3
" Attendance and Cleaning	33	4	10	" Rent—16 College Street	..	..	577 16 7
" Expenses	45	5	0	" Science House Returns	..	..	269 15 0
" Legal Expenses	36	16	8	" Balance to 1935-36	..	..	170 0 0
" Sydney University Biological Station	20	3	7				98 17 10
" Interest on Overdraft, etc.	147	17	1				
" Bank Expenses	11	0	9				
" Rent—Science House	1	10	4				
" Appropriation: Contingencies Reserve	177	19	2				
	9	9	0				
	£2,128 8 4						

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

11th March, 1935.

G. A. WATERHOUSE,  
 Hon. Treasurer.

4th March, 1935.

£2,128 8 4

**LINNEAN MACLEAY FELLOWSHIPS ACCOUNT.**  
**BALANCE SHEET at 28th February, 1935.**

	£	s.	d.		£	s.	d.
<b>LIABILITIES.</b>				<b>ASSETS.</b>			
Amount bequeathed by Sir William Macleay .. .. .	35,000	0	0	Consols .. .. .	10,900	0	0
Surplus Income Capitalized .. .. .	14,449	8	0	Loans on Mortgage .. .. .	37,700	0	0
				Rural Loan .. .. .	477	10	0
				Commercial Banking Company of Sydney, Ltd. ..	271	18	0
				Commonwealth Savings Bank .. .. .	100	0	0
	£49,449	8	0		£49,449	8	0

**INCOME ACCOUNT. Year Ended 28th February, 1935.**

	£	s.	d.		£	s.	d.
To Salaries of Linnean Macleay Fellows .. .. .	1,366	13	4	By Interest .. .. .	2,177	16	7
” Capital Account .. .. .	233	6	8				
” General Account .. .. .	577	16	7				
	£2,177	16	7		£2,177	16	7

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

11th March, 1935.

G. A. WATERHOUSE,  
 Hon. Treasurer.

4th March, 1935.

**BACTERIOLOGY ACCOUNT.**

BALANCE SHEET at 28th February, 1935.

	£	s.	d.		£	s.	d.
<b>LIABILITIES.</b>				<b>ASSETS.</b>			
Amount bequeathed by Sir William Macleay .. .. .	12,000	0	0	Consols .. .. .	15,820	0	0
Accumulated Income Capitalized .. .. .	3,820	0	0	Cash—			
Income Account at 28th February, 1935 .. .. .	516	15	8	Commercial Banking Company of Sydney, Ltd. .... .	294	11	10
				Commonwealth Savings Bank .. .. .	216	3	10
				In hand .. .. .	6	0	0
					516	15	8
	£16,336	15	8		£16,336	15	8

**INCOME ACCOUNT. Year Ended 28th February, 1935.**

To Salary .. .. .	£	600	0	0		£	518	7	9
" Expenses .. .. .		22	8	5	By Balance from 1933-1934 .. .. .				
" Petty Cash .. .. .		1	2	3	" Interest .. .. .				
" Balance to 1935-36 .. .. .		516	15	8					
		£1,140	6	4		£1,140	6	4	

Examined and found correct. Securities produced.

F. H. RAYMENT, F.C.A. (Aust.),

Auditor.

11th March, 1935.

G. A. WATERHOUSE,

Hon. Treasurer.

4th March, 1935.



REVISION OF AUSTRALIAN LEPIDOPTERA. OECOPHORIDAE. III.

By A. JEFFERIS TURNER, M.D., F.R.E.S.

[Read 27th March, 1935.]

In my last instalment the description of 240, *Borkhausenia xuthochroa*, was accidentally omitted. I have failed to trace this specimen, consequently it must be omitted. I have substituted another species for this number, and take the opportunity of describing several other species of that genus.

In the key to the genera is included a small group designated by Meyrick Scaeosophides, of which there are two genera known in Australia, together with a much larger group containing all the genera in which vein 7 of forewings terminates in the apex, with the exception of the *Machimia* group, which will be considered separately. Most of the genera are closely allied to *Eulechria*, and the distinctions are sometimes rather finely drawn. The criterion of the apical termination of vein 7 must not be applied too strictly. This vein seldom terminates in the mathematical apex, unless that is acute. When the apex is rounded, its termination is usually at the point where the upper end of the termen begins to curve; this we may term the anatomical apex. In some examples of several genera the termination may be just below this, and the determination of a species may then require the careful examination of several examples. In some instances the distinction may appear artificial, but in the present state of our knowledge we cannot dispense with it.

240. BORKHAUSENIA BRACHYSTICHA, n. sp.

*βραχυστιχος*, with short streaks.

♂. 13–20 mm. Head and thorax grey-whitish sprinkled with fuscous. Palpi with second joint reaching base of antennae, terminal joint three-fifths, whitish with a few fuscous scales. Antennae grey with blackish rings, ciliations in male 1. Abdomen grey. Legs grey; posterior pair whitish. Forewings very narrow, costa slightly arched, apex pointed, termen very oblique; grey-whitish finely sprinkled with fuscous; stigmata represented by short longitudinal fuscous streaks, first discal at one-third, plical before it, second discal at two-thirds, dot-like, a streak above and between discals, and another between plical and second discal; cilia grey-whitish with a few fuscous points. Hindwings and cilia pale grey.

Tasmania: Lake St. Clair (2,000 ft.) in January; two specimens.

247. BORKHAUSENIA LITHODES, n. sp.

*λιθωδης*, stone-coloured.

♂. 17 mm. Head whitish. Palpi with second joint reaching base of antennae, terminal joint three-fifths; fuscous. Antennae fuscous; ciliations in male 1. Thorax fuscous. Abdomen dark grey. Legs fuscous. Forewings with costa gently arched, apex pointed, termen very oblique; grey-whitish; markings and

some irroration fuscous; a narrow basal fascia; a curved line from one-third costa to one-third dorsum, and another from two-thirds costa to tornus, stigmata included in these lines, which tend to be suffused and interrupted; cilia grey-whitish. Hindwings and cilia grey.

Tasmania: Hobart, in January; one specimen.

248. *BORKHAUSENIA TORNOSPILA*, n. sp.

*τορνοσπιλος*, with tornal spot.

♀. 18 mm. Head and thorax whitish. Palpi reaching base of antennae, terminal joint three-fifths; fuscous, inner surface whitish. Antennae fuscous. Abdomen ochreous-grey; apices of segments and tuft whitish. Legs fuscous; posterior tibiae and rings on middle tibiae whitish. Forewings rather narrow, costa moderately arched, apex round-pointed, termen oblique; whitish with rather dense fuscous irroration and markings; first discal at one-fourth, plical before it, second discal about middle; a subterminal series of dots from beneath three-fourths costa around apex and termen to tornus; cilia grey, bases barred with fuscous. Hindwings and cilia whitish.

Tasmania: Mt. Wellington (2,500 ft.) in January; one specimen.

249. *BORKHAUSENIA BUTYREA*, n. sp.

*βουτυρεος*, butter-coloured.

♂, ♀. 15-16 mm. Head yellow. Palpi with second joint exceeding base of antennae, terminal joint two-thirds; fuscous. Antennae fuscous, ciliations in male 1½. Thorax fuscous; a posterior spot and tegulae except bases yellow. Abdomen fuscous; tuft ochreous. Legs fuscous; posterior pair ochreous. Forewings narrow, costa almost straight, apex rounded, termen obliquely rounded; ochreous-yellow; markings fuscous; first discal at one-third, plical beneath it, second discal at two-thirds, connected by a streak with tornus; a terminal fascia; terminal edge yellow; cilia yellow, on apex and tornus fuscous. Hindwings and cilia fuscous. Near *B. cosmanthes*; from this and its allies it may be distinguished by the absence of a basal fascia.

Western Australia: Kalamunda, near Perth, in December and January; five specimens received from Mr. W. B. Barnard, who has the type.

*Key to Genera.*

- |   |                            |
|---|----------------------------|
| 1. Hindwings with hyaline patch beneath cell .....                    | 2                          |
| Hindwings without hyaline patch .....                                 | 3                          |
| 2. Forewings with 7, 8, 9 stalked .....                               | 25. <i>Neossiosynoecha</i> |
| Forewings with 9 free .....   | 26. <i>Scaeosopha</i>      |
| 3. Middle and posterior tibiae with whorls of projecting scales ..... | 4                          |
| Middle and posterior tibiae not so .....                              | 6                          |
| 4. Forewings with 7 and 8 coincident .....                            | 27. <i>Celeophracta</i>    |
| Forewings with 7 and 8 stalked .....                                  | 5                          |
| 5. Antennae without pecten .....                                      | 28. <i>Trichomoeris</i>    |
| Antennae with pecten .....  | 29. <i>Petalanthes</i>     |
| 6. Tongue absent or rudimentary .....                                 | 7                          |
| Tongue normally developed .....                                       | 11                         |
| 7. Hindwings with 3 and 4 well separate at origin .....               | 33. <i>Gyrophylla</i>      |
| Hindwings with 3 and 4 connate .....                                  | 8                          |
| 8. Forewings with 7 and 8 coincident .....                            | 30. <i>Anomobela</i>       |
| Forewings with 7 and 8 stalked .....                                  | 9                          |
| 9. Palpi with second joint thickened .....                            | 10                         |
| Palpi with second joint slender .....                                 | 31. <i>Limothes</i>        |
| 10. Palpi with terminal joint obtuse .....                            | 32. <i>Eclactistis</i>     |
| Palpi with terminal joint acute .....                                 | 34. <i>Phloeochroa</i>     |



11. Anterior tibiae and tarsi thickened .....	12
Anterior tibiae and tarsi not thickened .....	15
12. Thorax without crest .....	13
Thorax with crest .....	14
13. Antennae without pecten .....	35. <i>Callimima</i>
Antennae with pecten .....	36. <i>Copriodes</i>
14. Forewings with tufts of scales .....	37. <i>Piloprepes</i>
Forewings smooth .....	38. <i>Epipyrga</i>
15. Forewings with tufts of scales .....	39. <i>Trachypepla</i>
Forewings smooth .....	16
16. Thorax with crest .....	17
Thorax without crest .....	20
17. Antennae without pecten .....	42. <i>Barea</i>
Antennae with pecten .....	18
18. Palpi with second joint dilated beneath, with rough scales towards apex .....	40. <i>Oenochroa</i>
Palpi not dilated towards apex .....	19
19. Palpi with terminal joint slender .....	41. <i>Placocosma</i>
Palpi with terminal joint stout .....	43. <i>Eucryphaea</i>
20. Forewings with 7 and 8 coincident .....	21
Forewings with 7 and 8 stalked .....	22
21. Forewings with 2 and 3 stalked .....	51. <i>Heliosteres</i>
Forewings with 2 and 3 separate .....	55. <i>Mermeristis</i>
22. Palpi with second joint in male dilated with loose hairs at apex .....	23
Palpi not so .....	24
23. Palpi with terminal joint slender .....	44. <i>Ioptera</i>
Palpi with terminal joint moderately stout .....	45. <i>Phriconyma</i>
24. Antennae without pecten .....	25
Antennae with pecten .....	30
25. Forewings with 2 and 3 stalked .....	52. <i>Actenotis</i>
Forewings with 2 and 3 not stalked .....	26
26. Palpi with second joint three times length of face .....	46. <i>Bathydoza</i>
Palpi with second joint not exceeding twice face .....	27
27. Forewings with 7, 8, 9 stalked .....	47. <i>Ancharcha</i>
Forewings with 9 free .....	28
28. Palpi with second joint not reaching base of antennae .....	49. <i>Utidana</i>
Palpi with second joint reaching base of antennae .....	29
29. Palpi with second joint slender .....	48. <i>Locheutis</i>
Palpi with second joint thickened .....	50. <i>Allodapica</i>
30. Forewings with 2 and 3 stalked .....	53. <i>Elaeonomma</i>
Forewings with 2 and 3 not stalked .....	31
31. Palpi with second joint extremely long, terminal joint less than half second .....	54. <i>Epithymema</i>
Palpi not so .....	32
32. Palpi with terminal joint stout, at least at base .....	33
Palpi with terminal joint slender throughout .....	35
33. Hindwings lanceolate .....	34
Hindwings elongate-ovate .....	58. <i>Trachyntis</i>
34. Hindwings with 4 and 5 stalked .....	56. <i>Phloeocetes</i>
Hindwings with 4 and 5 separate .....	57. <i>Ischnophanes</i>
35. Hindwings lanceolate .....	36
Hindwings elongate-ovate .....	38
36. Hindwings with 5 connate or stalked with 4 .....	59. <i>Elaphromorpha</i>
Hindwings with 4 and 5 separate .....	37
37. Hindwings with 5 strongly approximated to 6 .....	60. <i>Asthenica</i>
Hindwings with 5 not approximated to 6 .....	61. <i>Macronemata</i>
38. Palpi with second joint not reaching base of antennae .....	62. <i>Brachyzancla</i>
Palpi with second joint reaching base of antennae .....	39
39. Palpi with long rough hairs on posterior surface of second joint ..	63. <i>Anomozancla</i>
Palpi without such hairs .....	40
40. Palpi with second joint more than twice length of face .....	64. <i>Phanerozancla</i>
Palpi with second joint less than twice length of face .....	65. <i>Eulechria</i>

## 25. Gen. NEOSSIOSYNOECHA Turn.

*Trans. Ent. Soc.*, 1923, p. 171. Type, *T. scatophaga*.

Tongue present. Palpi ascending, recurved, smooth-scaled; second joint moderately long; terminal joint much shorter than second. Antennae with basal pecten; in male moderately ciliated. Forewings with 2 and 3 stalked, 5 absent, 7, 8, 9 stalked, 7 to termen. Hindwings with 3 and 4 stalked, 5 from middle of cell; a triangular basal hyaline area beneath cell.

This and the following genus belong to Meyrick's Scaeosophides characterized by the hyaline patches on the hindwings.

Two species: 250, *scatophaga* Turn., *Tr. E. S.*, 1923, p. 172 (Coen, N.Q.).—251, *agnosta*, n. sp.

## 251. NEOSSIOSYNOECHA AGNOSTA, n. sp.

*ἀγνωστος*, unknown.

♂. 35 mm. Head fuscous sprinkled with whitish. Palpi with second joint reaching base of antennae, terminal joint two-fifths; fuscous sprinkled with whitish. Antennae fuscous; ciliations in male 2. Thorax dark fuscous sprinkled with whitish. Abdomen ochreous-fuscous. Legs fuscous with whitish rings; posterior pair grey-whitish. Forewings narrow, suboval, costa slightly arched, apex rounded, termen obliquely rounded; dark fuscous with fine whitish irroration appearing grey; veins more whitish; stigmata blackish, first discal at one-third, plical beneath it, both these are narrow and streak-like, second discal before two-thirds; cilia fuscous sprinkled with whitish. Hindwings elongate; whitish-grey; cilia whitish-grey.

Structurally exactly as the type species, but with narrower wings. We should much like to know the larval habits of this species.

Queensland: Toowoomba, in October; one specimen received from Mr. W. B. Barnard, who has the type.

## 26. Gen. SCAEOSOPHA Meyr.

*Exot. Micro.*, i, p. 254. Type, *S. perchnaula* Meyr., from India.

Tongue present. Palpi with second joint not reaching base of antennae; terminal joint shorter than second. Antennae with basal pecten; in male shortly and unevenly ciliated. Forewings with slight tufts of scales; 7 and 8 stalked, 7 to apex, 9 free. Hindwings elongate-ovate; cell less than one-half; a triangular basal hyaline patch beneath cell; 5 from below middle.

There are two Indian species. Lower's name for the Australian species has a few months' priority. In one of my examples 7 and 8 are coincident in one forewing.

252, *epileuca* Low., *Tr. R.S. S. Aust.*, 1901, p. 94 (= *mitescens* Luc., *P.R.S.Q.*, 1901, p. 91).

## 27. Gen. CELEOPHRACTA, n.g.

*κηλεοφρακτος*, fiery-edged.

Palpi moderately long, recurved, ascending; second joint reaching base of antennae, slightly thickened, with smoothly appressed scales; terminal joint shorter than second, slender, acute. Antennae without pecten; in male with rather long ciliations. Middle and posterior tibiae with median whorls of projecting hairs. Forewings with 7 and 8 coincident. Hindwings with 3 and 4 coincident.

This and the two following genera form a peculiar little group. Type, *C. corusca*.

## 253. CELEOPHRACTA CORUSCA, n. sp.

*coruscus*, shining.

♂, ♀. 15-16 mm. Head fuscous; posterior margin ochreous-yellow. Palpi orange-ochreous; terminal joint three-fifths; fuscous. Antennae blackish; ciliations in male 2. Thorax dark fuscous; tegulae and a posterior spot shining brassy. Abdomen fuscous; apical segments fuscous-ochreous with whitish apices. Legs fuscous; tibiae and tarsi with whitish rings. Forewings narrow, costa nearly straight, apex rounded, termen oblique; blackish uniformly irrorated with slender whitish scales; some basal ochreous irroration; ochreous dots in disc at two-thirds and on fold; terminal edge and cilia brassy with metallic reflections; cilia on apex and tornus grey. Hindwings and cilia grey.

South Australia: Adelaide (Coll. Lower); Mt. Lofty (Blackwood; J. D. O. Wilson) in October; four specimens.

## 254. CELEOPHRACTA HYPEREPHANA, n. sp.

*ὑπερφανος*, conspicuous.

♂. 15-16 mm. Head fuscous; posterior margin orange-ochreous. Palpi orange-ochreous; terminal joint four-fifths, fuscous. Antennae fuscous; ciliations in male 2. Thorax fuscous with brassy lustre. Abdomen fuscous with a broad post-median ochreous band; underside mostly ochreous-whitish. Legs fuscous; tibiae and tarsi with ochreous-whitish rings. Forewings narrow, costa nearly straight, apex obtuse, termen oblique; brown-fuscous uniformly irrorated with narrow ochreous-whitish scales; a pale ochreous dorsal spot immediately followed by a tornal fuscous spot; terminal edge and cilia brassy with metallic reflections; cilia on apex and tornus grey. Hindwings orange-ochreous; terminal half fuscous; cilia fuscous.

Western Australia: Mundaring near Perth, and Busselton, in October; two specimens received from Mr. G. M. Goldfinch, who has the type.

## 28. Gen. TRICHOMOERIS MEYR.

*Exot. Micro.*, i, p. 156. Type, *T. amphichrysa*.

Tongue present. Palpi with second joint reaching base of antennae, terminal joint shorter than second. Antennae without basal pecten. Middle and posterior tibiae with median whorls of rough hairs. Forewings with 7 and 8 stalked, 7 to apex. Hindwings elongate-ovate; neuration normal.

Two species: 255, *amphichrysa* Meyr., *Exot. Micro.*, i, p. 156 (Darwin; Cairns).—256, *heterochrysa* Meyr., *Arkiv. f. Zool.*, xiv (15), 6 (Atherton).

## 29. Gen. PETALANTHES MEYR.

PROC. LINN. SOC. N.S.W., 1883, p. 335. Type, *P. sphaerophora* Meyr.

Tongue present. Palpi with second joint reaching base of antennae, terminal joint rather shorter than second. Antennae with basal pecten of few but long scales; in male with tufts of long cilia. Middle and posterior tibiae with median whorls of rough projecting hairs. Forewings with tufts of scales; 7 and 8 stalked, 7 to apex. Hindwings elongate-ovate; neuration normal.

Some of the species have remarkably spotted hindwings.

Five species: 257, *sphaerophora* Meyr., PROC. LINN. SOC. N.S.W., 1883, p. 335 (Toowoomba, Sydney, Katoomba).—†258, *diploxantha* Meyr., *Exot. Micro.*, i, p. 236 (Newcastle).—259, *hexastera* Meyr., PROC. LINN. SOC. N.S.W., 1883, p. 336 (Brisbane to Melbourne).—260, *microphrica*, n. sp. (Mittagong).—261, *pericylta* Meyr., *ibid.*, p. 337 (Brisbane, Toowoomba, Sydney).

260. *PETALANTHES MICROPHRICA*, n. sp.

*μικροφρικός*, minutely rippled.

♂. 14 mm. Head and thorax fuscous. Palpi white laterally, fuscous anteriorly and posteriorly. Antennae blackish with fine whitish annulations; ciliations in male 4. Abdomen and legs fuscous. Forewings dilated, costa straight, apex rounded, termen rounded, slightly oblique; whitish-ochreous evenly traversed by five sinuate fuscous transverse strigulae; a whitish-ochreous subcostal dot near base; a narrow transverse dark fuscous fascia at one-fourth, immediately followed by a median whitish-ochreous dot; a transverse median whitish bar, edged with dark fuscous and with a dark fuscous dot on lower end; a second dark fuscous fascia at three-fourths, broader on costa; cilia whitish-ochreous with two fuscous lines. Hindwings similar, but fuscous fasciae broadly suffused, separated by a moderate whitish fascia; cilia grey with a sub-basal line.

New South Wales: Mittagong, in November; one specimen in Coll. Goldfinch.

30. Gen. *ANOMOBELA*, n.g.

*ἀνομοβελος*, with unusual palpi.

Tongue absent. Palpi moderately long, ascending, recurved; second joint reaching base of antennae, thickened with appressed scales, rough towards apex anteriorly; terminal joint one-fourth or less, slender, acute. Antennae with basal pecten; ciliations in male moderately long. Thorax smooth. Forewings with 7 and 8 coincident. Hindwings elongate-ovate, neuration normal.

Allied to the following genus; the affinities of the two genera are uncertain.

262. *ANOMOBELA PLICILINEA*, n. sp.

*πλικιλίνευς*, with a line on fold.

♂. 15 mm. ♀. 18 mm. Head whitish. Palpi with terminal joint in male one-fourth, in female one-sixth; fuscous, most of inner surface and apex of second joint whitish. Antennae grey-whitish; ciliations in male 1½. Thorax fuscous; tegulae grey-whitish. Abdomen grey-whitish with some ochreous suffusion. Legs fuscous with ochreous rings; posterior pair ochreous-whitish. Forewings narrow, oval, costa rather strongly arched, apex pointed, termen extremely oblique; whitish with three suffused pale fuscous fasciae; first broad, basal; second broad on costa from one-third to two-thirds, becoming narrower towards dorsum before middle, ill-defined posteriorly; third narrow, from three-fourths costa to before tornus, acutely angled outwards in middle; stigmata shortly linear, blackish, first discal shortly before middle, plical before it, second discal at two-thirds transverse; cilia whitish. Hindwings and cilia whitish-grey.

North Queensland: Cape York, in June; two specimens received from Mr. W. B. Barnard, who has the type.

31. Gen. *LIMOTHNES*, n.g.

*λιμοθνήης*, starving.

Tongue absent. Palpi smooth, slender, ascending, recurved; second joint not reaching base of antennae; terminal joint shorter than second. Antennae with basal pecten; in male moderately ciliated. Abdomen stout. Forewings with 7 to apex. Hindwings ovate-lanceolate, 5 from below middle.

263. *LIMOTHNES LEUCOTOMA*, n. sp.

*λευκοτομος*, divided by white.

♂. 18-19 mm. Head fuscous; face whitish. Palpi with terminal joint three-fifths; fuscous, apex of second joint and base and apex of terminal joint whitish.

Antennae whitish; ciliations in male  $1\frac{1}{2}$ . Thorax whitish anteriorly and posteriorly suffused with fuscous. Abdomen ochreous-brown; apices of segments and tuft pale grey. Legs whitish-ochreous; anterior and middle pairs with some fuscous suffusion. Forewings rather narrow, oval, costa moderately arched, apex pointed, termen extremely oblique; fuscous; a rather narrow white fascia from one-third costa to one-third dorsum; terminal area suffused with whitish; a discal dot in middle, and two dots often confluent at two-thirds, fuscous; cilia whitish. Hindwings and cilia pale grey.

North Queensland: Cape York, in October and December; six specimens received from Mr. W. B. Barnard, who has the type.

32. Gen. ECLACTISTIS Meyr.

*Exot. Micro.*, i, p. 134. Type, *E. byrseuta* Meyr.

Tongue weakly developed and rudimentary. Palpi long, ascending, recurved; second joint reaching base of antennae, much thickened with appressed scales, slightly rough anteriorly; terminal joint much thickened like second joint, apex obtusely pointed. Face with a pair of strong tufts curving over eyes. Antennae without basal pecten; ciliations in male moderately long. Thorax smooth. Forewings with 7 to apex or nearly so. Hindwings elongate-ovate; neuration normal.

Also represented in New Guinea by the type species, which has additional male secondary characters in the posterior tibiae and tarsi.

264. ECLACTISTIS ANISOPASTA, n. sp.

*ἀνισοπάστος*, unevenly sprinkled.

♂. 17–20 mm. Head ochreous-whitish. Palpi ochreous-whitish with a few fuscous scales. Antennae ochreous-whitish; ciliations in male  $1\frac{1}{2}$ . Thorax ochreous-whitish. Abdomen and legs whitish-ochreous. Forewings not dilated, costa strongly arched, apex round-pointed, termen very obliquely rounded; ochreous-whitish with patchy fuscous irroration; stigmata dark fuscous, first discal at one-third, plical beyond it, second discal at two-thirds; suffused fuscous patches near base, above mid-dorsum, and on costa at three-fifths and four-fifths, from the last a more or less curved line to tornus; cilia ochreous-whitish with some fuscous points. Hindwings grey; cilia grey-whitish.

North Queensland: Cape York, in October and November; six specimens received from Mr. W. B. Barnard, who has the type.

33. Gen. GYROPHYLLA, n.g.

*γυροφύλλος*, with rounded wings.

Tongue absent. Palpi short, slender, not reaching middle of face; second joint with loose hairs beneath; terminal joint shorter than second, rather stout. Antennae without basal pecten; ciliations in male short. Thorax with a small posterior crest. Forewings with 2 from near angle, 7 and 8 coincident to apex. Hindwings with 3, 4, 5, 6, 7 nearly equidistant, parallel.

265. GYROPHYLLA EUMETRA, n. sp.

*εὐμετρος*, well measured.

♂. 22 mm. Head whitish-ochreous. Palpi fuscous. Antennae grey; ciliations in male two-thirds. Thorax grey-whitish. Abdomen grey; tuft grey-whitish. Legs fuscous; posterior pair whitish. Forewings oval, costa strongly arched, apex rounded, termen obliquely rounded; grey-whitish; costal and terminal edge grey; cilia pale grey. Hindwings grey; cilia grey-whitish.

New South Wales: Sydney (Manly) in March (G. H. Wyld); one specimen. Type in Coll. Goldfinch.

34. Gen. PHLOEOCHROA, n.g.

φλοιοχροος, coloured like bark.

Tongue absent. Palpi with second joint exceeding base of antennae, thickened throughout with appressed scales, dilated and slightly rough at apex; terminal joint less than one-half, slender, acute. Antennae with basal pecten. Forewings with 2 and 3 connate, 7 to apex. Hindwings elongate-ovate; neuration normal.

266. PHLOEOCHROA POLYRRHABDA, n. sp.

πολυρράβδος, many-streaked.

♀. 34 mm. Head and thorax whitish. Palpi with terminal joint one-third; grey, internal surface whitish. Antennae grey. Abdomen grey; tuft grey-whitish. Legs grey; posterior pair grey-whitish. Forewings elongate, costa slightly arched, apex pointed, termen very oblique; grey; costa towards base and dorsum broadly suffused with brown-whitish; disc sprinkled with a few fuscous scales; fine fuscous interneural streaks in post-median area; cilia grey. Hindwings and cilia pale grey.

New South Wales: Sydney (Manly) in March (G. H. Wyld); type in Coll. Goldfinch.

35. Gen. CALLIMIMA, n.g.

καλλιμιμος, a beautiful mimic.

Tongue present. Palpi with second joint reaching or exceeding base of antennae, thickened with appressed scales, expanded and sometimes forming a triangular tuft at apex; terminal joint shorter than second, slender or rather stout, acute. Antennae without basal pecten; ciliations in male moderately long. Thorax smooth. Anterior tibiae and tarsi strongly dilated. Forewings with costal tuft; 7 to apex. Hindwings ovate; 5 curved from below middle of cell.

Type, *C. lophoptera*. Near *Copriodes*, differing in the palpi and absence of antennal pecten.

Two Species: 267, *lophoptera* Low., *Tr.R.S.S.Aust.*, 1894, p. 96 (Brisbane to Allyn River, N.S.W.).—268, *daedalma*, n. sp. (Cairns).

268. CALLIMIMA DAEDALMA, n. sp.

δαίδαλμα, a work of art.

♀. 20 mm. Head whitish. Palpi whitish, outer surface of second joint fuscous towards base. Antennae grey, towards base whitish. Thorax grey-whitish. Abdomen ochreous-whitish. Forewings with costa strongly arched, bearing a strong median tuft, apex rounded, termen obliquely rounded; dark fuscous; costal edge except at base pale rosy; a well-defined whitish line along costa, continued around apex and termen to tornus; a broad ridge of whitish scales, anteriorly brown mixed with fuscous, from base to one-fourth dorsum; a curved whitish line from midcosta to before tornus, sharply defined and slightly waved on anterior edge; a narrow fuscous terminal line thickened on veins; cilia grey-whitish, on costa pale rosy. Hindwings grey; terminal edge whitish; cilia pale grey.

North Queensland: Kuranda, in May; one specimen.

36. Gen. COPRIODES Turn.

PROC. LINN. SOC. N.S.W., 1916, p. 339. Type, *C. aristocratica*.

Tongue present. Palpi with second joint reaching base of antennae, slender and smooth, or slightly thickened and rough anteriorly beyond middle; terminal joint shorter than second, slender, acute. Antennae with strong basal pecten; ciliations in male moderate or long. Thorax smooth. Anterior tibiae and tarsi strongly dilated. Forewings with costal tuft or with tufts of raised scales in disc; 7 to apex. Hindwings ovate or elongate-ovate; neuration normal.

In *C. aristocratica* the forewing has a peculiar shape (a specific adaptation for mimetic purposes) so that 7 runs apparently to costa. In *C. anassa* the costal tuft is scarcely developed, in *C. gelidella* it appears to be absent, but is replaced by raised scales in disc. The genus differs from *Piloprepes* in the absence of a thoracic crest.

Eight Species: 269, *aristocratica* Meyr., PROC. LINN. SOC. N.S.W., 1888, p. 1598 (Yeppoon to Fernshaw).—270, *perinephela*, n. sp. (Lismore).—271, *hypsiopha*, n. sp. (Cunnamulla, Dalby).—272, *polynephela*, n. sp. (Dimboola, Vic.).—273, *anguicula* Meyr., *Exot. Micro.*, i, p. 133 (Brentwood, Vic.).—274, *anassa* Meyr., PROC. LINN. SOC. N.S.W., 1888, p. 1597 (Toowoomba to Melbourne).—275, *glauca* Turn., *Tr.R.S.S.Aust.*, 1896, p. 19 (Brisbane).—276, *gelidella* Wlk., xxix, p. 766. = *lucasi* Turn., *ibid.*, 1896, p. 19 (Darwin, Brisbane, Sydney).

270. COPRIODES PERINEPHELA, n. sp.

περινεφελος, clouded.

♀. 18 mm. Head white. Palpi white; apex of terminal joint fuscous. Antennae grey. Thorax fuscous; tegulae white. (Abdomen missing.) Legs white; tarsi with blackish rings. Forewings with costa bisinuate, bearing a tuft before middle, apex round-pointed, termen obliquely rounded; 7 to apex; white; blackish dots on base of costa and dorsum, and paired dots in disc just beyond base; a fine fuscous line from one-fourth costa, outwardly oblique, angled, and continued along fold for a short distance; again angled and curved outwards to mid-dorsum; a cloudy incomplete fuscous fascia, inwardly curved from beneath three-fourths costa to tornus, strongly excavated anteriorly, less so posteriorly; a similar marginal fascia from three-fourths costa to midtermen, but not touching termen; an interrupted dark fuscous terminal line; cilia whitish, barred with fuscous around apex. Hindwings grey; cilia grey, on dorsum whitish.

Nearest *C. aristocratica*.

New South Wales: Rous, near Lismore, in November; one specimen received from Mr. V. J. Robinson.

271. COPRIODES HYPSIOPHA, n. sp.

ὑψιλοφος, high-crested.

♂. 14–20 mm. Head whitish; apices of side-tufts fuscous-brown. Palpi whitish. Antennae grey, towards base whitish; ciliations in male  $1\frac{1}{2}$ . Thorax ochreous-whitish; anterior edge and two posterior dots dark fuscous. Abdomen fuscous-brown; dorsum of first two segments whitish. Legs whitish; middle tibiae fuscous with whitish rings. Forewings suboval, costa strongly arched, with a slight indication of a tuft beyond middle, apex rounded, termen very obliquely rounded; ochreous-whitish; a raised tuft of scales in middle at one-third, and another at mid-dorsum, both dark fuscous at apices; some dark fuscous irroration in median area; two raised tufts arranged obliquely in disc beyond middle, dark fuscous; a fine crenulate fuscous line from costa beyond middle to tornus; beyond this line clear white except a small very faint subapical cloud; cilia

white. Hindwings whitish-ochreous, suffused with grey beyond middle; cilia whitish-ochreous, around apex grey.

Queensland: Cunnamulla; Jandowae near Dalby; two specimens.

272. COPRIODES POLYNEPHELA, n. sp.

*πολυνεφελος*, much clouded.

♂. 16 mm. Head whitish. (Palpi missing. Antennae imperfect.) Thorax whitish, central area and a posterior spot fuscous. Abdomen pale ochreous. Legs whitish. Forewings suboval, costa strongly arched, apex rounded, termen obliquely rounded; whitish; pale fuscous basal markings, namely, a narrow curved transverse line near base, a dot on costa at one-sixth, a large spot on dorsum at one-fourth, connected with fascia on dorsum, limited by fold, and a smaller spot in disc above fold; an ochreous-grey-whitish fascia from two-fifths costa to mid-dorsum, dilated in middle, constricted on fold, dilated again on dorsum; an irregular fascia from mid-costa to tornus, at first pale fuscous, connected with median above middle, becoming ochreous-grey-whitish in disc, but pale fuscous towards tornus, sharply indented posteriorly above tornus, posteriorly edged with black except towards margins, strongly outwardly curved, but indented above middle; a subapical bluish-fuscous crescent; cilia whitish with an apical fuscous dot, on tornus grey. Hindwings grey; cilia grey, towards apex whitish.

Victoria: Kiata, near Dimboola, in November; one specimen. Type in Coll. Lyell.

37. Gen. PILOPREPES Meyr.

PROC. LINN. SOC. N.S.W., 1883, p. 365. Type, *P. aemulella*.

Tongue present. Palpi with second joint reaching base of antennae, slightly thickened with appressed scales; terminal joint shorter than second, slender, acute. Antennae with basal pecten; in male with moderate ciliations. Thorax with a strong posterior crest. Anterior tibiae and tarsi slightly dilated. Forewings with tufts of scales; 7 to apex. Hindwings elongate-ovate; neuration normal.

Readily distinguished from *Copriodes* by the strong thoracic crest. With the two preceding genera it forms a natural group.

Two Species: 277, *aemulella* Meyr., PROC. LINN. SOC. N.S.W., 1883, p. 366 (Darwin, Cape York to Melbourne).—278, *antidoxa* Meyr., *ibid.*, 1888, p. 1599 (West Victoria, Adelaide. W.A.: Cunderdin, Beverly).

38. Gen. EPIPYRGA Meyr.

PROC. LINN. SOC. N.S.W., 1884, p. 791. Type, *E. agaclita*.

Tongue present. Palpi with second joint reaching base of antennae, thickened with rough scales anteriorly; terminal joint shorter than second, slender, acute. Antennae without basal pecten; in male moderately ciliated. Thorax not crested. Anterior tibiae and tarsi slightly dilated. Forewings smooth; 7 to apex. Hindwings elongate-ovate; neuration normal.

*E. hemiphanes* might be an aberration of *E. agaclita*, but I do not think so. It differs in the wholly fuscous thorax, basal fascia on forewings, darker apical half of wing without yellowish spot, and purple-fuscous cilia.

279, *agaclita* Meyr., PROC. LINN. SOC. N.S.W., 1884, p. 791 (Cairns to Brisbane and Milmerran).—280, *hemiphanes* Turn., *Tr. R.S.S. Aust.*, 1917, p. 58 (Brisbane).

39. Gen. TRACHYPEPLA Meyr.

PROC. LINN. SOC. N.S.W., 1883, p. 367. Type, *T. euryleucota* Meyr. from New Zealand.



Tongue present. Palpi with second joint not reaching, reaching, or exceeding base of antennae, thickened with appressed scales; terminal joint shorter than second, slender, acute. Antennae with basal pecten; ciliations in male moderate or long. Thorax sometimes with a small posterior crest. Forewings with tufts of raised scales: 2 usually separate, rarely connate or even stalked with 3, 7 to apex. Hindwings elongate-ovate or broadly lanceolate; neuration normal.

This genus is confined to Australia and New Zealand. Meyrick records twenty species from the latter region. It presents considerable variation in structure. The Australian species might be divided into two groups: (1) those with lanceolate hindwings and second joint of palpi not reaching antennae, (2) those of larger size with elongate-ovate hindwings and second joint of palpi exceeding base of antennae, but the New Zealand species are intermediate. It appears inadvisable to break up a natural genus of moderate size into artificial genera, which grade into each other.

Fifteen Species: 281, *atriversa* Turn., PROC. LINN. SOC. N.S.W., 1916, p. 347 (Brisbane to Sydney).—†282, *chari erga* Meyr., *ibid.*, 1888, p. 1566 (Bathurst; Deloraine, Tas.; Perth, W.A.).—283, *phaeolopha*, n. sp. (Nambour, Brisbane, Toowoomba, Stanthorpe).—284, *poliochroa* Turn., *Tr.R.S.S.Aust.*, 1898, p. 208 (Brisbane, Mt. Tambourine, Toowoomba, Stanthorpe).—285, *lasiocephala* Low., *ibid.*, 1916, p. 540 (Dalby).—286, *stenota* Meyr., PROC. LINN. SOC. N.S.W., 1888, p. 567 (Sydney; Perth, W.A.).—†287, *hemicarpa* Meyr., *ibid.*, 1887, p. 954 (North Tasmania).—288, *melanoptila* Meyr., *ibid.*, 1883, p. 370 (Brisbane, Sydney).—289, *diplospila*, n. sp. (Toowoomba).—290, *picimacula*, n. sp. (Sydney).—291, *capsellata* Meyr., *Exot. Micro.*, i, p. 157 (Beaconsfield, Vic.; Tasmania, Mt. Lofty).—292, *glebifera* Turn., *P.R.S. Tas.*, 1926, p. 142 (Tasmania).—293, *dasylopha* Low., *Tr.R.S.S.Aust.*, 1920, p. 61 (Dalby).—294, *haematea* Turn., PROC. LINN. SOC. N.S.W., 1916, p. 347. = *plinthinopa* Meyr., *Exot. Micro.*, ii, p. 368 (Eidsvold, Brisbane, Toowoomba).—295, *peplasmena*, n. sp. (Sydney).

283. TRACHYPEPLA PHAEOLOPHA, n. sp.

φαιολοφος, dark crested.

♂, ♀. 10–15 mm. Head white. Palpi whitish; second joint with basal half and a subapical ring fuscous. Antennae grey-whitish; in male slightly serrate, ciliations one-half. Thorax white. Abdomen pale grey; tuft ochreous-whitish. Legs fuscous mixed with whitish; posterior pair ochreous-whitish. Forewings narrow, costa gently arched, apex rounded; white with some pale ochreous-grey irroration; dark fuscous costal dots at one-fourth and beyond middle; a large tuft of raised scales on mid-dorsum extending half across wing, dark fuscous; cilia whitish finely sprinkled with fuscous. Hindwings lanceolate; grey-whitish; cilia grey-whitish.

Queensland: Eumundi, in November; Brisbane, in August; Toowoomba, in September and October; Stanthorpe; six specimens.

289. TRACHYPEPLA DIPLOSPILA, n. sp.

διπλοσπιλος, two-spotted.

♂, ♀. 19–20 mm. Head and thorax white. Palpi with second joint much exceeding base of antennae, terminal joint three-fifths; white, base of second joint dark fuscous externally. Antennae whitish; ciliations in male two-thirds. Abdomen whitish-ochreous. Legs whitish. Forewings rather narrow, suboblong, costa gently arched, apex rounded, termen very obliquely rounded; white; some pale grey suffusion towards apex and on dorsum; two dark fuscous spots with

large scales, being first discal at one-fourth and plical well beyond it, elongate; second discal sometimes indicated by a minute dot beyond middle; cilia whitish sprinkled with grey. Hindwings and cilia grey.

Queensland: Toowoomba, in November; two specimens received from Mr. W. B. Barnard, who has the type.

290. TRACHYPEPLA PICIMACULA, n. sp.

*picimaculus*, blotched with pitch-black.

♂. 22-24 mm. Head and thorax fuscous-brown. Palpi pale brown, on outer surface sprinkled with blackish; terminal joint three-fourths. Antennae fuscous; ciliations in male 1. Abdomen grey. Legs fuscous with whitish rings; posterior pair mostly whitish. Forewings slightly dilated, costa rather strongly arched, apex round-pointed, termen obliquely rounded; fuscous-brown with blackish markings; a strong line on fold from near base to two-thirds; a small irregular blotch, sometimes reduced to a short line, beneath costa at one-third; a second small blotch above middle emitting a posterior Y-forked line, its extremities approaching costa and dorsum, sometimes obscured by blackish irroration; sometimes two subterminal dots below its lower extremity; a series of terminal dots; cilia pale fuscous sprinkled with blackish. Hindwings with 5 from middle; pale grey; cilia grey-whitish.

New South Wales: National Park near Sydney, in August; two specimens received from Mr. G. M. Goldfinch, who has the type.

295. TRACHYPEPLA PEPLASMENA, n. sp.

*πεπλαμενος*, dissembling.

♂. 22 mm. Head brownish. Palpi with second joint exceeding base of antennae, terminal joint three-fifths; whitish, second joint with irroration and a subapical ring fuscous; terminal joint fuscous except apex. Antennae fuscous; ciliations in male 1. Thorax fuscous. Abdomen grey; tuft ochreous-whitish. Legs fuscous with ochreous-whitish rings; posterior pair mostly ochreous-whitish. Forewings strongly dilated, costa strongly arched, apex rounded, termen obliquely rounded; whitish with fine fuscous irroration, appearing grey; markings dark fuscous; a subdorsal ridge of raised scales from base to one-fifth; a tuft of whitish scales above two-fifths dorsum; first discal at one-fourth, second at middle, transversely elongate; plical represented by a short line on fold, partly overlapped by subdorsal tuft; a stout inwardly oblique line from costa before apex, very acutely angled above middle of disc, continued by a slender line to dorsum before tornus, connected by an interrupted longitudinal streak from angle with second discal; a series of dots on termen and apical fourth of costa; cilia fuscous, apices whitish. Hindwings and cilia grey-whitish.

New South Wales: Heathcote near Sydney, in August; one specimen received from Dr. R. J. Tillyard.

40. Gen. OENOCROA Meyr.

PROC. LINN. SOC. N.S.W., 1883, p. 327. Type, *O. laetella*.

Tongue present. Palpi with second joint reaching or not reaching base of antennae, thickened with appressed scales, and rough projecting scales towards apex anteriorly; terminal joint shorter than second, slender, acute. Antennae with basal pecten; in male shortly or moderately ciliated. Thorax with a small posterior crest. Forewings with 2 from well before angle, 7 to apex. Hindwings elongate-ovate; 5 from below middle.

Fifteen Species: 296, *thermistis* Low., *Tr. R.S.S. Aust.*, 1896, p. 166 (Victoria, Tasmania). = *atradelpha* Low., *ibid.*, 1903, p. 221.—297, *laetella* (*lactella*) Wlk., xxix, p. 648 (Meyr., *Proc. LINN. Soc. N.S.W.*, 1883, p. 328) (Brisbane to Melbourne).—298, *ochrosoma* Turn., *Tr. R.S.S. Aust.*, 1896, p. 13 (Brisbane, Toowoomba).—299, *lepida*, n. sp. (Roma).—300, *zophocosma*, n. sp. (Roma).—301, *molybdoptera*, n. sp. (Charleville).—302, *suffulva*, n. sp. (Atherton, Banana, Q., Birchip).—303, *gnophodes* Turn., *ibid.*, 1896, p. 14 (Brisbane, Melbourne).—304, *dinosema* Meyr., *Proc. LINN. Soc. N.S.W.*, 1888, p. 1575 (Victoria, Adelaide).—305, *zalotypa*, n. sp. (W.A.: Denmark).—306, *endochlora* Meyr., *Proc. LINN. Soc. N.S.W.*, 1883, p. 329 (Warragul, Quorn, Wirrabara, Mt. Lofty).—307, *dystena*, n. sp. (Brisbane).—308, *homora* Meyr., *Tr. R.S.S. Aust.*, 1902, p. 152 (Sydney, Hobart).—†309, *heptarcha* Meyr., *Proc. LINN. Soc. N.S.W.*, 1888, p. 1576 (W.A.: Geraldton).—310, *iobaphes* Meyr., *ibid.*, 1883, p. 330 (Brisbane to Tasmania, Mt. Lofty).

## 299. OENOCHROA LEPIDA, n. sp.

*lepides*, pleasing.

♀. 20–22 mm. Head and thorax blackish irrorated with grey-whitish. Palpi with second joint reaching base of antennae, terminal joint three-fifths; grey-whitish irrorated with blackish. Antennae blackish. Abdomen grey; apices of segments ochreous-whitish. Legs blackish; rings on tibiae and tarsi, and hairs on posterior tibiae ochreous-whitish. Forewings oval, costa strongly arched, apex pointed, termen very obliquely rounded; grey-whitish with some blackish irroration and markings; a rather large triangular sub-basal costal spot; an outwardly curved line from one-fourth costa to one-fourth dorsum, giving off in middle a fine or interrupted line to tornus; a thicker line from two-thirds costa to tornus, expanded in middle to contain a grey-whitish spot; a series of dots or short streaks on apical one-third of costa and tornus; cilia grey. Hindwings ochreous-yellow; apex suffused with grey; cilia grey.

Queensland: Roma, bred from larvae on leaves of a broad-leaved *Eucalyptus*, two specimens emerging in Brisbane in August.

## 300. OENOCHROA ZOPHOCOSMA, n. sp.

*ζοφοκοσμος*, darkly adorned.

♂, ♀. 16–19 mm. Head grey-whitish sprinkled with dark fuscous. Palpi with second joint slightly expanded with rough scales towards apex anteriorly; terminal joint four-fifths; dark fuscous sprinkled with grey-whitish. Antennae dark fuscous; ciliations in male 1. Thorax with small posterior crest; dark fuscous sprinkled with grey-whitish. Abdomen grey; tuft ochreous-whitish. Legs fuscous with grey-whitish rings; hairs on posterior tibiae ochreous-whitish. Forewings narrow, oval, costa gently arched, apex round-pointed, termen very oblique; grey-whitish; markings and some irroration dark fuscous; a rather large suffused basal patch; a broad dorsal streak separated, sometimes incompletely, from basal patch at one-fourth to tornus, containing some grey-whitish scales before tornus; a discal dot at two-thirds; a costal subapical spot sometimes connected by a fine line with tornus; a series of ill-defined spots or short streaks on apical fourth of costa and termen; cilia grey, bases and extreme apices partly whitish. Hindwings and cilia grey.

Queensland: Roma, feeding on the same *Eucalyptus* leaves as the preceding species, emerging in Brisbane in July and August; six specimens.

## 301. OENOCHROA MOLYBDOPTERA, n. sp.

*μολυβδοπτερος*, leaden-winged.

♀. 18 mm. Head dark fuscous; side tufts whitish. Palpi with second joint exceeding base of antennae, thickened with rough scales towards apex anteriorly, terminal joint three-fourths; fuscous. Antennae fuscous. Thorax dark fuscous. Abdomen whitish-grey. Legs fuscous; posterior pair whitish. Forewings elongate-oval, costa strongly arched, apex rounded, termen very obliquely rounded; leaden-grey, a broad dark fuscous median suffusion from base to costa before apex; in this discal dots are with difficulty discernible, first discal at one-third, plical before it, second discal at two-thirds; some dark fuscous irroration in terminal area; cilia grey. Hindwings grey-whitish; cilia grey-whitish, on apex grey.

Queensland: Charleville, in October; one specimen from larva feeding on joined leaves of *Eucalyptus*.

## 302. OENOCHROA SUFFULVA, n. sp.

*suffulvus*, rather tawny.

♀. 18 mm. Head and thorax fuscous, the latter with a small posterior crest. Palpi with second joint slightly expanded at apex, reaching base of antennae, terminal joint three-fifths; fuscous. Antennae fuscous. Abdomen brownish-grey; apices of segments paler. Legs fuscous; posterior pair ochreous-whitish. Forewings narrow, costa gently arched, apex rounded, termen very oblique; fuscous-grey; an inwardly oblique whitish streak at about one-third, not reaching either margin, immediately followed by a suffused dark spot; an obscure discal dot at three-fourths; cilia fuscous-grey. Hindwings whitish-grey-brown, towards apex grey; cilia grey.

Characterized by brownish hindwings and oblique mark on forewings.

North Queensland: Stannary Hills near Herberton (Dr. T. Bancroft). Queensland: Banana, in March (Mrs. Hobler). Two specimens.

## 305. OENOCHROA ZALOTYPA, n. sp.

*ζαλοτυπος*, with stormy markings.

♂. 20-23 mm. Head fuscous; face whitish. Palpi with second joint reaching base of antennae, terminal joint three-fifths; ochreous-whitish irrorated with whitish; terminal joint fuscous except extreme apex. Antennae grey; ciliations in male  $2\frac{3}{4}$ . Thorax fuscous. Abdomen grey. Legs fuscous with ochreous-whitish rings; posterior pair ochreous-whitish. Forewings suboblong, costa gently arched, apex round-pointed, termen obliquely rounded; ochreous-whitish densely irrorated with fuscous, and with some brown scales, especially on veins; ill-defined fuscous spots on costa at one-fourth and middle; stigmata dark fuscous, first discal at one-fourth, confluent with plical, which is before it, a pale dot above and beneath, second discal just beyond middle, rather large, an additional dot before and beneath it; a large suffused fuscous subapical spot, from which proceeds an obscure line to tornus; cilia grey with a fuscous median line. Hindwings and cilia whitish-grey.

W.A.: Denmark in March; four specimens received from Mr. W. B. Barnard, who has the type.

## 307. OENOCHROA DYSTENA, n. sp.

*δυστηνος*, miserable.

♂, ♀. 17-20 mm. Head and thorax grey; the latter with a small posterior crest. Palpi with second joint dilated with rough scales at apex anteriorly,

reaching base of antennae; terminal three-fifths; grey, second joint whitish towards base. Antennae grey; ciliations in male 1. Abdomen grey; tuft whitish-grey. Legs dark grey; posterior tibiae ochreous-whitish. Forewings oval, costa moderately arched, apex pointed, termen very oblique; grey; stigmata small, obscure, fuscous, often wholly or partly obsolete; first discal shortly before middle, plical much before it, second discal at two-thirds; cilia grey. Hindwings and cilia grey.

A poor specimen of this obscure species, which I sent to Mr. Meyrick many years ago, was placed by him under *O. homora* Meyr. Having seen a good example of that species from Sydney, I am now satisfied that this is distinct.

Queensland: Brisbane, in August, September, February and May; eight specimens.

41. Gen. PLACOCOSMA, n.g.

Meyr., Proc. LINN. Soc. N.S.W., 1883, p. 333. Type, *P. anthopetala* Meyr.

Tongue present. Palpi ascending, recurved; second joint reaching base of antennae, thickened with smoothly appressed scales; terminal joint shorter than second, slender, acute. Antennae with basal pecten; in male with moderately long ciliations. Thorax with a small posterior crest. Forewings with 7 to apex. Hindwings with 5 from middle or above middle of cell.

I know only the type species, and would not be sure of the exact position of this small genus.

Three Species: †311, *diantha* Meyr., *Exot. Micro.*, i, 1913, p. 134 (Darwin).—†312, *resumptella* Wlk., xxix, p. 681 (Sydney). = *hephaestea* Meyr., Proc. LINN. Soc. N.S.W., 1883, p. 333.—313, *anthopetala* Meyr., *ibid.*, 1883, p. 333 (Brisbane, Sydney).

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### THE PETROLOGY OF THE HARTLEY DISTRICT. III.

THE CONTACT METAMORPHISM OF THE UPPER DEVONIAN (LAMBIAN) SERIES.

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(Plate i; three Text-figures.)

[Read 27th March, 1935.]

#### INTRODUCTION AND PREVIOUS RECORDS.

The contact altered sediments of the Hartley district belong to the Lambian Stage (Brown, 1931) of the Upper Devonian Series. There are various records of the contact effects produced by the Hartley-Bathurst bathylith, but a number of these describe altered rocks that belong to a different sedimentary series. C. S. Wilkinson (1877) reported on the occurrence of wollastonite, epidote and garnet in rocks from Kirk's Farm on the Fish River, near Oberon; and as far as the present writer is aware these are altered Lambian sediments. The earliest record of the Hartley hornfels themselves is to be found in a note by G. W. Card (1896) in which he describes a series of specimens forwarded to him by Curran, Ball and Rienits (1896). In his report to the Metamorphic Committee of Section C at the Hobart Meeting of the Australasian Association for the Advancement of Science (1928), W. R. Browne gives a later reference to the Hartley hornfels, and they are again mentioned in the Sydney Handbook of the Australian and New Zealand Association for the Advancement of Science (1932). No detailed work, however, has been done on this aureole, and it is hoped that the present paper will contribute to our knowledge of this large and interesting bathylith.

Herein is given a detailed account of the metamorphism of the Lambian series, which consists of arenaceous, argillaceous and arenocalcareous sediments with intercalated lavas of acid and intermediate character.

#### SEQUENCE AND STRUCTURE.

It has been found convenient to divide the Lambian Stage, as developed at Hartley, into an upper and a lower series. The upper consists essentially of quartzites and is unfossiliferous. The lower includes all those types that are associated with the fossiliferous quartzites.

The upper series is found capping the spurs of the entrenched Cox's River and its tributaries. It is directly overlain by the Kamilaroi Upper Marine, and is usually deeply weathered. There appears to be little variation in the rock type, but this may be due to weathering which tends to produce uniformity. Highly jointed quartzites with intercalated "purple-hornfels" comprise the upper series.

The lower series outcrops along the river and in the beds of the tributary

creeks, and good unweathered sections may hence be obtained. Massive quartzites, crowded with *Spirifer disjunctus*, and interbedded with bands of "purple-hornfels" of varying width, are by far the most prominent beds in this series. Grits passing in places into conglomerates, calcareous cherty rocks and argillaceous types are developed to a lesser extent. Sills of altered porphyrite occur on several different horizons, and it is believed that the felsites outcropping on Cox's River, on Pine Ridge Creek, and on Moyne Farm, represent a flow at the base of the lower series. As most of the hornfelses with which this paper deals were collected from the lower series, it is pertinent to describe this series in a little further detail.

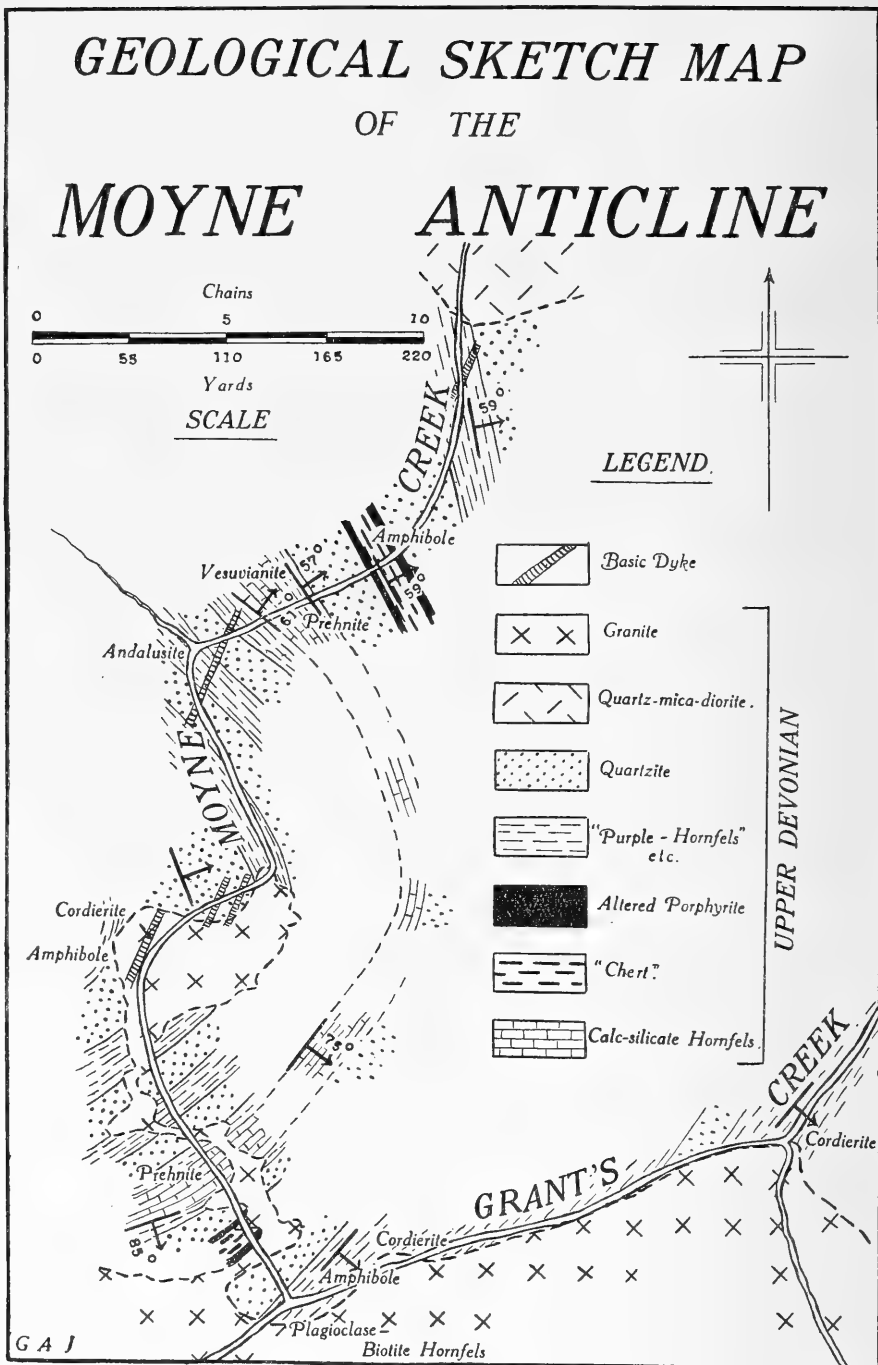
*The Fossiliferous Quartzites and "Purple-hornfelses"* are very intimately associated and, as has been stated above, the latter are also prominent in the upper series. With the fossiliferous quartzites, they occur in bands varying from a few millimetres to many feet in thickness. Occasionally they appear to be intermingled with the quartzites, and sometimes they predominate altogether and the quartzite occurs only as streaks and blebs in the "purple-hornfels". This latter type is more prominent in the upper part of the lower series, where only occasional fossiliferous quartzites are developed in association with great thicknesses of "purple-hornfels", which is associated here also with the more argillaceous beds. In the lower part of this series the calcareous quartzite is the predominating type, and the "purple-hornfelses" appear only in comparatively narrow bands. The name "purple-hornfels" is a convenient field term and, though it includes several different types of hornfels, all appear similar in the hand-specimen. They are extremely fine-grained rocks with a subconchoidal fracture, and show a characteristic purplish-brown colour, due to the presence of biotite.

In the quartzites the fossils are restricted to comparatively narrow bands. Such bands vary from a few inches to about a foot in thickness, and are crowded with *Spirifer disjunctus*, with an occasional *Rhynchonella pleurodon*. Between these richly fossiliferous bands the quartzite is quite barren, but the composition of the hornfels shows that a certain amount of lime was contained in the matrix of the original sediment.

Lithologically the "purple-hornfelses" and the fossiliferous quartzites pass imperceptibly into banded calcareous cherts in which the *Spirifer* bands are still abundant. The calcareous radiolarian cherts described below have never been found in association with the fossiliferous type, though both rocks are developed in the upper part of the lower series. These rocks bear a remarkable resemblance to the banded calcifintas and killas of Cornwall (Ussher *et al.*, 1909; Reid *et al.*, 1910).

*The Porphyrites and Banded Cherts* also show a close field association. The former usually occur as sills, though on Hughes' Creek a transgressive relation is apparent. On the map (Plate i) the thickness of these sills has been slightly exaggerated, and in some cases a single wide sill has been shown instead of two narrower ones separated by cherts, as on Liddleton Creek and Moyne Creek (see Text-fig. 1).

The cherts are usually distinctly banded, and Dr. W. R. Browne has found traces of radiolaria in the Moyne Creek type. On Cox's River, just above Marriott's Creek, a slightly different type of chert occurs. This is a pale pink rock with numerous dark purplish bands and blebs suggesting the "purple-hornfels" and its associate. No fossils, however, have been found in this rock, but the composition of the hornfels indicates a calcareous silt.



Text-fig. 1.



With regard to the structure of the Devonian beds, it has already been stated (Joplin, 1933) that they occupy a broad syncline between the northern and southern outcrops of granite. The major fold, which trends approximately east and west and pitches to the east, is turned over abruptly into sharp anticlines at the granite contacts. The basic stocks of the plutonic complex (Joplin, 1931, 1933) are injected into the trough of the syncline, and there is reason to believe that they are associated with fault zones.

The exact nature of the felsites on Cox's River and on Pine Ridge Creek is doubtful. They may represent pre-granite intrusions of an irregular nature, which have been subsequently contact-altered by the granite; or, what seems more likely, they may represent a basal flow which has been duplicated by faulting.

Reference to Plate i will show that the sequence of the beds indicates a repetition which is suggestive of a north-south fault along the western boundary of the eastern felsite. Actually there are indications of brecciation both in the felsite and in the adjacent calcareous beds along this margin, and the felsites are very highly jointed. Minor faults have been observed on the north-eastern margin of the felsite; and the displacement of the anticlinal axis is again suggestive of a north-south fault with a throw to the west.

It is difficult to correlate the Moyne Creek section without postulating another fault of considerable magnitude. The close association of the porphyrites and cherts on Moyne Creek and Liddleton Creek suggests a datum horizon. The occurrence of a small patch of felsite on Moyne Farm is another difficulty that might be explained by faulting.

It is not improbable that complex faulting would occur along a contact where there have been successive periods of injection. Only detailed mapping and contouring of this fairly rugged area will show the extent of such faulting and, as far as the present study is concerned, there is little to be gained from a piece of work that would involve such an expenditure of time. Nevertheless, the writer has pointed out (1933) that the nature of the Cox's River Intrusion is suggestive of faulting in that area, and it seems not impossible that both the basic stocks have been associated with fault zones. Moreover, if no faulting be postulated, there would be an unbroken succession of Cambrian strata over a distance of about four miles from east to west, and as the dip is usually at a high angle, this would give an abnormal thickness. On the other hand, if faults be assumed to be present west of the river and west of Moyne Creek, an approximate estimate gives a thickness of about 2,000 feet, which is in accord with more recent observations at Rydal.

On Plate i certain of the arrows indicating dips do not show the amount of dip. Where the amount of dip is indicated, measurements have been made with a clinometer rule, and where such is not shown, general compass directions have been taken along the strike of the bed.

#### CORRELATION WITH THE TYPE SECTION AT MT. LAMBIE, RYDAL.

In 1896 G. W. Card pointed out that the Hartley sediments "may be regarded as the eastern extension of the Mt. Lambie Beds". In the Rydal district, as at Hartley, *Spirifer disjunctus* occurs abundantly in restricted bands in a massive quartzite. On Mt. Lambie these beds are apparently unmetamorphosed and this prompted the writer to look for the bands corresponding to the Hartley "purple-hornfels". They were found to be represented by soft reddish-purple shaly rocks which readily weather away, and appear quite insignificant among the resistant

quartzites. That the "purple-hornfels", in their unaltered condition, correspond to the so-called "red shales" is further supported by the presence of an occasional pebble of "red shale" in the Kamilaroi conglomerate at Hartley. It is possible that these soft red rocks represent either fine-grained periodically extruded tuffs, or fine silts brought down by floods. A microscope examination of the Rydal rock shows small angular fragments of quartz and lends support to the former view. This material, whatever be its origin, has possibly been responsible for the sudden periodic killing off of the Spirifers, which evidently formed massive shell banks along the shallow coast.

At Rydal the Spirifer beds pass up into grits, "red shales", buff shales and quartzites and, if the so-called "red shales" may be taken as the equivalents of the "purple-hornfels", the sequence at Rydal closely corresponds to that at Hartley.

To the west of Mt. Lambie, below the Spirifer beds, there is an igneous rock, which may correspond to the basal felsite at Hartley.

As far as the present writer is aware, there are no porphyrites in the Rydal district, and only one bed of calcareous chert is known. This occurs near the top of the series just to the west of Rydal railway station. It is probable that the sills and their associated cherts are developed quite locally at Hartley.

At Rydal the general direction of strike is north and south, whilst at Hartley (10 miles distant from Rydal) the axes of the folds trend approximately east and west. It is possible that the intrusive masses of granite to the north and south of Cox's River at Hartley have acted as the jaws of a vice in which the sediments have been squeezed into their present position.

#### WIDTH OF THE CONTACT AUREOLE.

There are three difficulties in the way of measuring the width of the contact aureole, and of zoning the progressive changes as the igneous boundary is approached: (1) Owing to the close proximity of the overlying Kamilaroi strata, no unaltered Devonian rocks are exposed, and there is thus no standard of comparison; (2) the contacts of the basic stocks and of the granite are so close that if a bed be traced out of the aureole of one intrusion it immediately enters that of another; (3) apophyses some distance from the apparent boundary, as well as large inclusions of sediments in the igneous rocks, suggest that the roof of the batholith has not been completely removed; there is reason to believe, therefore, that the gradient of the intrusions is fairly shallow, and thus linear distances measured from the apparent contact are obviously incorrect. For reasons stated above, therefore, very little information may be gained by tracing a single bed along its strike, but in the next section it will be shown that some idea of the intensity of metamorphism, and of the width of the inner zone of hornfels, may be gained by an examination of a series of specimens of the same rock type from different parts of the area.

The first of these difficulties may be overcome to some extent by a comparison with unaltered rocks at Rydal.

In the petrographical sections, distances from the apparent contact are always stated, but it must be borne in mind that these are not necessarily correct, and that the actual contact may be much closer. The section dealing with incipient metamorphism indicates some of the anomalies that arise, if this be disregarded.

In a general way, it may be stated that the contact is widest in the arenaceous, arenocalcareous and calcareous chert beds, and less wide in those that contain

an appreciable amount of shaly material. Thus it is shown that calc-silicates, such as diopside, amphiboles and epidote, may develop as well-formed minerals, when associated more argillaceous rocks show only an incipient development of biotite.

As it seems very evident that distances cannot be measured from the true contact, it is useless to give figures for the width of the inner zone of hornfelses.

#### INCIPIENT METAMORPHISM.

It has been shown above that difficulties attend the study of this phenomenon, and the present section deals with a description of unmetamorphosed specimens from Rydal, and of scattered rocks at the greatest possible distance from the contact at Hartley. The main rock types that have given rise to the hornfelses in the Hartley district are: (i) "red shales", (ii) fossiliferous quartzites, (iii) calcareous cherts, (iv) sandstones and grits, (v) normal shales.

(i) Two of the so-called "red-shales" from Rydal have been examined, and are found to consist of small angular chips of quartz and a little alkaline felspar set in a matrix of chlorite with a small quantity of white mica. Greenish biotite, magnetite, sphene, zircon and tourmaline are accessories. The chlorite is much stained by haematite, which gives the rock its red colour.

In the Hartley region a rock in Deep Ravine, at a distance of 660 yards from the apparent contact, shows some evidence of metamorphism. It is exactly similar to the "purple-hornfelses" in the hand-specimen, but under the microscope a slightly clastic structure is apparent and the rock consists of quartz and alkaline felspar grains surrounded by a matrix of tiny flakes of greenish-brown mica and a little chlorite. This rock is something of an anomaly, and the contact is possibly closer than is apparent. The typical reddish-brown authigenic biotite has been noted at a distance of about 450 yards from the contact, and incipient brown biotite enters at 580 yards.

(ii) Fossiliferous quartzites from Mt. Lambie and from Solitary Creek, Rydal, have been examined, and in both cases calcite is conspicuously absent. Occasionally groups of calcite crystals have been noted in the field, and it appears that the carbonates have been removed by leaching. Though unaffected by contact metamorphism, the Rydal quartzites show evidence of silicification, which is possibly due to cementation (Van Hise, 1904), and it would appear that the lime had been removed during this process. In the hornfelsed type, where lime is fixed in the form of a silicate, it may be preserved. Both quartzites consist of quartz and a little alkaline felspar in a matrix of chlorite. Accessories are white mica, sphene, magnetite and haematite. It is believed that the fossiliferous quartzites at Hartley originally had a composition rather similar to this, and that calcite was present in the matrix as well.

At Hartley the fossiliferous quartzites do not occur at a greater distance than 580 yards from the contact, and at this distance the effects of thermal metamorphism are apparent. Hand-specimens show well preserved fossils and "nests" of secondary calcite crystals.

Under the microscope the rocks still show their clastic structure, but the fine-grained groundmass is entirely recrystallized and consists of quartz, basic plagioclase, diopside, amphibole and sphene. Small patches of calcite are also present, and though they appear to have been recrystallized, the temperature has not been sufficiently high for the formation of wollastonite. Wollastonite occurs abundantly at the actual contact in several localities and has never been found at a greater distance than 350 yards from the apparent contact. In most

of these cases wollastonite may be seen replacing the actual fossil, and recognizable Spirifers, partly changed to wollastonite, have been collected within a few inches of the contact. Shells pseudomorphed by aggregates of diopside, sometimes containing a little epidote or amphibole, have been noted at 580 yards, and the associated "purple-hornfels" bands show a development of incipient biotite.

(iii) One example of calcareous chert has been collected in the Rydal district, and it is quite unaffected by thermal metamorphism. It is a very fine-grained rock consisting mainly of quartz with a matrix of chlorite and a little calcite. Magnetite, biotite and a little plagioclase are also present, and zircon occurs as an accessory. No specimen of this rock has been found outside the inner zone of hornfels at Hartley.

(iv) A rock occurring on top of the ridge between Deep Ravine and Bonnie Blink Creek lies at a distance of about 850 yards from the granite, but in the hand-specimen it is a fairly typical quartzite.

Under the microscope, however, there is a distinctly clastic structure apparent. Large (0.4 mm.) somewhat rounded grains of quartz and alkaline feldspar are surrounded by a matrix of sericite and a little chlorite, and minute flakes of incipient biotite are just discernible. Magnetite and zircon are accessories.

(v) No unaltered or partly altered normal shales are known.

From these scanty observations it would appear that the width of the contact varied in the different beds and that the calcareous rocks responded to the thermal effects before the more argillaceous types.

In the more porous sandstone hornfels incipient biotite is noted at 850 yards, but in the more compact "red-shales" it does not make its appearance until within 580 yards of the contact.

#### PETROGRAPHY OF THE HORNFELS OF THE INNER ZONE.

##### (i) *Andalusite-cordierite-biotite Hornfels.*

Three examples of this class have been recorded from different parts of the aureole. They are fine-grained, dense, dark grey rocks. One, near the road crossing on the southern branch of Grant's Creek, at a distance of 880 yards from the granite and 660 yards from the diorite, shows a faint spotting, which under the microscope is seen to be due to aggregates of quartz grains associated with andalusite and flakes of muscovite.

A rock from Moyne Creek, at a distance of 130 yards from the granite and 300 yards from the diorite, is fairly typical of this class. Its structure is granoblastic with an average grain size of about 0.15 mm. The constituent minerals are quartz, andalusite, altered cordierite, biotite, orthoclase, magnetite and a little muscovite, chlorite and tourmaline. Rutile and sphene have been noted as accessories in rocks of this class.

The andalusite occurs in small stumpy prisms (averaging 0.1 mm.), which often show a strongly pleochroic rose-pink core. There is a slight marginal alteration to sericite. The cordierite is entirely altered into a green micaceous substance, and occurs in large aggregates of ill-formed stumpy prisms, or more commonly as xenoblasts. Small flakes of biotite are associated with these pseudomorphs and probably represent inclusions in the original cordierite. Deep-brown biotite ( $\alpha' = 1.592$ ,  $\gamma' = 1.637$ ) occurs in poikiloblastic flakes measuring up to 0.3 mm., and, though more frequently associated with the cordierite areas, is present to a lesser extent in the andalusite-quartz and andalusite-quartz-orthoclase areas.

A partial analysis of this rock is shown in Column I below:

	I.	II.	
SiO <sub>2</sub> .. .. .	67.00	62.80	
Al <sub>2</sub> O <sub>3</sub> .. .. .	16.34	19.74	
Fe <sub>2</sub> O <sub>3</sub> .. .. .	0.75	0.00	
FeO .. .. .	4.34	1.98	
MgO .. .. .	1.16	1.34	
CaO .. .. .	0.66	0.87	
Na <sub>2</sub> O .. .. .	2.14	1.22	
K <sub>2</sub> O .. .. .	5.44	6.56	
H <sub>2</sub> O + .. .. .	} 2.38	0.27	} Loss on Ignition, 2.71
H <sub>2</sub> O - .. .. .		0.86	
C .. .. .	—	1.58	
TiO <sub>2</sub> .. .. .	0.03	1.36	
P <sub>2</sub> O <sub>5</sub> .. .. .	abs.	0.60	
MnO .. .. .	pnd.	0.02	
S .. .. .	nd.	0.52	
	100.24	99.72	
Less O=S		0.23	
		99.49	

I. Andalusite-cordierite Hornfels, Moyne Creek, Por. 124, Parish of Hartley. Anal. G. A. Joplin.

II. Andalusite-cordierite Hornfels (Class 1), Gunildrud, Contact of Soda-Granite, Christiania. Anal. M. Dittrich. V. M. Goldschmidt, Die Kontaktmetamorphose im Kristianagebiet. *Videnskap. Skrift. I. Math.-Nat. Kl.*, No. 1, p. 148, 1911.

It appears that the main difference between these rocks lies in the greater abundance of andalusite and orthoclase in the Christiania hornfels, and the excess of quartz, biotite and magnetite in the Hartley rock.

In the field this rock is closely associated with a rather mottled, lighter grey hornfels. Under the microscope these are essentially the same, but the latter contains in addition an abundance of white mica and tourmaline. The biotite is also somewhat altered to chlorite. A very similar type of hornfels occurs on Cox's River below the mouth of Marriott's Creek at a distance of 400 yards from the diorite.

A very much altered rock is met with on Bonnie Blink Creek, and it is possible that it may belong to this class. In the hand-specimen it is a banded grey hornfels with rows of black rectangular spots which consist entirely of sericite and muscovite. Remnants of cordierite have been recognized, and it is possible that the dark spots were originally andalusite.

(ii) *Andalusite-biotite-orthoclase Hornfels.*

A rather unique type has been collected as a boulder in Bonnie Blink Creek. It is light purplish-grey rock containing abundant pinkish-white spots which measure about 6 mm. and stand out in relief on weathered surfaces. These spots are prismatic crystals of andalusite which show a good deal of sericitization.

The fine-grained groundmass consists of orthoclase, very abundant reddish-brown authigenic biotite ( $\alpha' = 1.595$ ,  $\gamma' = 1.635$ ), muscovite and a little quartz. Accessory minerals are greenish zircon, magnetite, tourmaline and sericite. The zircons commonly occur as inclusions in the andalusite.

(iii) *Cordierite-quartz Hornfels.*

C. E. Tilley (1924) has divided these hornfels into (a) Biotite-rich and (b) Biotite-free types. At Hartley no hornfels of the type absolutely free from biotite

has been recorded, but a number contain such a small amount of this mineral that they stand out in marked contrast to the Biotite-rich division, and it is proposed to consider them separately as Biotite-poor types.

(a) *Biotite-rich Types*.—These hornfelses are developed abundantly on Cox's River and Bonnie Blink Creek, and one example has been collected from the contact on Yorkey's Creek. Except for the total absence of plagioclase these rocks are similar to the cordierite-plagioclase assemblage described below. The constituent minerals are cordierite, quartz, biotite, orthoclase, magnetite and a little white mica. Accessory minerals are zircon and apatite, and a little sphene has been noted in a few examples. As in the more calcareous type described below, cordierite may occur as oval porphyroblasts giving the rock a spotted appearance, or it may form small xenoblasts in an even-grained granoblastic rock.

A typical example of the even-grained type occurs on the spur between the river and the junction of Liddleton and Bonnie Blink Creeks. It is a rather coarse-grained, resinous, greyish-brown rock, which, on weathered surfaces, shows a distinct banding. Under the microscope several types of banding may be recognized—differences in grainsize, alternations of biotite-rich and biotite-poor types, cordierite-rich seams and selectively altered cordierite seams.

In most of these rocks cordierite is very abundant, and several good examples of twinning have been noted. In longitudinal section multiple twinning is apparent and in cross section the mineral breaks up into sectors. The cordierite is frequently altered both to aggregates of white mica and to yellow, isotropic pinite. In some of the cordierite-rich seams this mineral is clouded by minute inclusions of iron ore. These evidently represent iron-rich chlorite seams in the original sediment.

(b) *Biotite-poor Types*.—It is stated above that these hornfelses occur interbedded with a biotite-rich assemblage near Cox's River. Another example occurs on Moyne Creek. Except for a marked decrease in biotite, a concomitant increase in orthoclase and magnetite and the total absence of white mica, these rocks are very similar to the above and need no further description.

The table below is an analysis of a cordierite-quartz hornfels containing a small amount of biotite; it is regarded as fairly typical of this class of hornfels. It is a medium-grained granoblastic rock consisting of cordierite, quartz, orthoclase, magnetite, and a little biotite ( $\alpha' = 1.587$ ,  $\beta' = 1.630$ ,  $\gamma' = 1.633$ ) and white mica.

The analysis used by C. E. Tilley (1924) in his discussion on this class of hornfels has been included to show that the resulting mineral assemblage is independent of the amount of quartz in the original rock. It is evident that the Hartley rock was a sandstone with an iron-chlorite matrix, whilst the rock in Column II represents an original chlorite-rich shale. As pointed out by Prof. Tilley, the mineral assemblage in these hornfelses depends upon the  $RO/R_2O_3$  ratio.

#### (iv) *Cordierite-plagioclase Hornfelses*.

A number of examples of this type are recorded from the contacts on Moyne and Grant's Creeks and, with but two exceptions, they occur within 5 yards of the igneous boundary. One rock of this type is found on Grant's Creek at a distance of 220 yards from the diorite and apparently 400 yards from the granite, but the fact that it is invaded by veins of tourmaline-aplite suggests an underground extension of the granite. Another example is recorded from near the head of Horse Hole Gully at a distance of 700 yards from the diorite.

	I.	II.
SiO <sub>2</sub> .. .. .	84.23	59.83
Al <sub>2</sub> O <sub>3</sub> .. .. .	7.13	17.47
Fe <sub>2</sub> O <sub>3</sub> .. .. .	2.06	4.09
FeO .. .. .	1.61	3.93
MgO .. .. .	0.64	3.70
CaO .. .. .	0.78	0.49
Na <sub>2</sub> O .. .. .	1.20	1.08
K <sub>2</sub> O .. .. .	1.53	4.42
H <sub>2</sub> O .. .. .	0.57	3.80
TiO <sub>2</sub> .. .. .	tr.	0.93
MnO .. .. .	tr.	—
P <sub>2</sub> O <sub>5</sub> .. .. .	abs.	0.18
SO <sub>3</sub> .. .. .	—	0.13
	99.75	100.05

I. Cordierite-quartz-biotite Hornfels, from granite contact on hillside above junction of Liddleton and Bonnie Blink Creeks, Por. 27, Parish of Lowther. Anal. G. A. Joplin.

II. Cordierite-quartz-biotite Hornfels, Abbenstein (Harz), described by O. H. Erdmannsdörffer (*Jahrb. Preuss. Geol. Landesanst.*, Vol. xxx, 1909, p. 357). Quoted by C. E. Tilley (*Quart. Journ. Geol. Soc.*, 1924, p. 37).

These rocks fall into three groups—a spotted type, a massive resinous dark grey hornfels, and a type very rich in biotite with indications of a parallel structure.

The rock on Grant's Creek, Por. 124, Par. of Hartley, is a typical spotted hornfels. It is a dense, dark purplish-grey rock crowded with resinous, black oval spots about 2 mm. in length. On weathered surfaces pitting is conspicuous.

Under the microscope the hornfels is seen to consist of numerous oval porphyroblasts of cordierite set in a fine granoblastic groundmass of biotite, quartz, plagioclase and orthoclase. Accessory minerals are magnetite, tourmaline and zircon. The cordierite is extremely fresh, and is crowded with inclusions of pale greenish-brown biotite, quartz and plagioclase. The biotite inclusions are by far the most abundant, and are of a paler colour than the biotite of the groundmass. In the groundmass flakes of biotite are particularly abundant as a fringe around the porphyroblasts, and this is probably due to the throwing out of inclusions during advancing metamorphism. The biotite of the groundmass occurs in numerous, strongly pleochroic, reddish-brown flakes ( $\alpha' = 1.587$ ,  $\beta' = 1.627$ ,  $\gamma' = 1.633$ ). The colour, pleochroism and refractive indices indicate a high iron content. Plagioclase is sometimes twinned and appears to be andesine.

The rock exhibits a slight parallelism due to the arrangement of the biotite flakes and of the longer axes of the porphyroblasts. This appears to be the original direction of bedding.

The tourmaline has no doubt been introduced by the tourmaline-aplite that invades the hornfels. In this rock muscovite is absent.

The analysis of this rock is given in Column I below, where it is compared with analyses of similar assemblages cited by Goldschmidt (1911). Except for a slightly greater abundance of silica and lime, and a little less magnesia, the

Hartley rock is intermediate in composition between these hornfelses. A strict comparison made on the basis of specific gravity might indicate closer affinities.

	I.	II.	III.
SiO <sub>2</sub> .. .. .	61·50	58·83	56·88
Al <sub>2</sub> O <sub>3</sub> .. .. .	19·84	17·54	20·68
Fe <sub>2</sub> O <sub>3</sub> .. .. .	1·39	0·00	2·66
FeO .. .. .	5·20	8·42	4·54
MgO .. .. .	2·67	3·40	3·15
CaO .. .. .	2·91	2·24	1·29
Na <sub>2</sub> O .. .. .	1·11	1·35	0·91
K <sub>2</sub> O .. .. .	4·39	4·35	7·49
H <sub>2</sub> O+ .. .. .	1·28	1·96	} 2·36
H <sub>2</sub> O— .. .. .	0·04	0·13	
TiO <sub>2</sub> .. .. .	0·42	0·59	—
MnO .. .. .	tr.	0·09	—
P <sub>2</sub> O <sub>5</sub> .. .. .	abs.	0·46	—
C (?) .. .. .	—	0·50	—
	100·75	99·86	100·12

I. Cordierite-plagioclase Hornfels, Grant's Creek, Por. 124, Parish of Hartley. Anal. G. A. Joplin.

II. Cordierite-plagioclase Hornfels (Class 3), Kolaas, contact of the nordmarkite, Christiania. Anal. M. Dittrich. V. M. Goldschmidt, Die Kontaktmetamorphose im Kristianagebiet. *Videnskap. Skrift. I. Math.-Nat. Kl.*, No. 1, 1911, p. 156.

III. Cordierite-plagioclase Hornfels, Monte Doja, Adamello. Pelikan (*Tscher. Min. Pet. Mitt.*, 12, 1891, p. 156). Quoted by Goldschmidt. *Ibid.*, p. 157.

An example of the massive, resinous type of hornfels occurs on Grant's Creek just above its junction with Moyne Creek at about 1 yard from the contact. It is a granoblastic rock with slightly coarser grain size (0·6 mm.), and contains the same mineral assemblage as above. The biotite is less abundant, and is of a more reddish colour with R.I.  $\alpha' = 1·588$ ,  $\beta' = 1·635$ ,  $\gamma' = 1·637$ . Cordierite is represented by masses of secondary mica.

The biotite-rich members of this class occur at the mouth of Moyne Creek and are banded with biotite-plagioclase and biotite-amphibole-plagioclase assemblages. The biotite may be arranged in criss-cross fashion, but is more often parallel to the original bedding.

(v) *Plagioclase-biotite-quartz and Biotite-quartz Hornfelses.*

These types are perhaps the most widely distributed in the Hartley aureole and represent the largest bulk of the "purple-hornfelses".

A hornfels of this type occurs in the upper series at the top of the spur to the west of Grant's Creek, Por. 118, Parish of Hartley, at a distance of 200 yards from the granite. Under the microscope it is seen to consist of a fine mosaic of quartz, biotite, plagioclase and orthoclase, with tourmaline in large irregular aggregates. There are very small veins of igneous material associated.

A typical example of this hornfels, containing a small amount of plagioclase, has been analysed (see Column I below). It occurs on Bonnie Blink Creek at a distance of 440 yards from the granite. It is a fine granoblastic rock consisting



of quartz, biotite ( $\alpha' = 1.585$ ,  $\gamma' = 1.633$ ), orthoclase, plagioclase, ilmenite and accessory zircon.

	I.	II.	III.
SiO <sub>2</sub> .. .. .	82.27	79.23	47.93
Al <sub>2</sub> O <sub>3</sub> .. .. .	9.32	6.60	20.34
Fe <sub>2</sub> O <sub>3</sub> .. .. .	abs.	0.51	4.35
FeO .. .. .	2.65	2.32	8.63
MgO .. .. .	1.09	1.96	5.58
CaO .. .. .	1.80	3.95	1.64
Na <sub>2</sub> O .. .. .	0.83	3.27	4.70
K <sub>2</sub> O .. .. .	1.27	0.96	4.88
H <sub>2</sub> O .. .. .	0.72	0.72	0.72
TiO <sub>2</sub> .. .. .	0.47	0.40	0.76
MnO .. .. .	nd.	0.25	0.13
P <sub>2</sub> O <sub>5</sub> .. .. .	abs.	0.11	—
CO <sub>2</sub> .. .. .	—	0.09	—
	100.42	100.42	99.66

I. Biotite-plagioclase Hornfels ("Purple-hornfels"), Bonnie Blink Creek, Little Hartley. Anal. G. A. Joplin.

II. Felspathic Hornstone of the Calc-flinta Series, Tregullan, 1½ m. SSW. of Bodmin, Cornwall (Slide E5458). Anal. E. G. Radley. W. A. Ussher *et al.*, *Mem. Geol. Surv. Eng. and Wales*, Sheet 347, 1909, p. 101.

III. Biotite-plagioclase Hornfels (Class 3), Christiania. Anal. M. Dittrich. V. M. Goldschmidt, *l.c.*, 1911, p. 37.

The Cornish hornfels occurs associated with calc-flintas, as does the one from Hartley. The Hartley rock appears to be less rich in plagioclase, but biotite and orthoclase are possibly more abundant. The Christiania hornfels has been included for contrast. This again emphasizes the fact that a similar mineral assemblage may arise in a shale or in a siliceous rock with a shaly matrix. There are other rocks of a very similar appearance in which plagioclase cannot be identified, and it is believed that these represent lime-poor assemblages related to those described above.

It will be shown later that with an increase of lime and magnesia these rocks pass into amphibole-bearing types from which they cannot be distinguished in the hand-specimen.

One example of the biotite-plagioclase assemblage occurs at the mouth of Moyne Creek, where it is interbedded with cordierite-plagioclase-biotite and amphibole-plagioclase-biotite types. All three types are much coarser in grain-size than the "purple-hornfels", which they closely resemble in mineral constitution, and their origin will be discussed later. They are often veined with igneous material.

(vi) *Amphibole-plagioclase-biotite Hornfelses.*

These rocks have been collected from within a few yards of the granite near the mouth of Moyne Creek, and from among the "cherts" on the northern limb of the Moyne anticline at a distance of 140 yards from the diorite.

The rock occurring at the mouth of the creek has been referred to above; it has a fairly coarse grainsize, is very rich in biotite, and exhibits a parallel structure similar to the associated assemblages which have already been described. The other example is typically a "purple-hornfels" in the hand-specimen. Under the microscope the coarser grained rock is seen to consist of biotite, plagioclase, amphibole, orthoclase, quartz, sphene and a little magnetite and/or ilmenite, tourmaline and pyrites.

The amphibole forms highly poikiloblastic plates (0.5 mm.) which are arranged in linear fashion, and evidently represent calcareous seams in the original sediment. The amphibole is green, markedly pleochroic, with an extinction angle of about  $22^\circ$ , and R.I.  $a' = 1.637$ ,  $\gamma' = 1.658$ . It is optically negative, and is thus a common hornblende near pargasite. The biotite shows a parallel arrangement which is in the same direction as the strings of amphibole xenoblasts. It is a strongly pleochroic reddish-brown type with R.I.  $a' = 1.580$ ,  $\gamma' = 1.633$ . The plagioclase is frequently twinned and occurs in small xenoblasts (0.1 mm.). It is andesine ( $Ab_{63}An_{37}$ ) with R.I.  $a' = 1.550$ ,  $\gamma' = 1.555$ .

Another rock of this type, also from Moyne Creek, is a little more calcareous and contains a nodule consisting almost entirely of large (3 mm.) sub-idioblastic crystals of amphibole, with refractive indices  $a' = 1.616$ ,  $\beta' = 1.625$ ,  $\gamma' = 1.635$ , and an extinction of about  $15^\circ$ . Thus, according to Winchell (1933), the mineral belongs to the tremolite-pargasite series, and has a composition  $Tr_{35}Pr_{65}$ .

(vii) *Amphibole-diopside-plagioclase-biotite Hornfelses.*

Only a few examples of this type have been recorded from the aureole. They occur on Moyne Creek, Bonnie Blink Creek, and on the river just above the mouth of Marriott's Creek.

Except for the entrance of a little granular diopside these rocks are essentially the same as the fine-grained types referred to above, and, like them, they occur among the so-called "cherts".

(viii) *Amphibole-diopside-plagioclase Hornfelses.*

These are usually fine-grained rocks constituting some of the lighter bands in the calcareous cherts.

One coarse-grained example occurs on Moyne Creek at the contact of a large granite apophysis. It is a mottled light and dark greenish-grey rock which, under the microscope, is seen to consist of large (0.75 mm.) highly poikiloblastic sheets of amphibole and smaller granules of diopside in a groundmass of plagioclase, quartz and orthoclase, with accessory sphene, zircon and magnetite. A little epidote and clinozoisite and a few flakes of biotite are also present. Scattered hexagonal pseudomorphs consisting mainly of chlorite and clinozoisite possibly represent cross-sections of biotite. The amphibole has an extinction of  $20^\circ$ , and the refractive indices ( $a' = 1.635$ ,  $\gamma' = 1.655$ ) and optically positive character indicate pargasite near common hornblende. Large pleochroic haloes are frequent around inclusions of zircon.

A coarser more quartzose member of this class occurs on the hillside north-west of the junction of Liddleton and Bonnie Blink Creeks. It contains abundant hollow crystals of pyrites, which are filled with sphene bordered by clinozoisite. A biotite-bearing assemblage is associated.

A rock on Moyne Creek shows this assemblage alternating with seams very rich in magnetite and containing a little biotite.

(ix) *Diopside-plagioclase Hornfelses.*

Banding is very common in rocks of this type. It may be caused by alternations with biotite-plagioclase or amphibole-bearing assemblages, by differences in texture and/or by seams consisting almost entirely of pyroxene.

Some of the bands are extremely narrow, and in one slide  $1\frac{1}{2}$  inches across as many as twelve such alternations have been counted. The pyroxene in some of these banded rocks is of a deep green colour and may contain up to 60% of the hedenbergite molecule ( $\alpha' = 1.710$ ,  $\gamma' = 1.732$ ). The sharp banding, however, does not admit of an addition of iron from the magma, and this pyroxene possibly arose from layers rich in feriferous chlorite and calcite, or from mixtures of these minerals with iron ores. Banding in these rocks appears to be indicative of slight fluctuations in sedimentation.

Spotted rocks containing small ellipsoidal aggregates of diopside and plagioclase, or groups of larger crystals of diopside, are also common in this class. A fine-grained massive type consisting almost entirely of diopside also frequently occurs. Dr. A. Harker (1904, 1932) records cherty diopside-rocks from Skye, where they occur as narrow bands in dolomitic limestones.

All the rocks belonging to this class are chert-like in the hand-specimen, and have a high specific gravity owing to their large content of diopside. They are light-coloured—white, pale pink, grey or, most frequently, pale green. They are extremely like the calc-flintas of the south-west of England.

A typical example from Delaney's Creek at a distance of 130 yards from the contact may here be described. Under the microscope it is seen to be a fine-grained granoblastic rock with some coarser patches. The constituent minerals are diopside, plagioclase, orthoclase, quartz, sphene, and a little iron-ore. The diopside is very abundant and forms small granules and sub-idioblastic prisms distributed throughout the rock. In the coarser patches the crystals are larger and are always sub-idioblastic. According to Winchell (1933), the composition is  $\text{Di}_{50}\text{He}_{51}$  ( $\alpha' = 1.695$ ,  $\gamma' = 1.712$ ) and  $Z \wedge C = 41^\circ$ . The plagioclase occurs in extremely minute grains associated with orthoclase. Small light-coloured oval patches are numerous and, under strong magnification, are found to consist of diablastic intergrowths of plagioclase and orthoclase. The plagioclase is untwinned and the refractive index is well above that of quartz, but the exact composition cannot be determined. In one of the banded types of slightly coarser grain size, it has been determined as  $\text{Ab}_{40}\text{An}_{60}$  ( $\alpha' = 1.559$ ,  $\beta' = 1.564$ ,  $\gamma' = 1.568$ ).

Under this class might be mentioned a rather unique assemblage consisting of plagioclase, sphene and quartz. The rock in which this type occurs was found as a boulder in the river just below the mouth of Campbell's Creek. It is a banded rock of the calcareous chert type. It consists mainly of fine "purple-hornfels" with a white calcareous band an inch in width. In the centre of this band there is a seam consisting only of pale green diopside ( $\text{Di}_{74}\text{He}_{26}$ ;  $\alpha' = 1.684$ ,  $\gamma' = 1.710$ ) and on both sides of this the sphene-plagioclase assemblage occurs. It would appear that magnesia had been withdrawn from the outer part of the calcareous band and deposited in the central seam, a change which probably took place before metamorphism (see p. 47). In the absence of magnesia the available lime has combined with titania and silica to give sphene. The titania may have been derived from either detrital rutile or ilmenite.

(x) *Plagioclase-diopside-epidote Hornfels.*

Only one example of this class is recorded from the Hartley aureole. It occurs interbedded with a vesuvianite assemblage and an unstable wollastonite-plagioclase assemblage on the northern limb of the Moyne anticline.

In this rock there seems little doubt that the epidote has arisen as a mineral of primary metamorphic crystallization, and not as a product of metasomatism. The constituent minerals are plagioclase, diopside, epidote, sphene and a little quartz and iron-ore. Orthoclase has not been detected with certainty. The plagioclase forms large poikiloblastic plates or granoblastic aggregates up to 3 mm. across, and encloses granules of epidote and diopside. The composition is basic labradorite. Diopside sometimes forms sub-idioblastic crystals 0.4 mm. across, but is more often developed as small xenoblasts intimately intergrown with epidote to form a granular mosaic. In places epidote shows alteration into clinozoisite and haematite. There is a slight textural banding.

(xi) *Plagioclase-diopside-wollastonite Hornfels.*

This is essentially an unstable assemblage, but is by no means uncommon in at least two other aureoles—Deeside (Hutchison, 1933) and Carlingford (Osborne, 1932). A number of wollastonite-diopside rocks containing a very small quantity of plagioclase and scapolite have been collected from many parts of the contact, but there are two examples containing a slightly greater amount of plagioclase, and these will be described here.

One occurs at the diorite contact on Cox's River just below the mouth of Deep Ravine and, except for the presence of a little andesine, is similar to other rocks with which it is interbedded. It is a cherty green hornfels with bands of radiating wollastonite, which are parallel to the stratification. Under the microscope the green cherty layers are found to be made up of a fine aggregate (0.1 mm.) of quartz, diopside, orthoclase, andesine, wollastonite and sphene.

The second example occurs on Moyne Creek, where it is associated with a plagioclase-diopside-epidote assemblage. This rock is also banded. Some of the bands consist almost entirely of andesine with a little wollastonite and diopside. These are intercalated with bands much richer in wollastonite, and which also contain diopside, scapolite, quartz, orthoclase and sphene.

As the Cox's River rock contains andradite as well, and because the scapolite of the Moyne Creek type is considered to be secondary, both these rocks will be referred to below under the heading of metasomatism.

(xii) *Diopside-grossular-wollastonite Hornfels.*

Only one example of this hornfels has been recorded. It was collected from the granite contact near the head of Liddleton Creek, and is here associated with wollastonite-diopside assemblages which show extensive metasomatism. In the hand-specimen this rock is green and chert-like, with large masses of radiating, silky wollastonite associated with brown garnet. On the weathered surfaces the wollastonite shows alteration into a white chalky substance described on p. 31. Under the microscope large plates of wollastonite, often measuring more than 6 mm., are seen to be surrounded by or partly wrapped by xenoblasts of garnet up to 5 mm. across. Both these minerals contain inclusions of, and are set in a granular mosaic (about 0.1 mm.) of, diopside, epidote, orthoclase, quartz and accessory sphene. In some cases the orthoclase forms large plates, but it is possible that some of this is of igneous origin. The wollastonite may

show twin lamellae, and cracks are often filled with calcite. The garnet is apparently of two different varieties—grossular and andradite. The grossular is pale yellow and xenoblastic and is obviously the primary and original mineral in this assemblage. The andradite is deep brownish-yellow and occurs in subidioblasts and xenoblasts intimately associated with the lighter coloured variety. Veins of the darker garnet cut through the rock and "blotching" is similar to that observed by G. D. Osborne (1932) at Carlingford. The grossular is sometimes anisotropic. Both garnets are poikiloblastic and exhibit a sieve-structure. They frequently form a granular intergrowth with epidote. Like the andradite, much of the epidote is possibly secondary, and this rock will be discussed later in dealing with metasomatism.

(xiii) *Vesuvianite-diopside Hornfels.*

Only one example of this hornfels has been met with in the Hartley aureole. It occurs as a well-marked band in the centre of the calcareous bed on the northern limb of the Moyne Creek anticline, and is there associated with a wollastonite-orthoclase-diopside assemblage. In the hand-specimen it is a fine-grained chert-like rock showing pale green, white and light brown bands. The rock is highly metasomatized, and it is rather difficult to recognize the original hornfels. It is possible that metasomatism closely followed the recrystallization of the sediment, and that normal thermal metamorphism passed into metasomatism as one continuous process.

As far as can be made out, the hornfels first consisted of a vesuvianite-diopside assemblage in which orthoclase was abundant. Garnet may have been present also. The vesuvianite forms large xenoblasts about 4 mm. across, and often encloses crystals (1 mm.) of altered orthoclase. Orthoclase also forms large independent xenoblasts with a sieve-structure and these, together with the vesuvianite xenoblasts, are set in a fine granular mosaic of diopside, orthoclase, quartz, prehnite, and a little epidote. Patches of anisotropic garnet also occur, and it is possible that this mineral, as well as the prehnite and epidote, belong to the period of metasomatism. The vesuvianite shows extensive alteration into prehnite and a fibrous mineral described below (p. 42).

This assemblage occurs in bands which alternate with a prehnite-apophyllite assemblage, and it is believed (see p. 40) that prior to metasomatism these latter seams were represented by a wollastonite-orthoclase-diopside hornfels.

(xiv) *Wollastonite-diopside Hornfelses.*

Examples of this type are recorded from the granite contact near the head of Liddleton Creek, from Bonnie Blink Creek just above the junction of Liddleton Creek, from Moyne Creek, and from the diorite contact on the river below Deep Ravine. As most of these rocks have suffered some form of metasomatism, they will be considered only very briefly here. They find a place in this section, however, for it is evident that many of the metasomatized hornfelses were originally of this type.

In the hand-specimen they are fine-grained, greenish, granular rocks very rich in quartz. Wollastonite varies in amount and sometimes may be so abundant as to make up most of the rock. When less plentiful it may occur in small radiating masses or in bands parallel to the original bedding. In the field it is evident that the brachiopod shells have been replaced by wollastonite which, on weathered surfaces, is now represented by a fibrous, white earthy mineral.

This mineral has not been identified. It is isotropic and has a very low refractive index (1.460). Under the microscope masses of radiating wollastonite measuring up to 5 mm. across are set in a fine (about 0.1 mm.) granoblastic groundmass of diopside, quartz, orthoclase, and sometimes a trace of plagioclase. Spheue and iron-ores are usually present as accessories. Alteration of the wollastonite into the unknown fibrous mineral seems to occur only on weathered surfaces, but in the body of the rock it commonly shows alteration into carbonates. Small andradite veins often thread through these hornfels, but the occurrence of this mineral is referred to below. Scapolite is sometimes associated, but this, too, is regarded as a product of metasomatism.

A partial analysis has been made of a rock from Bonnie Blink Creek. This hornfels contains traces of scapolite and plagioclase.

SiO <sub>2</sub>	..	..	..	..	..	..	73.16
Al <sub>2</sub> O <sub>3</sub>	..	..	..	..	..	..	4.33
F <sub>2</sub> O <sub>3</sub>	..	..	..	..	..	..	0.07
FeO	..	..	..	..	..	..	1.66
MgO	..	..	..	..	..	..	0.49
CaO	..	..	..	..	..	..	17.15
Na <sub>2</sub> O	..	..	..	..	..	..	0.38
K <sub>2</sub> O	..	..	..	..	..	..	2.07
H <sub>2</sub> O	..	..	..	..	..	..	nd.
TiO <sub>2</sub>	..	..	..	..	..	..	0.22

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 99.53

Wollastonite-orthoclase-diopside Hornfels, Bonnie Blink Creek, Little Hartley. Anal. G. A. Joplin.

#### (xv) *Sandstone Hornfels.*

These rocks are very abundant in the Hartley aureole, and occur at all parts of the contact on many different horizons. Many of them have suffered greisenization, and it is often difficult to distinguish between the greisenized sandstone hornfels and the greisenized cordierite-quartz hornfels where the cordierite has also been altered to white mica. Like the cordierite-quartz assemblages, the sandstone hornfels may be divided into two groups according to their biotite content.

(a) *Biotite-rich Types.*—In the hand-specimen these rocks are essentially dark grey quartzites, and sometimes slight banding is apparent. A typical example occurs in a small creek, south of Delaney's Creek, in Por. 128, Parish of Hartley, at a distance of 180 yards from the contact. Under the microscope this shows a granoblastic structure (0.2 mm.) and consists of quartz, orthoclase, biotite, magnetite and a good deal of white mica. Chlorite and carbonates have also been noted, but, like much of the white mica, these are probably secondary.

(b) *Biotite-free Types.*—These rocks have been collected on Moyne Creek, on the ridge north-west of the mouth of Grant's Creek (Por. 118, Hartley), on the old road east of Yorkey's Creek, and on the spur between Spring Creek and Marriott's Creek.

The Moyne Creek rock occurs as a well-marked bed of massive, resinous, white quartzite above the calcareous horizon of the Moyne anticline (see Text-fig. 1). Under the microscope this rock is seen to be almost a pure quartzite consisting of interlocking grains of quartz about 3 mm. in diameter. Occasional patches of white mica and iron-ores also occur, and a little carbonate and chlorite have been noted. These latter possibly represent the alteration products of a

ferro-magnesian mineral during metasomatism—they are associated with grains of magnetite. Two generations of white mica may be recognized. The first possibly represents a simple recrystallization of an original sericitic matrix, and the second, consisting of larger flakes of muscovite, may be attributed to metasomatism.

(xvi) *Altered Grits.*

Grits occur on Yorkey's Creek, Hughes' Creek and Delaney's Creek. In the hand-specimen they vary from fine siliceous conglomerates to coarse quartzites, and the colour of the matrix is usually purplish-brown. Under the microscope the rocks are distinctly clastic, and are made up chiefly of small, rounded grains of quartz and fine quartzite in a completely recrystallized matrix of quartz, reddish-brown biotite, orthoclase and magnetite. Sometimes a little plagioclase may be present in the matrix, so the hornfelsed grits may be considered as plagioclase-biotite-quartz or biotite-quartz assemblages.

A specimen from Hughes' Creek contains altered cordierite in the matrix, and the rock is very rich in white mica. This rock might be regarded as a greisenized cordierite-quartz hornfels.

The grit occurring on Yorkey's Creek passes into a conglomerate and has not been completely recrystallized.

METAMORPHISM OF THE INTERBEDDED IGNEOUS ROCKS.

There are two groups of igneous rocks within the Hartley aureole, (1) felsites, which appear to have been acid lavas at the base of the Lambian Series, and (2) porphyrites which occur as well-defined sills on several horizons.

(i) *Felsites.*

These are stony-pink, brownish-pink, or greenish-white rocks, which contain phenocrysts 3 mm. across. Muscovite may be seen in the hand-specimen, and some of the rocks have a rather chalky appearance and, when struck with a hammer, emit a hollow sound. The surface of these rocks shows a peculiar pitting. The hollows are sometimes an inch in diameter and about half an inch deep. Under the microscope there is no essential difference between the normal stony felsites and these apparently altered types. The phenocrysts consist of corroded quartz grains and tabular crystals of altered oligoclase. These are set in a fine mosaic of quartz and orthoclase, with accessory biotite and magnetite. Large flakes of muscovite, up to 5 mm. in length, replace the orthoclase and often enclose crystals of quartz. The plagioclase is altered both to kaolin and sericite.

A partial analysis of the rock gave the following results:  $\text{SiO}_2$  75.39,  $\text{CaO}$  0.23,  $\text{Na}_2\text{O}$  2.32,  $\text{K}_2\text{O}$  5.90. This indicates that the rock is a fairly normal potash felsite and that there has not been any appreciable addition of magmatic potash for the production of muscovite. The origin of this mineral is discussed below under metasomatism.

(ii) *Porphyrites.*

No unaltered representatives of this group of sills have been met, but the less altered types indicate that the rock was a porphyrite with slight variations in composition from place to place. Phenocrysts of both plagioclase and hornblende occur, but on Hughes' Creek the plagioclase phenocrysts predominate, and in other parts of the district the hornblende crystals are more abundant and

measure up to half an inch in length. In some of the less altered types the groundmass has a pilotaxitic fabric and consists chiefly of plagioclase and a little hornblende. In the more acid types an intergranular fabric is developed and interstitial orthoclase and quartz occur between small stout crystals of plagioclase. Sometimes there is an indication of an original ophitic fabric. Biotite may or may not have been present in the original unaltered rock, and accessory minerals are apatite and iron-ores.

An initial rise of temperature is indicated by the separation of magnetite, small flakes of biotite, and granular sphene in the hornblende phenocrysts, and biotite becomes abundant in the groundmass, particularly in the neighbourhood of iron-ores (Harker, 1904; Skeats, 1910; Tilley, 1921; McGregor *et al.*, 1929). In some of the rocks plagioclase shows alteration into calcite at this stage, but this may be superimposed by metasomatism. At a later stage reddish-brown biotite entirely replaces hornblende in the groundmass, and the whole rock takes on a somewhat granular appearance. The plagioclase phenocrysts become spangled with tiny granules of zoisite, and hornblende phenocrysts are gradually becoming pseudomorphed by criss-cross flakes of biotite.

A rock from the head of Hughes' Creek represents a portion of the roof of the intrusion and rests directly on the diorite. This is completely recrystallized, and ferromagnesian are represented by masses of chlorite.

With a slightly higher grade of metamorphism crystalloblastic structures come into evidence. Whilst there is still a tendency for biotite to replace hornblende, the biotite of the groundmass takes on a highly poikiloblastic structure, and a good deal of the felspar of the groundmass becomes recrystallized. At the same time the phenocrysts lose their sharp outlines and become indented by the recrystallizing groundmass. A little white mica occurs in the felspar phenocrysts, but this may perhaps be attributed to metasomatism.

A type from Hughes' Creek shows inverted zoning in the plagioclase phenocrysts, and the outer calcic rim is clouded (for references to clouding of felspar, see Joplin, 1933). In this rock the groundmass forms a fine mosaic and the hornblende is not converted into biotite. Some of the hornblende phenocrysts, however, are entirely pseudomorphed by criss-cross flakes of brown mica, and masses of granular sphene surround iron-ores.

A few rocks exemplify conditions at which hornblende was stable, and there is no alteration to biotite. Crystalloblastic structures are developed, and clear grains of recrystallized felspar surround the phenocrysts. It is interesting to note that the hornblende in these rocks has much higher refractive indices ( $\alpha' = 1.640$ ,  $\beta' = 1.645$ ,  $\gamma' = 1.663$ ) than that which is developed in the metamorphosed sediments.

Another rock from Hughes' Creek at a distance of 88 yards from the granite and 660 yards from the diorite shows crystalloblastic structures and a little granular diopside. Some of the pyroxene occurs as independent grains, but some fringes hornblende, which has become pale and fibrous with the throwing out of iron-ores. The phenocrysts of plagioclase are highly zoned, and poikiloblastic and criss-cross structures are present. Column I below shows an analysis of this rock, which is a fairly typical porphyrite. Slight metasomatism is evidenced by a little pyrites, epidote and calcite.



	I.	II.
SiO <sub>2</sub> .. ..	57.54	58.30
Al <sub>2</sub> O <sub>3</sub> .. ..	18.81	19.43
Fe <sub>2</sub> O <sub>3</sub> .. ..	3.88	4.40
FeO .. ..	3.49	3.33
MgO .. ..	2.54	2.64
CaO .. ..	8.00	7.46
Na <sub>2</sub> O .. ..	2.66	3.07
K <sub>2</sub> O .. ..	0.88	0.88
H <sub>2</sub> O+ .. ..	0.70	0.37
H <sub>2</sub> O- .. ..	0.09	—
TiO <sub>2</sub> .. ..	0.53	0.49
P <sub>2</sub> O <sub>5</sub> .. ..	0.30	0.22
MnO .. ..	0.18	—
CO <sub>2</sub> .. ..	0.79	—
S(FeS <sub>2</sub> ) .. ..	0.18	—
Cr <sub>2</sub> O <sub>3</sub> .. ..	abs.	—
	100.57	100.57
Sp. Gr. ..	2.802	—

	I.	II.
Quartz .. ..	18.90	17.34
Orthoclase .. ..	5.56	5.00
Albite .. ..	23.06	26.20
Anorthite .. ..	33.08	35.03
Corundum .. ..	1.12	0.51
Hypersthene .. ..	8.81	8.18
Magnetite .. ..	5.57	6.50
Ilmenite .. ..	0.91	0.91
Apatite .. ..	0.67	0.67
Pyrites .. ..	0.36	—
Calcite .. ..	1.80	—

I. Metamorphosed Porphyrite (Bandose, (I) II.4.4.4"). S.E. Corn., Por. 218, Parish of Louthier, Little Hartley. Anal. G. A. Joplin.

II. Andesilabradorite (Bandose, (I)II.4.4.4"). Carbet, Martinique, West Indies. Anal. A. Pisané. A. Lacroix, Mont Pélée, 1904, p. 573. In W.T., p. 411, No. 31.

METASOMATISM.

Although the Hartley hornfels are not intensely metasomatized, the phenomenon is fairly widespread, and evidence of it occurs at all parts of the contact. Several processes may be recognized, and it is proposed to deal here with these processes rather than with the individual assemblages that have been produced by them. In some cases there is evidence to show that metasomatism followed closely upon thermal metamorphism, and it is probable that there was an overlap. Nevertheless, thermal metamorphism preceded metasomatism to some extent, and earlier-formed hornfels were altered as a result of the later process. It is sometimes difficult to recognize the original hornfels, if such ever did exist; but in most cases both metasomatized and unmetasomatized hornfels are preserved, and the history of the later process may be clearly traced.

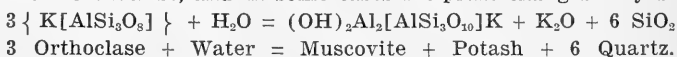
As is usually the case, metasomatism is more pronounced in the calcareous rocks, but greisenization has affected the more argillaceous and arenaceous types, so that most of the primary hornfels have been altered by the later process. Eleven new minerals owe their origin to metasomatism, and often a single one of these has been derived from more than one original mineral, as is shown below.

The possible derivation of the following will now be discussed: i, Muscovite; ii, Amphibole; iii, Epidote; iv, Andradite; v, Hedenbergite; vi, Scapolite; vii, Fibrous Mineral A, from Scapolite; viii, Apophyllite; ix, Prehnite; x, Fibrous Mineral B, from Vesuvianite; xi, Pyrites.

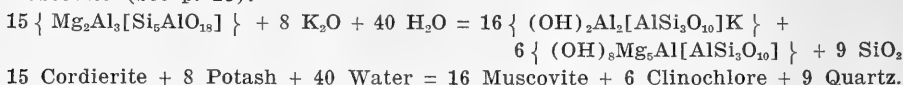
i. *Muscovite.*

Greisenization is apparent in the sandstone hornfels, in a number of the cordierite-bearing assemblages and in the recrystallized felsites, and it may be attributed to the break-down of both orthoclase and cordierite. Some of the muscovite in the hornfels occurs in parallel intergrowth with biotite and in the same specimens orthoclase is fresh and unsericitized. It is thus assumed that muscovite has arisen as a primary product of medium-grade thermal metamorphism at a temperature where conditions were stable for the production of both muscovite and orthoclase.

In other cases, however, large flakes of muscovite are numerous, orthoclase is much sericitized or absent, granular quartz is associated with the white mica and tourmaline is often abundant. In these rocks it is believed that muscovite is derived from orthoclase, and in some cases incipient changes may be observed.



In the cordierite-bearing hornfels the cordierite frequently shows alteration to finely divided white mica, but in some cases large flakes of muscovite occur not only replacing orthoclase but also pseudomorphing grains of cordierite. The associated biotite is usually chloritized, and chlorite is also associated with the muscovite (see p. 23).



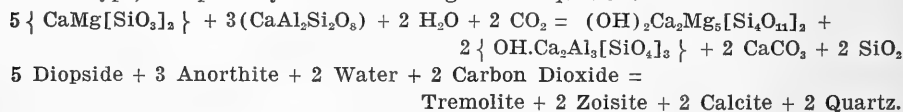
The potash may have been derived from the magma in the form of a silicate, or it may have been set free in the break-down of the orthoclase molecule.

From an inspection of the petrography it is obvious that finely divided white mica may be derived from andalusite as well, but this is not regarded as an important source at Hartley.

ii. *Amphibole.*

It has been shown that amphiboles frequently arise as primary products of thermal metamorphism, but there is little doubt that they also replace pyroxenes, and in this case they are considered as products of metasomatism. There is some evidence of an overlap between the periods of thermal metamorphism and metasomatism, and primary amphibole is sometimes found side by side with amphibolized pyroxene. An example of this change is shown in a rock from Moyne Creek, which is essentially a diopside-plagioclase-biotite hornfels with a little primary amphibole. Much of the diopside is changed to a pale green amphibole with distinct pleochroism, a very small extinction angle and positive elongation. It is associated with chlorite and iron-ores.

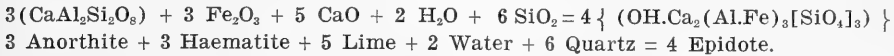
Other examples of secondary amphibole are accompanied by epidote. A rock from the head of Marriott's Creek, and another from near its mouth, show large ovoid masses of amphibole and granular epidote. This ovoid structure has been noticed in some of the diopside-plagioclase rocks (p. 29). The ellipsoids consist either of masses of diopside or of granular aggregates of diopside and plagioclase, and it is assumed that the altered rocks from Marriott's Creek were originally of this type, and possibly arose according to the equation:



In one of these rocks carbonates are abundant; from the other they have apparently been removed.

iii. *Epidote*.

It has been shown above that zoisite may be derived from a mixture of diopside and plagioclase, and with the incoming of iron-bearing solutions epidote may be formed. By the addition of iron and lime, epidote may be formed directly from plagioclase according to the following equation:



The fact that iron-bearing solutions of magmatic origin are abundant during the period of metasomatism has been established by many workers, but there is a difference of opinion concerning magmatically derived lime. In the case of the Hartley rocks, however, there is no need to postulate a magmatic origin for the lime, as there has probably been a circulation of this substance within the calcareous beds themselves. Barrell (1907, p. 127) considers that both lime and silica, derived from the rock itself, may circulate during metasomatism.

iv. *Andradite*.

Andradite occurs very abundantly among the calc-silicate hornfelses at the head of Liddleton Creek, on the hillside north-west of the junction of Liddleton and Bonnie Blink Creeks, and at the diorite contact just south of Deep Ravine. The most notable occurrence is that above the junction of the creeks, where the garnet may be seen veining and impregnating a quartz-plagioclase-diopside hornfels. At this locality an ellipsoidal nodule measuring about 2" x 1" was collected. It was enclosed in the normal quartz-plagioclase-diopside rock and evidently represented a more calcareous portion. The host rock is granoblastic with large (0.2 mm.) grains of quartz surrounded by a fine (0.06 mm.) mosaic of diopside and plagioclase. The nodule was much coarser in grain size (3.0 mm.) and consisted of large grains of diopside, epidote, garnet, orthoclase, quartz and a little sphene.

A partial analysis was made of the garnet from this nodule with the following results:

SiO <sub>2</sub>	..	..	..	..	..	36.46	Sp. Gr., 3.64*
Al <sub>2</sub> O <sub>3</sub>	..	..	..	..	..	10.14	Anal. G. A. Joplin.
Fe <sub>2</sub> O <sub>3</sub>	..	..	..	..	..	19.80	
FeO	..	..	..	..	..	1.59	
MgO	..	..	..	..	..	abs.	
CaO	..	..	..	..	..	30.94	
TiO <sub>2</sub>	..	..	..	..	..	0.38	
						99.31	

\* Possibly slightly low on account of small air bubble.

The calculated composition is thus Andradite (Ca<sub>3</sub>Fe<sub>2</sub>"[SiO<sub>4</sub>]<sub>3</sub>) = 57% and Grossular (Ca<sub>3</sub>Al<sub>2</sub>[SiO<sub>4</sub>]<sub>3</sub>) = 43%, and the garnet may be regarded as an aluminous andradite.

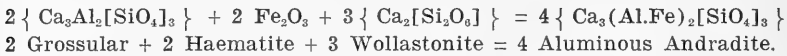
The colour is deep brown in the hand-specimen, and yellowish-brown in thin section, and the R.I. lies between 1.822 and 1.832, which is in accord with the calculated composition.

The refractive indices of the accompanying minerals were determined with a view to ascertaining their iron content:

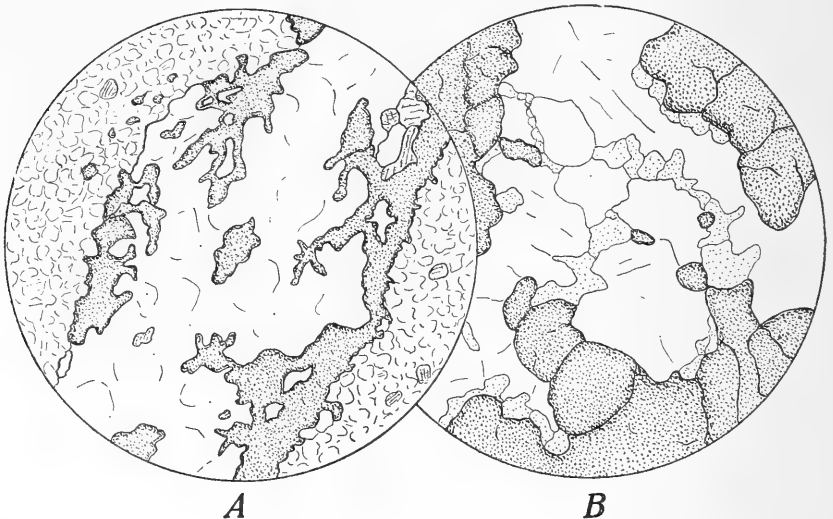
*Diopside*,  $\alpha' = 1.688$ ;  $\gamma' = 1.714$ ; FeO = 10%;  $\text{Di}_{88}\text{He}_{22}$ . *Epidote*,  $\alpha' = 1.728$ ;  $\gamma' = 1.753$ ;  $\text{Fe}_2\text{O}_3 = 17\%$ .

There appears to be no difference between the garnet of the nodule and that which impregnates the surrounding rocks, and in a few cases lower refractive indices have been measured, so it is assumed that the garnets contain at least 43% of the grossular molecule.

As the original composition of the nodule is unknown, the origin of the garnet and epidote is obscure. The nodule appears to have been more calcareous than its host, however, and it is possible that grossular was originally present. The epidote may represent an alteration product of grossular (Tilley, 1923) and, as in the case of the wollastonite-grossular-diopside hornfels (p. 31), the andradite may have been formed by the simple addition of iron to the lime garnet and wollastonite.



The garnet in the plagioclase-diopside assemblage, however, must have been of different origin. It appears that the alumina of the garnet was derived from the plagioclase feldspar by the action of lime- and iron-bearing solutions. The plagioclase has been determined as Labradorite,  $\text{Ab}_{28}\text{An}_{72}$  with R.I.  $\alpha' = 1.565$ ,  $\gamma' = 1.575$ . Occasionally epidote or clinozoisite may be seen separating the garnet and the feldspar, and this is regarded as an intermediate stage (see equation, p. 37). Text-figures 2 and 3, A and B, illustrate the occurrence of the aluminous andradite in these rocks. The garnet is often associated with quartz veins, thus giving a clue to its extraneous origin. Text-figure 2 shows the garnet passing out laterally into the feldspar at the margins of the vein.



Text-fig. 2.

A.—Quartz-garnet vein intruding diopside-plagioclase hornfels. Garnet may be seen passing out into the plagioclase at the margins of the vein.  $\times 27$ .

B.—Margin of the same vein highly magnified. Much of the garnet is separated from the plagioclase by grains of clinozoisite.  $\times 123$ .

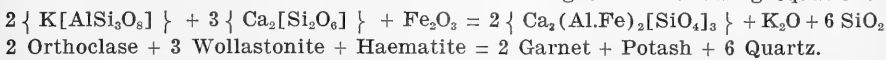
Actually the garnet may be derived by the addition of lime to the equation on page 37, thus:



The presence of clinozoisite as an intermediate stage indicates that the lime-bearing solution sometimes acted first, and that it was the advent of the iron-bearing fluid that changed the clinozoisite, with the addition of a little more lime, into the garnet. In many cases, however, no intermediate stage is observed and the two reactions possibly took place simultaneously.

The formation of garnet from plagioclase recalls a somewhat similar change recorded by McLintock (1915) from Ben More. Here zeolites pass to prehnite and epidote and finally to garnet.

In the wollastonite-orthoclase-diopside rocks the garnet appears to have obtained its alumina from the orthoclase according to the following equation:



#### v. *Hedenbergite*.

No pyroxene containing more than 60% of the hedenbergite molecule is present in the Hartley aureole, and in most instances this occurs in banded pyroxene-plagioclase rocks, and appears to represent the recrystallization of original iron-rich bands (see page 29).

On Liddleton Creek, however, there are rocks associated with the garnetiferous wollastonite-diopside assemblage that contain small patches of deep green pyroxene and a good deal of orthoclase. These rocks appear to have been impregnated with igneous material, and occur only a few yards from the granite contact. This pyroxene has refractive indices  $\alpha' = 1.708$ ;  $\gamma' = 1.730$ , and thus, according to Winchell, has the composition  $\text{Di}_{44}\text{He}_{56}$ , and contains 17% of FeO.

It is possible that the same solutions as were responsible for the formation of the iron-garnet also attacked the original diopside in these hornfelses. The orthoclase of these rocks seems to be of magmatic origin. The fact that the diopside remains so little affected by the iron-bearing solutions, which were so abundant at the contact in Por. 27, Parish of Lowther, is a little difficult to explain. An insufficiently high temperature is the only explanation that suggests itself. It is possible that the temperature for the formation of iron-garnet is below that for the conversion of diopside into hedenbergite.

#### vi. *Scapolite*.

Scapolite is not abundant in the Hartley aureole, though it is fairly widely distributed and occurs on Delaney's Creek, Moyne Creek, Cox's River, Bonnie Blink Creek and Liddleton Creek. It is found in a plagioclase-diopside assemblage and in wollastonite-diopside rocks where a little plagioclase may or may not be present.

In the rock from Delaney's Creek the scapolite forms poikiloblastic plates enclosing grains of diopside. These are set in a fine mosaic of diopside, plagioclase and quartz. The birefringence of the scapolite is fairly high and the mineral appears to be approaching the meionite end of the series. In the wollastonite-bearing rocks the scapolite is usually closely associated with the wollastonite, and its lower birefringence indicates its approach to marialite.

No definite statement can be made regarding its origin, but its association suggests that it has been derived from plagioclase during metasomatism. The

fact that labradorite occurs in the plagioclase-diopside rocks, and that andesine is met with in the wollastonite-bearing types, is in accord with the probable composition of the scapolite in these assemblages.

vii. *Fibrous Mineral A (from Scapolite).*

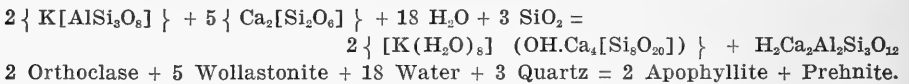
A good deal of the scapolite is fringed by or entirely replaced by a light brownish fibrous mineral, which has not been identified. This unknown mineral is biaxial and positive, with negative elongation and straight extinction. The optic axial plane lies parallel to the cleavage, and to the elongation of the fibres. The optic axial angle is very small. The mineral appears to be rhombic. The refractive indices determined by the Immersion Method lie between 1.480 and 1.490, though these readings are not regarded as satisfactory owing to the tendency for the mineral to break up on crushing, and the difficulty attending the identification of small fragments. In thin section the double refraction has been determined as 0.009. Fragments treated with concentrated hydrochloric acid became powdery and appeared to dehydrate, and when this material was tested for lime a weak positive reaction was obtained. There is not sufficient of this material for an analysis, but the above simple tests point to a hydrous silicate of lime, and the association with scapolite suggests the presence of soda and alumina.

viii. *Apophyllite.*

Apophyllite is abundant in the calcareous bed on the northern limb of the Moyne anticline, and it has also been met with in a boulder from Bonnie Blink Creek. Although it is not possible to trace every stage in its development, it is fairly evident that it arises in a diopside-orthoclase-wollastonite assemblage which, on Moyne Creek, is interbedded with vesuvianite-diopside types.

In the more altered rocks no remnant of wollastonite or orthoclase is evident, and the vesuvianite assemblage appears to be seamed by bands of apophyllite into which project blade-like crystals of prehnite (see Text-fig. 3, C).

A parallel band, half an inch above an apophyllite seam, consists of much carbonated wollastonite set in plates of kaolinized orthoclase, and in one or two places small patches and veins of apophyllite are apparent, and a little granular prehnite is associated. Apophyllite would thus seem to arise according to the equation:

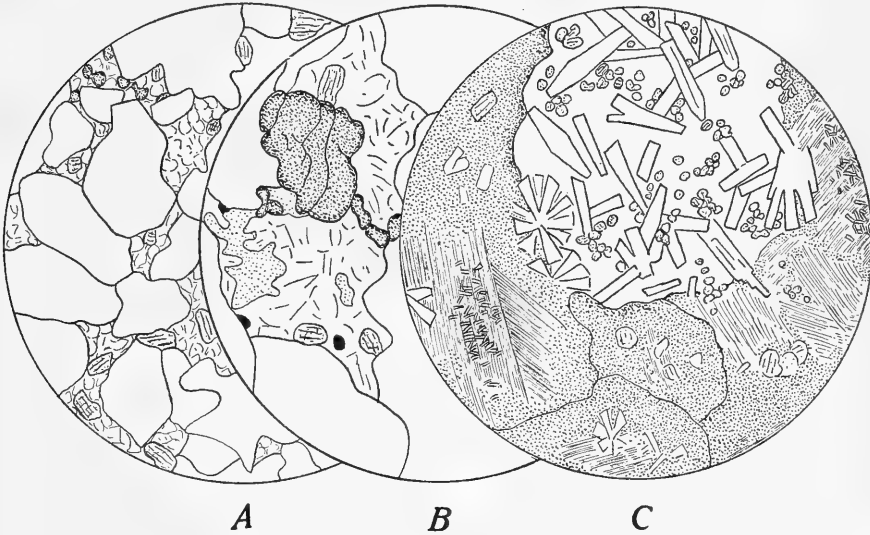


The preliminary break-down of orthoclase into kaolin and potassium carbonate, and of wollastonite into calcite possibly occurs as an intermediate stage, carbonated magmatic water acting as a catalyst.

In the rock from Bonnie Blink Creek the apophyllite occurs in vein-like patches associated with iron-garnet, scapolite and its alteration product, in a rock which consists almost entirely of wollastonite and diopside. This rock is so much altered by metasomatism that it is difficult to postulate its original composition, and to say how the apophyllite has arisen.

Hutchison (1933, p. 588) has shown by an equation that apophyllite may be formed by the action of potassium carbonate on wollastonite. With regard to the Hartley aureole it has already been suggested that  $\text{K}_2\text{O}$  may be released as a result of the formation of garnet from orthoclase, and of muscovite from orthoclase, and it is conceivable that a quantity of potash is present in the magmatic waters that were responsible for this late stage of metasomatism.

The close association of andraditic garnet and scapolite with the apophyllite in this rock suggests that the original hornfels may have been a wollastonite-orthoclase-diopside assemblage with a little plagioclase, and that the garnet arose from orthoclase, thus setting free  $K_2O$ , which immediately reacted with a further quantity of wollastonite and quartz to give apophyllite.



Text-fig. 3.

A.—Diopside-plagioclase hornfels showing large grains of quartz surrounded by a fine granular matrix of plagioclase and pyroxene. Garnet is seen replacing plagioclase in the top left-hand corner.  $\times 25$ .

B.—Portion of the same highly magnified. Grains of garnet and clinzoisite are intimately associated with plagioclase.  $\times 73$ .

C.—Banded vesuvianite-diopside hornfels with apophyllite-prehnite-diopside seams. Vesuvianite is shown changing to fibrous mineral B, and small crystals of prehnite appear interlaced in the fibres of the unknown mineral. The clear area represents colourless apophyllite in which are set blade-like and barrel-shaped crystals of prehnite, and small granules of diopside.  $\times 19$ .

#### ix. *Prehnite*.

Prehnite has been found only on Moyne Creek, where it is present in the calcareous bed on both limbs of the Moyne anticline. In the southern outcrop it forms large poikiloblastic plates in a rock which, in the field, looks like an aplite injected along the bedding-plane of a banded calc-silicate hornfels. The coarser aplite-like type and the finer hornfels which it appears to invade both consist largely of prehnite, the only apparent difference being one of grainsize and a larger percentage of iron-ore inclusions in the finer grained rock. The prehnite plates include grains of diopside, and a little wollastonite and plagioclase are occasionally associated. These rocks are so highly prehnitized that it is impossible to surmise their original composition, though the presence of remnants of wollastonite and plagioclase suggests that prehnite may have arisen according to the equation suggested by Hutchison (1933, p. 587).

On the northern limb of the fold, it is quite obvious that prehnite has been formed from more than one mineral, and that prehnitization of a single mineral has advanced in different directions, giving rise to several distinct assemblages.

Vesuvianite is the main source of this mineral, and three associated assemblages may be recognized: (i) Prehnite, grossular, calcite and quartz; (ii) prehnite and a fibrous mineral; (iii) prehnite, kaolin, calcite.

For the first change Osborne (1931, p. 297) has suggested equations, and he has also observed an association of kaolin and calcite. The fibrous mineral has not been identified, but is described below. In all these cases the prehnite forms granular masses, often clouded (Hutchison, 1933), usually in close association with the other products of the reaction.

It has been shown above that prehnite also arises with apophyllite in a wollastonite-orthoclase assemblage which is interbedded with the vesuvianite rock. In this case the prehnite forms well-shaped blade-like or barrel-shaped crystals, often in radiating groups, which are embedded in the apophyllite (see Text-fig. 3, C).

#### x. *Fibrous Mineral B (from Vesuvianite).*

As noted above, this mineral occurs with prehnite as an alteration product of vesuvianite. It is biaxial and positive, with a very large optic axial angle, and the axial plane across the cleavage. One well-marked cleavage is developed parallel to the length of the fibres, and the sign of the elongation may be both negative and positive, though the former is the more frequent. The maximum extinction angle measured from the cleavage is  $30^\circ$ , but straight extinction is often shown, and the mineral thus appears to be monoclinic. The refractive indices, as determined by the Immersion Method, are  $\alpha' = 1.610+$ ,  $\gamma' = 1.630+$ . From these it would appear that the double refraction was about 0.020, but in thin section it appears to be higher. A polysynthetic twinning parallel to the fibres has been observed in a few sections.

#### xi. *Pyrites.*

Small quantities of pyrites occur throughout the aureole and it sometimes carries a little arsenic. It is also met with in the plutonic rocks themselves, and is often concentrated along joint planes. Although a little pyrites is disseminated through most of the types within the contact aureole, it is particularly abundant in the altered porphyrites, and usually occurs within the hornblende phenocrysts.

Many years ago an attempt was made to work a small concentrate of arsenical pyrites in a porphyrite in the valley of Yorkey's Creek (M.L.1, Por. 214, Parish of Lowther). A shaft was put down at a distance of about 700 yards from the diorite contact, but the venture was unsuccessful and was abandoned.

#### GRADE OF METAMORPHISM AND COMPARISON WITH OTHER AREAS. ~

Reference to the petrography will show that primary muscovite is by no means uncommon among the more argillaceous hornfelses at Hartley. C. E. Tilley (1926) has suggested that muscovite arises in place of orthoclase when an abundance of water is present in the aureole. Not only is muscovite suggestive of the presence of water, but such hydrous minerals as biotite, vesuvianite and epidote (Tilley, 1924) are also characteristic. An abundance of water implies a concomitant lowering of the temperature, and amphiboles are thus formed instead of pyroxenes, muscovite instead of orthoclase, etc.



There is no doubt that equilibrium has been attained for the prevailing temperature conditions in the inner zone of hornfelses at Hartley, but it is also evident that the grade of metamorphism is fairly low. The aureoles of Christiania (Goldschmidt, 1911) and Comrie (Tilley, 1924) belong to a higher grade than that of Hartley. In these no muscovite occurs as a primary mineral, amphiboles and epidote though present are not characteristic, and biotite is a little less abundant. In the aureoles of Devon and Cornwall, however, muscovite is a prominent mineral in the killas of the inner aureole, and such assemblages as plagioclase-biotite-quartz and biotite-quartz are common (Reid, 1910). The calcifintas frequently contain tremolite and vesuvianite, and everything points to a "wet" grade of metamorphism. The Skiddaw aureole (Rastall, 1910) is also characterized by the presence of muscovite, and there is evidence of complete equilibrium under lower grade conditions.

The presence of both muscovite and orthoclase, and of amphibole and pyroxene in the Hartley aureole points to a temperature range over which both minerals were stable.

#### CLASSIFICATION OF THE SEDIMENTARY HORNFELSSES.

It is evident from the petrography that the hornfelses may be divided into two groups, (1) primary, thermal hornfelses, and (2) metasomatically altered types.

It is also apparent that there has been a considerable range of composition of the original sediments and, though no unaltered material is exposed, the hornfelses themselves indicate sandstones, shales and calcareous types. With but a few exceptions the composition of these sediments must have been comparable with the material which gave rise to some of the Christiania (Goldschmidt, 1911) and Comrie (Tilley, 1924) hornfelses, yet reference to the petrography shows that many of the index minerals of Goldschmidt's Classification are absent or not abundant at Hartley; and, again, minerals which are not prominent in the Christiania and Comrie aureoles are well developed at Hartley.

Amphiboles, epidote, muscovite, etc., which find no place in the Goldschmidt Classification, are found close to the contact at Hartley, and there is evidence to show that they occur as primary minerals in the *inner* zone of hornfelses, and cannot be attributed either to the unattainment of equilibrium or to metasomatism.

The foregoing discussion on metamorphic grades has shown that there has been an abundance of water during metamorphism, and probably a concomitant lowering of the temperature. It seems evident, therefore, that sediments of the same chemical composition will give different mineral assemblages under lower grade conditions. The relation between these mineral assemblages depends upon four important mineral transformations, which are brought about in the presence of water:

- (1) Cordierite + Orthoclase = Biotite;
- (2) Monoclinic Pyroxene + Rhombic Pyroxene = Amphibole;
- (3) Grossular + Anorthite = Epidote;
- (4) Grossular + Wollastonite = Vesuvianite.

These changes may be represented by the following equations, and in each case the right-hand side of the equation represents the lower grade conditions.



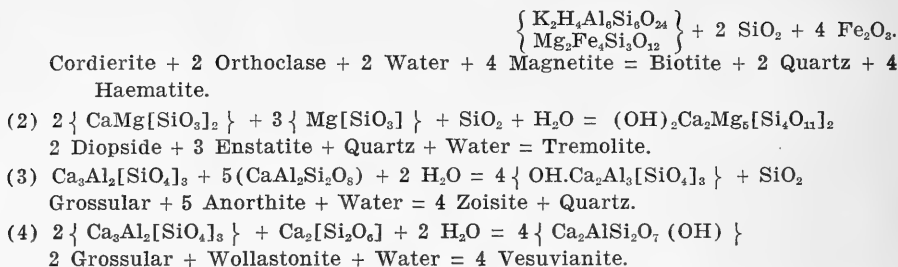


Table I shows the relation between similar sediments that have suffered high grade "dry" conditions, and those that have been subjected to a medium grade "wet" thermal metamorphism.

TABLE I.

Class.	High Grade (dry).	Medium Grade (wet).
I	Andalusite-cordierite-biotite-orthoclase Hornfels.	Andalusite-biotite-orthoclase-muscovite Hornfels.
I Mg i (a) and (b)	Cordierite-quartz Hornfels. (a) With Biotite. (b) Without Biotite.	Biotite-quartz Hornfels.
III	Cordierite-plagioclase Hornfels.	Biotite-plagioclase Hornfels.
VI	(Plagioclase-diopside-hypersthene Hornfels).	Amphibole - plagioclase - biotite Hornfels (near Class V). Amphibole - diopside - plagioclase - biotite Hornfels. Amphibole-diopside-plagioclase Hornfels (near Class VII).
VII	Plagioclase-diopside Hornfels.	
VIII	(Plagioclase-diopside-grossular Hornfels).	Plagioclase-diopside-epidote Hornfels.
IX	(Diopside-grossular Hornfels). Unstable Wollastonite-plagioclase-diopside Hornfels.	
X	Wollastonite-grossular-diopside Hornfels. Unstable Wollastonite-plagioclase diopside Hornfels.	Vesuvianite-diopside Hornfels.

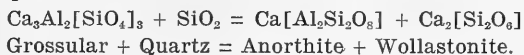
NOTE.—Hornfelses in brackets are *not* developed at Hartley.

It will be noticed that three types have been included as the medium grade equivalents of Class VI, and these show a progressive increase of lime. The amphibole-plagioclase-biotite assemblage must have a composition very close to a hornfels of Class V, but the amphibole contains sufficient lime to inhibit its inclusion in that class. Again, the amphibole-plagioclase-diopside rock is excluded from Class VII, because there is an excess of magnesia in the amphibole. Actually there can be no "wet" equivalent of Class VII, since the change from diopside to tremolite involves a change of composition.

The unstable assemblages that have been placed as the equivalents of Classes IX and X are rather difficult to account for. This assemblage occurs abundantly in the Carlingford (Osborne, 1932) and Deeside (Hutchison, 1933) aureoles, and has been interpreted differently by each of these authors. Hutchison considers that instability was caused by the relief of static pressure, whilst Osborne explains them on the presence of the albite molecule in the original sediment. With regard to the Hartley occurrences the present writer is inclined to agree with Osborne.

At the same time it might be pointed out that the Carlingford, Deeside and Hartley aureoles all indicate a "wet" type of metamorphism, and though inexplicable, this may possibly have some significance, and the unstable types might be included more correctly under medium grade (wet) metamorphism.

Hutchison has shown that wollastonite and plagioclase arise from grossular according to the equation:



If a very small quantity of wollastonite be present, the assemblage is considered to be an unstable member of Class IX, but if there be an abundance of wollastonite it is likely that it would be present in the hornfels represented by the left-hand side of the equation, and that the assemblage is an unstable hornfels of Class X.

Reference to Table I shows that certain hornfelses, described in the petrographical section, do not fall into this scheme, because the original sediment from which they arose did not belong to the shale-limestone series, for which this classification was drawn up. The wollastonite-orthoclase-diopside rocks were evidently calcareous sandstones, not argillaceous limestones, and thus do not find a place in the table. The hornfelsed sandstones and grits are excluded for a similar reason.

The presence of both high and medium grade types points to local variations in the conditions, and there is no evidence to show that the higher grade hornfelses are related to the contacts of the more basic plutonic rocks. It is found that both high and medium grade thermal types have suffered a subsequent metasomatism.

The discussion on metasomatism has shown that certain new minerals have arisen from those of the primary hornfelses. Table II shows the relation of the metasomatic assemblages to the primary types.

#### ORIGIN OF THE HORNFELSES, AND EVIDENCE OF PRE-METAMORPHIC ALTERATION.

In the preliminary discussion on incipient metamorphism, it has been pointed out that the original sediments at Hartley probably corresponded to well-known types at Rydal. Having examined the mineral constitution of the hornfelses, we shall now make an enquiry into the possible mineral assemblages of the sediments from which they arose.

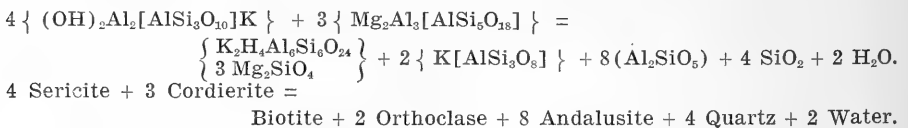
The cordierite-andalusite, cordierite-plagioclase and some of the cordierite-quartz hornfelses undoubtedly represent original shales. Some of these types, however, contain more quartz than normal shales, and it is evident that they were sandstones with an argillaceous matrix. The origin of such thermal assemblages has been discussed by Prof. C. E. Tilley (1924), and equations are given to show that they may arise from mixtures of sericite and chlorite. The appearance of plagioclase indicates a little admixed calcite.

The andalusite-biotite-orthoclase-muscovite assemblage described on page 23 has been classed as the medium grade equivalent of an andalusite-cordierite hornfels, but at the same time it is interesting to note that another origin for

TABLE II.

Primary Hornfels.	Metasomatic Assemblage.
Sandstone Hornfels.	Greisenized types.
Andalusite-cordierite-biotite Hornfels.	Andalusite-cordierite (altered)-biotite-muscovite-chlorite.
Cordierite-quartz Hornfels.	Greisenized types.
Plagioclase-diopside Hornfels.	1. Plagioclase-diopside-aluminous andradite. 2. Plagioclase-diopside-epidote-aluminous andradite. 3. Diopside-epidote-aluminous andradite. 4. Diopside-aluminous andradite. 5. Diopside-amphibole-plagioclase. 6. Diopside-amphibole-epidote. 7. Amphibole-epidote. 8. Plagioclase-hedenbergite. 9. Diopside-plagioclase-scapolite. 10. Diopside-prehnite.
Diopside-plagioclase-wollastonite Hornfels.	1. Diopside-plagioclase-scapolite-wollastonite. 2. Diopside-wollastonite-aluminous andradite. 3. Diopside-wollastonite-aluminous andradite-scapolite-mineral A. 4. Diopside-wollastonite-epidote.
Wollastonite-grossular-diopside Hornfels.	Wollastonite-grossular-andradite-epidote-diopside.
Wollastonite-diopside-orthoclase Hornfels.	1. Wollastonite-diopside-orthoclase-aluminous andradite. 2. Wollastonite-diopside-prehnite-apophyllite. 3. Diopside-prehnite-apophyllite.
Vesuvianite-diopside Hornfels.	1. Vesuvianite-diopside-prehnite-mineral B. 2. Vesuvianite-diopside-prehnite-grossular.

this assemblage is possible. A great abundance of sericite in the original sediment (such as might be derived from an acid-granite terrain) would inhibit the presence of cordierite, and at the same time give rise to an abundance of biotite, orthoclase and andalusite according to the equation:



Quartz is almost absent in this rock, however, and this equation is included to show that a similar assemblage may be produced in this way, rather than to suggest that this was the origin of the Hartley rock.

The biotite-quartz and biotite-plagioclase-quartz assemblages appear to represent fine-grained tuffaceous material with admixed detrital quartz. These rocks are interbedded with calcareous silts, and with gradual increments of lime, derived from the silts, they pass into amphibole-bearing hornfelses.

The silts themselves, uncontaminated by tuffaceous material, give rise to diopside-plagioclase rocks, and with increasing lime wollastonite-plagioclase and vesuvianite-bearing assemblages are produced. The original silt evidently

consisted of a mixture of chlorite, calcite and sericite, there being only a very small quantity of the last.

Most of the wollastonite-plagioclase rocks contain very little plagioclase and a good deal of orthoclase, and thus stand very close to the wollastonite-orthoclase-diopside assemblage. The texture, composition and field occurrence of these rocks all point to an original sandstone with shell bands. This sediment was probably of the nature of an arkose and contained a certain amount of unaltered felspar. The paucity of alumina in these rocks indicates a deficiency of sericite, and the fairly abundant orthoclase could not have derived its potash from this mineral, but must represent recrystallized original orthoclase.

The analogous type, containing a small amount of plagioclase, possibly represents similar sediments which consisted of quartz, orthoclase and a little acid plagioclase, with intercalated shell bands and a calcareous matrix. During metamorphism the acid plagioclase became more calcic (Osborne, 1932).

The sphene-plagioclase assemblage described on page 29 calls for comment. It occurs bordering a pyroxene seam and appears to be a case of pre-metamorphic alteration. The magnesia has been withdrawn from the surrounding material and deposited in the seam, possibly as original chlorite. On account of the withdrawal of magnesia from the outer bands available lime has combined with quartz and rutile to form sphene instead of diopside.

The banded hornfelses, showing alternations of the cordierite-biotite and the cordierite-orthoclase-magnetite assemblages, are another indication of pre-metamorphic alteration, the former seams arising from altered bands rich in hydrous minerals.

#### GRAINSIZE OF THE HORNFELSES.

Reference to the petrography shows that most of the hornfelses are very fine grained, and in most parts of the aureole there is no difference in the grain-size as the contact is approached. At the mouth of Moyne Creek, however, plagioclase-biotite, plagioclase-cordierite and amphibole-plagioclase-biotite hornfelses are coarser than similar assemblages elsewhere. These rocks lie within a few yards of the contact, and both field evidence and mineral constitution point to their being the equivalents of hornfelses that are very fine grained in other parts of the aureole. It is possible that at this locality a coarser grain-size was produced at the granite contact.

#### RELATION OF METASOMATISM TO FRACTURE.

At least two well-marked faults occur near the granite contact on the hillside west of the junction of Liddleton and Bonnie Blink Creeks. Actually the granite is difficult to map at this locality, as numerous aplitic dykes and apophyses thread through the sediments, and everything points to an intimate penetration of igneous material.

In the calcareous sandstone hornfelses themselves innumerable small fractures may be noted, and the rocks are impregnated by quartz and iron-garnets. These garnet veins frequently follow bedding planes, and in the hand-specimen they are sometimes suggestive of limy seams in the original sediments. In the field, however, it may be seen that the veins just as frequently cross the bedding, and sometimes form small dykes and sills up to about 4 inches in width. The larger intrusions are essentially garnet-quartz rocks with minute quantities of pyroxene and epidote.

It is thus suggested that shattering either accompanied or immediately followed the plutonic intrusion, and that these lines of weakness gave ready access to the metasomatic solutions. In his study of the Marysville contacts Barrell (1907) has come to a similar conclusion.

On Moyne Creek there is evidence to show that a certain amount of post-metasomatism shattering has occurred, but this may be of comparatively recent date. The calcareous bed containing banded vesuvianite and apophyllite assemblages provides excellent examples of miniature faults.

#### RELATION OF METAMORPHIC GRADE TO THE AGE OF THE SEDIMENTS.

The Hartley sediments are of late Devonian age and the plutonic complex responsible for their metamorphism is believed to belong to the Kanimbla Epoch (Sussmilch, 1914), which may have closed the Devonian Period. It is probable, therefore, that the sediments were only partially consolidated at the time of their metamorphism, and that their water content must have been fairly high. This suggests that the "wet" grade of metamorphism may be connected with the age and condition of the invaded sediments.

The fact that dry magmas such as the charnockite series (Holland, 1898) are associated with the older crystalline rocks, and that members of the mica-diorite stem invade geosynclinal deposits is regarded as significant, and it is believed that the magma derived part of its water from the rocks through which it passed. The relation of the metamorphic grade to the age of the sediments, however, seems to have received but little attention.

Typically "wet" aureoles such as those of Cornwall (Ussher, 1909; Reid, 1910) and New Galloway (Gardiner, 1890; Tilley, 1926) evidence intrusion closely following upon sedimentation, whilst the "dry" aureole of Comrie (Tilley, 1924) is an example of a long time lapse between the deposition of the sediments and their subsequent metamorphism.

Other examples appear to disprove this relation, but the fact that higher grade conditions are often connected with the more basic rocks must not be overlooked, and the suggested relation between metamorphic grade and the age of the sediments may be worthy of closer examination.

Unfortunately the higher grade hornfelds at Hartley cannot be related to the type of igneous rock.

#### SUMMARY.

1. The structure of the Upper Devonian (Lambian) Series at Hartley has been described and the sequence compared with that of the type area at Mt. Lambie, Rydal.
2. The difficulties attending observations on incipient metamorphism and the measurement of the contact zone have been discussed.
3. A detailed petrographical account of sixteen primary hornfelds and two interbedded lavas is given, and the subsequent metasomatism of some of the primary types has been treated genetically, and rock equations adduced to show the possible formation of some of the more important secondary minerals.
4. The primary hornfelds have been related to Goldschmidt's Classification, by means of a comparative table and a series of rock equations.
5. A table has been constructed to show the relation between the primary hornfelds and twenty-four metasomatic assemblages.
6. It has been shown that the Hartley aureole is an example of a medium grade "wet" type of metamorphism.

7. The metasomatism has been related to a period immediately following the intrusion with concomitant fracture.

8. Certain suggestions have been made regarding the relation between the grade of metamorphism and the age of the invaded sediments.

#### Acknowledgements.

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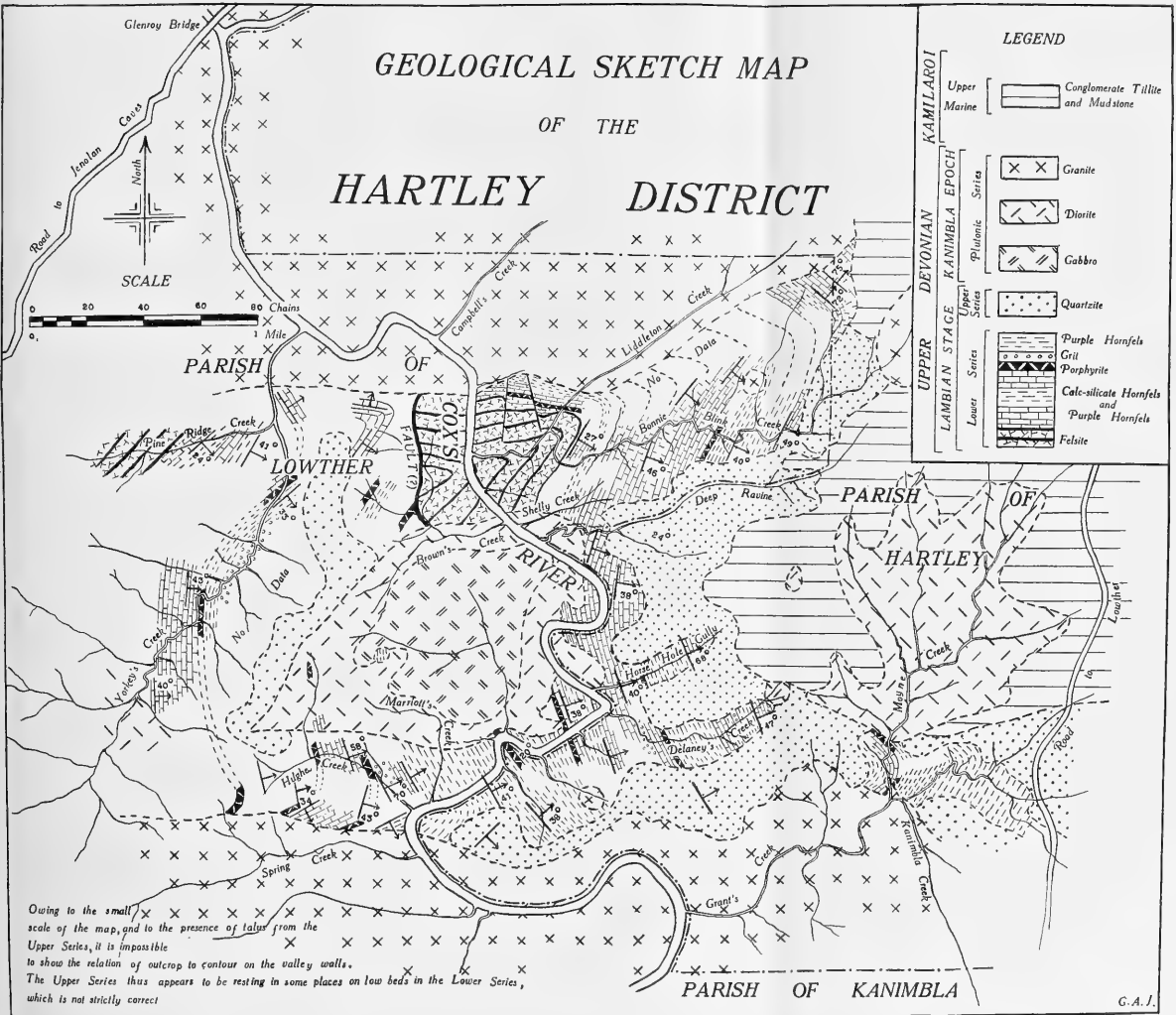
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## EXPLANATION OF PLATE I.

Geological Sketch Map of the Hartley District.







THE DIPTERA OF THE TERRITORY OF NEW GUINEA. II.

FAMILY TIPULIDAE.

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(Communicated by Frank H. Taylor.)

(Twenty Text-figures.)

[Read 27th March, 1935.]

The very interesting series of Tipulidae discussed herewith was collected in greater part by Mr. Frank H. Taylor, a small number of specimens being taken by Mr. S. V. Bayley and by Dr. H. Champion Hosking. The majority of the specimens were taken at Keravat, Rabaul, and at an altitude of about 1,000 feet on Mount Toma, all located on the Gazelle Peninsula of New Britain. Fewer specimens were taken on Makada Island, of the Duke of York Group, east of the Gazelle Peninsula. The types and uniques have been returned to Mr. Taylor for incorporation in the collection of the School of Public Health and Tropical Medicine of the University of Sydney. I wish to express my very deep gratitude to the Director, Professor Harvey Sutton, of the School of Public Health, and to my good friend and co-worker on the Diptera, Mr. Frank H. Taylor, to whom I express my deepest thanks for many appreciated favours.

TIPULINAE.

CTENACROSCELIS CONSPICABILIS ANGUSTILINEATA, n. subsp.

♀. Length about 25 mm.; wing, 30 mm.

Characters as in typical *conspicabilis* Skuse (North-eastern Australia), differing in slight details of coloration, especially the conspicuous brown median praescutal vitta, which is yellowish in the typical form; in the present case, it is much darker than the brownish-grey intermediate stripes; lateral praescutal stripes narrowly bordered by yellow. Pleura yellow, without dorsal brown stripe; fore coxae and ventral sternopleurite restrictedly and vaguely darkened. Abdomen with the tergites unbrightened, except laterally.

Holotype, ♀, Rabaul, January, 1933 (F. H. Taylor).

It is possible that the present fly represents a valid species, rather than a race. The antennae have the first flagellar segment elongate, exceeding one-half the second; lower faces of flagellar segments but little protuberant, with a pair of short setae at near midlength.

CTENACROSCELIS GLOBULICORNIS, n. sp.

Belongs to the *umbrinus* group; flagellar segments, ♂, very conspicuously produced on ventral side into nearly globular lobes, each tipped with a long seta; pleural stripe distinct; ventral pleurites and coxae spotted and streaked with pale brown.

♂. Length about 21 mm.; wing, 25 mm.

Frontal prolongation of head brownish-yellow above, darker brown beneath and on sides; nasus long and conspicuous; palpi brownish-black. Antennae with scape dark brown; pedicel pale yellow; flagellum black; flagellar segments beyond the first very strongly produced to appear almost globular, in degree exceeding that of the *serratus* group; a long conspicuous seta at apex of protuberance. Head brownish-black, sparsely pruinose behind; front and anterior orbits narrowly ochreous.

Pronotum blackish-grey medially, pale on sides. Mesonotal praescutum with the four usual stripes grey, bordered by blackish, the latter especially clear and evident as internal borders to the intermediate stripes; lateral borders of praescutum broadly brownish-black, margined internally by a narrow yellow line that forms an outer border to the lateral praescutal stripes; a capillary yellow median vitta on about the anterior two-thirds of praescutum; posterior interspaces darkened, concolorous with the stripes; posterior sclerites of notum chiefly brown; median region of scutellum yellowish; posterior and lateral margins of mediotergite broadly and conspicuously ochreous. Pleura ochreous, with a longitudinal brown stripe from cervical region to beneath the wing-root, becoming more diffuse behind; ventral pleurites and coxae with paler brown spots and streaks. Halteres brown, the knobs brownish-black. Legs with coxae as described; trochanters yellow; femora brownish-yellow, paler ventrally, the tips broadly blackened; tibiae and tarsi uniformly pale yellow. Wings tinged with brownish; cells C and Sc, together with the stigma, darker brown; outer ends of radial cells slightly infumed; m-cu and adjoining parts of Cu<sub>1</sub>, together with the anterior cord, narrowly seamed with brown; obliterative areas before stigma and across cell 1st M<sub>2</sub>; veins brown, except in obliterative areas. Venation: m-cu sinuous at posterior end, placed just before midlength of M<sub>3+4</sub>.

Abdominal tergites chiefly dark brown, each slightly brightened medially at base; lateral borders broadly, the caudal margins more narrowly pruinose; sternites pale yellow, the intermediate segments a little darkened medially, the outer segments uniformly darkened except for narrow pale margins; terminalla and its appendages paler, especially outwardly.

Holotype, ♂, Rabaul, January, 1933 (F. H. Taylor).

This fly is readily told from regional allies of the *umbrinus* group by the unusually produced flagellar segments, which here are fully as developed as in the *serratus* group.

#### TIPULA Linnaeus.

##### PAPUATIPULA, n. subgen.

Frontal prolongation of head elongate, subequal to the remainder of head; nasus distinct. Antennae 13-segmented; flagellar segments with verticils that greatly exceed the segments in length. Tibial spurs long and conspicuous; formula 1-2-2. Wings (Fig. 1) with Rs unusually short but not transverse, approximately two-thirds m-cu; R<sub>2+3</sub> very long and straight, exceeding twice m-cu; R<sub>1+2</sub> entirely atrophied or represented only by a short basal spur; vein R<sub>4</sub> elongate, lying unusually close to the costal border of wing, subequal in length to R<sub>2+3</sub>; cell 1st M<sub>2</sub> elongate, its inner end strongly pointed; cell M<sub>1</sub> deep; m-cu uniting with M<sub>2+4</sub> some distance before its fork, usually at near midlength of the vein. Macrotrichia of veins beyond cord unusually sparse and scattered, there

being a loose series on  $R_{4+5}$  and  $M_1$ ; squama naked. Male terminalia with the tergite separated by a suture from the sternite, fused only at extreme cephalic portion; basistyle fused with sternite. Tergite notched medially. Outer dististyle (Fig. 9) armed with a spinous apical point. Eighth sternite unarmed. Ovipositor with pointed, sclerotized valves.

Type of subgenus.—*Tipula* (*Papuatipula*) *novae-britanniae*, n. sp. (Australasian; Papuan subregion).

Other included species: *Tipula* (*Papuatipula*) *divergens* de Meijere, *T. (P.) leucosticta* Alexander, *T. (P.) meijereana*, new name (for *dentata* de Meijere, preoccupied), and *T. (P.) omissinervis* (de Meijere).

Most nearly allied to the subgenera *Acutipula* Alexander, *Indotipula* Edwards, and *Tipulodina* Enderlein; most readily told by the tibial-spur formula, the venation, and the fundamentals of structure of the male terminalia. This group of the genus *Tipula* has proved to be the most widespread and characteristic of those occurring in New Guinea and will probably be found to include numerous species when the Papuan fauna is better known. In their general appearance, the various forms bear a marked resemblance to one another and are best separated by the characters of the male terminalia.

#### TIPULA (PAPUATIPULA) NOVAE-BRITANNIAE, n. sp.

General coloration of mesonotum obscure yellow, the praescutum with three slightly more fulvous stripes that are indistinctly bordered by darker; wings with a greyish tinge; both cells C and Sc dark brown, concolorous with the stigma and narrow apical border in outer radial cells; seams at anterior cord and on m-cu scarcely evident; petiole of cell  $M_1$  very short, about one-half m; male hypopygium with the outer dististyle a flattened blade, near outer end produced into a powerful blackened spine.

♂. Length about 15 mm.; wing, 16.5 mm. ♀. Length about 22 mm.; wing, 19 mm.

Frontal prolongation of head orange; nasus with conspicuous black setae; palpi brown, paler at incisures and at outer end of terminal segment. Antennae with scape and pedicel yellow; flagellum bicolorous, the bases of the individual segments black, the remainder yellow, the bicolorous nature continued to the very end of the organ. Head pale brown, the inner border of eye narrowly yellow; midline of vertex with a narrow dark vitta.

Ground-colour of mesonotal praescutum obscure yellow, with three slightly more fulvous stripes that are narrowly and indistinctly bordered by darker; median stripe without an evident dark median vitta, as in other species of the subgenus; central portions of scutal lobes chiefly obscure orange, the mesal portions more infuscated; scutellum a little infuscated; mediotergite chiefly yellow. Pleura yellow. Halteres elongate, brown, the basal fifth of stem yellow. Legs with the coxae and trochanters yellow; remainder of legs dark brown; femoral bases rather narrowly more obscure yellow, the intermediate portions yellowish-brown, the tips dark brown. Wings (Fig. 1) with a greyish tinge; both cells C and Sc dark brown, concolorous with the stigma and a narrow apical border in cells  $Sc_2$  and  $R_3$  to the wing-tip; anterior cord and m-cu very narrowly and inconspicuously seamed with darker; veins brownish-black. Venation:  $R_{1+2}$  entirely atrophied; petiole of cell  $M_1$  very short, about one-half m; inner end of cell 1st  $M_2$  strongly pointed; m-cu at or shortly before  $M_{3+4}$ .

Abdomen with intermediate tergites having a glabrous basal ring of a greyish colour, contrasting with the fulvous-orange ground-colour of the tergites; a narrow, transverse yellowish ring immediately caudad of the glabrous ring, this in turn followed by a darker brown band; sternites more uniformly yellow. Male terminalia with the tergite (Fig. 9, *9t*) bearing a flattened lobe on either side of a small median notch; apices of lobes obliquely truncated and set with small blackened spines. Outer dististyle (Fig. 9, *od*) unusually broad and flattened, the cephalic margin near outer end produced into a powerful blackened spine. Inner dististyle with the main blade yellow, somewhat reniform, the outer margin with a single to partly double row of long yellow setae that are angularly bent near tips; at base of blade with two blackened lobes, as shown (Fig. 9, *id*).

Holotype, ♂, Toma, altitude about 1,000 feet, February, 1933 (F. H. Taylor). Allotopotype, ♀.

The nearest allied species is *Tipula* (*Papuatipula*) *meijereana*, n. name (*dentata* de Meijere, preoccupied by *Tipula dentata* Meigen, 1838), of South-western New Guinea, which is somewhat similarly coloured yet differs in the details of venation and structure of the male terminalia.

#### NEPHROTOMA FUMISCUTELLATA, n. sp.

General coloration yellow; occipital brand brown; pronotum entirely pale yellow; mesonotal praescutum yellow, with three dull velvety-black stripes, the median one with the posterior portion and a median extension on to anterior portion shiny plumbeous; scutellum of a medium brown, the base narrowly yellow; femora brownish-yellow; wings strongly tinged with yellowish-brown; basal five abdominal segments almost uniformly reddish-yellow, the extreme caudal borders blackened, the outer abdominal segments black.

♂. Length, 12-13 mm.; wing, 11.5-12.3 mm. ♀. Length, 17-18 mm.; wing, 13-14 mm.

Head yellow; occipital brand brown. Antennae with scape and pedicel yellow; flagellum black throughout.

Pronotum entirely pale yellow. Mesonotal praescutum yellow, with three dull velvety-black stripes, the median one with the posterior half and a further median extension cephalad almost to front border of stripe shiny plumbeous; lateral stripes dull velvety-black, the extreme antero-lateral ends more plumbeous; scutum pale yellow, each lobe chiefly covered by two confluent dull black areas; scutellum chiefly median brown, the base narrowly yellow; mediotergite yellow, the posterior border with a rectangular brown area that is narrowly bordered by darker brown. Pleura yellow, variegated by more reddish on the ventral anepisternum and ventral sternopleurite. Halteres faintly dusky, the knobs chiefly pale yellow. Legs with the coxae and trochanters reddish-yellow; femora brownish-yellow; tibiae brown, somewhat darker outwardly; tarsi passing into black. Wings (Fig. 2) strongly tinged with yellowish-brown, especially before the cord, the outer portions of wing without the yellow tints; stigma oval, brown; veins brown, more yellowish-brown in the flavous areas. Venation: Cell  $M_1$  sessile.

Basal five abdominal segments almost uniformly reddish-yellow, the extreme caudal borders of the basal four tergites narrowly darkened, more broadly so in female; more than outer half of tergite five blackened; remaining segments of abdomen black, the dististyles yellowish.

Holotype, ♂, Toma, altitude about 1,000 feet, February, 1933 (F. H. Taylor). Allotype, ♀, Rabaul, December, 1932 (F. H. Taylor). Paratypes, 1 ♂, with the allotype; 3 ♀, Keravat, January, 1933 (F. H. Taylor).

*Nephrotoma fumiscutellata* is allied to a number of Papuan species that have a somewhat similar pattern on the mesonotal praescutum, these including *N. dimidiata* (de Meijere), *N. melanura* (Osten Sacken) and *N. speculata* (de Meijere), all four species differing among themselves in details of coloration. The present fly is closest to *N. speculata*, differing in the strongly tinted wings and the brown coloration of the scutellum. Of the three species listed above, *N. dimidiata* has the scutellum entirely black; *melanura* entirely yellowish-red; *speculata* dull black, with the base yellow.

#### MEGISTOCERA FUSCANA (Wiedemann).

1821. *Nematocera fuscana* Wiedemann, *Dipt. Exot.*, i, 29.

Widely distributed throughout the Indo-Malayan Islands, as far north as Luzon, Philippine Islands, eastward into north-eastern Australia.

1 ♀, Rabaul, December, 1932 (F. H. Taylor).

#### LIMONIINAE.

##### LIMONIINI.

#### LIMONIA (LAOSA) FALCATA, n. sp.

Antennae yellow, the scape black; legs yellow, the extreme bases of tibiae black; wings with apex narrowly falcate, whitish subhyaline, with two broad crossbands and abundant brown dots in most cells; supernumerary cross-veins in cells  $R_3$  and  $R_5$ .

♂. Length about 9 mm.; wing, 11 mm.

Rostrum black; palpi with basal segments black, the small terminal two segments pale brown. Antennae with scape black; pedicel and flagellum orange-yellow, the narrowed apical half of the terminal segment brown; flagellar segments oval, the outer ones becoming more elongate; longest verticils subequal to the segments. Head with front silvery; posterior vertex brownish-grey, with a capillary dark brown median line; eyes contiguous at a single point on anterior vertex.

Pronotum brown. Mesonotal praescutum with four orange-brown stripes that are narrowly bordered by dark brown, the intermediate pair confluent in front, ending squarely some distance before the suture; lateral stripes with anterior ends bent laterad to margins; humeral region and posterior portion of praescutum more whitish pruinose, the latter traversed by two orange-brown extensions of the intermediate stripes; scutum blackened medially, the lobes with two dull orange areas that are narrowly bordered by brown; scutellum whitish, with a median brown triangle, the point directed cephalad; mediotergite chiefly covered by a dark triangle, its point directed caudad, the lateral angles more intensely darkened; a greyish area on each posterior portion of mediotergite. Pleura light grey, extensively variegated by brown, involving all of anepisternum, with smaller areas on sternopleurite, pteropleurite, pleurotergite and meron; a few yellow setae on sternopleurite. Halteres pale yellow, the knobs dark brown. Legs with coxae brownish-yellow, the mid-coxae more pruinose; trochanters yellow; femora yellow, the tips insensibly darker; tibiae yellow, the bases very narrowly but conspicuously blackened; tarsi yellow, the terminal segments darker, especially the fourth; claws with basal spine and microscopic denticles. Wings

(Fig. 3) whitish subhyaline, with two broad broken brown fasciae and numerous brown dots in most cells; basal band across proximal fourth of wing, beginning narrowly at R, widened behind, broadest in cell M, again narrowed where crossing the cubital and anal cells, reaching posterior margin in cell 2nd A and again at end of vein 2nd A; outer band very broad, virtually traversing the wing and extending from before cord to beyond the level of outer end of cell 1st  $M_2$ , in cell  $R_5$  extending to beyond the supernumerary cross-vein; the latter band variegated by ground-areas in base of cell  $R_5$  and more extensively in cell 1st  $M_2$ ; a more fulvous arm extends from the outer band across the radial field to cell  $R_2$ ; tips of longitudinal veins at margin extensively seamed with fulvous-yellow; all interspaces of wing, except near apex, with abundant brown dots, in cases more crowded and becoming confluent; veins yellow, more reddish-yellow in certain places, especially the outer radial field. Wings of unique conformation in the genus, falcate, the tip narrowed to a point at end of vein  $R_{2+3}$ , thence strongly incised. Costal fringe relatively short; macrotrichia of veins abundant, lacking on 1st A excepting a small group at apex. Venation:  $Sc_1$  ending about opposite  $R_{2+3}$ ,  $Sc_2$  at its tip; free tip of  $Sc_2$  and  $R_3$  both pale, the former more than its length beyond  $R_2$ ,  $R_{1+2}$  continued beyond it as a conspicuous spur provided with macrotrichia;  $Rs$  straight, oblique; supernumerary cross-veins in cells  $R_3$  and  $R_5$ , the former more oblique and lying more distad; cell 1st  $M_2$  widened outwardly,  $m$  straight, transverse, a little shorter than the arcuate basal section of  $M_3$ ;  $m-cu$  more than its own length beyond fork of  $M$ ; anal veins divergent, converging only at bases.

Abdomen with basal tergite pale orange; remainder of tergites dark brown, the caudal margins slightly paler; basal half of segment two more testaceous-yellow. Male terminalia (Fig. 10) of the usual type of the subgenus; tergite,  $9t$ , with caudal margin nearly transverse; ventral dististyle,  $vd$ , with prolongation long and slender, the two spines from a pale tubercle at base of prolongation; face of ventral dististyle with a long pale lobe that is tipped with elongate yellow setae.

Holotype, ♂, Rabaul, January, 1933 (F. H. Taylor).

I refer this very distinct fly to the subgenus *Laosa* Edwards (*Encycl. Ent.*, Diptera, 3, 1926, 48), where it is most closely allied to *Limonia* (*Laosa*) *manobo* Alexander (Mindanao), differing in the abundantly dotted, falcate wings, coloration of the antennae and legs, and numerous other characters. If *Laosa* is to be maintained as distinct from *Libnotes*, its characters will have to be slightly modified so as to include all those species of the last-named subgenus having one or two supernumerary cross-veins in the outer radial field of the wing. Besides the subgenotype, *gloriosa* Edwards, and the two species above mentioned, the subgenus will include the following: *L. (L.) diphragma* Alexander (western China); *L. (L.) fuscineris* (Brunetti) (Himalayas, Western China); *L. (L.) regalis* (Edwards) (Formosa); *L. (L.) riedelella* Alexander (New Guinea); and *L. (L.) transversalis* (de Meijere) (Formosa to Java). The strongly falcate wings of the present fly are quite unique in the genus, but may well prove to be a male character only. The wing-tip of the unique type is slightly injured, but it is believed that the figure as given is nearly correct.

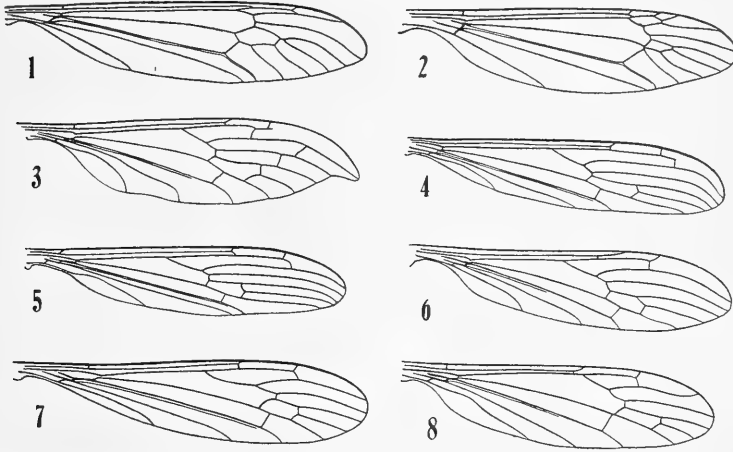
#### LIMONIA (LIBNOTES) SUTTONI, n. sp.

General coloration brownish-yellow, the mesonotum unmarked except for a dark area on either side of the mediotergite; knobs of halteres blackened; legs



yellow, the outer tarsal segments and very narrow tips of tibiae dark brown; wings yellow, sparsely variegated with brown; free tip of  $Sc_2$  more than twice its length before  $R_2$ ; inner ends of cells 2nd  $M_2$  and  $M_3$  about on a level; anal veins convergent at bases; male terminalia with the ventral dististyle small, oval, the rostral prolongation elongate, without definitely modified spines.

♂. Length about 14 mm.; wing, 15.5 mm.



Text-figs. 1-8.

1. *Tipula (Papuatipula) novae-britanniae*, n. sp., venation.
2. *Nephrotoma fumiscutellata*, n. sp., venation.
3. *Limonia (Laosa) falcata*, n. sp., venation.
4. *Limonia (Libnotes) suttoni*, n. sp., venation.
5. *Limonia (Libnotes) eboracensis*, n. sp., venation.
6. *Limonia (Libnotes) erythromera*, n. sp., venation.
7. *Limonia (Limonia) distivena*, n. sp., venation.
8. *Limonia (Dicranomyia) magnistyla*, n. sp., venation.

Rostrum brownish-yellow, darker medially; palpi pale yellow, the first segment darker basally. Antennae with scape and pedicel yellowish-brown, flagellum brown; basal flagellar segments globular, beyond the third becoming more oval, the outer segments rapidly passing into long-oval, the outer ones elongate; terminal segment long and slender, nearly twice the penultimate; verticils of intermediate segments about twice the segments alone. Head fulvous; anterior vertex reduced to a narrow strip that is only about one-fourth the diameter of the scape.

Mesothorax uniformly brownish-yellow, without markings, except for a brown spot on either side of the mediotergite. Halteres pale yellow, the knobs blackened. Legs yellow, the outer tarsal segments and very narrow apices of the tibiae dark brown; apices of femora with a dense group of setae. Wings (Fig. 4) tinged with yellow, very sparsely variegated with pale brown, as follows: Origin of  $R_s$ ; along cord and outer end of cell 1st  $M_2$ ; basal section of  $Sc_2$ ; free section of  $Sc_2$  and  $R_2$ ; outer portion of vein  $Cu$ , and tip of vein 2nd  $A$ ; a narrow infuscation at wing-apex in medial field; veins pale brown, darker in the clouded areas, in prearcular and costal fields clearer yellow. Costa incassated to apex of  $R_3$ , densely set with short trichia; vein  $R_1$  (between free apex of  $Sc_2$  and  $R_2$ ) with about nine macrotrichia.

Venation: Free apex of  $Sc_2$  more than twice its length before  $R_2$ ;  $R_{1+2}$  projecting slightly beyond  $R_2$  as a small spur bearing a single trichium;  $R_3$  bent very strongly caudad, terminating beyond wing-apex; r-m short; inner ends of cells 2nd  $M_1$  and  $M_2$  about on a level; m-cu at about one-third the length of cell 1st  $M_2$ ; anal veins converging near bases.

Abdominal segments obscure orange, the caudal borders of the intermediate segments very narrowly pale, preceded by a more blackish crossband. Male terminalia (Fig. 11) with the median area of caudal border of tergite,  $9t$ , very gently emarginate, the setae chiefly distributed along border. Ventral dististyle,  $vd$ , very small, its body subglobular to short-oval, prolonged into a slender, gently curved rostral prolongation; face of style with a small tubercle, the whole surface with unusually long, coarse setae, none of which is modified into a spine. Gonapophyses,  $g$ , with mesal-apical lobe straight, narrowed to an acute point.

Holotype, ♂, Keravat, January, 1933 (F. H. Taylor).

I take great pleasure in naming this distinct species in honour of Professor Harvey Sutton, Director of the School of Public Health and Tropical Medicine. By Edwards's key to the species of *Libnotes* (*Journ. Fed. Malay Str. Mus.*, xiv, 1928, 74-80), the present fly runs to couplet 28, where it disagrees with all species beyond by the nature of the wing- and leg-pattern, and, especially, the venation of the radial field of the wing. It agrees in some regards with *Limonia* (*Libnotes*) *sphagnicola* (Edwards), but is very distinct from this and all other described species known to me.

LIMONIA (LIBNOTES) EBORACENSIS, n. sp.

General coloration of thorax dark grey; palpi and antennal flagellum black; eyes of ♂ contiguous on anterior vertex; posterior vertex with a narrow black median line; legs reddish-brown; wings pale yellowish subhyaline, with three very pale brown, diffuse crossbands; m-cu at midlength of cell 1st  $M_2$ ; male hypopygium with the rostral prolongation of ventral dististyle bearing a series of four slender spines.

♂. Length about 11 mm.; wing, 12.5 mm.

Rostrum pale brown; palpi black, apparently only 3-segmented. Antennae with scape and pedicel dark brown, flagellum black; basal flagellar segments oval, with long, unilaterally arranged verticils that exceed the segments in length; outer flagellar segments becoming very long and slender. Head brownish-grey, the posterior vertex with a narrow blackish median line; anterior vertex more silvery; eyes contiguous for a short space on vertex.

Pronotum and mesonotum dark grey, somewhat clearer grey on lateral portions of praescutum and on pleura; praescutum with vague indications of stripes; pleurotergite somewhat paler and less pruinose. Halteres yellow, the knobs dark brown. Legs with the fore coxae darkened, the remaining coxae chiefly pale; remainder of legs reddish-brown, the outer tarsal segments blackened. Wings (Fig. 5) with the ground-colour pale yellowish-subhyaline, the prearcular and costal regions clear luteous; three diffuse but conspicuous, pale brown crossbands, the first very extensive, postarcular, occupying most of region before origin of  $Rs$ ; second band at and just beyond cord, extending from tip of  $Sc_1$  to posterior border, the centre of cell 1st  $M_2$  more or less pale; the third band is palest and least evident of all, occupying the wing-apex; seam at  $R_2$  heavier and more distinct; veins pale yellow, darker in the clouded areas.

Venation:  $R_1$  and  $R_2$  forming an evenly arcuated element beyond the free tip of  $Sc_2$ , the latter pale, erect; cells beyond cord long and narrow, the veins parallel; inner ends of cells  $2nd\ M_2$  and  $M_3$  about in transverse alignment; m-cu at mid-length of cell  $1st\ M_2$ ; anal veins convergent at bases.

Abdomen with basal tergite yellow, the remaining segments deep orange-fulvous; centres of discs of individual tergites a little darkened; terminalia yellow. Male terminalia (Fig. 12) with the tergite,  $9t$ , narrowly transverse, the median region of caudal margin very restrictedly and shallowly emarginate; setae of tergite chiefly along caudal border, including a linear row of about eight on either side of median line. Basistyle,  $b$ , of moderate size. Ventral dististyle,  $vd$ , considerably smaller in area than basistyle, produced into a darkened rostral prolongation that bears near its base a linear row of four (or possibly five) slender spines with obtuse tips. Aedeagus,  $a$ , broad.

Holotype, ♂, Duke of York Island (Dr. Hosking).

*Limonia (Libnotes) eboracensis* is allied to species such as *L. (L.) subfasciata* Edwards (Buru) and *L. (L.) trifasciata* Edwards (Pahang) in the presence of pale but distinct crossbands on the wing. From the former species it is readily told by the coloration, together with the position of the m-cu crossvein; from the latter it is told by the grey coloration of the thorax, coloration of the head, and, especially, the structure of the male hypopygium. From the unique type, I am uncertain as to whether there are four or five rostral spines.

#### LIMONIA (LIBNOTES) ERYTHROMERA, n. sp.

General coloration reddish-yellow, the mesonotum, pleura and abdomen unmarked; rostrum, palpi and antennae black; knobs of halteres and legs chiefly brownish-black; wings subhyaline, the prearcular and costal regions more yellowish; stigma and a narrow apical border brown;  $R_s$  unusually straight and oblique for a member of this group; anal veins parallel at origin; male terminalia with two very unequal rostral spines.

♂. Length about 8.5 mm.; wing, 7.8 mm.

Rostrum and palpi black. Antennae black throughout; flagellar segments oval, becoming more elongate outwardly, the terminal segment about one-third longer than the penultimate; longest verticils unilaterally arranged, about one-half longer than the segments. Head black; eyes contiguous on anterior vertex.

Extreme cephalic portion of pronotum darkened; remainder of thorax, including pleura, reddish-yellow, only the ventral sternopleurite restrictedly blackened. Halteres short, pale, the knobs blackened. Legs with the coxae and trochanters reddish-yellow; femora with bases obscure yellow, more extensively so on posterior legs, soon passing into brownish-black; tibiae brownish-black, the tarsi more reddish-brown; claws with basal spine. Wings (Fig. 6) subhyaline, the prearcular and costal regions more yellowish; stigma small, subcircular, brown; wing-apex and margin as far as  $Cu_1$  narrowly suffused with blackish; veins black, more brownish-yellow in the costal and prearcular regions. Venation:  $h$  apparently lacking;  $Sc_1$  ending opposite midlength of  $R_{2+3}$ ,  $Sc_2$  far from its tip,  $Sc_1$  alone about two-thirds  $R_s$ ; free tip of  $Sc_2$  and  $R_2$  subequal, pale;  $R_s$  unusually straight and oblique for this group, about four times the basal section of  $R_{4+5}$ ; veins  $R_3$  and  $R_{4+5}$  extending parallel to one another to margin; m-cu at midlength of cell  $1st\ M_2$ ; anal veins parallel at origin.

Abdomen reddish; terminalia with the ventral dististyles dusky. Male terminalia (Fig. 13) with tergite,  $9t$ , only gently notched, the margins of the

lobes thickened and provided with numerous setae. Ventral dististyle, *vd*, much larger than the basistyle; rostral prolongation stout, with two very unequal spines, the innermost a mere seta that is about two-thirds the length of the outer. Gonapophyses, *g*, with mesal-apical lobe blackened, the margin microscopically roughened into pale spinous points.

Holotype, ♂, Makada Island, Duke of York Group, February, 1933 (F. H. Taylor).

By Edwards's key to the species of *Libnotes* (l.c.), the present fly runs to couplet 61, disagreeing with the species involved and all others since described, in the uniform reddish coloration of the thorax and abdomen. The general appearance, course of the anal veins, and structure of the male terminalia, are all much as in *Limonia* (*Libnotes*) *novae-britanniae* (Alexander), *L. (L.) parvistigma* (Alexander), *L. (L.) semitristis* (Alexander) and *L. (L.) tayloriana* Alexander, all of the Australian and Papuan subregions, but the coloration of the body, wing-pattern, straight Rs, and shallowly emarginate tergite of the terminalia readily serve to distinguish the present fly from other similar forms.

LIMONIA (LIBNOTES) TAYLORIANA Alexander.

*Ann. Mag. Nat. Hist.*, (10) v, 1930, 149.

Known before only from the male sex, taken at Mossman, North Queensland, March, 1927, by F. H. Taylor.

One ♀, Keravat, January, 1933 (F. H. Taylor).

LIMONIA (LIBNOTES) OBLIQUA (Alexander), var.

*Libnotes obliqua* Alexander, *Rec. South Australian Mus.*, ii, 1922, 232.

Three ♂, Rabaul, January, 1933 (F. H. Taylor). One ♀, Keravat, January, 1933 (F. H. Taylor).

♂. Length about 5.5-5.8 mm.; wing, 6.4-6.8 mm. ♀. Length about 5.5 mm.; wing, 6 mm.

These specimens differ from the type (Cairns district, North Queensland) in the distinct, dark brown, median praescutal stripe, which contrasts conspicuously with the yellow to golden-yellow remainder of praescutum, the lateral stripes being obsolete or nearly so.

Much uncertainty still exists as to the exact limits of the species or races that centre about the fly formerly called *nervosa* de Meijere. This problem has been outlined briefly by Edwards (*Insects of Samoa, Nematocera*, part vi, fasc. 2, 1928, 80) and by the present writer (*Arch. für Hydrobiol.*, suppl. Band 9, *Tropische Binnengewässer*, ii, 1931, 160). Members of the complex range from Ceylon (*immaculipennis* Senior-White) throughout the Greater Sunda Islands (*nervosa* de Meijere) into North Queensland (*obliqua* Alexander, *subaequalis* Alexander) and thence to certain of the major oceanic island groups (*manni* Alexander, Solomons; *samoensis* Alexander, Samoa).

The name *nervosa* de Meijere (*Tidj. voor Ent.*, liv, 1911, 36) unfortunately is preoccupied by a prior usage of the name in the same paper (l.c., p. 26) and, in my opinion, both names are homonyms of a still earlier use of the name *nervosa* in the comprehensive generic concept *Limonia* (*Limnobia*). The next available name for a member of the group is *samoensis* Alexander (*Bull. Brooklyn Ent. Soc.*, xvi, 1921, 9), common and well known in the Samoan group. Of this species, or race, Edwards had rather abundant material for study, and this showed a surprising range in character of size, coloration and venation,

together with marked differences between the sexes. Small males tended to resemble the females in venation and stigmal size rather than the larger and more highly developed males. This unusual range in size and coloration makes it doubtful whether, in the above complex, we are dealing with a group of closely allied and generally similar species or whether these are nothing but subspecies or forms of a single species of great geographic range. The type of structure of the male terminalia is generally similar in all of these species in which the organ has been studied, but the same statement holds true for most other members of *Libnotes* where, on terminalian characters, the abundant species fall in only a few groups, showing a curious monotony of structure. This latter case especially holds true in the typical form of *Libnotes*, where a peculiar type of terminalia is found, and which, moreover, recurs in two other supposedly valid subgenera (*Laosa* Edwards, typical *Limonia* Meigen). If it is found that members of the *samoensis* group now under discussion represent but one or few species, then it seems certain that there will occur a similar and even more drastic consolidation of species names in other groups of *Libnotes*. Males of the species or subspecies of the present group in the Australasian region may be separated by the accompanying key.

1. Median praescutal stripe obsolete, the laterals continued across the suture on to the scutal lobes ..... *samoensis* Alexander
- Median praescutal stripe distinct, the laterals present or obsolete ..... 2
2. Radial and subcostal cells basad of stigma strongly suffused with brown .....
- ..... *manni* Alexander<sup>1</sup>
- No infuscation in the cells basad of stigma ..... 3
3. All elements of anterior cord of wings subequal in length and lying subtransverse to the length of wing .....
- ..... *subaequalis* Alexander<sup>2</sup>
- Elements of cord more oblique, Rs either distinctly longer or lying more proximad than the other elements .....
- ..... *obliqua* Alexander<sup>3</sup>

LIMONIA (LIBNOTES) SOLOMONIS (Alexander).

*Libnotes solomonis* Alexander, *Ann. Mag. Nat. Hist.*, (9) xiii, 1924, 39.

Described from the Solomon Islands. Rabaul, two ♂, one ♀, December, 1932, to January, 1933 (F. H. Taylor).

This species is allied to *notata* (van der Wulp), but is readily told from this species and all others in the group by the broad, conspicuous, black bases of all tibiae, in conjunction with the undarkened apices of the same. The vestiture of the femora is reduced to very short spinous setae. Apices of cerci bidentate.

LIMONIA (LIMONIA) SUBALBITARSIS Alexander.

*Philippine Journ. Sci.*, xli, 1930, 299.

Described from Luzon, Philippine Islands. One ♂, Keravat, January, 1933 (F. H. Taylor).

LIMONIA (LIMONIA) DISTIVENA, n. sp.

General coloration dark brown, the pleura somewhat paler than the central portions of the mesonotum; antennae black throughout, the flagellar segments moniliform, each with short but conspicuous necks; wings tinged with brown, the small stigma a little darker; macrotrichia of veins long and conspicuous; inner end of cell 1st M<sub>2</sub> arcuated; m-cu unusually far distad, lying more than one-half its length beyond the fork of M.

<sup>1</sup> *Libnotes manni* Alex., *Ann. Mag. Nat. Hist.*, (9) xiii, 1924, 41.

<sup>2</sup> *L. subaequalis* Alex., *Ibid.*, (9) viii, 1921, 554.

<sup>3</sup> *L. obliqua* Alex., *Rec. South Australian Mus.*, ii, 1922, 232.

♀. Length about 3.2 mm.; wing, 4 mm.

Rostrum and palpi black. Antennae black throughout; flagellar segments very strongly moniliform, the segments globular, with short glabrous black necks; outer segments more oval, but similarly pedicellate; longest verticils unilaterally arranged and exceeding the segments. Head dark grey.

Mesonotum relatively gibbous, projecting cephalad over the small pronotum. Pronotum dark brown. Mesonotum dark brown, the praescutum somewhat paler laterally. Pleura brown, the propleura slightly darker. Halteres with stem black, the base narrowly pale, the knobs broken. Legs with the coxae brown; trochanters testaceous; remainder of legs broken. Wings (Fig. 7) tinged with brown, the small, short-oval stigma a little darker brown; veins darker brown. Macrotrichia of veins long and conspicuous, including all longitudinal veins beyond cord; all of Rs excepting the extreme base; distal half of main stem of M; distal third of basal section of Cu<sub>1</sub> and extreme tips of both anal veins. Venation: Sc<sub>1</sub> ending about opposite two-thirds to three-fourths the length of Rs, Sc<sub>2</sub> at its apex; free apex of Sc<sub>2</sub> pale, lying a little basad of level of R<sub>2</sub>; inner end of cell 1st M<sub>2</sub> arcuated; m-cu more than one-half its length beyond the fork of M; cell 2nd A narrow.

Abdominal tergites brownish-black; sternites paler, brownish-yellow. Cerci slender, the tips acute.

Holotype, ♀, Keravat, January, 1933 (F. H. Taylor).

The present fly is most nearly allied to the Philippine *Limonia* (*Limonia*) *retrusa* Alexander, being told from this and other small similar members of the subgenus by the distal position of m-cu.

LIMONIA (GERANOMYIA) MANCA (Alexander), var.

*Geranomyia* (*Geranomyia*) *manca* Alexander, *Ann. Mag. Nat. Hist.*, (9) xiii, 1924, 180.

One ♂, Toma, altitude about 1,000 feet, February, 1933 (F. H. Taylor).

Close to the typical form (North Queensland) but differing in having the outer field of wing darkened to the wing-tip; m-cu fully its own length beyond the fork of M, exceeding in length the distal section of Cu<sub>1</sub>; vein 2nd A at near midlength, gently but distinctly concave. Male terminalia with the tergite narrow, transverse. Ventral dististyle very large and fleshy, much larger than in *argentifera* and allies; apex of rostral prolongation beyond the spines short and stubby. Dorsal dististyle long and unusually slender, strongly arcuated. Gonapophyses with the mesal-apical lobe slender, but provided with setae, as in all members of the *sorbillans* group.

LIMONIA (IDIOGLOCHINA) NEAR NOVOCALÉDONICA Alexander.

*Limonia* (*Idioglochina*) *novocaledonica* Alexander, *Encycl. Entomol.*, Dipt., v, 1929, 90.

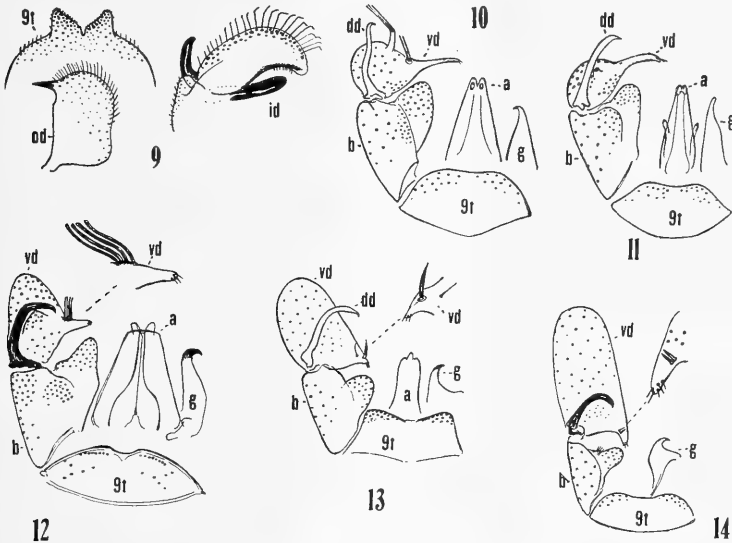
One broken ♂, Duke of York Island (Dr. Hosking).

LIMONIA (DICRANOMYIA) MAGNISTYLA, n. sp.

Belongs to the *punctulata* group; nearest to *kulin*; thorax dark grey; the praescutum with an ill-defined median stripe; femora brown, the tips very narrowly and abruptly yellow; wings of ♂ with long, conspicuous costal fringe; male terminalia with ventral dististyle very large and fleshy; rostral spines two, unusually short.

♂. Length about 3.8 mm.; wing, 4.3 mm.

Rostrum and palpi black. Antennae black throughout; pedicel enlarged; basal flagellar segments globular, the outer ones passing into oval. Head brownish-grey; anterior vertex reduced to a linear strip that is about one-half wider than a single row of ommatidia.



Text-figs. 9-14.

9. *Tipula* (*Papuatipula*) *novae-britanniae*, n. sp., male hypopygium, details.
10. *Limonia* (*Laosa*) *falcata*, n. sp., male hypopygium.
11. *Limonia* (*Libnotes*) *suttoni*, n. sp., male hypopygium.
12. *Limonia* (*Libnotes*) *eboracensis*, n. sp., male hypopygium.
13. *Limonia* (*Libnotes*) *erythromera*, n. sp., male hypopygium.
14. *Limonia* (*Dicranomyia*) *magnistyla*, n. sp., male hypopygium.

Thorax uniformly dark grey or dark plumbeous, the praescutum with a very ill-defined brown median stripe that is divided behind. Halteres pale, the base of knobs restrictedly darkened. Legs with the coxae brown; trochanters obscure yellow; femora dark brown, the bases restrictedly obscure yellow, the apices very narrowly and abruptly obscure yellow; tibiae paler brown; tarsi chiefly obscure yellow, the outer segments darkened. Wings (Fig. 8) with the ground-colour greyish-white, the prearcular and costal portions to apex clear pale yellow; a restricted grey spotted pattern, arranged as in the *punctulata* group; about three such spots in cell C beyond the humeral area; a dark spot at midlength of cell  $R_2$ ; veins pale brown or yellowish-brown, darker in the infuscated areas. Costal fringe (at least in ♂) very long and conspicuous. Venation as in group.

Abdomen dark brown. Male terminalia (Fig. 14) with the tergite, *9t*, transverse, the caudal margin very shallowly emarginate. Basistyle, *b*, small. Ventral dististyle, *vd*, very large and fleshy, its greatest length nearly equal to two and one-half times that of the dorsal dististyle; rostral prolongation small, with two unusually small spines placed on the side of the prolongation, near the lower margin; spines shorter than the diameter of the prolongation at point of insertion;

distance between spines shorter than the diameter of either. Gonapophyses, *g*, with the mesal-apical angle a slender curved hook.

Holotype, ♂, Rabaul, February, 1933 (F. H. Taylor).

The present species is readily told from all allies in the small size, long costal fringe and the structure of the male terminalia, especially the ventral dististyle and its rostral armature. The species having the terminalia and costal fringe most similar is *Limonia* (*Dicranomyia*) *kulin* Alexander (Victoria and New South Wales), a much larger fly with unvariegated costal region and with the spines of the rostral prolongation conspicuously more elongate.

LIMONIA (PSEUDOGLOCHINA) HOSKINGI, n. sp.

Mesonotum dark brown, the ventral thoracic pleura blackened; posterior femora uniformly blackened; all tibiae white, with two dark rings, the more basal one narrower on fore and hind tibiae, broader on mid-tibiae; wings with cell 2nd  $M_2$  deep, nearly twice its petiole; vein 2nd A unusually short and arched.

♀. Length about 6 mm.; wing, 6.3 mm.

Head broken.

Mesonotum dark brown, not or scarcely variegated by paler. Pleura chiefly blackened, including the entire sternopleurite, the dorsal pleurites more testaceous-brown. Halteres broken. Legs with the coxae obscure yellowish-testaceous; trochanters a little darker; fore femora obscure brownish-yellow, narrowly tipped with dark brown; mid-femora chiefly infuscated on basal half, thence passing into dirty white, becoming restrictedly pure white just before the narrow dark-brown apices; posterior femora entirely blackened; all tibiae pure white, the fore and hind pair each with two narrow black rings, the more basal one narrower and somewhat paler than the outer or post-medial band; on mid-tibiae, the basal black ring is much more extensive than the outer, being fully twice as wide, about two-thirds as extensive as the white enclosed annulus; tarsi white. Wings (Fig. 15) greyish-subhyaline; stigma oval, very distinct; veins brownish-black. Venation: Sc relatively short,  $Sc_1$  ending shortly before origin of Rs,  $Sc_2$  some distance from its tip,  $Sc_1$  alone longer than Rs; cell 2nd  $M_2$  deep, nearly twice its petiole; vein 2nd A unusually short and arched.

Abdominal tergites dark brown; sternites pale yellow.

Holotype, ♀, Rabaul, February, 1933 (F. H. Taylor).

I take pleasure in naming this species after Dr. Hosking, who collected several Tipulidae near Kokopo, New Britain. This is the first species of the subgenus from the Australasian region having two dark tibial rings, the two forms hitherto made known, *Limonia* (*Pseudoglochina*) *laticincta* (Edwards), of Samoa, and *L. (P.) pulchripes* (Alexander), of North Queensland, having a single darkened ring. From Malayan species having a single tibial annulus, as *L. (P.) kobusi* (de Meijere), of Java, and *L. (P.) unincinctipes* (Alexander) of Borneo and the Philippines, the present fly is amply distinct. The Oriental species having two tibial rings, as *L. (P.) bilator* Alexander, *L. (P.) bilatissima* Alexander, *L. (P.) pictipes* (Brunetti), *L. (P.) riukiensis* Alexander, and others, are readily told by the details of wing- and leg-pattern and the venation.

LIMONIA (THRYPTICOMYIA) ARACHNOPHILA (Alexander).

*Dicranomyia* (*Thrypticomomyia*) *arachnophila* Alexander, *Philippine Journ. Sci.*, xxxiii, 1927, 301.

Described from the Philippines. Keravat, January, 1933, February, 1933 (F. H. Taylor).



## LIMONIA (EUGLOCHINA) NOVAE-GUINEAE YORKENSIS, n. subsp.

Similar to typical *novae-guineae* in the large size (wing, ♂, more than 11 mm.); thorax reddish-brown; halteres and abdomen black; proximal third of basitarsus black, the remainder of tarsi yellowish-white.

♂. Length about 13 mm.; wing, 11.5 mm.

Rostrum and palpi brownish-black. Antennae black throughout; flagellar segments elongate-oval, very slender. Head dark brown.

Thorax reddish-brown. Halteres black. Legs with the coxae and trochanters reddish-brown; femora brownish-black, obscure yellow basally; fore tibiae brown, middle and hind tibiae brownish-black to black; basitarsi with a little more than the proximal third black, the remainder of tarsi yellowish-white. Wings (Fig. 16) hyaline, the tip weakly infumed; stigma oval, darker brown; veins brownish-black. Venation as shown.

Abdomen black.

Holotype, ♂, Duke of York Islands (Dr. Hosking).

The typical form of *Limonia (Euglochina) novae-guineae* (de Meijere), *Tijd. voor Ent.*, lviii, 1915, 101, Pl. 1, fig. 7, wing-apex) differs in the uniform brownish-yellow coloration of the body, including the abdomen; yellowish tibiae and basitarsi, and the yellow halteres. The type of this form was from "Hollandia", on the west coast of Humboldt Bay, Northern New Guinea (2° 32' 29" S. Lat., 140° 44' 12" E. Long.).

## HELIUS (RHAMPHOLIMNOBIA) PAPUANUS Alexander.

*Philippine Journ. Sci.*, liv, 1934 (in press).

A part of the type-material of this species was from Laup, New Britain (Dr. Hosking).

## HEXATOMINI.

## ELEPHANTOMYIA (ELEPHANTOMYODES) TAYLORIANA, n. sp.

General coloration black; halteres and legs black throughout; wings strongly suffused with blackish; cell 2nd A very long and narrow; abdomen black, the bases of the segments broadly greyish-nacreous.

♂. Length, excluding rostrum, about 6.5 mm.; wing, 7 mm.; rostrum, 3.5 mm.  
♀. Length, excluding rostrum, about 6 mm.; wing, 5.5 mm.; rostrum, 2 mm.

Rostrum black, about one-half the length of body in male, much shorter in female, as shown by measurements. Antennae black, the verticils very long and conspicuous. Head blackish.

Thorax entirely polished black. Halteres black. Legs with the coxae blackish on outer faces, the inner faces and all trochanters more brownish-testaceous; remainder of legs, including all tarsi, black. Wings (Fig. 17) strongly suffused with blackish, especially the basal region and cells C and Sc; origin of Rs and cord seamed with darker brown, more broadly so in male; veins black. Venation: Rs perpendicular at origin; anterior branch of Rs running very close to main stem; m-cu from about one-half to three-fourths its length beyond fork of M; cell 2nd A very long and narrow.

Abdomen conspicuously ringed with black and greyish-nacreous, the latter colour occupying the bases of the segments and involving a little less than one-half the segments; terminalia black. Ovipositor with the cerci black, only the extreme apices pale; hypovalvae black on basal half, the distal end bright horn-yellow.

Holotype, ♂, Keravat, January, 1933 (F. H. Taylor). Allotype, ♀, Toma, altitude about 1,000 feet, February, 1933 (F. H. Taylor).

*Elephantomyia* (*Elephantomyodes*) *tayloriana* is named in honour of the collector of this valuable series of Tipulidae, Mr. F. H. Taylor. It is strikingly different from the other species with black feet in the body-coloration and unusually long and narrow cell 2nd A of the wings. The Australian *E. (E.) fumicosta* Alexander (Queensland-Northern New South Wales) is readily told by the snowy-white tarsi.

## ERIOPTERINI.

## CONOSIA IRRORATA (Wiedemann).

*Limnobia irrorata* Wiedemann, *Aussereur. zweifl. Ins.*, i, 1828, 574.

One example of this widespread crane-fly, Keravat, January, 1933 (F. H. Taylor).

## TRENTEPOHLIA (TRENTEPOHLIA) PICTIPENNIS Bezzi.

*Trentepohlia pictipennis* Bezzi, *Philippine Journ. Sci.*, xii, D, 1917, 115.

The present specimens greatly extend the known range of the species to the east. One ♀, Rabaul, January, 1933 (F. H. Taylor). One ♂, Keravat, February, 1933 (F. H. Taylor).

The rather numerous species of *Trentepohlia* now known from New Britain may be separated by the following key:

1. Wings with cell 1st  $M_2$  closed; three outer medial veins,  $M_{1+2}$ ,  $M_3$  and  $M_4$ . . . . . 2  
Wings with cell 1st  $M_2$  open by the atrophy of m and the two distal sections of  $M_3$ ; two outer medial veins,  $M_{1+2}$  and  $M_4$  (*Trentepohlia* Bigot) . . . . . 7
2. Vein  $R_3$  atrophied (*Plesiomongoma* Brunetti) . . . . . *novae-britanniae*, n. sp.  
Vein  $R_3$  preserved (*Mongoma* Westwood) . . . . . 3
3. Apices of femora black or only vaguely brightened . . . . . 4  
Apices of femora and bases of tibiae broadly and conspicuously white . . . . .  
. . . . . *australasiae* Skuse
4. Tibiae entirely dark, not dilated at tips . . . . . *brevipennis* Alexander  
Apices of tibiae whitened; mid-tibiae conspicuously dilated at tips in *pennipes* and *subpennata* . . . . . 5
5. Basitarsi not darkened . . . . . *pennipes* (Osten Sacken)  
Basitarsi blackened, at least on proximal ends . . . . . 6
6. Costal fringe of wings long and conspicuous, especially in male; cell  $R_3$  at wing-margin less than one-half as extensive as cell  $R_2$ ; tibiae not dilated at tips; basitarsi darkened only at extreme bases; mid and hind femora with spines at bases . . . . . *costofimbriata*, n. sp.  
Costal fringe short in both sexes; cell  $R_2$  at wing-margin very wide, more extensive than cell  $R_3$ ; tibiae, especially the middle pair, conspicuously dilated at outer ends; basitarsi extensively blackened; mid and hind femora without spines . . . . . *subpennata*, n. sp.
7. Basal abdominal segments orange, the terminal segments black . . . . .  
. . . . . *trentepohlina* (Wiedemann)  
Abdomen black throughout . . . . . *pictipennis* Bezzi

## TRENTEPOHLIA (PLESIOMONGOMA) NOVAE-BRITANNIAE, n. sp.

General coloration pale yellow, the mesonotum a little darker; legs brown, the narrow tips of tibiae and all tarsi snowy-white; wings whitish-subhyaline, unmarked.

♂. Length about 6 mm.; wing, 6 mm.

Rostrum pale yellow, whitish-pruinose; palpi pale yellow. Antennae with basal two segments yellow; flagellum broken. Head very pale grey; anterior vertex reduced to a strip.

Pronotum pale yellow. Mesonotum chiefly pale reddish-brown, the scutal lobes and posterior portions of mediotergite darker brown; scutellum and median area of scutum more testaceous-yellow. Pleura pale yellow. Halteres yellow throughout. Legs (middle legs broken) with coxae and trochanters pale yellow; femora and tibiae pale brown, the apices of tibiae (distal eighth or less) and all tarsi snowy-white; fore femora with a linear group of four black setae near base, the outermost more powerful; in addition to these, with scattered, semi-erect black setae distributed throughout the length of the segment; posterior femora with a series of about 15 short, spine-like setae in a linear row near base, with additional, gradually more elongated setae distributed at increasing intervals throughout the length of the segment. Wings (Fig. 18) whitish-subhyaline, unmarked; veins pale brownish-yellow. Venation: Inner ends of cells  $R_5$  and  $M_3$  lying somewhat more basad than that of 2nd  $M_2$ ; m-cu shortly before fork of M.

Abdominal tergites pale brownish-yellow; sternites somewhat paler.

Holotype, ♂, Rabaul, January, 1933 (F. H. Taylor).

The occurrence of *Trentepohlia (Mongoma) pennipes* (Osten Sacken) in New Britain makes it advisable to compare the two flies critically, since it seems very obvious that the present species has been derived directly from species like *pennipes* through the total loss of vein  $R_3$  of the wings. Edwards (*Journ. Fed. Malay Str. Mus.*, xvi, 1931, 499) has recorded a specimen of *pennipes* from Borneo in which vein  $R_3$  is entirely lacking, making the specimen conform to the characters of *Plesiomongoma*. I have likewise seen specimens of *pennipes* with this abnormality, either on a single wing or on both wings. The present fly differs from *pennipes* in the pale wing veins, very narrow white tibial tips, and the evenly arcuated vein  $R_4$ , this vein in *pennipes* showing a slight angulation at the point of departure of vein  $R_3$ . The known species of the subgenus may be separated by the following key:

1. Wings with cell 1st  $M_2$  open by atrophy of m; mid-tibiae near apex with long, conspicuous fringes or paddles of black and white setae (Pahang, Sumatra, Borneo) ..... *nigropennata* Edwards  
Wings with cell 1st  $M_2$  closed; legs without modified hair fringes ..... 2
2. Wings with veins pale, stigma lacking; halteres yellow throughout; legs pale brown, the tarsi and narrow tips of tibiae white; no brightening of genua (New Britain) ..... *novae-britanniae*, n. sp.  
Wings with veins black, distinct; cord more or less seamed with darker; halteres with darkened knobs; legs not patterned as above ..... 3
3. Legs pale brown; femoral tips and tibial bases broadly white; tibiae chiefly white, in cases a little darkened beyond base; tarsi snowy-white (Selangor, Borneo) ..... *candidipes* Edwards.  
Legs bright yellow; tips of fore femora blackened (Assam) .... *venosa* (Brunetti).

#### TRENTEPOHLIA (MONGOMA) PENNIPES (OSTEN SACKEN).

*Mongoma pennipes* Osten Sacken, *Berlin. Ent. Zeitschr.*, xxxi, 1887, 204.

Keravat, January, February, 1933 (S. V. Bayley and F. H. Taylor). Toma, altitude about 1,000 feet, February, 1933 (F. H. Taylor).

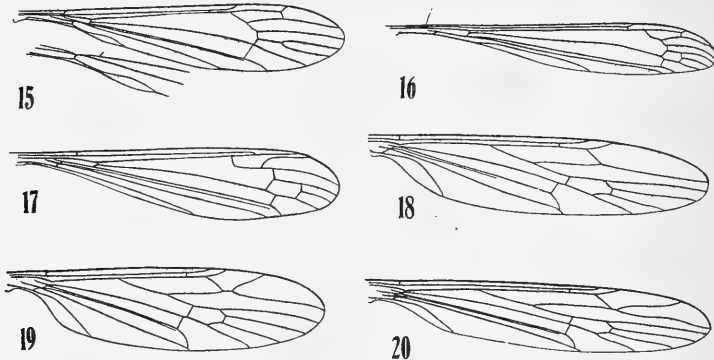
#### TRENTEPOHLIA (MONGOMA) COSTOFIMBRIATA, n. sp.

Mesonotum and pleura dark cinnamon-brown, the praescutum with a capillary brownish-black vitta on anterior half; femora black; tibiae black, the outer half paler, the apices narrowly pale yellow; tarsi yellowish-white, the extreme proximal ends of basitarsi darker; spines on bases of middle and hind femora; hind basitarsi with three or four long black setae at base; wings with a dusky tinge,

cells C and Sc blackish; wing-apex narrowly darkened; veins black; costal fringe (male) long; all elements closing cell 1st  $M_2$  subequal.

♂. Length about 5.5–6 mm.; wing, 6–6.5 mm. ♀. Length about 6 mm.; wing, 6.5 mm.

Rostrum and palpi brownish-black. Antennae black throughout; flagellar segments cylindrical, the verticils shorter than the segments. Head brownish-black; anterior vertex reduced to a narrow strip.



Text-figs. 15-20.

15. *Limonia (Pseudoglochina) hoskingi*, n. sp., venation.
16. *Limonia (Euglochina) novae-guineae yorkensis*, n. subsp., venation.
17. *Elephantomyia (Elephantomyodes) tayloriana*, n. sp., venation.
18. *Trentepohlia (Plesiomongoma) novae-britanniae*, n. sp., venation.
19. *Trentepohlia (Mongoma) costofimbriata*, n. sp., venation.
20. *Trentepohlia (Mongoma) subpennata*, n. sp., venation.

Cervical sclerites and pronotum dark brown. Mesonotum and pleura dark cinnamon-brown, the praescutum with a capillary brownish-black vitta on anterior half; scutal lobes slightly more darkened; scutellum dark brown; anterior pleurites slightly darker than the posterior ones. Halteres brownish-black, the base of stem a little paler. Legs with the fore coxae dark brown, the remaining coxae and all trochanters yellowish-testaceous; femora black; tibiae black basally, the outer half paling to dirty brownish-white, the extreme tips narrowly and conspicuously pale yellow; tarsi yellowish-white, the basitarsi very restrictedly darkened at proximal ends; middle femora in both sexes with a group of from 16 to 17 short black spines at base; hind femora with about 10 to 12 such spines; fore femora without spines; posterior basitarsi of both sexes with a group of about 3 or 4 long black setae at extreme base. Wings (Fig. 19) with a dusky tinge, cells C and Sc, except basally, strongly suffused with blackish; stigma not otherwise darkened; wing-apex narrowly more darkened; a dusky area between anal veins near bases; veins black. Costal fringe of male very long and conspicuous, short only on basal sixth or so; in female, fringe shorter but still longer than usual in the genus. Venation:  $R_{2+3+4}$  longer than  $R_s$ ; vein  $R_3$  oblique, so cell  $R_2$  is wide at margin; all elements closing cell 1st  $M_2$  subequal; m-cu just before fork of M; apical fusion of veins  $Cu_1$  and 1st A distinct.

Abdominal tergites dark brown; sternites obscure brownish-yellow; terminalia dark. Ovipositor with hypovalvae darkened at bases, the remainder yellowish horn-colour.

Holotype, ♂, Keravat, January, 1933 (F. H. Taylor). Allotopotype, ♀, pinned with type, paratopotype ♂.

*Trentepohlia (Mongoma) costofimbriata* is readily told from allied regional species by the long costal fringe of the wings. *T. (M.) fimbriata* Edwards (Borneo) likewise shows this character, but is otherwise a very different fly, without spines on mid-femora and with a very different venation of the radial field. By Edwards's key to the Australasian species of *Mongoma* (Ins. Samoa, Diptera Nematocera, vi, fasc. 2, 1928, 94), the present fly runs to couplet 5, disagreeing with both included species.

TRENTEPOHLIA (MONGOMA) SUBPENNATA, n. sp.

General coloration of mesonotum dark brown to brownish-black, the pleura obscure yellow; femora black, the apices very vaguely paler; tibiae black, the tips broadly snowy-white; basitarsi chiefly blackened, the remaining segments paling to yellowish-white; tips of middle and posterior tibiae dilated and fringed with conspicuous white setae; wings relatively long and narrow, faintly tinged with blackish, cell C and the stigma black; veins  $R_3$  and  $R_4$  only slightly divergent; cell  $R_2$  at margin more extensive than cell  $R_3$ .

♂. Length about 7.8–8 mm.; wing, 7–7.5 mm.

Rostrum and labial palpi pale yellow; maxillary palpi black. Antennae black throughout; flagellar segments cylindrical, with verticils that are shorter than the segments. Head black; anterior vertex reduced to a linear strip or even slightly interrupted by approximation of eyes.

Cervical sclerites and pronotum above dark brown, the latter yellow on sides beneath. Mesonotum dark brown to brownish-black, the humeral region of praescutum restrictedly and very vaguely brightened. Pleura obscure yellow, the propleura and anepisternum vaguely suffused with dusky. Halteres dark brown, the extreme base of stem pale. Legs with coxae yellowish-testaceous, the fore coxae a trifle darker; femora black, the extreme bases obscure yellow; tips of femora very vaguely paler, obscure yellowish-brown; tibiae black, the tips broadly snowy-white, slightly narrower on fore legs; basitarsi blackened, their extreme tips and the outer tarsal segments paling to yellowish-white; fore tibiae scarcely expanded at tips; hind, and especially the middle tibiae, conspicuously flattened and dilated, fringed with white setae that are shorter than the expanded portion; fore femora with three or four long erect black setae at some distance from base. Wings (Fig. 20) relatively long and narrow; ground-colour faintly blackish; cell Sc and the confluent stigma black; wing-tip insensibly darkened; veins black, very conspicuous. Costal fringe relatively short. Venation:  $R_2$  shortly before fork of  $R_{3+4}$ , the distance variable, longest in the holotype;  $R_3$  and  $R_4$  only slightly divergent, so cell  $R_3$  is narrow and parallel-sided for more than one-half its length; cell  $R_2$  at margin considerably more extensive than cell  $R_3$ ; vein  $R_4$  strongly sinuous; inner end of cell  $M_3$  slightly more basad than the other outer cells; m-cu close to fork of M; apical fusion of  $Cu_1$  and 1st A relatively extensive, nearly equal to m-cu; cell 2nd A long and narrow.

Abdominal tergites dark brown, the incisures of the intermediate segments vaguely paler; terminalia dark; sternites obscure yellow.

Holotype, ♂, paratopotype, ♂, Keravat, February, 1933 (F. H. Taylor).

By Edwards's key to the Australasian species of *Mongoma* (l.c., 1928, 94), the present fly runs to *tarsalis* Alexander. The present fly is very different from all other species known to me in the dilated tips of the middle and hind tibiae,

the black basitarsi, and the venation, as the only slightly divergent veins  $R_3$  and  $R_4$ . The key given on a preceding page will readily separate the species from others in New Britain.

TRENTEPOHLIA (MONGOMA) AUSTRALASIAE Skuse.

*Trentepohlia australasiae* Skuse, Proc. Linn. Soc. N.S.W., xiv, 1890, 834.

Toma, altitude about 1,000 feet, February, 1933 (F. H. Taylor). Makada Island, Duke of York Group, February, 1933 (F. H. Taylor).

The latter specimen has the thoracic dorsum paler, more reddish-brown, but I can detect no other differences.

TRENTEPOHLIA (MONGOMA) BREVIPES Alexander.

*Ann. Mag. Nat. Hist.*, (10) vii, 1931, 18.

The type, a female, was from Suali, Vailala River, Papua, collected by Littlechild. One ♂, Toma, altitude about 1,000 feet, February, 1933 (F. H. Taylor). The costal fringe is short.

STYRINGOMYIA CEYLONICA Edwards.

*Ann. Mag. Nat. Hist.*, (8) viii, 62, 1911.

One ♂, Karavat, December, 1932 (F. H. Taylor).

Edwards had previously (*Ann. Mag. Nat. Hist.*, (9) xiii, 1924, 270) recorded this species from Madang (Friedrich Wilhelmshafen), Seleo Is., off Aitape, and Aitape Roadstead (Berlinhafen), in north-eastern New Guinea, a notable eastward extension of the known range.

## AUSTRALIAN RUST STUDIES. V.

ON THE OCCURRENCE OF A NEW PHYSIOLOGIC FORM OF WHEAT STEM RUST IN  
NEW SOUTH WALES.

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

[Read 27th March, 1935.]

It is now well recognized that the specialization exhibited by pathogens profoundly affects plant disease problems. A fundamental requirement in control of a disease is a knowledge of the physiologic forms of the organism which may occur. Any changes which take place in the forms that are present may affect the measures adopted.

Specialization in the rusts has long been known and is attracting world-wide attention. In Australia studies have been in progress for a number of years dealing with both the stem and leaf rusts of cereals. As far as wheat stem rust is concerned, the determinative methods of Stakman and Levine (1922) have been followed.

Seven naturally-occurring physiologic forms of *Puccinia graminis tritici* E. & H. have so far been recorded (Waterhouse, 1934). From 1921 until 1926, forms 43, 44, 45, 46, 54 and 55 were present. In 1926, form 34 was found in Western Australia. Next year it occurred in the Eastern States, and since then has almost completely superseded the other forms. The virulence of this form has been an important factor in the serious rust losses which have been experienced in recent years. Nevertheless the work of breeding wheats resistant to stem rust has been comparatively simple with the one form present.

In order to show the relative abundance and time distribution of the forms in Australia, the results of the specialization studies on wheat stem rust up to the 31st December, 1934, are summarized in Table 1.

TABLE 1.

*Summary of the number of isolations of the naturally-occurring physiologic forms of Puccinia graminis tritici E. & H. in Australia.*

Physiologic Form.	Season of isolation ending 31st March of year stated.														Totals.
	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935*	
11					4	18	152	156	90	181	139	143	93	2	2
34					15	14	21				10	1		161	1,137
43	20	10	10	55	3	30	6							2	158
44	2	4		1	3	30	6								46
45	3			15	5	17	5								45
46	14		15	24	1	6	2								62
54		1				3	1								5
55	2			5		1	2								10
Totals	41	15	25	100	28	89	189	156	90	181	149	144	93	165	1,465

\* The record for 1935 extends only to 31st December, 1934.

The work of the current season has been largely helped, as usual, by officers of the State Departments of Agriculture and others who have forwarded rust specimens collected at various places from time to time. In all but four cases the rust present proved to be form 34. Two of the exceptions occurred in samples of rusted wheat from Casino and Kyogle, N.S.W., submitted by Mr. M. J. E. Squire. In these, form 43 was present mixed with form 34. It is interesting that all the records of form 43 since 1928 have been from this area in the N.E. corner of New South Wales and the S.E. corner of Queensland.

There were two other important exceptions. They were in wheats collected in November, 1934, the one by Mr. J. G. Churchward from Bectric, N.S.W., the other by Mr. R. N. Medley from Leeton, N.S.W. These rusts proved to be form 34 mixed with another form. Cultural studies involving many cross-inoculations demonstrated that this rust was form 11. Its typical behaviour in comparison with that of the other naturally occurring Australian forms is set out in Table 2.

TABLE 2.

*Typical reactions of the naturally-occurring physiologic forms of Puccinia graminis tritici in Australia.*

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

The occurrence of this form is important. It is a virulent rust which has long been known in America. Controlled work at the University of Sydney extending over several years—as yet unpublished—has shown that form 34 is heterozygous. One of the forms frequently derived from barberries infected in the plant-house by cultures of form 34 is form 11. Cultural comparisons of the naturally-occurring form from wheat with those derived from the barberry reveal no differences between them.

Last year (Waterhouse, 1934*a*) naturally-infected barberries were recorded from the Central Tablelands of New South Wales where form 34 was present on graminaceous hosts. It has not been possible to trace the origin of the two collections of form 11 from Bectric and Leeton back to barberry bushes, but it seems significant that so soon after finding infected barberries, this new form should be discovered. The eradication of susceptible types of barberry should be carried out without delay.



The presence of this virulent form 11 may influence the work of breeding wheats resistant to black stem rust. It is not yet possible to indicate the behaviour of parental types when inoculated with this form. This will be determined and the rust survey continued in order to obtain further evidence regarding its occurrence.

*Acknowledgements.*

Grateful acknowledgement is made of the invaluable assistance rendered by workers who have forwarded rust samples, and of the financial aid so generously continued by the Trustees of the Science and Industry Endowment Fund.

*Summary.*

Specialization studies of *Puccinia graminis tritici* E. & H. have shown that between 1921 and 1934 seven forms have occurred naturally in Australia. Form 34 has been the most widespread. In November, 1934, wheat from two centres in New South Wales was found for the first time to be attacked by form 11. This is one of the forms which have been derived from the barberry in the plant-house when it is infected by the heterozygous form 34. Significance attaches to the discovery, in December, 1933, of naturally-infected barberries in New South Wales where form 34 was present on graminaceous hosts.

*Literature Cited.*

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- WATERHOUSE, W. L., 1934.—Some aspects of cereal rust problems in Australia. *Proc. Fifth Pacific Science Congress, Canada*, pp. 3169-3176.
- , 1934a.—Australian Rust Studies. IV. Natural infection of barberries by black stem rust in Australia. *Proc. Linn. Soc. N.S.W.*, 59, pp. 16-18.

*Postscript, added 4th April, 1935.*

Whilst this paper was in the press a further determination of importance has been made.

About the middle of March, 1935, a number of collections of rust on *Agropyron scabrum* Beauv. were made near Yetholme on the Central Tablelands. In all cases but one, the rust proved to be *P. graminis tritici* form 34. In the remaining instance form 11 was present in addition to form 34. This considerably strengthens the link with the infections of the barberries.

THE DIPTERA OF THE TERRITORY OF NEW GUINEA. III.

FAMILIES MUSCIDAE AND TACHINIDAE.

By JOHN R. MALLOCH, Washington, D.C., U.S.A.

(Communicated by Frank H. Taylor.)

(One Text-figure.)

[Read 27th March, 1935.]

I have recently received from Mr. F. H. Taylor a large number of specimens of various families of Diptera from New Britain but have been unable to make a complete examination of them owing to press of other work. Below I describe a new genus closely related to *Stilbomyia* Macquart, a member of a rather anomalous group which has many characters of both Tachinidae and Calliphoridae, but which appears to me best placed in the former. Possibly information on the immature stages and the larval habits in particular will afford evidence that will more definitely establish its family position. '*Musca*' *opulenta* Walker, from Australia, is also placed in the above new genus.

The types of the new species described in this paper will be deposited in the Collection of the School of Public Health and Tropical Medicine, University of Sydney.

STILBOMYELLA, n. gen.

This genus is erected to receive several species from Northern Australia and some of the islands to the north of that region. I have previously included some of them in *Stilbomyia*, but now have decided that generic separation is proper. The characters that I make use of in thus separating these species from the old concept are to be found in the more evenly rounded postscutellum, the narrower frons in both sexes, in the male about one-fifth of the head-width and without proclinate supraorbitals, though the latter are present in the females, and the lesser extent of the basal section of the third vein that is setulose. In this last character the genus is similar to *Neoamenia*, but the latter has the facial carina deeply sulcate, and the male has distinct, though not very strong, proclinate supraorbital bristles.

Genotype, *Stilbomyella nitens*, n. sp.

Key to the Species.

1. Mesopleura with a rather conspicuous silvery-white-dusted central spot, sternopleura not at all noticeably white-dusted; abdomen brilliant metallic blue-green, the sutures a little darker ..... *opulenta* (Walker)  
Mesopleura either entirely without white dusting, or very slightly dusted and not as distinctly so as the sternopleura ..... 2
2. Facial grooves fuscous; genal hairs dark; sternopleura quite conspicuously silvery-white-dusted, mesopleura very faintly and evenly white-dusted; abdomen entirely brilliant metallic green ..... *nitens*, n. sp.  
Facial grooves not infuscated; genal hairs golden-yellow; pleura without white dust; abdomen brilliant metallic green, violet-blue on basal visible tergite and at sutures on dorsum, both the extreme apices and extreme bases dark coloured ..... *dubia*, n. sp.

It may facilitate the recognition of the group to note here that all are very brilliant metallic green to blue-green in colour, with the head golden-yellow except the interfrontalia, which is brownish-black, the similarly coloured antennae and palpi, and the dark upper half of the occiput, which latter is densely covered with golden-yellow dust. None of the species have white-dust spots on the mesonotum or on the abdomen, and all before me have the apex of the lower squama broadly darkened.

STILBOMYELLA OPULENTA (Walker).

*Proc. Linn. Soc. Lond.*, iii, 104, 1858.

I have finally decided to accept the Australian species as *opulenta*\* instead of *costalis*. Miss D. Aubertin informs me that the type-specimen of the latter is not now in the British Museum, so that it is impossible to determine exactly what it may have been. The same authority suggests that *decreescens* Walker is a synonym of *opulenta*.

She further states that a specimen identified as *costalis* by Walker has the eyes of the male separated by the width of the third antennal segment, which is evidence that it is distinct from those now before me. This specimen is placed in the Museum collection as a synonym of *gloriosa* Walker under 'New Genus'. As it has no pollinose pleural spots, this synonymy is apparently incorrect, as Walker's description of *gloriosa* definitely states that the pectus has four white tomentose spots, from which I infer that there are two spots on each pleura.

Another Walker species that evidently belongs here, according to Miss Aubertin, is *diffusa*, which may be distinguished from all the others by the restriction of the dark cloud on the costa to the extreme base instead of the anterior half of the wing.

STILBOMYELLA NITENS, n. sp.

A brilliant emerald-green species, with the typical head colouring, and the pleura lightly white-dusted, the sternopleura more distinctly dusted than the mesopleura.

♀. Frons at vertex not more than one-sixth of the head-width, widened anteriorly, the interfrontalia uniformly wide on its entire length, at middle narrower than either orbit at same point; all four verticals strong; ocellars short and hair-like; antennae rather short, third segment not more than half as wide as parafacial and not much longer than height of gena; facial carina slightly widened from upper to lower extremity, rounded above; epistome rather noticeably angulate; setulae extending on facial ridges to about middle. Genal hairs dark brown.

Mesonotum without a trace of vittae. Dorsocentrals 3 + 4, acrostichals 2 + 2. Dust on sternopleura most evident when viewed from above, and densest below.

Legs black, femora green. Fore tarsus with second to fourth segments dilated; mid tibia with a submedian ventral bristle.

Wings greyish hyaline, costa broadly blackened, the dark colour fading off behind. Third vein with setulae on less than basal half of its basal section above. Squamae yellowish-white, apical half or more of the lower one blackened. Halteres dark brown.

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\* Major E. E. Austen informed me several years ago *in litt.* that "*Musca*" *opulenta* Walker was a member of the family Tachinidae and that it required a new genus for its reception.—Frank H. Taylor, 24/4/34.

Abdomen entirely emerald-green, with slight coppery tinge on dorsum near base. Second tergite with a pair of strong apical central and one or two lateral bristles, third and fourth tergites each with a complete apical transverse series.

Length, 8.5 mm.

*Habitat*.—N. Britain: Keravat (F. H. Taylor). Type.

*STILBOMYELLA DUBIA*, n. sp.

Differs from the above new species in being more blue-green, with the apices of the tergites distinctly though narrowly violet-blue, and the pleura without any dust. The yellow genal hairs, and the longer third antennal segment, with the much more extensively setulose facial ridges, are additional characters for its distinction.

♂. Head coloured as in *nitens*, the upper extremities of the orbits and some parts of the vertex showing glossy green through the yellow dust; antennae deep black, the palpi dark brown in female but in the male brownish-yellow. Frons at vertex about one-sixth of the head-width, widened anteriorly, all four verticals strong, the ocellars also strong and divergent, but slightly proclinate, the fine hairs laterad of the inner marginal bristles on the orbits fuscous. Postocular orbits with some very fine yellow hairs between the serial bristles and eyes as in the other species. Third antennal segment about as wide as parafacial, distinctly longer and broader than in *nitens*, its length equal to twice the height of the gena and greater than that of arista; genal hairs yellow; facial ridges setulose to well above the middle.

Mesonotum blue-green, with coppery reflections on centre, becoming darker blue behind, the scutellum of that colour. Armature much as in *nitens*, but the acrostichals 4 + 4.

Legs black, femora blue-green. Fore tarsus slender; mid tibia with a submedian ventral bristle.

Wings broadly infuscated on costa, the dark colour shading off behind. Third vein setulose to about midway from base to inner cross-vein. Squamae greyish-white, apical third or more of the lower one blackened.

Abdomen brilliant blue-green, basal visible tergite and extreme apex and base of each of the others violet-blue. Dorsal armature as in *nitens*, the venter with long bristles that are quite dense and become fine at apices.

♀. Similar to the male, but the frons at vertex is wider, about one-fifth of the head-width, and each orbit has two strong proclinate upper orbitals. The antennae are also much shorter and the third segment narrower, almost as in *nitens* female, not more than 1.5 times as long as the height of the gena.

The fore tarsi are dilated as in the female of *nitens*, and the abdomen has the same armature, lacking the conspicuous ventral bristling of the male.

Length, 8-9 mm.

*Habitat*.—N. Britain: Rabaul (F. H. Taylor). Type ♂, allotype, and 5 paratypes.

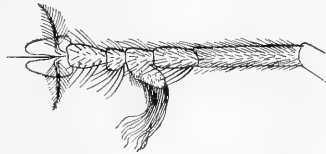
The much longer and stronger ocellar bristles in this species may be a constant character by means of which it can be distinguished from *nitens*, but I do not care to cite this as an invariable character on the basis of a single specimen of the latter. I at one time was inclined to accept the character of the fine hairs on the postocular orbits between the fringe of bristles and the eye as one that distinguished the Calliphoridae from doubtful Tachinidae, but it is somewhat variable, being sometimes present and sometimes absent in *Stilbomyia*.

## PYGOPHORA HIRTIMANA, n. sp.

A species of about the same size as the genotype, with the head similarly coloured, the frons, face, antennae, and palpi, bright orange-yellow, the thorax black, with dense grey-dusting and not vittate, the legs entirely testaceous yellow, and the wings hyaline. The abdomen is testaceous yellow and without distinct marks in the type specimen, though there are slight traces of a series of reddish dorsocentral spots on the tergites except the fifth, and on the fourth traces also of a dark mark on each side.

Length, 5.5 mm.

Head of the usual form, distinctly higher than long in profile, the eyes narrowed below and about twice as high as long in profile, the parafacials linear, slightly widened above, the gena about as high as width of third antennal segment, the latter about five times as long as second segment, rounded at apex, and nearly



Text-fig. 1.—*Pygophora hirtimana*, n. sp. Left hind tarsus of male from above, specimen aligned to give exact dorsal view.

attaining the epistome, the arista long-haired on basal half, proboscis short, palpi as long as apical section of proboscis, slightly clubbed, fine-haired basally, and with some stronger bristles apically, frons at vertex hardly half as wide as at anterior margin, where it is not half as wide as its length in centre, ocellar bristles slightly longer but weaker than the upper pair of orbitals, four pairs of bristles on orbits as usual, the second and third pairs much more closely placed than the others, the anterior pair longest.

Thorax with the presutural acrostichal hairs in two or three series, scutellum with four strong bristles, the basal pair slightly the shorter, and some setulose hairs on disc, and one pair basad of the basal bristles; sternopleura with the usual three long bristles.

Legs rather stout, the hind tibia without an apical process, mid coxae each with two strong and rather long straight bristles; mid femur with three or four strong bristles on the anteroventral and posteroventral surfaces centrally, a series of shorter slightly curled bristles near apex on the posterior surface, the apices of which are slightly flexed, the mid tibia with an incision close to the base on anteroventral side, and with the ventral hairs short, black, and rather dense, especially close to the incision, hind femur and tibiae almost normal, but the latter with three unusually long bristles near apex, two of them almost dorsal and the other posterodorsal, hind tarsus as in Text-figure 1, but usually slightly curved over so that it has to be viewed from different angles to show the characters in the drawing, all tarsal claws with much longer hairs on their sides than usual.

Wings with the usual shape and venation, outer cross-vein slightly bent, inner at about two-fifths from apex of discal cell.

Abdomen subcylindrical, compressed in front of the hypopygium, which is rather large, fifth tergite not keeled, with two or three long apical central bristles and a series of six or more similar bristles along the edges below, fifth sternite ending in a pair of wide chitinous unhaired broadly rounded lobes, hypopygial forceps with dense short black hairs at bases and on inner sides apically.

Squamae and halteres brownish-yellow.

*Habitat*.—New Britain: Rabaul (F. H. Taylor). Holotype ♂.

ON SOME AUSTRALIAN AND SOUTH AFRICAN SPECIES OF ACARINA OF  
THE GENUS STEREOITYDEUS. [PENTHALODIDAE.]

By H. WOMERSLEY, F.R.E.S., A.L.S., Entomologist, South Australian Museum.

(Three Text-figures.)

[Read 24th April, 1935.]

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STEREOITYDEUS AUSTRALICUS Sig. Thor (*Zool. Anz.*, 1934).

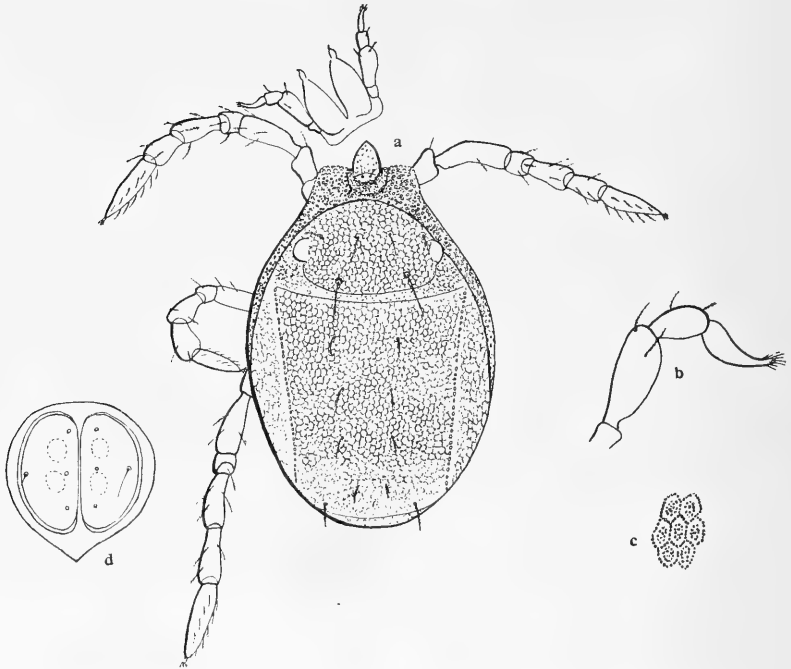
Dr. Sig. Thor described this species from a mounted specimen collected by me from moss at Crawley, Western Australia, in May, 1931. In my collection, now in the South Australian Museum, are three more specimens from the type locality and collected at the same time. In addition, there are two other specimens, one taken from moss at Glen Osmond, South Australia, in July, 1934, the other collected at Sassafras, Victoria, by Mr. H. G. Andrewartha in December, 1931.

STEREOITYDEUS AREOLATUS, n. sp. Text-fig. 1, *a-d*.

*Description*: Smaller than the above species, 330 $\mu$  long, 160 $\mu$  wide. Colour, in spirit, at first entirely blackish-green, gradually becoming pigmentless; in life dark greenish-black except for the dorsal body shield, legs and mouth-parts which are pinkish. Palpi 4-segmented, 108 $\mu$  long; segment I short, only 15 $\mu$  long, II 42 $\mu$  long, much swollen distally and outwardly, and with two ciliated hairs, III half as long as II, 21 $\mu$ , with two hairs, IV 30 $\mu$  long, swollen basally but rapidly tapering and curved (cf. fig.), ending in 4-5 short ciliated hairs. Mandibles as in *S. australicus*. Pseudocapitulum present but indistinct, with two short hairs. Epirostral plate distinct, trilobed and the lobes distinctly separated. Eyes distinct, large, one on each side placed anteriorly of the basal angles of the cephalothoracic shield. This shield with the usual pair of sensory hairs and two pairs of shorter ordinary hairs, one pair placed close to the eyes and the other medial to these and in the same horizontal line. Legs 6-segmented, much as in *S. australicus*, fairly stout, the femora of first pair not excessively narrowed at the base and not more than three times as long as wide. The dorsal body hairs are arranged in five pairs and are all long, 26 $\mu$ , and ciliated. The legs are clothed with ciliated hairs and a very fine pubescence, and end in two claws and an empodial pad. The cuticle of the cephalothorax and dorsum is ornamented with many fine pits which form roughly hexagonal areas, each of which has a small number of pits within itself.

*Locality*: Type from moss, Adelaide, South Australia, May, 1934; paratype from moss from Burnside, South Australia, in July, 1934.

*Remarks*: This species differs from *S. australicus* in the smaller size, sculpture and the characteristic palp.



Text-fig. 1.—*Stereotydeus areolatus*, n. sp. *a*, dorsal view; *b*, palp; *c*, cuticle of dorsal shield; *d*, genital opening.

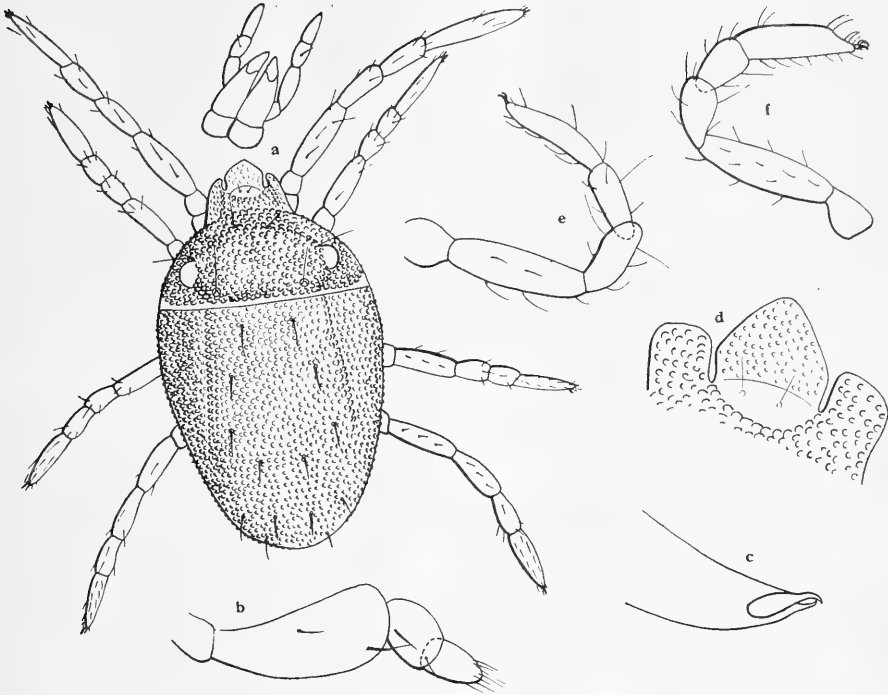
STEREOITYDEUS OCCIDENTALE, n. sp. Text-fig. 2, *a-f*.

*Description:* Length  $420\mu$ , width  $220\mu$ . Colour in life blackish, except for an indefinite rather narrow reddish stripe down the dorsum, and red legs and mouth-parts; in spirit entirely black at first, gradually becoming pigmentless. Palpi 4-segmented,  $99\mu$  long; segment I  $23\mu$  long, II  $52\mu$  long, very broad distally and with 2 hairs, III short,  $14\mu$ , with 2 hairs, IV shorter still,  $10\mu$  long, and stumpy, with a few terminal hairs. Mandibles as in other species. Pseudocapitulum present, with two hairs. Epirostral plate distinct, trilobed, lateral lobes distinctly separated from the medial. Eyes, one on each side, distinct and placed well in front of the basal angles of the cephalothoracic shield. Cephalothoracic sensory and normal hairs as in other species. Legs only 5-segmented, fairly stout, the fore femora not more than three times as long as wide. Legs clothed with ciliated hairs and a very fine pubescence, ending in a pair of claws and an empodial pad. The dorsal body hairs arranged in 4 pairs, then a row of four followed by two subapical hairs, all of which are ciliated and  $16\mu$  in length. The cuticle of the cephalothoracic and dorsal shield is uniformly covered with large rounded tubercles which are separated by about their own diameter.

*Locality:* Abundant in moss from Glen Osmond, South Australia, May to August, 1934.

*Remarks:* Rather close to *S. australicus*, but differs in size, sculpture and particularly the 5-segmented legs.





Text-fig. 2.—*Stereotydeus occidentale*, n. sp. *a*, dorsal view; *b*, palp; *c*, mandible; *d*, epirostral plate; *e*, leg IV; *f*, leg I.

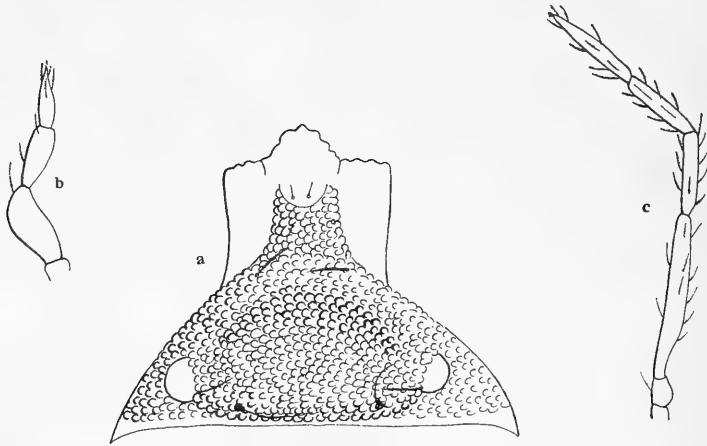
STEREOTYDEUS CAPENSIS, n. sp. Text-fig. 3, *a-c*.

*Description*: Length  $630\mu$ , width  $450\mu$ . Colour in life probably blackish, with or without some red. Palpi  $185\mu$  long; segment I  $40\mu$ , II  $66\mu$ , not unduly stout or broadened distally, with one (? two) hair, III  $50\mu$  long, with two hairs, IV  $42\mu$  long, with a number of apical and subapical hairs. Mandibles as in other species. Pseudocapitulum present with the usual two hairs. Epirostral plate distinct, trilobed, but the lateral lobes are fused to the medial and only lightly sculptured, or not at all. Eyes one on each side, large and slightly anterior of the basal angles of cephalothoracic shield. This shield has the usual sensory and other hairs. Legs very slender, 5-segmented; I and IV longer than the body,  $700\mu$ , femora of all legs very much contracted at the base and about  $8-8\frac{1}{2}$  times as long as wide at the widest point. Cuticle of cephalothorax and dorsum with large tubercles which on cephalothorax and medial lobe of epirostral plate are almost touching. Legs with ciliated hairs and very fine pubescence. Body hairs  $26\mu$  long and ciliated.

*Locality*: Type and 6 paratypes from Cape Town, South Africa, in August, 1930 (H.W.).

*Remarks*: The preparations available for study do not permit a more detailed description of this species to be given. It differs from all other forms, except *S. occidentale*, in having 5-segmented legs. From that species it is distinguished

by the sculpturing, form of the epirostral plate and the slender and basally contracted femora.



Text-fig. 3.—*Stereotydeus capensis*, n. sp. a, cephalothorax and epirostral plate; b, palp; c, leg I.

*Remarks on the Genus Stereotydeus.*

The genus *Stereotydeus* was erected by Berlèse and Leonardi (*Zool. Anz.*, Bd. 25, 1901) for two species, *S. notaphalloides* and *S. gamasoides*, from South America. In 1907 Trägårdh erected the genus *Tectopenthalodes* for *T. villosus* from the Subantarctic (Schwedischen Sudpolar Exped., 1901-3), which he stated was closely related to *Stereotydeus*, but differed in having a 5-segmented palp. It also lacked eyes.

In 1912 Berlèse (Deuxième Exped. Antarctic Française, 1908-10) again recorded *T. villosus*, and in his discussion reduced *Tectopenthalodes* to a subgenus of *Stereotydeus*, pointing out that Trägårdh was wrong in considering the palpi as 5-segmented. Berlèse defined *Tectopenthalodes* as a subgenus thus: "Characteres generis, sed oculi inconspicui. Adest pseudocapitulum."

Now, in all the species recorded in this paper the eyes are very conspicuous and the pseudocapitulum is distinct. They are, therefore, intermediate between *Stereotydeus* and *Tectopenthalodes*, and the latter cannot be maintained even as a subgenus.

In two of the species dealt with in this paper there is a remarkable difference from all other described species of *Stereotydeus* in that the legs are only 5-segmented instead of 6-segmented. This may possibly be of generic or subgeneric value.

NOTES ON THE MOSSES OF NEW SOUTH WALES. II.

ADDITIONAL RECORDS.

By ALAN BURGESS, M.Sc., late Linnean Macleay Fellow of the Society in Botany.

[Read 24th April, 1935.]

The following paper completes the check list of New South Wales Mosses which was begun by the late Rev. W. W. Watts and the late Mr. T. Whitelegge in the PROCEEDINGS of this Society in 1905 and continued by the present writer in 1932. As in Part I of these notes, the arrangement adopted by Brotherus in Engler and Prantl (*Natür. Pflanzenf.*, 2 Aufl., Bd. 10, 1924, and Bd. 11, 1925) has been followed except for one minor alteration (q.v., page 90) on the authority of Dixon (*Bull. N.Z. Inst.*, No. 3), and the species have been placed alphabetically within the genus.

The grateful thanks of the writer are due to Mr. Gepp, of the Natural History Museum, South Kensington, for assistance in obtaining references; to Mr. Cheel, of the National Herbarium, Sydney, for permission to work through the material in his charge; and to Professor T. G. B. Osborn, in whose department the work was carried out.

GRIMMIALES.

GRIMMIACEAE.

GRIMMIA.

*G. campestris* Burch., in Hook. Musc. ex.; *G. leucophaea* Grev.; *G. leiocarpa* Tayl.  
Frequent in many parts of the State.

RHACOMITRIUM.

*R. crispulum* H.f.W., Fl. Tas. Tumberumba (Forsyth).

FUNARIALES.

SPLACHNACEAE.

TAYLORIA.

*T. Maidenii* Broth., Linn. Soc. N.S.W., 1916. Kosciusko (Maiden).

EUBRYALES.

BRYACEAE.

MIELICHHOFERIA.

*M. australis* Hpe., Linn., 1859. Yarrangobilly Caves (Watts).

MNIOBRYUM.

*Mn. Tasmanicum* Broth., Oefv. af. Finsk., 1893. Yarrangobilly, etc. (Watts).

BRACHYMENIUM.

*B. Preissianum* Hpe., Icon. Musc., t. 25, 1844. Jervis Bay (Watts).

BRYUM.

*Br. altisetum* C.M., Hedw., 1897. Yarrangobilly Caves (Watts).

*Br. austro-affine* Broth., Linn. Soc. N.S.W., 1916. Richmond River (Watts).

*Br. bimum* Schreb., Spic. fl. lips., p. 83, 1771. Yarrangobilly Caves (Watts).

- Br. caespiticium* L., Sp. pl., p. 1121, 1753. Yarrangobilly Caves (Watts).  
*Br. Cheelii* Broth., Linn. Soc. N.S.W., 1916. Shell Harbour (Cheel).  
*Br. filarium* Broth., loc. cit. Richmond River (Watts).  
*Br. Forsythii* Broth., loc. cit. Kiama (Forsyth).  
*Br. Kiamae* Broth., loc. cit. Kiama (Forsyth).  
*Br. laevigatum* H.f.W., Lond. Jour. Bot., 1844. Yarrangobilly Caves (Watts).  
*Br. laxirete* Broth., Linn. Soc. N.S.W., 1916. Hill Top (Maiden).  
*Br. pohliaeopsis* C.M., Hedw., 1898. Yarrangobilly (Watts).  
*Br. subcurvicollum* Broth., Linn. Soc. N.S.W., 1916.  
*Br. subpachypoma* Hpe., Linn., 1869; *B. tenuicostatum* Broth. Richmond River (Watts).  
*Br. Sullivani* C.M., in Broth., Oefv. af. Finsk, 1893. Yarrangobilly (Watts).  
*Br. subventricosum* Broth., Linn. Soc. N.S.W., 1916. Tumberumba (Forsyth).

## RHIZOGONIACEAE.

## HYMENODON.

- H. piliferous* H.f.W., Lond. Jour. Bot., iii, 584, 1844. Cambewarra (Watts).

## RHIZOGONIUM.

- R. aristatum* Hpe., Linn., 1876. Blue Mts. (Whitelegge).

## HYPNODENDRACEAE.

## BRAITHWAITEA.

- B. sulcata* (Hook., as *Leskea*, Musc. Ex., t. 164) Lind.; *B. nematosa* C.M. Common in rain forests.

## HYPNODENDRON.

- H. spininervum* (Hook.) Jaeg., Ad., ii, p. 623. (See *H. arcuatum*.)  
*H. arcuatum* (Hedw., Sp. Musc., p. 245, 1801) Mitt.; *H. spininervum* (Hook.) Jaeg.;  
*H. Whiteleggei* C.M. Frequent in and near creeks.

## MEESEACEAE.

## MEESEA.

- M. Muelleri* Hpe., Linn., 1856; *M. macrantha* Mitt. Yarrangobilly Caves (Watts).

## BARTRAMIACEAE.

## BARTRAMIA.

- B. erecta* (Hpe., Linn., 1876, as *Glyphocarpa*) Broth., *Bartramidula Hampeana* Mitt., *Bartramia gymnostoma* Broth. in MS. Yarrangobilly Caves (Watts).  
*B. norvegica* (Gunn.) Lindl., in Oefv. af. Finsk., 1863. *B. Mossmaniana* C.M.,  
*B. Halleriana* Hedw. Yarrangobilly Caves (Watts).

## PHILONOTIS.

- Ph. austro-falcata* Broth. et Watts, Linn. Soc. N.S.W., 1912. Yarrangobilly Caves (Watts).  
*Ph. fontanoides* Broth. et Watts, loc. cit. Yarrangobilly Caves (Watts).

## ISOBRYALES.

## ORTHOTRICHACEAE.

## ZYGODON.

- Z. Hookeri* Hpe., Linn., 1860. Yarrangobilly Caves and Batlow (Watts).

## ORTHOTRICHUM.

- O. acrolephare* C.M., Hedw., 1897. Tumut River, Batlow, etc. (Watts).

## RHACOPILACEAE.

## RHACOPILUM.

*R. convolutaceum* Hpe., Linn., 1870. Common throughout the State.

## HEDWIGIACEAE.

## HEDWIGIA.

*H. albicans* (Web.) Lindl., Musc. Scand., 40, 1879. *H. ciliata* (Dicks.) Ehrh.  
*H. microcyathea* (C.M.). Throughout the State.  
*H. juratz* C.M., Rev. Bryol., 1876. Near Sydney (Kayser). Jaeger considers this  
a variety of *H. albicans*.

## HEDWIGIDIUM.

*H. imberbe* (Sm.), Bryol. eur., 1846. *H. Drummondii* Jaeg. Frequent in colder  
parts of the State.

## RHACOCARPUS.

*R. australis* (Hpe., Linn., 1859, as *Harrisonia*) Par. *H. Humboltii*  $\beta$  *australis*  
H.f.W. Common on wet rocks.

## CRYPHAEACEAE.

## CRYPHAEA.

*C. brevidens* C.M., Rev. bryol., 1876. Near Sydney (Kayser). Record doubtful.  
*C. novae-valesiae* C.M., in F.v.M., Frag. Phyt., xi, Suppl. "N.S.W."  
? *C. papillarioides* Broth. Richmond River (Watts). Apparently an error. Material  
determined by Brotherus as this species seems indistinguishable from  
*Papillaria filicaule* Tay.  
*C. Muelleri* (Hpe., Linn., 1856, as *Dendropogon*). Near Sydney (Kayser).  
*C. ovalifolium* C.M., Bot. Zeit., 1851, p. 564. Parramatta (Woolfs?).  
*C. squarrosulum* (Hpe., Linn., 1860) Par. Richmond River (Edwards).  
*C. tenella* (Sch., Suppl. ii, Pt. 2, p. 163, 1826) Hsc., *C. parvula* Mitt., *C. consimilis*  
Mont., *C. acuminata* H.f.W., *C. pusilla* C.M. Frequent in coastal rain forest.  
*C. viridissimum* C.M., in Wild Pl. Austr. n. 465. Parramatta and North Coast.

## LEUCODONTACEAE.

## FORSTROEMIA.

*F. australis* (C.M., in Linn., 1867, p. 620, as *Lasia*) Par. North Coast.  
*F. subproducta* (C.M., in Rev. bryol., 1877, p. 43) Par. Parramatta (Woolfs).

## CYRTOPODIACEAE.

## BESCHERELLEA.

*B. cyrtopus* F.v.M. (see Brotherus Bryales for figure). *B. brevifolia* Hpe.  
*Cyrtopus bescherellioides* C.M. Common on coast.

## PTYCHOMNIACEAE.

## HAMPELLA.

*H. pallens* (Lac., Archip. ined., p. 12) Fleisch. *Lepidopilum* Broth. *Whiteleggea*  
*australis* Broth., in MS. notes. *Sematophyllum australe* Broth. Olim. Coastal  
rain forests.

## GLYPHOTHECIUM.

*G. Perroti* C.M., in F.v.M., Frag. Phyt., xi, Suppl. "N.S.W."

## PTYCHOMNION.

*P. aciculare* (Brid., Musc. rec., ii, Pt. 2, p. 158, 1801) Mitt. Frequent in moist  
situations, especially in gullies.

## PTEROBRYACEAE.

## TRACHYLOMA.

- T. planifolium* (Hedw., Sp. musc., p. 206, t. 48, 1801, as *Neckera*) Brid. *Pterobryum* Mitt. Coastal districts.
- T. leptopyxis* (C.M., Hedw., 1897) Brid. Richmond River (Camara). In a letter to the late Rev. W. W. Watts, Brotherus stated that he considered this species distinct from *T. planifolium*, but does not appear to recognize it in Engler and Prantl (Natürl. Pflanzenf., Aufl. 2, Bd. 11, p. 129, 1925).

## ENDOTRICHELLEA.

- E. Dietrichae* C.M., in Linn., 1871-73, p. 156. North Coast rain forest.
- E. lepida* C.M., loc. cit., p. 157. Richmond River.

## EUPTYCHIUM.

- E. cuspidatum* (Mitt., in F.v.M., Frag. Phyt., Suppl. xi) Broth.; *E. neocaledonium* Schimp. Rain forests, Richmond and Brunswick Rivers.

## MUELLERIOBRYUM.

- M. Whiteleggei* (Broth., as *Pterobryum*, Oefv. af. Finsk., 1895). *Pilotrichum* C.M. Near Sydney (Whitelegge), Richmond and Brunswick Rivers (Watts).

## METEORACEAE.

## WEYMOUTHIA.

- ? *W. mollis* (Hedw., Sp. musc., p. 234, 1801, as *Leskea*) Broth. Was recorded by Woolls, but his specimens are apparently *Acanthocladium extenuatum*.

## PAPILLARIA.

- P. amblyacis* (C.M., Linn., xxv, 715) Jaeg. Common on northern rivers.
- P. cerina*, see *P. flavo-limbata*.
- P. crocea* (Hpe., Linn., 715, 1852) Jaeg. *Neckera Kermadecensis*; *Trachycarpus Hornschuchii* Mitt. Throughout the State.
- P. filipendula* (H.f.W., Fl. Tas., as *Meteorium*) Jaeg. Frequent in coastal rain forests.
- P. flavo-limbata* (C.M. et Hpe., Linn., 1853) Par.; *Meteorium cerinum* H.f.W. et Mitt. Blue Mtns. and coastal rain forests, but not far north.
- P. flexicaulis* (Tay. in MS.) Jaeg., Ad. ii, 175. This species was returned by Brotherus for material collected by Watts on the northern rivers, but in Engler and Prantl it is limited to New Zealand. Watts suggested that the Australian plant might be *P. squamata*, which Mitten (Cat. Austr. Musc.) considers may be a synonym for *P. flexicaulis*.
- P. intricata* (Mitt., Sam. Musc., p. 171) Broth. An early determination by Brotherus for *P. nitiduscula* Broth. Should be omitted.
- P. Kermadecensis* C.M., see *P. crocea*.
- P. nitiduscula* Broth., Linn. Soc. N.S.W., 1916. North Coast and Blue Mtns.
- P. squamata* (C.M.) Angst., in Oefv. af. Finsk., 1876. If this species is retained as separate from *P. flexicaule*, then its occurrence in N.S.W. is not yet proved. The specimens in the collection of the late Mr. Whitelegge named *P. squamata* are *P. flavo-limbata*.

## METEORIUM.

- M. dimorphum* (C.M.) Mitt., Proc. Roy. Soc. Vict., 1883, p. 82. Blue Mts.
- M. dicladioides* C.M., Rev. bryol., 1876. Name only published. Paris (Index Bryol.) thinks this is *Barbella (Neckera) trichoroides*. It was collected by Mrs. Kayser near Sydney.

## PHYLLOGONIACEAE.

## ORTHORRHYNCHIUM.

- O. cymbifolioides* C.M., Flora, 1896, p. 458. *O. Thorpianum* C.M. Cambewarra (Thorpe), Richmond River (Watts).

## NECKERACEAE.

## LEPTODON.

- L. australis* C.M., in Sched., see *L. Smithii*. On trees, Cambewarra (Whitelegge).  
*L. Smithii* (Dicks., P. crypt., Fasc. ii, 1791). Probably *L. australis* belongs here.  
 Blue Mts., Cambewarra, etc.

## CALYPTOTHECIUM.

- C. acutum* (Mitt., Proc. Roy. Soc. Vict., 1883, p. 81) Broth. Northern Rivers.  
*C. humile* (Mitt., loc. cit.) Broth. Richmond River.

## NECKERA.

- N. aurescens* Hpe., Linn., 1856, p. 212. N.S.W. (teste F.v.M., Frag. Phyt.).  
*N. hymenodonta* C.M., Bot. Zeit., 1851, p. 561. *N. pennata* H.f.W., but not of Hedw.  
 Cambewarra.  
*N. Leichhardtii* Hpe., Linn., 1869, p. 520. "N.S.W." (Leichhardt).  
*N. pennata*, see *N. hymenodonta*.  
 Note.—*N. Bauerlenii* Solms-Laubach was returned to Bauerlen as a new species, collected on Tingiringi Mt., in 1888. It is probably *N. hymenodonta*; *N. Bauerleni* is a New Guinea plant.

## HOMALIA.

- H. acuminata* C.M., in Sched. Cambewarra Mtn. (Thorpe).

## THAMNIUM.

- T. eflagellare* Ang., in Oefv. af. Finsk., 1872, p. 13. *T. eflagellare* at first. Wollongong (Anderson). Frequent throughout the coastal rain forest; often mistaken for *T. pumilum*.  
*T. gracillimum* Hpe., Linn., 1876, p. 314, as *Rhizogonium*. In creeks and gullies on the coast. A plant difficult to place. *Rhizogonium* Hpe.; *Porotrichum* al.; *Thamnium* Brotherus.  
*T. novae-valesiae* (Hpe.) Kindb. Maitland district (Vicary). Can find no complete description of this species. It is partly described in Kindberg's monograph in Hedwigia, 1902.  
 ? *T. pandum* (H.f.W., Fl. N.Z., ii, 105, as *Isothecium*). Parramatta (Woolfs). Watts considered this record a mistake.  
*T. pumilum* (H.f.W., Fl. Tas.) Par. *T. homalioides* Kindb., fide Broth. It is doubtful if this Tasmanian species has been found in this State; the records probably refer to *T. eflagellare*.

## LEMBOPHYLLACEAE.

## CAMPTOCHAETE.

- C. arbuscula* (Hook., Musc. Ex., t. 112, 1820) Jaeg. Fitzroy Falls and Cambewarra (Whitelegge).  
 var. *deflexa* (Wils.) Dix.; *C. deflexa* Wils. Throughout the coastal districts.  
*C. brisbanicum* C.M. (See Bailey, Comprehensive Cat. Qld. Plants, p. 667, fig. 643.) Richmond River, Bulli (Watts).  
*C. excavata* (Tay.) Jaeg., Ad., ii, p. 214. Coastal districts.  
*C. gracilis* (H.f.W., Lond. Journ. Bot., 1888, p. 553, as *Hypnum*) Par. Stanwell Park and Yarrangobilly (Watts).

- C. Leichhardtii* (Hpe., *Moosb.*, p. 21, as *Dendro-hypnum*) Broth. Northern rivers.  
 ? *C. novae-cambriae* Hpe. Name in Mitt., Cat. Austr. Musc. Locality unrecorded.  
*C. ramulosa* (Mitt., Fl. N.Z., as *Isothecium*) Jaeg. Mt. Tomah, Richmond R., etc.  
*C. Schlosseri* (Sendter, as *Rigodium*) C.M., Syn. Musc., ii, p. 451. Richmond River (Watts).  
*C. vaga* (Hsch., as *Hypnum* in *Act. Soc. Sc. Fenn.*, 1872) Broth. Common throughout the State in moist situations.

## LEMBOPHYLLUM.

- L. divulgatum* (H.f.W., Fl. N.Z., as *Hypnum*). Tia Falls (Whitelegge).

## ECHINODIACEAE.

## ECHINODIUM.

- E. arboreum* Broth., in Oefv. af. Finsk., 1893. Cambewarra (Watts and Whitelegge).  
*E. hispidum* (H.f.W., *Lond. Journ. Bot.*, iii, p. 552, as *Hypnum*) Jaeg. Richmond River, Cambewarra, etc.

## HOOKERIAEAE.

## DISTICHOPHYLLUM.

- D. amblyophyllum* (H.f.W., Fl. N.Z., as *Hookeria*) Mitt. Frequent on the Blue Mtns.  
*D. Baileyanum* C.M., Hedw., 1902, p. 123. Frequent on the Northern Rivers.  
*D. complanatum* (Hpe.) Mitt., *Proc. Roy. Soc. Vict.*, 1883, p. 77. Valley of the Waters (Forsyth).  
*D. crispulum* (H.f.W., Fl. N.Z., as *Hookeria*) Mitt. Blue Mtns. (Whitelegge).  
*D. fissidentoides* C.M., Hedw., 1902, p. 122. Mosman and Blue Mtns. (Whitelegge).  
*D. rotundifolium* (H.f.W., *Lond. Journ. Bot.*, 1844, p. 551) Broth. *D. squarrosulum* C.M., fide Broth. Blue Mtns., Cambewarra.

## ERIOPIUS.

- E. apiculatus* (H.f.W., *Lond. Journ. Bot.*, 1844) Mitt. Stanwell Park.

## PTERYGOPHYLLUM.

- P. dentatum* (H.f.W., *Lond. Journ. Bot.*, 1844) Jaeg. Richmond River (Watts).  
*P. hepaticaeifolium* (Hpe. et C.M.) Jaeg., Ad., ii. Fitzroy Falls (Whitelegge).

## CYCLODICTYON.

- C. Karstenianum* (Broth. et Geh.) Broth., Oefv. af. Finsk., 1893. *Hookeria lepida* Mitt. Richmond River (Watts).

## SAULOMA.

- S. tenella* (H.f.W., Fl. N.Z.) Mitt. Yarrangobilly Caves (Watts).

## HYPOPTERYGIACEAE.

## CYATHOPHORUM.

- C. bulbosum* (Hedw., *Sp. Musc.*, p. 43) C.M. *C. pennata* Brid. Common in wet gullies.

## HYPOPTERYGIUM.

- H. concinnum* (Hook., Musc. Ex., as *Leskea*) Brid. *H. pallens* (H.f.W.) Mitt. *H. hyalo-limbata* C.M. Common in rain forests on the coast.  
*H. Muelleri* Hpe., Linn., 1856. Coastal districts.  
*H. nematosum* C.M. Jaeg., Ad., ii, and Paris give N.S.W., but there are no records in Australian herbaria that I can find.  
*H. novae-seelandicum* C.M., in *Bot. Zeit.*, 1851. *H. Smithianum* H.f.W. In wet gullies on the coast.



*H. rotulatum* (Hedw., in sp. musc., 213, as *Leskea*) Brid. *H. Scottiae* C.M. North Coast.

*H. viridulum* Mitt., in Hook. f. Handbk. of N.Z. Flora. Recorded with doubt for Hunter and Macleay Rivers in the herb. Melb. Dixon regards this species as conspecific with *H. rotulatum*.

## HYPNOBRYALES.

## FABRONIACEAE.

## FABRONIA.

*F. australis* Hook., Musc. Exot. Yarrangobilly Caves (Watts).

*F. brachyphylla* C.M., in Broth., Oefv. af. Finsk., 1895. Near Sydney, Richmond River, etc.

*F. Hampeana* Send., C.M., Syn. Musc., ii, p. 34. Cook's River, Richmond River.

*F. Scottiae* C.M., Linn., 1867. Hunter River (Scott). Common on Northern Rivers.

## ANACAMPTODON.

*A. Wattsii* Broth., Linn. Soc. N.S.W., 1916, p. 593. Richmond River (Watts).

## LESKEACEAE.

## PSEUDOLESKEA.

*P. imbricata* (H.f.W., Fl. Tas.) Broth. *Leskea calochlora* C.M. Cambewarra (Whitelegge).

## THUIDIACEAE.

## HAPLOHYMENIUM.

*H. brevinerve* (Broth., Oefv. af. Finsk., 1890, as *Anomodon*) Broth. Cambewarra (Whitelegge), Richmond River (Watts).

## THUIDIUM.

*T. furfurosum* (H.f.W., Fl. N.Z.) Jaeg. This is apparently a composite species which varies fairly considerably. Some extreme forms like *T. sparsum* are usually considered as worthy of specific rank. *T. unguiculatum* H.f.W., *T. bastatum* (C.M.) Jaeg., and *T. amblystegioides* C.M. should probably be regarded as synonyms, or at the best varieties. Common throughout the State.

*T. laeviusculum* (Mitt., in Linn., 1859) Jaeg. Parramatta (Woolfs).

*T. liliputanum* Broth., Oefv. af. Finsk., 1899. Richmond River (Watts).

*T. nano-delicatulum* (Hpe., as *Cyrto-hypnum* Linn., 1876) Jaeg. Illawarra (Johnson).

*T. plumulosiforme* (Hpe., as *Cyrto-hypnum* Linn., 1876). Illawarra (Johnson).

*T. ramentosum* Mitt., Sam. Musc. Name appears in a MS. list in herb. Sydney, but no locality is given.

*T. sparsum* (H.f.W., Fl. N.Z., as *Hypnum*) Jaeg. *H. suberectum* Hpe. Frequent along the coast.

*T. subliliputanae* Broth., Oefv. af. Finsk., 1899. Richmond and Brunswick Rivers (Watts).

## AMBLYSTEGIACEAE.

## CAMPYLIIUM.

*C. decussata* (H.f.W., in Fl. N.Z., as *Hypnum*) Broth. Yarrangobilly Caves (Watts).

*C. relaxum* (H.f.W., Fl. N.Z., as *Hypnum*) Broth. Yarrangobilly Caves (Watts).

## SCIAROMIUM.

*S. elimbatum* Broth. et Watts, Linn. Soc. N.S.W., 1912, p. 377. Yarrangobilly Caves (Watts).

*S. Forsythii* Broth., loc. cit. Yarrangobilly Caves (Watts).

## AMBLYSTEGIUM.

- A. austro-hygrophilum* Broth., Linn. Soc. N.S.W., 1916, p. 594. Armidale (Watts).  
*A. convolutifolium*, see *Rhynchostegiella*.  
*A. fontinaloides* (Hpe.) Mitt., see *Drepanocladus*.  
*A. Muelleri* (Hpe. et C.M.) Jaeg., Ad., ii, p. 555. Frequent on damp rocks.  
*A. novae-valesiae* Broth. et Watts, Linn. Soc. N.S.W., 1912, p. 377. Yarrangobilly Caves (Watts).

## DREPANOCLADUS.

- D. brachiatus* (Mitt., in Hook. f. Hdbk. N.Z. Flora) Dix. Yarrangobilly Caves (Watts).  
*D. fluitans* (L., Fl. Suec., ed. 2, p. 899) Warnst.  
 var. *falcatus* Sch. Yarrangobilly Caves (Watts).  
*D. fontinaloides* (Hpe., as *Drepano-hypnum*) Broth. (See Jaeg., Ad., ii.)  
*D. strictifolium* Broth. et Watts, Linn. Soc. N.S.W., 1912, p. 378. Yarrangobilly Caves (Watts).  
*D. uncinatus* (Hedw., Musc. Frond., iv, p. 65) Warnst. Yarrangobilly Caves (Watts).

## ACROCLADIUM.

(This genus is included here following Dixon.)

- A. auriculatum* (Mont., Voy. au Pole Sud, p. 331 (Crypt.), 1843) Mitt. *Hypnum chlamydophyllum* H.f.W. Yarrangobilly Caves (Watts).  
*A. trichocladium* Bosw., *Journ. Bot.*, 1892, p. 99. "A doubtful species, perhaps *Acanthocladium extenuatum*" (Watts, in MS. notes).

## BRACHYTHECIACEAE.

## BRACHYTHECIUM.

- B. Kayseri* Geh., Rev. Bryol., 1876, p. 4. Near Sydney (Kayser).  
*B. novae-valesiae* Geh., loc. cit. Near Sydney (Kayser).  
*B. paradoxum* (H.f.W., in *Lond. Jour. Bot.*, iii, 554, 1844) Jaeg. Kosciusko, Kiandra, Yarrangobilly Caves, etc.  
*B. plumosum* (Sw., in Act. Hom., 1795, p. 256) Bryol. Europ. ? *B. pseudoplumosum* Brid. Cambewarra, Young, Richmond River, etc.  
*B. rivulare* Br. Eur. Tumut River (Watts).  
*B. rutabulum* (L., Sp. Pl., p. 1124) Bry. Eur. Common in the south and south-west.  
*B. salebrosum* (Hollm., Deutsch. Fl., ii, 74, 1796) Bry. Eur. Young, Yarrangobilly Caves, etc.

## RHYNCHOSTEGIUM.

- ? *R. albifrons* (Geh., in Sched.). Blue Mtns. (Whitelegge).  
*R. dentiferum* (Hpe.) Jaeg., Ad., ii, p. 437. Blue Mtns. (Whitelegge).  
*R. elusum* (Mitt., in Hdbk. N.Z. Fl.) Jaeg. Jenolan Caves (Blakely).  
 ? *R. Hodgkinsoniae* (C.M., ? F.v.M., Frag. Phyt., xi, Suppl.). N.S.W., no details; species seems doubtful.  
 ? *R. laevisetum* (Geh., Rev. Bryol., 1876). Near Sydney (Kayser).  
 ? *R. luridulum* (C.M., ? in F.v.M., Frag. Phyt., xi, Suppl.). "N.S.W." No details.  
*R. obtusissimum* (Geh., in Rev. Bryol., 1876). *R. obtusum* Mitt., in Cat. Austr. Musc. Near Sydney (Kayser).  
 ? *R. Parramattense* (Hpe. et C.M., in Mitt. Cat.). N.S.W. No details.  
*R. patulum* (Hpe.) Jaeg., Ad., ii, p. 436. Frequent near Sydney.

- ?*R. perpumilum* (C.M., in F.v.M., Frag. Phyt., xi, Suppl.). No details.  
*R. Plagiotheciella* (C.M., in Sched.). Mosman Bay (Whitelegge).  
 ?*R. pseudo-straminoides* (Hpe., in Linn., 1871-73). Blue Mtns.  
*R. tenuifolium* (Hedw., Sp. Musc., p. 283) Jaeg. *Hypnum confertum* H.f.W.,  
*H. collatum* H.f.W., *H. subclavatum* Hpe., *H. radicole* Hsch. Common  
 throughout the State.

## RHYNCHOSTEGIELLA.

- R. convolutifolium* (Hpe., Linn., 1869, p. 641) Broth. *Hypnum cucullatum* Mitt.;  
*Amblystegium* Mitt., Cat. Austr. Musc.; *Rhynchostegium strictiusculum*  
 (Broth.).  
*R. muriculata* (H.f.W., Fl. N.Z., p. 108). *Hypnum pterocladum* C.M. Richmond  
 River and Mosman, etc.  
*R. pseudo-teesdalei* (Hpe., Linn., 1859-60) Broth. In the Bryales Brotherus limits  
*R. muriculata* to Norfolk Is., New Zealand and Tasmania, and gives *R. pseudo-*  
*teesdalei* to east Australia.

## OXYRRHYNCHIUM.

- O. austrinum* (H.f.W., Fl. N.Z., as *Hypnum*) Broth. Yarrangobilly Caves.  
*O. remotifolium* (H.f.W., Fl. N.Z., as *Hypnum*) Broth.

## ENTODONTACEAE.

## ENTODON.

- E. myosurrella* C.M., in Rev. Bryol., 1876. Frequent on the coast.

## PLAGIOTHECIACEAE.

## PLAGIOTHECIUM.

- P. amblyostomum* C.M., in Sched. Mosman (Whitelegge).  
*P. novae-valesiae* Broth., Linn. Soc. N.S.W., 1916. Richmond River (Watts).

## SEMATOPHYLLACEAE.

## ACANTHOCLADIUM.

- A. Crossii* Broth. et Geh., in Oefv. af. Finsk., 1893. Manning River (Cross).  
*A. extenuatum* (Brid., Bryol. Univ., ii, p. 484) Mitt. *Hypnum crinitum* H.f.W.  
 Throughout the State.

## MEIOTHECIUM.

- M. Wattsii* (Broth., as *Pterogoniella*, Oefv. af. Finsk., 1900, p. 109) Broth.

## RHAPHIDOSTEGIUM.

- R. amoenum* (Hedw., Sp. Musc., p. 292, as *Hypnum*) Jaeg. *R. Cyparoides* Brid.  
*R. leptorhynchium* Brid. Richmond River (Bauerlen). Record doubtful.  
*R. callidioides* (C.M., as *Hypnum*) Jaeg., Ad., ii. ?*R. amoenum* (Hedw.). Blue  
 Mtns. and Yarrangobilly, etc.  
*R. contiguum* (H.f.W., in Fl. Tas.) Par. Homebush (Whitelegge).  
*R. homomallum* (Hpe., as *Leskea*, Ic. Musc.) Jaeg., Ad., ii. Blue Mtns. (Collie).  
*R. ovale* Broth., Oefv. af. Finsk., 1890. Cook's River, Richmond River, etc.  
*R. pseudo-demissum* (C.M., in Sched.). Sydney and Fitzroy Falls (Whitelegge).  
*R. pseudo-homallum* (C.M., as *Hypnum*, Rev. Bryol., 1876). Near Sydney (Kayser).  
*R. tenuirostre* (Hook., Musc. exot., t. iii) Jaeg. *R. luciduloides* C.M. (?).  
 Blue Mtns.  
*R. vesiculiforme* C.M. Name in F.v.M., Frag. Phyt., xi, Suppl. N.S.W.; no details.  
*R. Wattsii* (Broth., Oefv. af. Finsk., 1899, as *Syrrhopodon*) Broth. *R. micropyxis*  
 Broth. Richmond and Brunswick Rivers.

## SEMATOPHYLLUM.

*S. australis* Broth., see *Hampella pallens*.

## TAXITHELIUM.

*T. novae-valesiae* (Broth., as *Isopterygium*, Oefv. af. Finsk., 1899). Richmond River (Watts).

## HYPNACEAE.

## HYPNUM.

*H. cupressiformis* L., Sp. Pl. *H. Mossmanianum* C.M. Common throughout the State.

*H. Watterianum* C.M., Jaeg., Ad., ii, p. 584. Yarrangobilly Caves (Watts).

## ECTROPOTHECIUM.

*E. condensatum* Broth. et Watts, Linn. Soc. N.S.W., 1912. Yarrangobilly Caves (Watts).

*E. rivale* and *E. Slateri*, see *Vesicularia*.

*E. umbilicatum* (C.M., Linn., 1867, p. 623) Par. Throughout the State.

? *E. umbilicatum* (C.M., Rev. Bryol., 1876). Name only. Mosman (Whitelegge).

## ISOPTERYGIUM.

*I. amblyocarpus* (Hpe., as *Drepano-leskea* Linn., 1860) Broth. Probably *Acanthocladium extenuatum*, teste Mitt., Austr. Cat. Yarrangobilly Caves.

*I. amoenum* Broth., Oefv. af. Finsk., 1899, p. 128. Richmond River (Watts).

*I. arachnoideum* Broth., loc. cit. Richmond and Brunswick Rivers.

*I. austro-pusillum* (C.M., as *Hypnum*) Jaeg., Ad., ii, p. 501. Common on coast.

*I. candidum* (C.M.) Jaeg., Ad., ii, p. 503. Common throughout the State.

*I. latifolium* Broth., Oefv. af. Finsk., 1899. Ballina (Watts).

*I. novae-valesiae*, see *Taxithelium*.

? *I. pallido-virens* C.M., in Sched. Lilyvale (Whitelegge). The specimen in the herb. Syd. marked "type" is *Rhaphidostegium*.

*I. pseudo-subulata* (C.M., in Hedw., 1898, p. 115, as *Taxicaulis*) Par. Cambewarra (Whitelegge).

*I. subarachnoideum* Broth., Oefv. af. Finsk., 1899. Richmond River (Watts).

*I. umbilicatum* C.M., see *Ectropothecium*.

## VESICULARIA.

*V. rivale* Broth., Linn. Soc. N.S.W., 1916, p. 595. Richmond River (Watts).

*V. Slateri* (Hpe., as *Hypnum*, Linn., 1876, p. 321) Broth. Richmond River (Watts).

## POLYTRICHALES.

## BUXBAUMIACEAE.

## BUXBAUMIA.

*B. Colyeræ* Burg., Linn. Soc. N.S.W., 1932, p. 242. Williams River (Colyer).

In addition to the above, there are a number of incomplete records. Some refer to "nom. nud." of various authors, others to species described in publications unknown to the writer. In some instances species of *Brotherus* are represented by material labelled by the late Rev. W. W. Watts as "*Det. Broth.*" It is hoped to publish descriptions of these in a future note.

*Incomplete Records.*

*Acanthocladium sericeum* Broth., ? nom. nud. Material in herb. Syd. from Kurrajong (Musson).

- A. macro-extenuatum* C.M. Lane Cove (Whitelegge).  
*A. pseudo-extenuatum* C.M. Lawson (Whitelegge).  
*A. sub-extenuatum* C.M. Lawson (Whitelegge.) This and the preceding two species were considered by Watts as probably forms of *A. extenuatum* (Brid.) Mitt.  
*Amblystegium campylopioides* Broth., ? nom. nud. Kiandra (Forsyth).  
*Bryum leucoloma* Broth.; *B. sub-pseudotriquetrum* Broth.  
*Campyllum deflexula* C.M. Cambewarra (Thorpe).  
*Campyllum subrelaxum* Broth.  
*Distichophyllum subflexuosum* Broth.  
*Entodon flaccidsetus* C.M.; *E. Daemeli* C.M.; *E. Hartmanni* C.M.; *E. hypnodelphus* C.M.; *E. novae-valesiae* Hpe. These species names of *Entodon* appear in various MS. lists for N.S.W.  
*Fabronia novae-valesiae* Geh.  
*Hycomium brachythecioides* Broth.  
*Isopterygium viride-pallens* C.M.; *I. austro-subulatum* C.M.  
*Plagiothecium amblyostomum* C.M.  
*Pterygophyllum trichoides* Geh.  
*P. Wattsii* Broth. Listed in Engler, but can find no description.  
*Rhaphidostegium aciculum* C.M.; *R. brachytheciella* C.M.; *R. calocarpum* C.M.;  
*R. luciduloides* C.M.; *R. pseudo-demissum* C.M.; *R. Tingiringense* Geh.  
*Rhynchostegiella subconvolutifolium* Broth. et Watts.  
*Thuidium atrovirens* Broth.; *T. protensulum* C.M.; *T. squalidiusculum* C.M.
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## STUDIES IN THE GENUS *UROMYCLADIUM*. II.

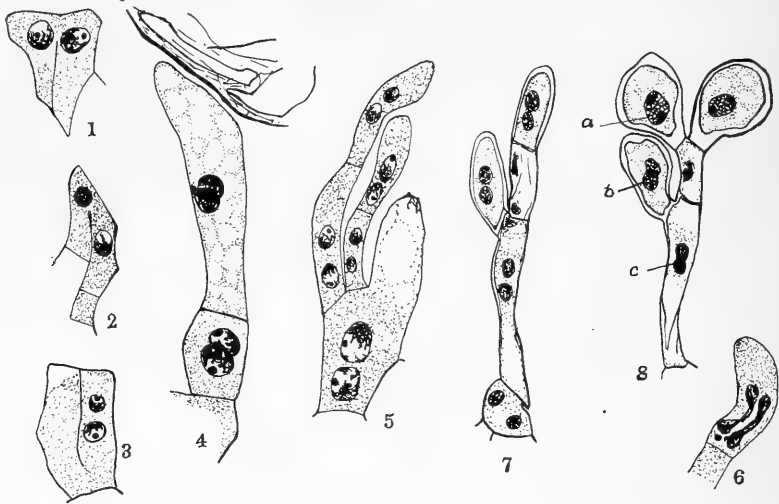
NOTES ON THE DIKARYON STAGE OF *UROMYCLADIUM* *TEPPERIANUM*.

By ALAN BURGES, M.Sc., late Linnean Macleay Fellow of the Society in Botany.

(Sixteen Text-figures.)

[Read 24th April, 1935.]

Since the publication of Part I of these studies (these *PROC.*, lix, 1934, p. 212), certain circumstances have arisen which make it unlikely that the writer will be able to continue this work on the life history of *Uromycladium* for some years. It was thought advisable, therefore, to place on record observations made to date on the dikaryon stage. As in the previous study, the material chosen for examination was stems of *Acacia stricta* Willd., infected with *Uromycladium Teppermanum* (Sacc.) MacAlp.



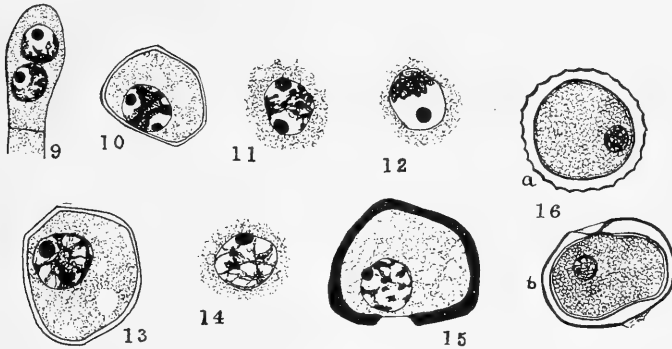
Text-figs. 1-8.

1.—Cell fusions in the developing teleutosorus. 2.—Cell fusion showing the suggestion of movement of the nucleus. 3.—Cell fusion showing both nuclei lying in the one cell. 4.—Hymenial cell and buffer cell. Crushed cells of host above. 5.—Hymenial cells with collapsed buffer cell and two spore-head initials. 6.—Conjugate division in the spore-head initial. 7.—Developing spore-head. 8.—A later stage in the development. Figs. 1-6,  $\times 1,500$ ; 7-8,  $\times 1,250$ .

The first indication of the formation of the teleutosorus in this species is a massing of hyphae, several layers of host cells deeper than the pycnia but connected with them by numerous strands of hyphae. Formation of the dikaryon

stage is by equal cell fusion in this hyphal mass (see Text-figs. 1, 2, 3); apparently any two cells may unite. Sometimes one of the fusing nuclei may migrate so that both lie in the same cell. When this occurs there follows usually a contraction of the cytoplasm in the non-nucleated portion (Text-fig. 3). Simultaneous divisions of the nuclei follow and a very limited binucleate mycelium is formed, seldom more than three or four cell-layers deep. Extension of the young sorus seems to be brought about by further nuclear migrations rather than by continued division of the first-formed binucleate hyphae.

Cells from the outer part of the binucleate zone form the hymenium. These cells are but little differentiated at first, but they enlarge somewhat as they grow older. By division they give rise to a row of buffer cells; these elongate rapidly (Text-fig. 4) and by their growth crush and eventually cause the shedding of the outer layers of the host tissue. In the later stages these buffer cells become vacuolated and then collapse. The formation of the buffer layer is not regular and frequently the pressure of the developing spores themselves causes the shedding of the external layers of host tissue.



Text-figs. 9-16.

9.—A very young spore with two nuclei. 10.—Fusion nucleus. 11.—Fusing nucleus showing aggregation of chromatin into masses. 12.—Fusion nucleus showing contraction of chromatin. 13, 14, 15.—Reorganization of the diploid nucleus. 16.—Mature spore: *a*, cross-section; *b*, longitudinal section. Figs. 9-16,  $\times 1,500$ .

Teleospore initials arise either directly, or as lateral outgrowths from the hymenial cells at the side of the buffer cells (Text-fig. 5). The developing hypha elongates slightly and typical conjugate division of the nuclei takes place (Text-fig. 6). The stages of segmentation have been figured diagrammatically in a previous paper (Burges, 1934).

The thickening of the spore wall takes place very irregularly (Text-figs. 7, 8) and the developing spore undergoes many changes in shape. Nuclear fusion begins about the same time as the thickening of the spore wall. Two nuclei prior to fusion are shown in Text-figure 9. They each possess a well-marked nucleolus and a deeply staining chromatin mass. On coming into contact, the membranes of the nuclei break down and the contents begin to fuse. The chromatin, which is more or less irregular at this stage (Text-fig. 10), aggregates into isolated lumps (cf. Text-fig. 11). The nucleoli fuse and the chromatin material tends to contract towards one side of the nucleus (Text-fig. 12). The

young spore by this time has reached its adult size. Changes in the chromatin distribution continue, resulting in its more even distribution throughout the nucleus (Text-figs. 13, 14, 15). The nucleus then shrinks slightly and remains in the resting condition till germination occurs.

The mature spores (Text-fig. 16) are depressed-globose in shape and deeply striated by longitudinal furrows as is shown in cross-section (Text-fig. 16a). There is a well-marked apical germ pore and a basal hilum. At maturity the stalk-cell elongates rapidly and carries the spore-head well up above the hymenium. The spores are shed and the pedicel shrivels. Further lateral growths from the hymenial cells give rise to more spore-heads. The spores when shed tend to dry out and contract, so that the hilum is drawn near to the germ pore. Their viability seems to be dependent on the amount of desiccation to which they are subjected. In the winter they may retain their viability for weeks, but in the summer a few hot days in the dry weather kills the majority of spores.

Spores germinated in the laboratory with the production of a copious growth of germ-tubes, but in all cases abnormal growth resulted. No sporidia were formed, even when spores were sown on gelatine or agar films in varying humidities.

This work was carried out in the Botany School of the University of Sydney, and my thanks are due to Professor Osborn for the facilities afforded me there.

#### *Summary.*

1. The dikaryon stage is formed by equal cell fusion, but the nuclei may move so that both lie in the same cell.
  2. The binucleate mycelium is very limited and may consist of only one or two layers of cells.
  3. Buffer cells cut off from the hymenial zone help to shed the outer layers of the host.
  4. Spore-head initials arise from the hymenial cells and segment to give three spores.
  5. Nuclear fusion occurs in the developing spores.
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AN INVESTIGATION OF THE SOOTY MOULDS OF NEW SOUTH WALES. III.  
THE LIFE HISTORIES AND SYSTEMATIC POSITIONS OF AITHALODERMA AND CAPNODIUM,  
TOGETHER WITH DESCRIPTIONS OF NEW SPECIES.

By LILIAN FRASER, M.Sc., Linnean Macleay Fellow of the Society in Botany.

(Sixty-five Text-figures.)

[Read 24th April, 1935.]

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*Introduction.*

The systematic position of the Capnodiaceae has been the subject of investigation by several workers, but as yet no ontogenetic studies have been made, with the exception of that of Arnaud (1910) on *Pleosphaeria (Aithaloderma) citri*. Arnaud followed the early development of the young fruit body, but was unable to trace the formation of an archicarp.

Theissen and Sydow (1917) and the older systematic mycologists placed the Capnodiaceae in the Perisporiales with the Erysiphaceae and Perisporiaceae. Arnaud (1911), and later Gaumann (1928), considered that their affinities lay rather with the Sphaeriales because of the presence of an ostiole and the method of development of the perithecium. Von Hoehnel (1918) described the Capnodiaceae as having Pseudosphaerialean structure. Woronichin (1925) considered them sufficiently distinct to be raised to the rank of an order, the Capnodiales. Von Hoehnel (1910) considered that some of the fungi which were included by Theissen and Sydow in the Capnodiaceae should be placed in the Sphaeriales, and Petrak (1929) believed that the Chaetothyriaceae, recognized by Theissen and Sydow as a sub-section of the Capnodiaceae, comprised very heterogeneous elements, most of which were probably not closely related to the Capnodiaceae.

Arnaud's classification involves the inclusion of the species of the Capnodiaceae in already described genera of the Sphaeriales. Thus *Capnodium citri* became *Pleosphaeria*, and *C. salicinum* became *Teichospora*.

Any discussion of the nomenclature of these species must, therefore, be based on a consideration of their systematic position.

Very little is known about the development of the fruit body in the Capnodiaceae, most of the work having been done on mature fructifications. Arnaud described the formation of a stroma by the division of cells of a vegetative hypha to form a flat disc which, by further growth, becomes almost globular. He did not describe the early development of the archicarp, but recorded the growth of the young asci at the expense of the stroma.

For the present investigation, material was fixed in the field, the most satisfactory reagents being Flemming's weak fixative, and chromo-acetic 1% solution diluted with an equal volume of water. Sections cut at  $4\mu$  were stained with Haidenhain's iron-alum Haematoxylin. For confirmation sections  $2\mu$  thick were

stained with safranin and gentian violet, and by Newton's iodine-gentian violet method.

The life-histories of four fungi are considered in the following account. Three of these, *Capnodium salicinum* var. *uniseptatum*, *Aithaloderma ferruginea* and *A. viridis*, are here described as new and will be discussed in more detail in the succeeding papers of this series. The genus *Aithaloderma* is placed in the sub-section Chaetothyriaceae of the Capnodiaceae by Theissen and Sydow, *Capnodium* being the type genus of the sub-section Eucapnodiaceae.

CAPNODIUM SALICINUM VAR. UNISEPTATUM, n. var.

Mycelio epiphylo. Hyphis fuscis, dense ramosis anastomosisque. Cellulis elongatis vel breviter constrictis, 3.5-5 × 5-12 $\mu$ . Pycnidii erectis, elongatis, 300-650 $\mu$  longis, ad basem 50-70 $\mu$  crassis, ad apicem 20-30 $\mu$  crassis. Apici fimbriata. Pycnidiosporis hyalinis, 1-septatis, ellipticis, prima nonconstrictis, 3.5-4.5 × 7-8 $\mu$ , dein constrictis 5 × 8-9 $\mu$ . Ascstromis globosis vel ellipticis, ad apicem obtusis, glabris, sessilibus vel saepe stipitatis, 80-120 × 100-200 $\mu$ . Ascis clavatis, ad basem attenuatis, 50-60 × 15-20 $\mu$ , octosporis. Ascosporis atrofuscis 3- vel raro 5-septatis, medio septo saepe constrictis, 1-4-longitudinaliter septatis, oblongis untrinque rotundatis, 17-22 × 7-9 $\mu$ .

Mycelium dark brown, dematioid, the cells 3.5-5 × 5-12 $\mu$ . Pycnidia elongate, 300-650 $\mu$  in length, 50-70 $\mu$  wide at the base, 20-30 $\mu$  wide at the apex. The apex is fringed by a ring of hyaline 1-2-celled, hair-like hyphae 20-30 $\mu$  long. Pycnidiospores hyaline, 1-septate, oval, 3.5-4.5 × 7-8 $\mu$ . Ascstromata globular or slightly vertically extended, shortly stalked, 80-120 $\mu$  wide by 100-200 $\mu$  long inclusive of the stalk. The stalk is 20-100 $\mu$  long. Asci are numerous, clavate, 50-60 × 15-20 $\mu$ , eight-spored. Ascospores are irregularly grouped in the ascus, greenish-brown, becoming dark brown when mature, with 3 or rarely 5 transverse septa, and a varying number of longitudinal septa, often two at right angles between each transverse septum. The mature ascospores are characteristically slightly constricted at the middle septum.

Type collection from Pennant Hills, on *Spartium* sp., 6, 1932.

AITHALODERMA FERRUGINEA, n. sp.

Mycelio epiphylo, late effuso, ex hyphis ramosis anastomosisque, plerumque longitudinaliter connatis, subfuscis, cellulis cylindricis, vix constrictis, 4-5 × 5-8 $\mu$ . Pycnidii breviter conoideis, 85-120 $\mu$  diam., ostiolis setis divergentibus fimbriatis. Setis atrofuscis, opacis, 70-140 $\mu$ . Pycnidiosporis hyalinis, continuis, ovoideis, 5-6 × 3 $\mu$ . Ascstromis breviter conoideis, 100-150 $\mu$  diam., 50-85 $\mu$  crassis, olivaceo-fuscis. Apice distincte ostiolato. Ostiolis setis elongatis, divergentibus opacis fimbriatis. Ascis oblongis vel cylindricis, 60-75 × 10-15 $\mu$ , octosporis. Ascosporis hyalinis, 5-7-septatis, ad septa constrictis, apice rotundatis, deorsum attenuatis, 25-28 × 5-6 $\mu$ .

The mycelium is thin, light brown, almost slimy, the cells are 4-5 × 5-8 $\mu$ , slightly constricted at the septa. The pycnidia are conical, 85-120 $\mu$  in diameter, the apical pore is encircled by 6-10 divergent dark brown setae 70-140 $\mu$  long, which are opaque or nearly so and taper to a rounded point. The pycnidiospores are hyaline, one-celled, ovoid, 5-6 × 3 $\mu$ . The ascstromata are conical, 100-150 $\mu$  in diameter, 50-85 $\mu$  high in the centre. The apical pore is surrounded by setae similar to those present on the pycnidia. The asci are cylindrical or oblong, 60-75 × 10-15 $\mu$ , eight-spored. The ascospores are hyaline, typically 5-septate, but

occasionally 6- or 7-septate, slightly constricted at the septa, oblong, rounded at both ends but often tapering slightly towards the base,  $25-28 \times 5-6\mu$ . The walls of the pycnidia and ascostromata are dull brownish-yellow by transmitted light, but by reflected light appear a bright golden-brown.

Type collection from Pennant Hills, on *Citrus* sp., 6, 1933.

*AITHALODERMA VIRIDIS*, n. sp.

Mycelio epiphylo, late effuso, ex hyphis ramosis anastomosisque plerumque longitudinaliter connatis, subfuscis. Cellulis cylindricis, ad septa vix constrictis, olivaceo-fuscis, septatis non manifestatis. Pycnidiiis  $200\mu$  diam., tenuis,  $45\mu$  crassis, hyphis radiantibus constatis, primo virido-fuscis, dein atris, mature apici incomposite fractis. Pycnidiosporis hyalinis, continuis, oblongis,  $4-5 \times 1\mu$ . ascostromis ex hyphis radiantibus constatis, primo virido-fuscis, dein atris,  $150-200 \times 50-80\mu$ . Ascis clavatis, ad apicem incrassatis,  $50-70 \times 17-20\mu$ , 4- vel 8-sporis. Ascosporis hyalinis, 4-septatis, constrictis,  $24-26 \times 4-5\mu$ .

The mycelium is thin, olive-brown, the cells are scarcely constricted at the septa, the transverse walls are not clearly distinguishable, the individual cells are  $3.5-4.5 \times 10-17\mu$ . The pycnidia average  $200\mu$  in diameter, and are rather thin,  $45\mu$  in height at the centre. When young the pycnidia resemble the fructifications of the *Microthyriaceae*, since they consist of a disc of closely-associated radiating hyphae. The pycnidiospores are hyaline, one-celled,  $4-5 \times 1\mu$ . The apex of the pycnidium splits by means of radiating cracks at maturity, and no setae are present around the apex. The ascostromata show the same radiating structure as the pycnidia. They are  $180-200\mu$  in diameter by  $50-80\mu$  in height. An apical pore is developed at maturity, but radiating cracks also appear as in the pycnidia, no setae are present around the apex. The asci are clavate, somewhat thickened at the apex,  $50-70 \times 17-20\mu$ , 8- or 4-spored. The ascospores are hyaline, 4-septate, somewhat constricted at the septa,  $24-26 \times 4-5\mu$ . The pycnidia and ascostromata are olive-green when young, and black at maturity with a radiating border of olive-green hyphae.

Type collection from Glenrock (Newcastle district), on *Elaeodendron australe* Vent., 8, 1933, coll. A. Burges.

*The Life History of Aithaloderma ferruginea.*

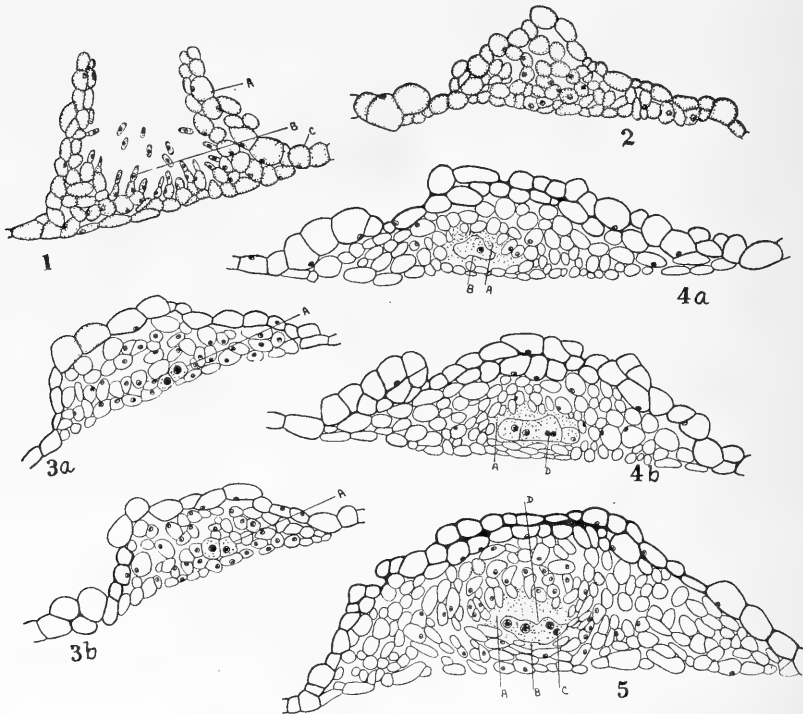
The mycelium of this species is brown and usually forms only a thin covering on the leaf. The hyphae, which consist of uninucleate cells, branch and anastomose at wide angles. The branching is in one plane only, parallel to the surface of the leaf, so that the mycelium forms a thin web over the surface.

The pycnidia arise on the young mycelium. Their development usually precedes the formation of ascostromata, but is very irregular and may not take place at all. They arise by the division of two or more adjoining cells of a hypha, frequently those of a branch joint or anastomosis, to form a thread of short wide cells. Further divisions give rise to a flat plate of cells. These cells then give rise to upward-growing hyphae which form a very short column which is further widened at the base by radial growth. The upward-growing hyphae form a wall layer of interwoven cells, leaving a central hollow area. Pycnidiospores are budded inwards into this hollow by the wall cells and the cells at the base of the young pycnidium. The mouth of the mature pycnidium is relatively wide and may be fringed by a few dark erect setae (Text-fig. 1).

The ascogenous fruits originate in a similar manner. A flat disc is formed by the lateral growth of hyphae originating by the segmentation of adjoining

cells of a hyphal thread, in the manner described for *A. citri* by Arnaud (1910). According to Arnaud, further growth in *A. citri* takes place under this flat disc. In *A. ferruginea* a certain amount of upward growth takes place also. After a brief period of upward growth, the uppermost cells of the disc differentiate out, becoming dark-walled and rigid (Text-fig. 2). The stroma then increases in size by the growth of hyphae beneath this covering. These hyphae become crowded and intertwined, and the centre of the disc becomes much thickened so that the stroma is finally hemispherical. Increase in diameter is effected by radial growth of hyphae around the margin of the disc. The young stroma therefore consists (Text-figs. 2-4) of a layer of dark-brown wall-cells, beneath which is a core-tissue of interwoven thin-walled hyphae, the base of which is in contact with the leaf of the plant on which the mould is growing.

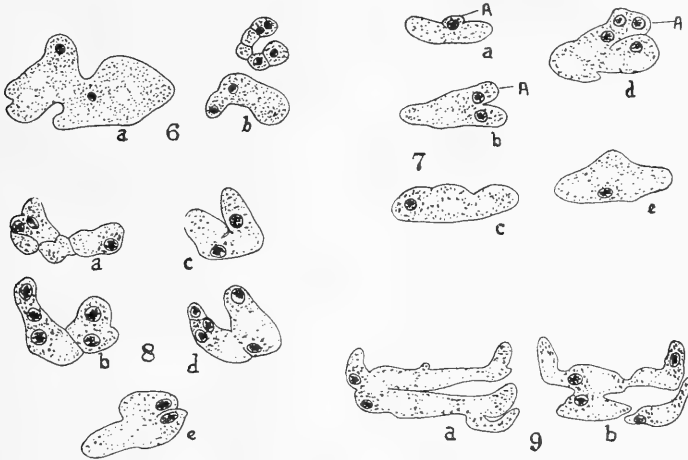
The archicarp arises in the core-tissue close to the base. In this species it can be distinguished from the core-tissue by the larger size of the cells, their



Figures 1-5. *Aithaloderma ferruginea*.

1.—Median longitudinal section of a mature pycnidium. A, wall; B, pycnidiospores; C, mycelium. 2.—Median longitudinal section of a young ascostroma, showing browning of the upper wall layer. 3.—Two successive median longitudinal sections of a young ascostroma, showing the development of the archicarp (A), part of which is shown in each of the sections. 4.—Two successive median longitudinal sections of a young ascostroma showing formation of multinucleate cell (B) and association of nuclei (D). A, mucilage. 5.—Median longitudinal section of an ascostroma showing increase in size of the archicarp (B) and the large size of the nuclei. A, mucilage; C, degenerating nucleus?; D, indentation in wall of archicarp showing probable position of resorbed wall. Figs. 1-5,  $\times 700$ .

greater tendency to hold stains and the size of their nuclei (Text-fig. 3, *a, b*). The number of cells which function as the archicarp could not be determined accurately, but appears to be four or more. The archicarp grows at the expense of the cells of the core-tissue surrounding it. These become disorganized and are resorbed. Very soon after increase in size commences in the archicarp, a deeply-staining layer of mucilaginous material becomes apparent around it. This is the unresorbed portion of the disorganized core-tissue, and it marks off the archicarp very sharply. The next stage in archicarp development is shown in Text-figure 4. The archicarp is seen to have enlarged considerably, and only two cell walls are visible in it. Though the process could not be observed in the material available, it seems certain that the walls between the archicarp cells break down and the nuclei are thus associated in one large cell. Certain indentations in the wall of the multinucleate archicarp (D in Text-fig. 5) indicate where septa probably



Figures 6-9. *Aithaloderma ferruginea*.

6.—Successive transverse sections of an archicarp showing branching; 6*b* shows the cut apices of vertical branches. 7, 8, 9.—Successive longitudinal sections of archicarps showing branching. Figs. 6-9,  $\times 1,170$ .

occurred. It is very unlikely that a multinucleate archicarp such as is shown in Text-figures 4 and 5 could be formed by the enlargement of one cell of the original archicarp, and division of nuclei in this, since no crushed archicarp cells were observed. Moreover, the entire archicarp is invested in a mucilaginous sheath and is clearly multicellular in the youngest stages.

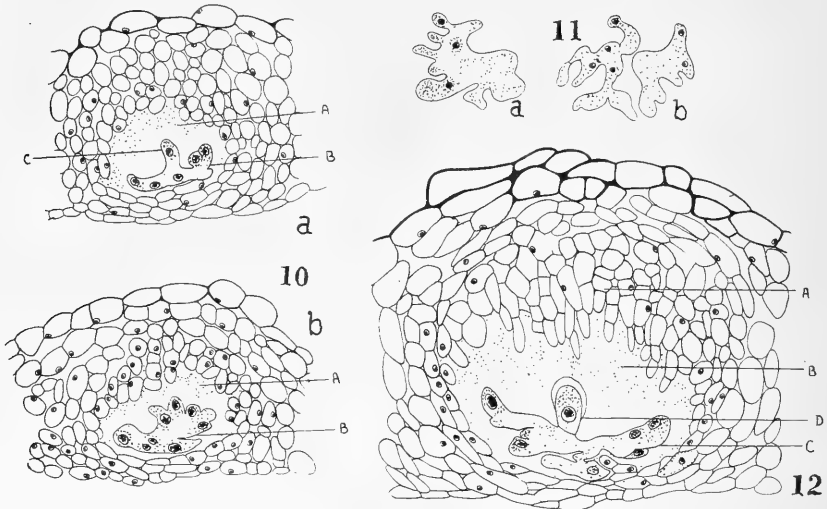
In the archicarp shown in Text-figure 4*b*, several septa appear to have been resorbed and one is still intact.

The writer considers it probable that the nuclei then fuse in pairs. Two nuclei are seen in close proximity in Text-figure 4*b* at D, and a similar condition has been observed in a number of other sections. (A few cases have been noted in which a pair of nuclei is in contact.) In Text-figure 5, which shows the archicarp at a slightly later stage, the nuclei are larger and fewer in number and the inference is that they are fusion nuclei.

Concurrently with the growth of the archicarp, the stroma has been increasing in size by means of hyphal growth and branching within the upper wall. There

is seen in section a tendency for the cells to be arranged in rows. This becomes very marked with further enlargement of the stroma and the rows develop definitely at right angles to the direction of growth of the ascogenous tissue (Text-figs. 10, 12). If the outer wall of the stroma breaks, which it does in places, due to the strain caused by the growing tissue below, the adjoining core-cells become brown and fill the gap. To cope with the internal growth which arches up the centre, further growth of the wall takes place in a radial direction around the edges, and further stromatic core-material is formed beneath this also, so that the radial as well as the vertical extent of the stroma is increased.

The archicarp nuclei then commence to divide. The actual process of division was not observed, and it is not known whether it is meiotic or mitotic in the first instance. The number of nuclei is considerably increased. At the same time the archicarp increases in size horizontally and a number of branches grow out from it. This is shown in surface section in Text-figure 6. Each of these out-



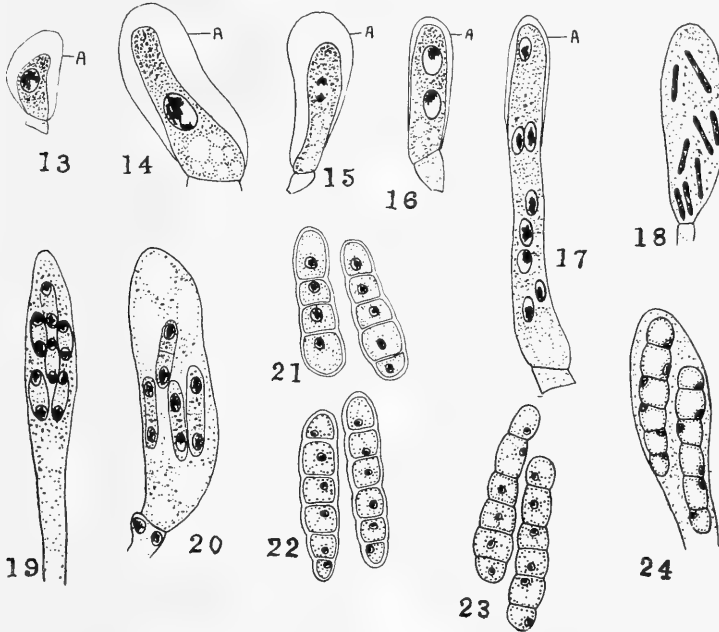
Figures 10-12. *Aithaloderma ferruginea*.

10.—Successive longitudinal sections of a developing ascostroma showing increase in size, and further branching of the archicarp. A, mucilage; B, ascogenous hyphae; C, young ascus. 11.—Successive transverse sections, *a*, lower, and *b*, upper, of developing ascogenous hyphae. 12.—Slightly oblique longitudinal section of a developing stroma to show the growth in strands of the stroma core tissue (A) around the ascogenous hyphae (C). B, mucilage; D, young ascus. Figs. 10-12,  $\times 880$ .

growths may branch repeatedly (Text-fig. 10) in all directions upwards and outwards. The further growth of these branches is chiefly horizontal. Text-figures 7 and 8 show stages in the early development of the branch system. The horizontal growth of the branches is shown in Text-figure 9, which shows an older stage in development, and in Text-figure 11, which shows the horizontal extent of the branch-system as seen in two successive surface sections. These branches, which arise from the archicarp and later give rise to the asci, are ascogenous hyphae. The number of nuclei in each branch is very variable, and

depends on the rapidity with which branching is taking place in relation to the rapidity of nuclear division in the branches.

Digestion of the overlying stroma cells continues concurrently with further growth of the stroma. Finally there results an almost globular fruit body, across the base of which is a complex branch-system of ascogenous hyphae, and the central part of which is occupied by the digested fragments of core-cells (Text-fig. 12). Early in the development of the ascogenous hyphal system, the asci commence to arise from the horizontal ascogenous hyphae as upgrowing branches which become cut off by a wall across the base (D, in Text-fig. 12). The young ascus is clearly distinguishable by its rounded shape and the large number of



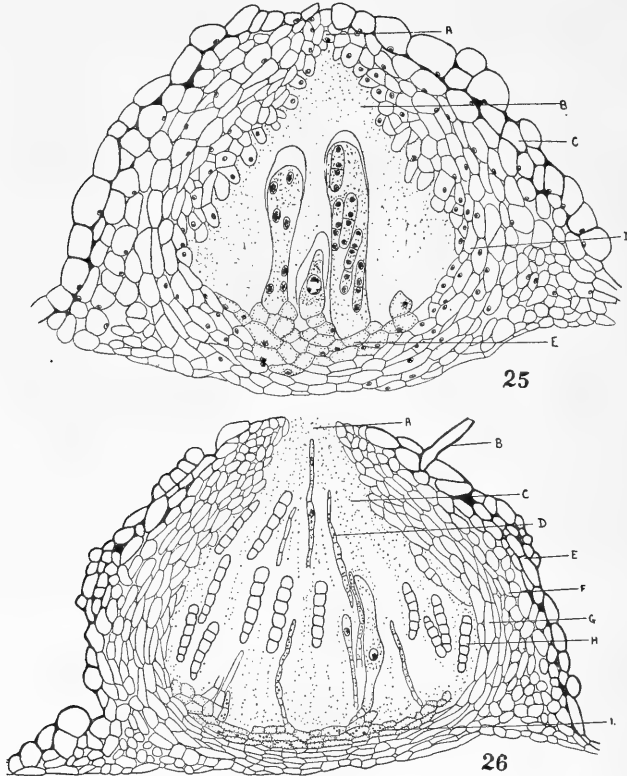
Figures 13-24. *Aithaloderma ferruginea*.

13, 14.—Young asci showing growth. A, mucilage cap. 15.—Ascus showing division of the nucleus. A, mucilage cap. 16.—Ascus showing binucleate stage, A, mucilage cap. 17.—Ascus showing 8-nucleate stage after increase in size of the nuclei. 18.—Ascus showing division of the eight nuclei. 19, 20.—Asci showing formation of ascospore walls. 21.—Young ascospores before the completion of the last division. 22.—Young ascospores showing thick hyaline walls. 23.—Ascospores showing contraction of walls. 24.—Mature ascospores. Figs. 13-24,  $\times 1,170$ .

densely-staining granules around the nucleus. As far as could be seen, only one nucleus enters the young ascus from the ascogenous hypha on which it arises, and no evidence has been obtained of nuclear fusion in it.

The young ascus is shown in Text-figures 13 and 14. The nucleus is large and the chromatin is usually aggregated in one mass to which a few loose threads are attached. This condition is strongly suggestive of synapsis. The resting nucleus is, however, of the karyosome type, in which most of the chromatin is aggregated in one mass, so that, in the absence of further stages in division, it is not possible to say with certainty whether the first division of the ascus nucleus

is meiotic or not. The small size of the vegetative and sexual nuclei increases the difficulty of such observations. Nuclear division appears to be intranuclear (Text-fig. 15). The ascus becomes successively two-nucleate (Text-fig. 16), four-nucleate, and eight-nucleate (Text-fig. 17). The eight nuclei then divide (Text-fig. 18). A cell wall forms around each pair of daughter nuclei (Text-fig. 19) and a cross wall is formed (Text-fig. 20). A small two-celled ascospore results. Each nucleus divides (Text-fig. 25) and two further cross walls cut the young spore into four cells (Text-fig. 21). The two end-cells then divide again, the



Figures 25-26. *Aithaloderma ferruginea*.

25.—Median longitudinal section of an ascostroma to show the process of resorption of the pore (A). B, mucilage; C, outer wall; D, inner part of stroma; E, probable extent of ascogenous cells.  $\times 700$ . 26.—Median longitudinal section of an old stroma. A, pore; B, seta; C, mucilage; D, paraphysis-like hypha; E, outer stroma wall; F, core tissue; G, partly resorbed core tissue; H, ascospore; I, probable extent of ascogenous cells.  $\times 400$ .

mature spore being five-septate (Text-fig. 22). The walls are at first thick and hyaline, the cells densely protoplasmic, and the nuclei more or less homogeneous (Text-fig. 22). As the spore matures, it contracts slightly, the walls become somewhat thinner but remain colourless (Text-fig. 23), and the nuclei contract somewhat and have a prominent central mass of chromatin. These nuclei often



finally come to lie against the cell wall and the protoplasm becomes vacuolate (Text-fig. 24).

As the stroma nears maturity, the apex becomes much thinner by resorption of the core-cells (Text-fig. 25) and finally a pore is formed, fringed by fragments of digested cells and those in the process of digestion (Text-fig. 26). At this stage it is difficult to distinguish the much-branched ascogenous hyphae at the base of the stroma from the stroma cells immediately below them, as they are in close contact, and all more or less collapsed.

Narrow multicellular paraphyses-like hyphae develop from the ascogenous layer as the stroma becomes old (Text-fig. 26). Double stromata may occur; cases have been seen in which two unrelated archicarps have arisen in the same stroma.

A number of setae surround the apex of the mature stroma. Spores are ejected by the swelling of mucilage in the stroma.

#### *The Life History of Aithaloderma viridis.*

Development is rather similar to that of *Aithaloderma ferruginea*, but is interesting in that it represents a further extension of the radial habit of growth which is seen to a certain extent in *A. ferruginea*.

An extensive radial flat plate is formed by the developing pycnidium before any growth in thickness occurs. Growth in thickness, when it takes place, is practically all under this covering, the apex of which is broken by the pressure of the developing spores.

The ascostroma also forms a flat plate of radiating cells of considerable extent before growth in thickness takes place and, as in the case of the pycnidia, further growth is localized below the first-formed disc of cells. The radial growth continues as the stroma increases in thickness, to a much greater extent than in *A. ferruginea*, so that in surface view the ascostroma is seen to have a border of radiating hyphae which grow out for a short distance all round it.

As the ascogenous hyphae develop, digestion of core-tissue proceeds as in *A. ferruginea*. The stroma tissue around the ascogenous hyphae, by continued growth, forms a definite wall which stands out from the outer loosely-woven stroma tissue by its compactness (E, in Text-fig. 27). In old stromata this zone has all the appearance of a perithecial wall. The upper wall layer of the stroma is unable to extend to accommodate this increase, and breaks therefore occur at the apex. These expose part of the outer core-tissue, which becomes in consequence much browned (A, in Text-fig. 27). As in *A. ferruginea*, an apical pore develops by resorption (Text-figs. 28 and 29). The wall surrounding the developing asci becomes much thinner at maturity, due to continued resorption.

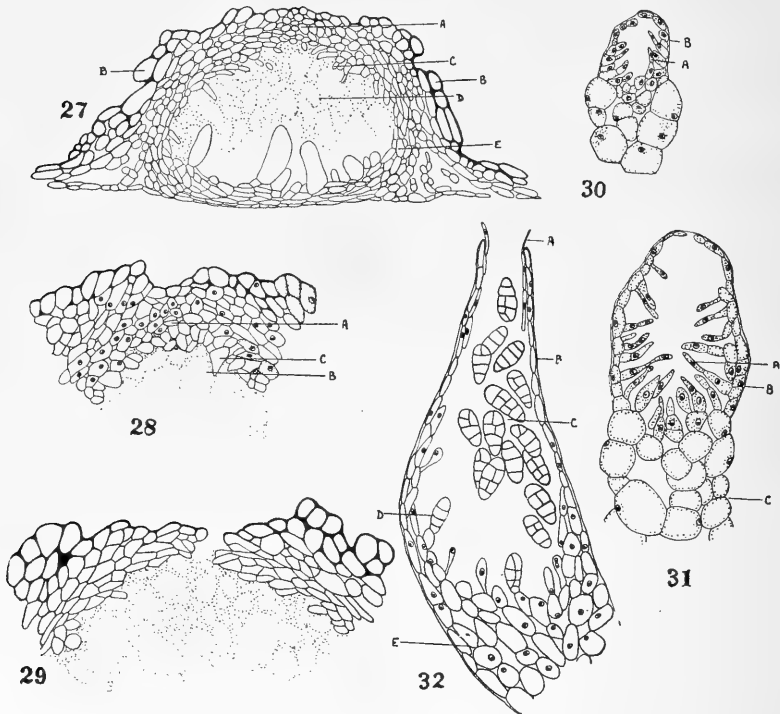
It is not uncommon to find two or more archicarps developing in the one stroma.

#### *The Life History of Capnodium salicinum Mont.*

The mycelium of *C. salicinum* consists of hyphae which branch and anastomose at wide angles in three dimensions to form a felt-like mass. The cells are brown-walled and uninucleate, the nucleus usually lying against the cell wall. There is a large central vacuole in the mature cell, and oil drops which were identified by their characteristic staining reactions, are frequently present.

Pycnidia arise on the young mycelium. The first indication is the division of two or more adjoining cells of a hypha, not infrequently those of a branch-joint or anastomosis, to form a thread of short wide cells. Further divisions give rise to a flat plate of cells whose walls are not so dark as those of the surrounding

mycelium. Cell walls are formed in all directions, and the cells round off slightly so that further divisions in these at right angles to their upper surfaces give rise to short filaments of cells. Only the upper cells of the plate are involved in this growth so that there results a short fascicle of upward-growing hyphae which are held close together by mucilage. The origin of the pycnidium is therefore compound meristogenous (Kempton, 1919). The basal cells of the fascicle enlarge and vacuolate, and become dark brown, thus forming a longer or shorter stalk. The hyphae of the stalk may branch, resulting in an increase in width. A certain amount of radial growth from the cells at the base of the stalk into the surrounding mycelium may also take place.



Figures 27-29. *Aithaloderma viridis*.

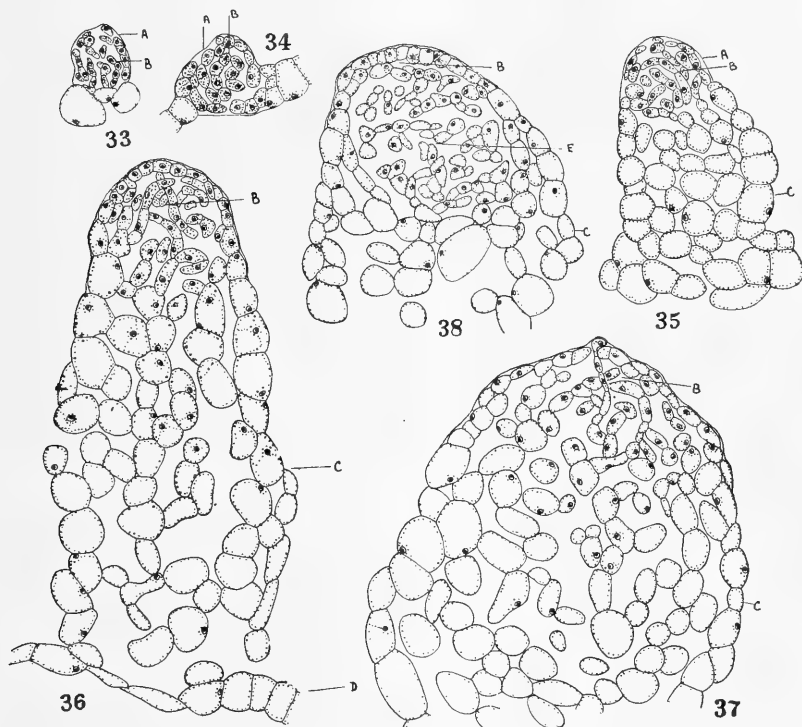
27.—Median longitudinal section of a young stroma showing the beginnings of the wall-like layer of the stroma tissue (E) round the young asci. A, stroma tissue which has broken through the upper wall layer (B). C, partly digested cells of the stroma; D, mucilage.  $\times 400$ . 28, 29.—Development of the apical pore by resorption. A, growing hyphae; B, mucilage; C, partly digested cells.  $\times 700$ .

Figures 30-32. *Capnodium salicinum*.

30.—Median longitudinal section of a very young pycnidium. A, young pycnidiospore; B, mucilage sheath.  $\times 700$ . 31.—Median longitudinal section of a young pycnidium. A, young pycnidiospore; B, mucilage sheath; C, stalk.  $\times 700$ . 32.—Median longitudinal section of a mature pycnidium. A, fringe of hairs; B, neck of pycnidium; C, detached spores; D, young spore; E, part of stalk.  $\times 400$ .

Further growth of the hyphae at the head of the stalk results in the formation of a wall layer 1-2 cells in thickness, and from these pycnidiospores are budded

off into the centre of the structure (Text-fig. 30). The wall-forming hyphae may be irregularly interwoven. The tips of the growing wall hyphae bend over so that the young pycnidium is almost enclosed. The wall hyphae continue their apical growth and further young pycnidiospores are formed, resulting in an irregular hymenial layer of growing spores which extends up the sides of the pycnidium (Text-fig. 31). The spores are not abstracted at this stage, but continue to increase in size. The mature pycnidium is shown in section in Text-figure 32. It is erect, standing well above the mycelium, and the apex is open and fringed with a row of hyaline hair-like cells which grow out from the inner wall layer.



Figures 33-38. *Capnodium salicinum*.

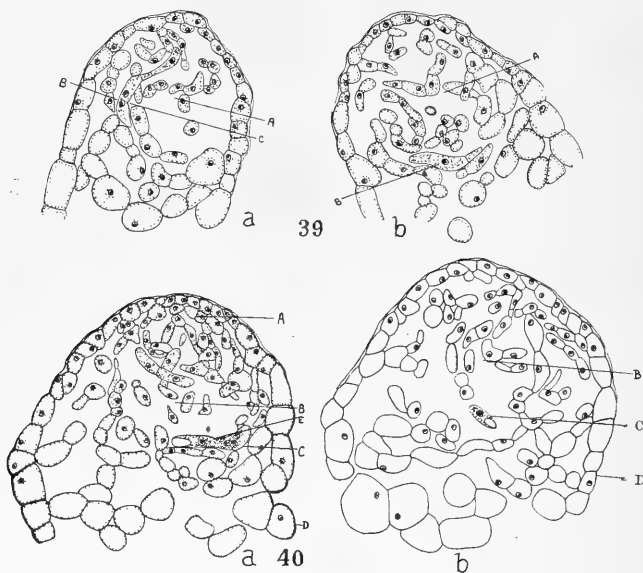
33, 34.—Median longitudinal sections of a very young stroma. A, mucilage sheath; B, young hyphae. 35-38.—Median longitudinal sections of developing stromata showing formation of a stalk. A, mucilage sheath; B, growing hyphae; C, stalk; D, mycelium; E, core tissue. Figs. 33-38,  $\times 700$ .

There are a number of spores lying free in the centre, which are typically brown-walled, three-septate, with or without additional longitudinal septa. Other spores are in the process of being budded off from the cells at the sides and base of the pycnidium. It is not known whether or not the same hymenial cell can bud off more than one spore, no chains of spores having been observed.

A considerable amount of mucilage is present in the mature pycnidium. This aids in spore dispersal by swelling with imbibition of moisture, thus bulging out through the neck and carrying detached spores.

The ascogenous fruits are produced at a later stage than the pycnidia. Young ones may be seen when pycnidial activity is at its maximum, but when they are mature few pycnidia are to be seen as a rule.

The early development resembles that of the pycnidium, a young stroma originating by the division of adjoining cells of a mycelial thread. A fascicle of upgrowing threads is formed (Text-fig. 33), but, unlike the young pycnidia, the hyphae form a more or less solid mass of intertwined cells. At first there is no differentiation into wall and inner cells, and hyphae twist indiscriminately about each other. The whole structure is invested in a mucilaginous sheath (Text-fig. 34). Further extension is by the apical growth and occasional branching of these cells. The older cells differentiate out behind the growing point, increase in size, become brown and vacuolated, and form a stalk of loosely-woven threads (Text-figs. 35-37).



Figures 39-40. *Capnodium salicinum*.

39.—Two successive median longitudinal sections of a young stroma showing the development of the archicarp, which is shown at B in both sections. A, core tissue; C, indentation marking probable position of resorbed cell wall.  $\times 700$ . 40.—Two successive longitudinal sections of a young stroma. The archicarp shows the association of 5 nuclei, 4 of which are shown in 40a and 1 in 40b. A, growing point of the stroma; B, core; C, archicarp; D, wall; E, probable position of resorbed cell wall.  $\times 700$ .

According to the growth of the apex, this stalk may be narrow (Text-fig. 36) or stout (Text-fig. 37), and may be long or so short as to be almost non-existent.

The growing point widens out considerably (Text-figs. 36-38), and soon a definite structure is visible in the young stroma, the stalk, a moderately well-defined wall of young growing cells, and a core of thin-walled densely protoplasmic hyphae which pass back into the brown-walled tissue of the stalk (Text-figs. 36, 37). This thin-walled area increases in extent, hyphal growth causing coiling within the sheath of the wall. Occasionally hyphae from the core may penetrate outside the wall and become wall elements (Text-fig. 37). Finally, as the stroma matures,

the cells of the core enlarge somewhat and become more vacuolate, but their walls remain thin and light in colour (Text-fig. 38). Growth continues at a slower rate at the apex. The core-cells contain considerable amounts of oil, identified by its characteristic staining properties, in the form of small droplets.

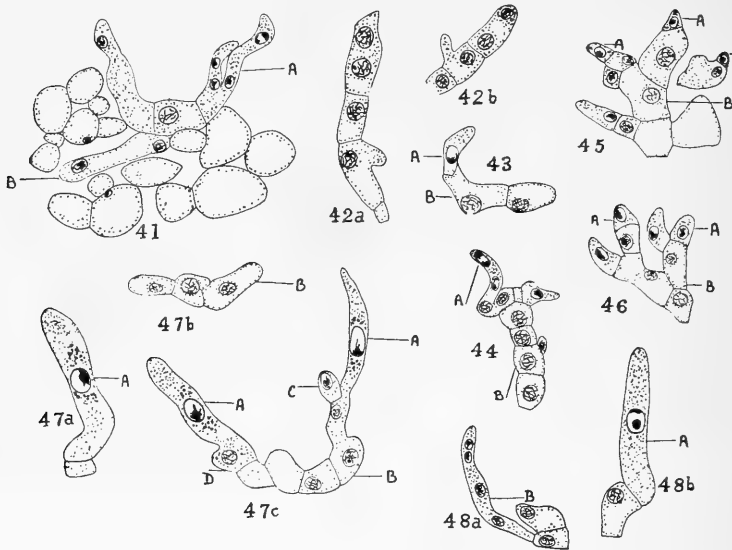
The time at which the archicarp appears is variable and does not altogether depend on the size of the stroma which may attain considerable dimensions before its appearance (e.g. Text-fig. 38).

The initiation of the archicarp is more obscure than in *Aithaloderma*, since a conspicuous layer of mucilage is not formed in the early stages of development. The first appearance is shown in Text-figure 39, *a* and *b*. An archicarp is visible at the base of the core at B, in which two nuclei are associated in the one cell. A distal cell with one nucleus is visible. In Text-figure 40, *a* and *b*, a later stage is shown. The young archicarp (C) is 5-nucleate and unicellular.

Since no stages in the actual breakdown of walls in the archicarp have been seen, it is impossible to say definitely that the multinucleate condition is not due to nuclear division and enlargement of one cell. Slight constrictions in the walls of the multinucleate archicarp, such as are shown at C in Text-figure 39 and at E in Text-figure 40, lend support to the idea that the multinucleate condition of the archicarp originates by the breaking down of cross walls in a filament of cells, and that these constrictions mark the original position of the cell walls. The shape of the archicarp which is invariably long and narrow further supports this view. Moreover, the nuclei are rather larger than those of the surrounding cells, and do not decrease in size with increase of numbers (compare Text-figs. 39 and 40) as, for instance, do the dividing nuclei in the developing ascus. The stages immediately following this nuclear association could not be followed in this species. It is suggested that they fuse in pairs since, in the next stage of development which has been observed, the nuclei are greatly enlarged (B, Text-fig. 41). One or more branches then grow out from the archicarp through the tissue at the base of the stroma core (Text-fig. 41). The nuclei divide, and cross walls are formed so that short filaments of three to four cells result (Text-fig. 42), the cells being uninucleate or occasionally binucleate by the non-formation of a wall. Several such hyphae may grow out from the archicarp, and in some cases their connection may be traced with a cell which is probably the archicarp, now empty and collapsed. After this stage the archicarp becomes entirely crushed out and cannot be detected with certainty. The nuclei of these ascogenous hyphae are many times larger than the surrounding vegetative nuclei, and the original archicarp nuclei. The chromatin is evenly distributed throughout them (Text-fig. 42). The cells of the ascogenous hyphae give rise to branches which may at once grow up as asci (A, Text-fig. 43). There are probably always one or two such primary asci in a stroma. Usually, however, the branches grow horizontally, further extending the range of the ascogenous tissue across the whole of the base of the stroma core (Text-figs. 44, 48, 49). Wall formation in these secondary ascogenous hyphae is not so regular as in the primary ascogenous hyphae, often no walls being formed except across the base of the young asci. Asci are produced at intervals by these hyphae and grow vertically upwards through the core of the stroma (Text-figs. 45 and 46). As far as could be seen, they each receive only one nucleus, and no evidence of fusion in the young ascus was obtained. As a general rule the ascus is cut off from the ascogenous hypha by a wall at an early stage. Cases have been observed, however, in which no wall had been formed and the base

of the ascus had budded out a further ascogenous hypha or an ascus (Text-fig. 47, D). Even when a wall is formed, young asci or ascogenous hyphae frequently grow out from immediately below it (C in Text-fig. 47c, and F in Text-fig. 49c). In a young stroma, therefore, asci are found in all stages of development (Text-fig. 49).

The young asci increase very much in size at the expense of the tissue they invade. A cap of mucilage soon becomes apparent over the top of the larger asci (Text-fig. 49). The early development of the ascus is shown in Text-figures 45 to 49. It is at first densely protoplasmic with numerous deeply-staining granules in the cytoplasm surrounding the nucleus. The nucleus increases in size, finally becoming very large. The chromatin is aggregated into one mass, usually towards



Figures 41-48. *Capnodium salicinum*.

41.—The development of the ascogenous hyphae (A) from the archicarp (B). 42.—Primary ascogenous hyphae showing septation and large size of nuclei. 43.—A young ascus (A) arising from a primary ascogenous hypha (B). 44.—A secondary ascogenous hypha (A) arising from a primary one (B). 45, 46.—Young asci (A) arising from ascogenous hyphae (B). 47a, b, c.—The development of asci from ascogenous hyphae as seen in three successive sections. A, asci; B, ascogenous hyphae; C, young ascus growing out from below an earlier formed one. 48a, 48b.—The development of asci (A) and an ascogenous hypha (B) from a primary ascogenous hypha, as seen in two successive longitudinal sections. Figs. 41-48,  $\times 880$ .

one end of the nucleus, and fine chromatin threads can sometimes be detected attached to it (Text-figs. 47 and 49). At times it has very much the appearance of a nucleus at the stage of synapsis, but, since the resting nuclei are of the karyosome type, it is impossible to say with certainty whether the first division of the ascus nucleus is meiotic or mitotic.

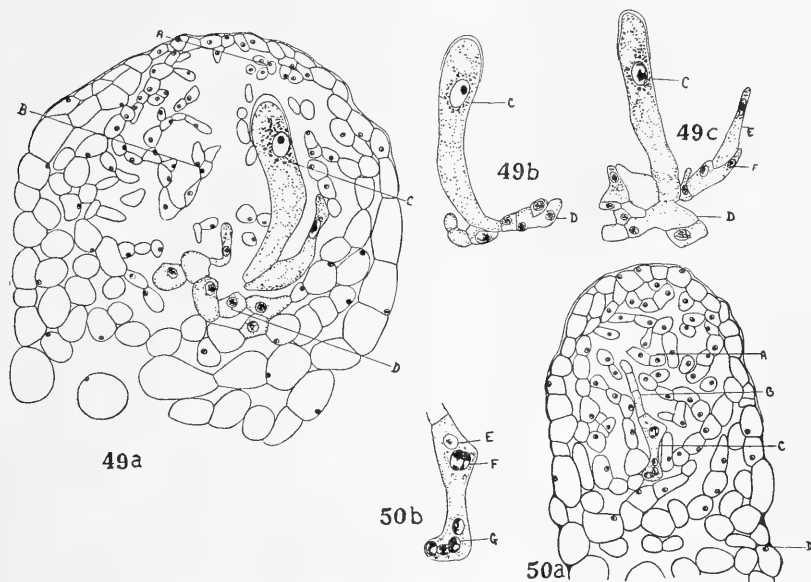
During the extension of the ascogenous hyphae and the development of the young asci, the stroma has continued its apical growth and the wall and outer core hyphae also increase by intercalary growth. A globular or slightly

elongated loculus results, which is usually of considerably greater diameter than the stalk. The central cells of the stroma are completely resorbed by the asci so that none remains between them.

Further development of the stroma and asci have been followed in a closely related variety *Capnodium salicinum* var. *uniseptum*.

*The Life History of Capnodium salicinum* var. *uniseptum*.

This variety differs from the type in that the pycnidia are frequently larger and more often branched; the pycnidiospores are smaller, uniseptate and hyaline, becoming brown when old if not ejected; and the ascostroma which, though of



49a, b, c. *Capnodium salicinum*.

The development of asci from ascogenous hyphae as seen in three successive sections. This also shows the development of the young stroma. A, growing point of the stroma; B, core of the stroma; C, asci; D, ascogenous hyphae.  $\times 700$ .

50. *Capnodium salicinum* var. *uniseptatum*.

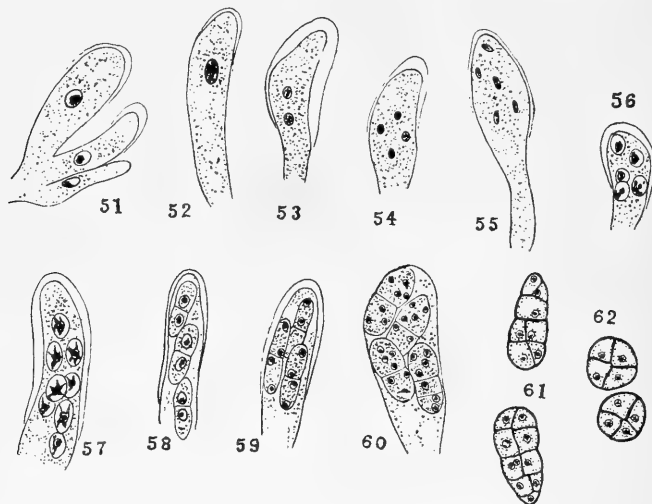
50a.—Median longitudinal section of a young stroma showing the development of the archicarp. A, core; B, distal part of archicarp hypha; C, archicarp; D, stalk.  $\times 700$ . 50b.—The archicarp shown in Text-fig. 50a showing greater detail. E, degenerating nucleus?; F, two associated nuclei; G, four associated nuclei.  $\times 1,500$ .

similar size and appearance, has a slightly more compact stalk and more closely woven core. The ascospores are identical in the two varieties. Pycnidium formation and ascostroma formation are the same as in *C. salicinum*.

The archicarp is differentiated in the same way from a vegetative hypha at the base of the core tissue (Text-fig. 50a). The distal part evidently does not function, but later collapses. The archicarp is multinucleate, as in *Capnodium salicinum* (Text-fig. 40b), and a constriction at the centre may indicate the original position of a cross wall which has been resorbed. Two nuclei are shown in close contact at F in Text-figure 50b, but no cases of actual fusion have been

observed. At E in Text-figure 50*b* a nucleus appears to be degenerating. As in *Capnodium salicinum*, ascogenous hyphae bud out and grow across the base of the core, sending up young asci into the core tissue. An extreme case of branching at the base of an ascus is shown in Text-figure 51. The stroma continues to enlarge, and the cells surrounding the old archicarp darken, forming an almost solid base for the core and developing asci.

As in *Capnodium salicinum* the young ascus is densely protoplasmic, with a number of deeply-staining granules around the nucleus. The chromatin is aggregated into one large mass in the nucleus, as in the previous type. Prior to division, the chromatin becomes more evenly scattered (Text-fig. 52). The daughter nuclei of the first division are smaller, and retain the even distribution of the chromatin (Text-fig. 53). These divide again to give four still smaller nuclei (Text-fig. 54), and again to give eight, small, rather elongated nuclei



Figures 51-62. *Capnodium salicinum* var. *uniseptatum*.

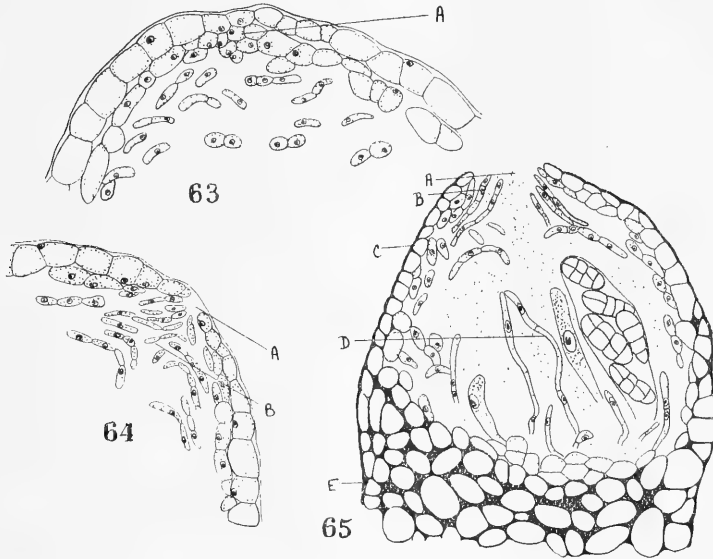
51.—Young asci showing branching. 52-60.—The development of the ascus: 52, the ascus prior to the first division; 53, the binucleate stage; 54, the ascus showing 4 daughter nuclei; 55, the ascus at the 8-nucleate stage, 5 nuclei showing; 56, 57, the enlargement of the nuclei at the 8-nucleate stage; 58, wall formation round the young ascospores; 59, 60, divisions in the young ascospore. 61.—The mature ascospore. 62.—Mature ascospores shown in cross section to show the position of the vertical walls. Figs. 51-62,  $\times 880$ .

(Text-fig. 55). These eight nuclei increase in size considerably before undergoing further division (Text-fig. 56 and 57). They then divide and a wall is formed around each pair of nuclei with a cross wall between (Text-fig. 58), thus delimiting the young ascospores. The young ascospores increase in size and the nuclei divide twice (Text-figs. 59, 60). A cross wall is formed in each cell. Further nuclear divisions and longitudinal wall formation may occur. The walls of the young spores are hyaline. As the spore matures the walls become brown and rather thick (Text-figs. 61, 62). The nuclei contract slightly, and in the resting condition have a central mass of chromatin with very few free threads. So far as could be determined the divisions were intranuclear.



The stroma continues to increase in size to accommodate the developing asci. The core tissue becomes entirely resorbed, except for a thin layer lining the wall. The wall cells finally become very dark brown and thick-walled.

The development of an apical pore commences as the ascospores mature. The wall at the apex of the stroma becomes thinner than elsewhere, due to the effects of strain and resorption which are most concentrated at that point (Text-fig. 63). Ultimately, in spite of continued intercalary growth the cells are parted. While this process is going on, hyphae of the outer core tissue grow up under the pore from the sides (Text-figs. 63, 64) and simulate periphyses. The opening is made wider by the passage of spores (Text-fig. 65).



Figures 63-65.—*Capnodium salicinum* var. *uniseptatum*.

63.—Longitudinal section through the apex of the young stroma showing growing point (A).  $\times 880$ . 64.—Longitudinal section through the apex of the stroma showing the formation of a pore (A) and the growth of pseudoperiphyses (B).  $\times 880$ . 65.—Median longitudinal section of an old stroma. A, pore; B, pseudoperiphyses; C, outer wall; D, paraphysis-like hyphae; E, stalk.  $\times 495$ .

Finally, all peripheral core tissue and the pseudoperiphyses are resorbed, and further development of the asci is prevented by lack of available food material. The asci which commence development at this late stage appear to disintegrate without completing their growth. Towards the end of the life of the stroma, long, narrow, multicellular, paraphysis-like hyphae arise from the ascogenous layer at the base of the core (Text-fig. 65, D).

Bifurcating stromata are not uncommon, due to the development of two archicarps independently in the one stroma, all degrees of separation having been found. Stromata are also frequently developed from the sides of old pycnidia.

#### *The Relationships of Capnodium and Aithaloderma.*

A study of the development of these four fungi shows that there is a real relationship between them.

The mycelium is similar in the method of branching and anastomosing, and in the uninucleate condition of the cells.

The origin of the pycnidia is in all cases compound meristogenous, and a developmental series can be traced from *Capnodium*, in which the growth is upwards with a certain amount of radial and intercalary growth at the base, through *Aithaloderma ferruginea*, in which growth is chiefly radial, but some upward growth takes place, to *A. viridis* which shows the extreme development of the radial growth type. All agree in the formation of a vegetative stroma in which an archicarp arises, but differ in the method of growth of the stroma. In *Capnodium*, growth causes an extension in length and an increased diameter by means of an apical localized growing-point. In *Aithaloderma viridis* there is no localized growing-point, the bulk of the growth taking place under a cover layer, and radially around the edges of the stroma. *Aithaloderma ferruginea* shows how these two growth types may be related, since in the early stages of development of the stroma a certain amount of upward growth takes place.

The development of the archicarp from a vegetative hypha appears to be similar in *Capnodium* and *Aithaloderma ferruginea*, as far as could be ascertained. The subsequent development of ascogenous hyphae in the two genera appears to differ chiefly in the greater degree of septation shown in *Capnodium*.

The growth of the young asci, the development of ascogenous hyphae from below the young ascus, and the continued formation of asci are identical in all types.

In all the species the development of the pore is by the digestion of the apical cells of the stroma wall. Growth of stromatal core hyphae to form pseudo-periphyses is marked in *Capnodium salicinum* var. *uniseptatum*, but does not occur in *Aithaloderma*.

A series can be traced in the development of a special wall around the asci. In *Capnodium* this does not occur, and the outer wall layer of the stroma, after the resorption of the core cells, serves as a wall for the mature ascospores. In *Aithaloderma ferruginea* the stromatal core is much more compact and wall-like, and by its method of growth forms a wall around the developing asci, but is not abruptly differentiated from the rest of the stroma. In *A. viridis* this layer is separated from the outer wall of the stroma at the base by much looser tissue, and stands out very conspicuously.

Von Hoehnel (1910) considers that the genus *Limacinula* is distinct from the Capnodiaceae, where it was placed by Theissen and Sydow, and describes the presence of a true perithecial wall more or less embedded in stromatal tissue. It is possible that this so-called perithecial wall may be a development of stroma tissue such as is described in *Aithaloderma viridis*.

#### *The Relationships of the Family Capnodiaceae.*

In considering the relationships of the family the nature of the ascospore-producing fruit-body must first be considered. Though reduced to a single loculus and resembling a typical perithecium when mature, developmentally it is a stroma—a stroma which continues to grow after the archicarp is initiated, and which may develop a stalk and a wall within itself.

The bearing of these observations on the systematic position of the family is here briefly discussed. The difference between the stromatic Sphaeriales and the Dothideales lies in the fact that a perithecial wall is developed around the ascogenous tissue within the stroma of the former, but in the latter no wall is

formed and the asci develop simply in locules in the stroma. In 1907 a new family, the Pseudosphaeriaceae, was described by von Hoehnel for certain species previously placed in the Sphaeriaceae. These fungi were considered to be intermediate in character between the stromatic Sphaeriales and the Dothideales. Their perithecia were considered to be unilocular stromata. No developmental studies were made, however, and all his conclusions were based on an examination of mature or nearly mature fructifications. The family was greatly enlarged by further additions from the Sphaeriales by von Hoehnel and Theissen, and in 1918 Theissen and Sydow raised them to the position of an order, the Pseudosphaeriales. Petrak (1923), in a comprehensive study of the group and its related species, attempted to trace a series showing the development of the perithecium of the typical Sphaeriales type from the stroma of the Dothideales through the Pseudosphaerialean genera *Pleospora*, *Pyrenopeziza* and *Leptosphaeria*. He also attempted to trace the development of the ostiole from a pore developed lysigenously to a true ostiole lined with periphyses, and the development of the paraphyses from strands of stroma tissue, connected above and below the developing asci, to true paraphyses of typical structure such as are found in the Sphaeriales. Gaumann (1928) adopted this scheme, and stated that true perithecia are formed by the fungi regarded as higher Pseudosphaeriaceae, and these are therefore truly Sphaeriaceous.

Recently Miller (1928a) has shown that the disagreements between the earlier writers over the nature of the fungi variously attributed to the Sphaeriales and Pseudosphaeriales were due to non-appreciation of the true nature of the perithecial wall in the Sphaeriales. He maintained that the stroma is vegetative tissue which does not arise as the result of sexual stimulus, and that the perithecial wall is "specialised tissue which arises from the archicarp and from the beginning encloses the ascogenous centrum" (p. 194), the asci, paraphyses and periphyses also being produced by the archicarp.

It is clear, therefore, that there can be no transition in the way maintained by Petrak from the Sphaeriales to the Dothideales, since the development of the elements of the ascospore producing fructification is fundamentally different. In the Pseudosphaeriales and Dothideales the apical pore develops lysigenously and the paraphyses are stromatic in origin, while in the true Sphaeriales periphyses grow up from the perithecial wall tissue to form a true ostiole lined by cells of ascogenous origin, and the paraphyses grow from the ascogenous hyphae at the base of the perithecium. Blain (1927) also maintained that in the Dothideales the development of the pore is lysigenous, and there is no perithecial wall. Orton (1924), in an extensive review of literature on the stroma, also came to the conclusion that it is definitely a vegetative structure.

Miller (1928a) has shown that in *Guignardia*, a fungus previously placed in the Sphaeriales, a homogeneous stromatic matrix is formed. In this stroma an archicarp is differentiated, and gives rise to asci which grow at the expense of the stroma, causing its disintegration. He also considered that *Teichospora* belongs to the Dothideales. Nichols (1896) has described in *Teichospora* the development of a solid stromatic body in which the asci develop. In the stromatic Sphaeriales, Wehmeyer (1926), Miller (1928b) and others have shown that a true perithecium wall and ostiole develop from coiled Woronin hyphae.

Miller concluded that the Pseudosphaeriales have no features not in common with the Dothideales, and recommended that they be merged with them, and

their position determined by characters of ascus and spores and ascial hymenium rather than by the thickness of the stroma wall or the number of locules in the stroma as hitherto.

He considered that the Pseudosphaeriales, Perisporiaceae, Coryneliaceae and Dothideaceae are characterized by the absence of a true perithecial wall, and by the asci being borne in locules of a stroma. Since they do not develop true perithecia he believes that they cannot be regarded as Pyrenomycetes.

Following Miller's scheme the Capnodiaceae belong to the Dothideales, since the perfect fruit-body has been shown to develop as a stroma, no perithecial wall being formed.

The Capnodiaceae are not related to the simple Sphaeriales which show the development of antheridia and ascogonia, or to the stromatic Sphaeriales in which the perithecium develops from coiled Woronin hyphae.

It does not appear that there is any close relationship to the Perisporiaceae or Erysiphaceae. In the Erysiphaceae it is well known that a true perithecium is developed after the formation of an ascogonium, with or without an antheridium. In *Meliola* (Perisporiaceae) Graff (1932) has recently shown that a true perithecium wall is formed under a shield-like structure, and that antheridium and ascogonium are produced though no fusion was observed.

Arnaud (1910) considered that the species of the Capnodiaceae showed close affinities with the Sphaeriales and placed *Capnodium salicinum* in the genus *Teichospora*, and *Capnodium (Aithaloderma) citri* in the genus *Pleosphaeria*. Nichols (1896) has shown that *Teichospora* forms a solid stroma, and Arnaud himself (1910) described the early stages of the development of a stroma in *Pleosphaeria citri*. Neither of these genera can therefore be placed in the Sphaeriaceae. In *Teichospora*, Nichols described the formation of an oval uninucleate cell from the parenchymatous tissue of the stroma, and stated that asci appear without fertilization.

The formation of the stroma in *Teichospora* appears to differ markedly from that in the Capnodiaceae in that an almost solid body is formed by the segmentation of a vegetative hypha, and the description of the development of the ascogenous hyphae is not sufficiently detailed to permit of close comparison. The habit of *Teichospora* which grows on dead branches, often partly submerged, also differs from that of *Capnodium*, which is superficial and grows only on the honey-dew excreted by scale insects. For the present, therefore, it seems best that *Teichospora* should not be included in the same genus as *Capnodium*.

Very little is known of the early stages in the development of the ascogenous hyphae in the Dothideales. In *Dothidella ulmi*, the only species which has been investigated in detail, Killian (1920) described the formation of an archicarp of 3-4 cells, each of which becomes 2-3-nucleate. These come into communication by breakdown of walls and fuse in pairs, then entering the ascogenous hyphae. This method of development resembles that of *Capnodium* and *Aithaloderma* more closely than any other described type. The chief difference is the number of nuclei in the cells of the archicarp.

It is impossible to say whether the stroma of the Capnodiaceae is reduced from a multilocular form such as *Dothidella*, or whether the tendency to form bilocular stromata indicates that it is a primitive type of the Dothideales.

Orton (1924) has shown that in *Catacauma* a rudimentary perithecial wall of a few "nurse" cells is formed, which is resorbed by the developing asci. This indicates that the Dothidealean type of fructification may have been derived from

the stromatic Sphaeriales by reduction, rather than that, as Petrak (1923) has attempted to show, evolution should have taken place from the Dothideales to the Sphaeriales. In this case the Capnodiaceae would represent a further stage in reduction of both perithecial wall and stroma.

There does not appear to be sufficient justification for Woronichin's proposed order, Capnodiales, as these fungi show no features which should exclude them from the Dothideales as defined by Miller.

Certain types of elaboration after reduction, so that structures are produced resembling those of different origin found in unrelated fungi, are seen in *Aithaloderma viridis* and *Capnodium*. In the one, a stromatic wall somewhat resembling a perithecial wall is developed within the stroma, and in the other, stroma threads may concentrate under the pore resembling periphyses to some extent.

In consideration of these facts the writer considers that the family Capnodiaceae should be placed in the Dothideales.

#### *The Nomenclature of Capnodium salicinum.*

Arnaud (1911) has pointed out that Montagne (1849), in his description of the type of *Capnodium salicinum*, confused the pycnidia and the ascogenous fructifications, both of which produce spores which are very much alike. Montagne's description of the ascogenous fructifications therefore included the shape types of the pycnidia. Later authorities have followed this error, but Tulasne, Kickx and later von Hoehnel (1909) have given revised descriptions which are quite adequate. There is no reason, therefore, for placing the species of the genus *Capnodium* in other later-formed genera as Arnaud has done, especially since, as has been shown in this paper, it is doubtful whether the relation to *Teichospora* is a close one. Further investigations on the life history of *Pleosphaeria* are necessary before the relationship of *Aithaloderma citri* to this genus can be proved.

#### *Summary.*

An examination has been made of the life histories of four species of *Capnodium* and *Aithaloderma*, members of the Capnodiaceae.

In all species the mycelium consists of uninucleate cells, and the hyphae branch and anastomose at wide angles.

In *Capnodium* the pycnidia are compound meristogenous in origin, and vertically elongated when mature. The ascogenous fructification arises as a stroma which develops from the division and subsequent growth of several adjoining cells of a hypha, and is composed of loosely-woven threads with an outer dark wall layer and a thin-walled core-tissue. The archicarp arises from a vegetative hypha at the base of the core, and consists of a number of cells. The archicarp becomes multinucleate, probably by the resorption of the walls between the cells. The nuclei associate and probably fuse in pairs. Ascogenous hyphae bud out and branch through the base of the core, giving rise to asci which grow vertically up through the core-tissue, resorbing it. No fusions have been observed in the young ascus. An apical pore develops lysigenously, and stroma hyphae grow up under it simulating periphyses.

In *Aithaloderma ferruginea* the pycnidia are compound meristogenous in origin, and are rather flat when mature. The stroma develops (1) by growth in thickness under a meristogenously formed disc, (2) radially by growth around the edges, and (3) by a certain amount of upward growth in the young stage,

as in *Capnodium*. The archicarp arises at the base as in *Capnodium*, and nuclear fusions probably take place. Ascogenous hyphae grow out across the base of the stroma, giving rise to asci as in *Capnodium*. The apical pore is developed lysigenously.

In *Aithaloderma viridis*, increase in thickness of the ascogenous stroma takes place exclusively beneath a radially growing disc. A compact wall of stromatic tissue is developed round the young asci distinct from the more loosely woven stroma tissue round it and resembles a perithecial wall.

It is concluded that the Capnodiaceae as represented by *Capnodium* and *Aithaloderma* should be placed in the order Dothideales.

In conclusion the writer desires to thank Professor T. G. B. Osborn and Professor J. McLuckie for helpful criticism and advice, and Miss J. Vickery and Mr. A. Burges for confirming observations.

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THE GASTEROMYCETES OF AUSTRALASIA. XVII.

SOME NEW SPECIES OF HYMENOGASTRACEAE.

By G. H. CUNNINGHAM, D.Sc., Ph.D., F.R.S.N.Z.

[Read 24th April, 1935.]

Three new species of Hymenogastraceae are here described and four new combinations recorded. The new combinations will be discussed in succeeding papers of the series.

OCTAVIANIA PALLIDA (Massee and Rodway), n. comb.

*Gymnomyces pallidus* Mass. et Rodw., *Kew Bull.*, 1898, p. 125.

*Type locality*.—Cascades, Hobart.

OCTAVIANIA GLABRA (Rodway), n. comb.

*Hydnangium glabrum* Rodw., *Proc. Roy. Soc. Tas.*, 1920 (1921), p. 157.

*Type locality*.—Cascades Hobart.

OCTAVIANIA BRISBANENSIS (Berkeley and Broome), n. comb.

*Hydnangium australiense* Berk. et Br., *Trans. Linn. Soc.*, ii, 1883, 66.—*Octaviana alveolata* Cke. et Mass., *Grev.*, xvi, 1888, 2.—*Hydnangium brisbanense* Berk. et Br., ex Cke., *Hbk. Aust. Fungi*, 1892, 247.—*Arcangeliiella australiensis* (Berk. et Br.) Dodge, *Ann. Miss. Bot. Gard.*, xviii, 1931, 463.

*Type locality*.—Brisbane, Queensland.

OCTAVIANIA STRIATA, n. sp.

Plants irregularly globose or pyriform, 15–25 mm. diameter, exteriorly reddish-brown and dull, smooth but wrinkled when dry. Peridium compact, 60–110 $\mu$  thick, of strongly gelatinized, densely woven hyphae. Gleba ochraceous when dry, firm, cells somewhat elliptical, or slightly labyrinthiform, empty, variable in size, about 2–4 mm. larger below; sterile base present or absent; tramal plates 55–75 $\mu$  thick, of densely woven gelatinized hyphae, firm; basidia 4-spored. Spores globose, hyaline, 8–10 $\mu$  diameter (including reticulations), shortly pedicellate, strongly reticulated, wings to 1.5 $\mu$  tall, arranged in the form of striae.

*Distribution*.—Australia.

New South Wales: Neutral Bay, 6/12, J.B.C.\* (Det. by L. Rodway as *H. brisbanense*).—South Australia: Mt. Lofty, 6/24, J.B.C.\* (Type collection); same locality, 5/28, J.B.C.\*

The species resembles *O. brisbanensis*, but differs in that although the spores are reticulated, the reticulations are arranged in the form of striae, and tend to parallel one another save where they converge at the poles; the peridium is of a somewhat different texture, and the tramal plates are more strongly gelatinized, so that the whole plant is much firmer. Lactiferous ducts are apparent in two collections, but have not been noted in the third, despite a careful search.

## DENDROGASTER FULVUS (Rodway), n. comb.

*Hymenogaster fulvus* Rodw., *Proc. Roy. Soc. Tas.*, 1918 (1920), 109.

*Type locality*.—Cascades, Hobart.

## DENDROGASTER PIRIFORMIS, n. sp.

Plants pyriform or subturbinate, to 15 mm. tall, smooth, reddish-brown. Peridium double, 200–250 $\mu$  thick, exterior layer of pseudoparenchyma, interior layer of brown, partly gelatinized parallel hyphae. Gleba reddish-brown or ferruginous, cells subglobose, 1–2 mm.; with a definite sterile base and traversed by a pallid yellow, dendroid, percurrent columella; tramal plates 90–110 $\mu$  thick, pseudo-parenchymatous; basidia 4-spored. Spores obovate, chestnut-brown, 12–14  $\times$  6.5–8 $\mu$ , shortly pedicellate, distinctly areolate, wall to 1.5 $\mu$  thick.

*Distribution*.—Australia.

South Australia: Encounter Bay, 8/23, J.B.C.\* (Type collection, in herb. Cleland).

The species is characterized by the double peridium and large obovate spores.

## GAUTIERIA MACROSPORA, n. sp.

Plants subglobose or somewhat irregular, 10–25 mm. diameter, pallid-white with a tinge of bluish-green, becoming ochraceous when dry. Peridium 150–200 $\mu$  thick, of a single layer of pseudoparenchyma and a prominent layer of crystals lying next the gleba. Gleba umber-brown, cells minute, 2–3 mm., filled with spores, appearing compact; traversed by a branched columella arising from a scanty sterile base; tramal plates 30–80 $\mu$  thick, of woven gelatinized hyphae; basidia 2-spored. Spores broadly elliptical or broadly fusiform, 20–27  $\times$  11–14 $\mu$ , ferruginous, apex acuminate, base shortly pedicellate, ribs about 8–10 in number, acute, vaguely anastomosed and to 2.5 $\mu$  tall.

*Distribution*.—Australia.

South Australia: Mt. Lofty, 7/28, J.B.C.\* (Type collection).

The species may be separated from *G. albida*, which it resembles in the large spores, by the larger cells of the gleba, different tramal plates, and broader, less acuminate, more acutely ribbed spores. Dr. Cleland recorded that plants of this abundant collection when fresh possessed a fragrant smell as of strawberry jam.

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THE RELATIONSHIP BETWEEN EROSION AND HYDROGRAPHIC CHANGES  
IN THE UPPER MURRAY CATCHMENT, N.S.W.

By FRANK A. CRAFT, B.Sc., Linnean Macleay Fellow of the Society in Geography.

(Plates ii-iii; nine Text-figures.)

[Read 29th May, 1935.]

The Upper Murray landscape has distinctive features as the result of the more recent phases of its development. Throughout its extent, all stream courses except those of a torrent character (Text-fig. 5) are marked by the presence of alluvials in two strata—an upper horizon of silt, soil material, or soil, and a lower horizon of pebbles, deposited on the fresh or weathered rock surfaces of the relevant parts of the landscape. Where torrent sections do not intervene, the deposits are continuous from the heads of the streams and valleys to the main alluvial sheet on which the Murray flows: where the courses are broken by torrents, the alluviated conditions apply to the gentler upper and lower valleys (including those of the high plateau, Text-fig. 2), and to breaks in the torrent courses themselves. The usual thicknesses of the strata are 5 to 10 feet for the pebbles, and 5 to 20 feet for the silt, except in the Murray bottoms, where the total thickness is as great as 50 feet. At valley junctions, or where fans from minor hillside streams merge into bottom lands, the pebble horizon is continuous, without discordancies, and the surface presented is of fine material. The only notable exceptions to this rule are found where the main streams (Tooma, Swampy Plain and Indi) emerge from major canyons, and the silt contains an intermixture of pebbles.

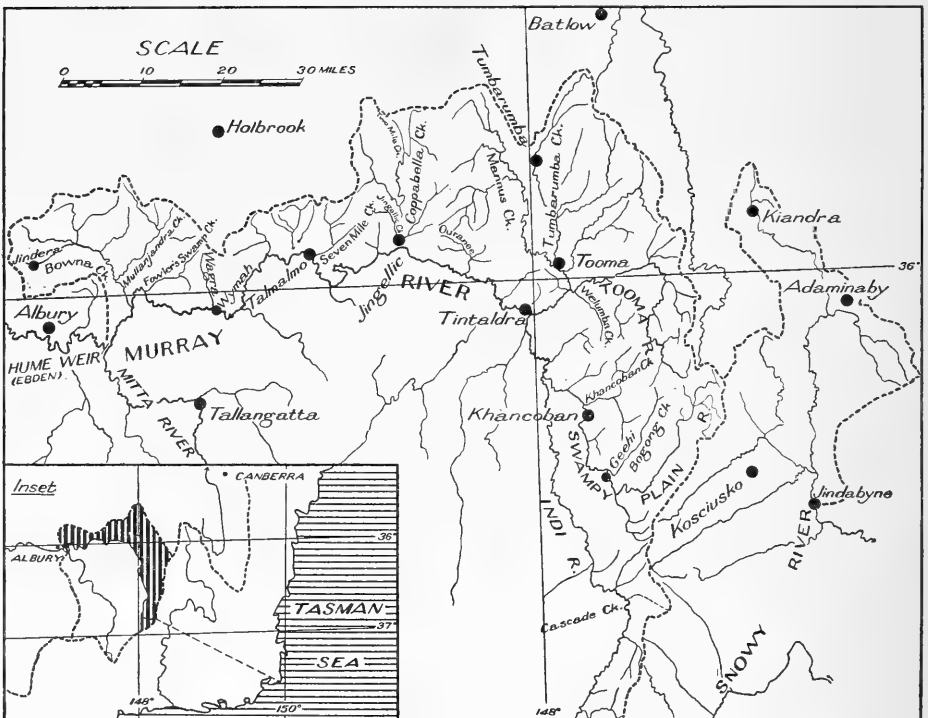
The more recent erosion has been directed towards the removal of these deposits, and makes the fourth stage in the late history of the surface material. The stages are: 1.—The valleys existed without extensive alluvium, and the material taken from their floors and sides was transported by the streams, 2.—The streams carried pebbles, which were deposited on the gentler grades of the main valleys. 3.—Movement of fine rock waste and soil from the middle and upper slope of valley sides, throughout their lengths, increased the colluvial deposits of the lower slopes, and buried the pebbles; at the same time, fine silt carried by the rivers was deposited in the main valleys below the torrent courses. 4.—The most recent action has been directed towards the cutting and removal of these silts, without corresponding deposition in the Murray course above the Hume weir, or on the bottom lands. The cutting has resulted in local terracing.

The definition of the most recent features necessarily depends upon the possibility of measurement within the limits available. Inspection discloses that the forest, scrub, or grass lands of the ridge tops and valley sides are retaining a surface cover of organic soil a few inches thick, whose denudation could only be measured by a great number of experiments extending over a period of years;

information under this heading is not available, so the modern lowering of ridge crests cannot be discussed. On the other hand, the more recent changes in the valley bottoms and alluvials may be defined by departures from pre-existing conditions, and individual examples may be readily measured by surveys with compass, tape, and level. The occurrences show an acceleration of erosion towards the present time, and the term "modern" is applied to cover the period concerned, which is of the order of the 50 or 60 years beginning about 1880 and 1870 respectively. The period itself was determined by reference to individual features which appeared during that time, and to an older series of forms which has been relatively stable since a time antedating the commencement of the modern period: in general, the two are clearly differentiated, and the acceleration of erosion represents a modern departure from the conditions of temporary equilibrium that had been previously attained.

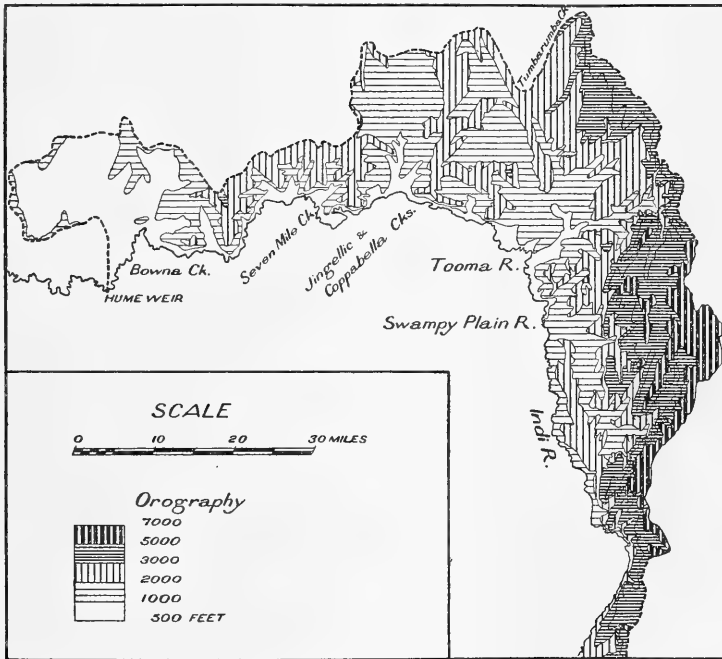
*Criteria of Age, and Distribution of Forms.*

Modern erosional forms occur on the courses of established streams, or where definite channels are now being cut: individual features have been dated by three principal references—human evidence, trees, and soils, which may be considered in that order.



Text-fig. 1.—Locality map of the New South Wales portion of the Hume catchment. This is barred in the inset, where the Victorian portion is outlined immediately to the south-west.

The largest active cuttings have been formed within living memory: the two major gullies at Tooma began "some fifty years ago", according to residents; that on Seven Mile Creek began about 1890, and three smaller examples at Khancoban are attributed to the period 1879 or 1880 to 1890. One of these latter finally undermined a dam at its then-existing head in the winter of 1926, since when (to 1933) it has progressed at a rate that would give an age of 40 years to the complete feature. In many cases, the re-location of roads and bridges, the destruction of fences by recent cutting, the continued deposition of sand below gullies, and the collapse of banks each winter give additional evidence of the recency of features, and the activity of processes. On the other hand, the presence of large trees or tree relics in channels is proof of greater age, and may serve to define cross-sections which existed before the modern phase of erosion commenced. This is particularly the case with eucalypts of diameter 30" or more that were ringbarked or felled so long ago that all branches have disappeared, or whose stumps are rotting in the ground (Plate ii, figs. 1, 3, 5). With these, and with living gnarled trees, an age of 40 to 50 years may be assumed with certainty (personal communication from Mr. C. E. Lane-Poole), which is the minimum required to place the surface features outside the modern period. This criterion is generally supported by soil evidence. All channels which are now being eroded have sandy floors, even where the surface being attacked is a mature chernozem soil (as in Plate iii, fig. 2): others, particularly that of Wagra Creek and the middle part of Fowler's Swamp Creek, have maturing black soils on their floors, and graded banks. The soils are forming *in situ*. These latter channels are older

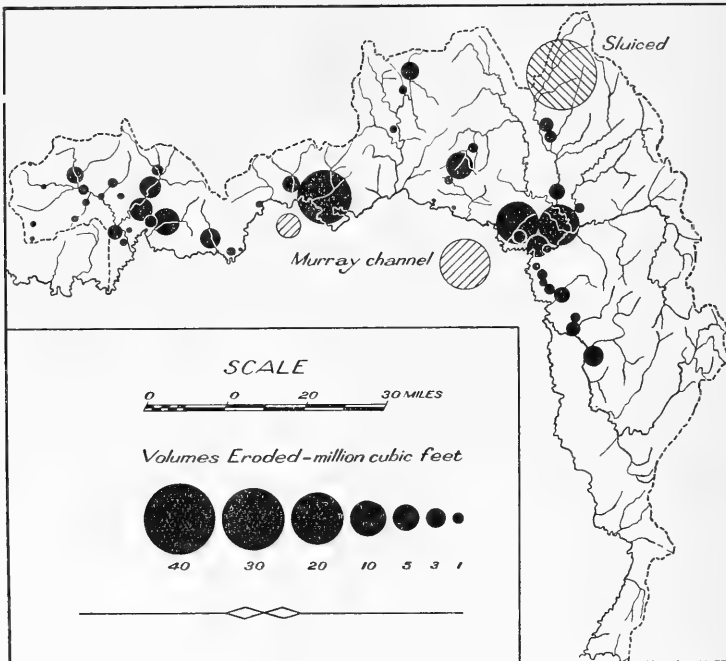


Text-fig. 2.—Orographic map. Approximate definitions are: highlands above 3,000 feet; uplands 1,000 feet to 3,000 feet; lowlands below 1,000 feet.

than the others, and only the portions which clearly diverge from such conditions are reckoned as modern.

Another form of modern erosion is purely artificial, namely, the gold workings on the uplands about Tumbarumba. Much of the excavated material was deposited on the valley bottoms at Tooma, where it is clearly differentiated from the other alluvials in texture, arrangement and vegetation, and gives the only modern example of large-scale deposition. In addition, there has been limited sheet erosion on the cultivated lands of the Bowna Creek and Tumbarumba districts. No estimate has been made of these, because most of the original surface appears to have been preserved, the streams flowing from such lands are generally clear, channels have not silted greatly, and the material carried by the streams in the former district is coarse and fine gravel, which is derived from certain of the channels.

On these criteria, it is apparent that there has been a distinctive phase of erosion confined to modern times, and spread over the half-century beginning about 1880, and the distribution of the volumes displaced in this action may be arranged as in Text-figure 3. This discloses that modern forms are confined to three horizons—the channels of the Murray River and streams immediately adjoining



Text-fig. 3.—Volumes removed by modern erosion, with a probable general order of accuracy of  $\pm 20\%$ . No great deposition is experienced, individual cases being less than 5% of the displaced volume in specific cases. The gold sluicings at Tumbarumba were estimated from deposits at Tooma, and the volume eroded from the Murray channel was approximated by attributing a standard cross-section of removal to all bends in the cutting sections for the general maximum lengths of erosion: the result of the latter is tentative, but it is probably a liberal allowance.

it; alluvial fans and aprons with a general slope of  $1^{\circ}$  to  $3^{\circ}$  facing the Murray valley bottoms, and deep soils or fans of similar gradient at the heads of minor valleys on the uplands to an altitude of some 2,000 feet. Apart from the Murray itself, Bowna Creek and the short lowland portions of the Swampy Plain, Indi and Tooma Rivers, this attack is one on the relics of sediments and hill wash that accumulated in the valleys, and on slopes over the whole landscape in times past. The exceptions named have a wide extent and depth on plains of gentle gradient, and have been preserved except in the narrower part of the Murray valley between Talmalmo and Fowler's Swamp Creek, where much of the original material has been removed.

#### *Shape of the Modern Features.*

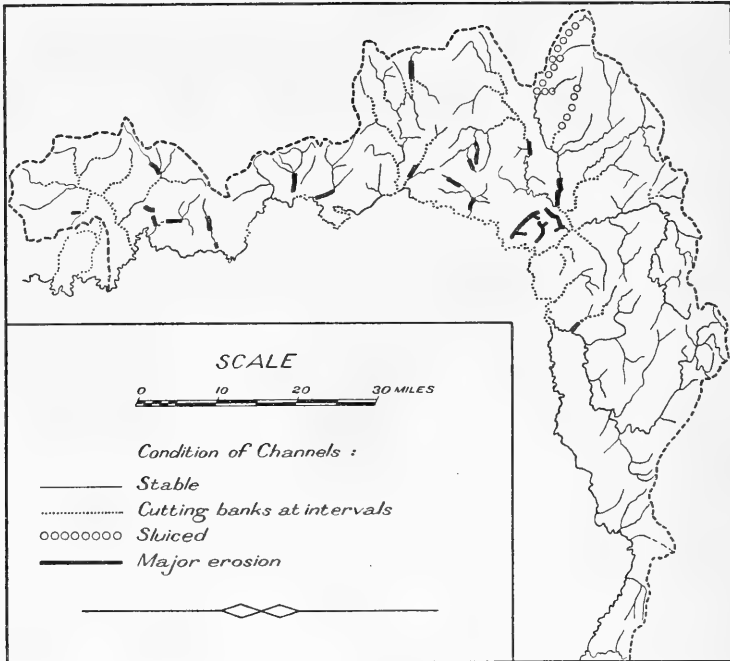
The restricted nature of modern cutting suggests that it is part of a cyclical action, and one may ask whether the forms themselves are in agreement with this. Three distinct considerations enter into the answer, because three sets of forms must be treated separately, namely, those of the Murray, of the Bowna Creek basin, and of the gullied lands.

With the Murray, the essential feature of the channel is, that a normal flood volume in September and October is contained by the banks, except in a few restricted places. In the section between the Swampy Plain River and Tintaldra, there is some activity in the formation of cut-offs (Plate iii, fig. 4), but where the river enters a narrower valley below Tintaldra, billabongs are usually found on one bank only, and are relic features (Plate iii, fig. 1). In times of exceptional flood, river water makes its way through them and over the low-lying plains, but they are usually filled by rain water. Here a change takes place in the river channel: above Tintaldra, there is extensive bank cutting in places by a shallow stream, but in the Jingellic district the river is deeper, and the channel is being extended laterally by the flood stream cutting behind lines of trees, and gradually destroying them (Plate iii, fig. 1). This enlargement may affect each bank at the same time, but it is limited downstream by the contraction of the flood plains below Talmalmo. From here to Fowler's Swamp Creek the course is more stable, and the banks are reinforced at intervals by massive granites: the condition approximates to the tributaries, because most of the sediments have been eroded, and at Wymah the river has sunk its course 30 feet below the old alluvial surface. Summing up, it is found that the modern work of the Murray has been directed towards the stabilization of a single channel below the level of the flood plains and billabongs, and to lateral expansion in places where the channel is not sufficient to carry the present flood volumes.

Turning now to the Bowna Creek drainage, a good deal of variety is met with. The streams are intermittent in character, and flow in channels carved in soil, alluvium and thoroughly decomposed rock at a depth of 8 to 12 feet below the plains. Certain of these channels are stable, particularly in the clay loams of the farming lands towards the west, but others in granite waste are suffering enlargement, or are in process of formation (Plate ii, fig. 1; Text-figure 4). The usual action is lateral enlargement without much change in local stream gradient, or vertical displacement of the stream, but in places this has been varied by a definite entrenchment of the order of 4 to 5 feet (Plate ii, fig. 2). From this, two salient facts emerge: firstly, most of the channels are pre-modern, and they have existed for some time with steep or vertical banks; secondly, there has been a revival in cutting, with the continued formation and recession of vertical

banks, and local entrenchment in older terraces. This resembles some phases of the third series of forms.

The gully lands include many new areas of erosion which may be described as simple barrancas or arroyos—in fact, practically all the examples east of Talmalmo merit such terms. On the other hand, Fowler's Swamp Creek illustrates



Text-fig. 4.—Condition of stream channels. The torrent, rock or rock bar channels of Text-fig. 5 may be regarded as having a limited erosion risk attached to them, but others classed as "stable" are merely in equilibrium with present conditions, and carry a much greater risk. Victorian conditions duplicate these.

the whole process of development of such features, from the stage of headward cutting into smooth flats, to that in which an old channel floor becomes silted by wash derived from upstream (Plate ii, figs. 3, 4). Towards the Murray, a road bridge has been almost obscured by drift: here, and immediately upstream, the channel floor appears as a definite terrace, with steep banks separating it from the original surface of the fan, but the features are less perfect in the middle course, where attack has recommenced on vertical banks. Other pre-modern forms along Wagra Creek (Plate ii, fig. 5) bear a close resemblance to the new cut at Talmalmo, but their progress has been limited by a rock channel.

In the foregoing cases, the older features are recognizable as expanded gullies, and they have some counterparts in the Maragle Creek drainage. Evidences of more complete action appear on many other streams in the form of terraces, or terrace relics, for the whole lengths originally alluviated. The greater part of the Maragle, Coppabella, Jingellic and Mannus Creek systems

come under this heading (Plate iii, fig. 5), and the modern attack on alluvial remains gives minor cutting with vertical banks at intervals (Text-fig. 4). In general, the tendency is for the slopes to assume the aspect they had before the deposition of alluvials. Modern erosional forms in this catchment of the upper Murray are due to a revival and expansion of cutting forces on the various parts of the landscape, making towards the complete removal of alluvials and deeply weathered material that have survived earlier attacks. A minor cycle of erosion is thus approaching completion, both as regards individual features and the surface as a whole, and the Murray is completing the stabilization of a single channel, which is being adjusted to the needs of the flood stream.

#### *The Factor of Human Interference.*

This account of modern features may be regarded as idealistic, because it does not consider the possible effects of human occupation with respect to the clearing of timber and shrubs, and their replacement by grasses. It might be argued that many specific erosional features can be traced directly to some form of human interference, and that streams have become more violent as the result of quicker run-off following partial deforestation, and consequently give increased erosion. This is the essence of Wood's (1928) contention, and it appears to be the standard opinion on the subject at the present time. If it be true, a new minor cycle has commenced as the result of settlement, contrary to the views expressed above. For this reason, the problem of human interference must be treated in its several aspects.

There is no doubt that many individual features are the direct result of human agency. According to residents, the greater part of the major gullies at Tooma were cut after the removal of scrub from shallow channels, and other features, here and at Khancoban, were initiated by drainage channels cut across deep soil or alluvial aprons. In addition, roadside drains at Jindera have been greatly enlarged and deepened. In the same districts, there are also incipient gullies which have been checked by the retention of scrub or trees on their sides. On the other hand, it is not difficult to mention examples of modern cutting despite the presence of trees. The channel of Seven Mile Creek, Talmalmo, is being enlarged at the expense of living trees (Plate ii, fig. 6), and the upper half of its modern length of  $2\frac{1}{2}$  miles, representing a quarter of the eroded volume, was swept out of the parkland during the single flood season of 1931. Enlargement of the Murray channel with the gradual destruction of tree lines has been noted, and in the section between the Swampy Plain and Tooma River junctions with the main stream, active cutting is in progress where the river passes through forests, apart from the cutting bends in cleared lands. In fact, the undermined trees set up further erosion by diverting the current against the opposite bank. Similar cases of sylvan destruction are found in the Bowna Creek drainage.

In addition, there are places which could not be protected by trees, namely, the steep or vertical banks left along the older channels, particularly in the lowlands adjoining the Murray. These have survived for some time whilst trees grew on the channel floors, and the soils tended to become mature, and they existed in all the channels classified as showing "cutting banks at intervals" (Text-fig. 4), and especially in those of Bowna, Fowler's Swamp and Jingellic Creeks. Modern revival of cutting and bank recession, which is now taking place rapidly, is a clear indication of changing stream conditions apart from the element of floristic protection, which was slight or non-existent in such cases. Moreover,

the actual presence of channels antecedent to the modern period throughout the lowlands and uplands, and their close resemblance to those developing at the present day, is enough to show a continuity of process.

Human interference with natural flora has thus been responsible for the development of some of the new erosional features, mainly of the barranca or arroyo type. Places similar to those attacked were reduced in the past in all districts where the modern attack on relics is active, at a time antecedent to the modern period, and others have lately developed or revived despite protection by trees: cutting has also recommenced on old, unprotected banks. The conclusion is, that settlement has accelerated erosion in some respects, but the places so attacked were those most liable to natural cutting, and which were unstable in any case.

Turning now to the question of accelerated run-off following partial or complete deforestation, it is desirable to have some understanding of the typical Australian forest with respect to run-off. Lane-Poole (1932) has outlined some of the characteristics of the sclerophyllous forests which comprise the greater part of the wooded lands in the Murray basin, as elsewhere. In general, the limiting factor is water rather than light, the forests have an open canopy, humus will not form naturally, and with the older trees, ". . . except in moist situations, all the ground is now quite bare of vegetation or carries but the smallest leafed shrubs and grasses" (p. 283). The floor of the forest is thus characteristically dry, and does not have an appreciable surface layer of humus: indeed, the opening words of the quotation make it clear that the relationship between the forests and moist places is a casual one. In the Upper Murray basin, the forest growth is low (generally less than 80 feet), the slopes vary up to 60°, but are usually in excess of 15° away from the valley bottoms and the uplands about Tumberumba, and the narrow hanging leaves of the eucalypts combine with these factors to give free admission of wind and sunlight. Exceptions to the rule are comprised in the forests of Mountain Ash (*E. gigantea*) found above 3,000 feet, smaller neighbouring areas of other species, and swamplands of the higher plateaus. Byles (p. 20) estimates the area of Mountain Ash at 87 square miles; the swamplands, with their dense covering of shrubs or tall grasses, cover rather less than 50 square miles, and other forests of close stand are probably not so extensive. The exceptions are grouped in the higher lands, and comprise about 10% of the New South Wales part of the catchment.

How do these forest types influence run-off? The minor areas, particularly the swamps and marshy places, supply water to streams throughout the year, and are thus capable of absorbing rainfall in quantity. This may apply to restricted parts of the close-stand forests as well, but it is not clear that the bulk of the forests make any great difference in run-off as compared, for example, with grasslands. This follows from the general nature of the forest floor, and is supported by experience. For instance, the shafts left by mining prospectors are almost invariably dry; there is an absence of springs and soaks from the mountain sides with vertical ranges up to 5,000 feet, even where the slopes are covered with a thick mantle of rock waste and soil over the impervious rocks; and streams rely for their perennial flow on the limited moist places, mainly in the higher lands. The greater part of the forests has very little extra means of water storage on which the checking of run-off necessarily depends, and it is difficult to see how partial clearing could have a significant influence on the run-off in times of exceptionally heavy rain (e.g., 1917 and 1931).



Of the field examples of modern erosion, the cut on Seven Mile Creek, Talmalmo, has the greatest immediate bearing on this topic. The hills forming the catchment are wooded, and have suffered little damage, if any, through fires (Plate ii, fig. 6). Despite this, the rush of the 1931 floods was enough to scour out the upper half of the cut, as already described. It may be concluded that there is no reason for postulating a greatly accelerated run-off from the settled districts as the result of partial deforestation, and the modern features may have had a like origin to those of earlier periods, which were similar in form and position, and lacked the complication of human interference. What was this origin?

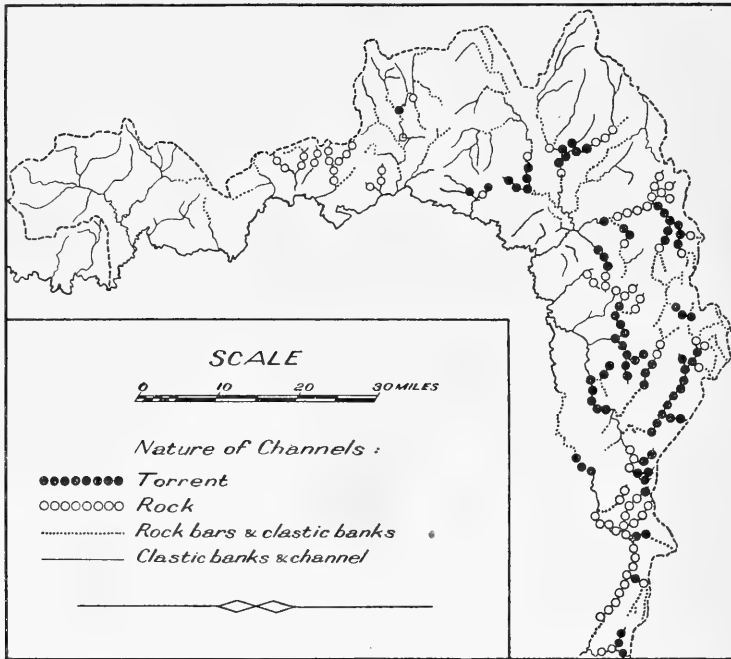
*Tectonics versus Hydrography.*

Physiographic and geological work on the coast of New South Wales has revealed evidences of vertical oscillations of a maximum order of 200 feet; the evidences include raised beaches (David and Etheridge, 1890) or shell deposits (Statham, 1892); submerged forest remains (Etheridge, Grimshaw and David, 1896; David and Halligan, 1908), and such features as drowned valleys (Andrews, 1903). From this it has followed that stream features, such as alluvial deposits or terraces, have been associated with these oscillatory movements (e.g., Morton, 1920, in Queensland; Taylor, 1923), and the interpretation of inland features may have been influenced by similar considerations. Thus Andrews (1910) refers to alternate submergences and uplifts as explaining the deposition and terracing of sediments at Forbes and Parkes, in the Lachlan valley, so it may be asserted that tectonic factors have been considered to be the determinants in the sculpture of the more recent land forms of this region.

Such an hypothesis cannot be admitted for the valley of the Upper Murray, for several reasons. Firstly, the modern and pre-modern erosional features in the fans and alluvials are distributed both above and below the torrent sections of all the main streams (Text-figs. 4, 5). These torrent sections, with their rapids and cascades, form a distinct break between the valleys and alluvials of the lowlands, on one hand, and the uplands and highlands on the other. It is difficult to imagine an action extending from the local base-level and passing them without a considerable delay; there is no evidence of such an action at present, but on the contrary similar features are developing, and have developed, at all levels. Secondly, it has been observed that the erosional features of the lowland streams do not involve a general or appreciable change of stream gradient, and they are often spasmodic in distribution along any one course; this applies particularly to Bowna Creek and the Murray itself. Thirdly, it is found that when individual examples are taken, cutting has proceeded without reference to the main stream course. For example, some of the largest cuttings at Tooma are separated from the main streams by widths of unaffected alluvial bottom lands, on which a part of the eroded material is being deposited: on Fowler's Swamp Creek, the Khancoban hillsides, or with the examples in the Tumbarumba uplands, there is a similar tendency to raise the local base-level by this secondary deposition.

From these considerations, it appears that any explanation of the more recent erosional forms on this landscape must apply equally well to all parts, and must also consider the relationships of the alluvials in which they have been cut: in any case, a rejuvenation by some form of differential uplift cannot be

allowed. Deprived of this explanation, recourse must be had to the streams themselves, and the cutting explained through variations in their flow.



Text-fig. 5.—Nature of stream channels. The difference between those classed as "torrent" and "rock" is, that the former are scoured by rapid streams, and the latter have stretches of still water, or aggradation flats at intervals.

#### *The Hydrographic Factor.*

An examination of the short- and long-term variations in rainfall and stream flow of the Upper Murray and Snowy Rivers has been made separately (Craft, 1934). So far as records show, the small region concerned is a unit with respect to winter rainfall, which is closely related to flood discharges of the rivers: Table I shows this relationship, and supplements the information already published (op. cit., p. 330).

Speaking generally, an earlier period of high flow was centred about the year 1890, and a similar later period commenced in 1917, and extended to the present day: between the two, there was a period in which low floods predominated. These conditions are rather similar to those disclosed by Morrison for the upper Nepean and Murrumbidgee Rivers, and for the Lachlan with greater irregularity (1919, graphs facing p. 13), or by Finucane and Forman (1929, p. 57) for the Swan River, W.A. They are reflected by the incidence of major individual floods, which occurred in the Upper Murray in the years 1878, 1887, 1889, 1890, 1893, 1894, 1906, 1916, 1917, 1918, 1920, 1921, 1923, 1926, and 1931, each being in excess of 4.5 million acre-feet for the year at Albury, whose average annual flow is 3.7 million acre-feet. Thus it appears that certain individual years and

TABLE 1.

*Correlation of winter rainfall (May–October) and stream flow records (June–November). Minor imperfections in records (op. cit., p. 328) have been interpolated from neighbouring stations.*

Elements.	Period.	Correlation Coefficient.	Probable Error.
Tumbarumba rainfall with			
Batlow rainfall .. .. .	1891–1932	0·93	0·01
Tooma rainfall .. .. .	1891–1932	0·98	0·004
Kiandra rainfall .. .. .	1891–1932	0·82	0·03
Albury rainfall .. .. .	1891–1932	0·86	0·03
Kosciusko rainfall–Jindabyne flow .. .. .	1912–1932	0·67	0·08
Kiandra rainfall–Jindabyne flow .. .. .	1903–1932	0·54	0·10
Batlow rainfall–Jingellic flow .. .. .	1891–1932	0·86	0·03
Tumbarumba rainfall–Jingellic flow .. .. .	1891–1932	0·83	0·03
Tooma rainfall–Jingellic flow .. .. .	1891–1932	0·78	0·04
Albury rainfall–Albury flow .. .. .	1878–1932	0·86	0·03

seasons have had excessive volumes, which have been associated with major inundations and destruction of human works; from the latter viewpoint, the winter seasons of 1917, 1931, and 1894, in that order, were the most disastrous, and the greatest disturbance of landscape equilibrium is to be expected at such times.

Whether such a disturbance has occurred must, of course, be determined in the field. Any relationship between flow and erosion rests on a purely empirical basis, because there is no rule that would enable one to say that a certain volume, or average, or intensity of flow, represents a critical value at which erosion begins to accelerate. Nor is the abstract trend a more reliable guide, because it is based on averages which have no demonstrable connection with stream work, and its gradient is largely determined by the negative features of excessively low floods: all that one can say is, that the positive annual flow or winter flood trends for the Murray, especially those disclosed by the more accurate records of the present century, indicate a rising flow which gives an expectation of increased stream work and erosion. If the individual major floods, or the periods in which they have been grouped, have been enough to overcome the inertia of those parts of the landscape which they affect, the later smaller flows could reasonably be expected to continue the work on weakened or damaged surfaces, and the recurrence of major floods at intervals would be sufficient to prevent the attainment of a new equilibrium for a considerable time.

Turning again to the field examples, it will be seen that the earlier period of large flows is approximately synchronous with the commencement of modern erosional features at Khancoban, Tooma and Talmalmo, where the success of the attack was partly due to previous clearing of the ground. If one takes a general view, it is clear that all the modern features—new gullies, receding stream banks, enlarged channels, and the further stabilization of the Murray

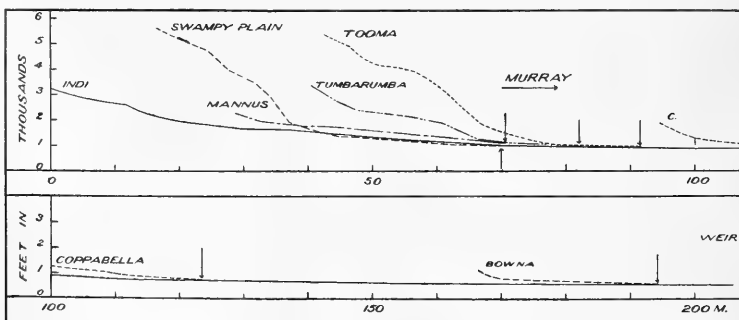
course at a lower level—many of which are independent of human action, have come into existence after a period of relative stability, in which the pre-modern features were either quiescent or senile. At the same time as this cutting, there has been a great increase in stream activity so that, in the absence of any other competent factor, the erosional revival must be ascribed to the increased cutting power of the streams, following the occurrence of major floods. In other words, the essentials of modern erosion are due to hydrographic changes, involving a slight redistribution of climatic elements, particularly with regard to a greater occurrence of exceptionally low and high monthly rainfall totals.

Following this conclusion, the local surface history since the deposition of the valley alluvials falls into three phases: an earlier period of erosion, possibly of a complex nature, giving the pre-modern channels and terraces; a period of relative stability immediately preceding modern times, followed by the most recent period of erosion, which is now proceeding, and which may not yet have reached its climax.

#### *History of the Alluvials.*

If hydrographic change is sufficient to account for modern erosion, it should also be capable of explaining the nature of the material now carried by streams, and the existence and disposition of the alluvials in which the greater part of the modern work has taken place. In other words, it must cover the full alluvial cycle, beginning with deposition and extending to the modern tendency of general removal; also, it must not involve assumptions that cannot be justified in other parts of the eastern Australian highlands, where conditions of alluviation and subsequent erosion are uniformly similar to those existing in the area under discussion. With this limitation in mind, the modern stream channels may be examined, and some definition of conditions made that would substitute deposition for cutting.

*Work in Modern Channels.*—Where the head streams of the Murray emerge from their gorges, they carry limited quantities of silt and mud, but flow over pebble beds in channels which show little alteration from year to year. The pebbles are similar in size, shape and material to those in the banks which are overlain by drift or silt: where the banks are undermined, masses of loosely cemented or incoherent pebbles are added to the channel. Where the basal pebbles are firmly cemented to form a conglomerate (e.g., Welumba Creek, Tooma, and Two Mile Creek, Jingellic), the channels are scoured clean, with occasional



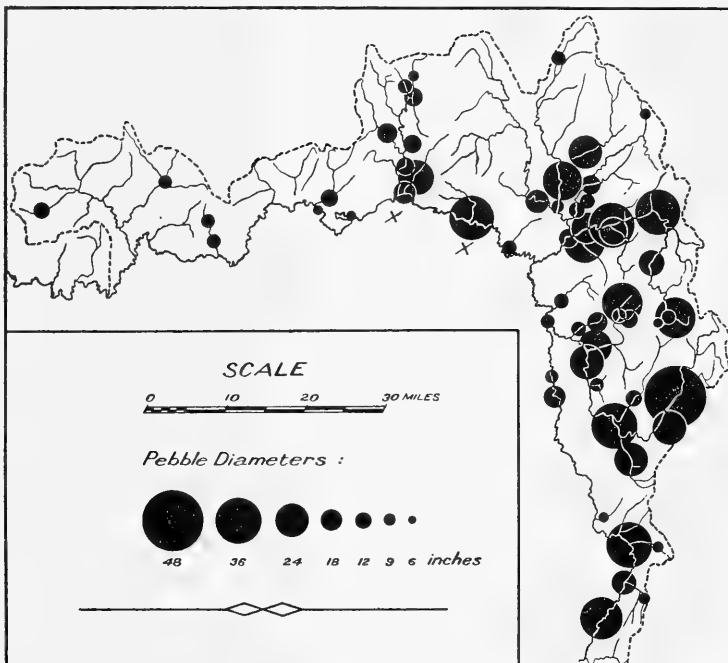
Text-fig. 6.—Talwegs of the principal streams. The name "Murray" is applied to the combined Swampy Plain and Indi Rivers.

loose pebbles on the pavement. The ideal ellipsoidal shape is common in all these occurrences; on the other hand, the restricted modern beaches of the Indi, Swampy Plain and lesser streams have flattish or sub-angular pebbles which usually do not exceed 6" to 8" in major diameter. From this, it is clear that the modern streams are not supplying large pebbles in quantity to the channels outside the canyons. Two possible reasons for this present themselves: either the streams are not sufficiently powerful to shift and transport the larger material, or they are capable of reducing almost all the rock fragments supplied before emerging from their gorges. The question is one of relative competence.

As a preliminary it will be realized that the torrent courses of the Swampy Plain and Tooma Rivers especially, involving a fall of 2,000 to 3,000 feet within a few miles (Text-fig. 6), favour high stream velocities: added to this, they discharge great volumes in time of exceptional flood, as these figures show:

	Annual.	June- November.
Swampy Plain River at Indi Junction, 1917 .. .. .	92"	69"
Swampy Plain River at Khancoban, 1931 .. .. .	50"	36"
Tooma River at Possum Point, Tooma, 1931 .. .. .	71"	51"

Equivalent depths of water over the whole catchment for the various discharges.

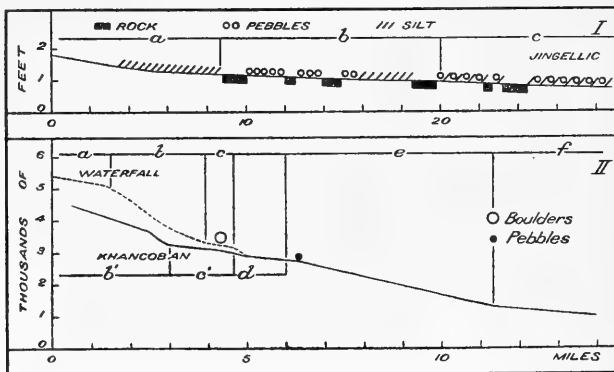


Text-fig. 7.—Major diameters of the largest pebbles found commonly in various places: the letter "X" indicates that the occurrence belongs to the tributary, and not to the Murray. No attempt is made to distinguish newly won material from that derived from the basal pebbles of the alluvials.

The principal highland streams thus have the two essentials of power—gradient and volume—and scour their channels (Plate iii, fig. 6); it would be difficult, if not quite impossible, to imagine conditions in these restricted areas of high country that would give the streams a greatly augmented volume, although high totals might easily become more numerous. If any doubt of the efficiency of the modern transporting medium remains, it will be dispelled by a consideration of the material carried now, or in times past (Text-fig. 7). The streams about Tooma and Jingellic have shifted and rounded material which approaches, in size, any of that carried by the mountain streams, with the exception of boulders of massive rock. Working at a lower elevation with restricted catchments, and forming relatively narrow channels in their torrent sections, their power can scarcely have approached that of the modern Swampy Plain and Tooma Rivers, so the latter may be looked on as highly efficient for purposes of transporting.

This view is confirmed by minor tributaries such as Khancoban Creek, and its highland branch, Waterfall Creek (Text-fig. 8). The latter moves boulders of 30" diameter freely above its cascades, but the pebbles in the bed of Khancoban Creek below the junction contain no visible representatives of the boulders, although they are mainly new material, with a general major diameter of 9" to 12". Downstream, the bed of Khancoban Creek on the flats by Swampy Plain River contains large, partly rounded masses of rock to a diameter of 30", but all are old, and visibly derived from the basal gravels. These streams are typical of the steeper tributaries.

From this it follows that the more powerful rivers and streams must be capable of reducing most of the greater rock fragments in their passage through canyon sections—a conclusion which is in line with the author's previous work on the active Blue Mountain rivers (Craft, 1932*c*, p. 285). Reduction is facilitated



Text-fig. 8.—I. Talweg of Coppabella-Jingellic Creek, to show the occurrence of major bars of hard rock, in black, and the alluvial deposits. *a*—upland valleys and plains; *b*—canyon sections in hard rocks, alternating with open, alluviated valleys; *c*—open valleys and plains adjoining Murray. The pebble horizon underlies the silts. II. Talwege of Khancoban and Waterfall Creeks, to show the relative positions of 30" diameter boulders, and 12" diameter pebbles carried by the streams. *a*—highland valleys and swamps; *b* and *b'*—upper canyons; *c*—partly aggraded valley with boulder deposits; *c'*—aggraded, swampy valley; *d*—middle canyon and rapids; *e*—lower canyon; *f*—plains to Swampy Plain River.

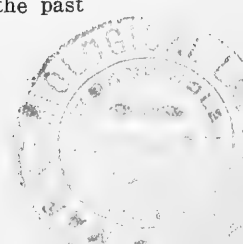
by two factors, namely, the presence of great "mills" on the stream courses above the alluviated valleys, and a poor supply of large material. The mills are torrent courses in narrow gorges of hard rock, where streams are excessively turbulent, and have many rapids. Each of the defined torrent courses (Text-fig. 5) may be so described, but those farthest downstream are the most significant, because rocks or pebbles must survive them before deposition is possible in the lower courses. The supply of material must be examined in rather more detail.

The supply of rock waste for transportation appears to be limited by geological character. Coppabella Creek may be used to illustrate the lower valleys and the uplands (Text-fig. 8). With it, the pebbles for alluvial deposits were derived from hard rocks in the middle courses, where the present channels are scoured clean, and massive pavements are exposed. Erosion in these former pebble-making places is very difficult, and the remainder of the landscape is covered with a mantle of soil or weathered rock that is virtually stable against any but direct stream attack, now being directed against the alluvials.

With the higher plateaus, the streams which traverse areas of more fissile rocks (e.g., the sedimentaries or metamorphics of Welumba, Bogong and Khancoban Creeks, and the northerly course of the Indi) gain many rock fragments which are not, and were not, deposited below the gorges. The other streams flow in massive granites or schists, in channels cut in fresh rock, and marked by a general absence of adjoining scree. The general condition of the highlands may be readily summed up by stating that, on the high plateau and its slopes, there is a thick mantle of soil and weathered rock, with relatively few bare cliffs and bluffs, and non-moving screes on slopes up to  $40^\circ$ ; on the other hand, the main stream channels and the slopes leading down to them are cleared and rocky, so that landslides into the river are few in number (for one example, see Byles, p. 30). The prevailing aspect is one of stability. It is clear that the streams have the power to shift material supplied to them, but the quantity is small; weaker stuff is reduced to silt, and the stronger to small grades, at the most, before the main alluviated valleys are reached. These conditions are greatly different from those which obtained in the past.

*Past Accumulation.*—The various deposits under this heading consist of two horizons: the basal material is of pebbles, whose coarseness decreases towards the upper limit, and the surface layer is of fine rock waste, silt or soil. The line of demarcation between the two is sharp, except in a few places adjoining the lower gorges; at Khancoban, for instance, the flats by Khancoban Creek have many pebbles (up to 12" diameter) scattered through the alluvium, but the limited nature of the exceptions is more remarkable than the fact of their occurrence. What were the conditions for the derivation of this material, and its deposition?

We are fortunate in having a model example of recent origin. Alluvial mining in the Tumberumba district caused the removal of quantities of fine, sandy drift, which passed the gorges and were deposited on the bottom lands at Tooma: removal is now being commenced by the consolidation and enlargement of a master stream channel. In this case, deposition was caused by the overloading of the stream without change in the total annual volume of water discharged, and probably without any great variation from normal flood conditions, as large storage dams were not available for the sluicing plants. Can it be denied that the succession of events may not be equally applicable to the past history of the upper Murray?



Turning now to the general problem, it is evident that all the streams carried much greater loads when the alluvials were being deposited than is now the case and that, for a time, they were able to discharge pebbles, even from the lower "mill" courses. These increased loads might be ascribed to greatly accelerated erosion following the disturbance of some limiting factor, such as forest removal, or to increased hydrographic activity. In the light of modern experience, the latter would need to follow a period in which the landscape had been subjected to gentle weathering conditions for a long time, and on which there was much material eligible for removal by streams of increasing competence. The former explanation is attractive for the colder districts, in view of the fact that the highest points in the region were visited by the Pleistocene glaciation, which may have passed as recently as 10,000 years ago (David, 1908). The writer favoured it for the upper Shoalhaven (Craft, 1932*a*, 209; 1932*c*, 289), but the universal distribution of such alluvials in the eastern highlands of Australia, and their varied altitude between sea-level and 6,000 feet makes it appear quite improbable.

The second possible explanation involves factors of process which may operate equally well over the whole landscape, and which are capable of accounting for the sharp distinction between the underlying pebbles and the overlying silts. The one assumption involved—a preliminary weathering during a period of erosional quiescence—is amply justified by reference to many other streams of the region, particularly in granite areas. For instance, the upland tributaries of the Snowy River in the Jindabyne district are cutting through deeply weathered granites, including many cores of exfoliated masses, and those in parts of the Shoalhaven valley about Marulan are winning pebbles and boulders under similar conditions, although deposits from upstream had obscured these in places (see Craft, 1931, Plate iv, 4). In the present area, the lower part of Maragle Creek, Tooma, is the most notable case of similar action, but these individual examples can be paralleled throughout the highlands. The weathering of stream beds and their subsequent erosion to give large pebbles, among other things, are thus found to be general phases of modern or recent action in the region; the assumption that such a process also affected the catchment of the Upper Murray as a whole must, therefore, be regarded as a strong probability, which is practically converted to a certainty when the present defective supply of rock fragments to the streams is borne in mind.

Granting this weathering and later increase in hydrographic power, it becomes necessary to explain the juxtaposition of silt and pebbles in the deposits. Marshall's experiments (1928) demonstrate that, when a mixture of pebbles of various sizes is subjected to movement in water, there is a survival of definite grades, with the elimination of many intermediate sizes. The end product is silt, and there is a general absence of material between the grades of silt and coarse gravel. In other words, if a mixture of rock waste were supplied to the upper parts of a stream and passed along a turbulent course, the actions of grinding, impact and abrasion which Marshall describes would tend to produce graded sizes, and after a time the lower parts of the stream would carry selected pebbles, and silt. If at this stage material were deposited, it should consist of pebbles, because the silt would not be deposited in the agitated water associated with a pebbly river. This appears to have happened with the Upper Murray, where there was a rough sorting of the pebbles according to distance from the lower gorges, and the spaces between the larger pebbles were filled with



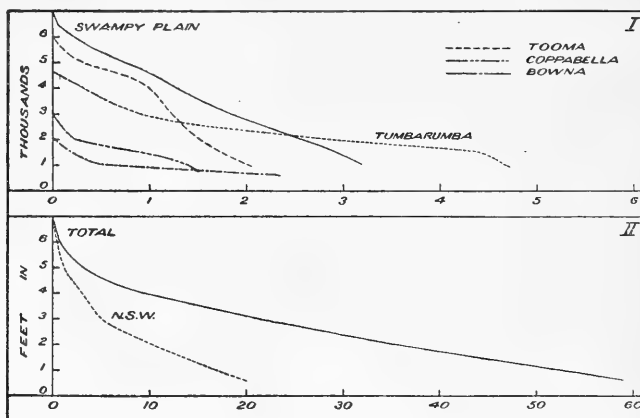
smaller pebbles, or with sandy drift. The latter may have been derived from country adjacent to the gentler valleys, as the truncated fans on the Indi hillsides above the Swampy Plain junction show; or it may be, in part, a residuum of unreduced material which has escaped from the gorges.

What were the conditions that made for the survival of the pebbles? Evidently the streams were not capable of reducing all the material supplied to them, either because of the greatness of the load, or because the maximum power had not been attained. The former alternative is probable on the assumption of an increase in stream power following a period of general weathering, and the latter is supported by the fact that, even after the discharge of pebbles from the lower gorges had almost ceased, there was a considerable supply of material that was used to form the upper horizon of silt. Probably both factors were effective, and the landscape as a whole suggests that the first rush of large fragments carried from the stream beds and neighbourhoods was succeeded by a flow of smaller material from more distant sources, as the pebbles in stream beds away from the main river valley bottoms are covered with a drift of soil and other fine material. In any case, a critical point is shown at which the pebble supply had decreased so greatly that silts were deposited below the gorges, and in the gentler sections above the lower torrent courses on each of the three main streams (Text-fig. 5). The supply of pebbles did not actually fail, as many are included in the fine silts at Khancoban, Tintaldra, and parts of the Indi River flats, but their occurrence is restricted, and their grading is remarkably uniform; individuals rarely exceed a major diameter of 12", and few are less than 3".

These facts appear to indicate that, after the main streams had removed the weathered material from their courses and reached fresh rock, the fragments brought from more remote sources or by weaker streams tended to become smaller, initially, and to be more easily reduced in the passage of the canyons. This action would be assisted by a further increase in stream power, but the latter was not essential. The maintenance of erosive and transporting ability can hardly be doubted, because pebbles were still carried, and the failure of destructive power would have resulted in the survival of the varied material supplied to the rivers in their swift upper courses, instead of its reduction to the fine brown silt of which the top alluvials are formed. In short, the formation and disposition of the alluvials can be explained readily in terms of stream mechanics, with definite limits imposed by the amount of weathering in stream channels, and the quantity of material which became subject to stream attack and removal. In such an action, the observed succession of basal pebbles and upper silts is inevitable and, if the stream volumes are sustained over a sufficiently long period, conditions like those of the present day must be reached. Under these, a defective supply of material is being gained by powerful streams in their upper courses; this is being reduced in the passage of the gorges and the clear streams are removing the existing alluvials from their lower valleys.

The conclusion of simple hydrographic change as the motive force in the inauguration and working out of the alluvial cycle is thus logical and inescapable. It explains the occurrence and juxtaposition of the fine silts and pebbles in the alluvials; the apparent contradiction of hillsides covered with a thick mantle of rock waste and soil, while the torrent channels are scoured clean to expose unweathered pavements; and the development of modern and pre-modern erosional features in the alluvials themselves.

*Discussion.*—From the viewpoint of altitude or gradient (Text-figs. 2, 6), the Upper Murray landscape as a whole is unstable, with an expectation of a continued reduction towards base-level; however, the process of reduction is slow, and the amount of valley extension since the close of the Tertiary era is limited to canyon formation. The time indicators are flows of basalt which occur at an altitude of 5,000 feet on the eastern divide of Tooma River (Andrews, 1901), with a fall to 3,800 feet in the case of the discontinuous extensions on the eastern divide of Tumarumba Creek, or 2,000 feet in the case of Mannus Creek. There is a further extension into the valley at Tooma (Plate iii, fig. 3), where the base of the flow is at 1,100 to 1,200 feet, and comes to the level of the modern valley floor. The extrusions are of a general Pliocene age (Browne, 1933, 34), and immediately to the east of the Tooma drainage, Tumut River has cut a canyon to a depth of more than 2,000 feet below the basalt (Andrews, 1901). In the Tooma district, canyon recession is of the order of 5 miles on Tumarumba Creek, with a probable maximum depth increment of 600 feet, so that post-Tertiary action from the local base-level has been responsible for the removal of basalt from valleys, and for limited canyon extension. The general form of the valleys below Tooma as regards depth and talweg is thus found to be the result of pre-basaltic action and, with no sign of later faulting, the existing relief of the whole surface dates back to the Pliocene, at least, together with the essential form of the Tooma and Swampy Plain Rivers (contrast David, 1932*a*, p. 95, who favours Andrews, 1910, p. 421, in granting regional late-Tertiary uplift, stream rejuvenation, and canyon cutting). It follows that, whilst absolute stability is not possible under the existing conditions of slope and altitude, the mean departure from equilibrium in post-Tertiary time has been comparatively small. Thus the hypsometric curves (Text-fig. 9) and the talwege (Text-fig. 6) are not so unstable as their form might lead one to believe.



Text-fig. 9.—Hypsometric curves for the principal stream basins; the horizontal scales are in hundreds of square miles. In II, the total is for the Murray above the Hume weir, of which the Victorian portion is taken from the International Map of the World, 1:1,000,000 (Sheets SI 55 and SJ 55), whilst the New South Wales portion, separately and in the total, is from surveys by B. U. Byles and the author, based on trigonometrical data.

This has been largely brought about by geological structure (refer to David, 1932b). The area consists essentially of a granite mass, with local coverings and inclusions of sedimentary and metamorphic rocks; the upper intrusive surface underlies towards the west. Thus a summit plane which appears to be not far below the original upper limit of the granite is found on the highest plateau at 7,000 feet, at the head of Snowy River, but it falls away in all directions, so that the country rock of the Albury district, at altitudes below 1,000 feet, consists of sedimentaries. The granites are diversified by masses of extra resistance (e.g., the hill of Plate iii, fig. 1), of which the greatest forms the high plateau to the west of the Upper Indi-Murray River line. Effects of this may be seen in the cases of small tributaries to the Indi, such as Cascade Creek, which flow on the high granite plateau, and then fall steeply to the metamorphics of the river line; of Khancoban Creek and its tributaries, whose downcutting is held up by granite bars immediately below the graded middle valleys (*c* and *c'* of Text-fig. 8, II); and by the presence of a falling belt of metamorphics on the western slopes of the highest mass, between Welumba Creek, Tooma, and the head of Indi River. The shape and resistance of the upper granite surface, therefore, gives an expectation of rectilinear hypsometric curves for the Murray and its highland source basins; the actual curves found are of this form, and are thus normal to the terrain concerned, and are not indicative of recent tectonic disturbance and major instability of land forms. Similar factors have existed in the development of certain minor streams: Tumarumba (including Mannus) and Coppabella Creeks have their lower torrent courses in an irregular east-west trending belt of hard schists and quartzites, which stand up in square profiles higher than the basins and local plains upstream, and impose minor inflections on the hypsometric curves by reason of the steep slopes associated with them, and the limited extent of the lowest country in each stream basin. With the disappearance of this factor to the west, other tributary drainages (e.g., Bowna Creek) take on a normal form.

On this landscape, the various disturbances of local equilibrium are closely related to one another, and are parts of a cyclical action in four stages, namely: 1.—Simple valleys existed without alluvial deposits. 2.—A period of cutting followed, with the formation of rounded and ellipsoidal pebbles in all channels, and their deposition in gentle valleys. 3.—This stage saw fine drift carried from the upper and middle slopes of the valley sides, while the streams carried and deposited silt, destroying most of their limited pebble supply in the process. 4.—The present condition is one of general equilibrium on the valley sides, and cutting in the alluvials, with a limited number of sub-angular and flat pebbles carried by the main streams as new material. In this scheme, modern erosion represents an acceleration of the fourth stage, with major floods as the disturbing factor. The tendency is to produce a topography like that which existed before the deposition of the two horizons of the alluvials, and the critical point was attained at the beginning of the fourth stage, when there was a break between the dominance of deposition, and the later assumption of cutting. Such conditions only apply to portions of the Murray River; the fact is recognized by Fenner (1934, fig. 4b), who distinguishes between the river of the uplands above Albury, that of the billabong lands below Albury, towards the Murrumbidgee junction, and the simple channel of the lower course in slightly raised country, where cutting again predominates (Fenner, 1930). As we have seen, the conditions responsible for the existence of the old billabongs above Albury—the wandering of a river

on the plains, with deposition balancing removal—no longer apply, but there is cutting, even on straight courses, with no apparent deposits of a permanent character. It may be remarked, that the stranding of these billabongs had been previously noticed by Smail (Interstate Royal Commission, 1902*b*, 279).

The processes of the fourth stage are resulting in the formation of a definite terrace series, and it would be competent for a repetition of the cycle to give a new series of deposits and terraces, because the talweg slope involved (average  $0^{\circ} 7'$  between Khancoban and Albury) has been sufficient for the removal of sediments that existed before the present alluvials were deposited. The action is evidently the result of the application of disturbing conditions over the whole landscape, and it gives the simplest possible explanation of the arrangement of river deposits, and their terracing. Many other examples to which attention has been paid (cf. Barrell, 1920; Steers, 1932, ch. v) occur close to sea-level, and near coasts, and are thus particularly susceptible to explanation by reference to changes in the level of the sea relative to the land. Such an explanation would be very far-fetched in the cases of the inland rivers of Australia, such as the Upper Murray, with terrace forms in a vertical range of 10, 20 and 50 feet in each locality, and at a distance of more than 1,000 miles from the river mouth. More extreme cases may be cited, such as the Upper Murrumbidgee and its terraces at an elevation of 3,700 feet (Craft, 1933*a*, Plate ix, 3), but the whole tenor of evidence in the eastern highlands is, that recent alluvials have been subjected to terracing at all altitudes and distances from the sea, and the alluvials operated upon in each case had the characteristic horizons of silt and pebbles. The alluvial cycle described for the Murray may well be of general application, even where later cutting and terracing are due to stream revival through external causes in the vicinity of coasts.

This leads to the consideration of the longer range history of the Upper Murray. It has been shown that material for the pebbles and silts of the alluvials of the whole landscape was derived by a general action on the stream channels and valley sides, at all elevations; this was in accordance with the existing hypsometric curves, and would give a slight general lowering of them without any great departure from their shape. Is it possible that the whole development of the landscape has followed similar lines since the beginning of the formation of the plateau?

The summit plane of the existing surface has a maximum fall of 5,000 feet from the highest points on the eastern Murray divide to the plateau edge near Albury, in a distance of 80 miles; the western limit of the country originally subjected to this particular uplift has naturally been obscured by erosion. The existing fall of the summit plane is equivalent to a slope of  $0^{\circ} 40'$ , and the uplift involved in the formation of the highlands has simply resulted in the formation of this slope, and the revival of streams on it. This contrasts with conditions on the eastern or Murrumbidgee-Snowy fall from the Murray divide, where the old summit plane at 5,000 to 7,000 feet on that divide has been largely obliterated towards the east, in the formation of successive peneplain levels (Craft, 1933*a*). With a definite tilt of limited value, stream revival is not concentrated at a point, as in the case of the scarp edge of a block mountain system, but it is distributed along the whole lengths of the streams affected with a natural maximum towards the downstream side. This gives the phenomenon of uniform revival and cutting, an ideal case being that of the Nepean tributaries on the "Nepean Ramp", immediately south of Sydney (Taylor, 1923, 67). If a point

of favourable inflection existed, a superimposed impulse of headward erosion would operate, and would gradually die out as it progressed upstream.

If a more complex example be supposed, with uplift in stages and peripheral extension of the uplifted country, there would be a series of stream revivals, with each succeeding one further removed from the centre of the affected area. With the gentle regional slopes existing in eastern Australia, of a general order of  $1^\circ$ , and a consequent limitation of the effect of each revival, especially during the attack on hard basement rocks, the talweg of a major stream would be expected to take on a rectilinear form. The conditions have been satisfied in this region (Craft, 1932*b*, 259), and a rectilinear-talweg stream class exists, including the Lachlan, Macquarie, Murrumbidgee, Snowy, Condamine and Castlereagh Rivers (Craft, 1933*b*, 452). As a contrast, other rivers have talwege and valleys determined by block mountain conditions, with a predominating impulse of headward erosion directed upstream from a limited zone, causing the regular migration of a fall line; typical examples are the Clarence and Macleay.

From this it follows that the gentle tilting of a surface without major inflections will give a uniform stream revival throughout the length of the streams affected, but a major inflection in the surface will give rise to an impulse of headward erosion. When the tilting effect is predominant, especially if a series of uplifts be envisaged, the stream talweg assumes a rectilinear form that is only gradually made concave by the operation of the normal forces of weathering and erosion. In such a process the gorges invading the central mass or core represent a very late stage of landscape development—a stage which is now being attained by the Upper Murray, operating on the slopes where outward expansion of the highlands has been a minimum.

#### *Conclusions.*

1. Modern erosion in the Upper Murray catchment is an acceleration of the attack on alluvial deposits in the main valleys, and along minor streams.
2. Acceleration of cutting has been due to increasing flood intensity, and to the occurrence of groups of exceptional floods. These have been caused by slight variations in the number of months of extremely high rainfall in the normal flood season, without any great climatic change.
3. A normal cycle of deposition and removal is shown with increasing stream power. Four principal stages are recognized, namely: 1.—A condition of equilibrium, involving weathering of stream beds and the landscape in general, with streams of insufficient power to remove all the weathered material. 2.—An increase in stream power, involving an attack on stream beds and surroundings to give rounded and ellipsoidal pebbles which are deposited in the gentler valleys. 3.—The removal of finer material from the valley sides, its partial deposition along minor streams, and the reduction of the balance in the torrent courses, together with a decreasing supply of rock fragments, to give fine silt, and a few pebbles. These are deposited on the pebble beds in the valleys. 4.—With the removal of the most unstable material, and the exposure of unweathered rock in torrent courses, the streams become clear; a maintenance of their power results in the attack, terracing, and removal of the alluvial deposits, with periods of maximum and minimum activity governed by flood conditions.
4. The size and shape of material carried by streams from the highlands depend on the stage of the cycle that has been reached.

5. With the maintenance of stream power, the larger grades of material transported become impermanent, and there is a strong tendency for the whole load to be reduced to the form of silt. Hence the cutting power in rock channels may decline with increasing flood volumes, because a poor supply of abrasional weapons is gained from the fresh channel rock, and individual pieces are more quickly destroyed.

6. The more recent erosion has tended to preserve the form of rectilinear hypsometric curves for the Upper Murray, and for certain of its principal tributary stream basins.

7. The original development of the topography depended on acceleration of cutting as the result of gentle tilting during the uplift of the highlands. Revival took place simultaneously along the whole lengths of the stream courses.

8. The streams of New South Wales have been subjected to two forms of rejuvenation. In the first, gentle regional tilting has been concerned, but in the second the presence of major surface inflections, or block mountain conditions, has caused the development of a dominating impulse of headward recession, which migrates upstream from a narrow zone.

9. On the estimates for modern erosion on the Upper Murray, the annual displacement measured is of the order of 50 acre-feet. If this be applied to the whole catchment above the Hume weir, the gross annual displacement is of the order of 150 acre-feet. On this basis, a period of the order of 8,000 years would be required to give a volume equal to that of the Hume reservoir (1,250,000 acre-feet). Unknown factors are the sheet waste from the catchment, and the proportion of eroded material passing the weir, but the potential useful life of the structure appears to be of the order of some thousands of years, on the experience of landscape change in the past half century.

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## EXPLANATION OF PLATES II-III.

## Plate ii.

- 1.—Stream in Bowna Creek Basin (at Gerogery), to show tree relics in channel, and the nature of modern cutting.
- 2.—View on Mullanjandra Creek, to show terracing, with a new channel in the foreground, and unprotected banks in the background. Erosion has re-commenced on the latter.
- 3.—Middle section of Fowler's Swamp Creek, to show modern bank cutting in alluvial relics and soil, with the fence to the right enclosing a flat of matured soil.
- 4.—Lower part of Fowler's Swamp Creek, with terracing in the alluvial fan and plain: this dies out with the fall towards the river.
- 5.—Pre-modern channel of Wagra Creek, Wymah, to show form, maturing soils on the channel floor, and trees which have been cut down *in situ*.
- 6.—Seven Mile Creek, Talmalmo. Note the wooded catchment, the destruction of trees, and the modern attack on the valley alluvials. A terrace above the flats represents an old valley floor, and the cross-section of the pre-modern course is in the foreground.

## Plate iii.

- 1.—Valley of the Murray below Jingellic, during the normal flood of October, 1933. The stream is enlarging its channel by attacking each bank, and the old billabongs are seen to the right.

2.—Modern attack on mature chernozem soil overlying pebble layers, upper part of Coppabella Creek, about 1,300 feet altitude. This also shows the general form of the uplands, looking downstream.

3.—Valley of Tumbarumba Creek, Tooma, with the valley of Maragle Creek between the ridges on the left, in the cleared portion. The background shows the lower part of the Tooma River gorge, and the altitude range is from 900 to 5,200 feet. The valley floor towards the foreground consists of sediments from gold workings at Tumbarumba, and the nearest hill on the left is part of a Tertiary basalt flow.

4.—Valley of the Murray above Tintaldra, with the Swampy Plain valley beyond the ridges in the middle distance, and Mt. Kosciusko in the far distance towards the right. Note the enlargement of the stream channel, the attack on tree lands, and the billabongs on the wet plains. The surfaces of alluvial fans and aprons are accordant with this plain, with a few minor exceptions on very steep hillsides.

5.—Maragle Creek, Tooma. The stream is attacking relics of hill wash and alluvium, which overlie pebbles and bouldery granites. This is a type of the channel described as having "cutting banks at intervals", and the equilibrium valley form is well shown. (Photo, B. U. Byles.)

6.—Torrent course of the Swampy Plain River above Geehi, showing the channel scoured in fresh rock, with few boulders and pebbles. This is a typical "mill" section. (Photo, B. U. Byles.)

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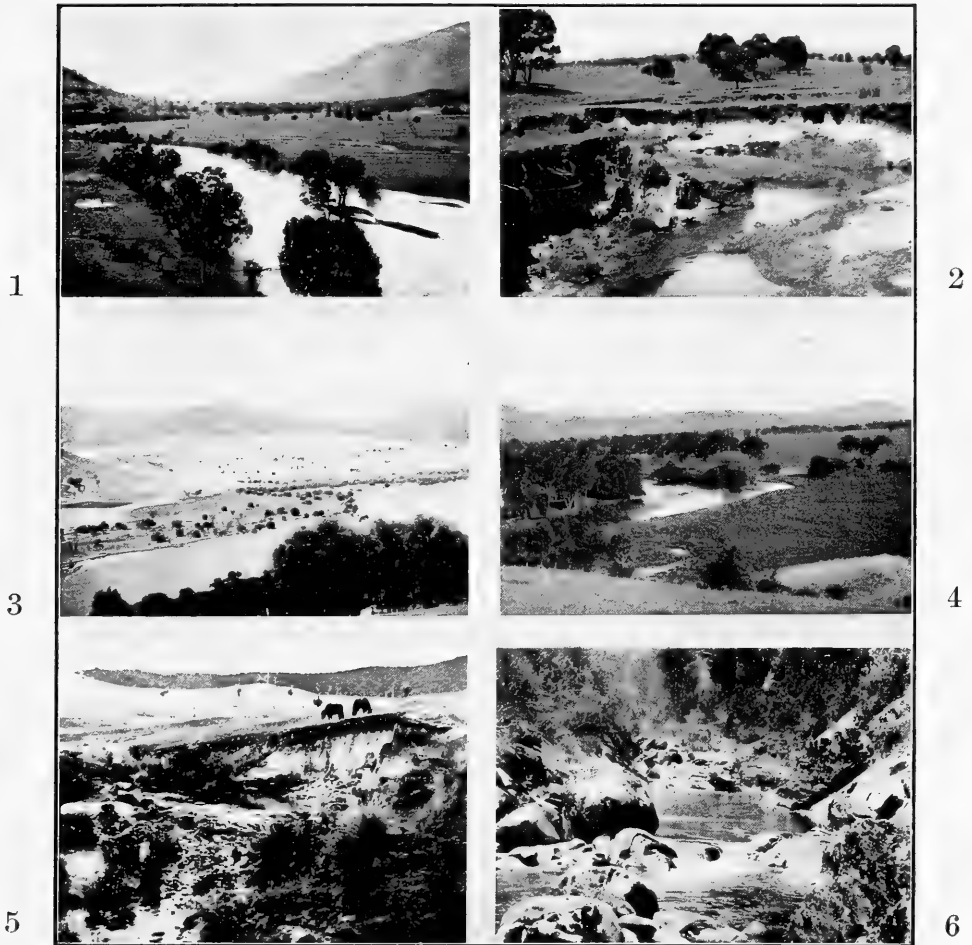


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Erosion in Upper Murray Catchment, N.S.W.





Erosion in Upper Murray Catchment, N.S.W.



### CONTRIBUTIONS TO THE MICROBIOLOGY OF AUSTRALIAN SOILS. III.

THE ROSSI-CHOLODNY METHOD AS A QUANTITATIVE INDEX OF THE GROWTH OF FUNGI IN THE SOIL, WITH SOME PRELIMINARY OBSERVATIONS ON THE INFLUENCE OF ORGANIC MATTER ON THE SOIL MICROFLORA.

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

(Two Text-figures.)

[Read 26th June, 1935.]

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#### *Introduction.*

Although a great deal of research work has already been carried out on the influence of various organic compounds upon the abundance and the composition of the soil microflora, we have yet very little information concerning the combined influence of organic matter and varying temperatures and moisture-degrees on the general composition of the soil microflora, in spite of the profound influence which these factors are known to exert upon the course of the decomposition of organic matter in the soil. The results of a number of preliminary experiments in this direction are presented in this contribution.

To a number of samples of soils of varying character were added various kinds of organic material, usually one per cent. on the basis of air-dry soil, whereupon the soils were adjusted to the desired degree of moisture and incubated at different temperatures for periods up to 15 days. The numbers of bacteria, actinomycetes and fungi were determined by plate counting, and in addition the development of fungal mycelium was controlled on microscopic slides placed in the soil.\* The arrangement of the experiments as well as the methods of counting and of staining of the slides were essentially the same as previously described (Jensen, 1934*b*), except that somewhat smaller quantities of soil were generally used, and when a slide was removed from the soil, a new one was placed instead of it (cf. Conn, 1932). The agar plates were incubated at 27–28°C. At an early stage of the work it was realized that the semi-quantitative description of the slides as more or less “rich” or “poor” in fungal mycelium is unsatisfactory. A more precise estimate of the density of mycelium was therefore sought by examining a large number of microscopic fields (usually 500–550), distributed as evenly as possible over the slide, and calculating the percentage of fields showing the presence of fungal hyphae. An oil immersion objective (Leitz 1/12, n. ap. 1.30) and a low-power eyepiece were used, and only a central square field of approximately 65 $\mu$  side-length was examined. This method, while not enabling us to express the quantity of mycelium in terms of the weight of soil, gives a good picture of the richness of different soils in fungal mycelium. At the same time the numbers of fungal spores, where present,

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\* The method introduced by G. Rossi and N. Cholodny (Jensen, 1934*b*).

were counted. These counts, however, cannot be taken as reliable indices of the actual content of spores; since most fungi produce their spores in clusters or chains, the distribution of the spores over the slides is not random, and the counts do not follow the Poisson series (Fisher, 1930). Moreover, it is not always easy to distinguish microscopically between solitary fungal spores and encysted protozoa, especially flagellates. Counting of the bacteria and actinomycetes on the slides was found impossible because of the frequent occurrence of fields too densely crowded with organisms to admit of any counting.

#### Experimental Results.

The results of this series of experiments are reproduced in Table 1. Several interesting facts emerge from these figures. Firstly, the numbers of bacteria show in parallel experiments almost constantly a decrease with increasing temperature, after 4-5 as well as after 12-14 days. An increase in the moisture is frequently, but by no means constantly, accompanied by an increase in the bacterial numbers. The numbers of actinomycetes, on the other hand, show in the large majority of cases a definite increase with increasing temperature, although there is little difference in their numbers at 27-28° and at 37-40° C. Increases in the moisture seem to tend to depress rather than to increase their numbers. The ratio of actinomycetes to bacteria shows even more definite relationships to the temperature and moisture, as shown in Table 2. It is seen here that in every case, except No. IV, 25.5% H<sub>2</sub>O, an increase in the temperature results in a narrowing of the ratio. Increased moisture has in most cases widened the ratio, or else failed to have any pronounced effect, such as in Exp. VI and X at room temperature.

TABLE 1.  
*Influence of Organic Materials on the Composition of the Soil Microflora.*

Soil and Addition.	Temperature. °C.	H <sub>2</sub> O. %.	Incubation. Days.	Bacteria.*	Actinomycetes.*	Fungi.		
						Plate Count.†	Density of Mycelium. %.	Spores. Average per 100 Microscopic Fields.
I. Heavy loam, rich in organic matter, pH 5.5, plus 2% CaCO <sub>3</sub> and 1.0% saccharose.	18-20	22.5	5	467.1	669.7	4,387	(rich)	(many)
		30.5	„	2,402.6	374.1	—	(rich)	(many)
		35.5	„	1,852.9	124.0	—	(rich)	(few)
	37	22.5	5	141.9	709.7	203	(scant)	(few)
		30.5	„	172.7	141.9	—	(scant)	(few)
		35.5	„	163.5	407.0	—	(scant)	(none)
II. Heavy loam, rich in organic matter, plus 4% CaCO <sub>3</sub> and 1.0% soluble starch.	16-18	27.5	4	156.9	29.8	71	1.1	3
			10	327.6	172.4	101	2.5	1
	28	27.5	4	424.1	346.9	84	4.8	1
			10	310.3	268.9	174	11.1	2
	41	27.5	4	93.1	153.8	30	1.3	1
			10	113.8	300.0	76	0.4	1

\* Millions per gram of dry soil.

† Thousands per gram of dry soil.

TABLE 1.—Continued.

*Influence of Organic Materials on the Composition of the Soil Microflora.—Continued.*

Soil and Addition.	Temperature. °C.	H <sub>2</sub> O. %.	Incuba- tion. Days.	Bacteria.*	Actino- mycetes.*	Fungi.		
						Plate Count.†	Density of My- celium. %.	Spores. Average per 100 Micro- scopic Fields.
III. Loam, rich in organic matter, pH 7.3, plus 0.75% xylan.	18-21	13.0	6	1,139.4	54.6	402	42.5	2
		22.5	„	1,858.0	17.7	245	31.0	1
	39	13.0	6	563.2	327.6	4,885	29.6	136
		22.5	„	398.4	64.5	4,549	20.5	159
IV. Same as III, plus 1.0% hay meal (mixture of young grass and clover).	18-21	15.0	6	647.0	270.6	676	54.6	5
		19.5	„	764.0	233.0	590	(rich)	(none)
	39	25.5	„	596.0	90.6	537	(rich)	(none)
		15.0	6	216.2	133.8	8,235	24.4	172
	40	19.5	„	(Lost)		10,311	(rich)	(many)
		25.5	„	532.5	82.8	1,644	(rich)	(many)
V. Sand, very poor in organic matter, pH 5.1, plus 1.0% hay meal.	18-21	4.9	6	562.6	2.6	571	58.3	18
			14	429.8	21.0	570	48.4	13
	40	10.3	6	376.2	(0)	452	44.7	11
			14	360.9	5.6	309	24.0	11
	40	4.9	6	195.3	17.1	71	16.9	4
			14	141.6	34.6	166	1.3	14
	40	10.3	6	178.4	11.1	56	22.0	1
			14	118.5	29.4	27	4.2	1
VI. Sand, same as V, plus 1.0% CaCO <sub>3</sub> and 1.0% hay meal.	18-21	5.5	5	1,304.2	1.3	222	48.5	1
			12	571.4	1.1	180	36.0	10
	40	10.8	5	731.5	2.8	242	29.4	4
			12	338.0	2.2	153	29.8	7
	40	5.5	5	316.1	43.6	77	11.2	6
			12	105.8	25.4	28	1.4	3
	40	10.8	5	316.7	14.0	31	2.4	4
			12	111.4	16.4	5	1.9	0
VII. Same as V, plus 0.5% dried my- celium of actino- mycetes.	18-20	4.8	5	625.0	(0)	158	(rich)	(few)
		9.4	„	524.3	(0)	221	(rich)	(few)
	39	4.8	5	252.1	94.5	1,815	(scant)	(many)
		9.4	„	275.9	33.1	154	(scant)	(few)

\* Millions per gram of dry soil.

† Thousands per gram of dry soil.

TABLE 1.—Continued.

*Influence of Organic Materials on the Composition of the Soil Microflora.—Continued.*

Soil and Addition.	Temperature. °C.	H <sub>2</sub> O. %.	Incubation. Days.	Bacteria.*	Actinomycetes.*	Fungi.		
						Plate Count.†	Density of Mycelium. %.	Spores. Average per 100 Microscopic Fields.
VIII. Red loam, pH 6.0, plus 1.0% hay meal.	18-21	17.0	5	551.7	123.5	133	31.6	0
	39	17.0	5	236.5	158.1	3,705	21.4	158
IX. Red loam, pH 6.8, plus 1.0% hay meal.	17-19	17.5	6	401.2	18.2	109	41.1	1
	28	17.5	6	175.8	130.9	945	21.0	18
	39	17.5	6	101.8	146.7	315	14.0	26
X. Heavy loam, rich in organic matter, pH 5.5, plus 1.0% hay meal.	16-19	18.2	5	442.4	1.5	206	46.3	1
			12	363.7	17.7	1,956	67.1	44
		25.0	5	756.7	4.2	300	44.6	1
			12	580.0	28.0	833	57.5	19
		30.0	5	912.5	4.5	300	55.6	0
			12	298.2	14.3	446	53.5	8
	27	18.2	5	287.3	35.1	3,545	57.3	82
			12	303.2	70.9	4,303	34.6	58
		25.0	5	540.0	48.3	2,233	47.5	43
	12		409.3	74.7	2,960	20.5	53	
	30.0	5	310.7	57.1	1,821	55.8	21	
		12	162.9	82.1	1,600	14.5	32	
39		18.2	5	68.9	35.1	7,182	49.6	147
	12		52.0	38.5	7,319	13.8	72	
	25.0	5	155.0	44.4	3,700	46.4	135	
12		57.7	40.3	4,933	11.3	78		
30.0	5	80.4	39.3	3,357	31.7	36		
	12	52.5	31.1	2,943	15.5	43		

\* Millions per gram of dry soil.

† Thousands per gram of dry soil.

We see thus, that with increasing temperature and decreasing moisture the balance of the microflora is shifted more and more from the bacteria towards the actinomycetes. This general principle, which is also supported by the appearance of the microscopic slides, and which applies both to different soils and different kinds of organic matter, is in full agreement with results previously obtained on soil samples taken from the field (Jensen, 1934a), but in the present experi-



ments, where extra organic matter is added, the influence of the temperature appears more important than that of the moisture, in contrast to the previous experiments. It is here to be noted that the limits of temperature and moisture were not precisely the same in the two series of experiments.

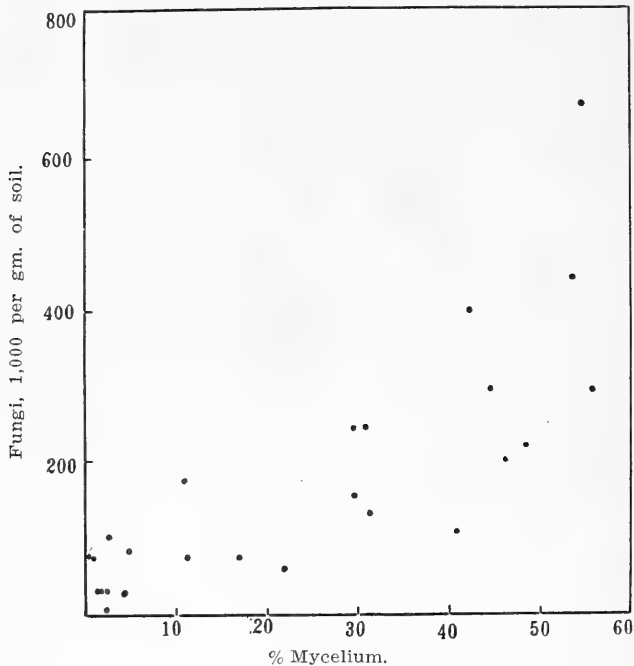
TABLE 2.

*Ratios of Actinomycetes to Bacteria in Relation to Temperature and Moisture.*

Soil No.	H <sub>2</sub> O%.	Incubation, Days.	Ratio of Actinomycetes to Bacteria at:		
			Room Temperature.	27-28° C.	37-41° C.
I .. .. .	22.5	5	1.43	—	5.00
	30.5	„	0.156	—	0.96
	35.5	„	0.067	—	2.50
II .. .. .	27.5	4	0.231	0.854	1.65
	„	10	0.526	0.709	2.64
III .. .. .	13.0	6	0.048	—	0.582
	22.5	„	0.010	—	0.162
IV .. .. .	15.0	6	0.418	—	0.619
	19.5	„	0.305	—	—
	25.5	„	0.153	—	0.155
V .. .. .	4.9	6	0.005	—	0.087
	10.3	„	(0)	—	0.062
	4.9	14	0.049	—	0.259
	10.3	„	0.015	—	0.062
VI .. .. .	5.5	5	0.001	—	0.138
	10.8	„	0.004	—	0.044
	5.5	12	0.002	—	0.239
	10.8	„	0.006	—	0.147
VII .. .. .	4.8	5	(0)	—	0.375
	9.4	„	(0)	—	0.120
VIII .. .. .	17.0	5	0.224	—	0.669
IX .. .. .	17.5	6	0.044	0.745	1.44
X .. .. .	18.2	5	0.003	0.122	0.511
	25.0	„	0.006	0.089	0.215
	30.0	„	0.005	0.184	0.489
	18.2	12	0.049	0.234	0.741
	25.0	„	0.048	0.182	0.699
	30.0	„	0.048	0.504	0.592

Table 1 also shows that the density of fungal mycelium (expressed as the percentage of microscopic fields showing presence of hyphae) is in 18 cases out of 21 higher, and often very much so, at 16-21° than at 37-41° C., regardless of the nature of the soil or the organic material added. At 27-28° C. the density is in 4 cases out of 9 lower than at room temperature, but in 7 cases higher than at 37-41° C. Experiments V, VI and X show that the strongest development of

mycelium takes place within the first 4-6 days, after which time the figures for the density of mycelium drop markedly at higher temperatures, while often remaining quite high or even increasing at room temperature. It is also noteworthy that increased moisture generally tends to reduce the development of mycelium, and that the alkaline soils No. IV and VI are with equal treatment nearly as rich in mycelium as the acid soils No. V and X. The plate counts of fungi tell quite a different story. They show in Experiments III, IV, VII and X a huge increase in fungi at 27-28°, and especially 37-41° C. At the last



Text-figure 1.—Correlation between density of mycelium and plate counts of fungi in 25 cases from Table 1.

temperatures the fungous flora was remarkably uniform in composition, mainly consisting of a green *Aspergillus*, probably *fumigatus*, and a species of *Monilia*, whereas Mucoraceae, Penicillia and Fusaria predominated at the other temperatures. The last column of Table 1 shows that in all cases of high plate-counts there is also a very large number of fungal spores present on the slides; the conidiophores of the *Aspergillus* and the spore-chains of the *Monilia* were clearly recognizable on such slides. Although, as stated above, these figures may not be reliable indices of the actual density of fungal spores, they nevertheless show a fine correlation with the plate counts; the correlation coefficient amounts to 0.865, a value which remains practically unaltered (0.864) when calculated as a partial correlation coefficient with constant density of mycelium. On the other hand, the figures for density of mycelium do not, when the whole set of data is considered, show any correlation with the plate counts. The correlation coefficient between these two values is only 0.112, and this value even disappears (0.036) when

calculated as a partial correlation coefficient with constant number of spores. This shows conclusively that the plate counting under these conditions measures only the number of fungal spores in the soil (cf. McLennan, 1928, and Conn, 1932). However, a real correlation between density of mycelium and plate counts appears if we consider only those 25 cases in Table 1, where the microscopical examination has shown an average of less than 10 spores per 100 fields (Text-fig. 1). Here the correlation coefficient between density of mycelium and plate counts amounts to 0.769, a value of very high significance with 25 observations (Fisher, 1930, Table V. A). The correlation coefficient between spore-numbers and plate counts is here insignificant (0.301). This shows us that the plate count is an index of the density of fungal mycelium only in cases where the number of spores is low in proportion to the amount of vegetative mycelium, but as the numbers of spores increase, they influence the numbers of colonies so strongly that the amount of vegetative mycelium becomes relatively unimportant.

A calculation of the distribution of  $\chi^2$  (Fisher, 1930) from the 61 counts of fungi\* in Table 1 and the 9 in Table 3 gave the following result:

Value of $\chi^2$ .	Frequency.	
	Expected.	Observed.
0.0	0.7	0
0.115	0.7	1
0.185	2.1	0
0.352	3.5	3
0.584	7	9
1.005	7	14
1.424	14	12
2.366	14	17
3.665	7	5
4.642	7	6
6.251	3.5	1
7.815	2.1	1
9.873	0.7	0
11.341	0.7	1

The agreement with expectation is here reasonably good, and the difference  $\sqrt{2\chi^2} - \sqrt{2n-1}$  was found to be -1.11. We may, therefore, conclude that the plate method is satisfactory for the determination of the number of fungus spores capable of growing on agar. But it is evident that, if we want to estimate the importance of fungi versus other microorganisms in biochemical soil processes, the plate counts may not be of much help, since the metabolic processes will presumably be carried out by the vegetative mycelia and not by resting spores which may be present in vast numbers in soil to which organic matter has been added. Here the determination of the density of mycelium by the microscopic method promises to be of value, particularly since this method has, in comparison with McLennan's (1928) method for distinguishing between spores and mycelium, the advantage of showing the presence of mycelia incapable of growth in artificial media although possibly capable of producing biochemical changes. A tentative

\* Four parallel plates in each set.

experiment may be quoted: a "synthetic soil" was made up from 80% pure sand, 18.5% pure kaolin, 1% calcium carbonate, and 0.5% ferric oxide; to this mixture were added 1% hay meal and 11.5% water. Three series of experiments were run: at room temperature (16-19° C.), at 28° C., and at 38° C. The production of carbon dioxide was determined daily,\* and plate counts of bacteria, actinomycetes and fungi as well as estimations of the density of fungal mycelium on microscopic slides were carried out after 4, 8 and 14 days. The results, shown in Text-figure 2 and Table 3, agree well with those previously obtained. The numbers of bacteria and actinomycetes are higher at room temperature, and particularly at 28° C. than at 38° C., and the ratio actinomycetes:bacteria becomes narrower with increasing temperature (Table 3). The development of mycelium, which reaches its maximum by the fourth day, approximately coinciding with a maximum in the production of carbon dioxide, remains considerable at room temperature, but decreases rapidly at the two higher temperatures. While the numbers of bacteria plus actinomycetes and the densities of mycelium show a fairly definite correlation with the carbon dioxide formation, the plate counts of fungi (Table 3) merely show figures increasing steeply with both the time and the temperature, due to production of spores (particularly of *Asp. fumigatus* at 38° C.) and entirely uncorrelated with the rate of carbon dioxide formation. It is noteworthy that the increased carbon dioxide production at 38° C. is not brought about by an increased number of microorganisms; other experiments with direct microscopic counting of the bacteria, to be described later, have given similar results.

TABLE 3.

*Numbers of Fungi and Ratios of Actinomycetes to Bacteria in Sand-Kaolin-Mixture plus Hay Meal.*

Incubation Period.	16-19° C.		28° C.		38° C.	
	Fungi.*	Ratio A : B.	Fungi.*	Ratio A : B.	Fungi.*	Ratio A : B.
4 days .. ..	474	0.0041	2,281	0.0394	5,010	0.147
8 " .. ..	1,339	0.0252	3,692	0.0734	38,670	0.249
14 " .. ..	3,213	0.092	6,313	0.0973	44,420	0.262

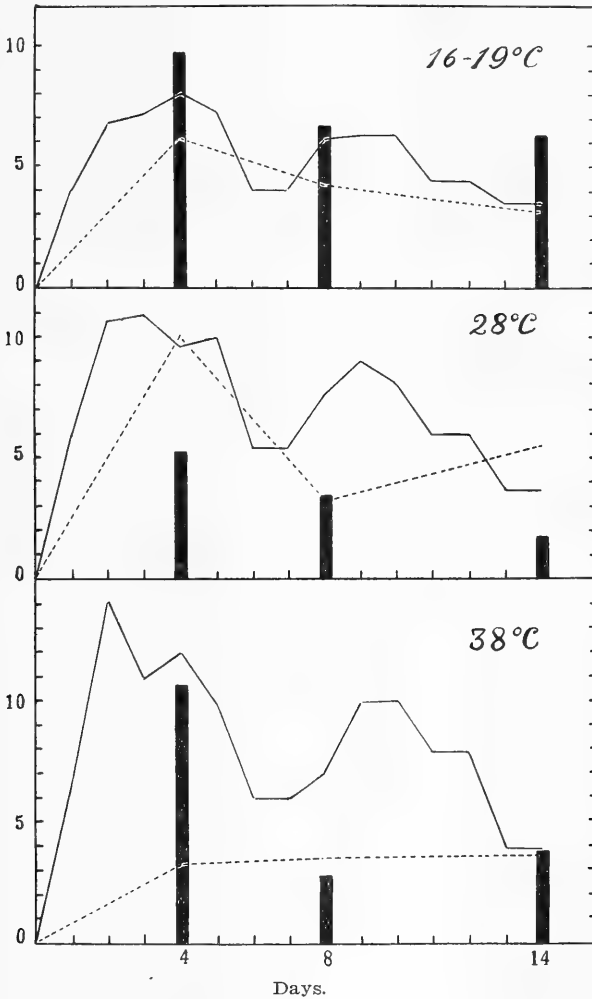
\* Thousands per gram of dry "soil".

#### *Summary.*

The influence of different kinds of organic material, mostly hay meal, on the microorganisms of various soils was studied at temperatures from about 16° to about 40° C. and at varying degrees of moisture. The multiplication of bacteria, as determined by plate counting, was found generally to be strongest at the lower temperatures, but the reverse applied to the actinomycetes. The ratio of actinomycetes was narrowest at high temperature and low moisture. A quantitative estimate of the vegetative development of fungi was obtained by determining the percentage of microscopic fields showing the presence of fungal hyphae on microscopic slides placed in the soil, according to the method of Rossi and Cholodny. By this method it was found that the fungi generally

\* The arrangement of these experiments and the method of carbon dioxide determination will be described in detail in a subsequent paper.

attain their most abundant vegetative development at 16-21° C., and that high plate counts of fungi at higher temperatures are merely due to an abundant production of spores. The method of plate counting, as applied to fungi, seems satisfactory only for the determination of the number of fungal spores in the soil. The figures for the density of mycelium, obtained by the microscopic



Text-figure 2.—Correlation between carbon dioxide production, density of fungal mycelium and numbers of bacteria plus actinomycetes in sand-kaolin-mixture plus hay meal.—Unbroken line: production of CO<sub>2</sub> in 24 hours; unit of scale: 10 mgm. CO<sub>2</sub> per 100 gm. dry material.—Dotted line: numbers of bacteria plus actinomycetes; unit of scale: 40 millions per gm. of dry material.—Black columns: density of fungal mycelium; unit of scale: 5 per cent. fields showing presence of hyphae.

method, as well as the plate-counted numbers of bacteria and actinomycetes, showed a correlation with the rate of carbon dioxide production.

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## NOTES ON AUSTRALIAN ORCHIDS.

A REVIEW OF THE SPECIES *DENDROBIUM TERETIFOLIUM* R. BR.

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

(Plate iv.)

[Read 29th May, 1935.]

Robert Brown's type form of *Dendrobium teretifolium* came from the Port Jackson area of New South Wales, where it may still be seen in secluded spots, clinging to the trunk or branches of the Swamp Oak (*Casuarina glauca*). A somewhat ungainly plant when not in bloom, the advent of early spring transforms it into one of the daintiest and most attractive of our epiphytes, with its perfumed wealth of feathery cream-white racemes. It extends southward at least as far as Mount Dromedary, while to the west a very distinctive form occurs in the Blue Mountains. Northward the species wanders far into the Queensland tropics; but I have been unable so far to trace the type form beyond the Richmond River, N.S.W. Several attempts have been made to classify the variations, but from various causes these have hardly been successful, and considerable irritating confusion has resulted. The present paper is an attempt to clarify the situation. I have had a wide experience, in the field, of the type form since 1909, and of the form here recognized as var. *Fairfaxii* (Fitzg. & v.M.) Benth. since 1923: of the two other forms dealt with, I have received ample material from correspondents, and have had plants under cultivation.

It has been suggested that where variants in a species are themselves variable—as is the case in *D. teretifolium*—it is better to include them all under one comprehensive description of the species, rather than attempt to define somewhat elusive variations. To this I would reply that (1) any description of *D. teretifolium* which could be framed to include even the outstanding variations from the type, would be extremely cumbersome and involved; (2) there are certain variants which differ in some of their characteristics so markedly from the type that they surely merit varietal recognition. One of these, indeed, was described by R. D. Fitzgerald and Baron von Mueller as a new species, and were it not for the discovery of intermediates linking this with the type, *D. Fairfaxii* might still be considered specifically independent of *D. teretifolium*.

Bentham describes the labellum and column as follows: "Labellum about half as long as the sepals, lanceolate, canaliculate, acuminate and recurved, the lateral lobes very small, the disk dotted with red and bearing 3 undulate raised lines or plates. Column dotted with red." To this I should venture to add, after the word *acuminate*, "or filiform", and after the word *red* in both cases, "or purple". It has been attempted to distinguish one or two forms from the type by differences in the length of the labellum, and variations in the contour

of its margins and the colour of the raised lines. From my examination of very numerous specimens I am thoroughly convinced that these distinctions cannot be relied upon. Except in the case of the North Queensland plant, which appears to vary hardly at all, the different features of the labellum which have been recorded as characteristic of this or that form, are interchangeable between all the forms. This statement holds good for the column also. I have reached this conclusion only after the most careful and prolonged investigation.

In the *Sydney Mail* of September 21, 1872, a description was published of a *Dendrobium* discovered by R. D. Fitzgerald in the brush forests of Mount Tomah, Blue Mountains, N.S.W. The description was prepared by Baron von Mueller, and was accompanied by a woodcut by Fitzgerald. In compliment to the proprietor of the "Mail", the plant was named *D. Fairfaxii*. Unfortunately the description and the woodcut do not agree, and in the table of comparison between the new species and *D. teretifolium* it is quite impossible to reconcile certain of the statements as they appear, with the known facts: by some mischance, characteristics of the two forms were transposed. Fitzgerald's woodcut, however, accurately represents the new plant, which is now familiar to orchid students in New South Wales, and is by no means confined to the Blue Mountains. Bentham (*Fl. Aust.*, vi, 285) noted the discrepancy between woodcut and description. He reduced *D. Fairfaxii* to a form of *D. teretifolium*, and this decision was endorsed by Fitzgerald himself in Moore and Betche's "Handbook of the Flora of New South Wales".

The general appearance and habit of this form distinguish it so strikingly from the type that for a year or two after my first acquaintance with it I was strongly disposed to advocate its restoration to specific rank. But from 1924 to 1929 I had ample opportunity to study both the type and the variety in the Paterson and Allyn valleys of New South Wales. On the swamp oaks in open forest country, only the type form was found. The plants showed considerable variation in the dimensions of the flowers, length and colouring of the labellum, etc., but in no case was there any approach to the special characteristics I associated with var. *Fairfaxii*, which I had studied in brush forests at Bullahdelah, 60 miles away. In brushes along the Paterson and Allyn valleys, however, *Fairfaxii* was found in abundance, agreeing exactly with the Bullahdelah plants. Then, about the edges of the brushes, I began to find plants combining the features of both forms: in a few instances flowers of both kinds were borne on the same plant. I was steadily driven to the conclusion, which has been confirmed by subsequent investigation, that *Fairfaxii* is the brush-forest form of *D. teretifolium*. I have never seen or heard of the type form being found in a brush forest. I have never known *Fairfaxii* to occur in open country, except in a few instances where brushes had once existed, but had been cleared away.

The features which distinguish this variety from the type are as follow:

1. Leaves (in the adult plant) at least twice as numerous, often more: always very slender indeed, and flaccid: pale green unless exposed freely to direct sunlight.
2. Flowers either in pairs or solitary: occasionally in two pairs, or raceme with one pair and a solitary flower.
3. Petals and sepals hardly recurved, most commonly straight, but often slightly *incurving*.
4. Base of petals and sepals inside (and often outside) heavily striate with deep red-brown or purplish-brown.



These features in combination give the plant an appearance strikingly different from that of the type.

F. M. Bailey (*Queensland Flora*, v, 1534) describes another form under the name var. *aureum*, with flowers of a deep golden yellow. I can find no appreciable difference between this and the common yellowish-green form of southern Queensland and the extreme north coast of New South Wales, and I think they should be taken together. This variety is morphologically very close to *Fairfaxii*, but the leaves are not nearly so numerous and are often robust, and the perianth-segments are more spreading; while the very distinctive colouring—all other forms being white or pale cream—is almost sufficient of itself to justify Bailey's name.

On the same page Bailey records var. *Fairfaxii* for Queensland, but the description he gives is certainly not that of the plant figured by Fitzgerald and familiar to orchid collectors in New South Wales. I suggest that possibly he endeavoured to fit the North Queensland form of the species into the tabulation of *D. Fairfaxii* as it appears in Mueller's original description, although it is strange that he makes no allusion to the discrepancy between this and Fitzgerald's woodcut.

The North Queensland form is really the most distinctive of all. The arrangement and form of the racemes exhibit so marked a departure from the type that I found it difficult to accept the two as conspecific; but the individual flowers are morphologically identical. In the type, the racemes are scattered and divergent, and upon each raceme the flowers also (4 to 8) are very divergent, on long stalklets. In the North Queensland plant the racemes are occasionally solitary, but normally two to five are clustered together directly at the base of a leaf. The axis of the raceme is quite straight, with the flowers (4 to 15) arranged along it in the form of a spike, though shortly stalked. A raceme of this form, in fact, if detached from the plant, would almost certainly be taken at first glance to belong to *D. linguiforme* Swz., or *D. aemulum* R.Br. The leaves of the plant agree fairly with the type, but are often much more robust and longer, light green in colour. I propose for this form the varietal name *fasciculatum*, alluding to the clustered racemes.

All four forms are reported to produce occasionally plants with flowers twice as large as the usual size. I can confirm this in regard to the type, var. *Fairfaxii*, and var. *aureum*, but all flowers of the tropical form seen by me are slightly under the average.

I am indebted to the following for specimens and plants from various localities received over a period of several years: Mrs. H. Curtis, Tambourine Mountain, S. Queensland; Dr. H. Flecker and Messrs. W. F. Tierney and G. Bates, all of Cairns, N. Queensland; Mr. K. Macpherson, of Proserpine, N. Queensland; Mr. F. Fordham, Brunswick Heads, N.S.W. Mrs. C. A. Messmer, of Lindfield, N.S.W., kindly sent full details of the original description of *D. Fairfaxii*, and Dr. R. S. Rogers offered some criticism of the first draft of this paper which induced me to modify some of the remarks there made. An admirable photograph by Mr. W. H. Nicholls of a raceme of var. *fasciculatum* proved very useful for purposes of comparison.

DENDROBIUM TERETIFOLIUM R.Br., var. FASCICULATUM, n. var.

Folia saepe robustissima, 5-60 cm. longa. Racemi fere spicati, plerumque 2-5 ad folii basem fasciculati. Flores 4-15, albi.—Tropical Queensland.

Key to the Determination of the Four Forms of *D. teretifolium* Recognized in this Paper.

Labellum and column varying in all forms approximately as indicated in the text. Length of perianth-segments very variable in all.

Type.	Var. <i>Fairfaxii</i> .	Var. <i>aureum</i> .	Var. <i>fasciculatum</i> .
Leaves few or numerous, 8-35 cm. long, average diameter 4-5 mm., dull green or purplish-brown, relatively rigid.	Leaves usually very numerous, up to 60 cm. long, very slender, light green or, in exposed situations, purplish-brown, flaccid.	Leaves variable, often as in v. <i>Fairfaxii</i> , but sometimes very robust.	Leaves sometimes more robust and longer than in any other form; never as slender or flaccid as in v. <i>Fairfaxii</i> , pale green.
Racemes 6-10 cm. long, the axis often branching and never quite straight; 1 to 4 (usually 3 or 4) divaricate near the base of a leaf.	Racemes 2-5 cm. long, axis as in the type; 1 or 2 near the base of a leaf.	Racemes as in the type or as in v. <i>Fairfaxii</i> .	Racemes pale, rather more robust, 5-8 cm. long, axis straight and unbranched; 1 to 4 or 5 clustered at the base of a leaf.
Buds green.	Buds green or brown.	Buds green or brown.	Buds white.
Flowers 4 to 9, cream to white.	Flowers 1 to 4, most frequently in pairs, usually white, occasionally cream.	Flowers 1 to 6 or 7, deep-golden-yellow or yellowish-green.	Flowers 4 to 15, very pure white.
Perianth-segments inside near the base spotted or streaked with red or purple, prominently recurved, especially the paired sepals.	Perianth-segments inside (and often outside) near the base striate with deep red-brown, hardly recurved but often slightly incurved.	Perianth-segments striate as in v. <i>Fairfaxii</i> , sometimes recurved.	Perianth-segments often without any markings, or with light streaks of purple, only slightly recurved.

#### NEW RECORDS.

*Sarcochilus spathulatus* Rogers.—This species was discovered by Mrs. H. Curtis on Tambourine Mountain, Q., in 1925, and by myself a few days later in the foothills of Barrington Tops, N.S.W. It was not recorded again for nine years, and was supposed to be rare. In October, 1934, I visited the Bellingen Valley in the north coast district, N.S.W., and the adjacent Dorrigo highlands. Mrs. D. J. Barr of Bellingen found *S. spathulatus* in a ravine 12 miles north of the town, and subsequently we collected it in abundance on the Dorrigo Mountain Cutting and in brush forests of the Dorrigo area, where it is quite common.

*Thelymitra chasmogama* Rogers.—This beautiful red *Thelymitra*, a recent discovery in South Australia, was found by Mr. M. W. Nicholls at Kurri Kurri, N.S.W., in Sept., 1934, the determination being endorsed by Dr. Rogers. It is allied to *T. luteociliata* Fitzg., but is larger, and the column is different. This is quite a notable addition to the orchids of the South Maitland coalfields, to which Mr. Nicholls has further added *Pterostylis grandiflora* R.Br.

#### EXPLANATION OF PLATE IV.

1.—*D. teretifolium*, type form, Woy Woy, N.S.W. The arrangement of the flowers is so divaricate that in a close-up picture focussing is very difficult.

2.—Var. *Fairfaxii*, Paterson, N.S.W.

3.—Var. *aureum*, yellowish-green form, Tambourine Mountain, S. Queensland.

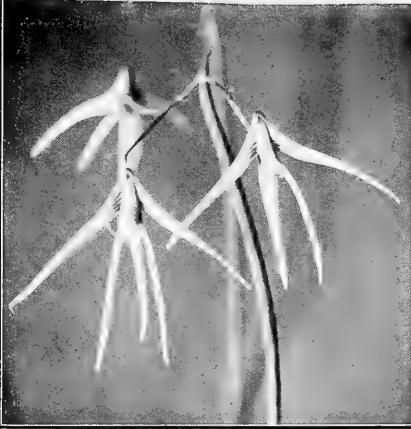
4.—Var. *fasciculatum*, Cairns, N. Queensland.



1



4



2



3

*Dendrobium teretifolium*: 1, type; 2, var. *Fairfaxii*; 3, var. *aureum*; 4, var. *fasciculatum*.



## AN INVESTIGATION OF THE SOOTY MOULDS OF NEW SOUTH WALES. IV.

### THE SPECIES OF THE EUCAPNODIEAE.

By LILIAN FRASER, M.Sc., Linnean Macleay Fellow of the Society in Botany.  
(Ninety-one Text-figures.)

[Read 29th May, 1935.]

When this investigation was commenced the number of authentic species of the Capnodiaceae known to occur in New South Wales was four (Fraser, 1933). In this and the following paper fourteen new species and varieties are described, and emended descriptions are given of a number of incompletely known types. Theissen and Sydow (1917) divided the family Capnodiaceae into sub-sections, the Eucapnodieae and the Chaetothyriaceae. The present paper deals with the species of the Eucapnodieae.

All the fungi belonging to this section produce some kind of pycnidial fruit. A difficulty encountered in the descriptions of the species was the correlation of the pycnidia with the proper ascogenous fructifications. In the past many species have been described as having a number of different kinds of pycnidial fruits, as well as conidia of various types such as *Triposporium* and *Helminthosporium*. It is now generally realized that only one kind of pycnidial fruit is produced by any member of the Capnodiaceae, and that the different types of conidia are produced by members of the Fungi Imperfecti growing in association with it. In many cases several species of *Capnodium* may grow together in the one sooty mould, and pure culture methods are necessary to establish their relationships.

Cultures have been made from all the types of fructifications herein described, and the pycnidia and ascostromata were correlated only after they had been proved culturally to have been produced by the same fungus.

Ascospore cultures were obtained by crushing the ascostromata and picking out the ascospores by means of a dry needle. The pycnidia were kept in a damp atmosphere, e.g. in a petri dish with a few drops of water on the bottom. The mucilage in the pycnidia then absorbed water and swelled, bulging out the mouth of the pycnidium and carrying with it a number of spores. This clear drop of mucilage hung at the apex of the pycnidium and was readily picked off with a sterile needle.

When the mycelium of the sooty mould is very distinctive, as in *Capnodium elegans* and *C. moniliforme*, the need for culturally relating the different fructifications does not arise.

#### CAPNODIUM SALICINUM Mont.

*Ann. Sci. Nat.*, 3rd Sér., xi, p. 233, 1849.

Evidence has been advanced in a previous paper to show that the generic name *Capnodium* should not be superseded by *Teichospora* as maintained by Arnaud (1910) and Gaumann (1928).

In New South Wales the typical form produces 4-celled brown pycnidiospores (rarely 2- or 7-celled), which are  $12-18 \times 5-9\mu$ , the average size being  $15 \times 8\mu$ . These pycnidiospores resemble the ascospores to a certain extent (Text-fig. 1).

The ascospores are often slightly constricted at the middle septum (Text-fig. 2). The ascostromata may be shortly stalked or almost sessile, the length evidently depending on the environmental conditions. An interesting variant (Text-fig. 2a and b) collected at Nowra developed stalks up to  $250\mu$  long, but was otherwise typical.

*C. callitris* McAlp. (McAlpine, 1896b) differs from typical *C. salicinum* only in the pycnidiospores which are 5-septate, and the ascospores which are markedly constricted at the middle septum. The ascostroma is described as being sessile. These features, however, do not appear to be sufficient to separate it specifically from *Capnodium salicinum*, since 5-septate pycnidiospores are not infrequent in this species, and the shape of the ascospores differs considerably in collections made from different localities. Owing to the kindness of Mr. C. French, of the Department of Agriculture, Victoria, the writer was able to examine specimens of *Capnodium callitris* determined by McAlpine, and could find no significant differences between it and *C. salicinum*. It is therefore desirable that *C. callitris* McAlp. be considered a synonym of *C. salicinum* Mont.

*Capnodium salicinum* has been found in collections from the following localities: Pennant Hills (near Sydney) on *Pittosporum undulatum* Ait., 5, 1932, on *Bursaria spinosa* Cav., 5, 1932, and on *Castanospermum australe* A. Cunn., 9, 1933; Springwood on *Leptospermum flavescens* Sm., 11, 1932; Burratorang Valley on *Leptospermum flavescens* Sm., 11, 1932; Glenorie on *Bursaria spinosa* Cav., 5, 1932; Narrabeen on *Casuarina glauca* Sieb., 11, 1932; Nowra on *Syncarpia laurifolia* Ten., 2, 1933; Mt. Kosciusko on *Epacris* sp., 1, 1934, coll. J. McLuckie.

#### CAPNODIUM SALICINUM VAR. UNISEPTATUM L. FRASER.

This variety has been described in a previous paper (Fraser, 1935). It differs from the type in the larger pycnidia (Text-fig. 3), the 2-celled hyaline pycnidiospores (Text-fig. 4), in the more compact nature of the ascostromata (Text-fig. 5), and in its cultural behaviour. It is a well marked and widely distributed form, and is common around Sydney on *Bursaria spinosa*, *Pittosporum undulatum*, *Leptospermum* spp., etc.

McAlpine (1896a) has described pycnidia and pycnidiospores similar to those of *C. salicinum* var. *uniseptatum* in connection with *C. citricolum*. Miss Fisher (1932) has recently shown that *C. citricolum* is, in part, *C. salicinum*. The imperfect fructifications described by McAlpine are produced by a number of different fungi (Fraser, 1933).

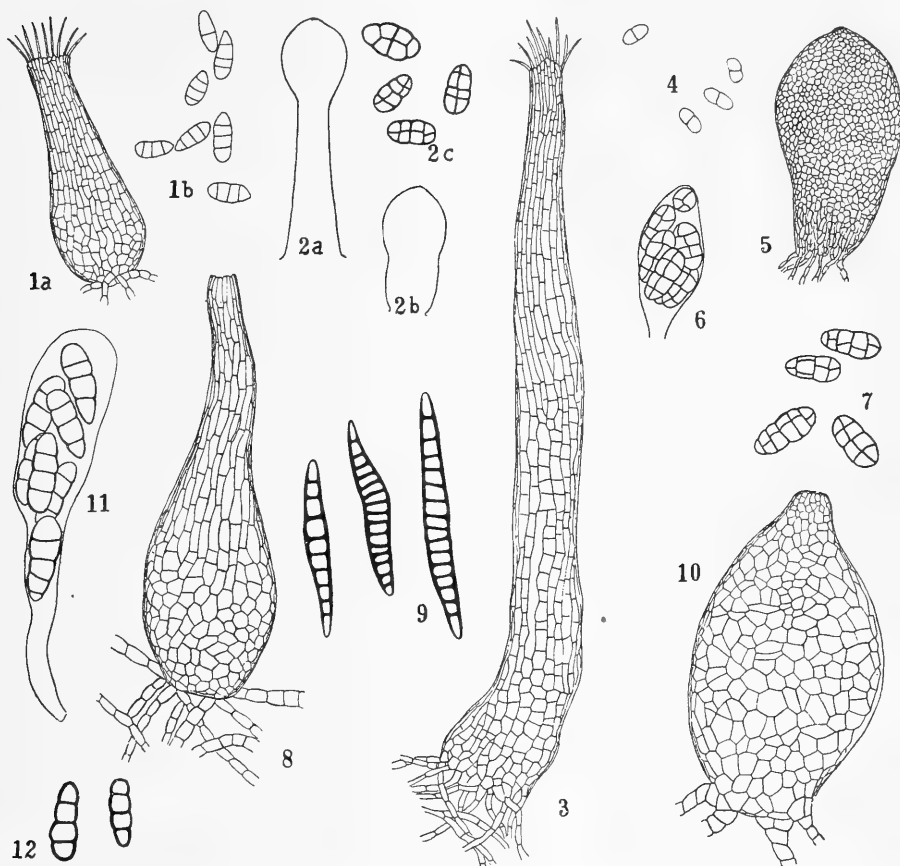
*Capnodium salicinum* var. *uniseptatum* has been found in collections from the following localities: Pennant Hills on *Spartium* sp., 6, 1932, Type; Macquarie Pass on *Palmeria scandens* F.v.M., 4, 1933; Huskisson on *Casuarina glauca* Sieb., 2, 1933; Narrabeen on *Leptospermum flavescens* Sm., *Synoum glandulosum* A. Juss., and *Casuarina glauca* Sieb., 1, 1934; Comboyne on *Doryphora sassafras* Endl., 1, 1934; Bateman's Bay on *Casuarina glauca* Sieb., 2, 1933; Dungog on *Eugenia Ventenatii* Benth., 5, 1934; Warialda on *Jacksonia scoparia* R.Br., 1, 1932, coll. J. Vickery; Gosford on *Melaleuca* sp., 1, 1934; Brisbane, Queensland, on *Brassaea* sp., and *Artocarpus* sp., 5, 1934, coll. A. Burges.

#### CAPNODIUM WALTERI Sacc. Emended description.

*Hedwigia*, 1893, p. 58.

Mycelium dark clear brown, usually rather thick and felt-like and black in mass. Hyphae often beaded, the cells constricted at the septa,  $5.5-10\mu$  long by  $5-9\mu$  wide, rounded, smooth.

Pycnidia usually rather numerous, with swollen basal portion and elongated neck, 110–230 $\mu$ , exceptionally 500 $\mu$ , long by 50–60 $\mu$ , exceptionally 100 $\mu$ , wide at the base, tapering to 10–20 $\mu$  wide at the apex (Text-fig. 8). The pycnidiospores are elongate-fusiform, often curved, tapering towards each end, brown, thick-walled, 20–42  $\times$  7–9 $\mu$ , with 7–13 transverse septa (Text-fig. 9).



1-2.—*Capnodium salicinum*. 1a, Pycnidium and mycelium.  $\times$  150. 1b, Pycnidiospores.  $\times$  425. 2a, 2b, Ascostromata, showing long stalks.  $\times$  80. 2c, Ascospores.  $\times$  425.

3-7.—*Capnodium salicinum* var. *uniseptatum*. 3, Pycnidium and mycelium.  $\times$  150. 4, Pycnidiospores.  $\times$  425. 5, Ascostroma.  $\times$  150. 6, A single ascus.  $\times$  425. 7, Ascospores showing septation.  $\times$  425.

8-12.—*Capnodium Walteri*. 8, Pycnidium and mycelium.  $\times$  285. 9, Pycnidiospores.  $\times$  425. 10, Ascostroma.  $\times$  285. 11, A single ascus.  $\times$  425. 12, Ascospores showing septation.  $\times$  425.

The ascostromata are 70–100 $\mu$  wide by 100–130 $\mu$  long, sometimes shortly stalked (Text-fig. 10), globular or slightly elongated, the apex rounded or slightly papillate. The wall cells are isodiametrical, smaller towards the apex, clear brown. An apical pore develops at maturity. The asci are clavate, 50–60  $\times$  10–15 $\mu$ , 8-spored. The spores are arranged irregularly in the ascus (Text-fig. 11).

The ascospores are brown, thick-walled,  $22-26 \times 7-9\mu$ , with three, or rarely four, transverse septa, slightly constricted at the septa, especially the median one, slipper-shaped, the upper half rather wider and more rounded than the lower half (Text-fig. 12).

The pycnidia have been figured by Miss Fisher (1932) under the name *Hendersoniella*. The ascostromata described by her as *Limacinia crassa* also belong to this fungus.

Saccardo's description of *C. Walteri* (1893) shows several errors: (1) The pycnidiospores are described as conidia and figured attached to the mycelium in an upright position. These spores are quite characteristic and unlike any others produced by sooty mould fungi. It is probable that the spore figured by Saccardo was germinating. (2) The pycnidia described by Saccardo belong to a different fungus, probably that described by Miss Fisher as *Microzyphium Leptospermi*. These pycnidia have been frequently found associated with *Capnodium Walteri* in New South Wales. (3) The ascostromata are not of typical shape, being figured with elongated necks. Miss Fisher considers that these represent the pycnidia of *Capnodium salicinum*, but this cannot be, since asci and ascospores are figured and described by Saccardo. Moreover, these ascospores are distinctly larger than the typical pycnidiospores of *C. salicinum*. It is probable that the specimens seen by Saccardo were rather aberrant in shape. Specimens somewhat resembling those figured by him, in which the apex is distinctly papillate, have been observed by the writer.

*Capnodium Walteri* has been found in collections from the following localities: Wyong on *Callistemon salignus* D.C., 5, 1934; Huskisson on *Bursaria spinosa* Cav., 2, 1933; Narrabeen on *Casuarina glauca* Sieb., 11, 1933; Gosford on *Melaleuca* sp., and *Leptospermum flavescens* Sm., 1, 1934; Springwood on *Leptospermum flavescens*, Sm., 8, 1932; National Park on *Ratonia* sp., 10, 1932; Nowra on *Epacris* sp., 2, 1933; Bulli on *Alphitonia excelsa* Reiss., 4, 1933; Barrington Tops on *Callistemon pallidus* D.C., 5, 1933; Picton on *Bursaria spinosa* Cav., 1, 1933; Comboyne on *Doryphora sassafras* Endl., 1, 1934. It is common around Sydney on *Bursaria spinosa*, *Leptospermum* spp., *Pittosporum undulatum*, *Eugenia Smithii*, etc.

#### CAPNODIUM FULIGINODES Rehm.

The mycelium is dark brown and felt-like, the cells cylindrical or slightly constricted at the septa,  $4-5 \times 4-7\mu$ .

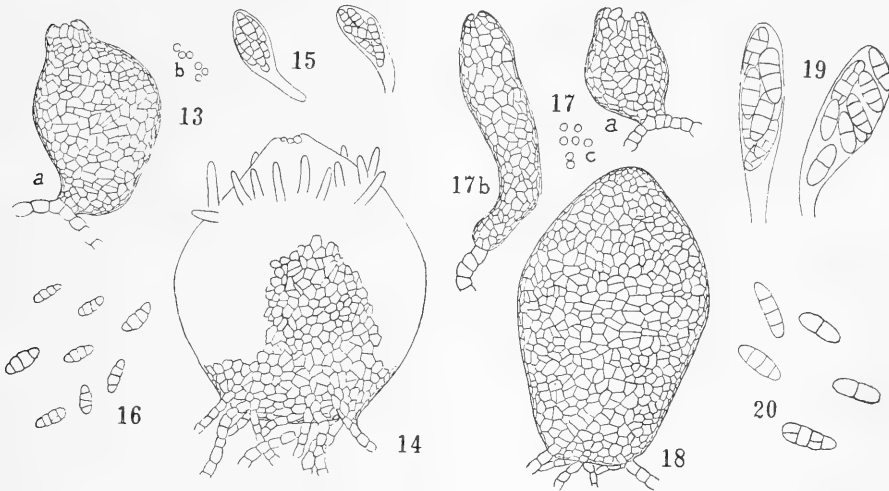
The pycnidia are globose or pear-shaped,  $50-70 \times 35-50\mu$ , slightly papillate at the apex (Text-fig. 13a). The wall of the pycnidium is pseudoparenchymatous and consists of light brown isodiametrical cells. This type of pycnidium is usually referred to as *Antennularia*. The pycnidia referred to as *Chaetophoma* by Miss Fisher (1932) are similar to these and probably belong to the same fungus. The pycnidiospores are hyaline, globose, 1-celled,  $1-1.2\mu$  diameter (Text-fig. 13b).

The ascostromata are very dark brown, globose or slightly elongated, sessile or very shortly stalked,  $70-100\mu$  in diameter by  $80-150\mu$  in length, typically  $80 \times 100\mu$  (Text-fig. 14). A number of dark, 1- or 2-celled spines are frequently present on the upper part of the fructification. These are  $10-40\mu$  long and  $1.5\mu$  in diameter at the base, slightly attenuated towards the apex which is rounded. They are, however, not always present even on all the fructifications of a single collection. The apex of the stroma is rounded, and a pore develops at the



summit at maturity. The wall is pseudoparenchymatous, consisting of brown isodiametrical cells which become smaller towards the apex.

The asci are clavate or slightly swollen at the apex, numerous, shortly stalked,  $30-35 \times 10\mu$ , 8-spored. The ascospores are brown, irregularly grouped in the ascus, fairly thin walled, 3-septate with an occasional longitudinal septum, fusiform, tapering slightly towards each end, scarcely constricted at the septa,  $10-12 \times 3.5-5\mu$ .



13-16.—*Capnodium fuliginodes*. 13a, Pycnidium and mycelium.  $\times 425$ . 13b, Pycnidiospores.  $\times 425$ . 14, Ascostroma showing setae.  $\times 425$ . 15, Asci.  $\times 425$ . 16, Ascospores showing septation.  $\times 425$ .

17-20.—*Capnodium fuliginodes* var. *grandisporum*. 17a, 17b, Pycnidia showing different forms.  $\times 285$ . 17c, Pycnidiospores.  $\times 425$ . 18, Ascostroma.  $\times 285$ . 19, Asci.  $\times 425$ . 20, Ascospores showing septation.  $\times 425$ .

This fungus has been referred to the species *Capnodium fuliginodes* by Miss Fisher, and her determination is followed here. Arnaud considered that *C. fuliginodes* was synonymous with *C. mori*.

The ascostromata are frequently shortly stalked; the species therefore should be placed in the genus *Capnodium*, not in the genus *Limacinia* (Arnaud, 1911). In a previous paper this fungus was referred to provisionally as *Antennularia scoriadea*. In a later paper on the cultural behaviour of the sooty moulds (1934) it was referred to as *Capnodium* sp.

*Capnodium fuliginodes* has been found in collections from the following localities: Comboyne on *Denhamia pittosporoides* F.v.M., 1, 1934; Yerranderie district on *Leptospermum flavescens* Sm., 10, 1933; Athol (Sydney District) on *Leptospermum flavescens* Sm., 5, 1932; Narrabeen on *Leptospermum flavescens* Sm., 11, 1933; Picton on *Bursaria spinosa* Cav., 1, 1933; Robertson on *Doryphora sassafras* Endl., 2, 1933; Pennant Hills (Sydney district) on *Bursaria spinosa* Cav., and *Pittosporum undulatum* Ait., 5, 1933; Tambourine Mountain, Queensland, on *Baccharis halimifolia* L., 5, 1934, coll. A. Burges; Brisbane, Queensland, on *Artocarpus* sp., 5, 1934, coll. A. Burges.

## CAPNODIUM FULIGINODES var. GRANDISPORUM, n. var.

Mycelio epiphylo. Cellulis subcylindricis, ad septa vix constrictis,  $4-5 \times 4-7\mu$ . Pycnidii globosis vel ovoideis, ad apicem papillatis, fuscis,  $35-50 \times 50-100\mu$ . Pycnidiosporis hyalinis, continuis, globosis,  $1.7-2\mu$  crassis. Ascostromis globosis vel ovoideis, ad apicem rotundatis, atrofuscis. Ascis clavatis vel ad apicem inflatis, octosporis. Ascosporis aggregatis, fuscis, ellipsoideis, medio inflatis, 3-septatis, vix constrictis, raro 1-2-septatis, raro 1-2-longitudinaliter septatis.

The mycelium and pycnidia closely resemble those of *C. fuliginodes*. The pycnidia are somewhat more variable in shape,  $35 \times 50\mu-50 \times 100\mu$ . The commonest types are spherical or pear-shaped, but elongated forms may also occur (Text-figs. 17a, 17b). The pycnidiospores are slightly but consistently larger than those of *C. fuliginodes*. They are hyaline, 1-celled, globose,  $1.7-2\mu$  in diameter (Text-fig. 17c).

The ascostromata are ovoid, dark brown, rounded at the apex, glabrous; the wall is pseudoparenchymatous, consisting of isodiametrical cells becoming smaller towards the apex where a pore develops at maturity,  $75-100 \times 100-140\mu$ , sessile or very shortly stalked (Text-fig. 18).

The asci are clavate, rather narrow, 8-spored (Text-fig. 19). The ascospores are similar in shape and colour to those of *C. fuliginodes*, but are distinctly larger. They are brown, rather thin walled, fusoid,  $13-19 \times 4.5-5.5\mu$ , usually  $15 \times 5\mu$ . They are typically transversely 3-septate, rarely with one or more longitudinal walls, but may be occasionally only 1-septate, not constricted at the septa (Text-fig. 20).

This form retains its differences from *C. fuliginodes* in culture, and appears to be quite constant. It does not appear to be so common as *C. fuliginodes*.

*Capnodium fuliginodes* var. *grandisporum* has been found in collections from the following localities: Pennant Hills (Sydney district) on *Eucalyptus eugenioides* Sieb., [Type], and *Pittosporum undulatum* Ait., 8, 1933; Glenorie on *Angophora lanceolata* Cav., 5, 1932; Glenbrook on *Leptospermum flavescens* Sm., 1, 1933; Wiseman's Ferry on *Leptospermum lanigerum* Sm., 11, 1934.

## CAPNODIUM ANONAE Pat.

*Bull. Soc. Myc. Fr.*, xx, 1904, pp. 134-138.

The mycelium is dark brown, often rather thick and felt-like. The cells are cylindrical, clear brown, smooth, slightly constricted at the septa,  $4-5\mu$  wide by  $6-10\mu$  long.

The pycnidia are identical with those described by Miss Fisher (1932) under the name *Microzyphium Leptospermi*. They are very variable in size, ranging from  $100\mu$  to  $1,000\mu$  in length, by  $20\mu$  to  $45\mu$  in diameter (Text-fig. 25). The spores are hyaline, continuous, elliptical,  $4.5-5 \times 1.5-2\mu$ .

The ascostromata are very rarely developed. They are ovoid, rounded at the apex where a pore develops at maturity, shortly stalked,  $100-150 \times 150-250\mu$ , the stalk being  $50-150\mu$  long (Text-fig. 26). The wall is composed of isodiametrical cells becoming smaller towards the apex, olive-green in colour. The asci are clavate and average  $60 \times 20\mu$ . They are 8-spored.

The ascospores are arranged irregularly in the ascus. They are olive-brown at maturity, with 5 or 6 transverse septa and one or more longitudinal septa, slightly constricted at the median septum, slightly narrower and more pointed in the lower part, usually  $25 \times 10\mu$ , but varying from  $23-35 \times 7-12\mu$  (Text-fig. 27).

*Capnodium anonae* has been found in collections from the following localities: Huskisson on *Hakea pugioniformis* Cav., and *Leptospermum flavescens* Sm., 2,

1933; Bateman's Bay on *Casuarina glauca* Sieb., 2, 1933; Picton on *Leptospermum flavescens* Sm., and *Bursaria spinosa* Cav., 1, 1933; Moss Vale on *Doryphora sassafras* Endl., 10, 1932, coll. T. G. B. Osborn; Comboyne on *Doryphora sassafras* Endl., 1, 1934; Bemboka on *Bursaria spinosa* Cav., 2, 1933; Bega on *Bursaria spinosa* Cav., 2, 1933; Port Macquarie on *Leptospermum flavescens* Sm., 1, 1934; Salisbury on *Eugenia Smithii* Poir., 8, 1933; Robertson on *Doryphora sassafras* Endl., 3, 1933; Wyong on *Callistemon salignus* D.C., 5, 1934; Narrabeen on *Synoum glandulosum* A. Juss., *Leptospermum flavescens* Sm., and *Casuarina glauca* Sieb., 10, 1933; Springwood on *Leptospermum flavescens* Sm., 8, 1932; Gosford on *Melaleuca* sp., 1, 1934; Dungog on *Eugenia Ventenatii* Benth., 5, 1934; Tambourine Mountain, Queensland, on *Psychotria loniceroides* Sieb., 5, 1934, coll. A. Burges; Tweed River district on *Croton Verreauxii* Bail., 5, 1934, coll. A. Burges; Brisbane, Queensland, on *Aegiceras majus* Gaertn., 5, 1934, coll. A. Burges; Wiseman's Ferry on *Cassinia aculeata* R.Br., 11, 1934. It is common in New South Wales, frequently growing in association with *Capnodium Walteri*.

CAPNODIUM ANONAE VAR. OBSCURUM, n. var.

Mycelio epiphylo. Cellulis subfuscis, ad septa constrictis, vel cylindricis. Pycnidiiis elongatis, rectis, 100–150 $\mu$  longis, 35–40 $\mu$  crassis, olivaceo-fuscis. Pycnidiosporis hyalinis, continuis, ovoideis, 5 $\times$ 1.5–2 $\mu$ . Ascstromis globosis vel ellipsoideis, breviter stipitatis, ad apicem obtusis, glabris, olivaceo-fuscis, 85–105 $\times$ 150–200 $\mu$ . Ascis clavatis, ad basem attenuatis, 50–60 $\times$ 18–25 $\mu$ , octosporis. Ascosporis primo hyalinis dein virido-fuscis, 5–6-septatis, medio constrictis, 1–4-longitudinaliter septatis, ellipsoideis, 20–26 $\times$ 8–10 $\mu$ , saepe 23 $\times$ 9 $\mu$ .

The mycelium is dark brown, cottony, often thick and felt-like. The cells are brown, smooth, slightly constricted at the septa, 4–5.5 $\mu$  wide by 5.5–10 $\mu$  long, very similar to the preceding species.

The pycnidia closely resemble those of *Capnodium anonae*, from which they can sometimes only be distinguished by cultural methods. They are usually rather shorter and stouter than the typical *C. anonae*, and the wall is composed of more isodiametrical cells. They are olive-brown or greenish, usually 100–150 $\times$ 35–40 $\mu$ , the apex is rather wide, surrounded by slightly incurved hyphae which are free from one another for a short distance (Text-figs. 21a, 21b). Larger branching forms may attain a length of 400 $\mu$ , but never approach the size of the larger specimens of *C. anonae* (Text-fig. 22). Under certain conditions abnormally stout pycnidia may be developed (Text-fig. 21c); in other cases forms closely resembling certain types of pycnidia produced by *Capnodium fuliginodes* may occur. The pycnidiospores are hyaline, continuous, ovoid, 5 $\times$ 1.5–2 $\mu$ .

The ascostromata resemble those of *Capnodium anonae* very closely in colour and shape, but are usually slightly smaller. They are globose or elliptical, glabrous, 85–105 $\times$ 150–200 $\mu$ , and shortly stalked (Text-fig. 23). The apex is rounded. The wall consists of isodiametrical cells which appear bright greenish-brown by transmitted light. The asci are clavate, 50–60 $\times$ 18–25 $\mu$ , 4-, 6- or 8-spored. The ascospores are hyaline at first, becoming olive-green. They have 5, or occasionally 6, transverse septa and are often strongly constricted at the median septum, frequently tapering towards the base, 20–26 $\times$ 8–10 $\mu$ , usually 23 $\times$ 9 $\mu$  (Text-fig. 24).

This variety shows constant cultural differences from *C. anonae*. In a previous paper on the cultural behaviour of Sooty Mould fungi it is referred to as *Microzophium* sp.

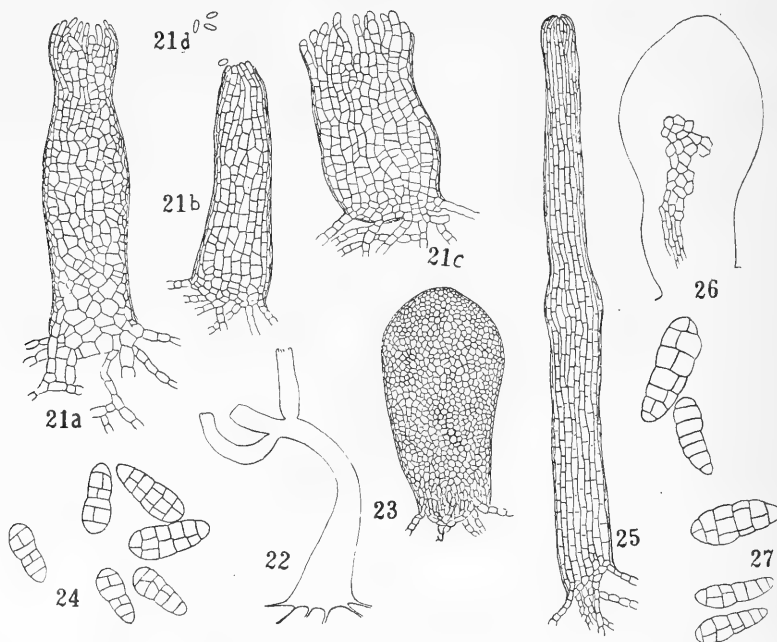
*Capnodium anonae* var. *obscurum* has been found in collections from the following localities: Narrabeen on *Synoum glandulosum* A. Juss., 1, 1933; Pennant Hills (Sydney district) on *Pittosporum undulatum* Ait., 5, 1933, and *Citrus* sp., 6, 1933; Macquarie Pass on *Palmeria scandens*, F.v.M., 2, 1933 (Type); Tweed River district on *Croton Verreauxii* Bail., 5, 1934, coll. A. Burges; Comboyne on *Doryphora sassafras* Endl., 1, 1934; Redlands Bay, Queensland, on *Artocarpus* sp., 5, 1934, coll. A. Burges; Tambourine Mountain, Queensland, on *Psychotria loniceroides* Sieb., 5, 1934, coll. A. Burges; Grafton district on *Eugenia australis* Wendl., 1, 1935.

CAPNODIUM MUCRONATUM Mont.

*Ann. Sci. Nat.*, sér. iv, xiv, 1860, pp. 167-185.

This species forms a very thick sooty covering on the twigs and leaves of plants. It usually develops a flat weft of mycelium from which erect fascicles of hyphae grow up. The fascicles are 2-15 mm. in length and consist of twelve or more parallel hyphae held together by anastomoses. Branches may be given off at the bases of these bundles of hyphae which connect neighbouring fascicles.

The young growing hyphae are olive-green, later becoming brown, with thick longitudinally striate walls when mature. The cells are cylindrical, scarcely constricted at the septa, 30-50 $\mu$  long by 10-15 $\mu$  wide. This mycelium is therefore very distinctive and can be recognized without difficulty. The shorter cells, e.g., of germ tubes or of the lateral branches of fascicles, may be almost beaded,

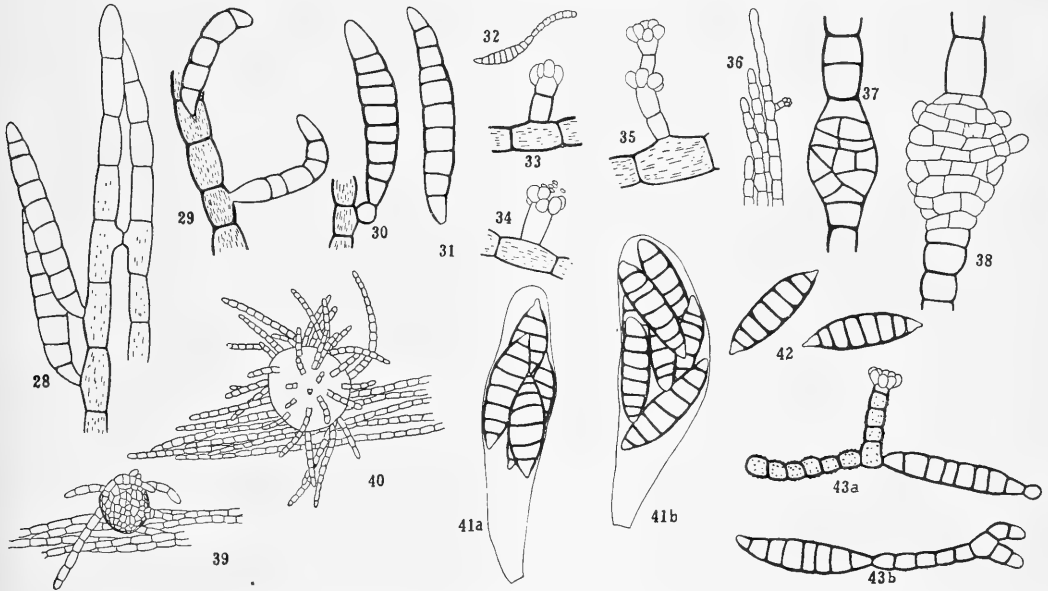


21-24.—*Capnodium anonae*, var. 21a, A typical pycnidium.  $\times 285$ . 21b, 21c, Other types of pycnidia.  $\times 285$ . 21d, Pycnidiospores.  $\times 425$ . 22, Pycnidium showing branching.  $\times 80$ . 23, Ascostroma.  $\times 150$ . 24, Ascospores showing septation.  $\times 425$ .

25-27.—*Capnodium anonae* Pat. 25, Pycnidium.  $\times 285$ . 26, Ascostroma.  $\times 285$ . 27, Ascospores showing septation.  $\times 425$ .

$15\mu$  long by  $10\mu$  in diameter, and the striations are short, giving a rugose appearance.

Conidia of two kinds are produced by this fungus: (1) Large transversely septate conidia are produced laterally by the outer cells of the upright fascicles (Text-figs. 28, 29, 30). These grow upwards parallel to the hyphae on which they are produced, and may be so numerous as to give the fascicles a furry appearance. When mature they are 7-9-septate, curved or straight,  $100-110 \times 20-25\mu$  (Text-fig. 31). The walls are clear olive-green, smooth or faintly longitudinally striate, thinner at the point of attachment than elsewhere. They are very easily dislodged when mature, and germinate directly (Text-fig. 32). (2) The basal outer hyphae of a fascicle or the free branches or occasionally the cells near the tips of old fascicles may produce short lateral branches of two or three cells which give rise to the second type of conidia. These lateral branches produce at the apex a ring of smaller thin-walled pale cells as shown in Text-figures 33 and 36, thus forming a shallow cup at the apex. Small hyaline thin-walled conidia,  $3 \times 1\mu$ , are then produced, apparently being budded off from the inner walls of the ring of hyaline cells (Text-fig. 34). These conidia were not observed to germinate. Occasionally the axis of one of these lateral branches may grow through the ring of cells and form a second ring above the first (Text-fig. 35).



28-43.—*Capnodium mucronatum*. 28, Part of the apex of a fascicle of hyphae showing anastomoses and attachment of conidia.  $\times 285$ . 29, 30, Hyphae showing the attachment of conidia.  $\times 285$ . 31, A mature conidium.  $\times 285$ . 32, A germinating conidium.  $\times 285$ . 33, A young lateral branch showing group of pale cells at the apex.  $\times 285$ . 34, Lateral branch showing conidia of the second type.  $\times 285$ . 35, A lateral branch showing further growth.  $\times 285$ . 36, Part of the apex of a fascicle of hyphae showing the position of a lateral branch which produces conidia of the second type.  $\times 100$ . 37-38, Stages in the development of the ascostroma.  $\times 285$ . 39, A young ascostroma showing the development of setae.  $\times 100$ . 40, A later stage in the development of the ascostroma.  $\times 55$ . 41a, 41b, Four- and eight-spored asci.  $\times 285$ . 42, Mature ascospores.  $\times 285$ . 43a, 43b, Germinating ascospores.  $\times 285$ .

Ascogenous fructifications are produced laterally on the young fascicles by the division of several adjoining cells of a single hypha (Text-fig. 37). Hypha-like appendages appear at an early stage (Text-fig. 38), becoming very numerous as the fructification approaches maturity (Text-figs. 39, 40). The mature fructification is  $350-400\mu$  in diameter and clearly visible macroscopically because of the numerous appendages. The cells of the wall are isodiametrical, brown, averaging  $20\mu$  in diameter. As far as could be seen no pore is developed, and the walls disintegrate at maturity, liberating the spores. The asci are clavate,  $110-130 \times 30-40\mu$ , 4- or 8-spored (Text-figs. 41a, 41b). The spores are fusiform, greenish-brown, the end cells being thinner and paler at the apices, which at maturity are slightly papillate (Text-fig. 42). They are transversely 7-septate,  $50-60 \times 15-18\mu$ . They germinate immediately after liberation, giving rise to a brown, rather rugose germ tube (Text-figs. 43a, 43b). Cases have been seen where conidia have been produced by short lateral branches on these germ tubes (Text-fig. 43a.)

This species has only previously been recorded by Montagne from Chili. Montagne described the characteristic fascicles of hyphae, the setose fructifications and the distinctive ascospores, but did not observe the conidia. It shows some resemblances to *Antennaria scoriadea* Berk. (J. D. Hooker, The Botany of the Antarctic Voyage, 1839-43, London, 1844, 1, p. 175), but differs in the ascigerous fructifications (von Hoehnel, 1909).

*Capnodium mucronatum* has been found in collections from the following localities: Salisbury on *Eugenia Smithii* Poir., and *Weinmannia rubifolia* Benth., 8, 1933, on *Eupomatia laurina* R.Br., 1, 1934, on *Cryptocarya microneura* Meiss., 8, 1934; Barrington Tops on *Callistemon pallidus* D.C., 1, 1934, 4, 1934; Comboyne on *Cryptocarya Meissneri*, F.v.M., 1, 1935; Mount Cook district, New Zealand, on *Podocarpus Hallii* T. Kirk., 1, 1933, coll. A. Burges.

CAPNODIUM MONILIFORME, n. sp.

Mycelio epiphylo. Cellulis moniliformibus, inflatis, saepe latioribus quam longibus, levibus, ad septa constrictis,  $10-15 \times 10-20\mu$ . Conidiis in brevibus ramulis ex 3-5 cellulis parvis, conidiis tantum uno lato ramuli latis, primo hyalinis, continuis, dein 1-septatis, fuscis, facile disiunctis. Conidiis maturis  $10-20 \times 7-10\mu$ , deorsum acutioribus, fuscis striatis. Pycnidii globosis vel ovoideis,  $20-30 \times 40-50\mu$ , apici papillatis. Pycnidiosporis hyalinis, continuis, ovoideis,  $5 \times 2.5-3\mu$ . Ascstromis oblongo-ovoides, subfuscis,  $150 \times 90-115\mu$ . Interdum circa apicem setulis divergentibus, 2-6-cellulis,  $20-40\mu$  longis,  $8\mu$  crassis ad basem. Ascis paucis, clavatis,  $65 \times 15\mu$ , octosporis. Ascosporis olivaceo-fuscis, 3-septatis, saepe curvatis, 3-4-stichis, vel conglobatis, ad septa vix constrictis, cellulis mediis inflatis,  $18-31.5 \times 9-11\mu$ , saepe  $21 \times 9\mu$ .

The mycelium forms a rather thick covering on the leaves and branches of plants. The hyphae are markedly beaded, the individual cells being much inflated and constricted at the septa,  $10-20\mu$  long by  $10-15\mu$  in diameter or occasionally larger when old. They are clear brown and smooth except when very old, when they may be slightly longitudinally striate (Text-figs. 44a, 44b).

Conidia are produced on short curved or straight terminal or lateral branches of 3 to 5 smaller cells (Text-fig. 45, a-c). These may occur singly (Text-fig. 45a) or in groups to form a small branch system (Text-fig. 47, which shows the branches after the shedding of the conidia). Conidia are budded off from one face only. They remain attached for some time forming botryoidal tufts (Text-fig. 46). The conidia are at first hyaline, then becoming light brown, and

finally thick-walled and very dark (Text-fig. 48). When mature they are very readily detached, 1-septate,  $10-20 \times 7-10\mu$ , the upper cell is rounded and broad, the lower cell narrower and pointed, and rather thin walled at the point of attachment.

Pycnidia are produced at a different time from the conidia, most frequently after they have fallen. They are of the *Antennularia* type, globose or pear-shaped, papillate at the apex,  $30-40 \times 40-50\mu$  (Text-fig. 49b). Occasionally more than one ostiole may be produced by the one pycnidium (Text-fig. 49c). The pycnidia are compound meristogenous in origin (Text-fig. 49a). The pycnidiospores are ovoid, hyaline,  $5 \times 2.5-3\mu$  (Text-fig. 49d).

Ascstromata are ovoid or slightly oblong,  $95-115\mu$  in diameter by about  $150\mu$  long, dark brown. A number of short, 2-6-celled, divergent setae may develop from the upper part of the fructification (Text-fig. 50). These are dark brown, rounded at the apex,  $20-40\mu$  long by  $8\mu$  in diameter at the base. The setae are not always present, even on all the fructifications in the one collection. The walls of the ascstromata are rather thin at maturity, composed of straw-brown isodiametrical cells which are smaller towards the apex.

The asci are clavate, not numerous, averaging  $65 \times 15\mu$ , 8-spored (Text-fig. 51). The spores are transversely 3-septate, typically fusoid or slightly curved, tapering towards each end, the end cells smaller than the middle ones, slightly constricted at the septa, averaging  $21 \times 9\mu$ , but varying considerably with age from  $18 \times 9\mu$  to  $31.5 \times 11\mu$  (Text-fig. 52).

This is a well marked species, easily distinguished by the large size of the mycelium cells and their pronounced constriction at the septa. It appears to resemble most closely *Phragmocapnias smilacina* Mendoza, but differs from it in the position of the appendages and in the size of the ascospores.

*Capnodium moniliforme* has been found in collections from the following localities: Robertson on *Doryphora sassafras* Endl., 2, 1933, 1, 1934; Barrington Tops on *Epacris* sp., 1, 1934; Salisbury on *Backhousia myrtifolia* Hook. and Harv., 1, 1934, 5, 1934 (Type), on *Callistemon salignus* D.C., 8, 1933, on *Weinmannia rubifolia* Benth., *Eugenia Smithii* Poir., and *Ficus stephanocarpa* Warb., 1, 1934; Moss Vale on *Doryphora sassafras* Endl., 10, 1932, coll. T. G. B. Osborn; Comboyne on *Doryphora sassafras* Endl., *Alyxia ruscifolius* R.Br., 1, 1934; Dorriggo on *Cryptocarya glaucescens* R.Br., 1, 1934; Pennant Hills (Sydney district) on *Tristania laurina* R.Br., 5, 1932; Mt. Wellington, near Hobart, Tasmania, on *Polystichum aculeatum* (L.) Schott., 1, 1933, coll. D. Martin; Mount Cook district, New Zealand, on *Podocarpus Hallii* T. Kirk, 1, 1933, coll. A. Burges.

#### CAPNODIUM ELEGANS, n. sp.

Mycelio epiphylo, cum hyphis polymorphis, fuscis. Hyphis repentibus cellulis cylindricis, vix constrictis, atrofuscis. Hyphis erectis ex hyphis repentibus ascendentis,  $500-1500\mu$  longis,  $20-40\mu$  crassis ad basem. Hyphis erectis ramosis arbori similibus.

Pycnidii ex hyphis erectis latis, fuscis, globosis,  $25-50\mu$  longis. Pycnidiosporis hyalinis, continuis, ovoideis,  $2.5\mu$  longis.

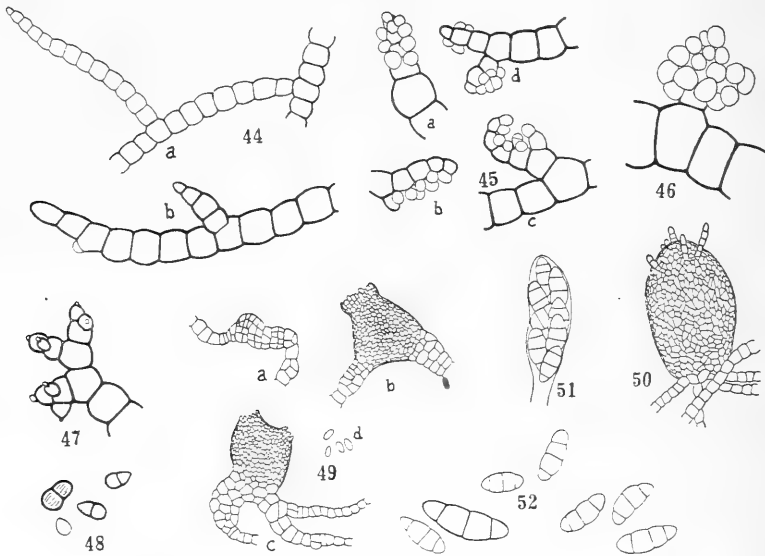
Ascstromis ex hyphis erectis latis, atrofuscis, ovoideis,  $100 \times 200\mu$ , muris ex cellulis atrofuscis, pseudoparenchymaticis. Ascis paucis, crasso-clavatis, 4-6-8-sporis,  $100 \times 35\mu$ . Ascosporis fuscis, 1-3-septatis, vix constrictis, oblongis,  $72-90 \times 15-18\mu$ .

The mycelium forms a very thick dark brown covering on the twigs and leaves of plants. There are two types of hyphae. The stoloniferous hyphae are

much interwoven and consist of tubular cells scarcely constricted at the septa,  $15\mu$  wide by  $20\text{--}30\mu$  long, becoming very thick walled and dark in colour so that the transverse septa cannot be distinguished. These hyphae give rise at intervals to upright growing branches (Text-fig. 53). These upright hyphae branch monopodially and, when full grown, present the appearance shown in Text-figure 54. Often, however, they are not so perfectly developed and examples such as are shown in Text-figures 55a and 55b may occur. They vary in height from  $500$  to  $1,500\mu$ ; the basal cells are  $20\mu$  wide by  $30\text{--}40\mu$  long and become very thick walled and dark and opaque. The upper cells are clear coffee-brown and become progressively smaller. The lateral branches may drop off and germinate to form a fresh mycelium (Text-fig. 56).

The pycnidia are terminal or intercalary on the upright branches. They are infrequent, small, and of the *Antennularia* type,  $25\text{--}55\mu$  diameter and almost globular, dark brown (Text-fig. 57). The pycnidiospores are hyaline, oval, 1-celled, about  $3\mu$  in length.

The ascostromata are sometimes terminal, but usually intercalary on the upright hyphae, the hypha continuing at an angle (Text-fig. 58). They are ovoid or slightly curved, sometimes narrowed towards the base into a short stalk. The walls are dark brown and consist of isodiametrical cells  $10\mu$  in diameter, becoming smaller towards the apex where a pore develops at maturity. The average size is  $100\mu$  wide by  $200\mu$  long. The asci are not numerous, broad clavate,  $100 \times 35\mu$ , 4-, 6- or 8-spored (Text-fig. 59). The ascospores are brown,



44-52.—*Capnodium moniliforme*. 44a, Part of the mycelium.  $\times 230$ . 44b, A growing hypha showing young branches.  $\times 230$ . 45, Conidiophores of various types.  $\times 120$ . 46, Older stages in the development of conidia.  $\times 230$ . 47, Conidiophore branch after the conidia have fallen.  $\times 230$ . 48, Mature conidia.  $\times 230$ . 49a, Development of a pycnidium.  $\times 120$ . 49b, A mature pycnidium.  $\times 120$ . 49c, A pycnidium showing the presence of two ostioles.  $\times 120$ . 49d, Pycnidiospores.  $\times 340$ . 50, Ascostroma showing setae.  $\times 120$ . 51, A single ascus.  $\times 340$ . 52, Ascospores showing septation and variation in size.  $\times 340$ .



thin-walled, usually 3-septate, but occasionally 1- or 2-septate by the non-development of a septum, rather oblong in shape, rarely constricted at the septa,  $72-90 \times 15-18\mu$  (Text-fig. 60).

This is a well-marked species, easily recognized in the absence of fructifications by the unusual mycelium.

*Capnodium elegans* has been collected in the following localities: Taree district on *Guioa semiglauca* Radlk., 1, 1934 (Type); Salisbury on *Backhousia myrtifolia* Hook. and Harv., *Eugenia Smithii* Poir., *Eupomatia laurina* R.Br., and *Weinmannia rubifolia* Benth., 8, 1933, and 1, 1934; Barrington Tops on *Epacris* sp., 1, 1934; Grafton district on *Guioa semiglauca* Radlk., 1, 1935; Comboyne on *Cryptocarya Meissneri* F.v.M., 1935.

#### LIMACINIA CONCINNA, n. sp.

Mycelio scoriadeo, epiphylo, atrofusco. Cellulis fuscis, vel olivaceo-fuscis, vix constrictis,  $7 \times 7-10\mu$ .

Pycnidii globosis vel ovoideis, fuscis  $20-55 \times 30-70\mu$ , ad apicem papillatis. Pycnidiosporis hyalinis, continuis, ovoideis,  $4 \times 1.5\mu$ .

Ascstromis globosis, sessilibus, atrofuscis, cum 4-12 setis mycelio similibus,  $80-110\mu$  crassis. Ascis cylindricis vel clavatis,  $45-50 \times 10-20\mu$ , octosporis. Ascosporis hyalinis, 3-septatis, tenuibus, deorsum attenuatis, apici rotundatis,  $13-14 \times 3-4\mu$ .

The mycelium characteristically forms a rather thick floccose layer. The hyphae are much interwoven, clear straw-brown to faintly olive-brown, rather coarse (Text-fig. 61). The cells are smooth, slightly constricted at the septa, averaging  $7\mu$  wide by  $7-10\mu$  long.

The pycnidia are of the *Antennularia* type, globose to ovoid, dark brown,  $20 \times 30$  to  $55 \times 70\mu$ . The ostiole is slightly papillate. The spores are hyaline, ovoid,  $4 \times 1.5\mu$  (Text-fig. 62).

The ascostromata are globular,  $80-110\mu$  in diameter, with four to nine long mycelial-like appendages,  $100-150\mu$  in length (Text-figs. 63a, 63b). The wall is dark brown, consisting of small isodiametrical cells  $6-8\mu$  in diameter, becoming smaller towards the apex where a pore develops at maturity. The asci are cylindrical to clavate or ovate,  $45-50 \times 10-20\mu$ , 8-spored. The ascospores are irregularly grouped in the ascus, hyaline, with three transverse septa, rounded at the top, tapering slightly to the base,  $13-14 \times 3-4\mu$ .

*Limacinia concinna* has been found in collections from the following localities: Gosford on *Melaleuca* sp., 1, 1934; Dorrigo on *Cryptocarya glaucescens* R.Br., 1, 1934; Glenorie on *Celastrus Cunninghamii* F.v.M., 5, 1932; Narrabeen on *Synoum glandulosum* A. Juss., 10, 1933; Pennant Hills (Sydney district) on *Pittosporum undulatum* Ait., 6, 1933, on *Ceratopetalum apetalum*, D. Don, 3, 1933 (Type); Tweed River district on *Mangifera indica* L., 5, 1934, coll. A. Burges.

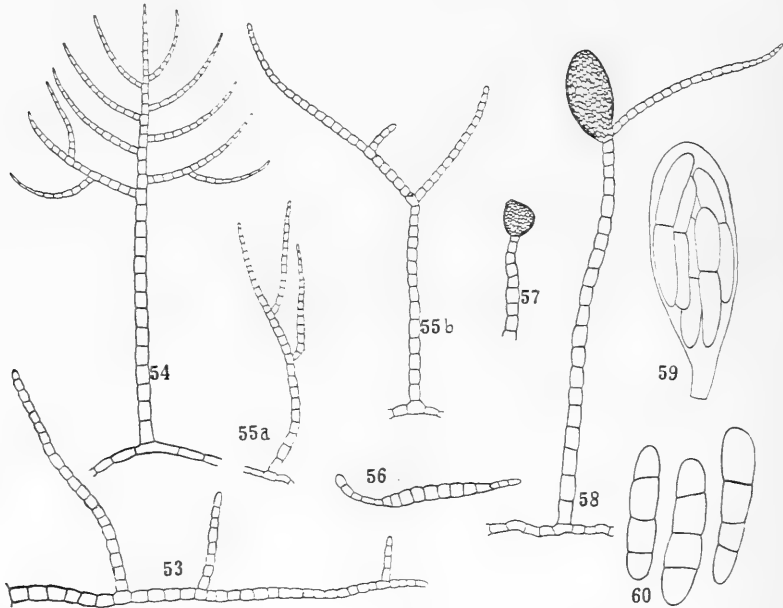
#### SCORIAS PHILIPPINENSIS Mendoza.

*Phil. Journ. Sci.*, 47, pp. 289-291, 1932.

The mycelium is flat, thin effused, rather slimy; the cells are cylindrical,  $7-10\mu$  long by  $4-6\mu$  wide. The hyphae often hang together in strands, forming an almost continuous weft one cell thick.

The pycnidia are very elongated, narrow, dark olive-green, becoming opaque black in the lower stalk region, so that the individual cells cannot be distinguished,  $400-900\mu$  long by  $20-35\mu$  wide in the middle, which is usually slightly swollen (Text-fig. 66). Branched pycnidia may occur (Text-fig. 67). The apex is lined by a few stiff hyaline hairs. The pycnidiospores are hyaline, ovoid,  $3.5 \times 1.5\mu$ .

The ascostromata are olive-green, ovoid to globose, shortly stalked,  $100 \times 100\text{--}160\mu$ . The wall is made up of isodiametrical cells  $3\text{--}4\mu$  in diameter (Text-fig. 68).



53-60.—*Capnodium elegans*.—53, A horizontal hypha showing the growth of erect hyphae.  $\times 65$ . 54, A mature upright hypha showing branching.  $\times 65$ . 55a, 55b, Upright hyphae showing imperfect branching.  $\times 65$ . 56, Growth of a detached lateral branch of an upright hypha.  $\times 65$ . 57, Pycnidium.  $\times 65$ . 58, Ascostroma on an upright hypha.  $\times 65$ . 59, A young ascus.  $\times 340$ . 60, Mature ascospores.  $\times 340$ .

The asci are clavate,  $30 \times 15\mu$ , 8-spored. The ascospores are hyaline, with three transverse septa, tapering slightly towards the lower end. They average  $17 \times 5\mu$  (Text-fig. 69).

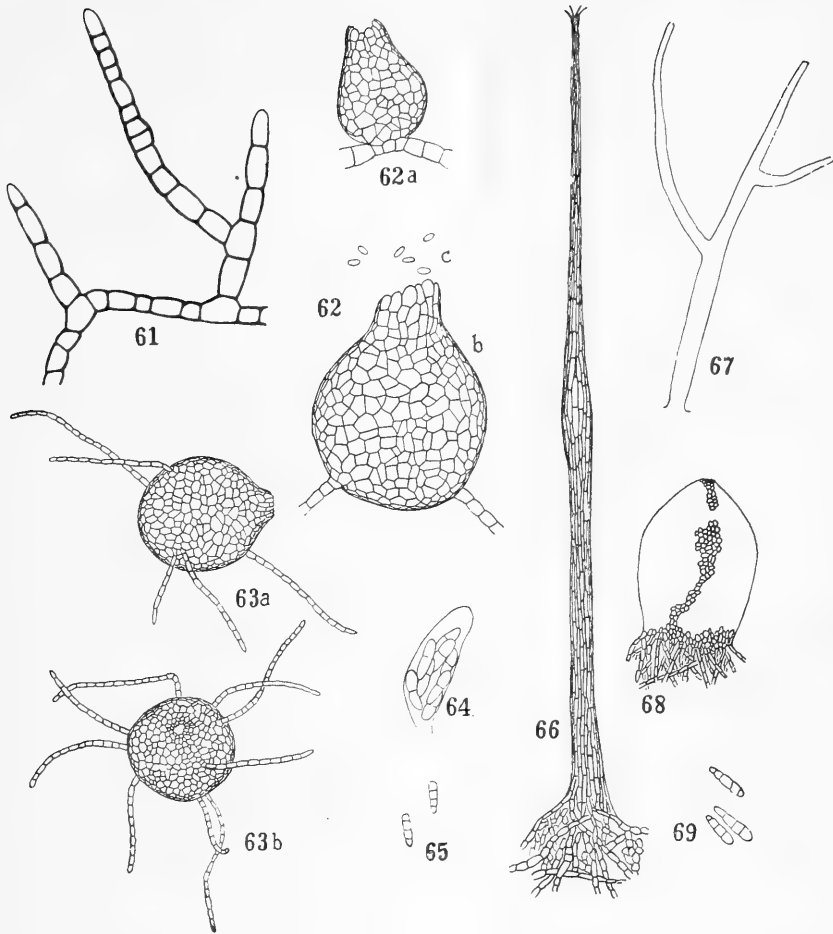
This fungus appears to agree fairly well with the type described and figured by Mendoza (1932). It differs in the smaller size of the spores and asci, which in the type are described as  $21\text{--}23 \times 3\text{--}4\mu$  and  $40\text{--}57 \times 12\text{--}13\mu$  respectively. The size and shape of the pycnidia and ascostromata and the shape of the ascospores however show very close resemblances.

The New South Wales type is therefore placed in this species.

*Scorias philippinensis* has been found in collections from the following localities: Salisbury on *Eupomatia laurina* R.Br., 1, 1934, on *Eugenia Smithii* Poir., 5, 1934; Bulga (Wingham district) on *Lyonsia straminea* R.Br., 1, 1934.

#### HENNINGSOMYCES AFFINE, n. sp.

Mycelio epiphylo, cellulis moniliformibus, inflatis, ad septa constrictis,  $8\text{--}10\mu$  latis,  $9\text{--}11\mu$  longis. Ascostromis ovoideis glabris, fuscis,  $95\text{--}115\mu$  longis,  $60\text{--}75\mu$  latis, apice papillatis. Ascis clavatis, ad apicem rotundatis,  $40\text{--}50 \times 15\text{--}20\mu$ , octosporis. Ascosporis conglobatis, fuscidulis, 1-septatis, ad apicem rotundatis, basi attenuatis,  $12\text{--}15 \times 3\text{--}5\mu$ .



61-65.—*Limacinia concinna*. 61, Part of the mycelium showing branching.  $\times 425$ . 62a, 62b, Pycnidia.  $\times 425$ . 62c, Pycnidiospores.  $\times 425$ . 63a, 63b, Different aspects of the ascostroma showing mycelium-like setae and apical pore.  $\times 425$ . 65, Mature ascospores.  $\times 285$ .

66-69.—*Scorias philippinensis*. 66, Pycnidium and mycelium.  $\times 150$ . 67, Pycnidium showing branching.  $\times 80$ . 68, Ascostroma.  $\times 150$ . 69, Ascospores.  $\times 425$ .

The mycelium forms a dark brownish-black, rather thin, cottony layer over the surface of leaves and twigs. The hyphae are prominently beaded (Text-fig. 70), resembling those of *Capnodium moniliforme* and scarcely to be distinguished from them. The cells are characteristically slightly smaller than those of *Capnodium moniliforme*, 8–10 $\mu$  in width by 9–11 $\mu$  in length, smaller when young, clear brown, smooth-walled. Branching of the hyphae takes place nearly at right angles, and at irregular intervals.

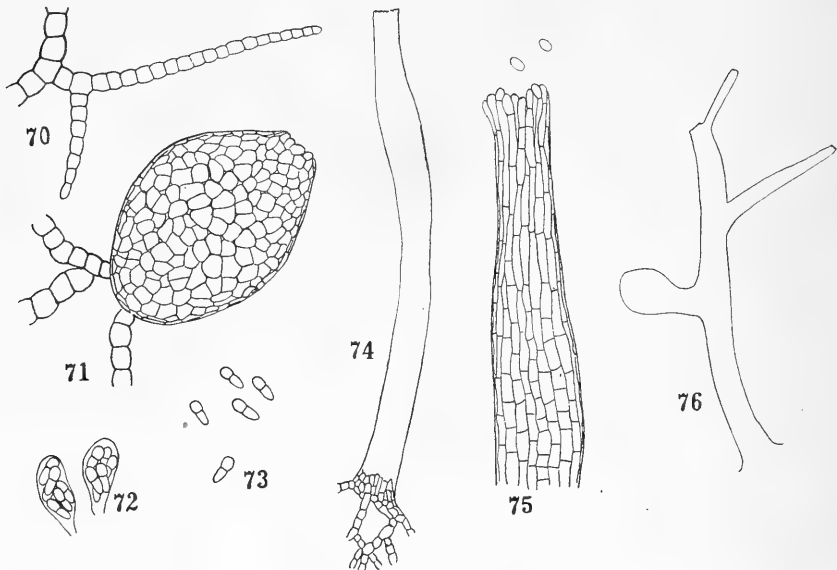
Pycnidia were not observed.

Ascostromata (Text-fig. 71) are developed meristogenously, the hyphae which give rise to them being very apparent. When mature the ascostromata are ovoid,

95–115 $\mu$  in length by 60–75 $\mu$  in diameter, sessile, glabrous, with a prominent, slightly raised apical pore. The pore is surrounded by cells slightly smaller than those forming the wall of the ascostroma. These wall cells are clear brown, the mature fructification appears black. Asci (Text-fig. 72) are not numerous, 40–50  $\times$  15–20 $\mu$ , clavate, rounded at the apex, 8-spored. The ascospores are irregularly arranged in the asci, and are 1-septate, light smoky-yellow in colour, 12–15  $\times$  3.5–5 $\mu$ , the upper cell is slightly shorter, wider and more rounded than the lower one, both apices are rounded (Text-fig. 73).

*Henningsomyces affine* has been collected in the Mitchell River district, between Glen Innes and Grafton, on *Eugenia australis* Wendl., *Rhodosphaeria rhodanthema* (F.v.M.) Engl., and *Bursaria spinosa* Cav. (Type), 1, 1935.

It differs from *H. pusillimus* Syd. in the glabrous condition of the ascostromata, and from *Parascorias spinosa* Mendoza in the colour and size of the ascospores, and in the smooth mycelium.



70-73.—*Henningsomyces affine*. 70, Mycelium.  $\times$  285. 71, Ascostroma.  $\times$  285. 72, Asci.  $\times$  285. 73, Ascospores.  $\times$  285.

74-76.—*Capnodium australe*. 74, Pycnidium and mycelium.  $\times$  150. 75, Apex of pycnidium and pycnidiospores.  $\times$  425. 76, Pycnidium showing branching and the development of an ascostroma on the stalk of the pycnidium.  $\times$  80.

#### CAPNODIUM AUSTRALE MONT.

*Journ. Hort. Soc. London*, iv, 1849, p. 253.

This species has been thoroughly described by Miss Fisher (1932) and others, but the pycnidial fructifications do not appear to have been noted. When present the pycnidia are very numerous. They are elongated, slightly swollen towards the middle (Text-fig. 74). The cells composing the walls are long and narrow in the region of the neck and stalk, rather shorter and more isodiametrical in the swollen centre part. The apex is not fringed (Text-fig. 75). The pycnidia branch very frequently, and occasionally ascostromata have been seen arising

from the stalks of old pycnidia (Text-fig. 76). The pycnidiospores are broad ovoid, hyaline, 1-celled,  $5 \times 3\mu$ .

*Capnodium australe* has been collected only from Ulladulla on *Casuarina glauca* Sieb., 3, 1933, and 8, 1934.

The following five species are incompletely known, and so no specific names have been applied to them. Only pycnidial fructifications have been found. They are all of common occurrence and some of them are of great importance in the formation of sooty moulds.

#### MICROZYPHIUM sp. 1.

This fungus belongs to the form genus *Microzyphium*. It produces elongated pycnidia resembling those of *Scorias philippinensis* but much stouter, and is quite distinct from it culturally. The pycnidia are 600–1,000 $\mu$  in length, 50–80 $\mu$  in diameter in the middle, which is usually swollen, the stalk being 30 $\mu$  in diameter and the neck 10–15 $\mu$ . The cells are olive-green, becoming black and opaque in the region of the stalk, elongated except in the central region, where they are short and broad (Text-fig. 77). The ostiole is fringed by numerous hyaline, pointed, 1–2-septate, hair-like cells (Text-fig. 78). The pycnidiospores are numerous, hyaline, 1-celled, ovoid,  $6 \times 3\mu$ . The mycelium resembles that of *Scorias philippinensis* but is slightly stouter and darker brown. In a previous paper (Fraser, 1934) this species was referred to as *Microzyphium* sp. B.

This species has been found in collections from the following localities: Pennant Hills (Sydney district) on *Citrus* sp., and *Pittosporum undulatum* Ait., 6, 1933; Pittwater on *Bursaria spinosa* Cav., and *Eugenia Smithii* Poir., 5, 1932; Tilba Tilba on *Ficus stephanocarpa* Warb., 2, 1933; Comboyne on *Doryphora sassafras* Endl., 1, 1934; Brisbane, Queensland, on *Brassaea* sp., and *Artocarpus* sp., 5, 1934, coll. A. Burges; Tweed River district on *Croton Verreauxii* Bail., 5, 1934, coll. A. Burges.

#### MICROZYPHIUM sp. 2.

The mycelium is dark brown and forms a rather thick mat of hyphae. The cells are cylindrical or slightly beaded,  $5 \times 5\mu$  to  $7 \times 10\mu$  in size, smooth, light brown. The pycnidia may be scattered but are more usually very closely massed together, forming compact cushion-like patches on leaves and twigs. The pycnidia are very elongate and commence as upgrowths of loosely interwoven hyphae invested in a mucilaginous covering (Text-fig. 79). The apex then grows up as a narrow neck composed of long narrow dark-brown closely-associated cells (Text-figs. 80–81). At maturity the ostiole is fringed by 6–10 hyaline hair-like cells 15–20 $\mu$  long (Text-figs. 82–83). The pycnidiospores are produced within the lower inflated part. This inflated part may be very long and branched (Text-fig. 84), or may be almost absent. The pycnidia vary from 500 $\mu$  to 1,500 $\mu$  in length, a frequent size being 500 $\mu$  by 55 $\mu$  in diameter at the base and 10 $\mu$  at the apex.

The pycnidiospores are hyaline, 1-celled, ovoid,  $4.5 \times 2\mu$ .

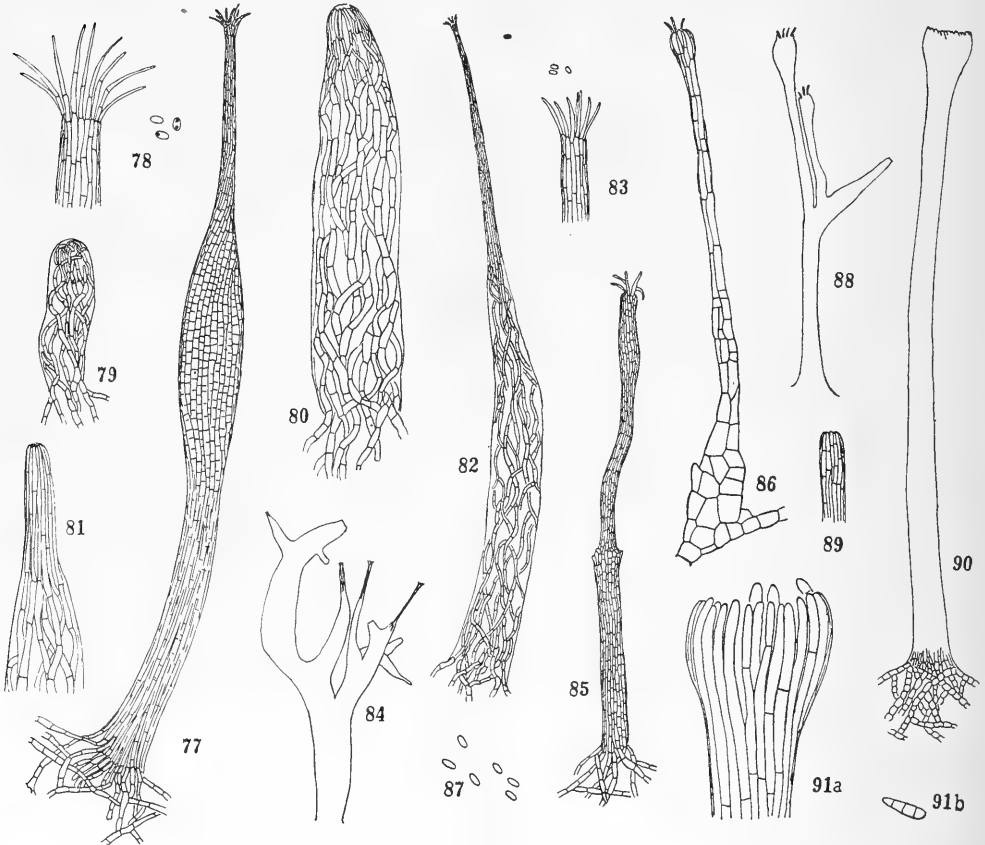
This is one of the commonest of the species in rain forest areas. *Capnodium* (?) *casuarini* McAlp. (McAlpine, 1902–3) appears to be identical with this form. In a previous paper (Fraser, 1934) this fungus was referred to as *Microzyphium* sp. C.

*Microzyphium* sp. 2 has been found in collections from the following localities: National Park (Sydney district) on *Rhodamnia trinervia* Blume, 5, 1932; Comboyne on *Doryphora sassafras* Endl., *Alyxia ruscifolius* R. Br., etc., 1, 1934;

Macquarie Pass on *Palmeria scandens* F.v.M., 2, 1933; Robertson on *Doryphora sassafras* Endl., 3, 1933; Dorrigo on *Cryptocarya glaucescens* R. Br., 1, 1934; Moss Vale on *Doryphora sassafras* Endl., 10, 1932, coll. T. G. B. Osborn.

MICROZYPHIUM sp. 3.

This species is always found growing in association with other species, and produces relatively few pycnidia. The cells are slightly constricted at the septa, the mycelium is interwoven, slender, light brown. The pycnidia have been figured by Miss Fisher (1932) and are unmistakable. They are flask-shaped with



77-78.—*Microzyphium* sp. 1. 77, Pycnidium and mycelium.  $\times 120$ . 78, Apex of pycnidium and pycnidiospores.  $\times 340$ .

79-84.—*Microzyphium* sp. 2. 79-81, Development of the young pycnidium.  $\times 230$ . 82, Mature pycnidium.  $\times 120$ . 83, Apex of the pycnidium and pycnidiospores.  $\times 340$ . 84, Pycnidium showing branching.  $\times 65$ .

85-89.—*Caldariomyces* sp. 1. 85, Pycnidium and mycelium.  $\times 120$ . 86, A small type of pycnidium.  $\times 340$ . 87, Pycnidiospores.  $\times 340$ . 88, Pycnidium showing branching.  $\times 120$ . 89, Apex of immature pycnidium showing similarity to *Microzyphium leptospermi*.  $\times 340$ .

90-91.—*Caldariomyces* sp. 2. 90, Pycnidium.  $\times 120$ . 91a, Apex of pycnidium.  $\times 340$ . 91b, Pycnidiospore.  $\times 340$ .

a globular basal part 50–80 $\mu$  in diameter, the walls of which are composed of isodiametrical cells of a clear ferruginous colour. The neck is elongated and narrow, averaging about 30 $\mu$  in diameter. The whole fructification varies from 200 $\mu$  to 400 $\mu$  in length. The pycnidiospores, which are produced in the enlarged basal part, are globose or slightly ovoid, 1- or 2-celled,  $9 \times 7.5\mu$ .

This species has been found in collections from the following localities: Pennant Hills (Sydney district) on *Pittosporum undulatum* Ait., 10, 1933; Macquarie Pass on *Palmeria scandens* F.v.M., 2, 1933; Comboyne on *Doryphora sassafras* Endl., 1, 1934; Tweed River district on *Croton Verreauxii* Bail., 5, 1934, coll. A. Burges.

#### CALDARIOMYCES sp. 1.

The mycelium is sooty-brown, loosely interwoven, fairly thick and floccose. The cells are cylindrical, scarcely constricted, 5–6 $\mu$  in diameter by 7–15 $\mu$  in length. The pycnidia vary considerably in size and form (Text-figs. 85–86). The stalk may be a slender structure only two cells in diameter (Text-fig. 86), or may be much stouter, slightly resembling the pycnidium of *Capnodium anonae* (Text-figures 85–89). The spores are produced at the apex of the stalk in a short cavity, fringed by 5–8 hyaline hair-like cells. Further growth may take place, the stalk continuing to grow through the pycnidial cavity forming another fructification at a higher level (Text-fig. 85). When the fungus is grown in culture the definite cup-like structure is not produced and the spores are borne on the inner surfaces of short, slightly divergent branches at the head of the stalk, very similar to those described by Zopf (1878; see also Woronichin, 1926). This species differs from *Caldariomyces fumago* Woronichin in its very much smaller size. The pycnidia are 200–500  $\times$  8–25 $\mu$ . They are often simple but may branch repeatedly (Text-fig. 88). The pycnidiospores are hyaline, ovoid, oblong,  $6 \times 1.5\mu$  (Text-fig. 87).

*Caldariomyces* sp. 1 has been found in collections from the following localities: Pennant Hills (Sydney district) on *Ceratopetalum apetalum* D. Don, 5, 1932, 3, 1933, on *Callicoma serratifolia* Andr., 5, 1932; National Park (Sydney district) on *Rhodamnia trinervia* Blume, 5, 1932.

#### CALDARIOMYCES sp. 2.

The mycelium is very dark brown. The cells are cylindrical or beaded, 5 $\mu$  in diameter by 5–10 $\mu$  in length. The pycnidia are scattered or in groups, usually simple but occasionally branched near the base. The stalks are very long and opaque-black, 600–1,000 $\mu$  by 35 $\mu$  at the base, tapering gradually to 25 $\mu$  at the apex (Text-fig. 90). At the apex the stalk expands into a small cup-like structure widest at the top (Text-fig. 91a). The spores are borne in this open cup. The spores are hyaline or yellowish, fusiform, tapering to the lower end, 1–3-septate,  $18 \times 5\mu$  (Text-fig. 91b).

*Caldariomyces* sp. 2 has been found in collections from the following localities: Comboyne on *Alyxia ruscifolius* R. Br., 1, 1934; Robertson on *Doryphora sassafras* Endl., 3, 1934; Barrington Tops on *Epacris* sp., 5, 1934; Salisbury on *Callistemon salignus* D.C., 8, 1933; Moss Vale on *Doryphora sassafras* Endl., 10, 1932, coll. T. G. B. Osborn; Tweed River district on *Croton Verreauxii* Bail., 5, 1934, coll. A. Burges.

#### SUMMARY.

Six new species and varieties of sooty mould fungi are described and their relationships discussed.

Emended descriptions are given of a number of incompletely known species: *Capnodium Walteri* Sacc., *C. fuliginodes* Rehm., *C. anonae* Pat., and *C. mucronatum* Mont.

*Scorias philippinensis* Mendoza is recorded for the first time in Australia.

The pycnidial stage of *Capnodium australe* is described.

Five common types of pycnidial fructification are recorded.

The writer wishes to express her thanks to Professor T. G. B. Osborn, in whose laboratory this work was carried out, for advice and helpful criticism, and to the members of the staff and the research students, past and present, of the Botany School, Sydney University, who have materially assisted in this work by collecting specimens in many localities.

Material of the new species and varieties herein described has been sent to the following institutions: The National Herbarium, Botanic Gardens, Sydney, N.S.W.; The Department of Agriculture, Burnley, Victoria; The National Herbarium, Royal Botanic Gardens, Kew, Surrey, England; The Imperial Mycological Institute, Kew, Surrey, England; The United States National Herbarium, Washington, U.S.A.; Botanisches Museum, Berlin-Dahlem, Germany.

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AUSTRALIAN COLEOPTERA.

NOTES AND NEW SPECIES. NO. IX.

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

(Seven Text-figures.)

[Read 26th June, 1935.]

Family BUPRESTIDAE.

MELOBASIS PAVO, n. sp.

Elongate-ovate; whole upper surface and antennae peacock-blue, underside and legs brilliant coppery, abdomen very sparsely clad with silvery hair.

*Head* wider than apex of prothorax, eyes large and prominent, their inside margins parallel. Forehead slightly concave, finely punctate and sparsely pubescent. *Prothorax*: apex and base lightly bisinuate, anterior angles declivous, posterior subrectangular, disc with large, round, close punctures, a tendency to transverse rugosity towards sides, medial line indicated on basal third by a short carina with a lineate fovea behind this at base. *Scutellum* rather large, triangular and laevigate. *Elytra* subparallel for two-thirds of length, arcuately narrowed to apex, subapical margins strongly denticulate; sulcate-punctate, the sulci crenulated by punctures, intervals convex and punctate, those on lateral half closely, transversely rugose. *Prosternum* coarsely, and closely punctate, metasternum and abdomen more finely and less closely so. Apical segment truncate between two scarcely emarginate spines. *Dim.* 10.5 × 4 mm.

*Hab.*—N.W. Australia: Lake Austin. (H. W. Brown.)

A single ♀ example was sent on the same card as a ♂ of *Notobubastes costata* Cart., from which it differs in sculpture and apical structure, besides colour and form. The strongly sulcate elytra easily distinguish it from the other species in Group ii, Sect. B, of my Revision (*Trans. Ent. Soc. Lond.*, 1923). The pronotum is subopaque, the elytra very nitid, the underside brilliant. Type in Coll. Carter.

STIGMODERA (CASTIARINA) PROLONGATA, n. sp.

Elongate-parallel; subnitid and almost glabrous. Head, prothorax, underside and appendages very dark blue, elytra orange-red, with narrow postmedial fascia, and apex widely, blue-black, the fascia enlarged at suture and extending to margins.

*Head* moderately excavate and canaliculate, rather closely, subrugosely punctate. *Prothorax* unusually convex, apex and base lightly bisinuate, anterior angles depressed and obtuse, posterior acute and produced, basal triangular excisions well marked and emphasized by preceding fovea; widest near, or slightly in front of, middle, sides widely rounded, sinuate behind; disc with round, moderately close punctures, these closer at sides, a smooth area within basal border and some smooth rugae near apex. *Scutellum* longitudinally concave. *Elytra* three and a half times as long as prothorax, lightly widened at shoulder, very lightly compressed behind this, subparallel for the greater part, little

narrowed behind, apices with small, but distinct lunation, margins entire; striate-punctate, intervals roundly convex throughout, striae punctures coarse, intervals irregularly punctate and transversely rugulose in places. Sternal regions strongly, abdomen more finely, punctate. *Dim.* 17-20 × 6 mm.

*Hab.*—Western Australia: Cue. (H. W. Brown.)

Two examples, both, I think, ♀, were given to me by Mr. Brown, one of which has the abdomen unusually extended beyond the elytra, exposing two tergites. It may be distinguished amongst those of like pattern by its elongate, parallel form and wide prothorax, somewhat as in *S. dilatata* mihi. Holotype in Coll. Carter.

STIGMODERA ERASMA, n. sp. Fig. 1 (page 188).

Ovate-acuminate; head and pronotum brassy-bronze, the latter widely margined red, elytra dark metallic blue in ♂, green in ♀, with elongate medial area of each elytron and two wide postmedial spots yellow, and a wide, arcuate, subapical area red; prosternum and abdomen red, rest of underside blue or green—reddish between middle coxae; short, pale pubescence at sides and apex of abdomen, more evident on metasternum.

*Head* feebly concave and scarcely canaliculate between eyes, front very finely, apical half more distinctly and evenly punctulate. *Prothorax* longitudinally convex, laterally subplanate, widest near base, apex arcuate, anterior angles produced, rather wide and deflexed, sides well rounded at the widest part, thence strongly narrowed to apex and subsinuately so to base; base bisinuate, posterior angles acute; disc very closely, not coarsely, punctate, medial line only indicated by elongate fovea near base. *Elytra* rather flat and subexplanate, sides sinuate, margins of apical half finely denticulate, apices bispinose, with wide lunation, external spine very long, sutural very short; striate-punctate, striae clearly impressed, striae punctures round and regular, humeral regions and intervals strongly punctate, the two nearest suture strongly, the rest lightly, convex, except towards apex, where all subcarinate, the suture itself sharply carinate on apical half. *Metasternum* clearly, abdomen vaguely, punctate. *Dim.* 11-12 × 4.5 mm.

*Hab.*—Victoria: Swift's Creek, E. Gippsland. (F. E. Wilson.)

Mr. Wilson captured 3 examples, "from a little patch of moribund wattles", of this very distinct species, of which two are sent for description. Belonging to the *producta* group, it is easily distinguished from the others (Nos. 56-65 of my tabulation, *Aust. Zool.*, 1931) by its red margined prothorax and different elytral pattern. Holotype in Coll. Wilson. Paratype in Coll. Carter.

Named in honour of F. Erasmus Wilson, who has done so much to advance Entomology in Australia.

CISSEIS PATRICIA, n. sp.

Narrowly ovate; subnitid coppery-bronze above, darker bronze beneath. Sides of prothorax, the greater part of elytra, and the abdomen thickly clad with pale, recumbent pubescence.

*Head* closely punctate, with well marked medial depression and channel. *Prothorax*: apex rather strongly produced in middle, anterior angle depressed and wide, sides evenly rounded, lateral carinae parallel on basal half, divergent in front; base bisinuate, disc transversely striolate. *Elytra* lightly compressed behind shoulders, sides feebly sinuate, apical margins very finely denticulate, the discal pubescence thickened to form indistinct fasciae, postmedial and pre-

apical, elsewhere generally scattered, whole surface densely scalose-punctate. Underside nitid and punctate. *Dim.* 4-5 × 1.3-1.8 mm.

*Hab.*—Western Australia: Bunbury. (F. Lawson Whitlock.)

Fourteen examples examined showed no sexual coloration. Belonging to the group of small species that include *parva* Blkb., *minutissima* Thoms, and *pygmaea* Blkb., the species is differentiated from all by the combination of uniform colour, surface thinly veiled by a fine but close pubescence, that gives a somewhat opaque appearance. It shares with *pygmaea* Blkb. the general pubescent surface and rather strongly impressed head, but differs from that species in its much brighter colour and more elongate, attenuate form. It is named after Miss Whitlock, who helped to find it. Type series in Coll. Carter.

Family ELATERIDAE.

GLYPHEUS NIGRINUS, n. sp.

Oblong-ovate; nitid black above and below, clypeus and basal segment of antennae red, rest of antennae piceous, upper surface sparsely clad with long upright hair of pale colour.

*Head* sparsely and rather coarsely setigero-punctate, transversely concave within the clypeus. *Prothorax* widest behind middle, apical angles rounded off, sides bisinuate, feebly towards front, more strongly near posterior angles, these strongly carinate and feebly divaricate; disc with sparse setigerous punctures and short, lightly impressed, medial sulcus. *Elytra* of same width as prothorax at base, striate-punctate, intervals flat except at base, striae distinct, the punctures therein large and setiferous, the suture subcarinate near apex, epipleural fold angulate at shoulders; prosternum and abdomen finely punctate and pubescent, metasternum glabrous. *Dim.* 13 × 4 mm.

*Hab.*—N.S.W.: Dubbo. (D. Wearne.)

A single example given me recently comes nearest to *G. piceus* Cand., but clearly separated as follows:

<i>piceus.</i>	<i>nigrinus.</i>
<i>Colour:</i> rufo-piceous .....	black.
<i>Prothorax:</i> post. angles strongly divaricate	feebly divaricate.
disc rather flat .....	disc more convex.
medial sulcus well marked ...	sulcus short and obscure.

Holotype in Coll. Carter.

GLYPHEUS SUBFASCIATUS, n. sp.

Rufo-piceous; very nitid, head and prothorax red, the latter with four elongate, black markings (more distinct in the ♀), elytra rufo-piceous with four testaceous patches, two subhumeral, extending over three lateral intervals, two larger, subfasciate, postmedial, extending from margins to the 2nd sutural interval, apical area reddish; upper surface with long, upright, pale hair sparsely scattered: prosternum and legs red, rest of underside dark piceous, abdomen with close, recumbent hair.

*Head* punctate, clypeus widely elliptic, front with triangular depression, antennae slender, black, the basal segment red. *Prothorax* subequally wide for the greater part, anterior angles more acute than in *G. villosulus* Cand., posterior angles divaricate and carinate; disc smooth save for minute piliferous punctures, medial sulcus very fine and inconspicuous. *Elytra* of same width as prothorax at base, sharply navicular, all intervals convex at base, sutural intervals only convex to apex, the suture itself subcarinate, the others seriate punctate, the

punctures large and round on basal half, fine and irregularly placed towards apex; prosternum and metasternum very nitid and glabrous. *Dim.* 9–10 × 2½–3 mm.

*Hab.*—N.S.W.: Mt. Irvine, Blue Mts. (H. J. Carter.)

I took two examples (the sexes) in December, 1934, one by beating wattle, the other under bark. It is readily distinguished from *G. villosulus* Cand. by its smaller size, navicular form and testaceous markings. The ground colour of elytra is also variegated by the light and dark shades of piceous red. As noted by Candeze (under *G. lansbergei*), *villosulus* often presents "quatre taches d'une teinte rougeatre", but this is very different from the testaceous markings of *subfasciatus*. Holotype and allotype in Coll. Carter.

The species of the genus known to me differ only slightly in structure and sculpture, but may be readily diagnosed by the following tabulation. My specimens are from the following localities: *villosulus* Cand.: Victoria (Mt. Macedon, Warburton, Wooriwallock); *nigrinus*, n. sp.: N. S. Wales (Dubbo); *piceus* Cand.: N. S. Wales (Mt. Wilson, Blue Mts.); *sanguineus* Elst.: Queensland (National Park), N.S.W. (Dorrigo); *subfasciatus*, n. sp.: N. S. Wales (Mt. Irvine, Blue Mts.).

Table of *Glypheus*.

1. More or less concolorous .....	2
Bicolorous without defined pattern .....	<i>villosulus</i> Cand.
Bicolorous with defined pattern .....	4
2. Colour black .....	<i>nigrinus</i> , n. sp.
Colour rufo-piceous .....	3
3. Prothorax canaliculate, 13 mm. long .....	<i>piceus</i> Cand.
Prothorax non-canaliculate, 7 mm. long .....	* <i>alpinus</i> Blackb.
4. Elytra sanguineous with dark pattern .....	<i>sanguineus</i> Elst.
Elytra rufo-piceous with testaceous patches .....	<i>subfasciatus</i> , n. sp.
Elytra dark with red maculae .....	5
5. Elytra with 4 red maculae .....	* <i>decoratus</i> Cand.
Elytra with 1 large red macula .....	* <i>lansbergei</i> Cand.

\* Species unknown to the author in Nature.

Family TENEBRIONIDAE.

*Helaeus spencei* Breme.—In these PROCEEDINGS, 1910, p. 90, I suggested that this was "possibly a var. of *H. kirbyi* Br.". Recently a specimen sent by Mr. Whitlock from Bunbury, W.A., seems to fit the description of *H. spencei* so closely that I am inclined to accept the distinctness of the species. Its form is exactly as in De Breme's figure (i.e., with much narrowed thorax and dilated elytra); and its dimensions almost exactly agree. The only discrepancy lies in the elytral clothing, said to be "poils fauves très fin, excessivement courts", whereas in the Bunbury example the hairs are long and brownish. There are, however, only 4 rows of these, at sides of disc, not, as in *perforatus* and *kirbyi*, over the whole surface.

*Sympetes acutifrons* Lea = *S. bicolor* Cart.—The latter name must be sunk. A long series taken by Mr. John Clark make this synonymy certain. The extreme forms present considerable differences in size and colour and even in the width of the foliate margins.

*Saragus bicarinatus* Champ.—I think a misprint occurred here; "bi" and "tri" are often confused in handwriting. The species has three clear carinae on each elytron, as stated in the author's excellent description and further shown in the figure (*Trans. Ent. Soc. Lond.*, 1894, p. 385).

SARAGUS OMEOENSIS, n. sp.

Ovate; nitid jet-black.

*Head* flat and almost impunctate, antennae with segment 3 as long as 4 and 5 combined, 8-10 increasingly transverse, 11 ovoid. *Prothorax* widest at base, apex arcuate-emarginate, anterior angles widely rounded off, sides roundly widened to near base, then a little narrowed to the obtuse posterior angles, base lightly bisinuate; foliate margins wide and subhorizontal (feebly concave towards front), with narrow reflexed border; disc moderately convex, minutely punctulate, medial sulcus clearly, not deeply, impressed, a small fovea near middle on each side of this. *Elytra* ovate, convex, widest at middle, foliate margins wide on basal half, narrowing towards apex, the reflexed border forming an increasing concavity to the apex; disc separated from foliation by row of large punctures; quadricostate, the suture also carinate, the first costa more nitid and prominent than the others, the 4th, along margin of disc, little raised; intervals between costae rugose and punctate, each containing four rows of rather large punctures, more or less interrupted by a longitudinal ridge midway between costae. *Prosternum* coarsely, abdomen finely, punctate. Hind tarsi with basal segment as long as the rest combined. *Dim.* 14 × 8½ mm.

*Hab.*—Victoria: Omeo. (F. E. Wilson.)

Two examples form another of Mr. Erasmus Wilson's discoveries. It is a very distinct species, differing from *S. confirmatus* Pasc. and *S. tricarinatus* Btkb. in its more nitid black, its wider foliation and the clearly punctate intervals. Only the first costa is at all prominent. Holotype in Coll. Wilson.

CORIPERA WILSONI, n. sp.

Oblong-ovate, flat; nitid dark bronze, glabrous, tarsi with yellow tomentum beneath.

*Head* with sparse, large, round punctures on forehead, epistoma laevigate, labrum prominent, antennae moniliform, 3 longer than 4, 11 narrowly ovate. *Prothorax*: apex arcuate-emarginate, anterior angles acute and prominent, base subtruncate, posterior angles a little less than 90°, and slightly produced outward, widest at middle, sides moderately rounded, sinuate behind, disc with a few large punctures irregularly disposed, medial line sharply cut throughout, subfoliate margins a little oblique and partly separated from disc by a short sulcus, a fine exterior border. *Scutellum* small, triangular. *Elytra* wider than prothorax at base, and less than twice as long, shoulders nearly squarely angulate, surface flat for the greater part, abruptly declivous behind; in part striate-punctate, in part irregularly embossed; three striae on each side of suture scarcely interrupted (only at one side, halfway, by a small transverse ruga), three scarcely defined lateral striae traceable; between lateral and sutural striae, smooth vermiculations enclose a few ocellate foveae and portions of punctured striae. *Epipleurae* with large sparse punctures, rest of underside sublaevigate. *Dim.* 12 × 5 mm.

*Hab.*—South Queensland: Eukey. (F. E. Wilson.)

A unique example is quite distinct from its congeners by its irregular elytral sculpture: in this respect it approaches, but differs from, *C. morleyana* mihi. Holotype in Coll. Wilson.

The following tabulation is an aid to the identification of the species.

*Coripera.*

- |   |                         |
|---|-------------------------|
| 1. Each elytron with 3 rows of ocellate foveae arranged symmetrically between geminate striae ..... | 2                       |
| Elytra not so .....   | 5                       |
| 2. Sides of prothorax abruptly narrowed before hind angle .....                                     | <i>distinctus</i> Cart. |
| Sides of prothorax merely sinuate behind .....  | 3                       |

- |   |                         |
|---|-------------------------|
| 3. Elytra with pale margins, 8-10 mm. long .....                      | 4                       |
| Elytral margins concolorous, 12-15 mm. long .....                     | <i>geminata</i> Lea.    |
| 4. Pronotum sublaevigate, medially sulcate throughout .....           | <i>mastersi</i> Macl.   |
| Pronotum rugose punctate, medial sulcus subobsolete .....             | <i>ocellata</i> Pasc.   |
| 5. Ocellate foveae irregularly disposed .....                         | 6                       |
| Elytra without ocellate foveae .....                                  | 8                       |
| 6. Elytra with pale margins .....                                     | 7                       |
| Elytral margins concolorous with disc .....                           | <i>wilsoni</i> , n. sp. |
| 7. Elytral surface embossed, a single stria each side of suture ..... | <i>bistriata</i> Cart.  |
| Elytral surface even, 3 striae each side of suture .....              | <i>morleyana</i> Cart.  |
| 8. Margins of pronotum lobate-crenate .....                           | <i>adamsi</i> Lea.      |
| Margins of pronotum entire .....                                      | <i>deplanata</i> Boisd. |

*N.B.*—*C. mastersi* Macl. has pale margins to elytra strongly marked (unmentioned in description), the pronotum, save for a few irregular punctures, very nitid and smooth; the elytral sculpture differs from that of *ocellata* Pasc. in having the striae clearly punctate and the ocellate intervals themselves containing interrupted striae. The colour is also a paler bronze than in Pascoe's species.

SEIROTRANA ANNULIPES, n. sp.

Brown-bronze, oblong-ovate, femora with a pale ring near (but not reaching) apex.

*Head* densely, subrugosely punctate, forehead with arcuate impression, antennae stout, segments 3-8 shortly ovate, 9-10 triangular, 11 very large, ovate. *Prothorax*: apex arcuate-emarginate, its angles prominent, acute, base truncate, its angles rectangular, sides rounded, widest at middle, evenly converging to apex, rather abruptly and sinuately narrowed towards base, margins clearly crenulate (except on posterior sinuation), disc densely strigose-punctate. *Elytra* wider than prothorax at base, striate-punctate, seriate punctures large and close, especially towards base and sides, intervals 3, 5, 7, 9 with well defined elongate nodules, the intermediate intervals narrower, with a few small pustules, the sutural interval with a few foveate punctures. *Epipleurae* with large, sparse punctures, prosternum sparsely punctate, abdomen with minute punctures. *Dim.* 11×4 mm.

*Hab.*—N. S. Wales: Hastings River district. (Carter and Davidson.)

Three examples are before me, one taken by myself in 1933, two by Mr. Harold Davidson in November, 1934. Rather close in form and upper surface to *S. mastersi* Macl., but a close examination, especially of the undersides, shows clear distinction of sculpture, besides those of size and colour, from the Gayndah species. The following comparison tabulates the chief differentiating characters.

<i>mastersi</i> Macl.	<i>annulipes</i> , n. sp.
<i>Colour</i> : pale, bright bronze .....	brownish-bronze.
<i>Antennae</i> yellow, slightly infusate at base	bronze.
<i>Femora</i> : apical 3rd yellow, tibiae also more or less pale.	with pale band near (but not including) apex, tibiae dark.
<i>Prosternum</i> finely transversely striolate-punctate at middle, with large, close punctures at sides.	sparsely punctate throughout.
<i>Abdomen</i> : basal segments with well defined longitudinal striae.	vaguely punctate.
<i>Dimensions</i> 8×3½ mm. ....	11×4 mm.

## ADELIUM PORCATUM F., var. FULGENS, n. var.

There is a striking colour variety of this common species, having the upper surface a brilliant violet-bronze colour, for which I propose the name *fulgens*. I have two examples from Bellingin and Nambucca River respectively.

## SEIROTRANA DAVIDSONI, n. sp.

Oblong-ovate; nitid coppery-bronze above, appendages and underside dark (almost black) bronze.

*Head* and *pronotum* closely and coarsely rugose-punctate, clypeus slightly reflexed, antennal segments shortly subconic, the three apical segments opaque-black. *Prothorax*: apex arcuate-emarginate, front angles finely rounded at tips, base truncate, sides well rounded, widest at middle, widely sinuate behind, angles subrectangular; margins with coarse irregular crenulations, chiefly on basal half; disc very coarsely punctate and rugose, with some small smooth areas near middle, sides and base with large subconfluent punctures. *Elytra* slightly wider than prothorax at base, epipleural fold evident on rounded humeri, narrow horizontal margin seen from above for one-third of the length; seriate-punctate, intervals (except the 7th) scarcely catenulate, the 3rd, 5th and 9th furnished with elongate humps of uneven size, becoming pustulose towards apex, those on the 7th subcostiform; intervals wide and sparsely bearing small nodules, irregularly placed; seriate punctures large and round on lateral half, smaller and somewhat elongate in the geminate rows next the suture. Underside finely striolate, the hind intercoxal process rectangular with rounded angles. *Dim.* 18-19 × 8 mm.

*Hab.*—N. S. Wales: Kindee, Hastings River district. (H. J. Davidson and H. J. Carter.)

Three examples taken in October in forest country. It can only be confused with *S. major* Bkckb., from which it is separated by its much more nitid surface, more coarsely sculptured prothorax and different elytra. In *major* the catenulations are costiform, that on the 3rd interval almost continuous for a great part. Holotype in Coll. Carter.

## Family CISTELIDAE.

## MELAPS STRIATUS, n. sp.

Obovate; nitid black above and below, lightly pubescent; antennae and legs piceous, tarsi red.

*Head* sparsely punctate, epistoma subcircular, eyes round, prominent and widely separated, antennae rather stout, 3-8 subequal in length, segment 3 lineate, 4-8 gradually more widened at apex, 9-11 wanting. *Prothorax*: apex subtruncate, its angles depressed and blunt, base feebly bisinuate, with deep foveae near angles, these obtuse; widest in front of middle, sides thence very lightly rounded to base, strongly so to apex; disc with fine, shallow punctures, without medial line. *Scutellum* transverse, impunctate. *Elytra* convex, of same width as prothorax at base, widest behind middle; striate, the striae very fine but well marked, especially the two nearest suture, intervals flat, rather strongly punctate, punctures largest near base, gradually smaller towards apex, in places giving an appearance of seriate arrangement; lateral border not seen from above, lightly pubescent at sides and on apical declivity. *Sternal regions* coarsely, *abdomen* finely, punctate, the latter with sparse recumbent hair, femora swollen, tibiae stout, basal segment of hind tarsi as long as the rest combined. *Dim.* 8 × 3 mm.

*Hab.*—South Queensland: Eukey. (F. E. Wilson.)

A single example is near *M. victoriae* mihi in form and fine elytral striae, but it differs strongly in wider prothorax, pubescent surface and different elytral sculpture. Holotype in Coll. Wilson.

Family DASCILLIDAE.

*Dascillus brevicornis* Macl. cannot be retained under this genus, in which, *inter alia*, the palpi are subsecuriform or triangular at apex and the antennae filiform. The name *Notodascillus* is here proposed, and a second species is described below.

NOTODASCILLUS, n. gen.

Palpi subulate or narrowly ovoid. Antennal segments 3-10 serrate. Mandibles prominent, toothed. Prosternal process acute, narrow, separating the fore-coxae but not produced beyond them. Coxae widely open behind. Mesosternum and metasternum sulcate. Tarsi bilobed, 3rd and 4th segments enlarged and lamellate beneath.

Genotype, *Dascillus brevicornis* Macl.

*N.B.*—The unique type of *D. brevicornis* Macl. in the Australian Museum has lost its abdomen.

NOTODASCILLUS SUBLINEATUS, n. sp. Figure 2.

Oblong, subparallel; subnitid reddish-brown, head darker, upper surface strongly, lower lightly, pubescent.

*Head*: Eyes large, round and prominent, a triangular suture separating epistoma from forehead; antennae: segment 1 oval, 2 small, triangular, 3 larger than 2, serrate, 4-10 subequal, widely serrate externally, each forming an elongate triangle, lightly emarginate on inside, 11 rather longer than 10, cylindrical. Closely pubescent. *Prothorax* nearly twice as wide as long, widest at base, sides narrowing gently and arcuately to apex, here not as wide as head, apex truncate, base lightly bisinuate, anterior angles rounded off, posterior subrectangular, lateral margins entire, faintly recurved behind, disc rather flat, sulcate in middle, punctate and covered with pale, decumbent hair. *Scutellum* large, subcircular. *Elytra* wider than prothorax at base, twice as long as wide, shoulders bluntly rounded, sides subparallel, separately and rather sharply rounded at apex; margins a little explanate on apical half and strongly bristled. Striate-punctate, the striae punctures close and regular, intervals lightly convex, this emphasized by lines of pale tomentum along suture and alternate intervals 3, 5, 7, 9, 11, these connected in pairs towards apex, the six lines becoming three on apical declivity. Front coxae very close, but not contiguous, mesosternum narrowly, metasternum widely, sulcate; tibiae armed with two sharp spines at apex. Last segment of abdomen produced in middle into a subtriangular lobe. *Dim.* 10 × 3½ mm.

*Hab.*—Queensland: Bunya Mountain; N.S.W.: Hastings River (H. J. Carter), Upper Williams River (F. E. Wilson).

A fine species having the general facies of the European *Dascillus cervinus* L., not uncommon in this region. Holotype in Coll. Carter.

The two species described by me as *Dascillus serraticornis* and *D. oblongus* are also erroneously placed, but differ from *Notodascillus* in having the head vertical, the anterior part of the prothorax narrowed and convex, and in the narrower tarsi. They appear so near *Epilichas* White, that I would, for the present, include them in this genus. An example of *Epilichas flabellatus* Kiesw. has been sent me for examination. This differs from my species in having



pectinate antennae, but I am not sure if that distinction is generic; in certain families (e.g. Lampyridae) this distinction is merely sexual. Mr. F. H. Taylor, of the School of Tropical Medicine, has given me another species, certainly congeneric with the above two.

EPILICHAS VARIEGATUS, n. sp.

Elongate-ovate; opaque brown, pronotum and elytra variegated by patches of pale red pubescence; on the latter forming some 8 or 9 irregular and discontinuous fasciae. Legs and underside dark brown, antennae and tarsi paler.

*Head*: Eyes large and prominent, antennae long and finely serrate, segment 1 stout, 2 very small, 3-10 successively shorter, 11 lanceolate. *Prothorax*: apex rounded and narrower than head, sides rather abruptly widened behind middle, basal third of sides nearly straight; base strongly bisinuate, its margins finely serrulate; whole surface clothed with pubescence of two colours, the dark ground-colour having short velvety clothing, the reddish hair chiefly at sides, base and two vague elongate branches on disc, of longer texture; two round deep foveae near base, one near each basal situation. *Elytra* as wide as prothorax at junction, slightly widening at shoulders, thence lightly narrowed to apex; striate, the striae without distinct punctures, largely concealed by clothing, except near base and apex; intervals here, and on smooth areas between fasciae, wrinkled, the pale hair forming a variegated surface and longest at sides. On the hind tarsi the basal and claw segments of about equal length, segments clearly lamellate, but not enlarged. *Dim.* 11 × 4 mm.

*Hab.*—N. Queensland: Millaa-millaa (Mr. F. H. Taylor).

A single example is very distinct from the other two by its variegated surface, of which only small areas near base and apex of elytra are subnitid and free from pubescence. The two basal foveae on pronotum are notable but may be individual. The prothorax is more than usually narrowed and convex anteriorly. Holotype in Coll. Carter.

MACRODASCILLUS, n. gen.

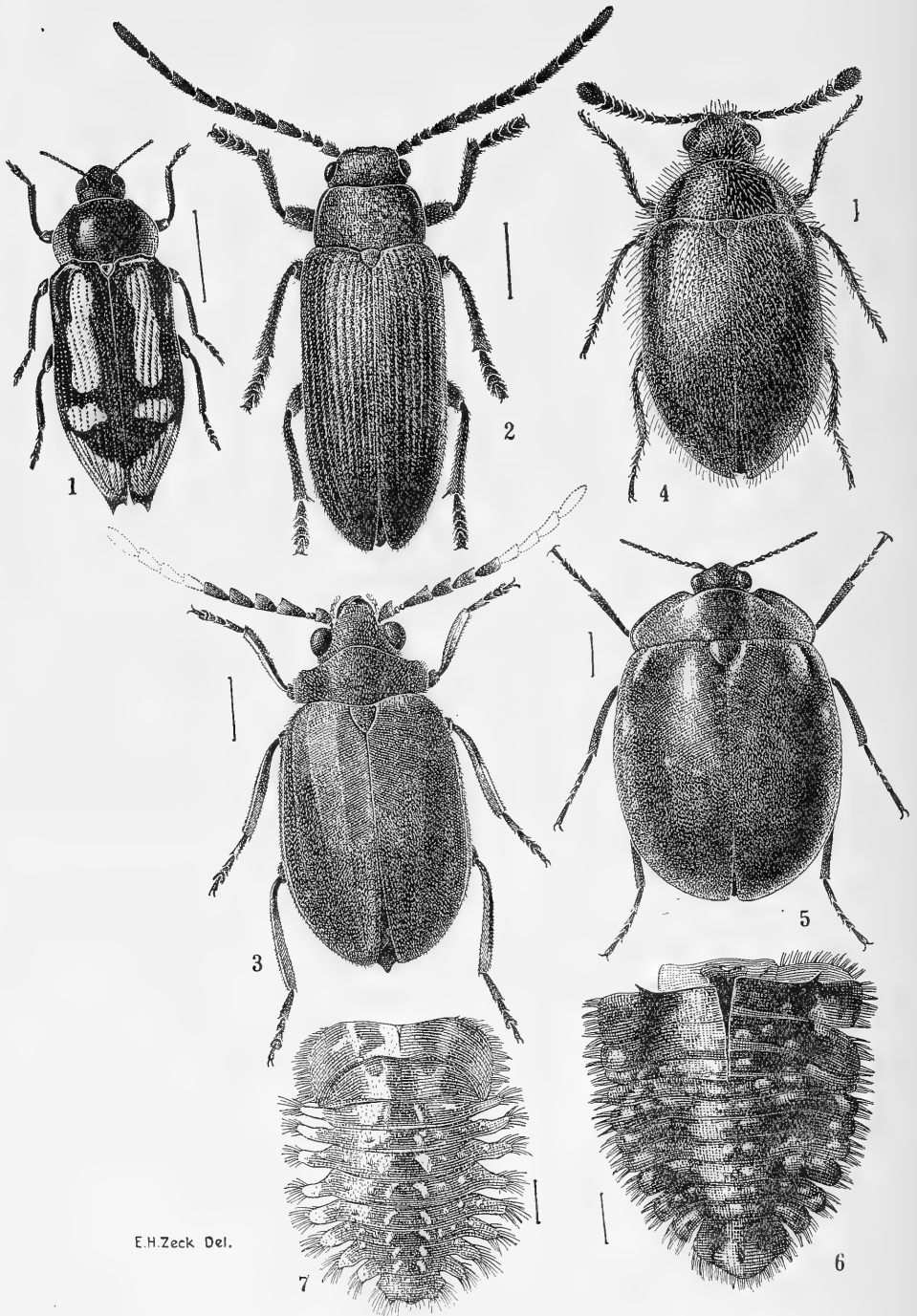
Body oval, convex. Head wide, hollowed beneath, eyes very prominent, clypeal suture not visible, mandibles acute and prominent, mentum triangular, maxillary palpi linear, apical segment more slender than the three preceding, labial palpi stout, apical segment subsecuriform, with lobate appendages at base; antennae long, extending beyond prothorax, dentate-serrate, segment 1 very wide, 2 and 3 very small, 2 bead-like, 3 cupuliform, 4-10 forming triangular serrations, 11 elongate-ovate. Prothoracic margins thin and sharply bordered, pronotum scarcely articulate with mesosternum. Hind coxae contiguous, its plates dilated; anterior and middle coxae approximate. Tarsi simple, slender, the penultimate segment only, lamellate.

A genus suggestive of *Dascillocyphon* Everts, from Sumatra, as figured by the author (*Tijdsch. v. Ent.*, 1909, p. 10), but differing very much in the structure of antennae and tarsi.

MACRODASCILLUS DENTICORNIS, n. sp. Fig. 3.

Oval, convex, nitid brownish-red above, subopaque beneath and with the appendages red; surface with sparse, short, recumbent pubescence.

*Head*: epistoma square, labrum prominent, minutely punctate. *Prothorax* very transverse ( $1\frac{1}{2} \times 3\frac{3}{4}$  mm.), apex strongly bisinuate, medial lobe wide, angles emarginate but rounded at extremity, base widely bisinuate, angles obtuse, widest



E.H.Zeck Del.

- 1.—*Stigmodera (Castiarina) erasma*, n. sp. 2.—*Notodascillus sublineatus*, n. sp.  
 3.—*Macrodascillus denticornis*, n. sp. 4.—*Trichelodes delicatula*, n. sp.  
 5-7.—*Sclerocyphon irregularis*, n. sp. (6, larval exuvia; 7, pupal exuvia.)

near base, sides lightly rounded and converging to apex, disc smooth and obfuscate, minutely punctate. *Scutellum* large, triangular. *Elytra* obovate, humeri not prominent, everywhere with light, close punctures, each with three very lightly raised costae. Underside smooth and almost impunctate, a thin pubescence at margins of segments. Legs moderately long, hind tarsi with basal segment as long as rest combined. *Dim.* 10 × 5 mm.

*Hab.*—N.S.W.: Barrington Tops (T. G. Sloane).

A single example (? female) of this interesting species was taken in January, 1921, and given to me. The antennae are remarkable, in the small 2nd and 3rd segments between the very wide 1st and the large triangular 4th. On its original card one antenna was complete but was, unfortunately, broken in remounting. General facies (except for antennae and head) of *Macrohelodes*. Holotype in the National Museum, Melbourne.

MACROHELODES VITTATUS, n. sp.

Elliptic, moderately convex; nitid, head, pronotum, palpi and 7 apical segments of antennae black, pronotum with narrow band of yellow within margin, legs and basal segments of antennae red. *Elytra* infusate (reddish-brown) with 5 subcostate yellow vittae, the 1st sutural, the 5th marginal, the 2nd, 3rd and 4th equally spaced between these. Underside infusate reddish or black.

*Head* rather closely punctate, with two foveae symmetrically placed between eyes. *Pronotum* punctate with a tendency to longitudinal rugosity on basal half. *Elytra* strongly, irregularly punctate. *Metasternum* strongly punctate, abdomen finely pubescent. *Dim.* 8-9 × 4-4½ mm.

*Hab.*—N.S.W.: Bulli (H. J. Carter), Hazlebrook (J. Armstrong).

While aware of the great variability of colour and pattern in this genus, as pointed out by Lea (*Trans. Roy. Soc. S. Aust.*, 1919, p. 249), I consider the three examples I am describing distinct from the variable *crassus* Blkb. by the more elliptic, less convex form and more strongly punctured surface (especially of head and pronotum), as well as by the more explanate sides and less bisinuate base of the prothorax. Lea also refers to "three vague longitudinal pale stripes on each" (elytron) of *gravis* Blkb., but in *M. vittatus* there is no vagueness, but clearly marked, raised lines. My pair appear to be the sexes, the male being darker above and below than the female. Type in Coll. Carter.

TRICHELODES, n. gen. Dascillidarum.

Oval, convex. General form that of *Macrohelodes*.

*Maxillary palpi* with apical segment elongate-ovate, almost subulate. *Antennae*: segment 1 oval, 2-4 cylindric, 5-6 shorter and narrower than 4, 7-10 increasingly transverse, serrate on inside, 11 ovate, as long as 9-10 combined. *Legs* very slender, tarsi especially so, not apparently lobed beneath. *Head* vertical, eyes large and widely separated, insertion of antennae rather close. *Underside* somewhat as in *Macrohelodes*, fore coxae transverse and approximate, but mid and hind coxae more widely separated than in that genus.

TRICHELODES DELICATULA, n. sp. Fig. 4.

Nitid reddish-brown. *Prothorax* obconic, as wide as elytra at base and closely adapted to it, base lightly bisinuate, apex rounded, the medial part produced over head, its angles obsolete and deflexed, margins widely foliate behind, the foliation disappearing towards apex, but for the greater part separated from disc by a punctate sulcus; whole upper surface, except head and the middle regions

of pronotum and elytra, with long, upright, red bristles; disc of pronotum almost impunctate, margins setose, extreme border finely crenulate. *Elytra* distinctly gibbous at shoulders, the bristles clothing the sides and apical third, leaving a considerable area bare, this region finely, irregularly and sparsely punctate. Under-side, except the raised, nitid, central area of metasternum, with long reddish, decumbent hair. *Dim.* 2 mm. long.

*Hab.*—Queensland: Roma (F. H. Taylor).

I am indebted to Mr. Taylor, of the School of Tropical Medicine, for this interesting little novelty, unfortunately unique. Holotype in Coll. Carter.

For the excellent drawing of this species, as for the other figures illustrating this paper, I am indebted to Mr. E. H. Zeck, the foremost entomological artist in Australia.

#### SCLEROCYPHON Blkb.

A genus interesting biologically, since, though commonly found on foliage near streams, it has been found (larva, pupa and imago) existing under water, associated sometimes with Dryopidae on submerged logs. This association is intensified by a striking similarity of the larvae of the two families. Yet the imagines are widely different in form, being widely ovate, like a somewhat flattened *Paropsis*. The genotype is *S. maculatus* Blkb., described from the Victorian Alps. It is, however, widely spread in Queensland, New South Wales, Victoria, and Tasmania. I have examined 42 examples of it, including two so labelled in Blackburn's handwriting. The localities include Queensland National Park, Dorrigo, Sydney, Warburton, Kinglake (V.), S. Morang (V.) and Tasmania. In no case, nor in other species, have I seen the carina on the antepenultimate ventral segment mentioned by the author for a male character, though undoubted males were examined. Lea states that in *S. striatus* the 2nd and 3rd abdominal segments are feebly carinate. Lea described four species, *striatus*, *serratus*, *basicollis* from Tamworth, *aquaticus* from Tasmania. I have three examples, determined by Lea as *basicollis*, from the Williams River; a cotype of *aquaticus*, taken by myself when collecting with Lea at Waratah is also before me. I have not seen *striatus* or *serratus*. Lea says of *aquaticus*, "the junction of the prothorax with the scutellum and elytra is very finely serrated". This is true of all examples of the genus so far seen, but I cannot find the serration on the "apex of penultimate abdominal segment" in *basicollis* as in the description. But in this, as in other species, the apical margin is fringed with short hairs, which could easily be mistaken for serration except under the binocular microscope.

#### SCLEROCYPHON IRREGULARIS, n. sp. Figs. 5-7.

Widely oval, strongly convex; upper side reddish-brown, unequally clothed with fawn-coloured pubescence, underside reddish-brown, antennae and legs dark, tarsi red.

*Head* almost withdrawn within prothorax, eyes not prominent, antennae short, slender, its segments short, subequal and linear. *Prothorax* with medial third very convex, nitid and very minutely punctate, marginal two-thirds thickly pubescent. Apex strongly emarginate, its angles widely rounded off but prominent, base bisinuate, its margins, as also of the opposing elytra, finely denticulate, posterior angles subfalcate; widest at basal fourth, sides widely rounded here, thence arcuately converging to apex. Margins widely foliate. *Scutellum* widely, arcuately triangular. *Elytra* obovate, more or less strongly pubescent save for abraded raised areas, giving an uneven surface, humeral callus, a convexity near

each side of scutellum and the area of maximum convexity behind middle thus denuded and punctate; one or two subobsolete costae with transverse rugae present, otherwise displaying a mottled surface with a few white patches. Abdomen strongly punctate. *Dim.* 6-7 × 4½-5 mm.

*Hab.*—Victoria: Belgrave and Warburton (F. E. Wilson); N.S.W.: Dorrigo (W. Heron, in Coll. Carter).

Three examples before me differ from *aquaticus* Lea in larger size (especially width), greater convexity, irregularity of surface and the variegated colour. Holotype in Coll. Wilson.

*N.B.*—Mr. Wilson's example was selected for type since with it came both larva and pupa case, a rare capture deserving illustration.

#### SCLEROCYPHON BICOLOR, n. sp.

Ovate, convex; nitid-black above, prothorax with margins widely red, prosternum, abdomen, and antennae red, meso- and metasternum, also legs, black, tarsi red beneath, the whole lightly pubescent.

*Head* largely enclosed by emarginate prothorax, eyes little seen from above, antennae short, lineate, segments close. *Prothorax* widest at base, thence arcuately converging to apex, anterior angles obtuse, base bisinuate, posterior angles acute, surface finely punctate, pale pubescence on margins and base. *Scutellum* arcuate-triangular. *Elytra* closely fitting prothorax, at the junction both margins finely denticulate; obovate, margins narrowly foliate, humeral callus prominent, surface with subobsolete striation and some feebly raised lines (three traceable on one example), everywhere punctate, transverse rugae seen on raised lines. Sternal regions longitudinally strigose. *Dim.* 4-5 × 3-3.6 mm.

*Hab.*—N. Queensland: Kuranda (F. P. Dodd), in Coll. Carter, Endeavour River (French, Coll. National Museum).

Four examples examined can be readily distinguished by nitid black surface and comparatively sparse pubescence. The black medial area of the pronotum occupies about one-third of the surface; the symmetrically coloured bright red sides being quite distinct from the irregular pale patches sometimes found in *S. maculatus*. Type series, 3 on card, Holotype indicated by arrow, in National Museum.

*Elodes olliffi* Blkb.—This comes so close to *E. (Cyphon) australis* Erichs. that there is some doubt as to their distinction. The only separating characters in the descriptions lie in colour and dimensions: *australis* obscure testaceous, 2½ lines long; *olliffi* obscure fuscous, 3 lines long.

The species determined as *australis* Er. is slightly more ovate, with only the barest sign of longitudinal lines on some examples, the pronotum more or less infusate. Examples from Tasmania, Victoria and S.W. Australia. Five examples taken by myself in S.W. Australia are a little larger and more strongly punctured than others, but two examples in the Australian Museum from King George's Sound are identical with Tasmanian examples. The species determined as *E. olliffi* Blkb. is from New South Wales, Victoria and South Australia.

*Elodes scalaris* Lea is a large, elongate species, of which 23 examples are before me, ranging from a specimen in the South Australian Museum, labelled "sent by Lea as *H. scalaris*", dimensions 10 × 6 mm. This is without antennae and firmly glued to a card. Others range from 9 × 4½ to 7 × 3¾ mm. and are from Dorrigo, Blue Mts., and Evelyn (Vic.). The smaller examples approach *E. olliffi* Blkb. but are distinguished by the longer antennae and extremely fine surface punctures.

## ELODES VARIEGATA, n. sp.

Oblong-obovate, rather flat, subnitid; head and pronotum reddish-brown, discal area infusate, elytra brown, irregularly variegated with pale pubescent areas. In the type (Warburton) example, these pale areas predominate and tend to form irregular, zig-zag fasciae on apical declivity. In a second example the dark areas predominate, the pubescence forming rounded spots in sutural region. Scutellum, underside, legs and antennae red, the second tending to fuscous at sides and apex.

*Head* rather wide, pubescent, eyes prominent, antennae long, segment 1 tumid, 2, 3 very short, 4-11 elongate, lineate, 4 slightly longer than rest. *Prothorax*: apex widely arcuate, its angles rounded, base bisinuate, posterior angles subrectangular, widest at base, sides thence arcuately narrowed to apex, margins widely foliate, disc pubescent, its surface a little uneven. *Scutellum* large, triangular. *Elytra* widest behind middle, wider than prothorax at base, finely punctate and transversely striolate, sculpture generally concealed by pubescence, three clearly elevated lines on each. Tibiae with a short spine at apex. *Dim.* 8 × 4 mm.

*Hab.*—Victoria: Warburton, Belgrave, Millgrove (F. E. Wilson); N.S.W.: Dorrigo (W. Heron in Coll. Carter).

Structurally similar to *E. olliffi* Blkb., it is readily recognizable by its large size and mottled surface. The Warburton example has been selected as Holotype since it is the only one having an undamaged antenna. Holotype in Coll. Wilson.

## ELODES COSTELLIFERA, n. sp.

Oblong-oval, convex; black, subnitid, margins of prothorax and parts of legs reddish; sparsely pubescent.

*Head* densely pustulate and pubescent, antennae rather short, its segments sublineo-conic, much shorter than in *E. variegata*, 4-10 subequal, 11 ovate-lanceolate. *Prothorax*: apex feebly, base more strongly, bisinuate, all angles rounded off, anterior very widely so, widest at base, sides arcuately narrowed to front, margins widely foliate, disc closely and strongly punctate, punctures larger near base and margins, sparsely clad with silvery pubescence, with an arcuate transverse depression near middle, and a sulcus within the narrowly raised basal margin. *Scutellum* large, triangular and punctate. *Elytra* wider than prothorax at base, feebly widened behind middle, everywhere coarsely punctate, each with three raised lines, more evident than usual, these irregularly granulate, signs of striation near suture; bristly pubescent near margins, this more reclinate and silvery towards apex. Underside very finely punctate and pubescent. *Dim.* 7 × 4 mm.

*Hab.*—Victoria: Ferntree Gully (F. E. Wilson), Mt. Buffalo (Blackburn Coll. in S. Aust. Museum).

Shorter and more convex than preceding, and more coarsely sculptured than any species known to me. Both examples are male. Holotype in Coll. Wilson.

Var. or n. sp.—Another example from Ferntree Gully in Mr. Wilson's collection can only be distinguished by its red colour (somewhat infusate on pronotum, legs and antennae black).

## ELODES DAVIDSONI, n. sp.

Upper surface, except extreme margins of prothorax, brownish-black, subnitid; prothorax with very narrow, pale red margins. A dense silvery pubescence on

sides and apex of elytra and sides of prothorax; underside and legs red, antennae with 3 basal segments yellow, the rest black.

*Head* much narrower than prothorax, labrum prominent, nearly square, eyes prominent and round. Antennae long and slender, segments 2-3 short, 4-5 stouter than the succeeding segments. *Prothorax*: apex widely, evenly arcuate, angles rounded off, base bisinuate, widest at base, here about three times as wide as the length; hind angles obtuse; surface, like that of two-thirds of elytra, delicately and closely punctulate, without foveae or medial line. *Scutellum* widely triangular. *Elytra* of same width as prothorax at base, sides nearly parallel for the greater part, each showing two light costae. *Dim.*  $6 \times 2\frac{1}{2}$  mm.

*Hab.*—N. S. Wales: Hastings River district.

Two examples were taken by my companion on a recent trip (Oct., 1934). It is more parallel and less convex than *E. olliffi* Bickb., with even finer sculpture, besides the colour distinction. Holotype generously given me.

ELODES TIGRINA, n. sp.

Elongate-elliptic; red strongly suffused with black above, underside and legs red.

*Head* pubescent, eyes prominent, antennae long, slender and lineate, basal segments red, 4-11 infusate, 3-10 subequal, 11 slightly longer than 10. *Prothorax* with semicircular outline, a large, black macula at middle of base. Base sinuate, hind angles rectangular. *Scutellum* large, triangular, red. *Elytra* obovate, wider than prothorax at shoulders, widest behind middle; red, with irregular reticulation and suffusion black; the red markings forming irregular stripes at suture and towards sides, elsewhere appearing as spots, suggesting its name. Each elytron with two or three raised lines, the whole surface pubescent, strongly so at sides and apex. Underside glabrous, the female with apical segment of abdomen carinate. *Dim.* ♂,  $6 \times 3\frac{1}{2}$  mm.; ♀,  $8 \times 4$  mm.

*Hab.*—N.S.W.: Mt. Kosciusko (A. J. Nicholson).

A pair, taken *in cop.* by Dr. Nicholson, were in the Entomological Department of the University of Sydney. There is little difference, except in size, between the sexes. Holotype and Allotype in the Macleay Museum.

## THE MARINE ALGAE OF LORD HOWE ISLAND.

By A. H. S. LUCAS, M.A., B.Sc.

[Read 26th June, 1935.]

This account of the sea-weeds of Lord Howe Island is based on observations and collections made by Mrs. F. Perrin and myself during a stay on the island in the winter of 1933, from 22nd May to 7th July. We were greatly helped by the practical assistance of Mr. Gower Wilson, a leading resident of the island. Mr. Wilson has an intimate knowledge of the shores, reefs and waters, and by aid of his motor launch and rowing boat we were able to make landings on the reef which protects the lagoon, to reach the plants growing in the lagoon itself, and to visit the more distant beaches. He also provided ample space and means for storing and mounting our gatherings.

Further material was available in a large collection made by Mr. J. H. Maiden in 1898, preserved in the Herbarium of the Botanic Gardens, Sydney, and in extensive collections made by Mr. R. Baxter, another resident, which came into my hands by the courtesy of Dr. Charles Anderson, Director of the Australian Museum, and of Dr. Darnell Smith, the late Curator of the Sydney Botanic Gardens. Mr. F. A. McNeill and Mr. A. Livingstone added a few more specimens, which they obtained during their explorations of the marine fauna of the island.

For the large number of specimens gathered and the rapidity and skill with which they were treated I wish to acknowledge my great indebtedness to the whole-hearted and untiring energy of my colleague, Mrs. Perrin.

### *The Algae of Lord Howe Island.*

#### CHLOROPHYCEAE.

<i>Ulva Lactuca</i> L.	<i>Caulerpa fastigiata</i> Mont.
<i>Enteromorpha Howensis</i> , n. sp.	<i>C. taxifolia</i> (Vahl) Ag.
<i>Chaetomorpha aërea</i> (Dillw.) Kuetz.	<i>C. thujoides</i> J. Ag.
<i>Cladophora Goweri</i> , n. sp.	( <i>C. Brownii</i> Endl.)
<i>Spongocladia vaucheriiformis</i> Aresch.	<i>C. racemosa</i> Forsk.
<i>Dictyosphaeria favulosa</i> (Mert.) Dcne.	<i>C. peltata</i> Lamour.
<i>Cladophoropsis Howensis</i> , n. sp.	<i>Chlorodesmis major</i> Zan.
<i>Valonia Forbesii</i> Harv.	<i>Codium Lucasii</i> Setchell.
<i>V. confervoides</i> Harv.	<i>C. spongiosum</i> Harv.
<i>V. pachynema</i> (Harv.) von Martens.	<i>C. bulbopilum</i> Setch.
<i>Acetabularia calyculus</i> Quoy & Gaimard.	<i>C. indicum</i> Setch.
<i>Bryopsis plumosa</i> (Huds.) Ag.	<i>C. cuneatum</i> Setch. & Gardn.

#### CHLOROPHYCEAE.

##### ULVA L.

##### ULVA LACTUCA L.

Growing in winter (June, July) abundantly on the floor of the lagoon on coral boulders, at the depth of 1 or 2 fathoms. Gower Wilson said that in summer plants of 4 or more inches diameter appear on the rocks bordering the



lagoon, and on the reefs, but we only met with a very few stunted specimens in these situations.

The fronds elongated, up to  $30 \times 20$  cm., with a limited attachment area, much divided into elongate lobes with undulate margins and broad rounded apices. The colour a bright light-green. The fronds regularly distromatic, the cells elongated at right angles to the surface. Among them, in one of the plants examined, were scattered much larger rounded green bodies, perhaps parasitic.

ENTEROMORPHA Link.

ENTEROMORPHA HOWENSIS, n. sp.

Forming soft vividly light-green mats on rocks covered at high tide at Ned's Beach. The plants are gregarious, growing close together with their bases buried in fine coral sand. Each has an erect stem about 10 mm. in height, tapering upwards from an enlarged base  $112-202\mu$  in diameter, and branching from the very base. Branches crowded, emerging on all sides at a wide angle, nearly as long as the central axis but slenderer,  $40-90\mu$  diameter, and again bearing similarly numerous, very much shorter and slenderer branchlets. All apices obtuse. The cells very small and compacted, subequal in length and width ( $3\mu$ ), the endochrome filling the greater part of the cell.

Frondes densissime pulvinatae; singulae pusillae, ad 10 mm. altae, erectae, strictae, omnino ramosae, basi incrassatae,  $112-202\mu$  diam., superne attenuatae; rami crebri, lato anguli exsurgentes, longi,  $40-90\mu$  diam., crebris brevioribus tenuioribus ramellis. Apices obtusi, cellulae compactae parvulae,  $3\mu$  diam. Color pallide laetevirens.

CHAETOMORPHA Kuetzing.

CHAETOMORPHA AËREA (Dillw.) Kuetz.

In clumps, much eaten down, on half submerged rocks on Blinkenthorpe Beach and the Old Gulch.

Filaments erect, rigid, light pale-green. Cells as long as, or shorter than, broad; about  $585\mu$ , contracted somewhat at the genicula.

CLADOPHORA Kuetz.

CLADOPHORA GOWERI, n. sp. Pl. v, fig. 1; Text-fig. 1.

Radical apparatus a small irregular disc from which rise a number of intricate fronds.

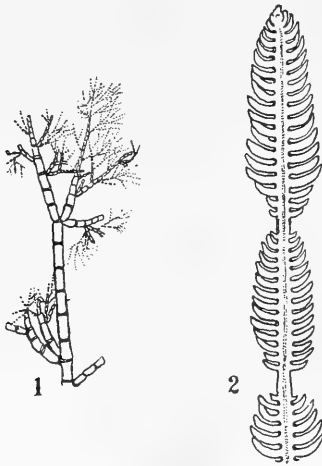
Fronds nitellaeform, 15-20 cm. high, repeatedly di-trichotomous or more often verticillate or fascicled. The branches shorten as they ascend, the ultimate whorls 2 or 3 mm. in length. Terminal segments of the ramelli are commonly and strongly recurved. Apices obtuse. Diameter of main stems  $450-600\mu$ , of branches diminishing to  $150\mu$ , of ultimate segments  $20-30\mu$ . Integuments and septa, especially of the main stems, lamellose. Articulations of main stems fairly uniform throughout, about  $4 \times 1$ , of ramuli 2,  $3 \times 1$ , cylindrical, not constricted at the joints. Colour a bright green (laetevirens).

Isolated plants growing on the floor of the lagoon at a depth of 2-4 fathoms.

Named after Mr. Gower Wilson, who with his boat and rake and intimate acquaintance with the lagoon and the coasts of Lord Howe Island was of the greatest help to us in our investigations.

Frondes intricatae exsurgentes e disco parvulo; singulae nitellaeformes, 15-20 cm. altae, repetite di-trichotomae vel saepius verticillatae aut fasciculatae. Rami superne gradatim breviores, verticilli ultimi 2, 3 mm. longi, saepe fortiter

recurvati. Apices obtusi. Diam. caulis 450–600 $\mu$ , ramorum 150 $\mu$ , segmentorum terminalium 20–30 $\mu$ . Integumenta septaque lamellosa. Articuli caulis circ. 4 x 1, ramulorum 2, 3 x 1, cylindrici non geniculis constricti. Color laetevirens.



Text-fig. 1.—*Cladophora Goweri*, n. sp., with epiphyte.  
Text-fig. 2.—*Caulerpa taxifolia* (Vahl) Ag.

#### SPONGOCLADIA Areschoug.

##### SPONGOCLADIA VAUCHERIFORMIS Aresch.

Growing on coral blocks or fragments, like a sponge, so closely attached to the rugosities of the coral that it cannot be removed without tearing. Compacted below but presently breaking into thick, free, irregularly dichotomous or digitate lobes reaching a height of to 10 cm. Thickness of the lobes to 1 cm. Lobes mostly terete but sometimes compressed. Apices of lobes very blunt, mostly rounded but occasionally somewhat pointed. Lobes often adhering together. Colour a light green.

The whole mass composed of a dense, closely compacted felt of filaments not to be separated and disentangled without tearing. Filaments pseudo-dichotomous at long intervals, with acute sinuses, 80–125 $\mu$  in diameter, irregularly articulate, joints from 1 to several mm. long, apices rounded obtuse.

The plant seems to answer to Areschoug's description.

#### DICTYOSPHAERIA Decaisne.

##### DICTYOSPHAERIA FAVULOSA (Mert.?) Dcne.

Growing in shallow pools on the reef, closely appressed for the most part to the rock surface. The margins monostromatic but the central attached part thick, in two or more layers. The cells of the mesh 600–800 $\mu$  in diameter. Of a rather dark green. Our largest plants were about 2 inches across.

Clearly the tropical form and differing from the *D. sericea* Harv. of our temperate regions in South Australia, Victoria and Tasmania. In all the many specimens I have gathered of *D. sericea* the cells of the mesh were very much smaller, measuring about 200 $\mu$ , and only very exceptionally reaching 300 $\mu$ . The colour of the growing plants of *D. sericea* is a vivid green.

CLADOPHOROPSIS Børgesen (= *Siphonocladus* Schmitz.).

## CLADOPHOROPSIS HOWENSIS, n. sp.

Irregularly ovate cushions to 10 cm. long, 5-8 cm. broad, with the habit of an Aegagropilous *Cladophora*. Soft, dense and spongy. Unicellular, much but rather distantly branched, branches intricate. Segments long intricate, usually straight and free, sometimes two approximating adhere by their adjacent convexities. Altogether and uniformly filiform, fila 150-225 $\mu$  in diameter. Apices round obtuse, not clavate. Cell membrane finely striated longitudinally. Endochrome saccate. Colour of the cushions dark green.

Frons pulvinum, ad 10 cm. longum, 5-8 cm. latum, more Cladophorae (Aegagropilae) efficiens, densa, mollis, spongiosa, copiose admodum distanter ramosa. Rami intricati; ramuli plerumque liberi nonnumquam adhaerentes. Omnino filiformis inarticulata; fila uniformiter 150-225 $\mu$  diam. Apices rotundato-obtusi, nec clavati. Color obscure virescens.

## VALONIA Ginnani.

## VALONIA FORBESII HARV.

Growing in small clumps in the pools of the outer reefs. A sessile form, mostly about 2 cm. high, obovate-pyriform.

I have this species from the Low Islands off Port Douglas, from the Michaelmas Cay off Cairns, and from Magnetic Island off Townsville. The northern plants are larger than those from Lord Howe, 2.5 to even 4 cm. long and much more attenuated into a pedicel.

It has a wide range in the tropics from Ceylon, the Friendly Islands, Tahiti to the Loo Choo Group and the Sandwich Islands.

## VALONIA PACHYNEMA (Harv.) von Martens.

Loose, not spongy, cushions, 10-16 cm.  $\times$  8-10 cm. and 2-4 cm. thick. Composed of a felt of intricately branched. No articulations. Branches loosely dichotomous or repeatedly but irregularly umbellate, axils rather acute. Fila coarse to 0.9 mm. in diameter. The saccate character of *Valonia*. Apices rounded obtuse. Bright green.

v. Martens obtained his plant from Sumatra. It seems to be near to *V. Cladophora* Kuetz. from New Caledonia. I have not seen specimens of either, and offer my determination with hesitation. The Lord Howe plant is a very definite form, but so intricate that it is difficult to dissect it out to discover the method of attachment and the exact ramification. We only found cast up specimens and did not observe it growing.

## VALONIA CONFEROIDES HARV.

Widespread caespitose, the lower part of the frond unbranched, the upper part branching, the branches subumbellate. All filaments nearly uniform, about 1 mm. diameter. Apices obtuse.

Collected by R. Baxter in 1922.

Widely distributed in warmer seas of all the oceans.

Recorded from Stone Island and the Bloomfield R., N. Queensland.

## ACETABULARIA (Tourn.) Lamouroux.

## ACETABULARIA CALYCVLUS Quoy &amp; Gaimard.

A single plant was found, growing on a coral block dragged up from the floor of the lagoon in shallow water.

The Australian plant was obtained by Freycinet in Western Australia. Clifton dredged it at Fremantle. I have it from Dongarra, and from Cottesloe, found by Miss Iris Banks growing on submerged rocks in the estuary of the Swan River. On the East Coast I have gathered it growing luxuriantly on dead oyster shells in Lake Macquarie, and scattered specimens at Sandgate, near Brisbane. I have specimens collected by Harvey at Newcastle, as well as others he had collected in Tonga. Dickie recorded it from Mauritius. It is thus evidently a plant of wide distribution on moderately warm shores, and is not recorded by Laing from New Zealand.

Kilner discovered a much larger form, *A. Kilneri* J. Ag., in tropical Australia at Edgecombe Bay.

BRYOPSIS Lamour.

BRYOPSIS PLUMOSA (Huds.) Ag.

Reinbold determined the Norfolk Island *Bryopsis* as *B. foliosa* Sond. Our specimen showed regularly distichous, not secund, ramenta.

CAULERPA Lamouroux.

CAULERPA FASTIGIATA Mont.

Collected by R. Baxter, 1922. Figured PROC. LINN. SOC. N.S.W., Vol. 52, Part 4, 1927, Pl. 43.

The West Indies, Brazil, the Friendly Islands.

CAULERPA TAXIFOLIA (Vahl) Ag. Text-fig. 2.

Growing freely in mats over the sides of rock-pools exposed to the rough action of the waves and billows on the reef at Blinkenthorpe Beach.

Surculus very slender, to 1 mm., but usually less, in diameter, ramifying, with slender radicles, freely intertwining so that plants form close masses, glabrous. Assimilators erect, mostly simple but occasionally giving off a branch, linear, to 10.5 cm. long, bearing to 90 pairs of ramenta almost from the base. Ramenta sessile, distichous in opposite pairs, patent, falcate-incurved, flat, rather acute to mucronate, to 4 mm. long and as wide as the axis, about 0.85 mm. Those near base and apex shorter. Dark green in colour.

Rarely some of the assimilators among the normal ones show an interrupted growth as occurs in *C. scalpelliformis*. I saw no tristichous fronds.

Particularly luxuriant examples of the species.

Dr. Nils Svedelius, to whom I sent samples of our Lord Howe Caulerpas, remarks: "A big form of this species, otherwise as far as I can see typical."

From the Friendly Islands (Harvey) and N.E. Australia (Kilner). Dr. F. Börgesen found it in the North Arabian Sea at Karachi and Okha Port, and gives a wide distribution of the plant from the West Indies, Red Sea, Ceylon, Malay Archipelago and Japan (Algae from Arabian Sea, 1934).

CAULERPA THUJOIDES J. Ag. Pl. v, fig. 2.

Creeping on the rough floor of the lagoon at depths less than a fathom or in pools on the coral reef. Common.

Surculus stout, to 2 mm. diam., branching, glabrous, terete or angular, with longitudinal ridges and furrows, sending up widely distant, 2-4 cm. apart, vertical assimilators, and sending down at similar wide intervals radicles with much divided fibrils. Assimilators erect, robust, 3-5 times dichotomous, subfastigate, naked and rugulose below to a height of 1.5 cm., and attaining a length of to

9 cm., bearing rammenta arranged in regular longitudinal, mostly 4, series. Rammenta very dense, imbricate, broadly ovate, apiculate or the apex drawn out into rather long mucro, a little longer than the width of the rachis, deep green.

The N.E. shores of Australia (Kilner).

The determination has been confirmed for me by Dr. Svedelius and Professor Kylin, the latter after comparison with the originals in J. G. Agardh's herbarium in Lund. The Australian species stands on its own merits, and it seems unwise to place it as a form of the West Indian *C. cupressoides* (Vahl) Ag.

#### CAULERPA BROWNII Endl.

"*C. Brownii* Endl. v. *minor* J. Ag. (Weber v. Bosse, Monogr. des Caulerpes, p. 306), but not *delicatula*."

Dr. Svedelius has given me this determination. This was an agreeable surprise to me, for I had not known that we had found this species at Lord Howe. We did not observe it growing or cast up. It looks as if I had inadvertently sent to Europe the only specimen or specimens occurring on the island. It is one of our most familiar and common species in Australia and Tasmania, as well as New Zealand.

#### CAULERPA RACEMOSA Forskaal.

The most abundant *Caulerpa*, growing especially on the slopes of the reefs in shallow water below low tide level, but also on the floor of the lagoon at no great depth. It grew luxuriantly in vividly green masses of clusters resembling currants or small grapes and often covering several square feet of area. The surculi robust, to 2 feet long and 3 mm. diam., branching distantly and attached to the rough coral surface by numerous stout radicles. The assimilators rising at intervals of 0.5 to 2 cm., attaining in some cases lengths of 10-12 cm., and bearing the rammenta on all sides so close together that they quite conceal the axis. Utricles spherical, to 3 mm. diam., supported on thick peduncles rather less than half as long as the complete ramentum.

Quite edible, of a rather pleasant taste.

Dr. Svedelius writes me: "*C. racemosa* with the exceptionally long assimilators is coarser than any *racemosa*-forma I have seen in Ceylon. However, it resembles the *C. racemosa* v. *occidentalis* Börg. from the West Indies, described and figured by Dr. Börgesen in his *The Marine Algae of Danish West Indies*, Vol. I, p. 152 (*Dansk. Bot. Archiv.*, Bd. I, 4, Copenhagen, 1913-14). It is a big form more than 10 cm. high. Specimens from Bermuda could reach 1 foot! This find is very interesting, as it is a new example of Algae common for the West Indies and the Pacific."

#### CAULERPA PELTATA Lamour.

Creeping among other algae on reefs, in pools just below low tide level.

Very slender and inconspicuous, but with the peltae so directed as to catch the light. When disentangled from the other weeds the appearance of the fronds was very much that shown in the excellent figure (Fig. 31) given by Svedelius in his "Ecological and Systematic Studies of the Ceylon Species of *Caulerpa*". The discs varied in diameter, the most mature reaching 3 mm. None were seen of the forms figured by Svedelius in Figure 32 "*ad nummulariam*" or in Figures 33, 34 "*ad claviferam*".

Not heretofore recorded from Australian seas. Previous localities: Red Sea, Mascarene Is., Ceylon and Java Sea.

## CHLORODESMIS Bail. &amp; Harv.

## CHLORODESMIS MAJOR Zan.

Spreading in rounded mats of surpassing beauty on the bottom or over the sides of reef pools or on the adjacent floor of the sea; at low tide even exposed to the atmosphere but usually only accessible by wading. Attached by a reddish-orange felt of threads distributed in loose coral sand, the plant grows out on all sides in a mop of long sparingly branching filaments of a deep dark green colour, which float freely in the water. These filaments, like fine green hairs, reached, in the plants we gathered, a length of 5 or 6 inches, but we were assured by residents of the island that in the summer plants were often thrown up with threads as much as four feet long.

Zanardini had some hesitation in separating the Lord Howe Island form from the *Chlorodesmis comosa* Bail. & Harv. which occurs on the Barrier Reef and South Pacific Islands. I think, however, that he was justified. Not only are the filaments of the Lord Howe plant vastly longer, they are also nearly twice as stout, about  $185\mu$  in diameter, whilst those of plants of *C. comosa* we gathered on the Low Islands and the plant I have of Harvey's Friendly Island Algae have the diameter  $92-108\mu$  and  $92\mu$  respectively. Again, the constrictions in the upper branches of *C. major* lie nearly at the same level, while in the smaller species there is a marked difference in level. The long isolation of Lord Howe has given time for the evolution of a form which seems to me to be worthy of specific distinction.

## CODIUM Stackhouse.

I forwarded specimens of the Lord Howe Codiums to Professor W. A. Setchell of the California University, who has for some years been devoting much attention to the genus. He has proposed a new arrangement of the species. This I have followed, and also availed myself of the full notes and descriptions which he has most kindly furnished for my use. He divides the genus into two subgenera, (1) *Tulecodium* (? *Tylecodium*), comprising the unbranched forms, and (2) *Schizocodium*, comprising the dichotomously branched forms.

*Tulecodium* Setchell, subgenus novum.

Thallus applanatus, pulvinatus, aut usque ad globosus, basi latiori angustiorive adhaerens, neque cylindricus, neque vere ramosus; utriculis ramosis, rare simplicibus (Codium sectiones *Adhaerentia* et *Bursae* Auctt. complectens).

## ADHAERENTIA De Toni (lim. mut. et restr.).

Codium thallis applanatis, marginibus leviter usque ad profunde lobatis; utriculis mesophysis, steno- usque ad hyp-euryphysis, obtusis.

## CODIUM LUCASII Setchell, n. sp. Text-fig. 3 (6-12).

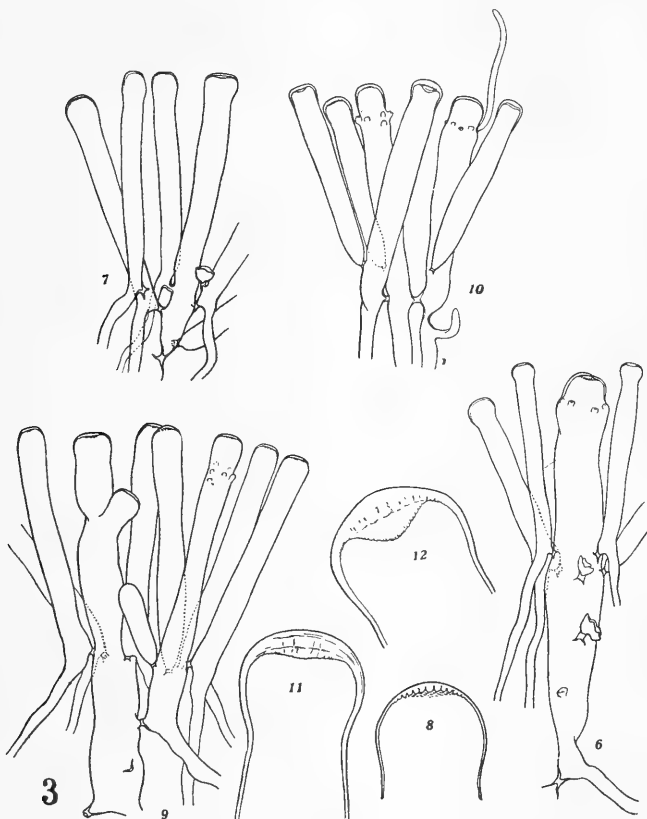
C. thallo primo pulvinato orbicularique, mox lobato, lobis latiusculis aut angustioribus laxe cohaerentibus, crassiusculis et atroviridibus, ad substrata laxiuscule adhaerentibus; utriculis mesophysis, libere ramosis, individuis elongatis ( $435-600\mu$  longis), modice ( $50-250\mu$ ) latis, cylindricis, apice depresso globuloso inflatis, pilis in circulo irregulari infra capitula inflata insertis, membranarum apicalibus tenuibus usque ad  $10\mu$  incrassatis, intus leviter usque ad conspicue alveolatis; gametangiis nondum visis.

Type specimen, herb. Univ. Calif., No. 395199, Bondi, N.S.W., Australia, legit A. H. S. Lucas; *Codium adhaerens* Harvey (non C. Ag.), Australian Algae, No. 576,

from Newcastle, N.S.W. (fide spec. in herb. Kew); additional occurrences, Maroubra Bay, N.S.W., A. H. S. Lucas, Oct., 1931; Long Reef, Collaroy (near Sydney), N.S.W., A. H. S. Lucas, Nov., 1930; Lord Howe Island, F. Perrin and A. H. S. Lucas, June, 1933; Point Lonsdale (Port Phillip Hds.) and Flinders (Western Port), A. H. S. Lucas.

I have not observed it in Tasmania.

Both in habit and utricles, the specimens referred to this species are sufficiently distinct from typical specimens of *Codium adhaerens* C. Ag., from the western coasts of Europe. It seems closely related to *C. intertextum* Collins and Hervey, from Bermuda and the West Indies. The lobing is coarser in the Australian plant and the lobes do not seem to "climb" over one another. The utricles differ somewhat in shape and size and lack the several successive circles of hairs characteristic of *C. intertextum*. The extreme geographic discontinuity also



Text-fig. 3.—*Codium Lucasii* Setchell.

6, 7. Utricle groups from specimen collected at Bondi, N.S.W., by A. H. S. Lucas, Aug., 1901.  $\times 70$ .—8. Tip of utricle from same specimen.  $\times 280$ .—9. Utricle group from specimen collected at Collaroy, N.S.W., by A. H. S. Lucas.  $\times 70$ .—10. Utricle group from specimen distributed as *C. adhaerens* (non C. Ag.) from Newcastle, N.S.W., by Harvey as 576 of his Australian Algae (in herb. Kew).  $\times 70$ .—11, 12. Tips of utricles from preceding.  $\times 280$ .

argues for separation. Possibly the gametangia, when observed, may assist in distinguishing the two species.

Plant prostrate, cushion-shaped, orbicular at first, soon giving off broader or narrower lobes which form a close, flat pattern, fairly loosely adherent to the substratum, of soft, spongy consistency, dark green; utricles mesophyse (or of moderate size), freely branched towards the base, the individual utricles elongated (435–600 $\mu$  long), moderately broad (50–250 $\mu$  wide), cylindrical, with depressed globose tips, and below this an irregular circle of hairs, apical membrane thin or up to 10 $\mu$  thick, slightly or decidedly alveolate within; gametangia have not yet been observed.

The above descriptions are Professor Setchell's. He founded the species on material I sent him on previous occasions from the south-east coasts of Australia. He also examined a type specimen collected by Harvey, Alg. Exs. No. 576, and preserved in Herb. Kew. Harvey identified it with *C. adhaerens* (Cabr.) Ag., but the differences are marked, as pointed out by Setchell.

Since receiving his description I have been fortunate in finding gametangia. Harvey does not seem (*Phyc. Brit.*) to have observed them in his British specimens, but O. C. Schmidt describes and figures the gametangia of *C. adhaerens* in his Monograph of the genus. Those of *C. Lucasii* are stout and ovate instead of cylindrical or spindle-shaped; of dimensions 230–277 $\mu$   $\times$  108–123 $\mu$ , in contrast to 275–350 $\mu$   $\times$  60–75 $\mu$  of *C. adhaerens*.

It always appears in the same habitat at low tide level, extending over ledges or on faces of rock, adapting itself closely to the inequalities of the rock surfaces; of variable outline, often ribbon-like but with rounded edges and lobes. The area covered may reach to a very few square inches, but I have never seen "patches of one, two or more feet in diameter" such as Harvey records of *C. adhaerens* in his *Phycologia Britannica*. The substance is tough and leathery, the surface smooth and slippery, and the colour a dark, almost black, green.

#### SPONGIOSA Setchell, sectio nova.

Codii thallis pulvinatis, convolutis usque ad globoso-lobatis, utriculis mega-, usque ad megistophysis, apice obtusis.

#### CODIUM SPONGIOSUM HARV.

Growing in great abundance in nooks and recesses of the rocks of the lagoon near low-tide level. Large plants 4–6 inches across and 2 or 3 inches deep were cast up in numbers by the storms.

Typical utricles, 1,500 $\mu$   $\times$  160–280 $\mu$ , with membranes scarcely thickened at the apex, and bearing, some single, others 2 or 3 gametangia.

O. C. Schmidt gives the distribution as West, South-west and East Australia, and New Caledonia. He adds a mysterious "Kap" which may mean Cape York; the specimen was given no further indication in the Hamburg Herbarium. Harvey describes it as "Most abundant in King Georges Sound; and it occurs at Geraldton". I have a specimen from Denial Bay in the Great Bight (Dr. Chambers) and a specimen gathered near Adelaide in St. Vincent's Gulf (Dr. J. B. Cleland); have not as yet met it in Victoria; in April, 1934, Mrs. Perrin and I found abundant but not very large plants at Currie's River on the North Coast of Tasmania. It grows near Sydney, in Middle Harbour and Botany Bay, and I have it from near Brisbane. Further north it grows freely on Green Island near Cairns, and the Low Islands near Port Douglas. Lastly, it is

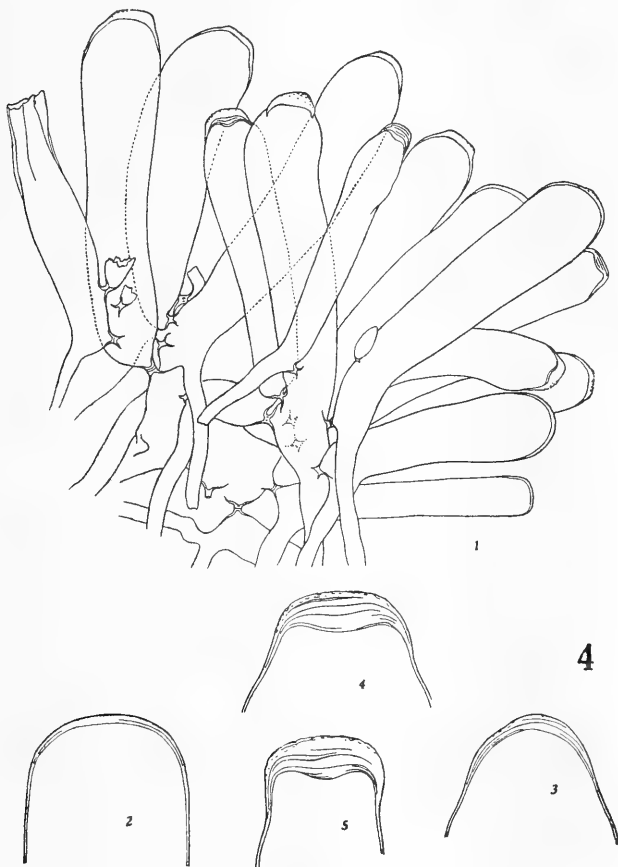


abundant at Lord Howe Island. Laing does not record it from New Zealand. It clearly prefers warm conditions.

I take the opportunity of recording and describing what seems to be a new species of the same section, though it hails from the Tamar Heads, Tasmania, and was not seen at Lord Howe.

*CODIUM PERRINAE*, n. sp. Text-fig. 4.

*C.* thallo pulvinato, glauco-viridi, primo (juvene) orbiculari, ultime (aetate provecta) lunulae crescentis formam evolvante; utriculis megistophysis (usque ad  $1,250\mu$  longis et ad  $375\mu$  latis), pauce aut moderate basi ramosis, oblongo ovoideis, apice applanato rotundatis usque ad truncato galeatis, pilis nullis ornatis, membrana apicali primo tenui, aetate provecta incrassata (usque ad  $32\mu$  crassa), subgaleata, striata, externe irregulariter crenulata aut leviter foveolata; gametangiis incertis, nullis maturis adhuc visis.



Text-fig. 4.—*Codium Perrinae* Lucas.

All figures from specimen collected at Low Head, Bass Strait, Tasmania, by P. Ferrin and A. H. S. Lucas, Jan., 1930.

1. Partial utricule group.  $\times 35$ .—2-5. Tips of utricles.  $\times 70$ .

Specimen typicum in herb. A. H. S. Lucas, cotypicum in herb. Univ. Calif., No. 403785, conservata.

Low Head, Bass Strait, Tasmania, leg. F. Perrin et A. H. S. Lucas, Jan., 1930.

This proposed new species approaches *Codium spongiosum* Harv. very closely in texture and utricular structure. It differs especially in its strong tendency to assume a definitely crescentic habit, the lack (or extreme scarcity?) of utricular hairs, and its subgaleate, somewhat foveolate apical membrane.

Plant usually cushion-shaped, orbicular in outline when young, but soon pushing out a pair of lobes at opposite sides which by their curving growth produce a crescent-shaped or even ring-shaped thallus; utricles of the largest size, up to  $1,250\mu$  long and  $375\mu$  broad, slightly to decidedly branched toward their bases, oblong-cylindrical or ovoid, somewhat flattened at the apex and rotund to truncate galeate by the thickened tip, up to  $32\mu$  thick, which is clearly stratified within and slightly crenulate or foveolate externally; no hairs have been observed on the utricles nor any gametangia.

#### SCHIZOCODIUM Setchell, n. subgenus.

Thallus erectus aut procumbens usque ad repens radicansque, cylindricus aut compressus, usque ad complanatus, rare simplex, vulgo ramosus, aut arcte dichotomus aut subdichotomus; utriculis simplicibus (sectiones aut subsectiones "Tomentosa", "Elongata", "Fragilia" et "Lata" Auctt., complect).

#### REPENTIA Setchell, sectio nova.

Thallus plus minusve compressus, decumbens, radicans, intertextusque; utriculis mesophysis, obtusis.

#### CODIUM BULBOPILUM Setchell. Pl. v, fig. 3.

Fronde decumbent, attached to the substratum or to one another at intervals through groups of rhizoidal filaments, from slightly to clearly compressed, somewhat irregularly dichotomous, 1-5 mm. diameter, dark green, soft spongy in texture; utricles more broadly or more narrowly obovoid, usually decidedly enlarged above, commonly about  $250-300\mu$  up to  $400\mu$  in diameter and  $500-600\mu$  in length; hairs single or few in circle surrounding the apex, usually sharply constricted at the base, membrane thin ( $1\mu$  thick) even at the apex, little thickened (up to  $6\mu$ ) even in oldest utricles; gametangia elongated oblong ellipsoidal, about  $200-250\mu$  long by  $62-5\mu$  broad, inserted near the middle of the utricle.

The type of *Codium bulbopilum* Setchell is a young plant from Tutuila, in American Samoa. Better plants were found in Tahiti. Harvey's No. 84, from Lifuka, in the Tonga Islands, distributed under the name of *C. tomentosum*, seems, so far as the specimen in herb. Sydney Bot. Gardens is concerned, to be of this species. It is widespread in the warmer waters of the eastern portion of the Pacific Ocean and is closely related—perhaps even too closely to be separated—to *C. Geppii* O. C. Schmidt of the Malayan Archipelago. It is also similarly related to *C. taitense* Setchell and possibly, when broader experience is available, it may be desirable to group all three species under *C. Geppii*.

I strongly incline to the view that the Lord Howe plants with low-lying and loosely-interwoven segments may be fairly assigned to *C. Geppii*. The utricles I measured were  $400-460\mu \times 123-215\mu$  in dimensions, which fall within Schmidt's limits. I could not find gametangia, but Schmidt states that those of *C. Geppii* also are unknown.

Growing in sheltered nooks or depressions on coral rocks in masses of 6-8 inches long, 4-6 inches wide and 2-4 inches high, composed of a tangle of crossing and adhering segments attached to rock by numerous tufts of rhizoids. Branches uniformly cylindrical, tough, 2 mm. diam. Dark green.

CODIUM INDICUM Setchell MS.

Two forms of digitate Codiums occur fairly abundantly on the rocks of the lagoon.

1.—A smaller form to 7 cm. high, frond erect, compacted, with slightly flattened 5, 6 dichotomous divisions.

2.—A larger form to 15 cm. high, frond erect, spreading, with evidently flattened (5-10 mm. wide) segments with 6, 7 dichotomies.

I had considered them to be among the many forms of *C. Muelleri* Kuetz., but Professor Setchell separates them, regarding them as examples of a new species, *C. indicum* Setchell, which he has obtained in other quarters.

The *C. tomentosum* var. *australasicum* Aresch., thence *C. Muelleri* Kuetz., appears in so many varieties around the southern (at least) half of the continent, as well as in Tasmania and New Zealand, that it is clear that a comprehensive revision of the whole is required. I have for long been accumulating material, but am quite unable to deal with it at present.

CUNEATA Setchell, sectio nova.

*Codia thallis* in toto complanatis, erectis, multoties dichotomantibus; utriculis megaphysis (in specie typica megistophysis sparse intermixtis), obtusis.

CODIUM CUNEATUM Setchell and Gardner. Pl. vi, fig. 1; Text-fig. 5.

*Proc. Calif. Acad. Sci.*, 4 ser., vol. 12, p. 708, pl. 16, figs. 34, 35, pl. 34, May, 1924.

Thallus decidedly flabellate, attached by a relatively small spongy disc, 12-16 cm. high, branching very close to the base, regularly dichotomous, distinctly flattened, especially immediately below the forking, angles rounded; segments between the forkings broadly cuneate, up to 2 cm. wide below the forking, terminal branches numerous, much reduced; utricles 0.5-1 mm. long, 200-250 $\mu$  diam., large type up to 450 $\mu$  diam. at the outer end; side wall 2-3 $\mu$  thick, end wall 8-12 $\mu$  thick; hairs short, attached near the outer end of the utricles; sporangia sub-fusiform, widest below the centre, 200-260 $\mu$  long, 90-110 $\mu$  wide; often extending beyond the utricle.

*Codium cuneatum* was described from a very regular and symmetrical specimen from the Gulf of California. When well developed there are 8-10 dichotomies and each segment is broadly cuneate.

Later specimens have been seen from British India (Kurrachee and Madras, in herb. Kew), from the southern tip of British India (M. O. P. Iyengar), from the Island of Bali (in herb. Univ. Calif.), from the eastern coasts of Australia (Botany Bay, May, 1930, and Dec., 1930, A. H. S. Lucas; Mosman's Bay, Sydney Harbour, W. A. Setchell, April, 1904); a very depauperate specimen from Low Island, North Queensland, Australia (F. Perrin and A. H. S. Lucas, May, 1931); Bowen, Queensland, Australia (E. H. Rainford, Nov., 1929). The several different areas constituted seemed each to have its own species, and tentative herbarium names were given to them. The differences of habit, however, were not constant, and where a number of specimens were collected in the same locality the variation within the local area, as well as the final disappearance of any definite discontinuity of distribution, has led toward considering all these forms to be simply reasonable variations of one widely distributed species.

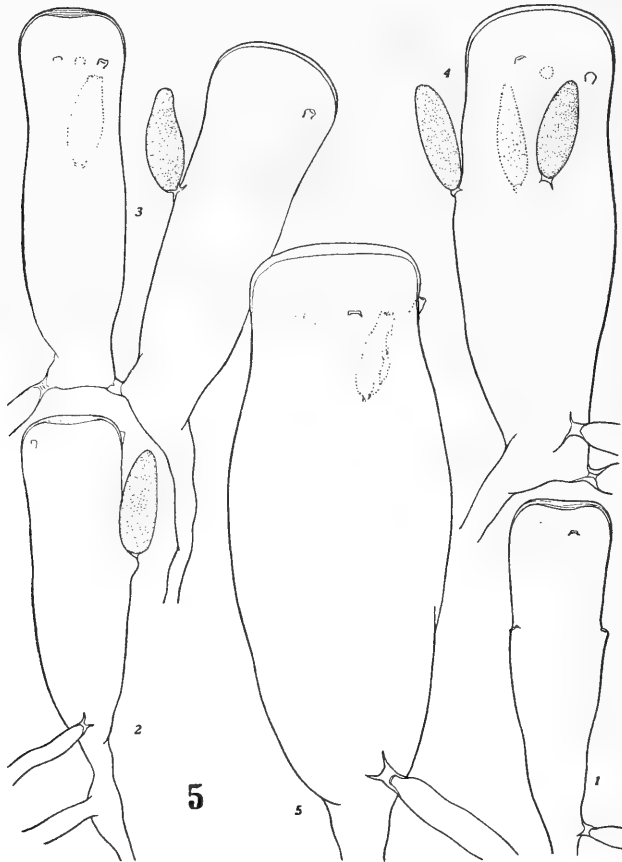
The above is the description by Setchell and Gardner, together with further comments by Professor Setchell. I add some details of the Lord Howe plants.

About a foot high, growing in deeper water probably, attachment not seen. Remnant of stipes nearly 2 cm. long, compressed. Frond flat throughout with few long broad divisions irregularly and sparingly, up to 4 or 5 times dichotomous, under the main forks up to 2.5 cm. wide. Axils rounded, almost semicircular. Apices very obtuse, rounded.

Utricles 1 or 2 mm. long, 120–210 $\mu$  broad, with flatly rounded-off tips. Walls of utricle 1.5 $\mu$ , of tip 3.5 $\mu$ . The utricles remarkable for a system of thin branched colourless trabeculae.

Gametangia about 200 $\mu$  long, 70–80 $\mu$  broad, situated about a quarter of the length of the utricle below the apex.

By far the flattest form of branched Codiums I have seen in Australia. It looks almost like a branched *C. laminarioides* Harv.



Text-fig. 5.—*Codium cuneatum* Setchell and Gardner.

All figures from specimen collected on Cremorne Point, Sydney Harbour, N.S.W., by W. A. Setchell, 2nd April, 1904.

1-4. Utricles to show variation from shorter to longer, and in both sterile and fertile condition.  $\times 70$ .

It is noteworthy that of the 24 green Algae observed, 18 (including *Cladophoropsis* and *Valonia*) belong to the unicellular Siphoneae. These, with the exception of *Acetabularia calyculus* and *Bryopsis plumosa*, present a tropical or subtropical facies, and most of them have a corresponding distribution elsewhere. Not one of the Caulerpas (except the doubtful resident, *C. Brownii*) occurs in extra-tropical Australia. Of the Codiums, *C. Lucasii*, *C. spongiosum* and *C. cuneatum* penetrate into more temperate locations, but are also subtropical, while *C. bulbopilum* and *C. indicum* are definitely warm sea forms.

Of the non-Siphoneae, *Dictyosphaeria favulosa* and *Siphonocladia vaucherii-formis* are tropical, *Ulva Lactuca* and *Chaetomorpha aerea* are cosmopolitan, while *Enteromorpha Howensis* and *Cladophora Goweri* are described as new forms peculiar to Lord Howe.

A quite remarkable feature is the apparently total absence of *Halimeda*.

## PHAEOPHYCEAE.

<i>Sargassum Howeanum</i> , n. sp. } Phyllotricha	<i>Dictyota prolificans</i> A. & E. S. Gepp
<i>S. sp.</i>	<i>D. sandvicensis</i> Sond.
<i>S. spinifex</i> Ag. } Eu-Sargassum	<i>D. rugulosa</i> , n. sp.
<i>S. leptopodium</i> J. Ag. }	<i>D. furcellata</i> Ag.
Two undetermined sp. }	<i>Glossophora Harveyi</i> J. Ag.
<i>Cystophyllum muricatum</i> (Turn.) J. Ag.	<i>Ecklonia radiata</i> (Turn.) J. Ag.
f. <i>utinodis</i> , n.f.	<i>Macrocystis pyrifer</i> a (Turn.) Ag.
<i>Hormosira Banksii</i> (Turn.) Dcne.	<i>Colpomenia sinuosa</i> (Roth.) Derb. & Soland.
<i>Gymnosorus nigrescens</i> (Sond.) J. Ag.	<i>Hydroclathrus cancellatus</i> Bory
<i>Padina Pavonia</i> (L.) Lamour.	<i>Ectocarpus simpliciusculus</i> Ag. ?
<i>Haliseris crassinervia</i> Zan.	<i>E. confervoides</i> (Roth.) Le Jolis
<i>H. plagiogramma</i> Mont., var. <i>Howensis</i> , n. var.	

## SARGASSUM Ag.

## SARGASSUM HOWEANUM, n. sp. Pl. vi, fig. 2.

Mingled with other Sargassa or in individual colonies, it forms the greater part of the vegetation of the lagoon floor, the sombre masses furnishing a striking contrast to the occasional green or red algae.

The attachment is discoid, a short swollen stock giving rise to three or more main branches or stems of a length of a foot, more or less, but never tall.

Stems naked and rugged to a height of an inch or so, then angular, clad with crowded pinnate rami spreading in all directions with slender rachides and a height of 6-10 cm., not refracted, bearing ramuli on all sides.

Ramuli decompositum dichotomous to 5 cm. long, with filiform segments diverging at broad angles and bearing vesicles and at length receptacles.

Vesicles borne, especially on the lower divisions of the dichotomy, on slender petioles longer than themselves, quite spherical and from the juvenile stage onwards absolutely mucous, to 4 mm. diam., and dark brown in colour.

Receptacles clustered, fusiform, much shorter than the leaf segments, 2-3 mm. long, stipitate, smooth, simple, forked or even branched. Colour dark fuscous-brown, becoming quite black on drying.

Stipes communis tumida disco affixus. Hinc exsurgunt 3 vel pluris stipites ad 30 cm., ascendentes stipites secundarii, ad 2.5 cm. nudi, non refracti, 6-10 cm. longi, crebris ramulis quoquoversum divergentibus.

Ramuli decomposito-dichotomi ad 5 cm. longi, segmentis filiformibus latis angulis patentibus, vesiculos et demum receptacula ferentes.

Vesiculi in longo petiolo sphaerici, omnes mutici, ad 4 mm. diam.

Receptacula fasciculata fusiformia, multo breviora quam folii segmenta, stipitata, simplicia furcata vel etiam ramosa.

Color obscure fusco-brunneus, in sicco nigrescens.

The plant must be included in Agardh's Section *Phyllotricha* and be placed near to *S. Sonderi* J. Ag. At first sight it might be attributed to that species, but seems to be distinct by possessing larger dark muticous receptacles, by its much darker colour, and by the absence of flattened stems bearing broad pinnatifid leaves. Though many growing plants were observed, no sign of such flattened stems and well developed leaves was seen. So far only known from Lord Howe.

*S. Sonderi* has a wide range from Western Australia and the South Australian and Victorian coasts to Tasmania. It has not been seen on the coasts of New South Wales and Queensland, nor has it been found in New Zealand.

#### SARGASSUM SPINIFEX Ag.

The more expanded form, up to a length of a foot, grew in fair quantity on the floor of the lagoon.

*S. spinifex* has a wide distribution, from Ceylon and China and the warmer waters of Australia. It was sent me from Bowen and Townsville on the coast of Queensland, and it has extended to Dirk Hartog Island on the west and to Lord Howe and Norfolk Islands on the east.

#### SARGASSUM LEPTOPODUM J. Ag.

Growing with *Haliseris* and other Sargassa on the floor of the lagoon.

Recorded doubtfully from Norfolk Island by Reinbold (*Nuova Notarisia*, 1900).

At least three other species of *Sargassum* were collected; one to be ascribed to Agardh's *Phyllotricha Pteromorphae*, of which only one sterile plant was seen, but which is almost certainly an undescribed species; and the others to be attributed to *Eu-Sargassum Malacocarpicae Racemosae*, but which, with my present knowledge, I do not venture to identify more closely.

It is to be noted that no species of *Phyllotricha Phylloporphae*, and no species of *Arthrophyucus*, was seen.

The absence of the genera *Cystophora* and *Phyllospora* is noteworthy. They occur abundantly on the rocks on the Sydney shores.

#### CYSTOPHYLLUM J. Ag.

##### CYSTOPHYLLUM MURICATUM (Turn.) J. Ag. forma UNINODIS, nova.

A number of rachides spring from a flat, rugged attachment to an inch in diameter. Rachides of two kinds; few shorter to 3 inches, simple, bearing leaves only; more elongated to a foot or more, much branched, bearing here and there a solitary reduced leaf, but mostly much branched ramuli, the lower carrying vesicles and the upper receptacles. Rachides rough with almost stalked glands. Leaves narrow linear, those of the leaf-bearing rachides to 2 cm. long, entire and glandulose. Vesicles stalked, ovate, 1.5 mm. long, usually solitary, glandular, crowned with a linear appendage to 7 mm. long.

Receptacles in terminal racemes 15-20 mm. long, 10 or more in a raceme, the older ones to 7 mm. long, mostly simple, linear, verrucose, rarely branched, sometimes carrying a vesicle laterally. Scaphidia crowded, one to each tubercle

excavated below the surface, with one oospore surrounded by mucilage in each scaphidium. I did not see antheridia.

Collected by R. Baxter in 1929; a fine example.

I have a very similar form from Darwin, but the lower parts and leaf-shoots are lacking, so that I cannot assert identity.

The form agrees with *C. muricatum* in general habit, the rough glandulose rachides, the entire basal leaves and the linear racemose receptacles. It differs in being slenderer, and in its crowded branchlets and vesicles, the latter almost invariably solitary and never in strings of three; in fact the plant might well be taken at first sight for a plant of *Sargassum Sonderi* J. Ag.

*C. muricatum* occurs, often plentifully, in sheltered harbours all round the Australian coasts.

#### HORMOSIRA Endl.

##### HORMOSIRA BANKSII (Turn.) Decne.

We saw, and only rarely, stunted specimens growing on the rocks. Mr. Gower Wilson pointed out wide reefs on the shore side of the lagoon, which, he informed me, had been covered with *Hormosira* till within the last two or three years, but that it had been cropped bare by shoals of Nannewai, a long dark fish locally known as "Stinkers". It seems that these fish had quite suddenly developed a liking for the *Hormosira* and had made a clean sweep of it.

I found *Hormosira* on the mud-covered rocks of Oyster Harbour, King George's Sound, but not further west. It is common on the coast of New South Wales, as far north as Port Stephens, but seems to be replaced by its congener *H. articulata* (Forsk.) Zan. in Queensland. Abundant in South Australia, Victoria and Tasmania, and New Zealand.

#### GYMNOSORUS J. Ag.

##### GYMNOSORUS NIGRESCENS (Sond.) J. Ag.

Common. In the warmer waters of Australia, not extending to Tasmania. R. M. Laing records it from the Kermadec Islands, about in the latitude of Lord Howe, but not from New Zealand.

#### PADINA Adans.

*P. pavonia* (L.) Lamour. is found freely on the rocks about low-tide level. There seem to be but slight differences in the Padinas of Australian coasts, and I am inclined to follow Harvey in referring them all to *P. pavonia*. The Lord Howe plants are large, to 10 cm. high, and of a brown colour, neither very dark nor very light, less pruinose than the British form. While occurring on all Australian coasts, it does not seem to have reached Tasmania. Laing does not include it in his List of New Zealand Marine Algae.

#### HALISERIS Targ.-Tozz.

Two species are found at Lord Howe Island, *H. crassinervia* Zan. and *H. plagiogramma* Mont. Both grow on coral boulders and rock on the floor of the lagoon, usually singly, but here and there in groups. Both are plentiful, and most of the plants bore spores at the time of our visit, May, June, July.

##### HALISERIS CRASSINERVIA Zan. Pl. vii, fig. 1.

*H. crassinervia* was described by Zanardini, 1874, in his "*Phyceae Australicae novae vel minus cognitae*". Lord Howe is the only locality given for the plant. The description is meagre and the fruits are left as unknown. De Toni and Levi

studied the material in Zanardini's herbarium, and De Toni (*Sylloge*, iii, p. 258) comments as follows: "Species inter maximas enumeranda. Cum *H. australis* Sond. haud male quadrat sed lamina evenosa crassiuscula exsiccatione fuscescente costaque valde conspicua robustiori nigrescente procul dubio diversa." It in truth is very much closer to *H. pardalis* Harv. than to *H. australis*. *H. pardalis* and *H. crassinervia* are both veinless and both have the same fructification.

Attached by a swollen stupose base, the terete slender stipes soon forks into several times dichotomous fronds. Below, the divisions lose their laminae, which are gradually eroded and finally leave the ragged or bare costae to function as prolongations of the stipes. The higher branches divide repeatedly into segments with not very wide axils, and spread in all directions to form a broad and high clump. The length of a single frond ranges to 23 cm. The upper segments maintain a very uniform width of 10 or 12 mm., the ultimate ones long, undivided to a length of even 25 mm. Apices very obtuse, rounded. The colour is brown-olive, rather darker on drying. The substance of the laminae delicately membranaceous, while the midrib, composed of several layers of longer narrow cells, is conspicuous and firm, and deeper in colour but not nigrescent.

The spores are distributed in bands about 1 mm. wide, which spread in a curve backward from the midrib nearly to the margin. These bands, separated by barren spaces about 2 mm. wide, appear in opposite pairs on the whole frond in the mature plant, from close under the apices of the ultimate segments down to the lowest undivided lamina. The spores, of a yellowish-olive when seen by transmitted light under a high power of the microscope, are scattered over the bands singly, but in large numbers, and are round, about  $87\mu$  in diameter, including the narrow transparent perispore. Among them, confined to the bands, short irregular chains of smaller darker cells,  $17.5\mu$  in diameter, sometimes occur. What their nature may be I cannot say.

It is obvious that *H. crassinervia* is very closely related to *H. pardalis*. The former has a stouter costa, the segments are less patent, and the colour is darker, not "a bright yellowish olive" which Harvey attributes to *H. pardalis*. It may be owing to the long geographical insulation of Lord Howe that these small differences have been developed; and it is perhaps most convenient to give to it a distinct name to distinguish it from its far distant relative of Western Australia. Harvey found *H. pardalis* at Fremantle. I have received it from Dongarra, south of Geraldton, and from Broome on the N.W. Coast.

#### HALISERIS PLAGIOGRAMMA Mont. Pl. vii, fig. 2.

Originally described by Montagne from Cuba. Apart from West Indian and adjacent habitats, De Toni records the species from the Sandwich Islands and Australian shores, basing the latter record on material in the Zanardini Herbarium. I know of no occurrence in any part of Australia except Lord Howe Island.

*H. australis* Sond. and *H. plagiogramma* have fronds in which, in addition to the midrib, the fronds are strengthened by numerous thin veins running obliquely from the midrib to the margin, and are thus quite distinct from all other Australian species of *Haliseris*.

The fruits of *H. australis* are unknown, so that it remains to be seen whether they are arranged in parallel curved bands as in *H. pardalis* and *H. crassinervia*, or in sori forming a sub-continuous cloud of spores on either side of the midrib as in *H. plagiogramma*.



*H. plagiogramma* grows in the lagoon in the same manner as *H. crassinervia*, and often in association with it. It is of smaller dimensions, attaining a maximum height of 17 cm., but usually shorter, 12–14 cm. The ultimate segments are nearly as broad as long, 3 to 5 mm. The bifurcations are patent, the apices rounded obtuse, and the colour rather lighter than in *H. crassinervia*. The spores are of the same size and shape as in that species,  $87\mu$ , with a clear border, but they are arranged in a long sorus adjacent to the midrib (as in *Blechnam*).

A. D. Cotton described a *Haliseris* collected in the Kermadecs by Miss E. M. Smith, in his paper on the "Marine Algae from the North of New Zealand and the Kermadecs" (*Kew Bulletin*, No. 61, 1912, p. 263). The Kermadecs lie in about the same latitude as Lord Howe and Norfolk Islands, many hundred miles to the east of the latter, and in a direct line between the Tongan Group and the North Island of New Zealand, nearer to the former. Lord Howe, Norfolk and the Kermadecs are all volcanic and form a natural region. Lord Howe has coral reefs well developed, which the others lack.

Cotton describes his species, *H. kermadecensis*, as a new form distinguishable from *H. australis* and *H. plagiogramma*. It is evidently very closely connected, if not identical, with the Lord Howe plant. His description is as follows: "15–18 cm. alta, basi eximie stiposa, plerumque stipite longo ramoso suffulta, sensim in segmenta dichotoma sinibus acutis abiens. Segmenta 5–8 mm. lata, linearia, venosa, apice attenuata, margine integerrima. Venae distinctae circ. 1 mm. distantes, a costa ad marginem oblique excurrentes. Tetrasporangia in soro elongato collecta. Oogonia ignota."

Our Lord Howe form, forma *Howensis*, differs in the markedly rounded, not acute, axils and the blunt rounded, not attenuate, apices.

I forwarded a Lord Howe plant to Dr. Cotton at Kew, and he writes: "We have looked at your specimen, and it is certainly distinct from my *Haliseris kermadecensis*. I am, however, not quite certain as to what it actually is, but it agrees well with our series of *H. plagiogramma* which we have represented from Australia."

Since writing the above I have received from Dr. Børgesen a copy of his paper on "Some Marine Algae from the northern part of the Arabian Sea, with remarks on their geographical distribution", 1934. In this he records *Dictyopteris australis* Sonder from the Indian coast at Dwarka, Okha Point, and Karachi. Dr. Børgesen's work has revealed an extraordinary extension of supposedly exclusively Australian algae into the Arabian Sea, and is of immense interest to an Australian worker.

The question of correct nomenclature has been raised. Targioni-Tozzetti gave the name *Haliseris* to the genus apparently about 1819 (1819? De Toni), and this has been in constant use for over a century. But the names *Neurocarpus* Web. & Mohr 1805, *Dictyopteris* Lamouroux 1809, and *Polyphodoidea* Stackhouse 1809 would seem to have rights of priority. Setchell adopts *Neurocarpus*, and it would seem on good grounds, but Børgesen, in the paper above quoted, prefers *Dictyopteris*. An Australian worker is not in a good position to decide in matters of priority, so I am employing the well-known name *Haliseris* in this paper.

#### DICTYOTA PROLIFICANS A. & E. S. Gepp.

Abundant on the shore reefs at low-tide level, and well in fruit. The typical surface proliferations present.

I have also several fruiting specimens collected by Mr. R. Baxter on Lord Howe in 1922, the month not specified.

*D. prolificans* was described from New South Wales material, forwarded by myself, in the *Journal of Botany*, 1906. I have gathered it on the ocean coast of New South Wales from Long Bay, near Sydney, and at Narrabeen, as also at Caloundra, in South Queensland. Harvey gathered it at Newcastle, labelling it *D. Kunthii*. R. M. Laing gives it from the Kermadecs. It is undoubtedly *Dictyota* in structure and not *Dilophus*, as apparently suggested by Laing for the Kermadec plant.

I may add to the original description that the attachment is fibrous, as in *D. radicans* Haw., and not stupose.

DICTYOTA SANDVICENSIS Sond. (?).

Small plants to 8 cm. high, stupose at base, much divided dichotomously, with narrow linear segments, rather acute apices, spores conspicuous, 80-85 $\mu$  diameter, in irregular sori scattered over the whole interior area.

*D. sandvicensis* is recorded from Cape York and the Gulf of Carpentaria, and from the Red Sea.

DICTYOTA RUGULOSA, n. sp.

Fibrous, much-branched stoloniferous radicles. Plants gregarious. From the tangled attachment spring simple or forked linear fronds to 10 cm. long and 3-5 mm. wide, much crinkled transversely, with obtuse rounded apices. No surface proliferations.

Typical *Dictyota* structure. Interior a single layer of large empty colourless cells; no intermediate cells; cortical monostromatic layer of small dark brown cells, about 4, bordering each external margin of the interior cells.

Spores about 8.7 $\mu$  diam. scattered over the median area of the frond.

Frondes gregariae, radiculis fibrosis stoloniferis affixae. Frondes e plexu basali simplices vel furcatae exsurgant, lineares ad 10 cm. altae, 3-5 mm. latae, valde transverse rugosae. Apices rotundato-obtusi.

Structura duobus stratis, interiori magnis vacuis, cellulis monostromatica, corticali parvis obscure brunneis cellulis monostromatica; circiter 4 corticales cellulae insident supra marginem singulae medullaris cellulae. Sporae supra mediam regionem frondis sparsae, circ. 8.7 $\mu$  diam. Color olivaceo-brunneus.

Species of the *D. dichotoma* group of *Dictyota* are notoriously difficult to place accurately. The above small and simple crinkled form, occurring, so far as I know, only at Lord Howe, seems to me to be best considered for the present as a distinct species.

DICTYOTA FURCELLATA Ag. (?).

A species of *Dictyota* was abundant in the lagoon, growing mostly as an epiphyte on other algae, in dense intricate little bushes of 7-10 cm. high. The fronds, repeatedly and regularly forked, were remarkably slender, from 0.4 to 1.3 mm. in diameter, those of the same bush fairly uniform in width. Not fenestrated. The cells, twice as long as broad, closely parallel. No fruits or paraphyses seen.

C. Agardh gave the name *Dictyota furcellata* to a plant obtained by Gaudichaud from New Holland. It is described as having very narrow (*angustissimis*) fronds with no conspicuous areoles, much divided above the middle, and bearing fertile cells scattered over the median part of the frond, but (somewhat contradictorily) seriate in several lines. No dimensions are given.

Harvey, with some doubt, ascribed the plant which he found in abundance in King George's Sound to Agardh's *D. furcellata*. Later, J. Agardh transferred it to his new genus *Pachydictyon* as *P. furcellatum*. He distinguished *Pachydictyon* as having three layers in the frond, an intermediate, at length pluriseriate region lying between the monostromatic internal large cells and the monostromatic cortical cells.

Our Lord Howe plant is a *Dictyota*, and it may be *D. furcellata*, but in the absence of fruits the identification would be premature.

GLOSSOPHORA J. Ag.

GLOSSOPHORA HARVEYI J. Ag.

Densely spongiöse attachment 15 mm. across passing into a narrow terete stipes of about 3 mm. diameter, also stupose. The frond forks above this and compressed and then flattened passes by 4, 5 dichotomies into digitately spread laciniae. The laciniae flat, linear or strap-shaped, to 10 in. in length, and an inch in breadth, with entire margins and blunt or but slightly attenuated apices. Colour dark brown, becoming black on drying.

Structure of the frond showing an interior 3 or 4 layers of large colourless thin-walled cells and a cortex of small quadrilateral deeply coloured cells, arranged in quadrangular groups as seen from the surface.

In the winter months the plants only rarely bore the surface folioles in which the fruiting organs appear; in a specimen gathered by J. H. Maiden in March, the folioles closely covered the surface.

Hitherto only known from New Zealand and the Chatham Islands.

ECKLONIA Hornem.

ECKLONIA RADIATA (Turn.) J. Ag.

*E. radiata* does not appear in the lagoon, but grows at some depth, 10 fathoms, on the outside of the coral reef. It was of the typically smooth form, not forma *exasperata*.

A similar, but young plant, was similarly found growing on the cable at a depth of 20 fathoms off Norfolk Island.

It is common in Port Jackson and on the coast of New South Wales. Also in New Zealand.

MACROCYSTIS Ag.

MACROCYSTIS PYRIFERA (Turn.) Ag.

We did not see any plants, but I was assured by Mr. Gower Wilson, a deep-sea fisherman of much experience, that in former years it flourished in the deeper water outside the reef.

Lord Howe is the most northerly habitat noted for *M. pyrifera*. It is abundant on the rocky coasts of Victoria and Tasmania, but has not extended west of Cape Northumberland and not up the coast of New South Wales. It is also a New Zealand kelp.

COLPOMENIA Derb. et Sol.

*C. sinuosa* (Roth.) Derb.—Not uncommon on the reefs.

HYDROCLATHRUS Bory.

*H. cancellatus* Bory.—A number of plants seen.

Both *Colpomenia* and *Hydroclathrus* range over the south and east coasts of Australia, from the tropics to Bass Straits. Both are cosmopolitan genera, each of only one species. *Hydroclathrus* is not recorded from New Zealand.

ECTOCARPUS Lyngby.

ECTOCARPUS CONFEROIDES (Roth.) Le Jolis.

Two plants were gathered, about 10 cm. in height. Both were fawn-brown, drying a bronze-green. Both bore plentifully plurilocular sporangia, in each case cylindrical, sessile and without pilum. In the one the sporangia measured  $140\text{--}200\mu \times 21\text{--}28\mu$ , in the other the sporangia were shorter,  $105\mu \times 28\mu$ .

ECTOCARPUS SORDIDUS HARV.

Covering other algae in a dense dull-green untidy tangle, closely attached by many radicles to the host. Irregularly and frequently branched at wide angles; branchlets short. Fila  $15\text{--}30\mu$  in diameter, joints of the larger constricted at the joinings, as long as broad. Plurilocular sporangia, few seen and not very distinct, sessile, about  $35\mu$  long.

Harvey's description of *E. sordidus* from Georgetown, Tasmania, is meagre and gives no measurements, but the present plant agrees very well with specimens we had gathered of *E. sordidus* in the type-locality.

Of the Brown Algae we may remark that the large southern kelps, *Ecklonia* and *Macrocystis*, occur only in the deeper waters which surround the island and its reefs, while *Arthrophyucus*, the southern subgenus of *Sargassum*, is altogether wanting. *Glossophora Harveyi* is the only characteristically New Zealand alga which we found established in Lord Howe.

The forms described as peculiar to the island are the Phyllotrichous *Sargassum Howeanum*, a form of *Cystophyllum muricatum*, with single, not seriate, vesicles, and Zanardini's two species of *Haliseris*.

RHODOPHYCEAE.

- |   |   |
|---|---|
| <i>Bangia</i> (?) <i>simplex</i> , n. sp.         | <i>Delisea pulchra</i> (Grev.) Mont.              |
| <i>Helminthora tumens</i> J. Ag.                  | <i>Asparagopsis taxiformis</i> Mont.              |
| <i>Liagora Howensis</i> , n. sp.                  | <i>Laurencia majuscula</i> Harvey.                |
| <i>Galaxaura rudis</i> Kjellmann.                 | <i>L. elegans</i> , n. sp.                        |
| <i>G. fastigiata</i> Dcne.                        | <i>L. concinna</i> Mont.                          |
| <i>G. tumida</i> Kjellm.                          | <i>Acanthophora orientalis</i> J. Ag.             |
| <i>Gelidium Maidenii</i> , n. sp.                 | <i>Polysiphonia implexa</i> H. & H.               |
| <i>G. australe</i> J. Ag.                         | <i>P. Baxteri</i> , n. sp.                        |
| <i>Pterocladia lucida</i> (R. Br.) J. Ag.         | <i>P. Gelidii</i> Zan.                            |
| <i>P. capillacea</i> (Gmel.) Bornet & Thuret.     | <i>Amansia glomerata</i> Ag.                      |
| <i>Gymnogongrus irregularis</i> Zan.              | <i>Enantiocladia Robinsonii</i> (J. Ag.) Falk.    |
| <i>Mychodea halymenioides</i> Zan.                | <i>Dasya fruticulosa</i> , n. sp.                 |
| <i>M. Zanardini</i> De Toni & Levi.               | <i>Euptilota formosissima</i> (Mont.) Kuetz.      |
| <i>Eucheuma spinosum</i> (L.) J. Ag.              | <i>Ceramium Setchellii</i> , n. sp.               |
| <i>Areschougia laurencia</i> (H. & H.) Harvey.    | <i>Halymenia</i> (?) <i>multifida</i> Zan.        |
| <i>Sarcodia ciliata</i> Zan.                      | <i>H. fimbriata</i> Zan.                          |
| <i>Sarcocladia</i> (?) <i>rhizophora</i> , n. sp. | <i>Carpopeltis Phyllophora</i> (H. & H.) Schmitz. |
| <i>Gracilaria Howensis</i> , n. sp.               | <i>Peysommelia</i> sp.                            |
| <i>Hypnea seticulosa</i> J. Ag. forma             | <i>Lithothamnion</i>                              |
| <i>H. Cenomyce</i> J. Ag.                         | <i>Goniolithon</i>                                |
| <i>Champia parvula</i> (Ag.) J. Ag.               | <i>Melobesia</i>                                  |
| <i>Plocanium hamatum</i> J. Ag.                   | <i>Amphiroa Howensis</i> , n. sp.                 |
| <i>P. leptophyllum</i> Kuetz.                     | <i>Jania rubens</i> Lamour.                       |
| <i>P. angustum</i> (J. Ag.) H. & H.               | <i>Corallina chilensis</i> Dcne.                  |
| <i>Martensia speciosa</i> Zan.                    | <i>C. rosea</i> Lamarck                           |

## BANGIA Lyngb.

## BANGIA SIMPLEX, n. sp.

Gregarious clumps of unbranched filaments, each clump springing from a small disc attached to worn stems of *Zostera*. Filaments to 4 cm. long, free, nearly uniformly cylindrical, except tapering at the very base, diameter 40–50 $\mu$ , transversely divided by colourless partitions about 14 $\mu$  apart. Each compartment so formed encloses within a wide colourless border a disc 10 $\mu$  long (in the direction of the filament) and as broad or a little broader. The discs are rose-coloured. They soon divide into two, a new partition of the frond forming pari passu with the division of the disc, and thus the filament increases in length by intussusception. When the frond is crushed the discs are seen to be circular. The whole filament constitutes a single series of discs.

Filamenta simplicia, gregaria, epiphytica basali communi disco affixa, 4 cm. longa, basi attenuata, cylindrica, 40–50 $\mu$  diam., transverse partita septis circ. 4 $\mu$  distantibus. Cellulae sic formatae intra marginem latum transparentem discum centralem roseum ad 10 $\mu$  longum praebentes.

Only seen by me on Lord Howe. The colour in mass is a dark rose-violet.

## HELMINTHORA J. Ag.

## HELMINTHORA TUMENS J. Ag.

Two forms were gathered. One, growing on coral lumps in the lagoon to a height of 15, 16 cm., with coarse divaricate much divided branches; the other, growing in pools on the Blinkenthorpe Beach, with many erect branches rising close together from a broad basal attachment to a height of 30 cm., clothed with numerous short slender lateral ramuli spreading in all directions. Both very mucilaginous and slimy.

Agardh separated the Australian plant from the *H. divaricata* of Europe, especially noting the swollen even globose terminal joints of the peripheral filaments. He worked on plants gathered in Port Phillip. I have found it myself at Portsea, near the Heads.

## LIAGORA Lamour.

## LIAGORA HOWENSIS, n. sp.

Frond 7 or 8 cm. high, of a densely fruticulose habit with fastigate branches. The lower main divisions regularly dichotomous, then these bear numerous pinnate branches of various length at short intervals, mostly alternate, with wide axils; in the upper parts of the branches of various orders more regular dichotomies again prevail, and the apices are regularly forked with divergent segments. The diameter of the stem and main branches about 1.5 mm., of succeeding divisions mostly 1 mm. All parts are coated with a continuous calcareous crust, smooth, wrinkled and occasionally rugose-annulose, so that on drying under pressure the plant does not in the least adhere to the mounting paper (in marked distinction to *L. Cheyneana*, *L. Harveyana* and *L. Wilsoniana* of Australian coasts). So impregnated is the plant with carbonate of lime that bleached specimens resemble Corallines in stiffness and fragility.

The frond has the characteristic axial longitudinal filaments, the exterior ones bearing at right angles densely crowded radial filaments. These have a pedicel or unbranched basal portion, which then forks a number of times, the diameter of these pedicel and lower forks about 6 $\mu$ , with colourless joints to 35 $\mu$  long. These branches fork a number of times, the last forks consisting of

strings of elliptical or globose cells, 2 or 3 in a string of about  $3\mu$  diam. These are densely packed in heads and are deeply coloured.

Unfortunately I have not observed any fruiting organs.

Frons 7, 8 cm. alta, dense fruticulosa ramis fastigiatis, inferne dichotoma, tunc pinnata, superne dichotoma, crusta calcarea continua investita. Diam. caulis ramorumque majorum 1.5 mm., ramorum secundariorum 1 mm. Apices furcati. Frons teres, levis, rugosa vel nonnumquam rugoso-annulata. Structura praebet axilla filamenta longitudinalia crebris radialibus filamentis horizontalibus. Filamenta radiantia pedicellata, repetite furcata, dense aggregata. Ultimae furculae moniliformes, 2, 3 cellulis sphaericis coloratis  $3\mu$  diam. constitutae.

The genus *Liagora*, widely dispersed in the warm seas of all the oceans, is particularly difficult to classify, because the "species" run into one another so greatly. De Toni in his *Sylloge*, Vol. iv, gives a classification based on J. Agardh (*Anal. Alg.*, iii), but in Vol. vi he gives no classification.

By Professor Setchell I have been favoured with an arrangement of the species based on the researches of Howe and himself. In this the primary divisions are:

I. *Dichopodiales*.

1. *Dichotomae*.—Truly and regularly dichotomous, ending in short furcations. . . . . Type, *T. valida* Harv.
2. *Subdichotomae*.—Dichotomies regularly and strongly unequal, giving a dichotomo-pinnate habit; apices longer or shorter furcate . . . . . Type, *L. farinosa* Lamour.
3. *Adventitioramae*.—Regularly dichotomous, with short lateral simple or slender dichotomous adventitious ramelli . . Type, *L. distenta* (Mert.) Ag.

II. *Monopodiales*.

4. *Pinnatae*.—Fronds monopodial, pinnate . . . . . Type, *L. pinnata* Harv.

The Lord Howe plant seems to find a place in the *Subdichotomae*, though it shows closer affinities to *L. rugosa* Zan. than to *L. Cheyneana* (which Howe includes in *L. farinosa*) in its more regular dichotomies, its continuous calcification, its fastigate habit and its robustness. I think it best to consider it as a distinct species. It does not agree with any of our other Australian forms and the Lord Howe Flora has a remarkable individuality of its own.

In Australia, *Liagora* is abundant in the tropical and subtropical waters, but also occurs in fair quantity on all the southern coast from Rottneest to Western Port. It has been found in Tasmania.

GALAXAURA Lamouroux.

GALAXAURA RUDIS Kjellman.

A coarse plant attached by a small disc to a fragment of *Goniolithon*. Almost equally thick from base to apices, diam. about 1.5 mm. Branches very numerous but leaving the principal axis evident in the lower part. Branching pinnate, more dichotomous above. Branches with a nearly continuous incrustation of lime, penetrated by the close short pila. Colour of specimen pinkish-grey. Height 12 cm.

The Friendly Islands are the habitat quoted for the species. Coarse fibres, large exterior cells.

GALAXAURA FASTIGIATA Dcne.

Fronde repeatedly forked, to 10 cm. high, axils fairly open, articulate; joints cylindrical, a little over a millimetre in diameter, the ultimate forks slenderer, 5-8 mm. long or a little more, the joints distinct but very narrow, often annulate-rugose, smooth with no hairs, strongly imbued with carbonate of lime and hence brittle. Colour purplish-pink.

Assimilatory filaments free beyond the basal tela, forked, composed of few cells, the penultimate often bearing two smaller ones, penultimate cells  $24\mu$  diam.

Characteristic cystocarps were seen.

The common *Galaxaura* of the Island, gathered at low water on the reef in abundance.

It clearly belongs to the *Eu-Galaxaura* group and is closely related to *G. fragilis* (Lamarck) Kuetz. of the West Indies. It is difficult to decide whether to assign it to *G. eburnea* Kjellm. from Queensland and Timor, or to *G. fastigiata* Dcne. from New Caledonia. I incline to the latter from the larger size and the more distinct annular rugulosities. Our plant is rather slenderer than both of the named species.

#### GALAXAURA TUMIDA Kjellm.

Frond regularly forked, spreading from a thickened attachment, loose, articulate with distinct joints. Joints obovoid or ellipsoidal, swollen, rounded at both extremities, 2-4 times as long as broad, diameter in the neighbourhood of 3 mm., mostly transversely wrinkled, thickly membranaceous, imbued freely with carbonate of lime but not so as to become brittle. Collapsible.

Colour a pinkish-fawn (beige).

Interior lax long hyaline fibres, exterior a tela of angular cells often with a rose-coloured chromatophore,  $24\mu$  in diameter, projecting in free round summits above the surface. I could not see definite fila assimilatoria.

Two plants were gathered in a wet place on the reef; 4 or 5 cm. high. No fruiting organs observed.

The plant belongs to the Cameratae group and agrees best on the whole with Kjellman's description of *G. tumida*, which is in the Areschoug Herbarium as sent by F. von Mueller from "Habrone Bay, New Holland". I cannot find the whereabouts of this locality.

I have the same plant from Norfolk Island, determined by Reinbold as *G. obtusata* (Soland.) Lamour.

#### GELIDIUM Lamouroux.

##### GELIDIUM MAIDENII, n. sp. Pl. vii, fig. 3.

From a plexus of stiff radical fibres rise several independent fronds, some of which attain a height of 37 cm. The axis continuous from base to apex of the frond, compressed; the lower half, stipes, 1-1.5 mm. in diameter, almost entirely bare with a few scattered abortive spinous processes, 1-2 mm. long; the upper half, rachis, distichously pinnate. Pinnae opposite or subopposite, patent, 3-5 mm. distant, to 8 cm. long, the compressed rachis percurrent throughout, bearing subopposite distichous pinnules separated by distances of 2, 3 mm. Pinnules to 5 mm. long, similarly again distichously pinnulate or bi-pinnulate. Ultimate segments short, flat, obtuse.

Structure: An interior core of densely packed colourless fibres occupying most of the rachis, with a few coloured rounded cells involved in the outer zone and an external cortex of compacted vertical series of small coloured cells. Eminently cartilaginous, not adhering to the paper when dry.

Colour a dark purple, fading through brown to a lutescent flesh colour.

Frondes plures e plexu radicali exsurgentes, compressae, axi continuo percurrente, ad 37 cm. altae. Inferne stipes planus longus, 1-1.5 mm. latus, fere nudus; superne rachis distiche pinnata. Pinnae oppositae vel suboppositae,

patentes, 3-5 mm. distantes, rachide compressa, ad 8 cm. longae, distichosis pinnulis 2, 3 mm. distantibus. Pinnulae pinnulatae vel bipinnulatae ad 5 mm. longae. Segmenta ultima brevia, plana, obtusa. Medulla fibris confertis maxime evoluta; cortex cellulis parvis coloratis verticaliter seriatis. Substantia cartilaginea. Color obscure purpureus.

Collected by J. H. Maiden in March, 1898.

GELIDIUM AUSTRALE J. Ag.

A small plant, 7 cm. high, collected by F. A. McNeill in May, 1932.

Common in Victoria and Tasmania, also in Botany Bay and Port Jackson.

PTEROCLADIA J. Ag.

PTEROCLADIA LUCIDA (R. Br.) J. Ag.

Abundant near the South Reef. Some coarser plants of the Western Australian type, but most were more compoundly pinnate with extremely fine terminal divisions. Unfortunately it proved to be the season of tetrasporangia. I could not find a plant bearing cystocarps. I think that there must be a definite season, the autumn, for the production of cystocarps. The only so-fruited specimens among the many which are in my herbarium are some gathered at Kiama, N.S.W., in April.

Reinbold determined certain plants sent to him from Norfolk Island as *Gelidium rigidum* (Vahl.) Grev., but did not recognize *Pterocladia lucida* in the collection. I have not seen authentic specimens, but the description accords well with the majority of the Lord Howe plants, and apparently only tetrasporangiferous plants of the *Gelidium* are recorded. Whether or not I am correct in assigning the Lord Howe plants to *Pterocladia* must remain doubtful until the cystocarps have been obtained. De Toni quotes tropical stations for *G. rigidum*, the only Australian record being the island of Toud, which lies in Torres Strait.

PTEROCLADIA CAPILLACEA (Gmel.) Bornet & Thuret.

Common on the floor of the Lagoon. Also from Norfolk Island (Reinbold).

GYMNOGONGRUS Mart.

GYMNOGONGRUS IRREGULARIS Zan.

Zanardini's description may be rendered: Frond setaceous; low, irregularly pinnately branched; branches issuing in all directions, alternate, opposite or more often secund, the ultimate branches short, issuing horizontally in the form of spines; apex obtuse; fruits unknown. Colour atro-purpureous.

Collected by Fullagar and Lind.

MYCHODEA Harvey.

We saw no examples of this genus. Zanardini, however, described two species from Lord Howe.

*M. natymenioides* Zan.—De Toni cites the same also from "Swan Island", Australia (J. Agardh). This may refer to the island of that name, which lies in Port Phillip near the Heads.

*M. fastigiata* Zan.—As this specific name had already been bestowed on another species, De Toni and Levi have given it another, viz., *M. Zanardini* De Toni and Levi.

*Mychodea* is a characteristic Australia-Tasmanian genus. Kylin (Die Florideen-ordnung Gigartinales, 1932) enumerates 14 species, all from this region.



He does not mention *M. Zanardinii*, but lists and figures *M. halymenioides* from the "Swan Island" example in the Agardh Herbarium at Lund.

De Toni records an example of *M. foliacea* (Harv.) J. Ag. collected at Port Chalmers, New Zealand, by Dr. G. Capra. This is, as far as I know, the only known occurrence of *Mychodea* outside Western and South Australia and Tasmania. De Toni and Forti, "Alge di Australia, Tasmania and Nuova Zelandia", 1923.

EUCHEUMA J. Ag.

EUCHEUMA SPINOSUM (L.) J. Ag.

Collected by J. H. Maiden in March, 1898. Sterile. A tropical species in Sumatra, Papua and tropical Australia, extending to Japan in the north, and, it would seem, to Lord Howe in the south.

The Eucheumas are eminently gelatinous. *E. speciosum* (Sond.) J. Ag. occurs freely in Western Australia, and *E. gelatinae* (Esp.) J. Ag. is recorded from northern Australia and New Caledonia and (fide Grunow) extends to Japan.

ARESCHOUGIA Harvey.

ARESCHOUGIA LAURENCIA (H. & H.) Harvey.

(= *A. gracilarioides* Harv.; = *A. congesta* J. Ag.).

Forma LONGIRAMEA, forma nova.

It was a surprise to find this genus represented at Lord Howe. All our described species live on the west and south coasts of Australia and in Tasmania, *A. laurencia* occurring throughout. Laing records it from New Zealand. We gathered two well developed specimens about 20 cm. in length. They differed from typical Tasmanian plants in the greater length and looseness of the branches, being much less bushy and recalling somewhat the habit of *Gracilaria lichenoides*; further, the intermediate zone between the axile tube and the cortex is much more developed, strings of fairly large coloured cells passing outwards, among which the colourless filiform branches of the axile tube are difficult to follow in the cross-section. In *A. laurencia* this zone is occupied by the filiform branches, and fills an extensive area. In both forms the stems and branches are terete. For the present I think it had better be described as a form of *A. laurencia*, produced during long isolation at Lord Howe.

SARCODIA J. Ag.

SARCODIA CILIATA Zan.

Common on and around the reefs and rocks at 1 or 2 fathoms. Colour red, fading into yellow, often conspicuously yellow when viewed from a boat.

Tetraspores remain to be seen.

So far as is known, endemic to Lord Howe.

SARCOCLADIA HARV.

SARCOCLADIA (?) RHIZOPHORA, sp. indescript. Text-fig. 6.

Prostrate rosette-like expansions of 5, 6 cm. in spread, consisting of a few layers of overlapping radiating regularly dichotomous fronds. Fronds flat, compressed, 2 mm. diam., below, may diminish to 0.5 mm. in ultimate segments, but in general fairly uniform. Axils wide, apices obtuse, almost absciss.

An extraordinary feature is the great number of cylindrical processes issuing from the whole under surface of the frond. These rise in small mamillae and may grow to a length of 5 mm. or more, mostly quite free, but occasionally are found attached at the extremity to the substratum. They seem to be clearly

organs for attachment, and may be considered as adventitious rhizoids. Frond cartilagino-coriaceous, does not adhere to the paper. Colour dark-red when fresh, turning black when dry.

The cross-section shows a Gracilarioid structure, entirely cellular, the innermost cells colourless, scarcely larger than those externally adjacent to them; these and the smaller, but not minute cortical cells, are deeply coloured.

Planta prostrata in rosetta, 5, 6 cm. diam., duobus vel tribus stratis frondium superpositis consistens. Frons plana, 2 mm. lata, superne ad 0.5 mm. minuata, regulariter dichotoma, axillis latis, apicibus obtusis fere abscissis. De pagina inferiore dependent plures processus adventitii cylindrici crassi, ad 5 mm. longi, liberi vel matriçi adhaerentes. Structura fere Gracilariæ, omnino parenchymatosa; cellulae interiores majores, incoloratae; cellulae intermediae vix minores, coloratae; cellulae corticales minores, coloratae, monostromaticae. Substantia cartilagineo-coriacea. Color obscure ruber, in sicco niger.

No reproductive organs seen.

Growing sparingly on the reef.

I forwarded this plant to Prof. Setchell, and it is on his suggestion that I refer it to *Sarcocladia* with a query, and employ the specific name *rhizophora*. It may demand a generic name of its own, but in the absence of reproductive organs nothing more precise can be asserted.



Text-fig. 6.—*Sarcocladia* (?) *rhizophora* Lucas.

Text-fig. 7.—*Laurencia elegans* Lucas.

#### GRACILARIA Greville.

#### GRACILARIA HOWENSIS, n. sp.

Frond terete, flattening on drying, with a stipes about 1 cm. long, then dichotomous, divaricate, above with subsecundate branches; ultimate ramuli very patent, acuminate with broad base, inclined to be arcuate. Substance thick, succulent, fleshy, main branches about 2 mm. diam. Adheres to paper. Height to 8 cm. Colour a dark purple.

Interior cells thin-walled, numerous, gradually diminishing in size towards the submonostromatic coloured cortex. Neither cystocarps nor tetrasporangia seen.

It is unlike any of the Australian species, but in habit and dimensions recalls *G. dumosa* Harv., from the Friendly Islands. The cross-section of one of Harvey's specimens in the N.S.W. National Herbarium showed the interior cells much fewer, the central ones very large and much exceeding those exterior to them.

Frons teres, in sicco complanata, ad 8 cm. alta, stipite 1 cm. longo, dichotoma, divaricato-patens, ramis superioribus nunc subsecundatis. Ramuli ultimi patentissimi, basi lato, acuminati nunc arcuati. Rami majores 2 mm. diam. Cellulae interiores muris tenuibus crebri, gradatim minores versus corticem coloratum submonostromaticum. Substantia carnea-succulenta; planta siccata ad chartam adhaeret. Color obscure purpureus.

Fragments of other Gracilarias were seen, but not identified.

HYPNEA Lamour.

HYPNEA SETICULOSA J. Ag. (?).

I refer to this species a few caespitose plants, densely intricate and drying a very dark colour, abundantly provided with seticules. Height to 5 inches, with an equal spread. At all events they belong to J. Agardh's Section Spinuligeræ, and are very closely related to *H. seticulosa* and *H. divaricata*. Fruiting organs not seen.

HYPNEA CENOMYCE J. Ag.

Plants collected by R. Baxter in 1922, bearing the characteristic stout inflated apiculate branchlets with immersed tetrasporangia.

Recorded by De Toni from Australia, without more specific reference to locality.

CHAMPIA Desvaux.

CHAMPIA PARVULA (Ag.) J. Ag.

Occurring with the usual intricate branching.

If the Australian forms attributed to *C. parvula* are truly the same as the European and American, then the species is indeed cosmopolitan.

Harvey records it for west, south and east coasts of Australia, from Tasmania and New Zealand, and from the Friendly Islands. I have found it in fair abundance in the harbours of the east coast, Moreton Bay, Port Stephens, Port Jackson and Botany Bay.

PLOCAMIUM Lamouroux.

PLOCAMIUM HAMATUM J. Ag.

The commonest Red Weed of Lord Howe.

Originally recorded from Norfolk Island and the mouth of the Burnet River, Queensland. I have it also from Caloundra, Queensland.

Cystocarps not seen. Three or four plants bore poorly developed sporophylls carrying tetrasporangia.

Mr. Basset Hull gathered a plant bearing large sessile cystocarps at Caloundra in August, 1922, and Mr. J. H. Maiden at Lord Howe in March, 1898.

PLOCAMIUM LEPTOPHYLLUM Kuetz.

Collected by J. H. Maiden in March, 1898. Cast up. Sterile.

Australia, Tasmania and New Zealand.

## PLOCAMIUM ANGUSTUM (J. Ag.) H. &amp; H.

Collected by J. H. Maiden in March, 1898. Cast up. Ripe sporophylls present. Common in southern and eastern Australia and Tasmania, and it extends to New Zealand and the Chatham Islands.

## DELISEA Lamouroux.

## DELISEA PULCHRA (Grev.) Mont.

A luxuriant specimen collected by J. H. Maiden in March, 1898.

The finest plants grow on the coast of New South Wales, where it is abundant. Occasionally met with in Western Australia and round the south coast. R. M. Laing lists it from the Kermadecs and from New Zealand (De Toni says *rarissime*) and adds South Georgia and Graham's Land. Harvey, after Hooker, attributes it to Kerguelen.

## ASPARAGOPSIS Montagne.

ASPARAGOPSIS TAXIFORMIS Delile (= *A. Delilei* Mont.).

Confirmed for me by Drs. Svedelius and Börgesen. It is extremely doubtful, indeed Harvey himself was doubtful, if *A. Sanfordiana* Harv. is distinct from *A. taxiformis*. As far as I can judge, the properties on which Harvey relied in his Western Australian species, viz., the great size (to 10 inches), the dark colour, much branched and developed surculi, comparative length of the naked portion of the stem, and the rounded tips of the tufts of ramelli, are all reproduced in the plants growing on the floor of the Lord Howe Lagoon at a depth of a fathom or so. Dr. Börgesen, who has observed *A. taxiformis* in the West Indies and Canary Islands, believes that it cannot be distinguished from *A. Sanfordiana*, and I do not think that the unarmed species which grows on the southern Queensland coast and Lord Howe differs materially from that which grows in Western Australia.

## MARTENSIA Hering.

## MARTENSIA SPECIOSA Zan. Pl. viii, fig. 1.

Not infrequent, growing on the reefs, especially in the larger pools.

Perhaps chiefly distinguished from its allies by the exiguous margins. Our largest specimen measured 8 cm. in length.

Zanardini apparently did not see tetrasporangiferous plants. We met, fortunately, with both cystocarpiferous and tetrasporangiferous individuals. The sporangia were scattered, immersed in the turgid transverse and longitudinal walls of the reticulum. Each sporangium was provided with a spherical colourless envelope, and divided into a tetrad of spores. Envelope about  $105\mu$  diam.

Apparently endemic.

*M. elegans* Hering is fairly abundant on the coast of New South Wales. Laing records it from the Kermadecs, quoting Oliver.

## LAURENCIA Lamour.

## LAURENCIA ELEGANS, n. sp. Pl. viii, fig. 2; Text-fig. 7.

A slender plant, 10 or 11 cm. high, with decompound pinnate ramification, the branches issuing in all directions, the lower ones as main axes. Diameter of the axis  $700\mu$ , and of the main branches rather less. Branches bearing numerous short alternate ramuli also issuing in all directions; ramuli with 3 or 4 segments, the segments similarly 3- or 4-lobed; ultimate lobes linear-oblong, with flat, blunt and thickened apices, surface cells somewhat projecting. Surface cells not palisade-like; no thickenings in the medullary or inner cortical cell-walls.

Fronds rather cartilaginous than soft, adhering closely to the paper. Colour purple-violet.

Tetraspores in all stages immersed in the lobes.

Cystocarps, on another plant, sessile, often in series, globular, containing stipitate pear-shaped spores rising from the basal placenta. Diameter 600 $\mu$ .

Found floating in drift, tangled with other algae.

Apparently allied to *L. nidifica* and *L. pannosa* and perhaps most closely to Yamada's *L. mariannensis* from the Marianne Group (Setchell).

Frons tenuis, 10, 11 cm. alta, decomposita pinnata, ramis quoquoversum emergentibus, inferioribus rachides majores informantibus. Stipitis diam. 700 $\mu$ . Rami crebris brevibus alternatis ramulis, quoquoversum divergentibus. Ramuli 3, 4 segmentis; segmenta 3, 4 lobis. Lobi ultimi lineari-oblongi, apicibus complanatis crassis obtusis. Cellulae superficiales in sectione transversali non radiatim elongatae; parietes cellularum medullariarum non incrassati. Cellulae superficiales apicum leviter prominentes. Substantia cartilaginea. Tetrasporangia in lobis immersa.

Cystocarpia sessilia, globosa, saepe seriata, 600 $\mu$  diam. Color purpureo-violaceus.

#### LAURENCIA MAJUSCULA Harv.

Yamada (Notes on *Laurencia*, with special reference to the Japanese species, 1931) considers that all the Australian forms referred to *L. obtusa* var. *majuscula* Harv. and *L. dendroidea* J. Ag. are the same thing, and to be separated from *L. dendroidea* J. Ag. from Brazil. They agree in the absence of palisade cells in the cortex, and the absence of lenticular thickenings in the walls of the medullary cells, but the surface cells in the Australian form are projecting and in the Brazilian are not projecting. J. Agardh himself had some doubts when he assigned the Australian form to his *L. dendroidea*. Yamada raises Harvey's other Australian variety of *L. obtusa*, *L. obtusa* var. *regia*, to definite specific rank as *L. regia* Harv. I propose in the same way to separate the var. *majuscula* from the English *L. obtusa* (Huds.) Lamour., and to erect it into a definite species, *L. majuscula* Harv.

A handsome arborescent species, of a rich red-purple colour, growing to more than a foot in height, and one of the conspicuous Red Algae growing on the floor of the Lagoon. Harvey's description is "fronde sanguinea crassiore elata (6-8 uncias longa) densissime composito-pinnata, ramis ramulisque brevibus, creberrimis".

Harvey records it from Rottnest Island and King George's Sound in the west, and from Cape Schank, Victoria. I have it from the coast of Queensland from Bowen and Caloundra.

LAURENCIA CONCINNA Mont., 1842, from Toud Island. Pl. ix, fig. 1.

Growing luxuriantly in deeper water, to a height of 14 cm., and of a rich reddish-purple colour. We found stichidia in abundance but saw no cystocarps. In fact no cystocarps seem to have been observed in the West Indian or Australian plants.

*L. concinna* has a wide range in tropical and subtropical seas of Australia. In Harvey's Alg. Exsicc. Austr. there is a specimen from Fremantle, and I gathered it on Rottnest Island; d'Urville found it in Torres Strait at the "Isle Toud"; Yamada identified a specimen from Port Douglas in the Herb. Thuret in Paris; the Melbourne Herbarium has it from Keppel Island; I gathered it freely at Caloundra, and it grows in excellent condition at Lord Howe.

Yamada considers that all the forms of *L. concinna* are really identical with *L. Brongniartii* J. Ag. from Martinique in West Indies, and this name has priority. I am not convinced, however, after studying the descriptions given in De Toni's Sylloge (De Toni places them in different groups) and the figures given by Yamada of typical *L. Brongniartii* that the Australian is identical with the West Indian species, and therefore prefer to keep our Australian forms apart under the name *L. concinna* Mont.

POLYSIPHONIA Greville.

POLYSIPHONIA IMPLEXA H. & H.

A four-siphoned ecorticate form growing entangled among other algae. Joints short as, or shorter than, the breadth. Diameter of lower branches  $225\mu$ . Here and there producing adhesive discs. Colour very dark, almost nigrescent purple. Fronds caespitose, about an inch in height.

Hooker and Harvey described *P. implexa* on New Zealand material. Harvey detected it in King George's Sound.

POLYSIPHONIA GELIDII Zan.

*Phyc. Austral. nov.*, 1874.—"Fronde parvula, tenuissima, repente, subdichotome ramosa, ramulis ultimis lateralibus subulato-attenuatis; articulis 4-siphoniis, primariis diametro sesqui-duplo longioribus, secundariis diametro subaequalibus; cystocarpis sphaeroideis, ad ramos sessilibus. Hab. in frondibus Gelidiacearum ad insulam 'Lord Howe'."

This form, which is preserved in Herb. Zan., would appear, from the above description, to be very close to, if not identical with, *P. implexa*. In the latter, however, the articuli are all about as long as broad. The cystocarps of *P. implexa* have not been described, and in neither have the tetrasporangiferous ramuli been observed. Further information is desirable.

POLYSIPHONIA BAXTERI, n. sp.

Growing as a fringe on a fruiting stem of *Gracilaria*. Diameter of branches from  $150\mu$  at base, diminishing upwards. Joints mostly  $2 \times 1$  below, and of ultimate segments  $1 \times 1$ . Four siphons. Cystocarps with a one-jointed pedicel, nearly spherical,  $170\mu$  diam. Height about 1 cm. Colour violaceous.

Collected by R. Baxter. A single specimen.

Frondes gregariae capillares in ramo *Gracilariae* epiphyticae. Rami ramulique acutis angulis alterne surgentes, basale diam.  $150\mu$ . Articuli basales  $2 \times 1$ , ultimi  $1 \times 1$ . 4 siphones. Cystocarpia uni-articulato pedicello suffulta, fere sphaerica,  $170\mu$  diam. Planta ad 1 cm. alta. Color violaceus.

AMANSIA Lamouroux.

AMANSIA GLOMERATA Ag.

Common on the South Reef; occasional on the eastern reefs, there dwarfed and stunted, cropped by animal life.

Base a disc. Stipes stout for the size of the plant, 2 mm. diam., terete and tough, to 12 mm. long, then branching with 3, 4 alternate divaricate terete branches to 15 mm. long. These sparsely divide in the same way. The secondary divisions bear near their apices, conglomerates of almost rosulate pinnae, folia. Folia sessile, flat, linear, to 14 mm. long, to 3 mm. broad, with marginal teeth and incurved rather obtuse apices. Midrib not apparent and no veins. The marginal teeth sometimes grow out into similar secondary folia, toothed like the

primary. Cells typical of the genus, large elongated hexagons in two layers, arranged in transverse zones. No cortex.

No cystocarps or tetrasporangiferous stichidia seen.

I referred an example to H. Kylin, who gives me the above determination.

It has not as yet been recorded from Queensland, but Sonder's *A. pumila* from Cape York comes near to it.

Widely distributed in the Pacific and Indian Oceans; Sandwich Islands (Gaudichaud), Samoa (Grunow), Friendly Islands (Harvey), Sulu (Falkenberg), New Caledonia (Vieillard), Mauritius, Madagascar, Dar-es-Salaam.

ENANTIOCLADIA Falkenberg.

ENANTIOCLADIA ROBINSONII (J. Ag.) Falk.

Originally described by J. Agardh from plants sent by Mr. Isaac Robinson from Norfolk Island. Our Lord Howe plants were, many of them, larger than those described from Norfolk, to a decimetre or more in length, and with a spread of 2 dm. Growing in abundance on the South Reef.

*Enantiocladia Robinsonii* is not confined to Lord Howe and Norfolk Islands. I gathered it at Caloundra, and Mr. H. A. Longman sent it to me from Noosa Heads, both on the South Queensland coast.

No cystocarps seen, and the slender branched marginal processes had developed no tetrasporangia. It appears to have been the wrong season of the year for the fruiting.

DASYA C. Agardh.

DASYA FRUTICULOSA, n. sp. Pl. ix, fig. 2.

Growing on coral boulders on the floor of the lagoon and on the piles of the jetty.

A delicate bushy plant, 10–13 cm. high, with an equal lateral spread. Attached by a disc from which rise several stems. Stems slender, about 300 $\mu$  diameter, smooth, for the greater part covered with branches issuing on all sides. Branches decompound pinnate, all closely corticate, except the ultimate ramuli which bear numerous dichotomous monosiphonious capillary ramelli forming long pencils. Five siphons. Siphons of the ramuli to six times as long as broad. Joints of the ramelli 3, 4  $\times$  1.

Stichidia broadly lanceolate, springing abruptly from a short 1–3-celled pedicel, long acuminate, often terminating in a monosiphonious filum which may have a length of one-fifth to one-half the length of the stichidium proper. The ripe sporangia biseriolate, with suppression of others in the same rank. Length of whole stichidium with filum 400–500 $\mu$ ; width to 75 $\mu$ .

Colour purple-crimson.

Perhaps nearest to *D. capillaris* Harv., but differing from it in the nearly complete cortication and bushy habit. *D. capillaris* from the Tamar is perflaccid, the ramelli extremely soft and tender, adhering so tenaciously to the paper that they cannot be removed on moistening without disruption, while those of the present species are readily detachable.

A. and E. S. Gepp (*Journal of Botany*, 1906) considered specimens of a *Dasya*, which I had sent them, to be the same as *D. capillaris* Harv. It is common in Botany Bay and occurs in Port Stephens. I have a specimen collected by Harvey in Port Jackson, which he labelled *Dasya* sp. It seems to me to be a form intermediate between *D. capillaris* and *D. fruticulosa*, but nearer to the latter. It is

the only *Dasya* which I know of from the east coast of Australia, with the exception of the little known *D. cuspidifera* of Sonder from the north-east.

Of the 46 described species of *Dasya*, 25 are resident in Australia-Tasmania. All of these are, so far, only known from Australia, except that *D. mollis* Harv. occurs in the West Indies, and *D. collaberis* H. & H. in New Zealand, while Yendo records *D. collaberis* and *D. elongata* Sond. from Japan.

Dr. Börgesen has recently described a new species of *Dasya*, *D. flagellifera*, from the Arabian Sea. He had previously recorded *Heterosiphonia Muelleri*, supposed to be exclusively Australian, from the same district.

Frons delicatula, fruticulosa, 10-13 cm. alta, aequaliter expansa. Rachides plures e disco communi exsurgunt. Stipes tenuis, 300 $\mu$  diam., glaber, ramis crebris quoquoversum emergentibus. Rami decomposito-pinnati, dense corticati. Ramuli ultimi articulati, ramellis crebris dichotomis, monosiphoniis, capillaribus penicillatis induti. 5 siphones. Articuli siphonum ramulorum 6  $\times$  1, ramellorum 3, 4  $\times$  1. Stichidia late lanceolata, pedicello brevi 1-3 cellulis suffulta, acuminata, in filum monosiphonium producta, 400-500 $\mu$  longa, 75 $\mu$  lata. Color obscure coccinea.

#### EUPHILOTA Kuetz.

##### EUPHILOTA FORMOSISSIMA (Mont.) Kuetz.

Single plant collected by J. H. Maiden in March, 1898. Known only from New Zealand and the adjacent islands. The specimen was clearly cast up on the beach and may have drifted from New Zealand waters.

#### CERAMIUM Wiggers.

##### CERAMIUM SETCHELLII, n. sp.

About 8 cm. high, altogether dichotomous, the lower forks at rather distant intervals, the branches free, erect. Diameter of the lower stem 230-250 $\mu$ . Upper divisions capillary. Lower joints to three times as long as broad, two-thirds of each naked, cortex of genicula sub-prominent; upper joints long as, or shorter than, broad, cortex confluent. The cortical bands are composed of crowded small coloured cells; in some genicula large colourless cells, often projecting, occur and give the band a heterocystid appearance, but I suspect these are foreign to the plant. Tetrasporangia periclinous, almost stalked, emergent. Colour pale purple.

Gathered floating among weeds carried in by stormy weather.

Not quite the same as any of the Australian Ceramia I have seen. As Prof. Setchell has pointed out, the plant belongs to the *C. strictum* and *C. diaphanum* group, and so is probably related to the Australian *C. aequabile*, to which J. Agardh gave the name without, however, giving the description.

I dedicate the species to Professor Setchell, who has given me much generous counsel with respect to the Lord Howe algae.

Frons ad 8 cm. alta omnino dichotoma. Dichotomia inferiora admodum distantia. Rami liberi, erecti, superiores ramulique capillares. Diam. partis inferioris rachidis 230-250 $\mu$ . Articuli inferiores 3  $\times$  1; duae partes cujusque nuda. Articuli superiores diametro aequales vel breviores, cortice continuo investiti. Genicula plerumque cellulis minutis confertis coloratis composita; hinc et illinc cellulas majores transparentes saepe prominentes, forsitan peregrinas, praebentia. Tetrasporangia periclinia subpetiolata, emergentia. Color purpureus.



## Order CRYPTONEMINAE.

## HALYMENIA C. Ag.

The two following species were founded on plants from Lord Howe Island collected by Fullagar and Lind, by Zanardini in 1874. We did not see either.

## HALYMENIA (?) MULTIFIDA Zan.

FronD flat, linear, stipitate-cuneate, gelatinous-membranaceous, dichotomomultifid, segments attenuated at the base, entire or with callous denticulations on the margin, apex obtuse. Colour vividly purpurascens. Fruits unknown. FronD rather thick.

Owing to the facies and substance being of *Callophyllis* and the structure of *Halymenia*, Zanardini thought that the plant might form a new genus.

## HALYMENIA FIMBRIATA Zan.

FronD flat, linear-lanceolate, substipitate-cuneate, gelatinous-membranaceous, repeatedly dichotomous, segments linear-lanceolate, densely ciliate on the margin, apex obtuse, mostly bifid, the cilia short, at length elongated-strap shape. FronD thin. Colour a pleasant rose. Cystocarps scattered in the disc of the frond.

## CARPOPELTIS.

## CARPOPELTIS PHYLLOPHORA (H. &amp; H.) Schmitz.

Two examples, intense red, some of the segments bearing fruiting *Melobesia*. A stout stipes, more than half an inch long; frond 5-6 inches long, irregularly dichotomous. No fruit.

"Clearly a *Carpopeltis*, and very close to, if not identical with, *C. Phyllophora*" (Prof. W. A. Setchell).

*C. Phyllophora* occurs in Western Australia and Tasmania, according to Harvey.

## INCRUSTING CORALLINACEAE.

I do not venture to report on the incrusting Corallinaceae, though they are by no means lacking. The outer part of the south-eastern fringing reef is composed of a thick crust of a red *Lithothamnion*. The reef is treacherous, often roofing over a current of deep water and liable to give way under the tread. It is only exposed at the time of exceptionally low tides, and none such occurred during our visit. Lumps of *Goniolithon* were cast up. Species of *Melobesia* were gathered incrusting other algae, and bore conceptacles, but I cannot attempt to identify them. The field will doubtless be an ample one for an expert investigator.

## AMPHIROA Lamouroux.

## AMPHIROA HOWENSIS, n. sp.

Cushion-like masses of about 10 cm. diam. Composed of intricate diverging dichotomous jointed fronds. Joints terete, 3-5 mm. long, 1 mm. diam. Forks diverging at wide angles, 45° or more. Apices blunt, rounded-abciss. Genicula inconspicuous, calcified externally. Conceptacles round, flatly conical, borne laterally. Colour pink. Highly calcified.

Belongs to the Section Eu-Amphiroa of Decaisne. By its regular dichotomies separated from the other species of De Toni (*Syll.*, Vol. iv, Sect. 5, and Vol. vi, Sect. 5), as also from the Amphiroas of Yendo (Corall. Japon.) of Japan.

Complanata moles ad 10 cm. diam., frondibus intricatis divergentibus dichotomis articulatis contexta. Articuli teretes, 3-5 mm. longi, 1 mm. lati. Apices obtusi, rotundato-abcissi. Genicula inconspicua, crusta calcarea investita. Conceptacula lateralia depresso-conicalia. Color erubescens.

## JANIA Lamouroux.

## JANIA RUBENS L.

Common on the reef and rocks around the lagoon.

## CORALLINA (Tournefort) Lamouroux.

## CORALLINA CHILENSIS Dcne.

Densely caespitose, covering the surface of the reef in places in the neighbourhood of low-tide mark. About an inch high. Dull pink. Conceptacles small, ovate, terminal, without antennae.

Common on the ocean shores near Sydney. Recorded from Norfolk Island, Chile and Japan.

## CORALLINA ROSEA Lamarck.

A most beautiful and graceful plumose species of a bright rose colour. Pinnules very numerous, slender, subcapillary, with joints thrice as long as the diameter. Conceptacles terminal, urceolate, with two long antennae of several joints. The characters agree well with Lamarck's description as given in De Toni, but the pinnules and antennae are longer than in Harvey's figure in *Nereis Australis*.

Our plants were cast up, probably from deeper water, caespitose, the separate fronds to 10 cm. high. Harvey's specimens were from King George's Sound, W.A.

The Red Algae are the most numerous in species, including, in fact, more forms than the Greens and Browns combined. The list shows Green 24, Brown 23, Red 53.

The stony *Goniolithon* and the massive *Lithothamnion* are tropical. The latter plays a prominent part in the building of the largest of the present-day live coral reefs.

In general, however, there is a mingling of forms, the Temperate Zone species being in the majority. Australian weeds are occasionally drifted across and the New Zealand *Euptilota formosissima* has once been picked up on the beach.

As in the other Groups, the Lord Howe isolation and environment have resulted in the development of peculiar forms. Zanardini described as new species *Mychodea halymenioides* and *M. fastigiata*, *Sarcodia ciliata*, *Martensia speciosa* and *Polysiphonia Gelidii*. To these in the present paper are added *Bangia* (?) *simplex*, *Liagora Howensis*, *Gelidium Maidenii*, *Sarcocladia* (?) *rhizophora*, *Gracilaria Howensis*, *Laurencia elegans*, *Polysiphonia Baxteri*, *Dasya fruticulosa*, *Ceramium Setchellii* and *Amphiroa Howensis*. Thus nearly one-third of the Red Algae are peculiar to the island.

## ECOLOGY.

There are three well marked regions: (1) the lagoon, (2) the fringing reefs exposed at low tide, (3) the deeper waters outside the reefs. Our work was practically confined to (1) and (2).

The plants of the lagoon were *Ulva Lactuca*, *Cladophora Goweri*, *Spongocladia vaucheriiformis*, *Acetabularia calyculus*, *Bryopsis comosa*, *Codium Lucasii*, *C. spongiosum*, *C. bulbopilum*, *Sargassum Howeanum*, *S. spinifex* and other *Sargassa*, *Hormosira Banksii*, *Gymnosorus nigrescens*, *Padina Pavonia*, *Haliseris crassinervis* and *H. plagiogramma*, *Glossophora Harveyi*, *Colpomenia sinuosa*, *Hydroclathrus cancellatus*, *Ectocarpus confervoides*, *Helminthocladia tumens*, *Pterocladia lucida*, *P. capillacea*, *Sarcodia ciliata*, *Plocamium hamatum*,

*Asparagopsis taxiformis*, *Laurencia majuscula*, *Dasya fruticulosa*, *Ceramium Setchellii*. The Browns were most abundant, often growing in groves, the Reds and Greens growing sporadically.

Characteristic of the Reefs were *Dictyosphaeria favulosa*, *Valonia Forbesii*, *V. pachynema*, *Cladophoropsis Howensis*, *Caulerpa taxifolia*, *C. thujoides*, *C. racemosa*, *C. peltata*, *Chlorodesmis major*, *Dictyota rugulosa*, *Helminthora tumens* (tall form), *Liagora Howensis*, *Galaxaura rudis*, *G. fastigiata*, *G. tumida*, *Sarcocladia* (?) *rhizophora*, *Martensia speciosa*, *Amansia glomerata*, *Enantiocladia Robinsonii*.

In the south the western reef is, in its outer border, submerged, except at the rare times of extraordinary low tides, and we were not able to reach it. Here is the *Lithothamnion* reef. Here also we suspect grow *Laurencia concinna*, *Pterocladia lucida*, *Sarcodia ciliata*, *Laurencia majuscula* and *Enantiocladia Robinsonii*, as we judged by the number of plants thrown up in rough weather on a small beach south of the reef.

Of the deeper sea forms we only obtained *Ecklonia radiata*, brought up on a fishhook, but were informed that *Macrocystis pyrifera* had been observed there in quantity.

#### PHYSICAL CONDITIONS.

Lord Howe Island lies in 31° 33' S. lat. and 159° 3' E. long. It is a tropical outlier. According to Hedley, it is the most southerly island possessing living coral reefs.

It lies 300 miles due E. of Port Macquarie and 450 m. NE. of Sydney, 500 miles W. of Norfolk Island and 750 NW. of New Zealand.

It is crescent-shaped, seven miles long, with an average breadth of one mile, and consists of three volcanic ridges, connected by lower undulating land formed by wind-borne coral sand, which has consolidated under percolation of rain and fresh water into a calcareous rock, with more than 90 per cent. of calcium carbonate in its composition.

The volcanic rocks occupy two-thirds of the island and form three elevated ridges; the southern massif forming roughly one-half of the island, with the giants Mt. Gower (2,840 ft.) and Mt. Lidgbird (2,804 ft.); a lower intermediate ridge, with Mt. Lookout (414 ft.); and a northern, with the conical Mt. Eliza and Mt. Malabar or North Peak (714 ft.).

The sea face of the northern and the southern ridges consists of precipitous cliffs, 600-700 feet high, or more in the south. On the east are three sandy beaches, Ned's, Middle and Blinkenthorpe, with fringing reefs on the coast between them. On the west, on the concave side of the crescent, is a lagoon about four miles long and averaging half a mile in breadth, protected by a fringing coral reef which forms the chord of the crescent. This reef stretches from North Bay to Mount Lidgbird and has five gaps in it, the widest of which serves as a channel for smaller craft; larger vessels are obliged to anchor outside. The lagoon has an average depth of less than a fathom at low tide, though there are one or two deeper holes in which the corals are alive; at high tide another six feet of water are added.

The geological structure shows that the island has never formed an integral part of Australia or of New Zealand. The origin seems to have been the eruption of a number of volcanic peaks in this section of the band of weakness which stretches round the West Pacific from the Kuriles to New Zealand. Some of

these, as the six Admiralty Islands only a quarter of a mile off, and Ball's Pyramid (1,816 ft.), a number of miles to the SE., have remained isolated, but the volcanic ridges of Lord Howe have become connected to form a larger island.

In periods of comparative rest, corals grew on the sides of the peaks forming fringing reefs; the debris of these formed the sandy beaches and was carried thence by the strong winds from east and west, to a height in places of 250 feet above sea-level. Thus the wind-blown sand accumulated and eventually filled in the channels between the several islets and, consolidating into rock, now forms the lower levels of the island. A depression of a comparatively few feet would reduce Lord Howe to its original condition of a group of small islets.

That the coral sand rock is of aeolian origin was pointed out by Etheridge, and is confirmed by the observations of Anderson, McCulloch and others. Thus Dr. Anderson writes: "This coral-sand rock consists of comminuted and completely rounded coral debris, with grains of volcanic material such as augite, magnetite, and altered lava, with occasional fragments of echinoderms, shells, foraminifera and other invertebrates. Speaking generally, the constituents of the coral-sand rock agree very closely with the component particles of the present beach at Lord Howe Island. It varies in thickness, its greatest elevation being about 250 feet above sea-level" (Dr. Charles Anderson, *Records of the Australian Museum*, Vol. xiv, No. 4).

The date or dates of the volcanic eruptions cannot be precisely specified. "These volcanic rocks", writes Sir Edgeworth David, "appear to belong to three leading types, (1) basalt with olivine, (2) basalt without olivine, lateritic, (3) basalt diabasic, probably of considerable geological antiquity. . . . A vast period of time must have elapsed between the eruption of (3) and (1). . . . All the basalts, with the exception of the diabasic types, are probably not earlier than Tertiary, and some may be Post-Tertiary. The diabasic basalt is probably Pre-Tertiary, and may be Palaeozoic."

The age of the coral-sand rock may be surmised from the organic remains preserved in it. These include shells of the large land shell *Placostylus*, commonly found in the rock, together with bones and eggs of the burrowing Mutton Bird (*Puffinus*), and scattered bones and four eggs of the large Chelonian *Meiolania platyceps*. The last is the only extinct form known from the rock. Dr. Anderson has given us two important memoirs on this reptile. He concludes that *Meiolania* was essentially a terrestrial reptile, in gait and posture very similar to *Testudo*. He has further described another species, *M. mackayi*, from Walpole Island, one hundred miles SE. from New Caledonia. He writes: "In my previous paper I pointed out that, as Walpole Island is of coral origin, and has apparently never been connected with any larger land mass, the occurrence there of *Meiolania mackayi*, a form very similar to *M. platyceps*, indicates that the animal was able to cross a considerable stretch of ocean. This possibility is not excluded by its adaptation for a terrestrial existence, for *Testudo* is a good swimmer, as Beebe has pointed out (Galapagos). But on the whole, the skeleton of *Meiolania*, the proportions of its limb bones, the structure of its phalanges, and its heavily armoured condition, strongly indicate that it was built for life on land" (*Records Australian Museum*, Vol. xvii, No. 7).

From the above I think we may conclude that the sand-rock formation may have commenced in the Pliocene, but has been chiefly built up in Pleistocene times, and that we may claim that the island has been isolated from the beginning of the Pleistocene, which gives ample time for the evolution of new forms of life.

## SOURCES OF THE MARINE FLORA.

The origin of the Marine Flora must naturally be considered in conjunction with the origin of the other denizens of the island.

With regard to the land fauna, much research has been made. No indigenous mammalia have existed. Rats came ashore in 1919 from a stranded vessel and proved a pest. They have destroyed almost all the native birds, and are still present in hordes to the grave detriment of the palms and garden produce. The land birds were almost all peculiar to the island, showing, according to Basset Hull, closer relations with Australia than with New Zealand, while, according to Tom Iredale, the extinct Pigeon and the extinct Rail were definitely of New Caledonian association. Even among the sea birds, an endemic species of Mutton Bird (*Puffinus*) has been described, which breeds on the island. Of the three small indigenous lizards, the commonest is known from north-west Australia. A. M. Lea noted the affinity of the insects with those of northern New South Wales, but there is an admixture of forms which have reached New Zealand.

Of the land mollusca, Tom Iredale writes me as follows: "Land mollusca are comparatively numerous, and some of large size indicating a continental connection." [Unfortunately the rats have played havoc amongst them and, though dead shells exist in great numbers, living animals are very scarce.] "These indicate New Caledonia as the land from which they arrived, so much so that it is difficult to separate the *Placostylus* of Lord Howe from New Caledonian species. This form has somehow managed to reach New Zealand, and is the cause of most of the Neozelanean sympathy. All the other Lord Howe Island land shells are of New Caledonian affinity, most being very closely related."

The land vegetation is most luxuriant, and the Palms, Screw-Pine, Banyan and *Marattia* are eminently tropical. There is a large proportion of endemic species. The affinities are preponderantly Australian, according to Prof. Ralph Tate. The plants may be presumed to have come south by a course parallel to that of the great southern migration of the Indo-Malayan Flora along the east of Australia from Cape York to Croajingolong.

Of the marine fauna the mollusca are pre-eminently New Caledonian (Tom Iredale), and the crustacea (F. A. McNeill) and echinodermata (A. Livingstone) all show a northern origin, with some Australian affinities.

The Great Equatorial Current of the Pacific due to the SE. trade winds is bisected as it impinges on New Caledonia. The southern branch passes on to the coast of Australia, which it reaches in the neighbourhood of Sandy Island, and is then deflected south to flow parallel to coasts of Queensland and New South Wales as far as Jervis Bay. It is a warm, constant current with a width of at least 300 miles seaward. This current must have been the main agent in the dispersal of tropical organisms to the south.

In accord with the land plants and animals and the marine invertebrates, the marine algae have a distinctly tropical facies, as seen in the separate analyses of the Greens, Browns and Reds. The conclusion seems to be that during Pleistocene time the algae have streamed down from the north, from New Caledonia, along with *Meiolania*. Some of the Lord Howe algae, as *Plocamium hamatum*, *Laurencia concinna*, *Amansia glomerata* and *Enantiocladia Robinsonii*, have been found at Noosa Heads and Caloundra on the coast of Queensland, and quite recently I have received specimens of the last three from Point Archer on the Queensland coast, nine miles north of Cooktown. Such migration goes a long way to explain the Australian affinities of the Lord Howe forms. It seems to be

pretty clear that none of the forms came from New Zealand, but rather that some forms, as *Glossophora* and *Placostylus*, passed from the north on a continuation of the line of migration, and thus reached the North Island of New Zealand. Probably in this way the slenderer affinities of all the organisms with those of New Zealand may be best explained.

## EXPLANATION OF PLATES V-IX.

## Plate v.

- Fig. 1.—*Cladophora Goweri*, n. sp.  
Fig. 2.—*Caulerpa thujoides* J. Ag.  
Fig. 3.—*Codium bulbopilum* Setch.

## Plate vi.

- Fig. 1.—*Codium cuneatum* Setch. & Gard.  
Fig. 2.—*Sargassum Howeanum*, n. sp.

## Plate vii.

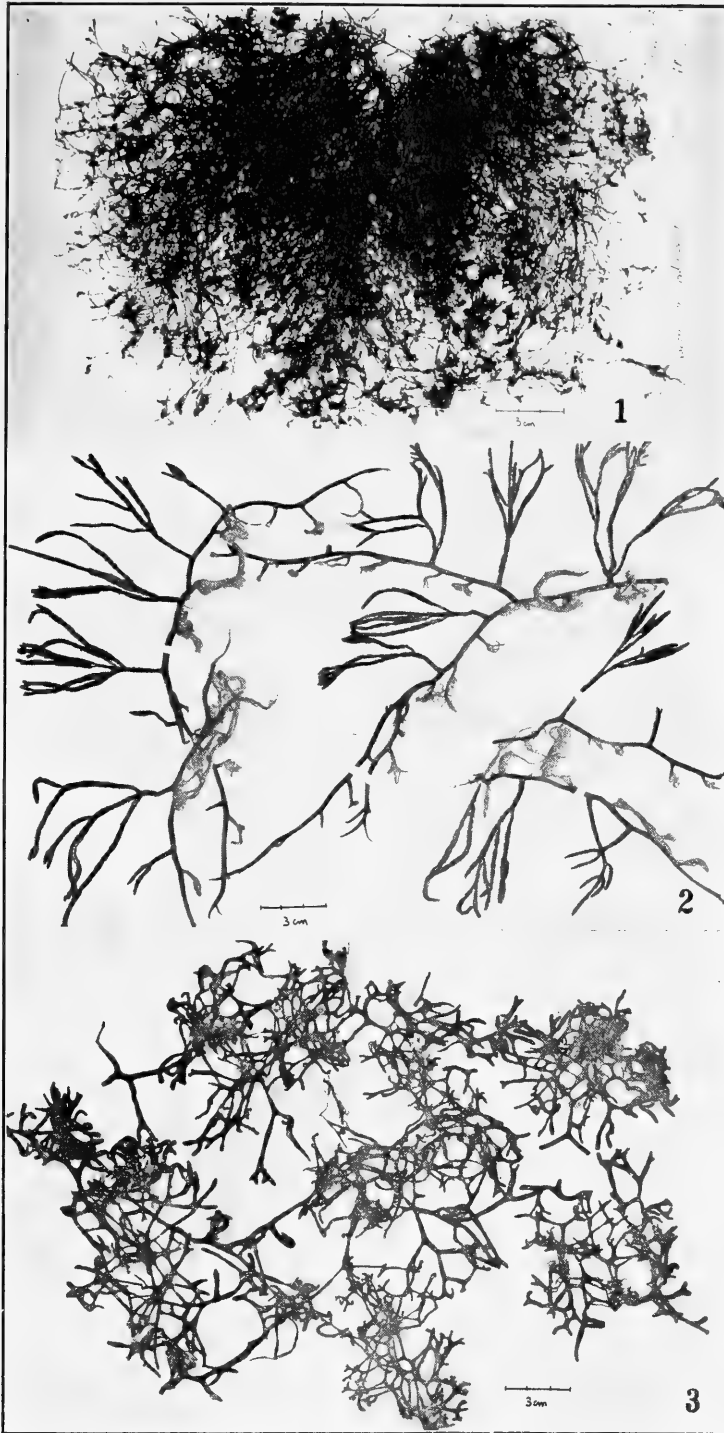
- Fig. 1.—*Haliseris crassinervia* Zan.  
Fig. 2.—*Haliseris plagiogramma* Mont.  
Fig. 3.—*Gelidium Maidenii*, n. sp.

## Plate viii.

- Fig. 1.—*Martensia speciosa* Zan.  
Fig. 2.—*Laurencia elegans*, n. sp.

## Plate ix.

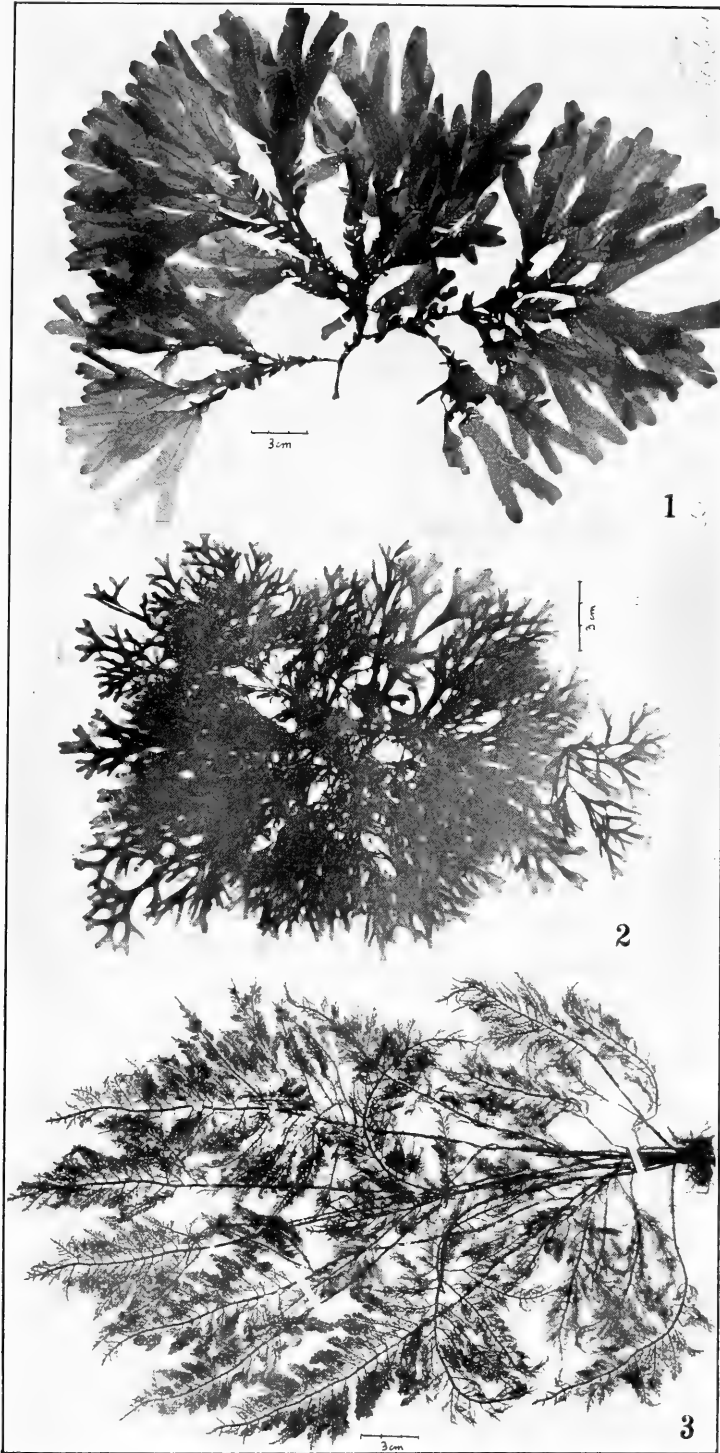
- Fig. 1.—*Laurencia concinna* Mont.  
Fig. 2.—*Dasya fruticulosa*, n. sp.
-



1, *Cladophora Goweri*; 2, *Caulerpa thujoides*; 3, *Codium bulbopilum*.

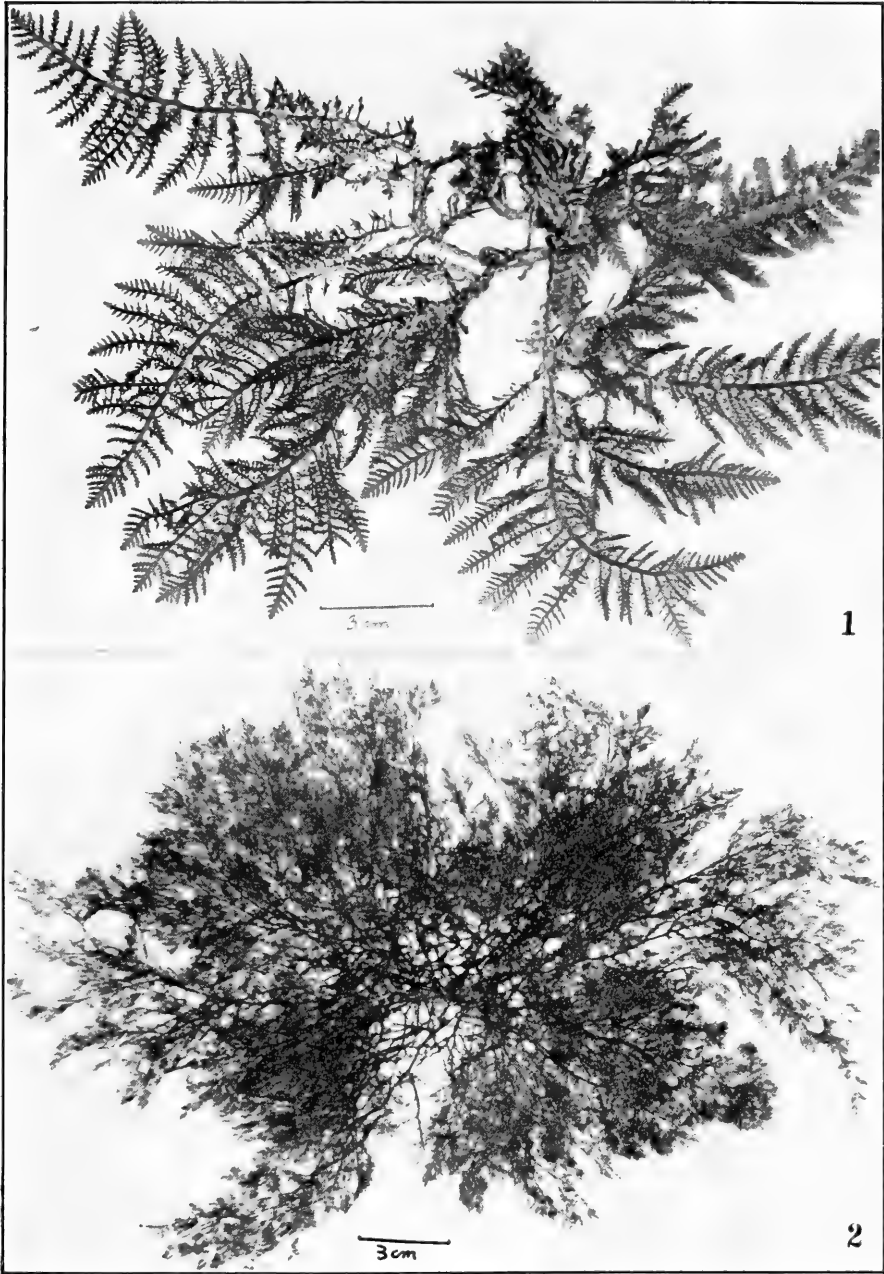






1, *Haliseris crassinervia*; 2, *H. plagiogramma*; 3, *Gelidium Maidenii*.





1, *Laurencia concinna*; 2, *Dasya fruticulosa*.



THE RELATIONS BETWEEN THE INTERNAL FLUID OF MARINE  
INVERTEBRATES AND THE WATER OF THE ENVIRONMENT,  
WITH SPECIAL REFERENCE TO AUSTRALIAN CRUSTACEA.

By ENID EDMONDS, M.Sc., Zoology Department, University of Sydney.

(Five Text-figures.)

[Read 31st July, 1935.]

During the last forty years considerable interest has been shown in the osmotic and chemical relations between the body fluids of aquatic animals and the surrounding water. To some extent the results of experiments, made to determine the degree of physiological dependence between the two media, have been conflicting and, in the endeavour to discover the forces regulating the internal fluids, there has been need for fundamental changes in our conception of the phenomena as the number of investigations has increased. Naturally much attention has centred round the question of the permeability of the surfaces separating the two media.

The study of this work was introduced to me by Professor Dakin of the University of Sydney, and the experiments described in this paper were made at his instigation and in continuation of work conducted by him (Dakin, 1912). Their purpose was the relation of the behaviour of certain Australian aquatic invertebrates in sea-water and in fresh water to the behaviour of those already examined in other countries. Brief reference will, therefore, be made to the results of certain other investigators.

*Condition of the Blood of Marine Invertebrates when immersed in  
ordinary Sea-Water.*

Before examining the osmotic conditions of the blood of animals immersed in experimental solutions of sea-water, it is necessary to be certain of the osmotic pressure conditions existing under normal circumstances. It has frequently been stated that when crustaceans and other invertebrates are living in ordinary sea-water the blood has exactly the same osmotic pressure as the surrounding water.

In recent years, however, several workers have shown that this is an inadequate expression of the conditions actually prevailing. Bottazzi (1897) was satisfied with finding that the mean ( $-2.29^{\circ}$ ) of the freezing points obtained for the blood of all the invertebrates examined, was equal to the average freezing point of the water in the same locality. For a more accurate result it would appear necessary to measure the freezing point of the water from which the animals have actually been taken and for every case separately. Retention in a laboratory for some time is frequently the only method of doing this with certainty.

Most of the early workers noticed slight differences between the  $\Delta$  of the body fluids and the  $\Delta$  of the sea-water. But the differences were only of the order  $0.03^{\circ}$  or thereabouts. More recently M. Duval investigated a number of species of marine invertebrates in their natural state and compared the freezing

point of their blood with that of the external water. He found that the difference between the two freezing points never exceeded  $0.02^{\circ}$ , which he regards as merely of the order of experimental error, and consequently speaks of the media as "exactement isotonique". It is perhaps natural that this small difference should have been disregarded by the earlier investigators, and come only to be considered as significant when it was found that a larger difference occurred in some species.

Schlieper (1929) found that in the crab *Carcinus maenas* the concentration of the blood was never equal to that of the external medium. The difference, though still slight, was too great to be due to experimental error. It varied from  $0.04^{\circ}$  to  $0.09^{\circ}$ , the blood having always the higher concentration.

Monti, quoted by Schlieper, finds a greater difference between the  $\Delta$  of blood and of the external water in the case of *Carcinus maenus*. He gives the latter as  $1.96^{\circ}$ – $1.99^{\circ}$ , the former as  $2.17^{\circ}$ . Again in the Mollusca, Monti finds the internal fluid to be hypertonic to the sea-water. For example, in water of  $\Delta$   $2.11^{\circ}$ – $2.14^{\circ}$ , he obtained  $\Delta$  2.23, 2.26 and 2.16 for the internal fluid of an oyster, mussel and octopus respectively.

(It is interesting to note that Duval and Prenant have shown the same thing for ascidians. (Blood  $\Delta = 2.08^{\circ}$ ; sea-water  $\Delta = 1.98^{\circ}$ .) Although these animals belong to the phylum Chordata, their behaviour would seem better comparable to that of invertebrates than that of the higher chordates.)

On the side of hypotonicity of the blood to the surrounding medium, Baumberger and Olmstedt have discovered a very striking example in *Pachygrapsus crassipes* where, under normal conditions, the  $\Delta$  for the blood is  $1.327^{\circ}$  for an external  $\Delta$  of  $1.975^{\circ}$ .

Thus the older view that there is *complete* isotonicity between the internal and external media of marine invertebrates has had to be modified. My examination of a number of species of Australian crabs furnishes further proof that complete isotonicity is by no means of universal occurrence among the invertebrates.

The crab *Heloeccius cordiformis* has proved a very suitable Australian invertebrate for this type of investigation.\* This species is common near the coast of New South Wales and occurs in very great numbers on mangrove flats, which are uncovered at low tide. The depression of the freezing point was taken as a measure of the osmotic pressure and given the usual designation of  $\Delta$ . It was determined by a Beckmann apparatus. The crabs are so small that a single specimen does not furnish enough blood for a freezing point determination, the blood from three, four, or five being necessary for each determination. The blood was obtained by cutting one of the chelae. During all the experiments described in this paper the crabs were kept in water which was either constantly stirred or else aerated by the bubbling through it of air under pressure.

It was found that when *Heloeccius cordiformis* is immersed in ocean sea-water the blood is markedly hypotonic. Specimens were kept for about a week in sea-water brought from their own locality. (This was far more than the time required for the cessation of any change in the blood which might occur if the water was somewhat different from that in which they were immersed prior to capture.) It was found that the depression of the freezing point for the blood was about  $0.25^{\circ}$  less than that of the water. Below is a table giving some of these results.

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\* *Heloeccius cordiformis* was selected by Professor Dakin and was used in the experiments reported on by Dakin and Edmonds (1931).

TABLE 1.

Time of Immersion.	$\Delta$ of Medium. (° C.)	$\Delta$ of Blood. (° C.)	Difference. (° C.)
6 days .. .. .	2·21	1·92	0·29
7 days .. .. .	2·18	1·96	0·22
8 days .. .. .	2·16	1·95	0·21
8 days .. .. .	2·16	1·89	0·27
6 days .. .. .	2·23	1·88	0·35
16½ hours .. .. .	2·17	1·99	0·18
16½ hours .. .. .	2·17	1·95	0·22

It is strange that the inequality in this case should be on the side of hypotonicity of the blood, whereas it was on the side of hypertonicity in *Carcinus maenus*, the crab which has been so much used for European experiments, and which is found under similar conditions. Anything but a small degree of hypotonicity seems to have been recorded previously only for *Pachygrapsus*.

But the hypotonicity is not confined to the one species of Australian crabs. The rock crab, *Leptograpsus variegatus*, which occurs very abundantly on the coast around Sydney, was also examined. Specimens of the crab were taken straight from the rocks below the Biological Station at the mouth of the harbour, and there put into running or aerated sea-water. The depression of the freezing point of the blood was found to be approximately 0·16° less than that of the water.

TABLE 2.

Blood (0° C.).	Sea-Water (0° C.).
1·99	2·13
1·95	2·13
1·97	2·15 (approx.)

For some reasons it was more interesting to discover this in *Leptograpsus* than in *Heloeccius*. As the latter occurs on river flats, with a distribution from the sea to the places where the water contains very little salt, it might be expected that the position of equality would be at some place (and concentration) between the two extremes. But *Leptograpsus* is found very commonly all along the actual coast and so normally lives in ocean sea-water.

The third crab examined for its  $\Delta$  in normal sea-water was *Sesarma erythroductyla*, which is found on mangrove flats and river banks at the same places as *Heloeccius*. This crab is even smaller than *Heloeccius* and it is therefore necessary to use a number of specimens for each determination. It was more difficult to obtain precise results for this crab, because it exhibits a greater variability of internal concentration under the same external conditions than do the species previously considered. However, it would seem that in this crab, too, the concentration of the blood is below that of the sea-water in which it normally lives. A number of specimens collected from a mud

flat near the sea were kept for twenty days in water with a freezing point of  $-2^{\circ}$ . Two determinations of the freezing point of the blood at the end of this period gave  $-1.85^{\circ}$  and  $-1.91^{\circ}$ . One would expect (in the light of facts which will be set forth later) that in fully concentrated sea-water ( $\Delta = 2.15^{\circ}$  approximately) the difference of the internal from the external medium might be slightly greater.

Certain fresh-water crabs (at present undescribed) from the Hawkesbury River also provide data interesting in this connection. When this species is introduced into sea-water its blood increases in concentration, but does not, even after several weeks' immersion, reach the point of isotonicity with the surrounding water. The  $\Delta$  of the blood of such specimens was  $1.91^{\circ}$ , with an external  $\Delta$  of about  $2.13^{\circ}$ , giving a difference of  $0.22^{\circ}$ , which is similar to the difference in the case of *Heloeccius*.

*The Osmotic Conditions of the Blood of Marine Invertebrates in dilute Sea-Water, and in Sea-Water of increased salinity.*

From this preliminary discussion of the relations between the internal and external fluids in normal sea-water, we can now consider these relations when the conditions are varied by the dilution or concentration of the sea-water. In the natural state, certain marine species are found distributed over a wide variety of concentrations of sea-water, perhaps with little movement from place to place within this range. Such are a number of species which inhabit the salt and brackish portions of rivers. It is chiefly with Crustacea of this type that my own investigations have been carried out.

There are others which are found only where the sea-water is fully concentrated, but which can withstand certain abnormal salinities, as has been shown by experiment.

It was originally held that the internal fluid of marine invertebrates was "the plaything of the conditions of their environment". Early experiments confirmed this view and suggested that complete isotonicity was attained after alteration in the salinity of the external medium. Later, however, it was found that whilst this held to a certain extent for echinoderms, a number of molluscs and some worms, in other groups the internal medium was not so dependent upon the external and, in fact, isotonicity was far from attained after alterations in the salinity of the latter.

A number of workers have now indicated the diversity of the reactions of marine invertebrates in this respect. Duval, for example, found that even in the typical marine crabs, *Platycarcinus pagurus*, *Maja squinado*, and *Portunus puber*, the salinity of the blood remained higher than that of the external medium when the salinity of the latter was reduced to a point where its  $\Delta$  was  $1.4^{\circ}\text{C}$ .

Much of our recent information has been obtained by extensive experiments using the crab *Carcinus maenas*, which occurs on the European coast and in brackish water at the mouths of rivers. It is worth setting forth these experiments at some length, firstly because *Carcinus* is so admirably suited for this type of experiment, being able to withstand great changes in salinity, and secondly because this crab makes an interesting comparison with the Australian crab, *Heloeccius cordiformis*. Both these crabs occur naturally in sea-water of a wide range of salinities, and the concentration of their blood is similarly affected by a low external salinity.

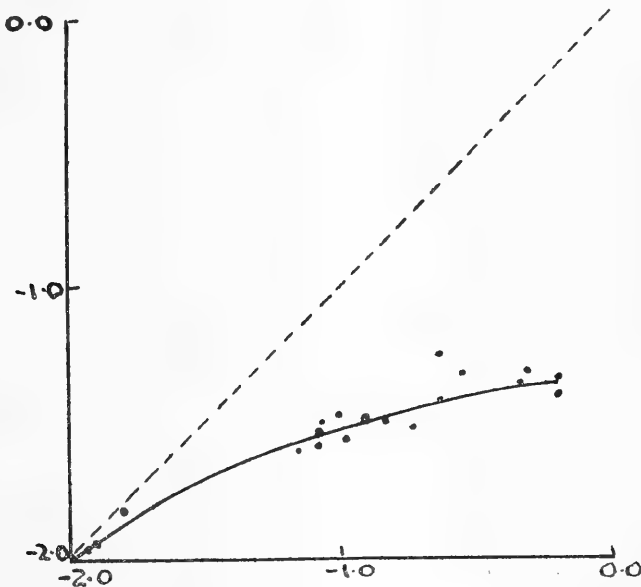
Frédéricq (1901) took specimens of *Carcinus* and put them into dilute solutions. He found that these crabs were slow in adapting themselves to the



new medium. From his results it was not clear whether the outer and inner media would have become equal in molecular concentration if the time of the experiment had been extended, or whether the blood of the crabs would have remained permanently hypertonic to the external water. The latter case appeared the more likely in the light of Frédéricq's previous discovery of the excess of calcium chloride in the blood above that in the brackish water which members of the species inhabit in nature.

Subsequently, experiments by Duval and by Schlieper proved conclusively that this difference in salinity was not the result of a slow establishment of equilibrium, but always occurred for anything but very slight dilutions. (Duval found that it required not more than twenty-six hours to reach a state where the  $\Delta$  of the blood remained constant.)

Schlieper (1930) obtained the same results as Duval for *Carcinus maenas* placed in dilute solutions and his results are summed up in Figure 1, where the dotted line indicates the curve for the freezing points of the external medium and the unbroken line that for the blood.



Text-fig. 1.

The results for *Carcinus maenas* taken together provide a very convincing proof that the "law of poikilosmoticity" is by no means universally applicable among marine invertebrates.

That this is not an exceptional case has been shown by the examination of several species of Australian crabs. In none of these species is there isotonicity between the external and internal media when immersed in a diluted sea-water (except for the special case of a solution just below the concentration of ocean water. This will be explained later).

I shall now give an account of the behaviour of certain of these Australian crabs in dilute solutions, both under conditions of nature and in laboratory experiments.

The dilute solutions were made by mixing fresh tap-water with sea-water. For convenience the different dilutions will be spoken of as percentages. Thus a 100% solution means one composed entirely of normal sea-water, a 75% solution is one made from 75% of sea-water, 25% of fresh, and so on. As before, the crabs were kept, several at a time, in glass jars in which the water either was stirred or had air constantly bubbling through it. The crabs were put straight into the new medium without any sojourn in an intermediate concentration. In all cases the depression ( $\Delta$ ) of the freezing point below 0° C. was taken as the measure of osmotic pressure.

It will be best to commence with a description of the phenomena for *Heloeicius cordiformis*, as it is with this crab that the investigations have been most thorough and extended. They were commenced by Professor Dakin in 1929 and first reported on by Dakin and Edmonds in 1931. Since then the experiments have been extended and carried out on a large scale to eliminate the risk of chance variations giving an erroneous picture of the real facts. *Heloeicius cordiformis* is particularly suitable for such experiments, for it will live well when suddenly transferred from normal sea-water into almost any mixture of salt and fresh water, though it dies quickly in absolutely fresh water. Very few (out of large numbers of specimens) have been kept in fresh water for as long as two days. It is rather amazing to note the difference in survival, which can be brought about by the addition of a very small amount of sea-water to the fresh. Thus in one experiment of 30 hours' duration, where the solutions were 0%, 2%, 4% and upwards, the crabs in the fresh water were dead, but the others survived. Still more striking are the differences recorded in Table 3, where the amount of sea-water seems almost inappreciable. (See also Dakin, 1908.)

TABLE 3.  
*Heloeicius cordiformis* after immersion of 41 hours.

Fresh Water.	0·5% Sea-Water. 99·5% Fresh Water.	1% Sea-Water. 99% Fresh Water.	1·5% Sea-Water. 98·5% Fresh Water.	2% Sea-Water. 98% Fresh Water.
Dead: 7	Dead: 1 Dying: 2	Dead: 3 Dying: 2		
Alive: 1	Alive: 5	Alive: 3	Alive: 8	Alive: 8

Before discussing the question of isotonicity or anisotonicity between the two media for this crab, it is necessary to have some idea of the time required for the cessation of the internal changes which are induced by the external change, i.e., for the attainment of a new equilibrium. Table 4, for a 25% solution, indicates that the internal change takes place at first quickly, then slows down, and may be regarded as practically complete after about twelve hours. As will be shown later, differences up to a tenth of a degree occur as a result of the variation between different crabs when in the same solution for the same length of time.

TABLE 4.  
*Heloeccius cordiformis* immersed in water 25% sea-water, 75% fresh water.

Time of Immersion.	$\Delta$ of blood. (° C.)
2 hours .. ..	1.96
7½ hours .. ..	1.78
10¼ hours .. ..	1.75
12 hours .. ..	1.75
62 hours .. ..	1.70

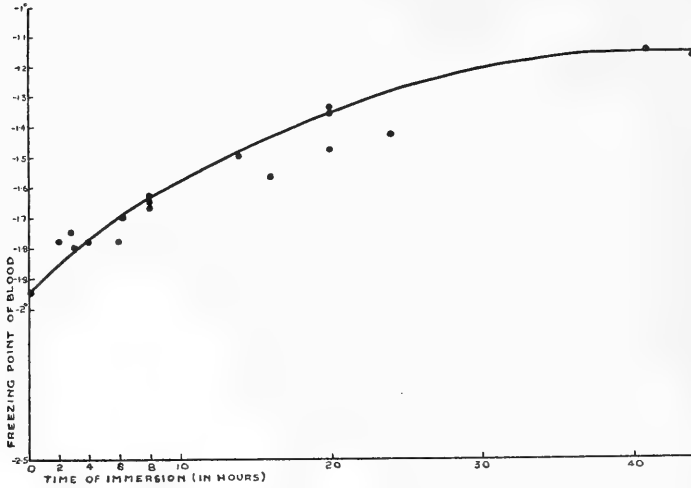
In the experiments for determining the effect of dilute solutions, however, to make accuracy more certain, the crabs have been left for a longer period, usually thirty to forty hours. The time of immersion is indicated wherever tables are given. Naturally it would be expected that the farther from normal the external salinity is, the longer will be the time before completion of the change. This is borne out by a comparison of the results of Table 4 with those for fresh water. Table 5 and Figure 2 indicate that when the crabs are immersed in fresh water the point of constant salinity for the blood is not reached in twenty-four hours, and it is impossible to judge whether it is reached even in forty-four hours, as death prevents the time from being extended.

TABLE 5.  
*Heloeccius cordiformis* immersed in fresh water.

Time of Immersion. (In hours.)	$\Delta$ of Blood. (° C.)
0	1.95
2	1.78
3	1.80
4	1.78
6	1.78
8	1.65
14	1.50
16	1.57
20	1.36
24	1.43 (approx.)
41	1.15
44	1.17

In the experiments which are now to be considered, for solutions other than fresh water and for very low salinities, the changes may be regarded as complete at the time when the blood was taken from the crabs.

The more the water was diluted, the more also did the blood of the crabs become diluted, the concentration of the blood decreasing at much the slower rate, until, for very low external concentrations (20% solution and less), further dilution seemed to cause little, if any, additional change in the concentration of the blood.

Text-fig. 2.—*Heloecius cordiformis* immersed in fresh water.

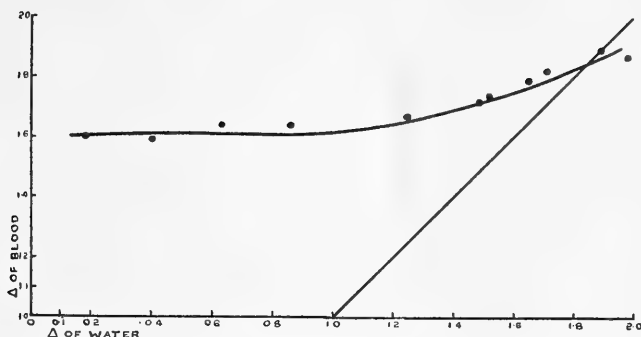
As a result of this slower rate of decrease in the internal concentration, the two media are of course anisotonic in dilute solutions, the inner one becoming more and more hypertonic as the dilution is increased. This is very evident from Table 6 and Figure 3.

TABLE 6.  
*Heloecius cordiformis* immersed for 34 hours in dilute solutions.

Percentage of Sea-Water in the Solution.	$\Delta$ of Solution. (° C.)	$\Delta$ of Blood. (° C.)
100	2.19	2.19*
90	1.98	1.87
80	1.71	1.82
70	1.52	1.74
60	1.25	1.67
40	0.86	1.64
30	0.63	1.64
20	0.40	1.59
40 hrs. 10	0.18	1.60

\* It is most unusual for the internal and external  $\Delta$  to be equal at this salinity. The corresponding point has therefore been omitted from the graph.

In order to make quite certain that this hypertonicity was not due to a very slow rate of change in the osmotic pressure of the blood while the animals were becoming accommodated to the new salinity of the environment, a number of crabs were kept in the diluted sea-water for longer periods than those already indicated. A series of dilutions in which the time of immersion was six to eight days still showed the discrepancy between the internal and external  $\Delta$ . The former gave a  $\Delta$  as large as 1.62 in a solution containing only 40% sea-water.



Text-fig. 3.—*Heloecius cordiformis* immersed for 34 hours in dilute solutions of sea-water. (The diagonal represents equality of  $\Delta$  in the two media.)

Moreover, on two occasions, enough crabs for a freezing point determination were kept in a diluted sea-water for several months. At the end of this time the blood was still found to be markedly hypertonic to the water. Below are the results of one such case.

*Heloecius cordiformis.*

	$\Delta$ of Water. (° C.)	$\Delta$ of Blood. (° C.)
Two months' immersion	0.72	1.38

It has been already shown that, under normal circumstances of 100% sea-water, the blood has a decidedly lower osmotic pressure than the surrounding water. As a consequence of this, when very slight dilution of normal water takes place, the slower rate of internal change at first brings the osmotic pressures of the two media closer together, until for one point (roughly between 80% and 90%) the two become identical.

In a previous paper (Dakin and Edmonds, 1931) we have stated that for *Heloecius cordiformis* the blood is isotonic with the sea-water within certain limits and that this crab is "another example of a marine crustacean which is . . . poikilosmotic in the sea . . . but is homoiosmotic in diluted sea-water". We have since found that this statement is not quite accurate. The inaccuracy, however, does not invalidate the conclusions drawn in the paper in question. It is more important in the present connection.

Further, more precise investigation has revealed, for *Heloecius cordiformis*, that the occurrence of isotonicity is so restricted that it can hardly be spoken of as a "range" at all. In Table 7 the points where the internal and external  $\Delta$  are identical in different experiments are very close together (the exceptional case must have some other explanation).

Finally, to confirm these experimental results, a series of crabs was collected along the Hawkesbury River, N.S.W., beginning at Wiseman's Ferry (which is the part of the river where the mangrove flats frequented by *Heloecius cordiformis* occur farthest from the sea) and continuing down the river to the mouth. The figures for the  $\Delta$  of the blood obtained for these crabs accord well with the experimental ones, and show that it was right to conclude from the latter that the

TABLE 7.  
*Heloeccius cordiformis* immersed in Sea-Water solutions which permitted of isotonicity.

Duration of Immersion.	$\Delta$ of Water. (° C.)	$\Delta$ of Blood. (° C.)
44 hours	1.89	1.89
34 hours	2.19	2.19 (exceptional)
8 days	1.77	1.75
8 days	1.77	1.75
Some days	1.85	1.83

blood is hypertonic to dilute external media and that the hypertonicity becomes very great when the external  $\Delta$  is small. The results obtained along the river are given below (Table 8) and compared with the experimental ones. The first column of figures gives the  $\Delta$  for the water at both high and low tides, the last column gives the  $\Delta$  of the blood under experimental conditions, where the external medium was of about the same salinity as the water of the part of the river under consideration. The comparison cannot be very precise, because the  $\Delta$  of the river water can be only approximately that of the water in which the crabs were actually immersed at or before the time of capture. The similarity between the two columns is, however, marked enough to indicate that the laboratory results are not artificially induced by the unusual conditions, but that they are valid as a record of the effect of change in external concentration only.

TABLE 8.  
*Heloeccius cordiformis* under Natural Conditions—Comparison of blood  $\Delta$  with that from crabs of same species in Experimental Solutions of similar Concentration.

Place.	$\Delta$ of Water. (° C.)	$\Delta$ of Blood. (° C.)	$\Delta$ of Blood in Experimental Solutions of similar salt-content. (° C.)
Wiseman's Ferry .. ..	0.38-0.58	1.43	1.59
" " " " " "	" "	1.47	
" " " " " "	" "	1.39	
Laughtendale .. ..	0.62-0.84	1.47	1.38
" " " " " "	" "	1.49	1.64
Mill below Laughtendale ..	?-0.99	1.61	1.64
" " " " " "	" "	1.59	
Spencer .. ..	1.05-1.32	1.57	1.67
" " " " " "	" "	1.59	
Brooklyn .. ..	1.82-1.85	1.92	} 1.71-1.89
" " " " " "	" "	1.87	

At the time of the investigation the water at Wiseman's Ferry had a salinity giving  $\Delta$  0.38 at low tide. Although a more extensive search would be required for complete certainty, this seemed to be the freshest water in which the crabs were living, despite the fact that laboratory experiments indicated that they could live healthily, at least for some time, in more dilute water. It may be that this salinity ( $\Delta$  0.38) is approximately the lowest for which they can live indefinitely,

or it is more likely that in times of flood the salinity drops and then reaches the minimum for healthy life. A third and very important factor confining them to this region would be the unsuitability of the banks. No other flats where they are found in such abundance were observed for some distance higher up the river than Wiseman's Ferry. No *Heloeccius* at all were found in the freshwater parts of the river, so it would seem that the death of this crab, when taken from sea-water and immersed in fresh water, is due not merely to inability to survive the sudden change, but to its being fundamentally impossible for this species to live in water devoid of salt. Thus another experimental conclusion is confirmed.

No other crabs have been examined in such detail as *Heloeccius cordiformis*, but with several other species a small number of experiments have been made—sufficient to indicate that, in general, when in dilute solution, the relations between internal and external osmotic pressure are similar to those for *Heloeccius*.

Several experiments parallel to those with *Heloeccius cordiformis* were carried out for *Sesarma erythroactyla*. Sometimes the two were examined at the same time and under exactly the same conditions. As in *Heloeccius*, the blood of *Sesarma* became more dilute with addition of fresh water to the external medium. Again a slower rate of decrease in osmotic pressure for the blood made it hypertonic to the solution for any but slight dilutions. Thus in water, 80% of which was salt and whose  $\Delta$  was 2°, the blood of crabs after twenty days froze at -1.85° and -1.91°, while in 50% solution with the water freezing at -1.17° the blood froze at -1.64° when the crabs had been fourteen days in the medium.

These results also were confirmed by an examination of specimens found along the Hawkesbury River.

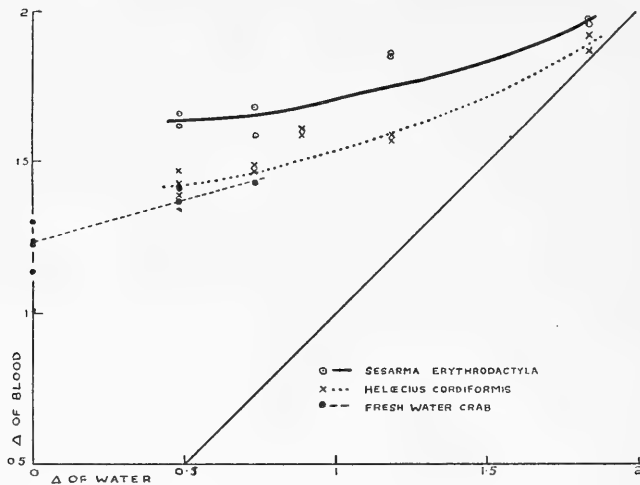
TABLE 9.  
*Sesarma erythroactyla* on *Hawkesbury River Banks*.

Place.	$\Delta$ of Water.	$\Delta$ of Blood.
Wiseman's Ferry .. ..	0.38-0.58	1.66 1.62
Laughtendale .. ..	0.62-0.84	1.59 1.68
Spencer .. .. .	1.05-1.32	1.85 1.86
Brooklyn .. .. .	1.82-1.85	1.98 1.96

That the internal concentration will vary according to species, even among animals of the same Order, is shown by the points on the graph (Fig. 4), which gives the values for the  $\Delta$  of the blood of freshwater crabs in the localities which have been under consideration, as well as representing graphically the Tables 8 and 9.

A species of the crab *Macrophthalmus* provided another example of marked hypertonicity of the blood over the external fluid. The freezing point of its blood was as low as -1.42° in a solution containing only 25% of sea-water.

Yet another crab, *Leptograpsus variegatus*, has been examined, and it displays the same hypertonicity of the blood if it is placed in dilute solutions of sea-water. This crab has a habitat entirely different from that of the preceding species, and



Text-fig. 4.—Comparison of internal and external media for three species of crab in dilute water on the Hawkesbury River. (The diagonal represents equality of  $\Delta$  for the two media.)

it is therefore of especial interest to find that the behaviour of its blood, resulting from external dilutions, is the same. It is found only in a rocky environment on the actual coast or near the mouths of rivers and harbours. It is sensitive to dilution, but can live for at least six days in a 50% solution of sea-water. A solution containing 10% of sea-water appeared to be about the border line between those salinities which were too low for the animal to survive and those in which it was able to live healthily (a specimen immersed in such a solution survived for two or three days). Values of  $\Delta$  have been obtained only for 50% solutions. They are summarized in Table 10.

TABLE 10.  
*Leptograpsus variegatus* Immersed in a 50% Solution of Sea-Water.

Duration of Immersion.	$\Delta$ of Water. (° C.)	$\Delta$ of Blood. (° C.)
43 hours .. ..	1.07	1.79
43 hours .. ..	—	1.89
6 days .. ..	1.20	1.73

Thus the results for Australian species combine with many of those obtained by investigators elsewhere to show that a "law of poikilosmoticity" is by no means applicable to all marine invertebrates when the surrounding water is of lower salinity than ordinary sea-water. It is, however, of greater validity when the external concentration is increased above that of ocean sea-water.

Both Frédéricq and Duval found isotonicity in different species of crabs under conditions of increased salinity. The former found identity of internal and external freezing points for *Carcinus maenas* when immersed for three days in water of  $\Delta$  3.11° and  $\Delta$  3.84°. The latter obtained his result from *Platycarcinus*



*pagurus*, *Palinurus vulgaris*, *Maja squinado* and *Carcinus maenas* immersed in various solutions which froze between  $-2^{\circ}$  and  $-3^{\circ}$ .

The crab *Heloeocius cordiformis* was examined under conditions of increased external concentration. It can endure a large increase in the concentration of the external water, and will live for some time at least in double strength sea-water.

The previous notation for strength of solution will be used for setting out these results. Thus a 100% solution is one of normal concentration, 150% is a solution half of ordinary sea-water and half of double strength sea-water, and so on.

When *Heloeocius* was first put into concentrated sea-water the specimens were left only for a day or two before the freezing point of the blood was determined, as this time was all that was necessary for the completion of the changes in dilute solutions. The results were very surprising in comparison with those of Duval, which showed isotonicity for *Carcinus* in 26 hours. In water of nearly double strength ( $\Delta$   $4.14^{\circ}$ ) the blood of *Heloeocius* gave a  $\Delta$  equal only to  $2.50^{\circ}$ . Again, for a 150% solution of  $\Delta$   $3.14^{\circ}$ , the  $\Delta$  for the blood was  $2.18^{\circ}$  on one occasion of immersion for 38 hours, and  $2.29^{\circ}$  on another when the experiment lasted 42 hours. A large number of experiments were subsequently carried out, and they all showed that the blood remains hypotonic to a large degree when the external medium is concentrated above the normal, and the time of immersion only one or two days.

It was now necessary to determine whether this hypotonicity was permanent, or whether it was due to a slower rate of change than under conditions of dilution. The latter alternative was found to be the true one.

Examination over a long period showed that the internal change is at first fast, but becomes gradually slower. Instead of ceasing altogether after a day or so (as is the case for dilutions) the change continues at a slow rate, until the salinities of the inner and outer media are almost equal (the difference being no larger than that for crabs in ordinary sea-water). The time necessary for the completion of the change was not constant, but varied from two to five weeks.

The rate of change can best be seen from the following tables and the graph (Fig. 5), which unite the results of typical experiments.

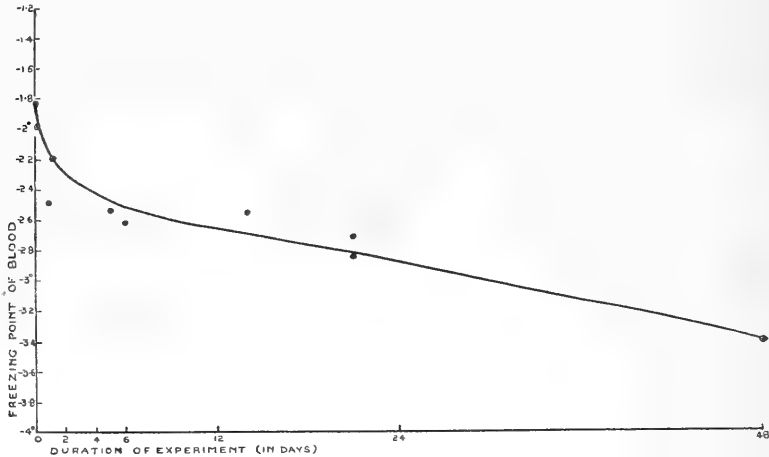
TABLE 11.  
*Heloeocius cordiformis* Immersed in Solutions of  $\Delta = 3.30-3.40$ .

Duration of Experiment.	$\Delta$ of Blood. ( $^{\circ}$ C.)	Difference between the Two Media. ( $^{\circ}$ C.)
0 .. .. .	1.83	1.49
4 hours .. .. .	1.98	1.34
21 hours .. .. .	2.49	0.89
28 hours .. .. .	2.19	1.21
5 days .. .. .	2.54	0.78
6 days .. .. .	2.62	0.70
14 days .. .. .	2.56	0.82
21 days .. .. .	2.72	0.68
21 days .. .. .	2.85	0.55
48 days .. .. .	3.41	*

\* The external concentration would have been a little altered by evaporation and, as it was not obtained at the end of the experiment this difference must be omitted.

TABLE 12.  
*Heloccius cordiformis* Immersed in Various Solutions of Increased Concentration.

Duration of Experiment.	$\Delta$ of Solution. ( $^{\circ}$ C.)	$\Delta$ of Blood. ( $^{\circ}$ C.)
6 days .. .. .	2.37	1.96
7 days .. .. .	2.64	2.18
28 days .. .. .	3.28	2.92
29 days .. .. .	3.17	3.15
36 days .. .. .	3.24	3.10
36 days .. .. .	2.42	2.28



Text-fig. 5.—*Heloccius cordiformis* immersed in solutions of  $\Delta$  3.30-3.40.

Thus we find that *H. cordiformis* agrees with the marine invertebrates previously investigated in that, after an increase in the concentration of the surrounding water, its blood comes into the same relation with that water as it was originally with the ordinary sea-water. It differs considerably, however, from the crabs examined by Duval and Frédéricq in the length of the time taken to complete the internal change.

#### SUMMARY.

A number of species of Australian crabs from diverse habitats, such as a typical ocean coast, estuarine flats, and fresh waters, have been examined in order to determine the relationship of their body fluids to the external medium under natural and under experimental conditions.

Five species of crabs have been found to be homoiosmotic in diluted sea-water. This gives much additional support to the view that the condition may be regarded as general for the crustacea.

The number of species of marine crabs in which, under normal circumstances, there is a distinct anisotonicity between the body fluids and the external medium, has been increased. The difference is on the side of hypotonicity.

It is noticeable that, as in other cases, *Heloccius cordiformis* survives in highly diluted sea-water for a much longer time than in fresh water. The effect of the trace of salts is important.

The osmotic pressure of the blood varies amongst the individuals of any one species when taken from the same conditions and the same locality.

Although *Heloccius cordiformis* behaves like certain previously examined European crustacea in that its blood comes ultimately to a poikilosmotic condition when the crab is placed in water of increased concentration above normal ocean salinity, it differs from the known cases in taking about a month to reach this condition in highly concentrated solutions.

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MISCELLANEOUS NOTES ON AUSTRALIAN DIPTERA. III.

By G. H. HARDY, Queensland University, Brisbane.

[Read 31st July, 1935.]

Subfamily CHRYSOSOMATINAE.

In my catalogue of the Dolichopodidae, I drew attention to the need for improvement in the treatment of genus *Chrysosoma* and allies. I gave in the key the treatment usually adopted, but did not follow the system when arranging species under the genera. I was unaware of the paper by M. l'Abbé O. Parent redescribing two of Macquart's types, for the periodical containing that paper is not in any Australian library. A second paper by this author came to hand when the catalogue was going through the press and I was able to refer to new species described there. Much has been done since by Parent, and I append a list of the papers that contain references to Australian species as far as I know them. Half of these papers are not accessible in Australian libraries at the present time.

It is necessary here to point out that Parent uses Becker's system of classification, and hence he and I place species in quite different genera. He has found that the antennal structure is ambiguous in a minute percentage of specimens, whereas, dealing only with the Australian material, I find this ambiguity in a big percentage. I therefore divide the species into natural groups which are defined as far as possible.

*Key to genera of the Chrysosomatinae.*

1. Frons deeply excavated between eyes. Wings usually with second median vein strongly indicated (i.e., fourth vein forked), but may be missing ..... CHRYSO-SOMATINAE. 2
- ..... Frons slightly or not excavated. Second median vein absent. Rarely do these characters occur, then if frons be excavated the radial veins all end at costa well before the apex of the wing, and if the second median vein is indicated there is also an appendix at the bend of the first median. In both cases the hind tibiae have many strong bristles which are about as long as the thickness of the tibia ..... *Other subfamilies.*
2. Second median vein entirely eliminated and the first median gently curved ..... 3
- Second median vein present usually and the first median branches away abruptly .. 4
3. Abdomen short, wings normal ..... *Mesorhaga* Schin.
- Abdomen long, wings very narrow ..... *Australiola* Par.
4. First median vein strongly sinuous at its basal half. Antennae with a swelling on basal segment forming a long process ..... *Megistostylus* Bigot.
- First median vein only bowed or straight. Antennae without a process at basal segment ..... 5
5. Male with the first radial vein very long, reaching costa at a point beyond that above the apex of the median cell. Male with hook-shaped cilia on costa..... *Parentia*, n. gen.
- ..... Male with the first radial vein short and the costa not ciliated ..... 6
6. First median vein strongly bent to a right angle. Median cross-vein strongly sinuous and often with a veinlet in centre or somewhat angulated there ..... *Heteropsilopus* Big.
- ..... Without these characters combined ..... 7

7. Antennae with a long conical third segment and a terminal arista. A well developed sinuous median cross-vein and two pairs of scutellar bristles are usually present ..... *Chrysosoma* Guér.  
 Antennae normally short and with a dorsally placed arista but variable. It may reach the length of one and a half times or even twice as long as thick with a terminal arista. Other characters variable ..... *Sciapus* Zell.

SCIAPUS complex.

It seems necessary to review the position of this complex as far as it affects the Australian fauna, the names and synonyms being as follows:

*Sciapus* Zell. 1842 (*Sciopus* of authors) with type *platypterus* Fab., Europe, includes *Leptops* Fall. 1823 (preoccupied), *Psilopus* Meig. 1824, *Psilopodinus* Bigot 1840, and *Psilopodius* Rond. 1861.

*Chrysosoma* Guérin 1832, and *Agnosoma* Guérin 1838, type *maculipennis* Guérin, from New Guinea, would seem to have as synonyms *Oariostylus* Bigot 1859, *Mesoblepharus* Bigot 1859, *Tylochaetus* Bigot 1888, *Spathipsilopus* Bigot 1890. *Oariopherus* Bigot 1890 and *Eudasyppus* Bigot 1890.

*Heteropsilopus* Bigot 1858 can be isolated as a definite concept with type *grandis* Macq., and possibly *Plagiozopelina* Engel 1912 as a synonym.

The genus *Condylostylus* Bigot 1859, type *bituberculatus* Macq. from Brazil, forms a good concept that seems to have little in common with the Australian material and so Australian forms placed under it revert to *Sciapus*.

There are a number of other generic names proposed but founded on American forms that do not seem related intimately with those of Australia and so are ignored here. Nevertheless, I can detect six main groups in the Indian and Australian forms that seem to warrant names in accordance with the following key:

1. First radial vein reaching to and beyond a point level with apex of median cell on the male at least ..... 2  
 First radial vein short ..... 3
2. Costa ciliated on male ..... \*(1st group) ..... *Parentia*, n. gen.  
 Costa not ciliated ..... (2nd group) ..... Type, *über* Par., Fiji.
3. Costa ciliated, wings slender ..... (3rd group) .. Type, *adhaerens* Beck., India.  
 Costa not ciliated, or rarely so ..... 4
4. Median cross-vein strongly sinuous and more or less angulated in centre, often with a veinlet there. First median vein bowed to a right angle .....  
 ..... (4th group) ..... *Heteropsilopus* Big.  
 Without these characters combined ..... 5
5. Third segment of antennae long and strongly conical with an apical arista. Median cross-vein sinuous, at least usually so .....  
 ..... (5th group) ..... *Chrysosoma* Guér.  
 Third segment of antennae variable, usually short, arista apical or dorsal. Median cross-vein often sinuous but usually straight .....  
 ..... (6th group) ..... *Sciapus* Zell.

The 5th and 6th groups are heterogeneous and I think *Mesoblepharus* Bigot, type *senegalensis* Macq. and synonym *Eudasyppus* Big., might make a nucleus for another group, possibly incorporating the Australian *interruptum* Beck.

PARENTIA, n. gen.

Type, *Condylostylus separatus* Parent. Tasmania.

The arista is placed dorsally or apically on a short or rather short third antennal segment. Normally the scutellum has two pairs of bristles. The wings have the first radial vein on the male unusually long, reaching beyond the level of the apex of the median cell and in addition there is a fringe of rather long hook-shaped cilia along the costa (illustrated by Becker, 1922, fig. 203). The female has a short radial vein and is without the cilia. The forms are all dark

blue-green, except the typical form which seems to have colour dimorphism in this respect.

This genus is well represented in New Guinea and may occur beyond that area. It is not known from New Zealand and India, where another group with ciliated costa seems to take its place.

*Key to males of species of Parentia.*

1. Wings with a duplicated row of cilia on costa ..... *duplociliata* Par.  
Wings with a single row of cilia on costa ..... 2
2. With wings dark and hairs abnormally abundant. Legs entirely dark .....  
..... *nigropilosa* Macq.  
Wings hyaline. Normally haired species ..... 3
3. Legs entirely dark ..... 4  
Legs partly light coloured ..... 5
4. Anterior femora with long black bristles on ventral surface ..... *tricolor* Walk.  
Anterior femora with only yellow or white hairs on ventral surface .... *dubia* Par.
5. Femora rather widely yellow-brown at apex ..... *separata* Par.  
Femora entirely dark, except perhaps at the tip ..... *dispar* Macq.

PARENTIA DUPLOCILIATA (Parent).

*Chrysosoma duplociliatum* Parent, *Ann. Soc. Sci. Bruxelles*, (B) liii, 1933, 172.

*Hab.*—Northern Territory.

PARENTIA NIGROPILOSA (Macquart).

*Psilopus nigropilosus* Macquart, *Dipt. Exot.*, suppl. 2, 1847, 56.—*Sciapus nigropilosus* White, *Proc. Roy. Soc. Tasmania*, 1916, 251.—*Condylostylus nigropilosus* Hardy, *Aust. Zool.*, vi, 1930, 131; Parent, *Ann. Soc. Sci. Bruxelles*, (B) lii, 1932, 126.

Determination of this species is based on White's identification, but there is no assurance that White identified the species correctly. This list of references may cover a complex. Only the male is known to me.

*Hab.*—Tasmania.

PARENTIA TRICOLOR (Walker).

*Psilopus tricolor* Walker, *Ent. Mag.*, ii, 1835, 471.—*Psilopus gemmans* Walker, *List Dipt. B. Mus.*, lii, 1849, 644; Parent, *Ann. Mag. Nat. Hist.* (10), xiii, 1934, 34; and *Ann. Soc. Sci. Bruxelles*, (B) liii, 1933, 178.—*Condylostylus amoenus* Becker, *Cap. Zool.*, i, 1922, 219, fig. 203; Hardy, *Aust. Zool.*, vi, 1930, 131; Parent, *Ann. Soc. Sci. Bruxelles*, (B) lii, 1932, 126.

Walker's description fits well this common species, so I am giving preference to the name *tricolor*. Parent found that the type of *gemmans* was conspecific with Becker's species. Both sexes are before me.

*Hab.*—New South Wales and Victoria. Walker and Parent also record it from Western Australia.

PARENTIA DUBIA (Parent).

*Chrysosoma dubium* Parent, *Ann. Soc. Sci. Bruxelles*, (B) xlix, 1929, 201, figs. 50, 51; and lii, 1932, 109.—*Condylostylus dubius* Parent, *Ann. Soc. Sci. Bruxelles*, (B) lii, 1932, 126.

A Queensland species before me agrees fairly well with the description of this one and runs to it in the key, but differs in having the lamellae very long and bifid. Both sexes are before me. I have not seen Parent's form.

*Hab.*—South Australia.

PARENTIA SEPARATA Parent.

*Condylostylus* sp., Hardy, *Aust. Zool.*, vi, 1930, 130 (in key).—*Condylostylus separatus* Parent, *Ann. Soc. Sci. Bruxelles*, (B) lii, 1932, 127, fig. 19.

The only females I have been able to associate with this species have the femora and tibiae entirely yellow. These occur together and are quite common; I have not seen females with legs like those of the male or males with legs like those of the females. Also the female is green in colour.

*Hab.*—Tasmania: Generally distributed over the eastern half of the island from December to March. Victoria: Common in the Melbourne district.

PARENTIA DISPAR Macquart.

*Psilopus dispar* Macquart, *Dipt. Exot.*, suppl. 4, 1849, 125.—*Sciapus dispar* White, *Proc. Roy. Soc. Tasmania*, 1916, 251.—*Chrysosoma dispar* Parent, *Ann. Soc. Sci. Bruxelles* (Vol. Jub.), xlvi, 1926, 18; and (B) lii, 1932, 109.

*Hab.*—New South Wales.

CHRYSOSOMA Guérin.

*Chrysosoma* Guérin, *Voy. Coq. Zool.*, 1831, Atlas, Tab. xx, 25, vii.

The species I place in this genus have the third segment of the antennae at least one and a half times longer than broad and the very long conical appearance with the arista placed terminally. The median cross-vein is sinuous on all described forms and probably all species with the straight median cross-vein are best relegated to *Sciapus* until its true associations can be worked out.

Doubtless *Chrysosoma* as here understood is a complex group; nevertheless there seems to be a general alliance between the majority of them.

*Key to species of Chrysosoma, based mainly on males.*

1. Arista with a spatulate apex ..... *callosum* Parent.  
Arista simple, at most slightly flattened at apex and then white in that area ... 2
2. Wings entirely fuscous or almost so. Long black hairs on frons .. *fulviale* Parent.  
Wings with fuscous markings. Costa ciliated ..... *interruptum* Becker.  
Wings hyaline ..... 3
3. Intermediate legs on male with the fourth tarsal segment slightly enlarged and longer than the two prior segments united ..... *caelicum* Parent.  
Intermediate legs of male with tarsi not so formed ..... 4
4. Anterior femora yellow, the others black ..... *diversicolor* Parent.  
All femora yellow or practically so. Hind tibiae with a black ring on male. Fourth segment of intermediate tarsi white on male ..... *leucopogon* Wiedemann.

HETEROPSILOPUS Bigot.

Bigot, *Ann. Soc. Ent. France*, (3) iii, 1859, pp. 215, 224.

Type, by original designation, *Psilopus grandis* Macq., Australia.

A natural group is formed by *cingulipes* (syn. *grandis*) and associated species distinguishable by characters given in the key to genera.

*Key to species of Heteropsilopus.*

1. Wings clear. Arista subapical on a very short third segment. Two pairs of scutellar bristles ..... *cingulipes* Walker.  
Wings marked. Usually a dorsal arista and one pair of scutellar bristles ..... 2
2. Wings lightly shaded along veins ..... *jacquelinei* Parent.  
Wings with spots limited to cross-veins and any shading elsewhere exceedingly faint ..... *brevicornis* Macq.  
Wings with well marked fascia ..... 3
3. Apical segments of intermediate tarsi peculiarly formed on male. With conspicuous bristles on tibiae ..... *ingenuus* Erichson.  
Segments of intermediate tarsi more normal but with a fringe of cilia. With rather inconspicuous bristles on tibiae ..... *plumifer* Beck.

HETEROPSILOPUS CINGULIPES Walker.

*Psilopus cingulipes* Walker, *Ent. Mag.*, ii, 1835, 472; Parent, *Ann. Mag. Nat. Hist.*, (10) xiii, 1934, 9.—*Chrysosoma cingulipes* Hardy, *Aust. Zool.*, vi, 1930, 126.—*Psilopus sydneyensis* Macquart, *Dipt. Exot.*, suppl. 1, 1846, P. xi, f. 16.—*Psilopus*

*sidneyensis* Macquart, *ibid.*, suppl. 2, 1847, 56; White, *Proc. Roy. Soc. Tasmania*, 1916, 251.—*Psilopus grandis* Macquart, *ibid.*, suppl. 4, 1849, 126; Parent, *Ann. Soc. Sci. Bruxelles*, (B) lii, 1932, 231 (synonymy).—*Psilopus eximius* Walker, *Ins. Saund. Dipt.*, i, 1852, 209; Parent, *Ann. Mag. Nat. Hist.*, (10) xiii, 1934, 16.—*Psilopus angulosus* Bigot, *Ann. Soc. Ent. France*, (6) x, 1890, 285; Parent, *Ann. Soc. Sci. Bruxelles*, (B) lii, 1932, 216.—*Chrysosoma alatum* Becker, *Cap. Zool.*, i, (4), 1922, 188, fig. 159; Parent, *Ann. Soc. Sci. Bruxelles*, (B) lii, 1932, 109.—*Chrysosoma micans* Parent, *ibid.*, 1932, 109.—? *Chrysosoma metallicum* Parent, *ibid.*, 1932, 113.

Much of the above synonymy is recognized by Parent who added *sydneyensis* Macq. and *micans* Par. to the list. The new synonymy is *angulosus* Big. and *metallicum* Par. I have a specimen of the latter, but regard it as a variation and it will require a male before it can be established definitely as a distinct species; meanwhile it seems to me advisable to place the name as a possible synonym.

*Hab.*—Queensland to Victoria.

#### HETEROSILOPUS BREVICORNIS Macquart.

*Psilopus brevicornis* Macq., *Dipt. Exot.*, suppl. 4, 1849, 124.—*Sciapus brevicornis* White, *Proc. Roy. Soc. Tasmania*, 1916, 249; Hardy, *Aust. Zool.*, vi, 1930, 126; Parent, *Ann. Soc. Sci. Bruxelles* (Vol. Jub.), 1926, 16; and (B) lii, 1932, 117.—? *Psilopus venustus* Walker, *Ins. Saund. Dipt.*, i, 1858, 209; Parent, *Ann. Mag. Nat. Hist.*, (10) xiii, 1934, 36.—*Psilopus chrysurgus* Schiner, *Novara Reise Dipt.*, 1863, 214.—*Chrysosoma chrysurgum* Becker, *Cap. Zool.*, i, (4), 1922, 172; Parent, *Ann. Soc. Sci. Bruxelles*, (B) lii, 1932, 109; Hardy, *Aust. Zool.*, vi, 1930, 126.—*Sciapus chalceus* White, *Proc. Roy. Soc. Tasmania*, 1916, 250.—*Chrysosoma volucre* Becker, *Cap. Zool.*, i, (4), 1922, 142, figs. 74-6; Hardy, *Aust. Zool.*, vi, 1930, 126.—*Sciopus bimaculatus* Parent, *Ann. Soc. Sci. Bruxelles*, (B) lii, 1932, 117, figs. 7-9.

The above synonymy is new. Parent agrees with me, in a letter, that his form is the same as Becker's, but is not yet prepared to give assurance that these are identical with Macquart's type which is incomplete. Nevertheless, he writes that he can find nothing to disagree with this synonymy in the descriptions. The names given by Walker, Schiner, and White, according to the descriptions, would also fall to synonymy, and there can be no doubt in this respect concerning Schiner's description, whilst that of White applies evidently to a variation.

In describing *venustus*, Walker gives the characters of a male with wing marks, whereas Parent, redescribing from Walker's material, refers to a female without wing marks, missing the appendix to the median cross-vein, but apparently agreeing in other respects.

*Hab.*—New South Wales to Tasmania. Records would indicate that this species occurs widely over Australia.

#### HETEROSILOPUS INGENUUS Erichson.

*Psilopus ingenuus* Erichson, *Arch. f. Nat.*, xiii, 1842, 273.—*Sciapus ingenuus* Hardy, *Aust. Zool.*, vi, 1930, 127.—*Sciapus trifasciatus* White, *Proc. Roy. Soc. Tasmania*, 1916, 248; *nec* Macquart, 1849.—*Sciopus gloriosus* Parent, *Ann. Soc. Sci. Bruxelles*, lii, 1932, 119.

The above synonymy is amended from that of my catalogue, with Parent's name added as a new synonym.

*Hab.*—Tasmania (abundant) and Victoria. The species is plentiful in the Melbourne district, and there are females before me from Adelaide, South



Australia, and from the extreme north (Tooloom) of New South Wales, and these apparently are the same species.

HETEROSILOPUS TRIFASCIATUS Macquart.

*Psilopus trifasciatus* Macquart, *Dipt. Exot.*, suppl. 4, 1849, 126.—*Chrysosoma trifasciatum* Becker, *Cap. Zool.*, i, (4), 1922, 176; Parent, *Ann. Soc. Sci. Bruxelles*, (B) lii, 1932, 109.—*Sciopus trifasciatus* Parent, *Bull. Mus. Hist. Nat.*, (2) iv, 1932, 879; and *Ann. Soc. Sci. Bruxelles*, (B) liii, 1933, 179.

By comparison of the figures with specimens of *ingenuus*, I conclude that Parent has been misled in regarding *trifasciatus* Macq. as distinct from *ingenuus*. It seems probable that his figure, made from one of Macquart's specimens, is the result of faulty interpretation due to the specimen being in poor condition and not to differences in actual structure. This matter needs elucidating, but in the meanwhile the above references are kept separate.

HETEROSILOPUS PLUMIFER Becker.

*Sciapus plumifer* Becker, *Cap. Zool.*, i, (4), 1922, 206, figs. 183-4; Parent, *Ann. Soc. Sci. Bruxelles*, (B) lii, 1932, 122.

From near Becker's type locality comes a form that is to be distinguished from *ingenuus* Er. by structures, some of which are mentioned in Becker's description, and this form doubtless will prove conspecific with *plumifer*. The anterior tarsi are much longer than those on Erichson's species, being one and a half times longer than the anterior tibiae. This occurs on both sexes, and the male has the posterior tarsi similarly much longer. Also the tibiae are relatively bristleless in appearance, the bristles being small and yellow instead of well developed and black. In addition the male has the intermediate tarsi ciliated for their complete length and none of the segments are otherwise ornamented.

*Hab.*—New South Wales: Blue Mts.

SCIAPUS Zeller.

Zeller, *Isis*, xi, 1842, 831.

Other than those with wing markings, there are very few species below that lend themselves to ready recognition, but I have made an attempt to give a key that will aid in the determination of species. Many forms are known only from the female, and the species I have been able to identify are marked with an asterisk (\*).

Key to species of *Sciapus*.

- |  |                                  |
|--|----------------------------------|
| 1. Wings with distinct markings. Median cross-vein straight .....  | 2                                |
| Wings without markings, clear or more or less suffused with grey .....   | 5                                |
| 2. Two bands joined at the base along costa .....  | 3                                |
| Not so marked .....  | 4                                |
| 3. Third radial vein distinctly though slightly sinuous. Hypopygium long, with laterally directed and rounded lamellae .....                         | * <i>conexus</i> Walk.           |
| Third radial vein not sinuous. Hypopygium short and lamellae apically directed and pointed .....   | <i>proximus</i> Par.             |
| 4. Wings with two fascia across wings, usually complete and basal one not quite reaching costa. Lamellae not exerted beyond apex of hypopygium ..... | * <i>discretifasciatus</i> Macq. |
| Wings with interrupted bands, making four spots, two of which touch costa. Lamellae long, exerted well beyond apex of hypopygium .....               | <i>quadrinaculatus</i> Par.      |
| 5. Median cross-vein sinuous .....   | 6                                |
| Median cross-vein straight or practically so .....   | 8                                |
| 6. All coxae black .....   | 7                                |
| Anterior coxae yellow .....  | <i>difficilis</i> Par.           |
| 7. Squama black .....  | <i>imparile</i> Par.             |
| Squama yellow. Male with a fringe of cilia on intermediate tarsi .....   | <i>nobile</i> Par.               |

8. Legs entirely black. Base of fifth radial vein recurrent ..... *\*australensis* Schin.  
 Legs otherwise coloured. Radial vein not recurrent at base ..... 9
9. Femora black or metallic-green, but yellow at apex ..... *\*nigrofasciatus* Macq.  
 Femora entirely yellow ..... 10
10. Hypopygium with elongated processes on lamellae ..... 11  
 Hypopygium presumably without such processes ..... 12
11. With two pairs of such processes ..... *anomalicornis* Beck.  
 With three pairs of such processes ..... *\*triscutatus* Hardy.
12. Third radial vein strongly bent downwards towards the first median vein and away  
 from the second radial. First median vein branches remote from the median  
 cross-vein by about one and a half times the length of the latter .....  
 ..... *graciliventris* Par.  
 Wings normal ..... 13
13. Antennae entirely black ..... 14  
 Antennae yellow ..... 16
14. Knees black ..... *sublectus* Walk.  
 At most only knees of posterior legs black ..... 15
15. Face parallel-sided ..... *chetiscutatus* Par.  
 Eyes converging on face ..... *nigrociliatus* Par.
16. Hypopygium with four long sinuous apical bristles on each lamella .. *\*sordidus* Par.  
 Hypopygium presumably not so formed ..... 17
17. First median vein bent, with a low circular arch, practically a quadrant .....  
 ..... *sonatus* Par.  
 First median vein bent to a broad rectangular arch ..... *\*mollis* Par.

#### SCIAPUS NIGROFASCIATUS Macquart.

*Psilopus nigrofasciatus* Macquart, *Dipt. Exot.*, suppl. 4, 1849, 126.—  
*Condylostylus nigrofasciatus* Parent, *Bull. Mus. Nat. Hist. Paris*, (2), iv, 1932,  
 876.—*Psilopus viduus* Schiner, *Novara Reise Dipt.*, 1868, 216.—*Condylostylus*  
*viduus* Becker, *Cap. Zool.*, i, (4), 1922, 220; Hardy, *Aust. Zool.*, vi, 1930, 131;  
 Parent, *Ann. Soc. Sci. Bruxelles*, lii, 1932, 127.—*Chrysosoma regale* Parent, *ibid.*,  
 lii, 1932, 111.

Schiner's name is placed here as a new synonym. Both sexes are before me  
 and the male agrees with the description of *regale* which was placed by Parent as  
 a synonym of *nigrofasciatus*, after seeing the type.

*Hab.*—New South Wales.

#### SCIAPUS SUBLECTUS Walker.

*Psilopus sublectus* Walker, *Ins. Saund. Dipt.*, i, 1852, 211.—*Condylostylus*  
*sublectus* Parent, *Ann. Mag. Nat. Hist.*, (10), xiii, 1934, 31.

The identity of this species is unknown, and for its probable position in the  
 key I depend entirely upon Walker's description.

*Hab.*—Tasmania.

#### SCIAPUS SORDIDUS Parent.

*Sciopus sordidus* Parent, *Mitt. Zool. Mus. Hamburg*, xliii, 1928, 193; Parent,  
*Ann. Soc. Sci. Bruxelles*, (B) lii, 1932, 123; Hardy, *Aust. Zool.*, vi, 1930, 132.—  
*Sciapus anomalipennis* Hardy, *ibid.*, vi, 1930, 128, figs. 1, 2; Parent, *Ann. Soc. Sci.*  
*Bruxelles*, (B) lii, 1932, 117.

A male from Victoria agrees with *S. anomalipennis* Hardy, having identical  
 characters except that the hypopygium is apparently larger and reaches the apex  
 of the fourth abdominal segment, whereas on Queensland specimens it reaches  
 to between the apex and middle of the fifth segment. Parent, who has only  
 seen the female of his form and both sexes of mine, is in agreement with me,  
 regarding them as conspecific.

*Hab.*—Queensland to Victoria. A male from Carrum, in the latter State,  
 is in the collection of Mr. F. E. Wilson.

## HYDROPHORINAE.

Already five genera recognized as occurring in Australia are listed under this subfamily, namely: *Hydrophorus* Fallen, *Paralipatus* Bezzi, *Liparomyia* White, *Scorpiurus* Parent, and *Paranthinophilus* Parent. To these must be added *Thinophilus* Wahlbg., recorded here for the first time. The genus was discovered by Mr. L. Wassell and myself when making an unsuccessful attempt to secure *Paralipatus*, only two specimens of which are hitherto known, both taken by Mr. Wassell at a light when on camping trips with a motor-boat, and both specimens were sent to the late Dr. E. W. Ferguson.

## HYDROPHORUS PRAECOX Lehm.

Parent, *Ann. Soc. Sci. Bruxelles*, (B) lii, 1932, 71.

Records of this species are given by Parent from Canberra and New South Wales. Specimens from Sydney and Hobart are before me and were mentioned (erroneously as two species) in my catalogue without specific determination. The species conforms well with Lundbeck's description (*Diptera Danica*, iv, 1912, p. 346).

## THINOPHILUS WASSELLI, n. sp.

♂. The whole body is covered with a blue-green iridescence with purple tinges more or less obscured by a pulverulent olive-yellow. The antennae have the two basal segments yellow, the third black or mainly so, and the palpi also yellow. One pair each of vertical, ocellar and postvertical bristles all black, and one row of white postoculars that gives place to black towards the vertex and where extra bristles tend to form two rows, the second row numbering up to three bristles or may be absent. Some yellow and white hairs form a small scanty beard.

Each side of the prothorax are four short black bristles placed in a row. The mesonotum is without hairs, except for a small group of short stiff ones that run into eight dorsocentral bristles, the last two only being strongly developed. Outside these there is a line of four bristly hairs reaching the transverse suture, beyond which, in the same line, two supra-alar bristles occur. One each of humeral, posthumeral, notopleural and postalar bristles stand isolated except for two bristly hairs on the humeral tubercle. Two pairs of bristles occur on the scutellum. Some scanty long hairs occur on the propleura anterior in position to the spiracle, otherwise the pleura is bare. The abdomen contains six normal large segments uniformly covered with black stiff hairs, followed by a complex of much reduced segments and the hypopygium which is mainly retracted into a groove on the venter and reflexed, but showing a Y-shape induced by two diverging slender parts reaching the fourth segment.

The anterior coxae are yellow, with long black hairs placed anteriorly, and covered with a pulverulent white. The remainder of the anterior legs are similarly yellow except the apical tarsi, which are stained with black, the whole being covered with short scanty black hairs and only four bristles occur all on the anterior side of the tibiae. The intermediate and posterior coxae are yellow with a pulverulent grey that makes them unicolorous with the pleura, the remainder being coloured as the anterior legs, but the bristles of the tibiae are more plentiful and more generally distributed. The posterior coxae have a lateral bristle. The venation is typical.

The female is similar, but only five abdominal segments are to be detected and on the anterior coxae only short black hairs occur.

*Hab.*—Queensland: Southport, December, 1932, and January, 1933; 7 males and 12 females, occurring plentifully on the uncovered tidal mud around Mangrove swamps.

*Note.*—In Parent's key, this species runs to *Parathinophilus*, but may be separated by the absence of acrostichal bristles and other characters.

*References.*

- HARDY, G. H.—*Australian Zoologist*, vi, 1930, pp. 124-134. (Contains full references to literature except those of Parent's papers.)
- PARENT, O.—*Ann. Soc. Sci. Bruxelles*, (B) xlvi, 1926, pp. 205-229; xlix, 1929, pp. 169-246; lii, 1932, pp. 105-176, 215-231; liii, 1933, pp. 170-187.
- .—*Mitt. Zool. Mus. Hamburg*, xliii, 1928, pp. 155-198.
- .—*Bull. Mus. Hist. Nat. Paris*, (2), iv, 1932, 872-881.
- .—*Stett. Ent. Zeit.*, xciii, 1932, pp. 220-241.
- .—*Ann. Mag. Nat. Hist.*, (10), xiii, 1934, pp. 1-38.
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ADDITIONS TO OUR KNOWLEDGE OF THE FLORA OF THE NARRABEEN  
STAGE OF THE HAWKESBURY SERIES IN NEW SOUTH WALES.

By N. A. BURGES, M.Sc.

(Plate x; eleven Text-figures.)

[Read 28th August, 1935.]

During 1933 a systematic examination was undertaken by the Students' Geological Society of the University of Sydney of the fossil flora of portions of the Narrabeen Stage. This Stage is as yet very imperfectly known, notwithstanding its ready accessibility from Sydney. Plant remains and geological data were collected. The Research Committee of the Society consisted of its President, Mr. M. D. Garretty (Chairman), Mr. N. A. Burges, M.Sc., of the botanical staff at the University of Sydney, and Mr. S. W. Carey, B.Sc. The following members participated in the excursions which were held in addition to frequent committee visits: Misses T. Christie, M. Cogle, G. Edgecombe, M. Hayward, B. E. Johnston, V. M. B. May, D. Pearce, N. Repin, N. Robards, E. J. Thompson, N. L. Wilkie; Messrs. F. A. Hanlon, D. J. Lee, R. McGlynn, K. MacKinnon, W. McNiven, K. Mosher, W. Nichols, L. Noakes, J. Pryke, M. L. Wade, J. Yeager.

Thanks are due to Dr. A. B. Walkom for much help in connexion with the plant determinations, and also to Professor T. G. B. Osborn, and to Professor L. A. Cotton, for permission to carry out work in the Departments of Botany and Geology, respectively, in the University of Sydney. The geological notes on the Narrabeen Stage are due to Mr. M. D. Garretty.

GEOLOGICAL SUMMARY.

The Triassic Hawkesbury Series of the Sydney District has been divided into three stages, the lowest being the Narrabeen Stage. This is for the most part conformable with the underlying Kamilaroi (Permo-Carboniferous) Coal Measures; it is overlain conformably by the Hawkesbury Sandstone Stage. It was placed by the late Sir T. W. Edgeworth David (1932) as early Triassic (Lower Bunter), and the beds were tentatively regarded as Lower Triassic on botanical grounds by Walkom (1918). Fossil fish and a labyrinthodont lead to the same conclusion. *Unio* indicates the freshwater nature of the sediments. The palaeontological equivalent of the structural continuity of Palaeozoic and Mesozoic exists locally as a gradation in the flora for a few feet (Dun, 1910).

The Stage forms part of the Sydney Geosyncline, and has at Sydney a maximum thickness of about 1,800 feet. It thins out to the south (about Kiama), west (about Lithgow), and north (Gunnedah and Murrurundi), and is truncated to the east at the coastline. Outcrops are in general restricted to the coast and margin of the geosyncline. The sediments near Sydney consist largely of shales and carbonaceous shales, with associated sandstones, tuffs, and hard

fontainebleau sandstone in thin bands. To the north, west, and south, coarser types prevail. On the South Coast near Otford numerous pebbles apparently derived from a Narrabeen conglomerate were found; these in part closely resemble certain Upper Devonian lavas from Yalwal (50-60 miles to the south-south-west). Fragments of large trees and smaller plant remains occur here in a charred state in the tuffs, indicating proximity to points of eruption. These occurrences strengthen the view (David, 1887) that "the probable source of these [cupriferous, see below] particles is the line of volcanic country between Kiama and Mittagong".

A kind of rhythmical alternation of sandstone and shale, on various scales, is not uncommon. The coarser bands frequently have macerated plant remains showing internal signs of far-carriage, while much better preserved specimens occur in the finer laminae. Important and distinctive beds are the Estheria Shales, Cupriferous Tuffs, and the Chocolate Shales. The first (with *E. coghlani*) overlie the Kamilaroi sediments for about 560 feet, below Sydney. Copper-bearing tuffs follow for about 40 feet at Sydney, and also occur higher in the Stage, associated with Chocolate Shales. The latter form a band up to 170 feet thick near Sydney, near the top of the Stage; elsewhere they thin out, and may split into several bands. The Chocolate Shale is considered to be a redistributed tuff, with admixed sediment. The top of the upper Chocolate Shale zone is sometimes taken "for convenience" (Harper, 1915) as the actual top of the Narrabeen Stage, but this is not the case, as it may continue for some distance higher up, as at Sydney. This is important, since most of the plants described were collected not far above the upper limit of the chocolate shale, the principal localities being: Turrimetta Head, Mona Vale, Avalon, and Terrigal. (For a sketch geological map of the area see Culey, 1932.)

Recent work (Culey, 1932) on ripple-marks has shown "the Triassic Narrabeen Lake as a shallow, subsiding, freshwater lake, probably elongated in a N.E.-S.W. direction. Surrounding it one would see areas of low relief from which the sediments are brought down and deposited quietly in the lake, the prevailing calm being interrupted by local disturbances and ejections of tuffs followed again by quiet sedimentation". Washaways are common in sectional form in the cliffs and could be due to sub-aerial erosion, or to local channels in sheet flood erosion. There is abundant evidence of deposition in separate hollows or lakes, and the beds are lenticular (in extent measurable usually as a fraction of a mile). For this reason the Society's original project of zoning the Stage by its flora is seen to be impracticable. Periodical floods seem to have brought sediment and plants for some distance, forming persistent pebble bands and torrential bedding, accompanied by plant remains in a macerated condition. At quieter times plants would come merely from the borders of the individual ponds, and be gently covered by fine sediment. That at times part of the area was dry land is indicated by the occurrence in interformational conglomerates (as at Mona Vale immediately above the Chocolate Shale) of fragments of already solidified shale from elsewhere in the Stage; one such fragment contains a well-preserved *Cladophlebis*.

The work of this paper, geological and botanical, has thus given to the Narrabeen Landscape a greater heterogeneity than was formerly supposed. While occasional events of an all-embracing nature took place, the more peaceful times saw semi-isolated and moisture-zoned plant communities around the separate small lakes, resembling numerous oases in a desert of what was probably dry land (plain of accumulation).

Certain structures were described by Walkom (1925, plate xxxi, figs. 7-9) as "Plantae incertae sedis". Of these, figs. 7 and 8 have been referred to *Araucarites sydneyensis* (q.v.). Occurrences of the structure represented by fig. 9 were found to be quite numerous on certain horizons at Turrimetta Head. They were found not to be referable to a plant or plants, but to be concretions. They are generally dome-shaped, with surface, and the cavity of the overlying shale, striated radially and having a slickensided appearance. Slides show that the concretions have formed in bands of shale with an unusually fine texture; no nucleus was observed as such. Application of the criteria of Richardson (1921) did not lead to decisive classification, but there seems no doubt in this case that the concretions are subsequent rather than contemporaneous. Nodules of an apparently similar type, but without the slickensides, have been collected in the Triassic Wianamatta Stage at Strathfield.

#### PLANT DESCRIPTIONS.

The following section of the paper contains descriptions of plants found during the course of the work. Some record additional features for species already described, while others are new species. Well-known plants previously recorded from the Narrabeen stage are not discussed, as these have been treated fully by Walkom (1925).

The distribution of the plants is interesting—seldom were many types found on one horizon. Usually the beds contained *Thinnfeldia* and *Phyllothea* almost to the exclusion of other plants, but here and there beds occur which contain little or no *Thinnfeldia* but are rich in other plants. At Mona Vale an horizon was found in which all the plant remains were referable to *Araucarites*; at Avalon extensive beds were found with *Williamsonia* stems.

Of the following records, the occurrence of fossil wood of the cupressinoid type from the base of the Triassic is of most interest.

#### LYCOPODIALES.

##### LYCOSTROBUS LONGICAULIS, n. sp. Text-fig. 1.

Included in the material collected from Avalon are several specimens of cones. These structures are borne on stems which in some cases are a metre in length. The stems are 2 cm. wide and very long, they show no trace of structure other than a few longitudinal striations, some of which are probably due to folding during preservation. The cone itself is about 8 cm. long by 4 cm. wide and tapers away towards the apex. It resembles fairly closely in general appearance a male cone of *Macrozamia spiralis* even to the suggestion of pointed sporophylls with upturned ends, becoming longer towards the apex of the cone. The sporophylls are spirally arranged. Little can be made of their structure. The specimens are partly casts and partly composed of organic matter. Treatment with hydrofluoric acid followed by nitric acid and potassium chlorate shows the presence of the remains of both thick and thin walled cells and structures which are probably spores; these are much distorted but would be about  $20\mu$  in diameter.

#### FILICALES.

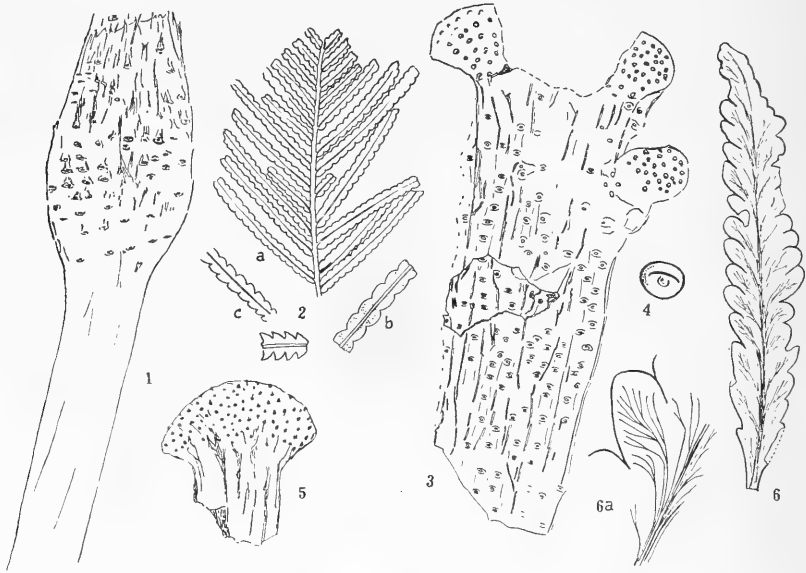
##### TODITES NARRABEENENSIS, n. sp. Text-fig. 2.

Fronds pinnate, probably 30-50 cm. long or more, pinnae linear, pinnatisect, at least 20 cm. long; 3-5 mm. broad in the fertile material, 5-8 mm. in the sterile; the segments in the fertile material orbicular or reduced to crenulations

of the pinna margin; segments of sterile pinnae acute, slightly falcate. Sporangia scattered over the undersurface as in *T. Williamsoni* (Brong.).

*T. narrabeenensis* differs from *T. Williamsoni* in its much smaller size and its sharp distinction of the sterile from the fertile material.

Material of this species is not plentiful and appears to be concentrated in two or three layers in the grey shales about forty feet above the chocolate layers. Specimens were collected from Turrimetta Head, Mona Vale and Avalon.



Text-fig. 1.—*Lycostrobus longicaulis*. Cone and portion of stalk,  $\times \frac{1}{2}$ . Specimen No. 2003.\*

Text-fig. 2.—*Todites narrabeenensis*. a, Fertile frond,  $\times \frac{1}{2}$ ; b, pinna showing sporangia,  $\times \frac{2}{3}$ ; c, sterile pinnae,  $\times \frac{1}{2}$ . Specimen No. 2004.

Text-figs. 3, 4.—*Caulopteris* sp.? 3, Stem with expanded apex,  $\times \frac{1}{2}$ . 4, Leaf scar enlarged,  $\times 2\frac{2}{3}$ .

Text-fig. 5.—Expanded apex of a stem probably referable to *Caulopteris*,  $\times \frac{1}{2}$ . Specimen No. 2006.

Text-figs. 6, 6a.—*Odontopteris dubia*. 6, Frond,  $\times \frac{1}{2}$ . 6a, Portion enlarged,  $\times 2$ . Specimen No. 2007.

#### FERN STEMS.

##### CAULOPTERIS sp.? Text-figs. 3, 4.

In one horizon at Avalon, large numbers of casts and impressions of stems were found. Some of these are quite large—up to 5 cm. in width and 20 cm. long. The main part of the stem is covered with a series of scars, irregularly placed but tending to form rows with ridges of raised tissue between them. These ridges are usually not regular and are often oblique to the main axis of the stem. The apex is slightly expanded, bearing scars more closely set and less typical in shape. Intermediate types of scars are present at the base of the expanded

\* The numbers are those of specimens in the collection of the Geology Department, University of Sydney.



portion. The stem is probably partly or wholly decorticated in the lower region. The scars are elliptical, 2-3 mm. by 1.5 mm. (Text-fig. 4), and show markings which are interpreted as representing an upper sclerenchyma band of tissue and a U-shaped vascular strand.

The specimen illustrated in Text-figure 5 probably also belongs here. Both are referred with doubt to the genus *Caulopteris*.

PTERIDOSPERMS?

? *TAENIOPTERIS UNDULATA*, n. sp. Plate x, fig. 1.

Leaf linear, at least 0.5 metre long, 1.4 cm. wide, midrib very prominent, about 2 mm., lamina very regularly undulate in most specimens, venation taeniopteroid, at right angles to the midrib, veins very delicate, numerous, 30 per cm.

This species resembles in some ways *T. spathulata*, but no basal or apical parts have been seen even in pieces 40 cm. long.

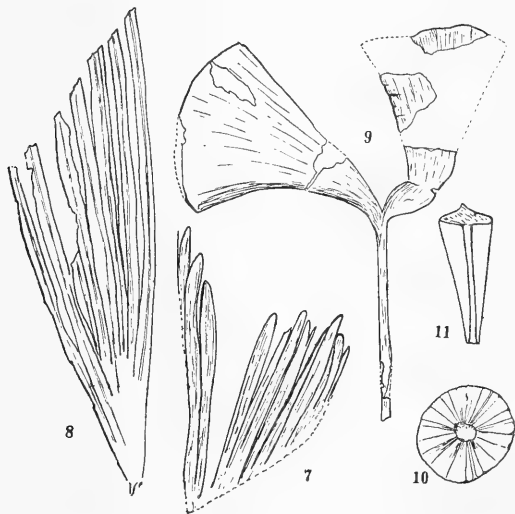
*ODONTOPTERIS DUBIA*, n. sp. Text-fig. 6, 6a.

Leaves simple, linear, lanceolate, 10-12 cm. long, 2 cm. wide, pinnatisected segments rounded, venation odontopteroid. Tapering at the base.

GINKGOALES.

*BAIERA SIMMONDSI* (Shirley). Text-figs. 7, 8.

Several specimens are probably referable to this Queensland species. There is in one specimen (Text-fig. 8) a suggestion of a midvein in each linear segment. This may be due to folding during preservation, or may indicate that the specimen belongs elsewhere. It is certainly larger than the average *Baiera Simmondsi*.



Text-figs. 7, 8.—*Baiera Simmondsi* (Shirley). 7, Portion of leaf,  $\times \frac{1}{2}$ . 8, Portion of leaf,  $\times \frac{3}{4}$ . Specimens No. 2008, 2009.

Text-fig. 9.—*Rhipidopsis narrabeenensis* Walkom. Leaf showing petiole,  $\times \frac{1}{2}$ . Specimen No. 2012.

Text-figs. 10, 11.—*Araucarites sydneyensis* Walkom. 10, Cross section of cone,  $\times \frac{1}{2}$ . 11, Cone scale,  $\times 2$ . Specimens No. 2010, 2011.

*RHIPIDOPSIS NARRABEENENSIS* Walkom. Text-fig. 9.

Further material of the above species confirms Walkom's (1925) opinion that it belongs to *Rhipidopsis* rather than *Psymophyllum*. The specimen figured (Text-fig. 9) possesses a petiole about 5 cm. long—it agrees with that figured by Walkom (1925, fig. 4, Pl. xxx) in having the two segments forming the leaf blade.

## CONIFERALES.

*ARAUCARITES SYDNEYENSIS* Walkom. Text-figs. 10, 11.

The following additions can be made to the description of the above species.

The remains described by Walkom of this species are evidently those of megaspore cones. The specimens illustrated by Walkom (1925, Pl. xxxi, figs. 7, 8) and placed by him in *Plantae Incertae Sedis* are probably cross sections of a cone referable to this species.

A large series of specimens obtained from Mona Vale shows that the cones were preserved in such a way that all aspects of the cone may be examined. The cones appeared to fracture easily and many were preserved showing cross-sections in which the scales may be seen in situ (cf. Text-fig. 11). Large numbers of detached cone scales were also found.

The cone scales are approximately triangular, about 1 cm. long and about 5 mm. broad, tipped by a short point, with a marked ridge along one side.

## PETRIFIED MATERIAL.

Previous descriptions of plants from the Narrabeen Stage have been made from casts, impressions or carbonized remains. During the present investigation, material was obtained from Terrigal which, although unpromising in surface view, was well preserved and yielded good sections. Two trips were made to the locality, one by Mr. Noakes, in 1933, who was making a reconnaissance of the area when he found the first piece of material, and a second in 1934 when other members of the society accompanied Mr. Noakes and collected specimens of at least two species.

The remains consisting of petrified stems were embedded in the tuffaceous sandstones which form the cliffs of the Skillion and the headlands immediately to the south. These cliffs in most places are difficult to climb, so the main collecting was carried out among the fallen rock. In one instance material was obtained on the cliff face. Nowhere did the plant remains seem to be at all plentiful, and three to four hours' careful search revealed only six pieces of stem.

When dug from the matrix the specimens are usually surrounded by a layer of coaly material which is more or less prismatic. Frequently they are rounded at the ends, suggesting that disintegration has occurred before preservation. Considerable crushing has occurred, but this has been irregular and areas of undisturbed material are available for examination. The preservation is due to infiltration of calcareous substances, and much of the original carbonaceous material is still present. The cellular structure is well retained and the tracheidal pitting is easily visible. In some specimens the protoxylem elements and the pith cells are recognizable.

Three forms of the material are present, two of these can be assigned to *Cupressinoxylon*; the third is difficult to place, but is here considered as *Cedroxylon*.

## CUPRESSINOXYLON NOVAE-VALESIAE, n. sp. Plate x, figs. 2-5.

The specimens are portions of stems or branches, and vary in length, one measuring 70 cm. Owing to compression and also disintegration, they have assumed an oval shape, 5.5 cm. by 2.8 cm., with an ex-centric pith. The pith is well preserved in some pieces but in others has been lost; it measures 3-8 mm. in diameter. The cells increase in size towards the centre,  $40\mu$ - $60\mu$  in diameter, the walls with circular pits, air spaces between the cells triangular,  $8\mu$ . Protoxylem endarch, tending to be split up into wedge-shaped pieces. Tracheids nearest the pith small,  $10\mu$ , annular or spiral, metaxylem larger,  $30\mu$ , scalariform. Secondary wood showing somewhat irregular annual rings, 0.5-3 mm. wide; spring tracheids large,  $30$ - $40\mu$ , slightly irregular, summer tracheids smaller,  $20$ - $30\mu$ , and thicker walled, pits in a single row, bordered with circular orifice, rims of sanio apparently poorly developed, usually not distinguishable; checking is evident. Rays simple, 2-8 cells deep, usually 2-4, the cells 20 by  $30\mu$  in tangential section and  $50$ - $60\mu$  long, tangential pits not clearly shown, 2-4 in the field. Proportion of medullary ray to the wood in tangential section about 1:15. Resin tissue consisting of isolated rows of parenchyma cells fairly evenly distributed, abundant.

In addition to the above, there is material of *Cupressinoxylon* (Pl. x, fig. 6) very similar to *C. novae-alesiae* but differing somewhat. The general features vary little in essential points, the differences being more apparent than real. In cross-section the protoxylem is more irregular than in *C. novae-alesiae* as is the secondary xylem. The only well marked feature is the size of the medullary rays, which are 6-9 cells deep and usually narrower than in *C. novae-alesiae*.

## ? CEDROXYLON TRIASSICUM, n. sp. Pl. x, figs. 7-9.

Specimens are parts of stem showing fairly well preserved pith and xylem, oval in cross-section, partly due to crushing and partly to weathering or decay prior to embedding.

The pith is about 8 mm. in diameter, the cells about  $40\mu$  in diameter, the walls not very definitely pitted. Protoxylem fairly abundant, in wedge-shaped pieces jutting into the pith. The smaller elements spiral,  $15\mu$  in diameter, the larger scalariform,  $25\mu$  in diameter. Secondary wood with well-marked annual rings 2-4 mm. apart. Tracheids  $30\mu$  in diameter, the summer wood composed of slightly smaller tracheids with thicker walls, bordered pits in a single row, with oblique orifices, rims of sanio very distinct, checking well marked. Rays simple, 3-10 cells deep, usually 4-5 deep, cells  $18\mu$  by  $25\mu$  in tangential section,  $50$ - $60\mu$  long in radial section, walls with 2-6 pits in the field. Wood parenchyma scarce, one or two cells among the summer wood, resinous.

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## DESCRIPTION OF PLATE X.

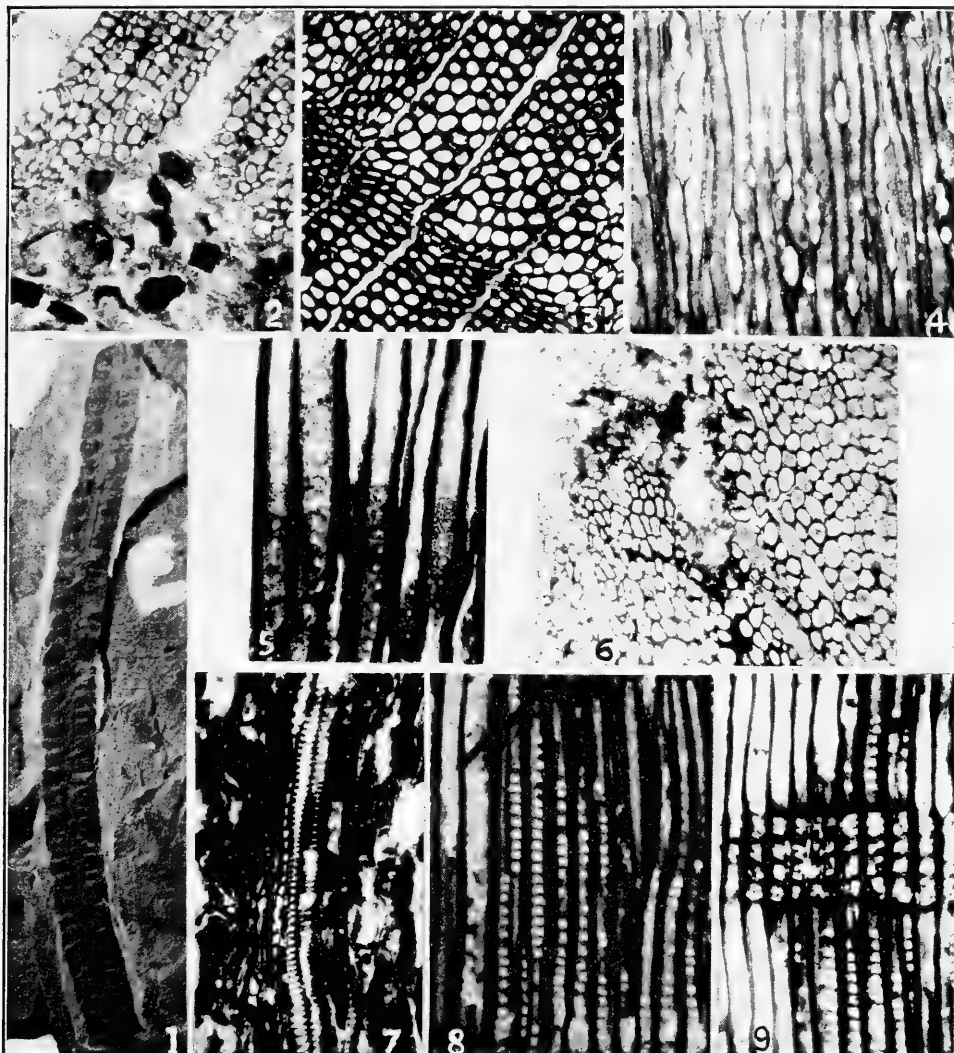
Fig. 1.—? *Taeniopteris undulata*, n. sp. (Specimen No. 2005).

Figs. 2-5.—*Cupressinoxylon novae-valesiae*, n. sp. 2, Transverse section of pith and protoxylem. 3, Secondary wood showing annual rings. 4, Tangential section of the wood. 5, Radial section of the wood showing the bordered pits.

Fig. 6.—*Cupressinoxylon* sp. Primary wood and early secondary wood.

Figs. 7-9.—*Cedroxylon triassicum*, n. sp. 7, Longitudinal section of the protoxylem. 8, Longitudinal section of the secondary wood. 9, Longitudinal section through a medullary ray.

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1. *Taeniopteris undulata*; 2-5, *Cupressinoxylon novae-valesiae*; 6, *Cupressinoxylon* sp.;  
7-9, *Cedroxylon triassicum*.



## UPPER PERMIAN INSECTS OF NEW SOUTH WALES. III.

THE ORDER COPEOGNATHA.

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F.R.S.N.Z., F.R.E.S., F.G.S.

(With thirteen Text-figures.)

[Read 28th August, 1935.]

This paper is a continuation of the series which I began in 1926 (Tillyard, 1926*a*) with a paper dealing with the Upper Permian fossil insects of the Order Hemiptera, and followed with a second part (Tillyard, 1926*b*) on the Orders Mecoptera, Paramecoptera and Neuroptera. During the intervening nine years, a very large number of new fossil insects have been discovered in Upper Permian rocks from Warner's Bay, thanks to the persistent labours of Messrs. T. H. Pincombe, M. S. Stanley, Rev. A. J. Barrett and myself; to whom must be added more recently Master Malcolm Stanley, who in the course of a year or so has discovered quite a considerable number of fine wings.

The insect fauna of the Upper Permian in New South Wales, as now presented to us from a study of about five hundred specimens, is a very remarkable one for a Palaeozoic Fauna. Most of the older types of insects are either absent or very rare. Orthopteroid insects of all kinds appear to be entirely absent, including Cockroaches. No Palaeodictyoptera, Megasecoptera or Mayflies have been found, and only a single larva of definite Perlarian affinity. Dragonflies are so far represented only by two or three fragments of a wing which appears to belong to the family Ditaxineuridae, known only from the Lower Permian of Kansas. The Suborder Homoptera of the Order Hemiptera was the dominant group. As these insects must have fed mainly on *Glossopteris*, their remarkable abundance must be taken into account as a possible factor in the decline and eventual disappearance of the *Glossopteris* flora at the close of the Upper Permian. Closely related to the Homoptera, and by no means uncommon, were the members of the Order Copeognatha or Psocoptera, dealt with in this Part.

Apart from the above Hemimetabolous Insects, the fauna is mainly composed of Holometabola and their ancestors. Quite a number of new and interesting types of Coleoptera have been discovered, together with further representatives of the Order Protocoleoptera. Next to the Homoptera, the most abundant Order of Insects was the Mecoptera or Scorpion-flies, of which many new types have been found. The derived Order, or Sub-order, Paratrachoptera is represented by quite a number of primitive genera, and these in turn had already produced, alongside of them, true representatives of the Order Diptera. The only other Order known for certain from these beds is the Neuroptera Planipennia, of which a number of very fine new types have been discovered. There is one wing, which is unfortunately very fragmentary, which may belong to some primitive type of Hymenopteron, but this is not at all certain.

The present Part deals with the Order Copeognatha only, and presents for the first time a Copeognathous fauna of great richness and variety which is evidently a marked advance on that of the Lower Permian of Kansas.

#### Order COPEOGNATHA.

The earliest known representatives of this Order come from the Lower Permian of Kansas, and were described by me in 1926. Two families are there represented, viz., the Dichentomidae and the Permopsocidae. So far, no Copeognatha have been described from the Upper Permian of New South Wales. But, in the more recent collections from Warner's Bay, this Order proves to have been well represented by more than twenty specimens. Unfortunately the conditions of fossilization are generally such that the wings become badly crumpled or torn. This is particularly the case with a fine species belonging to the family Dichentomidae. I have before me several specimens of which I am quite unable to give descriptions. Not only are the wings torn or crumpled, but it is evident from the habit of this insect of resting (and, evidently, also dying) with its wings held close together in a steep roof-wise position, either all four wings, or sometimes only two, became stuck together in the glue-like mud in which they were preserved, leaving impressions of either four or two very faint systems of venation, crossing one another at slight angles, and making it impossible to restore the venation as it originally was.

So far, the family Permopsocidae has not been discovered in the Upper Permian beds of Australia; unless, perhaps, the new genus *Megapsocidium* should happen to belong to this family, when the structure of its cubitus is revealed. The Dichentomidae are well represented, and there are also two remarkable new families possessing quite unexpected types of venation. One of these, the Zygopsocidae, would appear to be a specialized group which has left no descendants. But the other, the Zoropsocidae, proves to be of special interest for two reasons: firstly, it appears to represent the ancestral stock of the recent Suborder Zoraptera, now confined to the nests of Termites; and, secondly, it supplies a connecting link between the more typical Copeognatha and the family Lophioneuridae (inclusive of Dr. F. M. Carpenter's family Cyphoneuridae), which can now be shown to be true Copeognatha and not Homoptera as we both originally supposed. Included in the present collection are a number of new genera allied to both *Lophioneura* and *Cyphoneura*. Some of the specimens are practically complete, and prove to be insects having the general character of Copeognatha, with depressed head, hypognathous mouth-parts, no sign of a sucking-beak, wings held roof-wise over the back, and other characters of the Order. It is therefore now necessary for me to remove the family Lophioneuridae from the Homoptera and to include it in the Copeognatha. It will further be abundantly evident that Carpenter's family Cyphoneuridae (Lower Permian of Kansas) cannot stand, but must be merged with the Lophioneuridae.

The Copeognatha of the Permian now prove to have been quite abundant in families, genera and species. They are evidently very closely allied to the Homoptera, and there can be no doubt that the two groups arose from a common stem. Apart from the very obvious differences in the shape of the head and the structure of the mouth-parts, it is possible to distinguish the wings of the Permian Copeognatha at once by the fact that Rs is always branched, whereas in the Permian Homoptera Rs is always simple (except for short terminal branchlets in the abundantly-veined Prosbolidae).



In the figures of this paper, except only figs. 7A and 9, which are complete insects, the wings are drawn always with apices to the right, to facilitate comparison.

*Key to the Families of Permian Copeognatha. (Forewings only.)*

- 1. Rs with four branches arranged in an anteriorly pectinate series ..... Family *Zygopsocidae*, n. fam.  
Rs with less than four branches, not arranged as above ..... 2
- 2. M three-branched; Cu<sub>1</sub> forked or simple ..... Family *Dinopsocidae* Mart.  
(Upper Permian of Russia only.)  
M with either four or two branches ..... 3
- 3. M four-branched; Cu<sub>1</sub> forked ..... 4  
M two-branched; Cu<sub>1</sub> usually simple, rarely with a weak posterior branch ..... 5
- 4. Fork of Cu<sub>1</sub> deep and strongly arched, connected with M<sub>3-4</sub> above by a cross-vein ..... Family *Permopsocidae* Till.  
(Lower Permian of Kansas.)  
Fork of Cu<sub>1</sub> less arched, often long and flat, not connected with M<sub>3-4</sub> .....  
..... Family *Dichentomidae* Carp.  
(Lower Permian of Kansas and Upper Permian of Australia.)
- 5. Main veins more or less strongly curved, Cu<sub>1</sub> sigmoidally; Rs, M and Cu<sub>1</sub> arising separately from R<sub>1</sub> ..... Family *Lophioneuridae* Till.  
(Upper Permian of Australia and Lower Permian of Kansas.)  
Main veins normal, Cu<sub>1</sub> not sigmoidally curved; their modes of origin also normal ..... Family *Zoropsocidae*, n. fam.

Family 1. DICHENTOMIDAE Carp.

Psocidiidae, Tillyard, 1926c, p. 319.—Dichentomidae, F. M. Carpenter, 1932, p. 3.

Dr. Carpenter considers the genus *Psocidium* Till. to be synonymous with *Dichentomum* Till. As the latter takes page precedence, the name of the family should be changed to Dichentomidae. Pending a restudy of the types, I think that this alteration should stand. The two genera are in any case very closely allied.

There are three new generic types in the material before me, which may be distinguished as follows:

- 1. Medium-sized wings with the branches of Rs arising distad from the level of the end of R<sub>1</sub> ..... 2  
Large wings with the branches of Rs beginning at a level well before the end of R<sub>1</sub> ..... Genus *Megapsocidium*, n.g.
- 2. Sc simple; R well removed from costa; M 4-branched in forewing ..... Genus *Austropsocidium*, n.g.  
Sc branched; R fairly close to costa; M 5-branched in forewing ..... Genus *Stenopsocidium*, n.g.

Genus 1. AUSTROPSOCIDIUM, n.g. Figs. 1, 2.

Forewing elongate-oval in shape, the costa gently curved, the apex well rounded. Sc ending on R<sub>1</sub>. R well removed from costa. Rs either two- or three-branched, but the branches short in any case. M four-branched, normal, connected with Rs by a radio-median cross-vein. Cu<sub>1</sub> arising just below M and having a long, rather flat fork not connected with M in any way. Cu<sub>2</sub> a straight, weak furrow-vein bounding a small but well developed anal area or clavus with two anal veins; 1A nearly straight, close to Cu<sub>2</sub>; 2A slightly sigmoid.

Genotype: *Austropsocidium pincombei*, n. sp.

Horizon.—Warner's Bay. Upper Permian of New South Wales.

*Key to the Species of the Genus Austropsocidium.*

- Rs two-branched, R<sub>1</sub> without strongly marked pterostigma ..... *A. pincombei*, n. sp.
- Rs three-branched, R<sub>1</sub> with large strongly marked pterostigma .. *A. stigmaticum*, n. sp.

1. *AUSTROPSOCIDIUM PINCOMBEL*, n. sp. Fig. 1A, 1B.

This specimen consists of fore and hind wings lying one upon the other, the apices being to the left. The venation of the forewing is not difficult to make out, but that of the hindwing, being fainter, is more difficult to trace. In the figures, the wings have been separated.

*Forewing* (fig. 1, A).—Length 7.9 mm.; breadth 2.8 mm. Membrane very delicate; venation faint except for the anal veins. Sc very faint basally but clearer as it approaches its junction with  $R_1$ , which it does with a slight downward curve.  $R_1$  forked distally but with little or no formation of a pterostigma. Rs arising at about one-third and forking into two just beyond the level of the end of  $R_1$ . M arising from R at about one-fifth and forking a little beyond middle of wing; the upper fork,  $M_{1+2}$ , is connected with Rs by a cross-vein after arching strongly upwards; its fork is at the same level as that of Rs. Fork of  $M_{3+4}$  slightly basad from that of  $M_{1+2}$ .  $Cu_1$  running basally just below  $R+M$  and leaving it just before M, descending obliquely to fork somewhat before half-way along the wing; the long, flattish fork reaches to just beyond the level of the fork of  $M_{3+4}$ . 1A and 2A strong veins on a well formed clavus with slightly convex posterior margin.

*Hindwing* (fig. 1, B).—Length 6.4 mm.; breadth 2.5 mm. Differs from forewing in the much narrower costal area and much wider space between  $R_1$  and Rs.  $R_1$  unbranched. Stem of  $M_{3+4}$  much shorter than in forewing. Arch of  $Cu_1$  flatter than in forewing, with  $Cu_{1b}$  placed more obliquely. Clavus smaller, apparently with only a single anal vein, 1A, present.

Type.—*Holotype*, Specimen P. 218, found by Mr. T. H. Pincombe at Warner's Bay, 23rd October, 1926. This was the first Psocid wing discovered in the Upper Permian beds of Australia.

2. *AUSTROPSOCIDIUM STIGMATICUM*, n. sp. Fig. 2.

This species is only represented by the distal two-thirds of a rather long, slender wing, obviously a forewing, the apex to the left.

Length of fragment 6.6 mm., representing a total length of about 9.5 mm. Breadth 2.6 mm.

Sc not visible.  $R_1$  widely forked, forming a rather long, triangular pterostigma, distinctly pigmented. Rs almost straight, forking into three short terminal branches well beyond level of pterostigma. M running parallel to Rs and forking rather narrowly below level of pterostigma; upper branch,  $M_{1+2}$ , continues almost parallel to Rs and connected with it by a perpendicular cross-vein, rm, before the fork; lower branch,  $M_{3+4}$ , diverging slightly and forking just before level of end of pterostigma.  $Cu_1$  forking only slightly before level of fork of M, and not so long or flat as in *A. pincombei*.

Clavus and anal veins missing.

Type.—*Holotype*, Specimen found by Rev. A. J. Barrett at Warner's Bay in 1930.

Genus 2. *MEGAPSOCIDIUM*, n.g. Fig. 3.

Differs from *Austropsocidium* in having  $R_1$  and Rs connected by a cross-vein below the fork of  $R_1$  and in having Rs forking strongly at this cross-vein and again forked distally on the upper branch. Only the distal third of the wing is preserved, but it appears as if the four branches of M were not normally arranged, there being three branches on  $M_{1+2}$  and  $M_{3+4}$  being unbranched.

Genotype, *Megapsocidium australe*, n. sp.

Horizon.—Warner's Bay. Upper Permian of New South Wales.

3. MEGAPSODIDIUM AUSTRALE, n. sp. Fig. 3.

This specimen consists of the distal half only of a forewing (apex to the right), measuring 6.0 mm. long by 3.5 mm. wide, and probably representing a wing of total length 10 mm. or more. The apical portion is complete, but the basal break is very irregular and there is also an irregular patch of rather large size broken away from the centre.

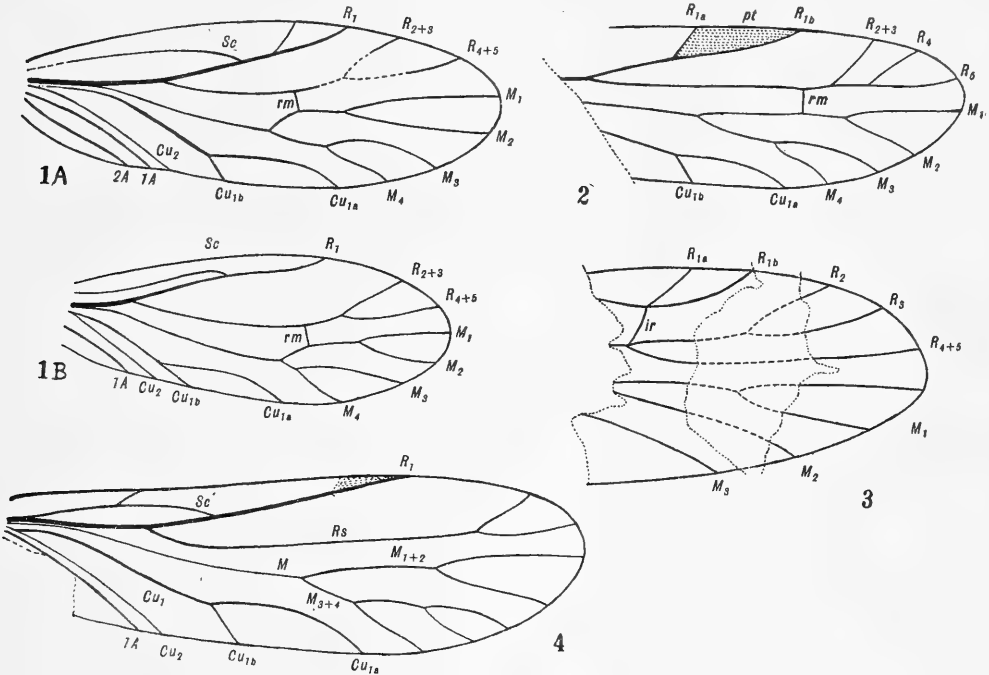


Fig. 1.—*Austropsocidium pincombei*, n.g. et sp. A, Forewing (7.9 mm.). B, Hindwing (6.4 mm.). Both with apex turned to right. Family Dichentomidae.

Fig. 2.—*Austropsocidium stigmaticum*, n. sp. Distal half of forewing (6.6 mm.) with apex turned to right. Family Dichentomidae.

Fig. 3.—*Megapsocidium australe*, n.g. et sp. Fragment of forewing (6.0 mm.). Family Dichentomidae (?).

Fig. 4.—*Stenopsocidium elongatum*, n.g. et sp. Forewing (6.5 mm.), with apex turned to right. Family Dichentomidae.

The wing is very slightly tinted pale brown, the shading being a little more marked in the region of the pterostigma, which extends downwards well below  $R_1$ . At the basal fracture,  $R_1$  is seen diverging quite strongly from the costa, and shortly afterwards gives off an oblique veinlet  $R_{1a}$  to the costa, while its main stem continues in a strong curve as  $R_{1b}$ . At the lowest point of  $R_{1b}$  a slightly oblique interradial cross-vein ( $ir$ ) passes to  $R_s$ , which divides immediately distad of this into two main branches, of which the upper,  $R_{2+3}$ , again divides into a large distal fork. Below  $R_s$ , on the basal fracture, the stem of  $M_{1+2}$  appears and at once divides into  $M_1$  and  $M_2$ , the upper branch apparently again dividing into a large distal fork, though the central break in the rock-surface has eliminated the

actual point of forking. The two distal pieces of veins lying below this are almost certainly  $M_3$  and  $M_4$ . Cubital and anal areas missing.

Type.—Specimen B.109, found by Rev. A. J. Barrett at Warner's Bay in 1930.

This species is placed only provisionally in the family Dichentomidae, as the form of its cubital area is not yet known. It is conceivable that the genus *Megapsocidium* may in the end prove to be the Upper Permian Australian representative of the family Permopsocidae, which would otherwise be missing from this fauna.

#### Genus 3. STENOPSOCIDIUM, n.g. Fig. 4.

Wings narrow elongate-oval in shape, the costa nearly straight to end of  $R_1$ , the apex well rounded. Sc ending on  $R_1$  but having also a branch veinlet to costa. R not far removed from costa, simple. Rs two-branched, the branches short, terminal. M five-branched in forewing, four in hind.  $Cu_1$  with a long, flattish fork, not connected with M in any way.  $Cu_2$  an extremely faint furrow-vein. 1A strong, nearly straight. (2A missing.)

Genotype, *Stenopsocidium elongatum*, n. sp.

Horizon.—Warner's Bay. Upper Permian of New South Wales.

This interesting genus is fairly closely allied to *Austropsocidium*, from which it differs by the narrower, more elongate wing, with simple radius placed closer to costa, Sc with a branch veinlet to costa and M five-branched in forewing.

#### 4. STENOPSOCIDIUM ELONGATUM, n. sp. Fig. 4.

This specimen is a very faint impression on a piece of smooth shale, somewhat darker than usual for Warner's Bay. It shows the faint outline of a slender body, 4.6 mm. long, of which the parts are barely distinguishable, together with one pair of wings, also faint, the forewing overlying the hind. The basal portions of Rs and M, and also the whole of  $Cu_2$ , are almost obliterated, but the rest of the venation can be made out in the forewing.

*Forewing* (fig. 4).—Length 6.5 mm.; breadth 2.0 mm. Membrane very delicate; venation very faint except for  $R_1$ ,  $Cu_1$  and 1A. Sc arises with R and rejoins it at about one-third of the wing-length, giving off an oblique veinlet to the costa just beyond half-way.  $R_1$  reaches the costa at a very acute angle and there is slight chitinization and darkening of the pterostigma. Rs forks well beyond level of end of  $R_1$ . Primary fork of M lies a little beyond middle of wing;  $M_{1+2}$  forks well before level of fork of Rs;  $M_{3+4}$  has three branches, the extra one being on  $M_3$ . Fork of  $Cu_1$  long, covering about one-fifth of the posterior margin.  $Cu_2$  very faint, 1A very strong; these two veins appear to be almost straight, fairly close, and slightly diverging.

*Hindwing* almost as long as fore, but definitely narrower basally and very slightly narrower distally. Venation too faint to be made out definitely, except in the case of  $R_1$ , distal end of Rs, distal half of M and fork of  $Cu_1$ . Rs forks much as in forewing, but fork a little narrower. M has only four branches, there being no extra branch on  $M_3$ . Fork of  $Cu_1$  apparently not so long as in forewing.

Type.—*Holotype*, Specimen B.300, found on a piece of rock collected at Warner's Bay by Rev. A. J. Barrett in 1927.

The species has such delicate wings that it is extremely fortunate that a specimen has been discovered in which the venation can be made out with fair accuracy. Several other specimens have been discovered which appear to belong to this species, but it is quite impossible to follow out the extremely faint venational scheme.

## Family 2. ZYGOPSOCIDAE, n. fam.

Wings broad, the anal area with two anal veins, 1A being fused distally with  $Cu_2$ .  $Cu_1$  simple. Rs four-branched. M two-branched.

## Genus 4. ZYGOPSOCUS, n.g. Fig. 5.

Forewing well rounded, broadest at level of pterostigma. Sc ending on  $R_1$  just before half-way. Rs arising not far from base and again connected with  $R_1$  by an inter-radial cross-vein (ir) beneath the end of Sc; just below this cross-vein, Rs forks, and its lower branch again forks into three branches. M arising close to base, very faint for the first fourth of its length, then becoming stronger and connected with Rs at about two-fifths by a radio-median cross-vein (rm): M then curves downwards somewhat sigmoidally and branches into two just beyond half-way.  $Cu$  very indistinct at base but apparently separated from M.  $Cu_1$  indistinct almost to level of rm, then becoming strong and ending about half-way along posterior margin by a strong downward bend.  $Cu_2$  and 1A united at about half their lengths to form a Y-vein which continues straight on to end on the posterior margin not far from  $Cu_1$  but diverging slightly from it. 2A arising contiguously with 1A but diverging slightly from it and ending on the border by a slight downward curve. There is a faint indication of a humeral veinlet. Except where they are indistinct, all the veins are broad and flat, without signs of macrotrichia. The margin of the wing is fairly broadly chitinized all round, particularly in the posterior apical portion. The base of the wing was heavily chitinized.

Genotype, *Zygopsocus permianus*, n. sp.

Horizon: Warner's Bay. Upper Permian of New South Wales.

## 5. ZYGOPSOCUS PERMIANUS, n. sp. Fig. 5.

*Forewing*.—Length 4.7 mm.; breadth 1.8 mm. Apex to the right. A practically perfect wing but with the veins rather faintly impressed on the rock. Apart from a dark patch at the extreme base and slight darkening of the pterostigma, the colouring was confined to the veins, the darkened portions being the forks of Rs and M and 1A around its fusion with  $Cu_2$ ; the costal margin is also darkened from near base to apex.

Type.—*Holotype*, Specimen B.107, found by Rev. A. J. Barrett at Warner's Bay in 1930.

Besides the type, there are two other specimens which belong to this genus and probably to this species. One is a nearly complete insect showing a distorted and indistinct head, but with the thorax, forelegs and abdomen complete, and obviously a mature female. The foreleg has a rather wide, flattish femur, 0.6 mm. long, the tibia 1.0 mm. long, slender, the tarsus short, 0.25 mm., apparently consisting of three short segments. The head appears to have been large and pear-shaped, the compound eyes rather small and not prominent, the mouth-parts hypognathous and very prominent, but these and parts of the antennae are badly preserved. Thorax with rather short, wide pronotum; meso- and metanota subdivided into two lateral portions and a large subtriangular scutellum. Wings extending at an angle on either side of the body, but the left wing crumpled and the right forewing incomplete; portion of the left hindwing lies across the body, showing a very wide fork on M. Abdomen broadly fusiform but the segmentation rather indistinct. The other specimen is an incomplete forewing, showing the regions of R and M, but with the posterior margin folded or crumpled.

## Family 3. ZOROPSOCIDAE, n. fam.

Wings narrow, the anal area reduced and having only one anal vein, 1A.  $Cu_2$  short;  $Cu_1$  unbranched. Rs and M both only two-branched. Origins of veins Rs, M and  $Cu_1$  normal; a weak cubito-median Y-vein may be present.

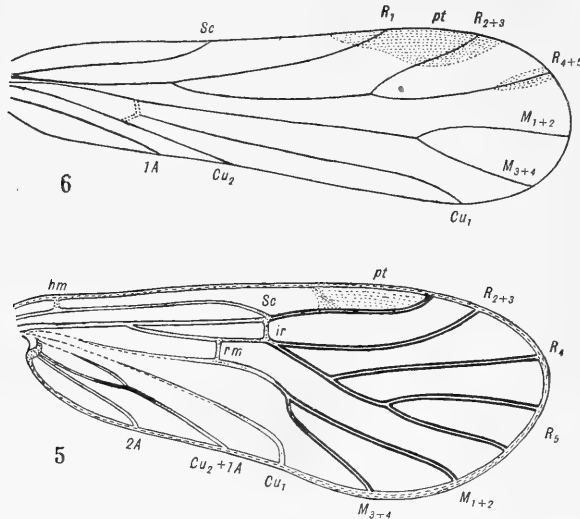


Fig. 5.—*Zygopsocus permianus*, n.g. et sp. Forewing (4.7 mm.). Family Zygopsocidae.

Fig. 6.—*Zoropsocus delicatulus*, n.g. et sp. Forewing (2.5 mm.). Family Zoropsocidae. Apex turned to the right.

This interesting family appears to stand at the base of two very curious groups, one fossil and one recent. On the one hand, it evidently represents the more primitive ancestral type from which the Lophioneuridae have been derived by movement of the points of origin of Rs, M and  $Cu_1$  along R and also by specialized curvature of these veins; on the other, it would appear to represent the type of wing from which the recent Suborder Zoraptera must have been derived long ago, before it took on the specialized habit of living in the nests of Termites. Wings in recent Zoraptera are only of secondary importance, and the great majority of the specimens found are apterous. In the rare winged forms, the venation is greatly reduced and has only with some doubt been referred to the Copeognathous type. The Zoropsocidae are very small insects having wings of about the same size and shape as those of the Zoraptera. In both, the basal part of the wing is narrow and the apical portion widened, the apex itself being well rounded; the pterostigmatic area is long and well chitinized. But, in the Zoraptera (genus *Zorotypus* Silv.), Rs and M are both simple veins and are fused for some distance in the middle of the wing; the cubito-median Y-vein has been lost and the main stems of M and  $Cu_1$  have become united; and, finally, the anal vein, 1A, has either become completely lost or, possibly, fused for most of its length with  $Cu_1$ . These characters indicate that *Zorotypus* stands far in advance of the Zoropsocidae; but they also show that there are no characters in which the Zoraptera could not have been directly descended from the Zoropsocidae, except only in the possibly branched  $Cu_1$ . If the basal short

branch of this vein in *Zorotypus* really represents either the free end of a partially fused 1A, or perhaps the free end of  $Cu_2$ , then the whole venational scheme of *Zorotypus* is directly derivable from that of *Zoropsocus*, n.g., by reduction.

Genus 5. *ZOROPSOCUS*, n.g. Fig. 6.

Wings much narrowed at base, widest in the region of the distal portion of the pterostigma. Costa and posterior margin fairly straight, apex well rounded. Sc short, ending at about one-third along costa.  $R_1$  simple, ending at about two-thirds on costa. Both branches of Rs ending before apex. Pterostigma chitinized, covering both  $R_1$  and  $R_{2+3}$ . M long and straight, forking at a level somewhat distad from that of the fork of Rs.  $Cu_1$  long and only slightly curved distally, ending beyond the level of the fork of M.  $Cu_2$  ending just beyond one-third. A weak cubito-median Y-vein present. 1A straight, diverging very slightly from  $Cu_2$ . Posterior margin of wing only slightly curved basally.

Genotype, *Zoropsocus delicatulus*, n. sp.

Horizon.—Warner's Bay. Upper Permian of New South Wales.

This very remarkable genus stands well apart from all known fossil and recent Copeognatha and certainly required the establishment of a new family to contain it. It would appear to represent the type of wing from which the recent Suborder Zoraptera may have been derived by further reduction of the venation. The size and shape of the wings are about the same, both being narrow basally and widest towards the well-rounded apex. Both have the pterostigma long and well chitinized. But in the Zoraptera (genus *Zorotypus* Silv.) the veins Rs and M are both simple and are anastomosed for some distance in the middle of the wing; the cubito-median Y-vein has been lost and the main stems of M and Cu are united; finally, the anal area and vein 1A have been entirely lost, or 1A may be fused with  $Cu_1$ .

6. *ZOROPSOCUS DELICATULUS*, n. sp. Fig. 6.

*Forewing*.—Length 2.5 mm.; breadth 0.6 mm. Apex to the left. The wing is tinged with brownish along costa and more especially at distal end of pterostigma, which is irregularly shaped as in figure 6. The cubito-median Y-vein is very indistinct. All the veins are rather lightly chitinized but carry the sockets of numerous macrotrichia fairly regularly placed in a single row along each vein.

Type.—*Holotype*, Specimen S.29, found by Mr. Stanley in rock collected at Warner's Bay in 1934.

Specimen P.215, found by Mr. Pincombe at Warner's Bay in 1933, appears to belong to this species also. It is a forewing slightly larger than the type specimen (length 2.6 mm.) and with the venation very similar to it, but the shading around the pterostigma less extensive. The other forewing lies beneath it, so that some of the veins show through, making it somewhat difficult to follow the individual veins correctly.

Family LOPHIONEURIDAE Till.

Lophioneuridae, Tillyard, 1921, p. 418.—Cyphoneuridae, Carpenter, 1932, p. 18.

The genus *Lophioneura* Till., 1921, was founded on a beautifully preserved forewing found in burnt shale from the railway embankment at Merewether Beach, Newcastle, N.S.W. It was placed in a new family Lophioneuridae and assigned to the Suborder Homoptera of the Order Hemiptera, with an indication that its affinities lay with the recent Division Sternorrhyncha and particularly the family Psyllidae.

Dr. F. M. Carpenter described the genus *Cyphoneura* in 1932, with two species from the Lower Permian of Kansas, one of which, the genotype, *C. permiana*, he claimed to be the smallest known Palaeozoic fossil wing, its length being only 1.9 mm. He placed his new genus in a new family Cyphoneuridae, allied to the Lophioneuridae, the principal differences being that in the Cyphoneuridae "Sc is more reduced, Rs and M arise more distad along R and 1A is independent".

In the new material before me from Warner's Bay, there are a considerable number of wings allied to both *Lophioneura* and *Cyphoneura*. One of these, a hindwing, measures only 1.5 mm. in length, and thus is considerably smaller than the forewing of *Cyphoneura permiana* Carp. and must therefore undoubtedly be the smallest Palaeozoic insect wing yet discovered.

A study of the new types shows at once that the two families Lophioneuridae and Cyphoneuridae cannot be maintained as distinct. All the types which possess a sigmoid  $Cu_1$  and abnormal origins of Rs, M and  $Cu_1$  should now be placed together in the family Lophioneuridae.

Further, specimens of these insects with the head, thorax and abdomen preserved show clearly that they were Copeognatha and not Homoptera. The head is depressed, with hypognathous mouth-parts and with no sign of a sucking-beak such as can be seen in the Permopsyllidae and other Permian Homoptera; the general form of body is copeognathous and the wings are held always in a steep roof-wise position. The forked Rs in both fore and hind wings is now seen to be definitely a copeognathous character, all the true Homoptera of the Permian having this vein simple except the heavily-veined Auchenorrhynchous Prosbolidae, where the distal forking of Rs is evidently secondarily developed. In the females, the abdomen shows no signs of an ovipositor.

Two new genera are represented in the collection before me; these may be distinguished from *Lophioneura* Till. and *Cyphoneura* Carp. by the following key:

*Key to the Genera of the Family Lophioneuridae.* (Forewings.)

1. Rs, M and  $Cu_1$  arising rather close together from R, not far from base ..... 2  
    Rs, M and  $Cu_1$  arising further from base, Rs at one-third or beyond ..... 3
2. No clearly marked clavus or anal veins.  $R_1$  straight apically .....  
    ..... Genus *Lophioneura* Till.  
    A small clavus present, with short vein 1A.  $R_1$  upcurved apically .....  
    ..... Genus *Lophiocypha*, n.g.
3. Sc present as a distinct vein. No connecting vein (basal part of  $Cu_1$ ) uniting  
     $Cu_1$  with  $Cu_2$  ..... Genus *Cyphoneura* Carp.  
    Sc obsolescent or absent. A connecting vein uniting  $Cu_1$  with  $Cu_2$  near base .....  
    ..... Genus *Austrocypha*, n.g.

Genus 6. LOPHIOCYPHA, n.g. Figs. 7-9.

Characters generally of *Lophioneura* Till., but differing in the presence of a distinct clavus with short anal vein 1A well marked. The clavus makes a definite angle with the posterior margin of the forewing at the end of  $Cu_2$ .  $Cu_1$  is not so abruptly curved distally as in *Lophioneura*, but is gently sigmoid in curvature. Hindwings much shorter than fore, with  $R_1$  very short, Rs and M forked.

Head depressed, hypognathous, with eyes rounded and wide apart. Thorax with well developed pronotum, meso- and metathorax closely fused together. Legs medium to strong. Abdomen much shorter than wings.

Genotype, *Lophiocypha permiana*, n. sp.

Horizon.—Warner's Bay. Upper Permian of N.S.W.



*Key to the Species of Lophiocypha, n.g.*

1. Clavus strongly angulated near base; wings distinctly hairy along margins .....  
 ..... *L. thysanella*, n. sp.
- Clavus not angulated; wings not distinctly hairy along margins ..... 2
2.  $R_1$  long, ending well beyond half-way; Sc very short ..... *L. stanleyi*, n. sp.
- $R_1$  shorter, ending at about half-way; Sc well developed, ending just beyond level of  
 origin of Rs ..... *L. permiana*, n. sp.

7. *LOPHIOCYPHA PERMIANA*, n. sp. Fig. 7A, 7B.

Length of forewing, 2.75 mm.; breadth 1.0 mm. Distance from insertion of forewing on thorax to end of abdomen, 1.8 mm.

*Head* crushed down flatly from above; large and subglobular. Compound eyes both visible, circular, of moderate size, fairly well separated. Behind the eyes lies a large epicranial region, divided midlongitudinally by a well marked suture. Insertions of antennae small, lying well in front of eyes; two cylindrical segments of left antenna visible. A sclerite lying anterior to the antennae apparently represents the labrum, with indistinct signs of palpal segments projecting from one side of it. *Thorax* fairly large, the pronotum apparently short and wide; just in front of the insertions of the forewings are two curious embossments. *Legs* rather large and strong; only the middle and hind femora and hind tibia and tarsus are indicated, the latter faintly. *Abdomen* rather short, subcylindrical, with apparently ten segments, the first of which is small and indistinct; tenth

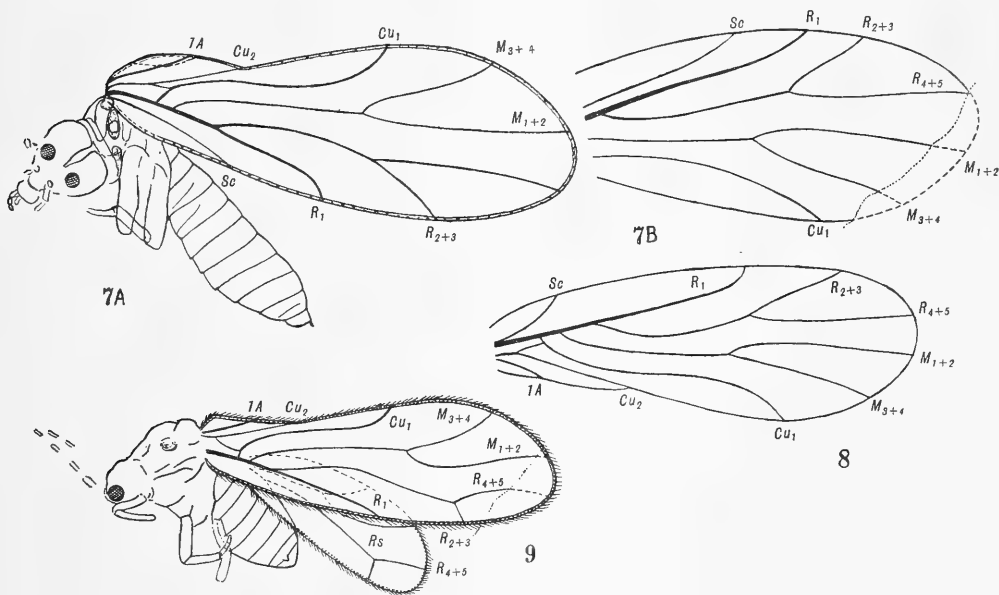


Fig. 7.—*Lophiocypha permiana*, n.g. et sp. A, Complete insect with forewing (2.75 mm.); B, Hindwing, with apex turned to right. Family Lophioneuridae.

Fig. 8.—*Lophiocypha stanleyi*, n. sp. Forewing (2.5 mm.) with apex turned to right. Family Lophioneuridae.

Fig. 9.—*Lophiocypha thysanella*, n. sp. Complete insect, with tip of forewing restored beyond the break (dotted line), and marginal hairs also restored. Length of forewing 3.2 mm. Family Lophioneuridae.

segment small, ending in a minute process which may have been an unjointed cercus. The specimen appears to have been a male.

*Wings: Forewing* as in fig. 7A. The margin appears to have been provided with strong sockets of macrotrichia, fairly widely spaced, suggesting a row of short, stiff hairs or setae. Sc ending at about same level as clavus, i.e., at one-fourth;  $R_1$  ending slightly before half-way. Rs arising from R slightly before level of end of Sc, and forking at about half its length;  $R_{4+5}$  ending just above apex. M forking slightly before level of fork of Rs. 1A gently curved, ending just before half-way along the curved border of the clavus.

*Hindwing* (fig. 7B) lies slightly detached from the main specimen, its base being a short distance from the apex of the forewing and somewhat crumpled; most of it is well preserved. Length about 2.5 mm., breadth 1.1 mm. Sc and  $R_1$  longer than in forewing;  $Cu_1$  longer and less curved distally; no sign of a definite clavus or anal vein, but these may be hidden in the crumpled basal portion.

Type.—*Holotype*, Specimen S.16, found by Mr. Malcolm S. Stanley in rock collected at Warner's Bay in 1934.

#### 8. LOPHIOCYPHA STANLEYI, n. sp. Fig. 8.

Length of forewing 2.5 mm.; breadth 0.9 mm. Apex to the left.

This species differs from the previous one in the much shorter Sc, the straighter and more sharply upturned  $R_1$ , the narrower forks of Rs and M, the longer connecting vein from  $Cu_2$  to  $Cu_1$ , and the somewhat less prominent clavus.

Type.—*Holotype*, Specimen S.31, found by Mr. Malcolm S. Stanley in rock collected at Warner's Bay in 1934.

#### 9. LOPHIOCYPHA THYSANELLA, n. sp. Fig. 9.

Length of forewing, 3.2 mm.; breadth 1.1 mm. Distance from insertion of forewing on thorax to end of abdomen, 1.5 mm.

*Head* depressed, hypognathous, of medium size, compound eyes (only one visible) fairly large, circular; fragments of four segments of one antenna and two of another visible, indicating that they were long and with numerous cylindrical segments. *Thorax* large and compact, but with the main subdivisions not well enough preserved to be distinguishable. *Legs* short and moderately stout; foreleg lying close up to head and showing short femur and tibia; middle and hind legs larger and stouter, the former showing femur, tibia and faint outline of short tarsus lying across femur of hind leg. An embossment lies in front of the insertion of the forewing. Abdomen short and stout, broadly fusiform; length only about one-fourth that of forewing. The specimen appears to have been a female from the shape of the abdomen, but there is no sign of an ovipositor, as would be the case if the insect belonged to the Homoptera.

*Wings: Forewing* as in figure 9. The whole of the wing-margin is pitted with strong sockets close together, indicating a strong fringe of marginal hairs. Sc is not visible but may nevertheless be present.  $R_1$  runs straight, ending about half-way. Rs is curiously bent soon after leaving R, and its fork is short and terminal, shaped like an *areola postica*,  $R_{2+3}$  being a short, upward branch.  $M_{1+2}$  is more arched than in the two previous species, approaching more closely to the condition found in *Lophioneura*. The descending piece of  $Cu_1$  is short and its connection with  $Cu_2$  rather long and curved. Clavus short, ending at one-fourth, strongly angulated near base, with 1A strong and straight.

*Hindwing* projecting partly below forewing; much shorter, about 1.8 mm. long, with marginal hair-sockets as in forewing but weaker.  $R_1$  short, ending

well before half-way. Rs with terminal fork similar to that of forewing; rest of venation not visible, hidden beneath forewing, except a portion of what appears to be  $M_{1+2}$ .

Type.—*Holotype*, Specimen P.K3, found by Mr. T. H. Pincombe, in rock taken from Warner's Bay in 1931.

Genus 7. AUSTROCYPHA, n.g. Figs. 10-12.

Forewings with well developed wedge-shaped clavus,  $Cu_2$  running straight through in line with continuation of posterior margin distad. Sc absent or obsolescent. Area between costa and R rather wide.  $R_1$  distally upcurved. Rs, M and  $Cu_1$  arising fairly close together.  $Cu_1$  connected with  $Cu_2$  by a basal piece.

Genotype, *Austrocypa abrupta*, n. sp.

Horizon.—Warner's Bay. Upper Permian of New South Wales.

Key to the Species of *Austrocypa*, n.g.

- $R_1$  turned up abruptly at distal end; fork of M arising slightly before level of fork of Rs ..... *A. abrupta*, n. sp.
- $R_1$  ending distally much less abruptly and nearer level of fork of Rs; forks of Rs and M arising at about the same level ..... *A. barretti*, n. sp.

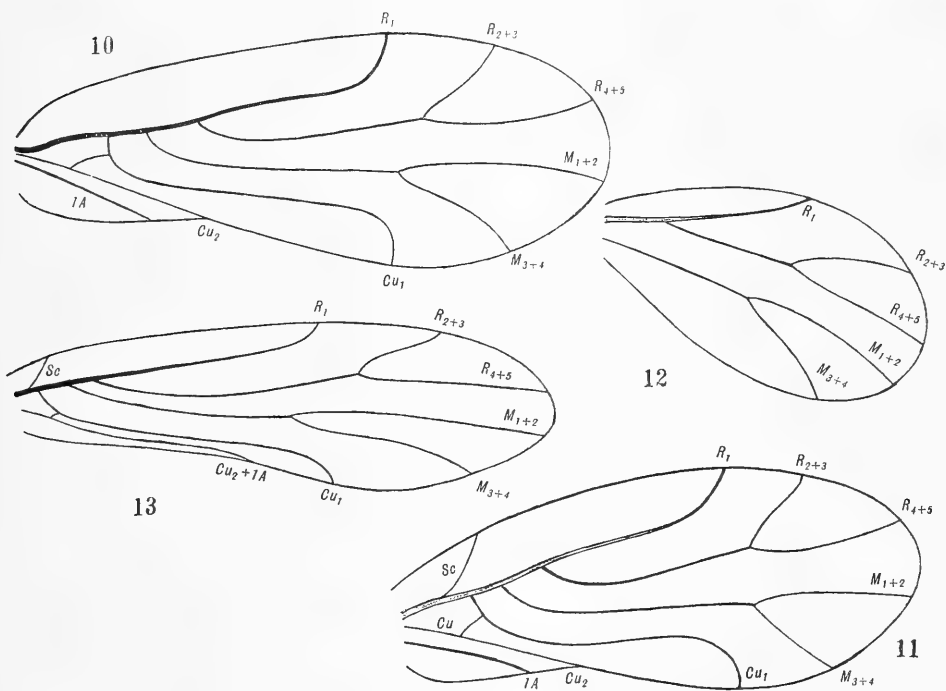


Fig. 10.—*Austrocypa abrupta*, n.g. et sp. Forewing (2.6 mm.). Family Lophioneuridae.

Fig. 11.—*Austrocypa barretti*, n. sp. Forewing 2.3 mm. Family Lophioneuridae.

Fig. 12.—*Austrocypa* sp. indet. Hindwing (1.5 mm.); probably belongs to *A. abrupta*, n. sp. Family Lophioneuridae.

Fig. 13.—*Lophioneura angusta*, n. sp. Forewing (3.2 mm.). Family Lophioneuridae.

10. *AUSTROCYPHA ABRUPTA*, n. sp. Fig. 10.

*Forewing*.—Length 2.6 mm.; breadth 1.0 mm.; clavus, 0.9 mm. long. Apex to the right. Sc absent. R slightly waved basally and near middle, then turning up very abruptly to meet costal margin almost at right angles at about three-fifths. M arising slightly nearer to  $Cu_1$  than to Rs, the origin of latter vein at level of end of clavus or slightly beyond. Fork of Rs arises beyond level of end of  $R_1$ , the two branches wide apart. Fork of M arises only slightly distad from level of end of  $R_1$ , the two branches also wide apart.  $Cu_1$  arising from R at right angles, its basal piece from R shorter than the connecting piece to  $Cu_2$ , which is arched.  $Cu_1$  strongly curved sigmoidally and ending abruptly almost at right angles to the posterior margin.  $Cu_2$  very straight. 1A strong, straight, diverging slightly from  $Cu_2$ , ending about two-thirds along margin of clavus. Clavus gently curved near base, then running straight to end of  $Cu_2$  and ending in a sharp wedge making an angle of about  $25^\circ$  with  $Cu_2$ .

Type.—*Holotype*, Specimen A.35, found by Mr. Pincombe in rock taken from Warner's Bay in 1933.

11. *AUSTROCYPHA BARRETTI*, n. sp. Fig. 11.

*Forewing*.—Length 2.3 mm.; breadth 1.0 mm.; clavus 0.75 mm. long. Apex to the right. This wing differs from that of the previous species only in having a faint indication of Sc being present, in the less abrupt ending of  $R_1$ , in the slightly steeper origins of Rs and M from R, in having Rs and M both forking at about the same level, in the shorter connection between  $Cu_1$  and  $Cu_2$  basally, and in the slightly shorter and broader clavus. It is also of somewhat smaller size, and is actually the smallest forewing discovered in the Upper Permian of New South Wales, though not quite as small as the forewing of *Cyphoneura permiana* Carp., from the Lower Permian of Kansas (length 1.9 mm.).

Type.—*Holotype*, Specimen B.104, found by Rev. A. J. Barrett in rock taken from Warner's Bay in 1931.

*Hindwing of the Genus AUSTROCYPHA*. Fig. 12.

*Specimen B.102*, found by Rev. A. J. Barrett in rock taken from Warner's Bay, is the smallest wing ever found in any Palaeozoic strata. It is evidently a hindwing of the genus *Austrocypha*, and may be placed provisionally in *A. abrupta*, from the form and position of the forks of Rs and M.

Length 1.5 mm.; breadth 0.8 mm. Apex to the right. Base narrow, costal and apical margins evenly rounded, posterior margin only slightly curved basally. Sc absent. The only veins present are  $R_1$ , ending in a gentle upward curve just beyond half-way, Rs, arising not far from base, and running straight to fork at about half its length, and finally M, which is also straight basally and forks slightly before the level of the fork of Rs. No clavus present.

Genus 8. *LOPHIONEURA* Till.

Tillyard, 1921, p. 417.

Genotype, *Lophioneura ustulata* Till.

Horizon.—Merewether Beach. Upper Permian of New South Wales.

12. *LOPHIONEURA ANGUSTA*, n. sp. Fig. 13.

*Forewing*.—Length 3.2 mm.; breadth 1.0 mm. Apex to the right.

This wing differs markedly from that of the genotype, *L. ustulata* Till., in the greatly shortened Sc, in having  $R_1$  slightly upturned distally instead of

straight, in the much longer forks of Rs and M, that of M being much narrower than in *L. ustulata*, in the much flatter Cu<sub>1</sub> with much less distal curvature, and finally in the basal half of the wing being much narrower, with the posterior margin slightly emarginate at end of Cu<sub>2</sub>.

Type.—*Holotype*, Specimen S.K1, found by Mr. Malcolm S. Stanley, in rock taken from Warner's Bay in 1934.

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AN INVESTIGATION OF THE SOOTY MOULDS OF NEW SOUTH WALES. V.

THE SPECIES OF THE CHAETOTHYRIEAE.

By LILIAN FRASER, M.Sc., Linnean Macleay Fellow of the Society in Botany.

(Thirty-nine Text-figures.)

[Read 31st July, 1935.]

The members of the subsection Chaetothyriaceae of the family Capnodiaceae are much less conspicuous than those of the Eucapnodiaceae. They never form a thick sooty covering on the leaves of plants. Their mycelium is characteristically very thin and widely effused. The fructifications are scattered irregularly. No fungi belonging to this group have hitherto been recorded for New South Wales, and only one, *Chaetothyrium* (*Meliola*, *Zukalia*) *loganiense* (Sacc.) Th. and Syd., has been recorded for Queensland.

The species here described belong to the genera *Aithaloderma* and *Chaetothyrium*. In referring species to the genus *Chaetothyrium* the writer has followed the emendations of Petrak (1929). Petrak considers that the genera *Chaetothyrium*, *Phaeosaccardinula* and *Treubiomyces*, which are separated by Theissen and Sydow (1917) by the presence or absence of setae and the nature of the septation of the ascospores, are not generically distinct. He points out that intergrading forms between types with setae and those lacking setae may occur in the one species. Boedijn (1931) has come to a similar conclusion.

In Theissen and Sydow's key to the Chaetothyriaceae the differences between the genera *Aithaloderma* and *Chaetothyrium* are given as follows:

Spores 4 to many celled, colourless.

x. Setae present around the ostiole only, mycelium smooth .... *Aithaloderma*

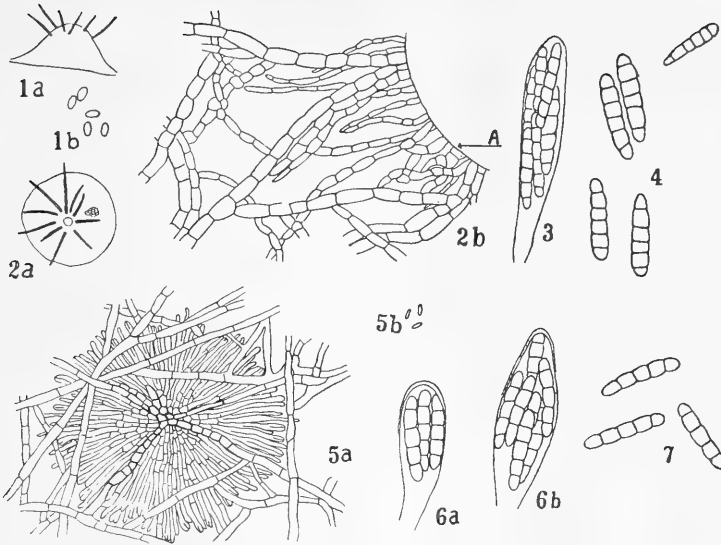
xx. Setae present on the mycelium or perithecium ..... *Chaetothyrium*

Von Hoehnel (1918) has come to the conclusion that the presence of setae round the ostiole in *Aithaloderma* is not necessarily a generic character. He quotes cases in which they are absent altogether from some fructifications and present on others of the same species.

Since, therefore, the presence of setae on mycelium or fructification is not a valid feature for the separation of genera, the key of Theissen and Sydow breaks down. The two genera *Aithaloderma* and *Chaetothyrium* are admittedly distinct, but must therefore be separated on different features.

It is suggested that the following may serve as a basis for separation:

*Aithaloderma*.—Ascostroma conical, widest at the base, usually about 100 $\mu$  in diameter. The wall pseudoparenchymatous. The apical pore often surrounded by divergent dark setae. Asci as numerous as in *Capnodium*. Pycnidium conical, similar to the ascostromata. Mycelium without setae, dark coloured, usually fairly stout. (Various types of pycnidia have been described as belonging to species of *Aithaloderma*, but it is probable that elongated forms such as *Microzyphium* belong to other fungi.)



Text-figs. 1-4.—*Aithaloderma ferruginea*.—1a, Pycnidium, side view, showing setae,  $\times 81$ ; 1b, Pycnidiospores,  $\times 425$ ; 2a, Ascostroma, surface view, showing setae,  $\times 81$ ; 2b, Edge of ascostroma (A) showing radiating hyphae and mycelium,  $\times 285$ ; 3, A single ascus,  $\times 425$ ; 4, Ascospores showing variation in size,  $\times 425$ .

Text-figs. 5-7.—*Aithaloderma viridis*.—5a, A young pycnidium, surface view, showing radiating hyphae,  $\times 81$ ; 5b, Pycnidiospores,  $\times 425$ ; 6a, 6b, Four- and eight-spored asci,  $\times 425$ ; 7, Ascospores,  $\times 425$ .

*Chaetothyrrium*.—Ascogenous fructification conical, hemispherical to subglobose, with or without setae. Fructifications typically large, more than  $200\mu$  in diameter. The wall of closely interwoven hyphae, may approach the pseudo-parenchymatous condition, but individual hyphae always to be distinguished. Asci very much more numerous than in the preceding. Pycnidia typically lacking. Mycelium slender, typically light coloured.

#### AITHALODERMA FERRUGINEA L. Fraser.

This species has been described in a previous paper (Fraser, 1935). It is distinguished from *A. clavatispora* Sydow, which it most closely resembles, by the size and colour of the fructifications, the length of the setae, the septation and shape of the ascospores and the size of the pycnidia. Text-figures 1a and 2a show the pycnidium and ascostroma. Asci and ascospores are shown in Text-figures 3 and 4. Text-figure 2b shows the radiating hyphae around the margin of the ascostroma, which are common in this species.

This species is one of the commonest members of the Chaetothyriaceae in New South Wales. It has been found in collections from the following localities: Pennant Hills on *Citrus* sp., 6, 1933, Type, on *Ceratopetalum apetalum* D. Don, 3, 1933, and on *Pittosporum undulatum* Ait., 10, 1933; Tilba Tilba on *Ficus stephanocarpa* Warb., 2, 1933; Salisbury on *Callistemon salignus* DC., 8, 1933; National Park (Sydney district) on *Eugenia Smithii* Poir., 5, 1932; Narrabeen on *Synoum glandulosum* A. Juss., 11, 1933; Pittwater on *Bursaria spinosa* Cav., 5, 1932, on *Breynia oblongifolia* J. Muell., 10, 1934, on *Eugenia Smithii* Poir., 8, 1933; Port Macquarie on *Cryptocarya glaucescens* R. Br., 1, 1934; Glenrock (Newcastle district) on *Elaeodendron australe* Vent., 8, 1933, coll. A. Burges; Mt. Irvine on *Doryphora sassafras* Endl., 9, 1934, coll. J. McLuckie; Twofold Bay

on *Monotoca elliptica* R. Br., 1, 1935; Wiseman's Ferry on *Rapanea variabilis* Mez., 11, 1934; Grafton district on *Bursaria spinosa* Cav., 1, 1935.

*AITHALODERMA VIRIDIS* L. Fraser.

This species has been described in a previous paper (Fraser, 1935). It is characterized by the radiating structure of the pycnidia (Text-fig. 5a) and ascostromata. The young pycnidia and ascostromata are clear olive-green, the mature fructifications are black, but the radiating border of hyphae is olive-green and stands out conspicuously against the brown mycelium. Four- and eight-spored asci are shown in Text-figure 6, *a* and *b*. Ascospores are shown in Text-figure 7.

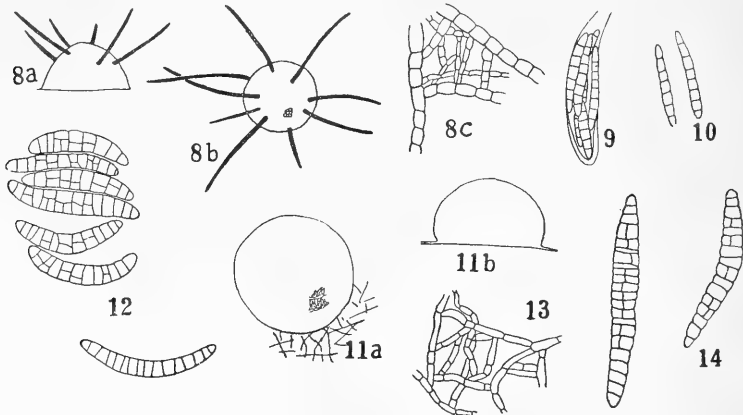
*Aithaloderma viridis* has been found in collections from the following localities: Glenrock (Newcastle district) on *Elaeodendron australe* Vent., 8, 1933, coll. A. Burges, Type; Pittwater on *Synoum glandulosum* A. Juss., 9, 1934; Grafton on *Pittosporum undulatum* Ait., 1, 1935.

? *CHAETHOTYRIUM LOGANIENSE* (Sacc.) Theiss. and Syd.

The mycelium is light olive-brown, thin, widely effused. The cells are  $5 \times 8\text{--}15\mu$ , somewhat thinner, lighter-coloured hyphae may form a network between the larger hyphae (Text-fig. 8c). No pycnidia were observed.

The ascogenous fructifications are conical,  $75\text{--}150\mu$  in diameter by  $50\text{--}70\mu$  high (Text-fig. 8a, 8b). Setae are present around the ostiole but are absent from the lower part of the fructification and the mycelium. The wall is pseudo-parenchymatous, consisting of isodiametrical cells becoming smaller towards the apex. The spines are very dark brown or almost black, opaque, up to  $200\mu$  in length, tapering to a rounded point, continuous or one-septate. The asci are oblong-cylindrical  $50\text{--}60 \times 10\text{--}12\mu$ , eight-spored (Text-fig. 9). The ascospores are hyaline, 6–8-septate, usually  $7\text{--}8 \times 3\text{--}4\mu$  (Text-fig. 10).

The fungus agrees well with the description and figures given by Saccardo (1885) for *Meliola loganiense*. Later Saccardo (1891) placed it in a new genus, *Zukalia*. *Zukalia* has been taken as a synonym of *Chaetothyrium* by Theissen and



Text-figs. 8-10.—*Chaetothyrium loganiense*.—8a, 8b, Side and surface views of the ascostroma showing disposition of setae,  $\times 55$ ; 8c, Part of mycelium,  $\times 285$ ; 9, A single ascus,  $\times 285$ ; 10, Ascospores,  $\times 285$ .

Text-figs. 11-14.—*Chaetothyrium roseosporum*.—11a, 11b, Surface and side views of the fructification,  $\times 55$ ; 12, Ascospores showing variation in septation,  $\times 285$ ; 13, Part of the mycelium,  $\times 285$ ; 14, Ascospores showing large size and degree of septation,  $\times 285$ .



Sydow (1917). If the specimens examined by the writer are definitely identical with Saccardo's species, it would seem that the affinities of the fungus lie rather with the fungi of the genus *Aithaloderma* from which it appears to differ only in the absence of an apical pore. This feature is variable in the family Capnodiaceae and does not seem adequate for generic separation. Von Hoehnel (1910), who examined the type specimen of *Zukalia loganiense*, could find only unripe fructifications without any setae, and suggested that it should be placed in the genus *Limacinula* (*Phaeosaccardinula*).

This fungus has been found in collections from the following localities: Robertson on *Doryphora sassafras* Endl., 3, 1934; *Aegiceras majus* Gaertn., 5, 1934, coll. A. Burges.

#### CHAETOTHYRIUM ROSEOSPORUM (von Hoehnel) Petrak.

The mycelium is effused, scanty, the cells are cylindrical,  $3-4 \times 7-10\mu$ , rather thin-walled, often with somewhat smaller thin-walled hyphae forming a network between the larger cells (Text-fig. 13). The ascogenous fructifications are hemispherical, flattened at the base,  $250-300\mu$  in diameter by  $150\mu$  in height (Text-fig. 11a, 11b). The wall consists of interwoven hyphae slightly larger than the mycelial hyphae, rather dark brown, becoming smaller and light brown towards the apex where a pore develops at maturity. The mycelium around the base of the fructification is denser than elsewhere, forming a continuous layer of dark-brown interwoven hyphae. This layer is not so conspicuous as in other species of this genus.

The asci and spores are rose-pink in mass. The asci are oblong cylindrical,  $60-90 \times 12-15\mu$ , eight-spored. The ascospores are hyaline, curved or straight and vary considerably in size and degree of septation in different collections.

In specimens from Macquarie Pass the ascospores were  $46-62 \times 9-11\mu$ , with 10-15 transverse septa and a number of longitudinal septa. Others were  $65 \times 8\mu$ , with 15 transverse septa and no longitudinal septa (Text-fig. 12). In specimens from Pittwater the ascospores were 14-22-septate, with additional longitudinal walls, and measured  $70-100 \times 5-10\mu$  (Text-fig. 14). In specimens from Salisbury the ascospores were 10-12-septate, without longitudinal walls, and measured  $50-60 \times 12\mu$ . In specimens from Grafton the spores measure  $80-98 \times 10-13\mu$ , with 15-22 transverse septa and additional longitudinal ones.

*Chaetothyrium roseosporum* has been found in collections from the following localities: Macquarie Pass on *Doryphora sassafras* Endl., and *Cryptocarya glaucescens* R. Br., 4, 1934; Salisbury on leaves of unknown plant, 5, 1933; Pittwater on leaves of *Guioa semiglauc*a Radlk., 10, 1934; Grafton on leaves of *Sideroxylon australe* Benth. & Hooker, and *Endiandra Sieberi* Nees, 1, 1935.

#### CHAETOTHYRIUM FUSISPORUM, n. sp.

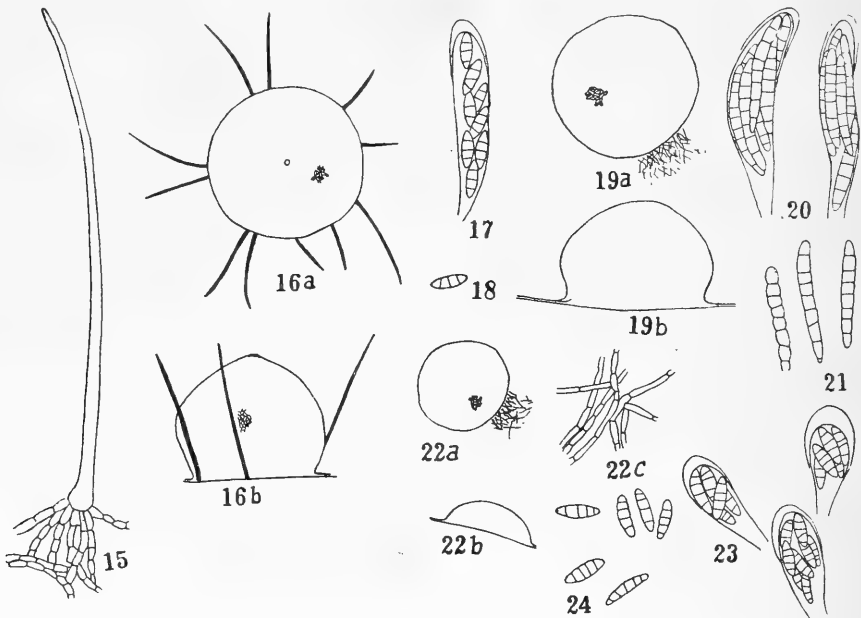
Mycelio effuso, tenuissimo vel conferto. Cellulis cylindricis, ad septa vix constrictis, subfuscis,  $4.5 \times 10\mu$ . Setis ex mycelio et circa basem ascotromae emergentibus. Setis atris, 3-4-septatis, opacis,  $180-240\mu$  longis, ad basem  $5\mu$  crassis, ad apicem vix attenuatis.

Fructis ascophoris subglobosis,  $150-250 \times 100-150\mu$ , muris hypharum contextarum, olivaceo-fuscis. Ascis creberrimis, oblongo-cylindricis,  $60-65 \times 10-12\mu$ , ad apicem parvis incrassatis, octosporis. Ascosporis ascisque collectis subpunicis. Ascosporis fusoides, hyalinis, 3-septatis, non constrictis,  $11-12 \times 3.5-4\mu$ .

The mycelium may be thin and effused, or rather dense so as to form an almost continuous network over the surface of the leaf. The cells are slightly constricted at the septa, straw-brown,  $10 \times 4.5\mu$ ; somewhat thinner, paler hyphae may form a network between the larger cells. Setae are present on the mycelium

and around the base of the fructification (Text-fig. 15). The mycelium forms a continuous web around the base of the setae. The setae are dark brownish-black, 3-4-septate, opaque, 180-240 $\mu$  in length, 5 $\mu$  in diameter at the base, tapering very slightly to the rounded apex. Old spines are frequently covered by a thin layer of hyphal threads. The ascogenous fructifications appear black by reflected light, but when crushed the wall is seen to be composed of olive-green hyphae. The fructifications are subglobose, 150-250 $\mu$  in diameter by 100-150 $\mu$  in height (Text-fig. 16a, 16b). The wall consists of very closely interwoven hyphae similar to those of the mycelium, becoming smaller towards the apex, which may be slightly papillose, and in which a pore develops at maturity. Setae develop from the mycelium around the base of the fructification but not from the walls. The asci are very numerous, oblong-cylindrical, 60-65  $\times$  10-12 $\mu$ , slightly thickened at the apex, eight-spored (Text-fig. 17). The ascospores and asci are pale-pink in mass. The ascospores are fusiform, hyaline, 3-septate, 11-12  $\times$  3.5-4 $\mu$  (Text-fig. 18). The mycelium is somewhat more dense around the base of the fructifications than elsewhere but does not form a definite subicle.

*Chaetothyrium fusisporum* has been found in collections from the following localities: Macquarie Pass on *Acacia binervata* DC., 3, 1934, and *Cryptocarya glaucescens* R. Br., 3, 1934; Robertson on *Doryphora sassafras* Endl., 3, 1934; National Park (Sydney district) on *Dodonaea triquetra* Wendl., 6, 1932, *Synoum*



Text-figs. 15-18.—*Chaetothyrium fusisporum*.—15, Seta and mycelium,  $\times$  285; 16a, 16b, Surface and side views of the fructification showing disposition of setae and apical pore,  $\times$  81; 17, An ascus showing thickened apical part of the wall,  $\times$  425; 18, Ascospores,  $\times$  425.

Text-figs. 19-21.—*Chaetothyrium globosum*.—19a, 19b, Surface and side views of the fructification,  $\times$  55; 20, Ascus showing thickened tip,  $\times$  285; 21, Ascospores,  $\times$  285.

Text-figs. 22-24.—*Chaetothyrium griseolum*.—22a, 22b, Surface and side views of the fructification,  $\times$  55; 22c, Part of the mycelium,  $\times$  285; 23, Ascus showing thickened tips,  $\times$  285; 24, Ascospores,  $\times$  285.

*glandulosum* A. Juss., etc., 6, 1932; Pittwater on *Syncarpia laurifolia* Ten., *Tylophora* sp., and *Smilax glycyphylla* Sm., 9, 1932; Salisbury on *Bacchousia myrtifolia* Hook. et Harv., etc., 5, 1933, on *Rhipogonum album* R. Br., on *Pleiococca Wilcoxiana* F.v.M., etc., 5, 1934; Pennant Hills (Sydney district) on *Ceratopetalum apetalum* D. Don, 12, 1933; Bulga (Wingham district) on *Bosistoa euodiformis* F.v.M., 1, 1934; Mt. Irvine on *Doryphora sassafras* Endl., 9, 1934, coll. J. McLuckie; Austinmer on *Endiandra Sieberi* Nees, 10, 1934, coll. J. McLuckie; Comboyne on *Rhipogonum album* R. Br., 1, 1934; Point Clare on *Wilkiea macrophylla* A. DC., 9, 1934, coll. A. Melvaine, Type.

CHAETOTHYRIUM GLOBOSUM, n. sp.

Mycelio tenuissimo, effuso. Cellulis subfuscis, cylindricis, ad septa vix constrictis,  $4.5 \times 5-10\mu$

Fructis ascophoris spargentibus,  $200-350 \times 190-250\mu$ , subglobosis; muris hypharum contextarum, olivaceo-fuscis. Fructis ad basem myceliis confertim contextis circumdatis. Ascis ascosporis collectis subpunicis. Ascis creberrimis, clavatis vel oblongo-cylindricis,  $95-100 \times 15-20\mu$ , octosporis, ad apicem incrassatis. Ascosporis 6-9-septatis, ad septa vix constrictis, hyalinis,  $50-58 \times 5-6\mu$ .

The mycelium is sparse, effused, and forms a thin network. The cells are light straw-brown, thin-walled, cylindrical, slightly constricted at the septa,  $4.5 \times 5-10\mu$ .

The ascogenous fructifications are scattered and appear like small black spots,  $200-350\mu$  in diameter by  $190-250\mu$  in height (often with a narrow pale brown border) (Text-fig. 19a, 19b). The wall of the fructification consists of interwoven hyphae, olive-brown in colour, becoming smaller and lighter towards the apex where a pore develops at maturity. The fructifications are depressed at the apex when dry and have a conspicuous border,  $50-100\mu$  in width, of very closely interwoven hyphae several layers thick, becoming thinner and passing into the ordinary mycelium. According to von Hoehnel the presence or absence of this "subicle" appears to have some importance in the classification of species.

The asci and spores are rose-pink in mass. The asci are very numerous, clavate to oblong-cylindrical,  $95-100 \times 15-20\mu$ , somewhat thickened at the apex, eight-spored (Text-fig. 20). The ascospores typically have 7, sometimes 6-9 transverse septa, and no longitudinal septa. When mature they are hyaline, slightly constricted at the septa, the two terminal cells more so than the others. The average size is  $50-58 \times 5-6\mu$  (Text-fig. 21).

*Chaetothyrium globosum* has been found in collections from the following localities: Point Clare on *Wilkiea macrophylla* A. DC., 9, 1934, coll. A. Melvaine, Type; Myall Lakes on *Sideroxylon australe* Benth. & Hook., 9, 1934, coll. O. D. Evans.

CHAETOTHYRIUM GRISEOLUM, n. sp.

Mycelio effuso, tenuissimo. Cellulis olivaceo-fuscis, pallidis,  $3-3.5 \times 7-10\mu$ , cylindricis, ad septa vix constrictis.

Fructis ascophoris plano-hemisphaericis,  $200-250 \times 60-120\mu$ . Muris hypharum contextarum, glauco-fuscis, pallidis. Fructis ad basem myceliis confertim contextis circumdatis. Ascis creberrimis, clavatis vel oblongo-cylindricis, ad apicem incrassatis,  $40-50 \times 15-20\mu$ , octosporis. Ascosporis hyalinis, 4-6-septatis, rectis vel curvatis, deorsum attenuatis,  $19-25 \times 4-5\mu$ .

The mycelium is scanty, effused, consisting of a network of hyphae (Text-fig. 22c). The cells are thin-walled, pale olive-brown,  $3-3.5 \times 7-10\mu$ , cylindrical, slightly constricted at the septa. The ascogenous fructifications are rather flattened-hemispherical in shape, depressed at the apex when dry (Text-fig. 22a,

22b), 200–250 × 60–120 $\mu$  in height. The wall consists of closely interwoven hyphae, pale greyish-brown in colour, and similar in size to the mycelial hyphae, becoming smaller and paler towards the apex where a pore develops at maturity. The fructification is surrounded by a zone of closely interwoven dark brownish-grey hyphae forming a definite border, which grades gradually into the mycelium.

The asci are very numerous, clavate to oblong-cylindrical, thickened at the tip, 40–50 × 15–20 $\mu$ , eight-spored (Text-fig. 23). The ascospores are hyaline, 4–5-, occasionally 6-septate, 19–25 × 4–5 $\mu$ , straight or slightly curved, often tapering slightly towards the base (Text-fig. 24).

*Chaetothyrium griseolum* has been found in collections from the following localities: Pittwater on *Syncarpia laurifolia* Ten., 9, 1932; Pittwater on *Dodonaea triquetra* Wendl., Type, *Ficus rubiginosa* Desf., *Synoum glandulosum* A. Juss., and *Ceratopetalum apetalum* D. Don, 10, 1934.

#### CHAETOTHYRIUM PELTATUM, n. sp.

Mycelio effuso, tenuissimo. Cellulis fumoso-glaucis, cylindricis, ad septa vix constrictis, 3–5 × 6–9 $\mu$ .

Fructis ascophoris plano-hemisphaericis, 300–420 × 120–150 $\mu$ . Muris hypharum contextarum, fusco- vel caeruleo-glaucis, apici fere pseudoparenchymaticis. Fructis ad basem myceliis confertim contextis, subradiantis, circumdati, caeruleo-glaucis. Ascis creberrimis, clavatis vel oblongo-cylindricis, apice incrassatis, 55–65 × 13–15 $\mu$ , octosporis. Ascosporis hyalinis, 6–9-septatis, rectis vel curvatis, deorsum attenuatis, non-constrictis, 28–32 × 4.5–6.5 $\mu$ .

The mycelium is thin and effused. The cells are smoky greyish-brown, cylindrical, slightly constricted at the septa, 3–5 × 6–9 $\mu$  (Text-fig. 25c). The fructifications are discoid, rather flattened, 300–420 $\mu$  in diameter by 120–150 $\mu$  in height (Text-fig. 25a, 25b). The walls consist of interwoven hyphae of a brownish- or bluish-grey colour, becoming almost pseudoparenchymatous towards the apex. A pore develops at the apex at maturity. The fructification is surrounded by a border of closely interwoven rather radiating hyphae of a dark greyish-blue colour which appears to be characteristic of this species. The asci are very numerous, clavate to oblong-cylindrical, thickened at the tip, 55–65 × 13–15 $\mu$ , eight-spored (Text-fig. 26). The ascospores are hyaline, 6–9-, usually 7-septate, straight or slightly curved, often tapering to the lower end, usually not constricted at the septa, 28–32 × 4.5–6.5 $\mu$  (Text-fig. 27).

*Chaetothyrium peltatum* has been collected on the leaves of *Eugenia Smithii* Poir., Salisbury, 5, 1934, Type.

#### CHAETOTHYRIUM FUSCUM, n. sp.

Mycelio effuso, tenuissimo. Cellulis cylindricis, ad septa vix constrictis, fumoso-fuscis, 3.5–4.5 × 7–10 $\mu$ .

Fructis ascophoris plano-hemisphaericis, atrofuscis, 200–250 × 75 $\mu$ . Muris cellularum isodiametricarum, pseudoparenchymaticis. Ascis creberrimis, angustocylindricis, 50–60 × 10–15 $\mu$ , octosporis. Ascosporis hyalinis vel flavidis, pallidis, 3–4-septatis, fusiformis vel deorsum attenuatis, rectis vel curvatis, 16–18 × 4–5 $\mu$ .

The mycelium is thin and effused. The cells are cylindrical, slightly constricted at the septa, smoky-brown, 3.5–4.5 × 7–10 $\mu$  (Text-fig. 28c).

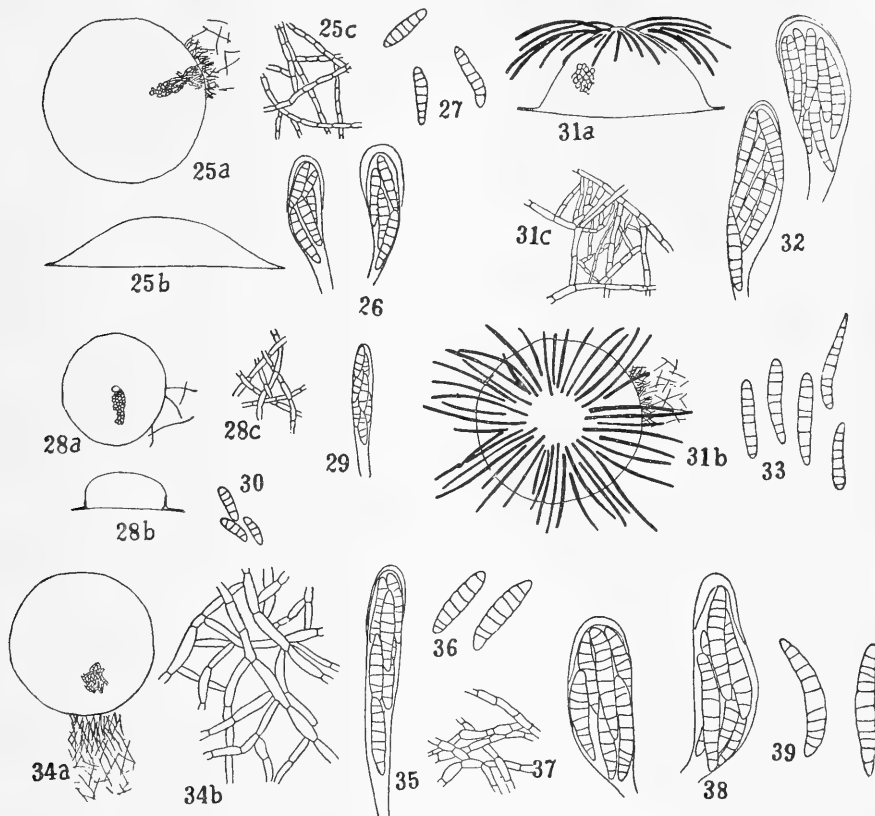
The fructifications are dark-brown, flattened-hemispherical, 200–250 $\mu$  in diameter by 75 $\mu$  in height (Text-fig. 28a, 28b). The walls consist of dark-brown hyphae, the cells of which are almost isodiametrical, and so closely interwoven as to appear pseudoparenchymatous. The wall cells decrease in size towards the apex where a pore develops at maturity.

There is no concentration of mycelium to form a subicle round the base of the fructification.

The asci are very numerous, narrow cylindrical,  $50-60 \times 10-15\mu$ , eight-spored (Text-fig. 29). The ascospores are 3-4-septate, hyaline or yellowish, fusiform or tapering slightly towards the base, straight or slightly curved,  $16-18 \times 4-5\mu$  (Text-fig. 30).

The fructification resembles that of *Chaetothyrium javanicum*, but the ascospores are much smaller and less septate.

*Chaetothyrium fuscum* has been found in collections from the following localities: Pittwater on *Syncarpia laurifolia* Ten., 9, 1932, on *Synoum glandulosum*



Text-figs. 25-27.—*Chaetothyrium peltatum*.—25a, 25b, Surface and side views of the fructification,  $\times 55$ ; 25c, Part of the mycelium,  $\times 285$ ; 26, Asci showing thickened tips,  $\times 285$ ; 27, Ascospores,  $\times 285$ .

Text-figs. 28-30.—*Chaetothyrium fuscum*.—28a, 28b, Surface and side views of the fructification,  $\times 55$ ; 28c, Part of the mycelium,  $\times 285$ ; 29, A single ascus,  $\times 285$ ; 30, Ascospores,  $\times 285$ .

Text-figs. 31-33.—*Chaetothyrium strigosum*.—31a, 31b, Side and surface views of the fructification,  $\times 55$ ; 31c, Part of the mycelium,  $\times 285$ ; 32, Asci showing thickened tips,  $\times 285$ ; 33, Ascospores,  $\times 285$ .

Text-figs. 34-36.—*Chaetothyrium cinereum*.—34a, Fructification, surface view,  $\times 55$ ; 34b, Part of the mycelium,  $\times 285$ ; 35, A single ascus,  $\times 285$ ; 36, Ascospores,  $\times 285$ .

Text-figs. 37-39.—*Chaetothyrium depressum*.—37, Mycelium,  $\times 285$ ; 38, Asci,  $\times 285$ ; 39, Ascospores,  $\times 285$ .

A. Juss., 10, 1934, Type; Pennant Hills (Sydney district) on *Tristania neriifolia* R. Br., 12, 1933; Salisbury on *Eugenia Smithii* Poir., 5, 1934; Wiseman's Ferry on *Rapanea variabilis* Mez., 11, 1934.

CHAETOTHYRIUM STRIGOSUM, n. sp.

Mycelio effuso, tenuissimo. Cellulis cylindricis, ad septa vix constrictis, fumoso-fuscis,  $3\text{--}4.5 \times 7\text{--}10\mu$ .

Fructis ascophoris hemisphaericis,  $200\text{--}400 \times 150\text{--}200\mu$ . Muris hypharum contextarum, atrofuscis. Apice creberrimis setis circumdato. Setis atrofuscis, 1-2-septatis,  $300\mu$  longis, apice vix attenuatis. Fructis ad basem myceliis confertim contextis, fuscis. Ascis ascosporisque collectis subpunicis. Ascis creberrimis, clavatis vel oblongo-cylindricis, apici incrassatis,  $90\text{--}95 \times 20\text{--}30\mu$ , octosporis. Ascosporis hyalinis, rectis vel curvatis, deorsum attenuatis,  $32\text{--}46 \times 5\text{--}7\mu$ , 7-9- vel 14-15-septatis.

The mycelium is scanty and effused. The hyphae are slender, pale smoky-brown, the cells are cylindrical, slightly constricted at the septa,  $3\text{--}4.5 \times 7\text{--}10\mu$ , slightly smaller paler hyphae may form a network between these larger threads (Text-fig. 31c).

The fructifications are hemispherical,  $200\text{--}400\mu$  in diameter by  $150\text{--}200\mu$  in height (Text-fig. 31a, 31b). The walls consist of closely interwoven hyphae similar to those of the mycelium, or slightly larger,  $7\mu$  in diameter, dark brown, becoming smaller and lighter towards the apex where a pore develops at maturity. The apex is surrounded by very numerous setae which grow out from the upper part of the wall of the fructification. These setae are dark smoky-brown, rather irregular in outline, rounded and scarcely attenuated at the apex, usually 1-2-septate, up to  $300\mu$  in length. They are characteristically rather reflexed over the sides of the fructification.

The asci and ascospores are pinkish or yellowish-pink in mass. The asci are very numerous, clavate or oblong cylindrical, slightly thickened at the apex,  $90\text{--}95 \times 20\text{--}30\mu$ , eight-spored (Text-fig. 35). The ascospores are hyaline, curved or straight, slightly tapering towards the base,  $32\text{--}46 \times 5\text{--}7\mu$  with 7-9 transverse septa.

In a specimen from Salisbury the ascospores measured  $42 \times 7\mu$  but were 14-15-septate. This specimen was otherwise identical with the typical form and is probably only a local variation.

*Chaetothyrium strigosum* has been found in collections from the following localities: Point Clare on *Wilkiea macrophylla* A. DC., 9, 1934, coll. A. Melvaine, Type; Salisbury on *Eugenia Smithii* Poir., and *Pleiococca Wilcoxiana* F.v.M., 8, 1933.

CHAETOTHYRIUM CINEREUM, n. sp.

Mycelio effuso, tenuissimo. Cellulis subfuscis, cylindricis, ad septa vix constrictis,  $3\text{--}4 \times 7\text{--}12\mu$ .

Fructis ascophoris plano-hemisphaericis,  $300 \times 95\text{--}120\mu$ . Muris hypharum contextarum, cellulis prope isodiametricis, subfuscis. Fructis ad basem myceliis confertim contextis, fuscis. Fructis macroscopicis pallidis. Ascis creberrimis, elongato-cylindricis, apici incrassatis,  $100\text{--}120 \times 12\text{--}15\mu$ , octosporis. Ascosporis fusiformis, vel deorsum attenuatis, 7-septatis, non-constrictis,  $35\text{--}42 \times 7\text{--}9\mu$ .

The mycelium is scanty and effused. The cells are straw-brown, cylindrical, slightly constricted at the septa (Text-fig. 34b). A network of slightly thinner paler hyphae may develop between the larger ones.

The fructifications are scattered, rather flattened-hemispherical, averaging  $300\mu$  in diameter by  $95\text{--}120\mu$  in height (Text-fig. 34a). The walls consist of

closely interwoven light brown hyphae, the cells are broad almost isodiametrical, slightly darker than the mycelium, becoming smaller and lighter towards the apex where a pore develops at maturity. The fructifications are surrounded by a zone of closely interwoven hyphae, slightly darker in colour than the mycelium, forming a border round the fructification up to  $250\mu$  in diameter, the border is irregular in its development and may be quite small. Macroscopically the fructifications appear pale yellowish-brown.

The asci are very numerous, elongate oblong cylindrical,  $100-120 \times 12-15\mu$ , slightly thickened at the tip, eight-spored (Text-fig. 35). The ascospores are fusiform or slightly tapering towards the base, 7-septate, not constricted at the septa,  $35-42 \times 7-9\mu$  (Text-fig. 36).

*Chaetothyrium cinereum* has been collected at Pittwater on *Guioa semiglauca* Radlk., Type, and *Backhousia myrtifolia* Hook. & Harv., 10, 1934; Wahroonga (Sydney district) on *Eugenia Smithii* Poir., 10, 1934, coll. J. M. Wilson.

#### CHAETOTHYRIUM DEPRESSUM, n. sp.

Mycelio effuso, tenuissimo, cellulis subfuscis, cylindricis, ad septa vix constrictis,  $5-6 \times 10-15\mu$ . Fructis ascophoris hemisphaericis ad apicem depressis,  $200-350 \times 100-150\mu$ . Fructis ad basem myceliis confertis contextis. Ascis creberrimis, clavatis, apici incrassatis rotundatisque,  $90-100 \times 28-30\mu$ , octosporis. Ascosporis rectis vel curvatis, fusiformis vel deorsum attenuatis, 9-13-septatis,  $48-60 \times 8-10\mu$ .

The mycelium is thin and effused, forming a web-like pellicle on the surface of leaves. It consists of a network of interwoven hyphae  $5-6\mu$  in diameter, the individual cells being  $10-15\mu$  in length, thin-walled, pale yellowish-olive (Text-fig. 37).

The ascogenous fructifications are scattered irregularly, disc-shaped, depressed in the centre when dried,  $200-350\mu$  in diameter,  $100-150\mu$  in height at the centre. There is a conspicuous border up to  $150\mu$  in diameter surrounding the fructification consisting of hyphae similar to the mycelial hyphae, but much more closely woven together, this gradually becomes thinner towards the outer margin, grading almost imperceptibly into the mycelium. The wall of the fructification is composed of closely interwoven hyphae the cells of which are shorter and wider than those of the border and mycelium, becoming smaller towards the apex, where a pore develops at maturity.

The asci are very numerous, clavate, rounded at the apex,  $90-100 \times 28-30\mu$ , eight-spored, faintly pink in mass (Text-fig. 38).

The ascospores are usually slightly curved, 9-13-, usually 10-septate,  $48-60 \times 8-10\mu$ , tapering slightly towards each end, or slightly wider near the apex and tapering towards the base (Text-fig. 39).

*Chaetothyrium depressum* has been collected at Grafton on the leaves of *Sideroxylon australe* Benth. and Hooker, 1, 1935.

#### SUMMARY.

Eight new species belonging to the sub-section Chaetothyriaceae of the family Capnodiaceae are described.

The relationships of *Chaetothyrium loganiense* are discussed.

*Chaetothyrium roseosporum* (von Hoehnel) Petrak is recorded for the first time in Australia.

The writer wishes to express her thanks to Professor T. G. B. Osborn, in whose laboratory this work was carried out, for advice and helpful criticism, and to members of the staff and the research students, past and present, of

the Botany School, Sydney University, who have materially assisted in this work by collecting specimens in many localities.

Material of the new species herein described has been sent to the following institutions: The National Herbarium, Botanic Gardens, Sydney, N.S.W.; The Department of Agriculture, Burnley, Victoria; The National Herbarium, Royal Botanic Gardens, Kew, Surrey; The Imperial Mycological Institute, Kew, Surrey, England; The United States National Herbarium, Washington, U.S.A.; Botanisches Museum, Berlin-Dahlem, Germany.

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## NOTES ON AUSTRALASIAN ANISOPODIDAE (DIPTERA).

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(Thirty-eight Text-figures.)

[Read 28th August, 1935.]

The family Anisopodidae (Rhyphidae) is rather poorly represented in the Australasian region. Two species, *Anisopus dubius* Macq. and *A. neozelandicus* Schin., are known from Australia and Tasmania; one, *Anisopus hellwigi* de Meij., from New Guinea; one, *Olbiogaster insularis* Tonn., from Lord Howe Island; and four species have been described from New Zealand. There is no published information about the life-histories of any of these species. In fact, it was not until Keilin (1928) gave a detailed description of the early stages of *Anisopus fenestralis* Scop. and *Olbiogaster africanus* Edw. in "Genera Insectorum" that an adequate account of the larvae of any species of these genera was published.

In the present paper *Anisopus funebris*, n. sp., and the hitherto unknown male of *Olbiogaster insularis* Tonn. are described, and descriptions are given of the early stages of *Anisopus dubius* Macq., *A. funebris*, n. sp., and *O. insularis*.

The writer is indebted to Mr. A. L. Tonnoir for material, advice, and assistance in preparing this paper, and to Miss V. Irwin-Smith for material and notes.

### OLBIOGASTER INSULARIS TONN.

Mr. A. L. Tonnoir named this species from a solitary female from Lord Howe Island in 1923. The larvae, which were identified by Mr. Tonnoir by a male fly bred from them, were collected by Miss V. Irwin-Smith on Lord Howe Island in February, 1934. Two of the larvae, collected on 23rd February, were examined on 21st March, when one was found to have pupated and produced a fly, whilst the other was still larval. On 6th April this second larva had pupated and the fly emerged on 9th. Notes made by the collector state that the larvae were very numerous in the debris inside decayed and rotten logs. It is of interest to note that the three other species of *Olbiogaster* whose life-histories are known, from Brazil, Trinidad and West Africa respectively, were all recorded from rotten wood.

#### *Description of Adult.*

♂.—Length 7 mm.; wing 5.5 mm.; antennae 4 mm.

Head black, mouth parts testaceous; occiput with sparse long yellow hairs; scape of antennae orange, flagellum black with a greyish pruinosity, covered with short black bristles.

Thorax black with yellow striations, humerus yellow, scutellum yellow; thorax clothed with fine yellow hairs; halteres light brown with yellow stems. Legs yellow, shading to darker on tarsi; posterior coxae slightly stained brown; hind tarsi darker than others; legs covered with minute brown spines; anterior tibiae with one spur, the others with two; spurs yellow.

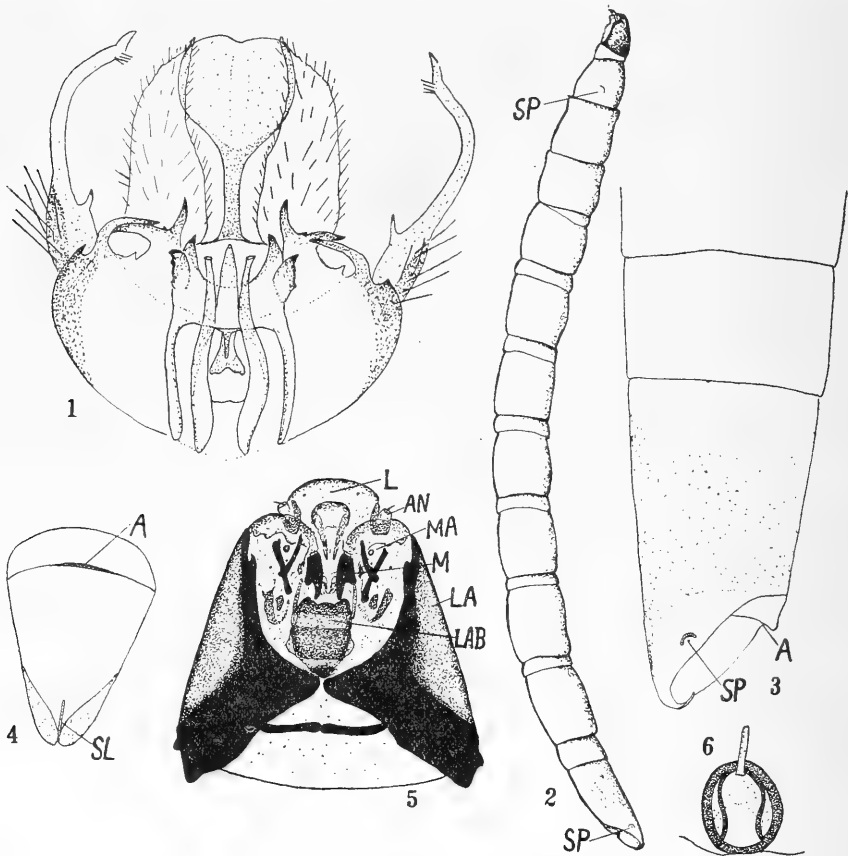
Wings bare, iridescent with a very faint brownish tinge, stigma smoky-brown. Venation the same as in female.

Abdomen narrow and elongated; the first five segments yellow on anterior half and black on posterior half, giving the abdomen a series of transverse stripes. Terminal segments black. Abdomen covered with fine yellow hairs. Genitalia as figured (Text-fig. 1). Except for some small differences in detail the male shows a close resemblance to the female as described by Tonnoir.

Bred from larva collected in rotten wood on Lord Howe Island on 23rd February, 1934, by Miss V. Irwin-Smith. The allotype male is in the collection of the Division of Economic Entomology, Canberra.

*The Larva* (Text-fig. 2).

The full-grown larva measures from 16 to 18 mm. in length. It is narrow, cylindrical and vermiform. All the segments are approximately the same width,



Text-figs. 1-6.—*Obiogaster insularis*.

- 1.—Male hypopygium,  $\times 60$ . 2.—Larva,  $\times 7$ . *sp*, spiracles. 3.—Posterior end of larva,  $\times 26$ . *a*, anus; *sp*, spiracle. 4.—Anal plate,  $\times 43$ . *a*, anus; *sl*, slit. 5.—Head of larva, ventral surface,  $\times 60$ . *an*, antenna; *l*, labrum; *la*, lateralium; *lab*, labium; *m*, mandible; *ma*, maxilla. 6.—Antenna,  $\times 290$ .

the first and last tapering to the extremities. The last segment is noticeably longer than the others. The colour of the larva is uniformly white, except for the last segment, which has a smoky tinge on the posterior third. The free head-capsule is brown. The skin is quite smooth and shining. Both pairs of spiracles are external and visible. The anterior pair are borne laterally on the first thoracic segment and appear as tiny brown half-circles. The posterior pair are on the eighth abdominal segment, dorso-lateral in position, and a short distance from the apex. They are also semicircular in outline and light brown in colour.

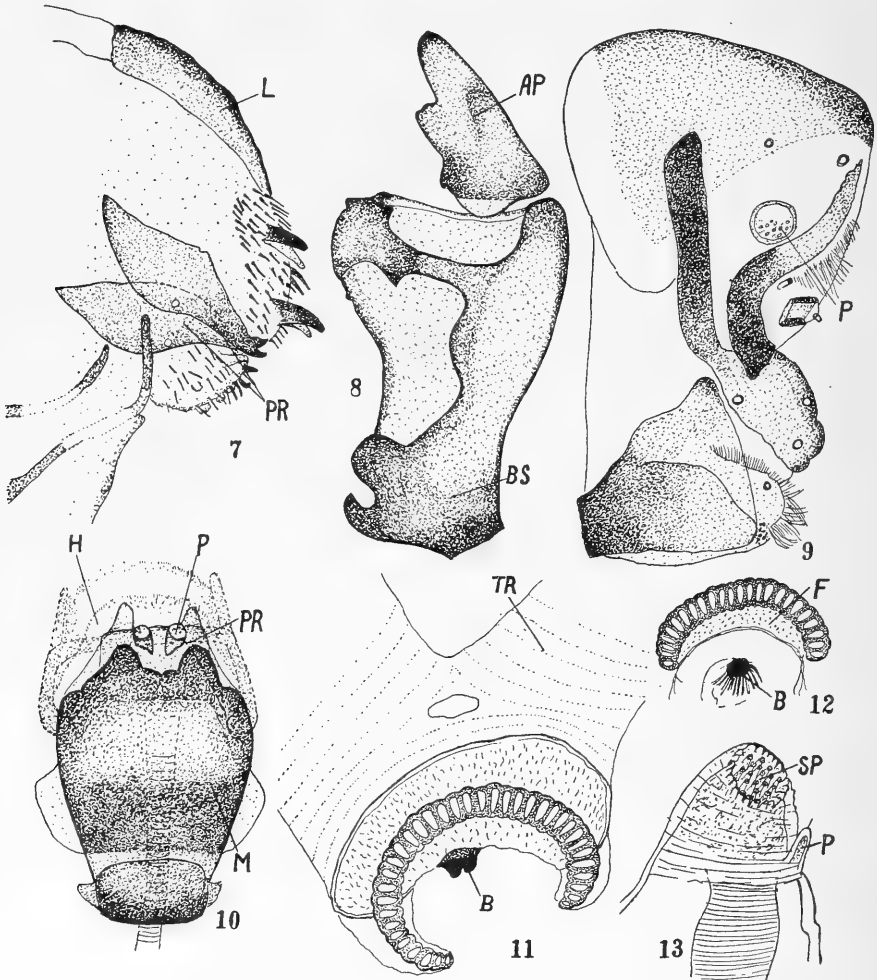
The segmentation is distinctive. There are three thoracic segments and nine abdominal. Between each of the abdominal segments, except the eighth and ninth, is a secondary annulation. The junction between both primary and secondary segmentation is marked by a slight overlapping of the skin. The annulation between the seventh and eighth segments is wider than the others.

The first to the seventh abdominal segments are all similar. The eighth is about one and a half times the length of the others and tapers towards the posterior end (Text-fig. 3). It is cut away sharply in the posterior third and produced to a ventrally hooked process, which curves around the ninth segment at the extreme apex of the body. The ninth segment is small and entirely latero-ventral. The anus appears as a lipped cleft about a third the distance from its anterior edge. The whole sclerite may be detached as a plate (Text-fig. 4) bearing the anal opening, and a little posterior notch where the prolongation of the eighth segment fits in.

*The head* (Text-fig. 5).—The head capsule is complete and, from a dorsal aspect, is oval in shape. It consists of the prefrons, which is narrow and pointed at its posterior end, widening towards the anterior and ending in the labrum. Each side of this are the lateralia, large roughly triangular sclerites which curve round the sides of the head. The points of the lateralia meet ventrally behind the mouth-parts, and their ventral margins are banded with heavy black chitin. On the dorsal surface of each, in its anterior half, is a small depression with an irregular dark spot in its centre, representing the rudimentary eye. Anterior to these and close to the base of the labrum are the antennae (Text-fig. 6). Each consists of a large globular basal segment and a small elongated pencil-like apical segment, very similar to the antennae of *O. africanus*. The tentorium consists of a pair of bars arising from the posterior ventral edge of the lateralia and directed backwards and inwards, meeting to form an arch inside the head. There are no longitudinal rods.

*Mouth-parts*.—The labrum (Text-fig. 7) is fairly strongly chitinized, being the anterior curved extremity of the prefrons. On its ventral side it continues into the epipharynx, which bears two pairs of large blunt spines near the apex. In the same area are numerous small sharp spines. Laterally behind the apex are the "premandibles" (Goetghebuer, 1925), which are large, roughly triangular in shape, not very heavily chitinized and bearing a single tooth apically. Keilin refers to the premandibles as "comb-like chitinous plates", and states that *Olbiogaster* is devoid of these. Below and between the premandibles the epipharynx bears numerous hairs and sensory papillae. There is a chitinous support associated with this part and known as the U-shaped piece. The mandibles lie each side of the labrum, and in the resting position are folded inwards close together and pointing posteriorly. When extended they project in front of the head. The mandibles (Text-fig. 8) are remarkable in that they

are jointed, each consisting of two segments. The basal segment is a large elongated sclerite which is most heavily chitinized on its curved exterior edge and at the basal extremity. There is also a strong piece of chitin on its inner edge anteriorly. There are two deep bays or indentations in the sclerite, one being anterior and the other on the inner edge. Joined at the outer anterior edge is the apical segment, consisting of a small thick plate with a large blunt tooth apically, and a smaller one on the inner edge. The mandibles of *O. africanus* also consist of two parts, the apical part bearing three teeth.



Text-figs. 7-13.—*Olbiogaster insularis*.

7.—Labrum-epipharynx,  $\times 290$ . *l*, labrum; *pr*, premandibles. 8.—Mandible,  $\times 290$ . *ap*, apical segment; *bs*, basal segment. 9.—Maxilla,  $\times 290$ . *p*, palp. 10.—Labium,  $\times 180$ . *h*, hypopharynx; *m*, mentum; *p*, palp; *pr*, prementum. 11.—Posterior spiracle,  $\times 330$ . *b*, button; *tr*, transverse trachea. 12.—Anterior spiracle,  $\times 330$ . *b*, button; *f*, felt-chamber. 13.—Pupal breathing horn,  $\times 95$ . *sp*, spiracle; *p*, papilla.

The maxillae (Text-fig. 9) are large, somewhat elongated and comparatively lightly chitinized. The inner edge is curved and bears a tuft of fine hairs associated with which is a short broad papilla. Above this on the lower face of the maxilla is another papilla in the form of a circular mound bearing numerous tiny sensillae. The base of the maxilla is occupied by a curved chitinous plate, near the inner edge of which is a fringe of fine hairs and an area of minute papillae. There are two large chitinous bars in the maxilla, one curving parallel with the inner edge and the other running diagonally with a sharp curve near the bottom, and ending in a regular chitinous mass containing three small holes. This structure projects out on the inner edge of the maxilla near its base.

The labium (Text-fig. 10) is strongly developed in *Olbiogaster*. It consists of a large heavily-chitinized plate which, at its anterior end, is produced into two lobes, and posteriorly ends in a small rounded mass of chitin, with a pair of wing-like flanges. The main body of the plate, which is probably the mentum, also bears a lateral pair of flanges. Attached to, and in front of, this sclerite is a small, thinner plate bearing two large palp-like sensory organs. This represents the prementum. The hypopharynx is closely associated with the labium. It is attached to the dorsal surface of the mentum and projects upwards and forwards into the head. It is a delicate plate with a supporting border of strong chitin and a pair of trabeculae running forwards above the prementum. It bears delicate fringes and rows of hairs.

*The spiracles.*—The posterior spiracles (Text-fig. 11) each consist of a single curved slit which assumes a C shape, with the opening of the C facing backwards and slightly outwards. The slit has a scalloped chitinous border and is crossed by a regular series of bars. In the hollow of the curve is a small irregular chitinous mass, the button or scar. Below the spiracle is a short felt-chamber. There is a transverse tracheal trunk connecting the two posterior spiracles and joining the main lateral trunks just behind the felt-chamber. The anterior spiracles (Text-fig. 12) also consist of a single slit curved into a crescent shape and smaller than the posterior spiracle. It is of the same construction with a similar button and felt chamber.

*The pupa.*—No complete pupae were available, but an examination of the pupal skins shows that it is quite distinct from the pupa of *Anisopus*. It is much more narrow and elongated, being 10 to 11 mm. in length. There are no bristles on the thorax and each of the abdominal segments bears only two pairs of large lateral spines, except the first segment which has only one pair. The breathing horns (Text-fig. 13) are in the same position as in the pupa of *Anisopus*, but they are larger and more chitinous. The slit is circular in outline and a little behind the apex in position. A number of short chitinous tubes open at the surface of this slit. A papilla with a short fine bristle is borne on the side of the breathing horn.

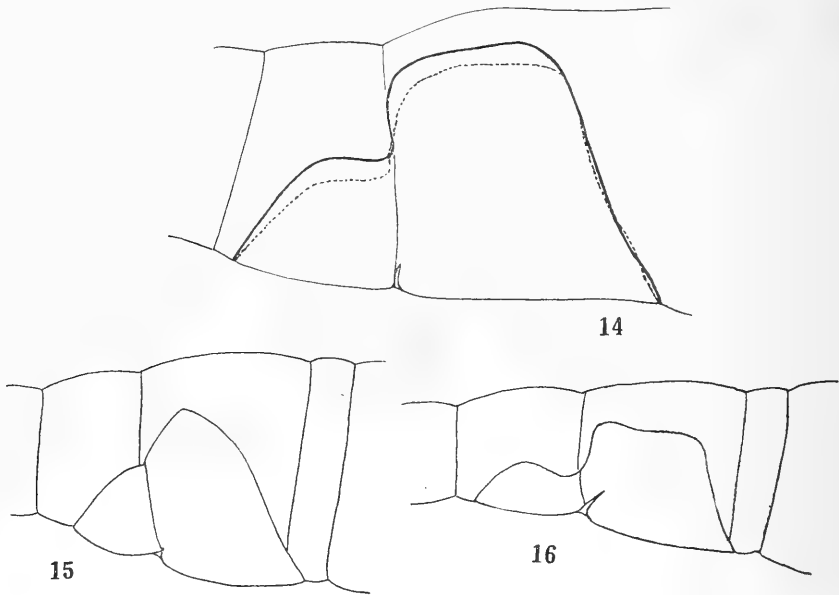
Except for some small differences in detail, the larvae and pupae of *O. insularis* show a close resemblance to those of *O. africanus*, which is the only other species in which the early stages have been described.

*Key to adults of the Australian species of Anisopus.*

1. Large species; antennae entirely yellow, shading to dark at tip of flagellum; cell  $R_1$  dark except at base ..... *A. neozelandicus* Schin.  
Smaller species; antennae entirely dark or only scape yellow; cell  $R_1$  with pale area beyond middle ..... 2
2. Brown species; antennae with yellow scape ..... *A. dubius* Macq.  
Black species; antennae entirely black ..... *A. funebris*, n. sp.

*Key to larvae of Australian species of Anisopus.*

1. Length 17 to 18 mm.; anal plate with conspicuous edges, pointed antero-ventrally, sides of anterior lobe straight (fig. 14) ..... *A. neozelandicus* Schin.  
Length 12 to 13 mm.; anal plate without sharply defined edges, more rounded antero-ventrally ..... 2
2. Anal plate with edges of anterior lobe just reaching dorsal surface, sides sharply curved (fig. 15) ..... *A. dubius* Macq.  
Anal plate with edges of anterior lobe reaching well on to dorsal surface, sides nearly straight (fig. 16) ..... *A. funebris*, n. sp.



Text-figs. 14-16.—Anal plates.

14.—*Anisopus neozelandicus*,  $\times 35$ . 15.—*A. dubius*,  $\times 35$ . 16.—*A. funebris*,  $\times 35$ .

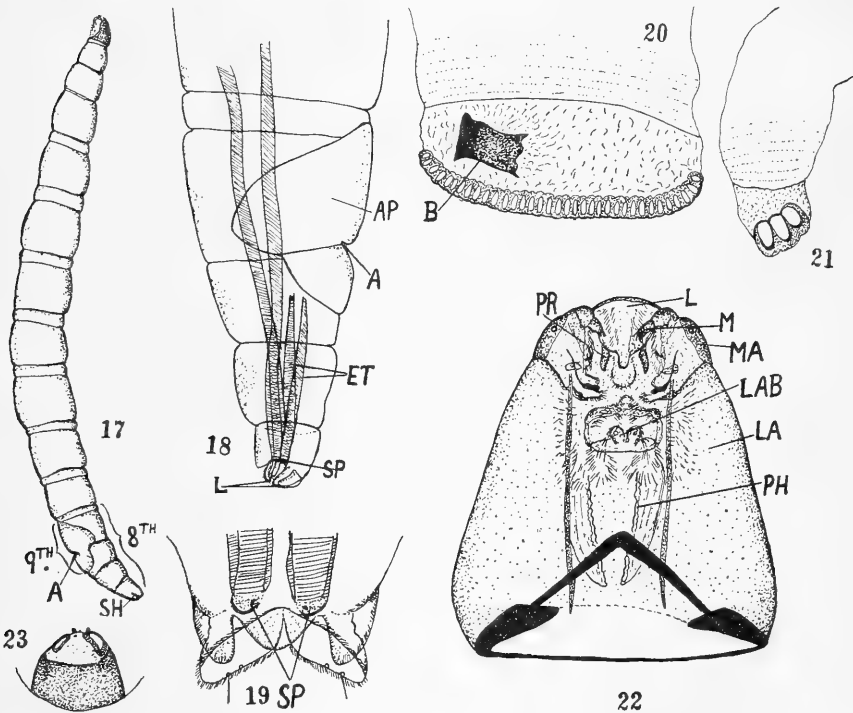
## ANISOPUS DUBIUS Macq.

*A. dubius* Macq. was redescribed in 1919 by Hardy, who also listed the literature and synonymy. Figures of the wing (Text-fig. 31) and genitalia (Text-fig. 36) are included in the present paper to facilitate identification.

The larvae have been found most abundantly in Canberra during July and August in a variety of media, but always under very moist conditions. The flies have always emerged in September from larvae collected at this time. But larvae have also been found occasionally in April, when the adults have appeared in May, June and July. They have been taken in old carcasses, rotting mushrooms, masses of rotting vegetables and hay, and in drains containing manure.

The full-grown larva (Text-fig. 17) is 12 to 13 mm. long, cylindrical, slender and worm-like, tapering at both ends. The body is smooth, devoid of folds or papillae. It is strikingly marked with a brown pigmented pattern. The thoracic segments have an irregular reddish-brown pattern with a series of oval yellow patches. The abdominal segments are more faintly marked with a lighter brown. The head is brown.

The thoracic segments become progressively wider from the first to the third and the sections of the eighth abdominal segment become increasingly narrower towards the terminal end. As in *Olbiogaster*, each of the abdominal segments exhibits a secondary annulation. The first to the seventh appear to have a narrow, creamy-yellow ring between each one. The eighth (Text-fig. 18), however, is divided into four sections, exclusive of the ring between the seventh and eighth, the posterior two of which are produced out past the ninth. The ninth segment is represented by a large ventral plate, the "anal shield" of Keilin, lying beneath the anterior part of the eighth and bearing the anal cleft. This plate (Text-fig. 15) is very readily detached from the rest of the integument and is seen to be considerably broader than the ninth segment of *Olbiogaster*. It is notched, dividing it into two unequal lobes with the anus between. The posterior extremity of the eighth segment bears five short lobes (Text-fig. 19). Two of these lobes are dorsal, bear fringes round the edges, and are longer than the ventral lobes. The ventral pair have a short, wide, median lobe between them. These are not fringed, but are finely grooved or striated round the margins. The spiracles occur at the bottom of a chamber formed by the five terminal processes. They



Text-figs. 17-23.—*Anisopus dubius*.

17.—Larva,  $\times 7$ . *a*, anus; *sh*, spiracular hollow. 18.—Posterior end of larva,  $\times 26$ . *ap*, anal plate; *a*, anus; *et*, extra tracheae; *l*, lobes; *sp*, spiracles. 19.—Apex of 8th abdominal segment of larva,  $\times 90$ . *sp*, spiracles. 20.—Posterior spiracle,  $\times 330$ . *b*, button. 21.—Anterior spiracle,  $\times 330$ . 22.—Head of larva, ventral surface,  $\times 75$ . *l*, labrum; *la*, lateralium; *lab*, labium; *m*, mandible; *ma*, maxilla; *ph*, pharynx; *pr*, premandible. 23.—Antenna,  $\times 290$ .

are similar in structure to those of *Olbiogaster*, but are less chitinous and of a much shallower crescent shape (Text-fig. 20). The anterior spiracles are smaller than in *Olbiogaster*, having only three clefts (Text-fig. 21).

The head (Text-fig. 22) is broadly sub-conical in shape, being strongly convex dorsally and almost flat ventrally. The head-capsule consists of a narrow prefrons which widens a little towards the anterior end, and two side pieces or lateralialia, which curve round and almost meet ventrally. The posterior margin of these is strongly chitinized, particularly ventrally. From the strong ventral margin of each a bar projects into the head, the two meeting medianly to form an arch. The tentorial rods, which run longitudinally inside the head as far as the anterior end of the lateralialia, are connected with these bars. Each side of the prefrons is a small black spot representing the eye. At the inner anterior edge of the lateralialia are the antennae (Text-fig. 23). Each consists of a short mound-like segment, bearing at its summit two flat sensory areas and several tiny papillae.

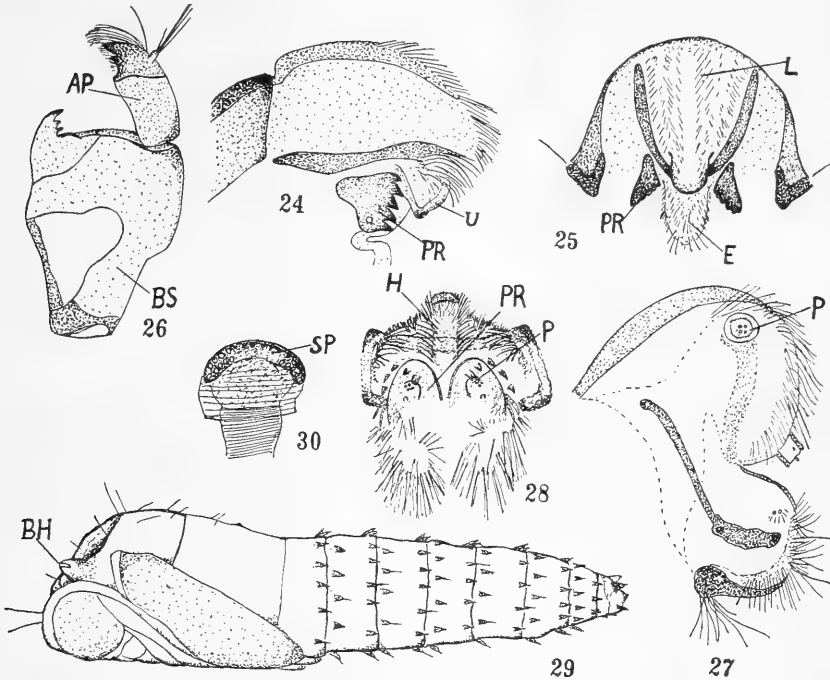
The mouth parts, although similar in general construction and arrangement to those of *Olbiogaster*, show a marked contrast in details. The labrum (Text-fig. 24) is strongly curved under, continuing into the epipharynx on the ventral surface. The curved dorsal part is smooth and chitinous, whilst the ventral part or epipharynx is densely clothed with hairs. The posterior ventral projection with its U-shaped support is large and conspicuous and bears a tuft of hairs in front. Each side of the labrum and behind the apex are the premandibles (Text-fig. 25). These are more strongly developed than in *Olbiogaster*, each consisting of a small thick plate bearing a row of five teeth along the anterior edge. A strong bar runs along each side of the labrum to the premandibles.

The mandibles (Text-fig. 26) are two-segmented as in *Olbiogaster*. They may also be folded in to lie with their apices facing backwards, or extended in front, when they project before the labrum and are visible from above. They arise from the head near the anterior border of the lateralialia. The basal segment of the mandible is a strong, hollow, almost rectangular sclerite with a deep indentation on the inner face. At the inner anterior corner it is produced to a point and bears three small teeth directed outwards. The apical segment is articulated at the outer anterior corner and is small and narrow. The end is curved inwards and possesses two teeth which are rather obscured by the large tuft of hairs arising from the outer dorsal edge. There is a smaller fringe on the ventral side and a large compound bristle on the outer edge.

The maxillae (Text-fig. 27) are large and composed of thin chitin. They are more hairy than the maxillae of *Olbiogaster*. The outer curved edge is more chitinous than the rest, and the inner edge is fringed with fine hairs for the whole length. A short wide palp projects inwards about the middle of the inner edge. Near the anterior end is a round slightly-raised area bearing a number of minute sensory papillae. The posterior inner edge of the maxilla is densely haired and also bears sensory papillae. There are two chitinous bars as in *Olbiogaster*, but they are thinner and not so well developed. The labium (Text-fig. 28) is much more reduced than in *Olbiogaster*. There is no large chitinous mentum, but simply a thin membranous area occupying a corresponding position and surrounded by fringes and tufts of hair. The prementum is a delicate bi-lobed structure, each lobe bearing five short backwardly-directed cone-like spines on the outer edge and a large flat papilla on the ventral surface. The posterior border is densely haired. The hypopharynx lies above the prementum,



projecting into the head and forwards. It also has a curved border of strong chitin and is itself thin with abundant fringes of short and long hairs.



Text-figs. 24-30.—*Anisopus dubius*.

24.—Labrum-epipharynx,  $\times 200$ . *pr*, premandible; *u*, U-shaped support. 25.—Labrum-epipharynx,  $\times 200$ . *e*, epipharynx; *l*, labrum; *pr*, premandible. 26.—Mandible,  $\times 200$ . *ap*, apical segment; *bs*, basal segment. 27.—Maxilla,  $\times 200$ . *p*, palp. 28.—Labium,  $\times 180$ . *h*, hypopharynx; *p*, palp; *pr*, prementum. 29.—Pupa,  $\times 12$ . *bh*, breathing horn. 30.—Breathing horn of pupa,  $\times 95$ . *sp*, spiracle.

The pharynx is greatly modified, forming a large organ composed of several plates of thin chitin and tubular structures with striated wavy walls. The whole has the appearance of being a mechanism for straining the liquid food. The tentorium appears to be modified to form a supporting structure for the organ. The rods are connected with a strong arch projecting into the head, the pharynx lying between the rods and above the arch.

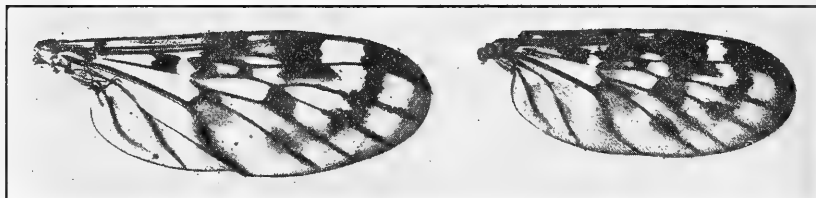
The pupa (Text-fig. 29) is 6 to 7 mm. long and dark brown in colour. The breathing horns (Text-fig. 30) are short, situated behind the antennal sheath and projecting forwards. The curved narrow slit is apical and bears a double row of small round openings. The pupa is truncated anteriorly and narrows to a point posteriorly. There are several pairs of bristles on the back of the thorax whilst the abdominal segments bear a circle of large spines near the posterior margin and a row ventrally and laterally near the anterior margin.

#### ANISOPUS FUNEBRIS, n. sp.

*Female*. Length 4 to 5 mm. Wing 4.5 mm. Head small, eyes well separated, black. Face black with greyish sheen, end of palps pale yellowish; frons and

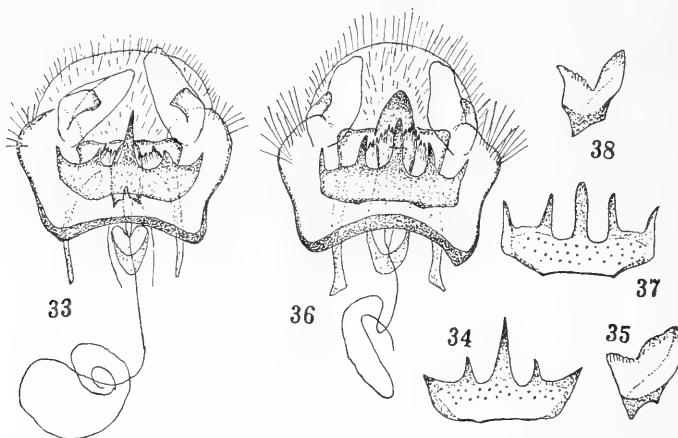
occiput dull velvety black; ocellar tubercle raised, one-third width of frons; occipital bristles black. Antennae entirely black and bristly; same length and form as in *A. dubius*.

Whole of thorax black, except for brownish tinge in front of scutellum; mesonotum dull and velvety with no trace of markings, covered with pale gold to whitish hairs and some black bristles; scutellum black with two long bristles. Wings typical, with macrochetae and series of blotches, markings being somewhat similar to those in *A. dubius*, but infuscations more extensive and grey to black in colour (Text-figs. 31 and 32). Halteres whitish. Legs dark with ventral

Text-fig. 31.—Wing of *A. dubius*.Text-fig. 32.—Wing of *A. funebris*.

surfaces pale brownish, covered with fine dark bristles; tarsi paler than tibiae, all segments darker at tips; one tibial bristle on foreleg, two on others; fore tibial bristle paler than others. Abdomen narrow and elongate, black; each segment with a narrow colourless posterior border; abdomen covered with whitish to pale gold hairs; genital appendages yellowish.

*Male*. Similar to female. Head larger, eyes contiguous, facets enlarged at top; ocellar tubercle prominent. Halteres darker than in female, legs slightly paler; hind legs with all but coxae pale brown. Genitalia as figured (Text-figs. 33 to 35). This species is most closely related to *A. dubius*, from which it may be readily distinguished by the characters given in the key and by the genitalia.



Text-figs. 33-38.

33.—Male hypopygium of *A. funebris*,  $\times 133$ . 34.—Sternal plate of hypopygium,  $\times 133$ . 35.—Dististyle,  $\times 133$ . 36.—Male hypopygium of *A. dubius*,  $\times 133$ . 37.—Sternal plate of hypopygium,  $\times 133$ . 38.—Dististyle,  $\times 133$ .

The genitalia of *A. funebris* and *A. dubius* (Text-figs. 36 to 38) appear to differ markedly from those of the species of *Anisopus* figured by Edwards (1923).

*Distribution*.—Anglesea, Victoria (March, 1934). Bred from *Xanthorrhoea australis*. The holotype male, allotype female and a paratype male and female are in the collection of the Division of Economic Entomology, Canberra.

*Larva*.—A piece of *Xanthorrhoea* trunk received from Mr. J. H. Bowen from Anglesea, Victoria, in March, 1934, contained a number of larvae and pupae of this species. They were present only in the very moist rotting tissues. The adults emerged within a fortnight.

The larva is of the same size and general appearance as *A. dubius*, and is essentially the same in structure. The pigmentation is slightly different in character from that of *A. dubius*, particularly on the thorax where the colour markings are broader and deeper in tone. The larva of *A. funebris* may, however, be distinguished from that of *A. dubius* by the shape and size of the anal plate. It is larger and curves higher up the sides on to the dorsal surface (Text-fig. 16). The anterior lobe of the plate has also straighter sides, lacking the sharp curve of that in *A. dubius* (Text-fig. 15). The annulations of the eighth segment are more elongate in *A. funebris*, and the terminal papillae slightly longer and more spreading.

*Pupa*.—There were no obvious differences noted in the pupae of the two species.

#### ANISOPUS NEOZELANDICUS Schin.

Preserved larvae of this species from Aniseed Valley, N.Z., taken in rot holes in trees by Mr. Tonnoir, were examined, but were not in a suitable condition for description. They were considerably larger than those of the two species described, some reaching 18 mm. in length. They were also distinguishable from the other larvae by the shape and size of the anal plate, as indicated in the key and figure (Text-fig. 14).

#### DISCUSSION.

The larvae of *Anisopus dubius* show some interesting adaptations to an aquatic environment when compared with the less specialized terrestrial larvae of *Olbiogaster insularis*.

In both species there is a secondary annulation of the abdominal segments, but in *Anisopus* this has been strikingly developed in the eighth segment, which, excluding the intercalary ring, has been divided into four sections, producing it well beyond the ninth. The tendency to produce the eighth abdominal segment beyond the ninth is seen in *Olbiogaster* in the small posterior prolongation of the eighth, which curves round the ninth. This special development of the eighth abdominal segment in *Anisopus* is evidently for the purpose of carrying the highly developed respiratory organ, an adaptation due to its aquatic environment. Martini (1927) points out that in some Psychodid larvae the eighth abdominal segment is entirely dorsal, lying above the ninth, and in Culicine larvae the eighth segment bears a postero-dorsal prolongation, extending beyond the ninth and tenth, and forming the respiratory siphon.

The posterior spiracles are external and unprotected in *Olbiogaster*, whilst in *Anisopus* they occur in a hollow, surrounded and hidden by five lobes which are fringed and striated. The tracheae also show special features in *Anisopus*. In addition to the two main tracheal trunks there is an extra pair of equal size lying below them in the eighth segment. These tracheae coincide with the

main trunks at the spiracles and peter out into thin ends just behind the ninth segment. The four large tracheae are close together and are intimately connected by a network of fine tracheoles, the whole forming a gill-like organ. In living larvae there is always a mass of air bubbles associated with this organ, doubtless allowing the larva to live submerged for considerable periods. In *Olbiogaster* there is a transverse trachea connecting the posterior spiracles just as the anterior spiracles are joined. The air sacs of *Anisopus* may be a modification of this tracheal bridge, which, with the prolongation of the eighth segment, has divided in the middle and formed two short longitudinal trunks.

All the mouth parts are less chitinous and more hairy in *Anisopus* than in *Olbiogaster*, further adaptation to the aquatic habit in the former. *Olbiogaster* has a strongly developed mentum which is absent in *Anisopus*. Both larvae possess two-segmented mandibles, those of *Olbiogaster* being the larger and stronger. In *Anisopus* the premandibles are more distinct and well developed, and the pharynx is peculiarly specialized, forming what appears to be a straining mechanism. The differences in the mouth parts of the two larvae show that *Anisopus* has to obtain its food from liquids, whilst *Olbiogaster* has to deal with solids.

The tentorium of each larva is distinctly different. The lateralia, with their strongly chitinized ventral edges, seem to be the chief head-support in *Olbiogaster*, which possesses in addition only a small chitinous arch in the back of the head. The strong chitinous head is necessary to a larva forcing its way through woody material. *Anisopus*, on the other hand, has thinner chitin forming the epicranium and lateralia, but has a much larger arch extending further forward into the head, and also a pair of longitudinal tentorial rods connected with the arch near their posterior ends. This specialized tentorium is doubtless a support for the highly developed pharynx.

The above comparison indicates how the chief differences in structure of the larvae of *A. dubius* and *O. insularis* are closely related to differences in environment. On larval structure *Mycetobia* (Keilin, 1919) is closer to *Anisopus* than is *Olbiogaster*, but adult characters place *Olbiogaster* closer than *Mycetobia* to *Anisopus*. The reason for this is that the larvae of *Mycetobia* and *Anisopus* live under similar conditions whilst those of *Olbiogaster* have a different habitat.

Hence, within the family Anisopodidae, larval characters should be used circumspectly in assessing systematic relationships, as they are largely expressions of environmental influences.

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OBSERVATIONS ON THE SEASONAL CHANGES IN TEMPERATURE, SALINITY, PHOSPHATES, AND NITRATE NITROGEN AND OXYGEN OF THE OCEAN WATERS ON THE CONTINENTAL SHELF OFF NEW SOUTH WALES AND THE RELATIONSHIP TO PLANKTON PRODUCTION.

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Zoology Department, University of Sydney.

(Plate xi; eleven Text-figures.)

[Read 25th September, 1935.]

*Introduction.\**

In our first paper on the seasonal changes in the plankton off the coast of New South Wales (Dakin and Colefax, 1933) we indicated that little investigation had been made of the biological conditions prevailing throughout the year in Australian coastal waters. The same criticism holds good in regard to physico-chemical studies. In fact, had it not been for the Barrier Reef Expedition of 1928-29 one might have said that no physico-chemical observations extending over even a few months had ever been made round the Australian continent. Surprising as it may seem, it is not easy to discover sea-temperature records for the ocean coastal waters apart from those which have been taken by various ocean-going vessels and reported to the Commonwealth Government. These temperature records have been ably utilized by Mr. G. H. Halligan (Halligan, 1929) in plotting a series of isotherms for the Tasman Sea (S.W. Pacific), and an area of the Indian Ocean off Western Australia. They are all surface records—over of the sub-surface water if the temperatures were taken in the engine room.

The observations to be reported in this paper are the result of a prolonged series of records made in conjunction with a biological investigation at one station situated approximately 3 to 4 miles east of the entrance to Port Jackson, coast of New South Wales. They extend over 3½ years, but reliable nitrate nitrogen analyses were only made during part of the time and certain other tests (oxygen) were made over a still shorter period.

The purpose of the investigation was primarily to discover the conditions under which plankton production took place in our southern waters and also to obtain information regarding any physical conditions which might be correlated with seasonal variation in plankton and the movements of fishes.

Such a survey as ours—concentrating on one station, although other odd records were made not far away (some in deeper water and some closer in-shore)—must be regarded as a preliminary to larger scale ocean investigations. The use of a small auxiliary yacht (Pl. xi, fig. 1), without which our work would

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\* The pursuit of these marine investigations has been valuably aided by grants from the Research Endowment Fund of the Council for Scientific and Industrial Research, to whom our thanks are tendered.

have been quite impossible, still left us without the means to conduct anything like the seasonal voyages of the investigation vessels employed in similar hydrographical work in the North Sea and English Channel. It is also a pity that our work is so isolated—comparisons with similar observations that might be made to the south off Tasmania and to the north off the Barrier Reef would be distinctly interesting. Notwithstanding the difficulties and limitations, this first work has revealed some interesting facts, more especially since the plankton investigations at the same station are the first in Australasian waters to show a seasonal rhythm akin to that so well known in the Northern Hemisphere (actually the first discovery of spring and autumn phyto-plankton maxima in the Southern Hemisphere).

#### *Technique.*

Since the usual oceanographic apparatus has been utilized we shall only comment on any points which have been unusual or which may be helpful to workers placed in a similar position elsewhere.

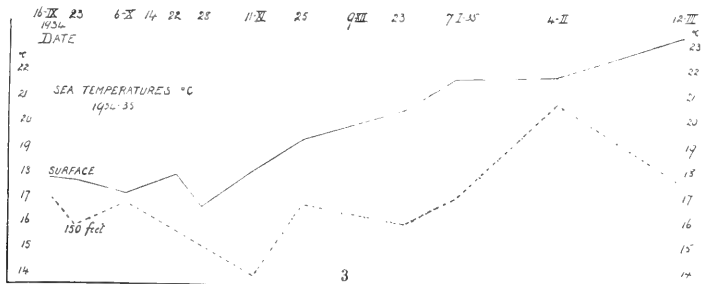
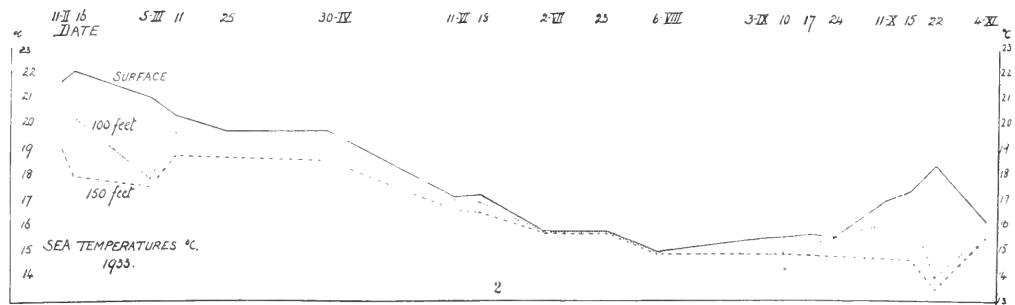
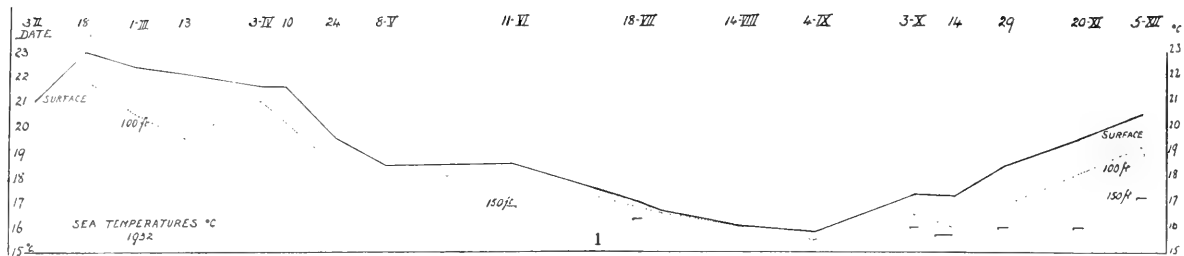
The auxiliary yacht "Thistle" utilized for our work is a strongly built cutter of about 12 tons, length (waterline) 29 feet, beam 11 feet 6 inches, and draft 5 feet. She has a tuck stern—no overhang. She is gaff rigged and is admirably adapted for ocean cruising, except that for more prolonged deep-sea work under bad conditions a smaller cockpit would be desirable if not essential. The auxiliary engine is a 25 h.p. Ailsa Craig, but sails are used whenever possible. The engine is, however, almost always utilized when towing plankton nets horizontally, in order that they will be drawn at uniform and similar speeds on the different occasions.

Considerable difficulty was experienced at the outset in rigging a well known type of meter wheel at the end of a boom, owing to the fact that the movements of the boat in a bad sea were extremely lively (especially when at work but not under way). It was soon found essential to limit the movements of the associated gear so that there were as few freely moving parts as possible. Eventually, with this in view, the boom shown in the photograph (Pl. xi, fig. 2) was constructed. It carries a reel with 100 fathoms of stranded wire, also the recording mechanism of a meter wheel, and in addition a simple mechanism of springs and pulleys to act like the old-fashioned accumulator and counter severe and sudden strains caused by the upward and downward plunges of the vessel. Unfortunately the machine is hand worked. The mechanism could be improved considerably by the addition of a small electric winding motor. The boom is supported on the "forrad" side of the mast on a spider band about one foot above the deck, with a single topping lift and two guy ropes.

A Lucas sounding machine is mounted as illustrated (Pl. xi, fig. 3), the scaffold of galvanized iron enabling the machine to project slightly overboard and to support it adequately, notwithstanding the lack of bulwarks. It is placed just aft of the shrouds on the starboard side; the boom with the gear referred to above is used on the port side.

The water bottle generally used is the Nansen Petersen, but we also have Ekman reversing bottles, and reversing thermometers are available.

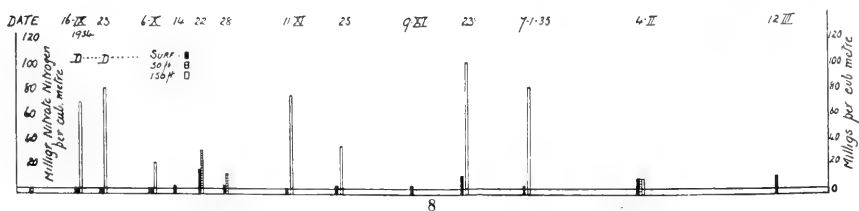
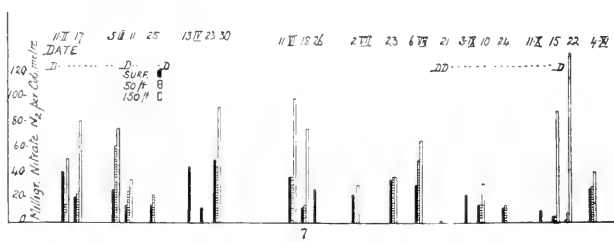
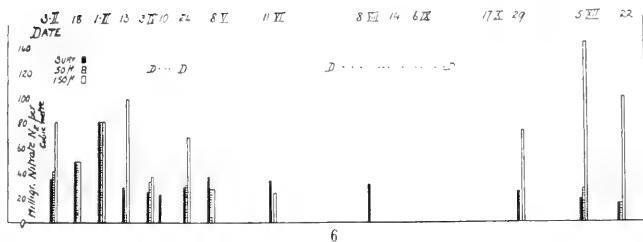
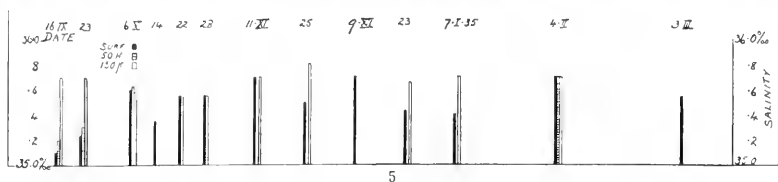
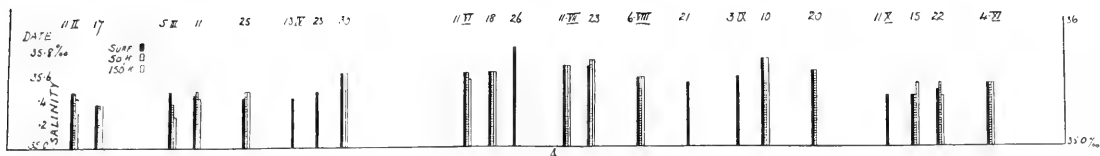
The usual procedure has been to sail out from the harbour of Port Jackson to our station which has been chosen sufficiently far out to be beyond the influence of tidal water emerging from the harbour and sewer outfalls on the coast. The station is fixed by bearings taken with sextant or range finder. At the beginning



Text-figs. 1-3.—Diagrams showing the seasonal variations in the sea temperatures, at depths—surface, 100 feet, 150 feet, 1, during the year 1932; 2, during the year 1933; 3, during the half-year 1934-35.







Text-figs. 4-5.—Diagrams showing seasonal variations in salinity of the sea-water during the year 1933 (fig. 4) and the half-year 1934-35 (fig. 5), at depths—surface, 50 feet, 150 feet.

Text-figs. 6-8.—Diagrams showing seasonal variations in nitrate nitrogen in the sea-water at depths—surface, 50 feet, 150 feet.

6, during the year 1932; 7, during the year 1933; 8, during the half-year 1934-35.

D.....D indicates diatom maxima. The presence of an ordinate column only between the base lines indicates that a sample was taken, of which the nitrate nitrogen content was zero.



of our investigations a sounding was always made before other work was commenced, but later it was found unnecessary as the sea-bottom was of fairly uniform depth in the neighbourhood of our mark and our position could be found satisfactorily. In any case, we could not risk making observations very near the sea-bottom, owing to the usually prevailing swell and the consequent considerable rise and fall of our vessel. It was decided, therefore, to make collections in surface water, 25 feet depth, 50 feet depth, 100 feet depth and 150 feet depth, and at greater depths on the shelf according to plan when making other stations further from the land. The depth at our station was approximately 30 fathoms (54.8 metres).

Water samples were brought back to the shore laboratory for analysis, but pH observations and the preliminary additions of reagents for oxygen determinations (Winkler's method) were carried out at sea.

#### NOTES ON ANALYTICAL METHODS.

The method adopted for phosphate analysis has been the colorimetric method of Déniges as set out by Atkins (1923, 1925, and 1926) using ammonium molybdate solution and stannous chloride in the presence of sulphuric acid.

Nitrate nitrogen has been estimated by the method introduced by Harvey (1928*a*), using a reduced strychnine product in sulphuric acid. At first we had great trouble in applying this analytical method—similar troubles seem to have been met with elsewhere. The difficulty was, however, eventually traced to impurities in the reagents.

During the preparation of the "hydrostrychnine", it was found advisable to heat for periods ranging from 24 to 36 hours, the contents of the flask being carefully shielded from any foreign gases.

An interesting fact that came to light was that a good batch of the reagent could be diluted to an amazing degree with chemically pure sulphuric acid and still retain its sensitivity unimpaired. Thus, in one case, from a litre of hydrostrychnine and sulphuric acid, prepared according to Harvey's directions, no less than four litres of sensitive reagent were made, by the addition of fresh quantities of pure sulphuric acid.

Chlorine has been determined by titration of sea-water with silver nitrate using potassium chromate as indicator according to the plan set out by Oxner and Knudsen (1920). "Normal" sea-water (as used in European laboratories) has, however, not as yet been obtainable. We shall be able to make any small correction later to allow for a fine comparison with results of observers elsewhere. This does not of course seriously affect the main issue—a review of the changes prevailing at our station during the period of observation.

A variation of the usual method of applying Winkler's method for oxygen analysis was developed, which may be of considerable service to other workers faced with our difficulties at sea. We had found at the outset that it was both expensive and inconvenient to try and introduce 0.5 c.c. of 40% manganous chloride solution and 1 c.c. of the concentrated caustic soda-potassium iodide solution into a filled 100 c.c. bottle of sea-water on a very unstable deck. The pipettes were too often broken and the caustic soda spilled about.

To obviate this, small glass bulbs (serum capsules) of the desired capacities were obtained and *filled* with the correct quantities of the reagents by immersing them in the fluids concerned under a bell-jar attached to a vacuum pump. This method made it unnecessary to heat the bulbs or to inject the fluid into them with a fine syringe. The bulbs were next sealed in a blowpipe flame. All that was

then necessary was to take boxes of the two sorts of bulbs to sea. The method was as follows: A 200 c.c. glass-stoppered bottle, the capacity of which was exactly known with the stopper inserted, was filled to the brim with sea-water. Two bulbs, one containing manganous chloride, the other caustic soda-pot. iodide solution (according to the usual formula), were next carefully dropped in and smashed at the bottom of the bottle by pressing on them with a glass rod which was then carefully withdrawn. The stopper was inserted, adopting the usual precautions, and the contents well shaken and allowed to stand. The rest of the procedure was carried out in the usual manner for Winkler's test. A great advantage of this method is that it removes any necessity for carrying the caustic soda solution (except in the little phials) and obviates all work with the small pipettes usually necessary and often difficult to keep clean and ready for use at sea.

In commencing our work on the plankton cycle in south-eastern Australian waters, attention has been focussed particularly on the phosphate and nitrate content of the sea-water in view of the conclusions already reached by European workers on the importance of these substances as controllers of plankton production. They are amongst the essential substances for the development and growth of the phytoplankton and they are limited in quantity in the sea; nitrate nitrogen was regarded quite early in plankton investigations as of especial significance in limiting the production of phytoplankton in the sea. Nitrites were tested for on several occasions but, as the amount present was less than 1 mg. per cubic metre in the ocean-water examined, further work was left until the research could be extended to cover other substances not at present investigated.

The differences in hydrogen-ion concentration during the successive visits to our station were all of such a small order as to make the most accurate determinations essential if to be of any use. A continued investigation was therefore left until an electrical method of determination was available.

#### THE TEMPERATURE CONDITIONS.

The range of temperature met with at our station is small and on the whole the changes in temperature are both gradual and steady. We are evidently influenced but little by the land, but more elaborate observations are urgently necessary on lines running out from Port Jackson to the edge of the continental shelf. The total annual range of temperature variation of the surface water is only about 7° C. The annual range at a depth of 30 fathoms is less still.

The highest temperatures reached are usually between 22° and 23° Centigrade and occur in February or March. The lowest surface temperatures are to be found in August or September. The range is shown in the graphs (Figs. 1, 2, 3).

It will be noticed that during the winter months the surface temperature at our station differs but little from the temperature at depths of 25, 50 and 150 feet. During the period that the temperature is at its lowest the water between surface and bottom is almost at the same temperature. From the date in spring when the surface waters begin to rise in temperature the difference between surface and bottom becomes more and more pronounced.

These features are all of a well recognized character in other parts of the world. There is quite a definite "layering" in the summer (more perhaps than we expected, considering the turbulence of the seas), and the deeper water attains its maximum later than the surface water.

But it is clear that before drawing any further conclusions, many more data are essential and there should be a chain of stations from the land to the edge of the continental shelf. We prefer, therefore, merely to set out the facts covering the temperature conditions observed in order to make known the general prevailing conditions for correlation with our biological data. The data given are, however, sufficient to indicate one important factor in connection with the nitrate and phosphate content of the water. The conditions in summer will hinder any rapid regeneration of nitrate and phosphate supplies if these substances are exhausted in the surface waters by the activity of the plankton. The pronounced "layering" will tend to prevent supplies passing upwards from the sea bottom. On the coastal shelf, however, as at our station, abnormal weather conditions may bring about a temporary destruction of the summer conditions, as indicated on Figure 3 for February 4, 1935.

The range of sea temperatures within the harbour of Port Jackson is of course far greater than at our offshore station and variations between 12.3° C. and 27° C. have been noted.

#### SALINITIES.

Chlorine analyses have been made on samples taken at our station over a period of three years. Some of these results are plotted in Figure 5. There is no reason to depict or tabulate the full three years' work.

The water off our coast is of an average salinity of approximately 35.5‰. This corresponds to the "general" ocean salinity that may be expected in 30° latitude. It might, however, be regarded as a high salinity for coastal waters. In this connection it must be remembered that, normally, relatively little fresh water enters the sea from Port Jackson (except after heavy rains) and we have deliberately avoided that area which might be expected to be swept by currents from the harbour at ebb tide.

If we take the surface water and the water at 150 feet depth for comparison, it is apparently just as likely for the salinity to be the same throughout, or for the surface salinity to be greater, or less than that of the deeper layer. These differences are, however, rarely greater than 0.3‰, and usually less (see figs. 4 and 5).

Throughout the year there is a slight fluctuation in the salinities, but it is neither large nor regular and, so far, we have not been able to correlate the very small "ups and downs" with changes in the weather or with heavy rains. The range is too small, as, for example, 35.46‰ February 11 to 35.36‰ a week later, then from 35.46‰ to 35.40‰ between March 5 and April 13, when a slight increase led up to 35.60‰ on April 30. A salinity of 35.8‰ was recorded on June 26. The extremes for the surface in 1933 were 35.80‰ and 35.36‰. There is some indication that the salinity of the deeper water is more constant than that at the surface. This might well be expected. Probably most of the small changes are due to complex tidal currents in proximity to the coast and it seems just as likely that if we had been making successive daily observations we should have met with variations of similar degree in close succession, even on adjacent days.

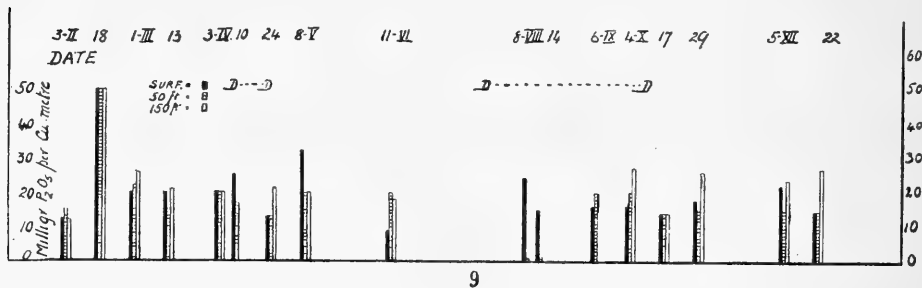
So far, then, we can take it that no seasonal rhythm has made itself apparent, and that the water at our station preserves the salinity of ocean water.

#### PHOSPHATE.

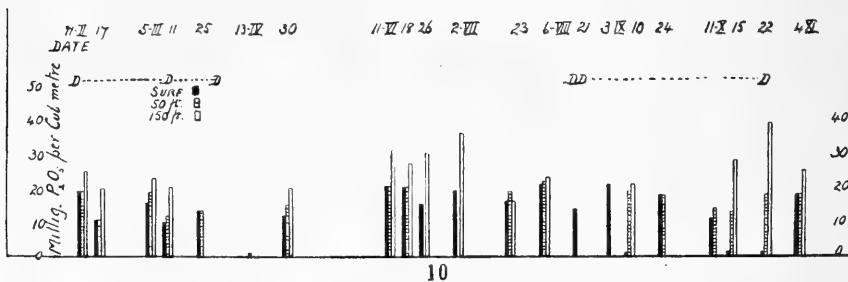
In view of the fact that phosphate is regarded as one of the essential foodstuffs of the phytoplankton, its mean quantity and its seasonal variation in our waters is of considerable importance.

The data given in the figures and tables cover the period from February 3, 1932, to November 4, 1933, and from September 17, 1934, to March, 1935. Unfortunately, owing to difficulties in obtaining a crew during the summer vacations, the summer months of the season 1932-33 (December to January) and 1933-34 presented many lacunae. These unavoidable gaps were covered by a special effort made to run weekly or fortnightly cruises between September, 1934, and March, 1935. This sequence was one of our most successful, and threw considerable light on the chemical conditions of the offshore waters during the summer.

The first point that strikes one on glancing at the graphs (Figures 9, 10, 11) is that the phosphate content is on the whole very stable during the year. There



9



10



11

Text-figs. 9-11.—Diagrams showing seasonal variations in Phosphate at depths—surface, 50 feet, and 150 feet.

Fig. 9, during the year 1932; Fig. 10, during the year 1933; Fig. 11, during the half-year 1934-35.

The presence of an ordinate column only between the base lines indicates that a sample was taken, of which the phosphate content was zero.

(D.....D), diatom maxima.

are ups and downs, but the average during the summer months is not appreciably less than during the winter months, and at the surface it varies between say 15 and 25 milligrams of  $P_2O_5$  per cubic metre.

As these are the first phosphate determinations to be made regularly in the coastal waters of south-eastern Australia, it is particularly interesting to make a comparison with other areas of the sea where the phosphate content is now fairly well known.

According to Harvey (1928*a*) the surface water of the English Channel is at its maximum during the months from October to March inclusive, the amount being roughly 30 mg.  $P_2O_5$  per cubic metre. In the summer months (May to September), however, there is a great fall in the phosphate content, and the amount goes down almost to zero—varying between 0 and 8 mg.

In the cold waters of the Antarctic (Hart, 1934) the phosphate in the surface waters also suffers a depletion during the phytoplankton season, but the total never goes below 50 mg.  $P_2O_5$  per cubic metre, which is twice our average amount. On the other hand, well over 100 mg. per cubic metre is frequently recorded.

As a result of the Great Barrier Reef Expedition of 1928–29, there are records (Orr, 1933) for phosphates in the Barrier Reef Lagoon waters which are exceedingly interesting for comparison with ours. The quantity of phosphate was relatively uniform, but only about 5 mg. per cubic metre. It was rare for it to reach 8 mg. per cubic metre, and 14 mg. per cubic metre at 28 metres depth was regarded as so high a value as to be due to contamination and not a true record. Unfortunately, few observations were made in the open sea, but those seaward of the reefs showed just as low figures in the surface waters.

On the whole, therefore, our coastal water approximates more to the English Channel conditions, but without the exhaustion of  $P_2O_5$  in the summer—in other words, a seasonal cycle is not pronounced. It is worthy of note that Atkins' analyses (1926) of waters collected in the open Pacific Ocean between the Galapagos and the Marquesas (in latitude  $0^\circ$  to  $8^\circ$  S.) showed contents between 5 and 27 mg. with the average of 18 mg. for 5 samples.

When, however, we look more closely into the details of the tables, we find variations of importance, even though they be of short duration. On certain dates the phosphate content of the surface water went down to zero or to a mere trace. These dates were April 13, 1933, September 3, 1933, and October 15 and 22, 1933 (see fig. 10). The phosphate content was down to zero again on September 16 and 23, and October 6, 1934 (see fig. 11), which means that it was practically absent during the whole month of September and the first week of October (see Tables I and II).

An inspection of the plankton catches for the dates mentioned provided a striking confirmation of the theories put forward in Europe to explain the variation in nitrate and phosphate content of the surface waters of the sea during the year. They showed that the phosphate content of the sea off our coast never went down to zero without there being an unusual (for this place) development of diatoms.

As a matter of fact the taking of the summer series of observations 1934–35 (Table II) was entirely unpremeditated and was initiated as a result of finding no nitrate and no phosphate in a sample of water, on September 17, 1934, which had been collected for bacteriological examination. This result was so surprising that the boat was immediately taken out again with fine plankton nets. It was

TABLE I.—*Composition of the Ocean Water from N.S.W. Coastal Shelf.*  
Phosphates. 1933.

Depths. (Metres.)	Dates.																				
	Feb.		Mar.			Apr.		June.			July.		Aug.		Sept.			Oct.			Nov.
	11	17	5	11	25	13	23	11	18	26	2	23	6	21	3	10	24	11	15	23	4
Surface . . . . .	19	14	16	10	13	0	tr.	20	20	15	19	16	21	14	21	tr.	17	11	tr.	tr.	18
15·2 . . . . .	19	11	19	13	13	—	—	21	20	—	—	18	23	—	—	19	17	—	13	18	18
30·5 . . . . .	21	14	22	18	14	—	—	23	25	—	—	19	22	—	—	22	—	—	13	43	18
45·7 . . . . .	25	20	—	20	—	—	—	31	27	—	36	16	23	—	—	21	—	—	28	39	25
61 . . . . .	—	22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

The figures indicate milligrams of P<sub>2</sub>O<sub>5</sub> per cubic metre.

In this and following tables, where no figure is given no sample was taken.

TABLE II.—*Composition of the Ocean Water from N.S.W. Coastal Shelf.*  
Phosphates. 1934-1935.

Depths. (Metres.)	Dates.												
	Sept.		Oct.				Nov.		Dec.		Jan.	Feb.	Mar.
	16	23	6	14	22	28	11	25	9	23	7	4	12
Surface . . . . .	tr.	tr.	0	20	17	21	16	22	22	33	19	22	27
15·2 . . . . .	16	15	tr.	—	26	25	—	—	—	—	20	22	—
30·5 . . . . .	—	—	—	—	—	—	—	27	—	35	28	22	31
45·7 . . . . .	26	30	23	—	—	—	39	29	—	38	—	25	—

discovered that the sea was thick with phytoplankton. In fact the catches were as big as any ever taken by us in these waters. The occasion provided such a remarkable demonstration of the relationship of phytoplankton to the quantity of phosphates and nitrates in the water that it was decided to make a special effort to continue the water analyses, notwithstanding possible bad weather, and to follow up the return of the chemical substances in question. A detailed picture of the water at our station during the summer months 1934-35 was the result. Notwithstanding, however, the fact that a large outburst of phytoplankton reproduction will bring down the phosphate content of our coastal waters to zero, this condition does not continue for the long season noted in British waters. On the occasions noted above in 1933, when the phosphate in the surface waters was reduced to a trace, it was back again ten days or so afterwards. After the spring diatom maximum in September, 1934, the phosphates were down to zero for about three weeks. Regeneration from deeper waters then resulted in the amount rising to 20 mg. per cubic metre, and this figure was kept up during the summer.



Whilst, therefore, the presence of large numbers of diatoms and other phytoplanktonic organisms may reduce the phosphate content of our waters, it cannot be said that the spring or the autumn maxima of the phytoplankton are dependent upon the phosphates gradually attaining a maximum. Phosphate has been available in sufficient quantity for two or three months before the spring plankton maximum, and it is also present during the greater part of the summer.

The rapid regeneration of phosphate in the surface waters after the diminution in the speed of plant production may be accounted for by the quantity present in deeper water. On all the occasions mentioned in 1933 when the surface phosphate was reduced to zero, it was never less than 13 mg. per cubic metre at 50 feet, and was between 20 and 38 mg. per cubic metre at 150 feet.

NITRATE CONTENT.

The work carried out at Plymouth, England, in particular, shows that there are considerable fluctuations in the nitrate content of the sea-water of the English Channel which are similar to those of the phosphate. Harvey's curves (1928*a*) show that there is as much as 60-80 mg. of nitrate nitrogen per cubic metre in the surface waters between October and March. A very rapid reduction of this substance takes place during the spring months of April and May, and eventually during the summer the nitrate nitrogen is reduced to only 0 to 4 milligrams per cubic metre.

We have also found that in New South Wales waters there are fluctuations in the nitrate nitrogen content of the sea which can be correlated quite clearly with fluctuations in the productivity of the sea in plankton. But once again it is evident that the seasonal changes are not nearly of such amplitude as those of the English Channel. What is specially interesting, however, is the fact that the nitrogen content is apparently much more sensitive to the reproduction of the phytoplankton than is the phosphate. Possibly this may be correlated with the fact that the nitrate nitrogen is rarely more than 40 mg. per cubic metre in the New South Wales coastal waters, and usually is less.

The details of the analyses are shown in Tables III and IV and the graphs (Figs. 6, 7, 8). It will be seen that there is usually a very considerable difference between the amount of nitrate present in the surface waters and at a depth of 150 feet. The quantity at the surface and at 50 feet is often very similar.

TABLE III.—Composition of the Ocean Water from N.S.W. Coastal Shelf. Nitrates. 1933.

Depths. (Metres.)	Dates.																						
	Feb.		Mar.			Apr.			June.			July.		Aug.		Sept.			Oct.			Nov.	
	11	17	5	11	25	13	23	30	11	18	26	2	23	6	21	3	10	24	11	15	23	4	
Surface .. ..	40	20	25	14	13	42	11	49	36	12	24	23	33	30	tr.	22	14	11	10	0	0	25	
15.2 .. ..	14	25	60	22	22	—	—	44	36	15	—	—	36	47	—	—	14	12	—	0	6	27	
30.5 .. ..	22	17	70	22	31	—	—	13	89	39	—	—	33	58	—	—	32	—	—	13	134	35	
45.7 .. ..	51	80	—	33	—	—	—	90	98	73	—	—	32	36	63	—	—	32	—	—	87	134	40
61 .. ..	—	150	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	

The figures indicate milligrams of Nitrate N<sub>2</sub> per cubic millimetre.

TABLE IV.—*Composition of the Ocean Water from N.S.W. Coastal Shelf.*  
Nitrates. 1934-1935.

Depths. (Metres.)	Dates.												
	Sept.		Oct.				Nov.		Dec.		Jan.	Feb.	Mar.
	16	23	6	14	22	28	11	25	9	23	7	4	12
Surface ..	0	0	0	tr.	15	tr.	0	tr.	tr.	10	tr.	8	10
15.2 ..	0	0	0	—	30	11	—	tr.	—	—	tr.	8	—
30.5 ..	—	—	—	—	—	—	—	11	—	50	80	10	40
45.7 ..	67	80	20	—	—	—	74	33	—	100	—	8	—

During the winter of 1932 the surface nitrate varied between 20 and 30 mg. per cubic metre. The nitrate was not reduced to zero during the spring maximum of the diatoms in 1932, although it went down to less than 15 mg. per cubic metre. The first occasions when we noticed the nitrate nitrogen reduced to zero were during the spring outburst of phytoplankton in 1933. On August 21 and October 15 and 22 a great diminution occurred. On all these occasions big catches of diatoms were netted. There seemed, however, judging by the summer analyses (February and March) at the beginning of 1933, to be no evidence of a summer exhaustion of nitrogen. The more exact and reliable results\* of the 1934-35 season presented a somewhat different picture.

Together with the phosphate, the nitrate nitrogen was reduced to zero or a trace on September 16, 1934, concurrently with a great diatom outburst. This low content now prevailed week after week, with a slight and temporary rise to 10 mg. per cubic metre in December, but it was not until February that a slow and steady increase was to be observed. The concentration of the nitrate nitrogen in the surface water remained, however, below 10 mg. per cubic metre for practically the whole of the summer. During the same period, amounts varying between 32 mg. and 100 mg. per cubic metre were found at a depth of 150 feet. That such differences can be present may be accounted for on the basis of the temperature gradient which prevails in these coastal waters during the summer (see section on Temperature). It is quite usual to find a difference of 3° to 5° C. between the temperature of the surface water and that at 150 feet (during the summer), and unless a storm should develop at this season there seems to be little mixing due to vertical circulation or wave motion.

It will be seen that at any time during the year there is less nitrate nitrogen in the New South Wales waters than in those of the English Channel. The amount recorded from the Antarctic (Hart, 1934) ranges in summer from 350 to 500 mg.  $\text{NO}_3$  per cubic metre. The Great Barrier Reef Expedition (Orr, 1933) only obtained a few samples for nitrate examination, and the analyses were made long afterwards in England. The figures in any case could give no indication of the seasonal cycle, but actually those given do not seem to be reliable.

\* The difficulty of obtaining satisfactory reagents for the earlier nitrate tests has already been mentioned.

The results described above are, up to date, the only indications which have been set forth showing the nitrate content of Australian coastal waters. In view of the very close relationship between quantity of plankton and nitrate content, there is a valuable field of inquiry here. In particular, it would be interesting to see how far the concentration of nutrient substances in ocean waters is affected by the proximity of coasts. This work could be tackled here with relative ease where the coastline runs for miles with few indentations and where an offshore line of stations extending out a matter of only 30 miles may bring one to water of 1,000 fathoms depth.

Some discussion of the bearing of our nitrate and phosphate analyses on the New South Wales seasonal production of plankton in 1932-34 will be made in a paper to be published on the plankton of these coastal waters.

#### OXYGEN.

Oxygen determinations have not been made in a continuous series throughout the full period of our plankton observations.

The data which we have at present show that the oxygen content of the ocean sea-water varies fairly consistently with the temperature of the water. It is lowest in summer and highest in the winter months. The summer average for surface water is approximately 5.0 c.c. per litre, whilst during the winter the amount rises to 5.6 c.c. per litre (Temperature 15.75°C., Cl. 19 gr. per 1,000 gr. water).

On no occasion has the ocean water been found supersaturated at our station. Unfortunately, no samples were analysed on the few occasions on which the phytoplankton reached its greatest points of development. It is too great a task at present to undertake more than a few activities at sea with a small ship and unprofessional crew, and the initial steps in oxygen determinations are not amongst the easiest things to carry out when the sea's movements are considerable. A further study of the seasonal variation in  $O_2$ ,  $CO_2$  and certain other substances will be undertaken at a future date, when we hope for greater facilities.

#### SUMMARY.

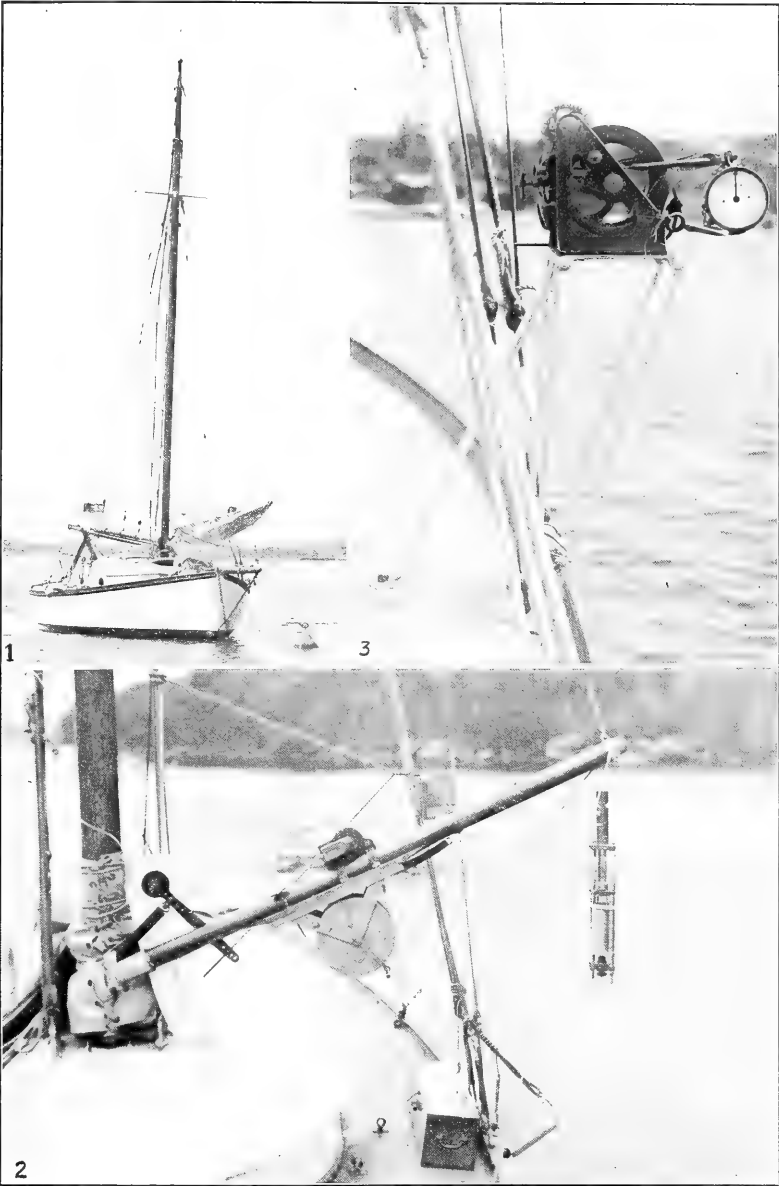
1. The paper sets out the results of a series of analyses of sea-water (temperature, chlorine, nitrate nitrogen, phosphate and oxygen) at the surface and at various depths at a station 3-4 miles off the coast of New South Wales. These observations are taken as giving a fair idea of the physico-chemical conditions prevailing in the sea-water of the continental shelf at the latitude of Sydney throughout the year.

2. The most important chemical investigations have been the tracing of the variations in nitrate nitrogen and phosphate during the year with a view to correlation with the biological conditions of the sea-water.

3. It has been discovered that the nitrate nitrogen and phosphates in these waters are present in what might be termed medium quantity, and that both substances undergo fluctuations which are definitely traceable to the influence of the plankton. The variations in nitrate and phosphate are not so extensive as those of English seas. It is possible, however, for great developments of phytoplankton, as in the spring, to reduce both nitrate and phosphate to zero. Usually the phosphate is fairly quickly regenerated in the surface waters. The nitrate nitrogen appears, however, to be more sensitive to the consuming plankton and is definitely at a minimum during summer months. Full details of the fluctuations are shown in the graphs.

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1.—Yacht "Thistle". 2.—Boom constructed for use of meter wheel.  
3.—Mounting of Lucas sounding machine.



REVISION OF AUSTRALIAN LEPIDOPTERA. OECOPHORIDAE. IV.

By A. JEFFERIS TURNER, M.D., F.R.E.S.

[Read 25th September, 1935.]

42. Gen. BAREA Wlk.

Wlk., xxix, p. 819; Meyr., Gen. Ins. Oecoph., p. 65. Type, *B. consignatella*.

Tongue present. Palpi with second joint reaching or exceeding base of antennae, thickened with appressed scales, smooth or slightly rough anteriorly; terminal joint shorter than second, slender or rather stout, acute. Antennae without basal pecten; ciliations in male very short, moderate, or long ( $\frac{1}{4}$  to 3). Thorax with a posterior crest. Forewings with 2 from angle or near it, separate, connate or stalked with 3, 7 to apex. Hindwings ovate or elongate-ovate; 5 from middle or below middle of cell.

A somewhat isolated genus of considerable size, confined to Australia, except one indigenous New Zealand species. Two Australian species (*B. atmophora* and *B. exarcha*) have been introduced into that region. The genus forms a compact whole, and should not be divided; the stalking of 2 and 3 of the forewings, usually a good generic character, should in this instance be regarded as only specific. Occasionally 7 of forewings runs to termen (as in the type of *B. chloreis*) in species in which it usually runs to the apex. Except in *B. sideritis*, in which there is an occasional scale, I have found the absence of a pecten to be absolute. From *Eulechria*, which many species resemble, it can be distinguished by this character and the thoracic crest. There would be no possibility of confusion, were it not that both these structures are liable to denudation. The genus is somewhat isolated, but I believe it to be derived from *Eucryphaea*, and that both genera entered Tasman Land from the south, and flourished there before this united with Austral Land to form Australia. *Barea* is most abundant in species in the rain-forests of the Eastern Cordillera, in the Australian Alps, and in Tasmania, but some species have established themselves in more typically Australian country. Only three are recorded from Western Australia.

Eighty-one species: 314, *cratista*, n. sp. (Toowoomba).—315, *hicanopa*, n. sp. (Stanthorpe).—316, *viduata* Meyr., *Exot. Micro.*, ii, p. 371, = *hermatopis* Meyr., *Arkiv f. Zool.*, xiv, (15), p. 7 (Duarina, Toowoomba, Mt. Tambourine).—317, *prepta*, n. sp. (Stanthorpe).—318, *leucocephala* Turn., *Tr.R.S.S.Aust.*, 1896, p. 18 (Atherton, Yeppoon to Sydney).—319, *psilon*, n. sp. (Bunya Mts., Macpherson Range, Allyn R.).—320, *euprepes* Turn., *ibid.*, 1896, p. 17 (Atherton, Bunya Mts., Brisbane, Tweed Heads).—321, *eucapnodes* Turn., *ibid.*, 1896, p. 16 (Atherton, Cairns to Allyn R.), = *trizyga* Meyr., *Exot. Micro.*, i, p. 169.—322, *semifixa* Meyr., *ibid.*, i, p. 298 (Cooktown to Tweed Heads, Toowoomba).—323, *sciaspila* Low., *Tr.R.S.S.Aust.*, 1904, p. 168 (Cape York, Duaringa).—324, *coeliota*, n. sp. (Dunk I.).—325, *ophiosticha*, n. sp. (Macpherson Range).—326, *dicranotypa*, n. sp. (Guyra, N.S.W.).—327, *basigramma* Turn., *ibid.*, 1896, p. 16 (Nambour, Brisbane, Tweed Heads).—328, *lampроза* Low., *ibid.*, 1923, p. 55 (Rockhampton to Dorrigo).—

329, *confusella* Wlk., xxix, p. 682; Meyr., Proc. LINN. Soc. N.S.W., 1883, p. 354 (Toowoomba, Lismore to Castlemaine).—330, *atmosphora* Turn., *ibid.*, 1916, p. 345 (Gisborne to Hobart; W.A.: Busselton).—331, *chlorobaphes*, n. sp. (Mt. Tambourine, Macpherson Range, Dorrigo).—332, *hylodroma* Turn., *ibid.*, 1916, p. 343 (Mt. Tambourine, Macpherson Range, Lismore).—333, *chloreis* Turn., *ibid.*, 1914, p. 561 (Macpherson Range, Ebor).—334, *bryopis*, n. sp. (Eungella, Macpherson Range, Lismore).—335, *poliobrya*, n. sp. (Atherton, Cairns, Eungella).—336, *phaulobrya*, n. sp. (Tweed Heads, Lismore).—337, *phacobrya*, n. sp. (Atherton).—338, *bryochroa* Turn., *ibid.*, 1916, p. 342 (Mt. Tambourine).—339 *subviridella* Turn., *Tr.R.S.S.Aust.*, 1896, p. 15 (Brisbane to Dorrigo), = *chlorozona* Low., *ibid.*, 1923, p. 54.—340, *consignatella* Wlk., xxix, p. 819 (Brisbane to Melbourne), = *pyrgonota* Meyr., Proc. LINN. Soc. N.S.W., 1888, p. 1564, = *melanospila* Turn., *Tr.R.S.S.Aust.*, 1896, p. 17.—341, *melanodelta* Meyr., Proc. LINN. Soc. N.S.W., 1883, p. 359 (Brisbane to Launceston).—342, *xanthoptera*, n. sp. (Tweed Heads, Macpherson Range, Lismore).—343, *synchyta* Meyr., *ibid.*, 1883, p. 355 (Tweed Heads, Macpherson Range, Sydney).—344, *aleuopasta*, n. sp. (Cairns).—345, *acritopis* Turn., *Tr.R.S.S.Aust.*, 1917, p. 116 (Brisbane, Tweed Heads).—346, *ptochica* Turn., *ibid.*, 1917, p. 117 (Mt. Tambourine).—347, *arrhythma* Turn., *ibid.*, 1917, p. 117 (Brisbane).—348, *disincta* Meyr., Proc. LINN. Soc. N.S.W., 1884, p. 788 (Toowoomba to Melbourne), = *strophopeda* Low., *Tr.R.S.S.Aust.*, 1914, p. 105.—349, *angusta*, n. sp. (Brisbane, Macpherson Range, Sydney).—350, *ectecta*, n. sp. (Mt. Kosciusko).—351, *graphica*, n. sp. (Mt. Kosciusko).—352, *zygophora* Meyr., Proc. LINN. Soc. N.S.W., 1888, p. 1592 (Brisbane to Sydney, Ebor, Barrington Tops), = *eusciastra* Turn., *ibid.*, 1916, p. 344.—353, *anerasta* Turn., *ibid.*, 1916, p. 344 (Cape York to Kiama).—354, *glaphyra*, n. sp. (Bunya Mts.).—355, *mesocentra* Meyr., *ibid.*, 1888, p. 1590 (Mt. Kosciusko).—356, *ochrospora*, n. sp. (Cairns to Mt. Wilson).—357, *panarcha* Turn., 1915, p. 193 (Macpherson Range, Lismore, Ebor).—358, *tanyptila*, n. sp. (Mt. Kosciusko).—359, *ectadia*, n. sp. (Killarney, 3,000 ft.).—360, *exarcha* Meyr., *ibid.*, 1883, p. 357 (Barrington Tops, Victoria, Tasmania, Mt. Gambier).—361, *asbolaea* Meyr., *ibid.*, 1883, p. 349 (Beaconsfield, Vic., Tasmania).—362, *hyperarcha* Meyr., *ibid.*, 1888, p. 1591 (Barrington Tops, Mt. Kosciusko, Victoria, Tasmania).—363, *orthoptila*, Low., *Tr.R.S.S.Aust.*, 1901, p. 87 (Melbourne).—†364, *lithoglypta* Meyr., Proc. LINN. Soc. N.S.W., 1883, p. 358 (Sydney).—365, *pissina*, n. sp. (Stanthorpe).—366, *ebenopa*, n. sp. (Tweed Heads).—367, *sideritis*, n. sp. (W.A.: Albany).—368, *micropis* Meyr., *ibid.*, 1888, p. 1593 (Mt. Kosciusko, Beaconsfield, Vic.).—369, *periodica* Meyr., *Exot. Micro.*, ii, p. 308 (Emerald, Q., Brisbane, Toowoomba, Macpherson Range).—370, *limpida*, n. sp. (Macpherson Range).—371, *pasteodes* Turn., Proc. LINN. Soc. N.S.W., 1914, p. 559 (Bunya Mts. to Beaconsfield, Vic.).—372, *nymphica* Turn., *ibid.*, 1916, p. 343 (Atherton to Lismore).—373, *psologramma* Turn., *ibid.*, 1916, p. 345 (Victoria, Tasmania).—374, *psephophora* Meyr., *ibid.*, 1883, p. 352 (Katoomba, Victoria, Tasmania).—375, *pyrora* Meyr., *Exot. Micro.*, i, p. 166 (Macpherson Range, Gosford, Mittagong).—376, *eophila* Turn., *Tr.R.S.S.Aust.*, 1918, p. 57 (Ebor).—377, *ceramodes*, n. sp. (Macpherson Range).—378, *zeugmatophora*, n. sp. (W.A.: Denmark).—379, *plestiocticta*, n. sp. (Eungella).—380, *bathrochorda*, n. sp. (Sydney).—381, *semocausta* Meyr., Proc. LINN. Soc. N.S.W., 1883, p. 350 (Victoria, Tasmania).—382, *banausa* Meyr., *ibid.*, 1883, p. 356 (Newcastle to Tasmania, Adelaide).—383, *epethistis* Meyr., *Tr.R.S.S.Aust.*, 1902, p. 154 (Macpherson Range, Lorne, Vic., Tasmania).—†384, *sphaeridias* Meyr., *Exot. Micro.*, i, p. 169 (Sydney).—385, *crassipalpis*, n. sp. (Bunya Mts.).—386,



*helica* Meyr., Proc. LINN. Soc. N.S.W., 1883, p. 351 (Tasmania), = *heterophanes* Turn., Proc.R.S.Tas., 1926, p. 143.—387, *platyochra*, n. sp. (Bunya Mts., Macpherson Range).—388, *arbitra* Meyr., Exot. Micro., i, p. 170 (Gisborne, Lorne, Zeehan).—389, *centropis* Meyr., Proc. LINN. Soc. N.S.W., 1888, p. 1592 (Dorrigo, Sydney, Robertson).—390, *umbrosa* Meyr., Exot. Micro., i, p. 167 (Tasmania), = *hypselotropha* Turn., Proc.R.S.Tas., 1926, p. 143.—391, *cyclopis* Meyr., Exot. Micro., i, p. 307 (Tweed Heads, Macpherson Range).—392, *turbatella* Wlk., xxix, p. 765; Meyr., Proc. LINN. Soc. N.S.W., 1883, p. 353 (Cairns to Melbourne, Milmerran, Q.).—†393, *fenicoma* Meyr., Exot. Micro., i, p. 170 (Mt. Kosciusko).—†394, *crypsicentra* Meyr., ibid., i, p. 170 (Mt. Lofty).

## 320. BAREA EUPREPES TURN.

I now consider this distinct from *B. eucapnodes* Turn. It differs in the white ground-colour without irroration, the strong expansion of first fascia on dorsum, the expansion of second fascia on costa, and the connection or approximation of the two fasciae beneath costa.

## 328. BAREA LAMPROTA LOW.

This and the two following species are nearly allied and agree in their short antennal ciliations ( $\frac{1}{2}$ ). *B. lamprota* is readily separated by its yellow (or at least ochreous) hindwings with pale fuscous suffusion at apex, together with the whitish fuscous-sprinkled forewings.

## 329. BAREA CONFUSELLA Wlk.

Characterized by the white forewings with little or no fuscous irroration, but heavy dark fuscous markings, and pale hindwings sometimes faintly ochreous.

## 330. BAREA ATMOPHORA TURN.

Meyrick considers this a geographical race of *B. confusella*, but I do not think so. The forewings are grey-whitish, heavily irrorated with fuscous, the hindwings uniform pale-grey.

## 363. BAREA ORTHOPTILA LOW.

I have examined the type.

## 345. BAREA ACRITOPIS TURN.

Correctly referred here by Meyrick. In this, together with *B. ptotchica* Turn. and *B. arrhythma* Turn., the male antennal ciliations are very short ( $\frac{1}{2}$ ). All have narrow forewings with vein 2 separate.

## 348. BAREA DISCINCTA MEYR.

Antennae without basal pecten; ciliations in male  $\frac{1}{2}$ . Thoracic crest present. Forewings with 2 and 3 separate.

## 369. BAREA PERIODICA MEYR.

This species, if I have identified it rightly, has the terminal joint of palpi stout as in *B. banausa* Meyr., *B. crassipalpis*, and several other species. The antennal ciliations in male are nearly 1.

## 371. BAREA PASTEODES TURN.

This and *B. nymphica* Turn. are closely similar, but the length of the antennal ciliations in the male is distinctive; in *pasteodes*  $3\frac{1}{2}$ , in *nymphica* 1.

314. *BAREA CRATISTA*, n. sp.

*κρατιστος*, very strong.

♂, ♀. 30-32 mm. Head whitish; posterior edge of crown blackish. Palpi with second joint exceeding base of antennae, terminal joint  $\frac{3}{4}$ ; ochreous-whitish, base of second joint dark fuscous. Antennae dark fuscous, towards apex grey; ciliations in male  $\frac{1}{2}$ . Thorax blackish; tegulae, except bases, and a posterior spot white. Abdomen ochreous; sides dark fuscous. Legs dark fuscous with ochreous rings. Forewings elongate, not dilated, costa slightly arched, apex round-pointed, termen slightly rounded, slightly oblique; 2 and 3 separate; white with blackish markings; an oblique fascia from costa near base broadening on dorsum from one-third to two-thirds; a second fascia from one-third costa, sometimes interrupted, confluent with first on fold; a third oblique fascia from two-thirds costa to tornus, giving off a slight inward projection in middle (representing second discal); a broad terminal fascia confluent with third towards tornus; terminal edge white; cilia ochreous-whitish, apices grey, on tornus grey, on apex blackish. Hindwings orange-ochreous; terminal area suffused with fuscous; cilia grey.

Near *B. viduata*.

Queensland: Toowoomba in October; two specimens received from Mr. W. B. Barnard, who has the type.

315. *BAREA HICANOPA*, n. sp.

*ικανωπος*, seemly.

♂. 25-26 mm. Head white. Palpi with second joint exceeding base of antennae, terminal joint four-fifths; white, base of second joint dark fuscous. Antennae fuscous with whitish annulations; ciliations in male 1. Thorax dark fuscous; apex of tegulae and a posterior spot white. Abdomen ochreous. Legs ochreous; anterior pair grey. Forewings elongate, not dilated, costa gently arched, apex round-pointed, termen oblique; 2 and 3 separate; white, more or less ochreous-tinged; markings blackish; a broad streak from base of costa along fold, joining a narrow transverse fascia at one-third; a slightly broader fascia from before two-thirds costa to tornus, where it divides and encloses a small tornal spot; a subapical fascia sometimes reaching posterior division of second fascia; cilia ochreous-whitish with incomplete fuscous bars. Hindwings dark grey; cilia ochreous, bases grey, on apex wholly grey.

Queensland: Maryland (N.S.W.), near Stanthorpe, in November; two specimens received from Mr. W. B. Barnard, who has the type.

317. *BAREA PREPTA*, n. sp.

*πρεπτος*, distinguished.

♀. 21 mm. Head white. Palpi with second joint exceeding base of antennae, terminal joint  $\frac{3}{4}$ ; dark fuscous, subterminal and apical rings and most of inner surface of second joint whitish. Antennae dark fuscous. Thorax blackish mixed with white except in centre. Abdomen dark fuscous; tuft and underside ochreous. Legs fuscous with ochreous rings; posterior pair mostly ochreous. Forewings rather narrow, suboval, costa moderately arched, apex round-pointed, termen obliquely rounded; 2 and 3 separate; blackish; markings whitish, on costa and termen tinged with ochreous; a basal costal spot; a curved fascia from near base of costa nearly to one-third dorsum; a second fascia from three-fifths costa to two-thirds dorsum, its edges irregular, sometimes united with first beneath costa; a third fascia, broad on costa at four-fifths, sinuate, narrowing to a point above tornus; a narrow terminal fascia not reaching tornus; cilia fuscous with

incomplete pale ochreous bars. Hindwings dark fuscous; cilia ochreous, bases dark fuscous.

Queensland: Maryland (N.S.W.), near Stanthorpe, in October and November; two specimens received from Mr. W. B. Barnard, who has the type.

319. *BAREA YPSILON*, n. sp.

(From the inverted  $v$  on forewings.)

♂, ♀. 16-24 mm. Head white, sometimes ochreous-tinged. Palpi with second joint reaching base of antennae, terminal joint three-fourths; whitish, basal two-thirds of second joint dark fuscous. Antennae fuscous; ciliations in male 1. Thorax dark fuscous; apices of tegulae and a large posterior spot white. Abdomen brown, sometimes partly suffused with fuscous; tuft whitish-ochreous. Legs fuscous with whitish-ochreous rings; middle tarsi and all posterior pair whitish-ochreous. Forewings not dilated, costa moderately arched, apex pointed, termen oblique; 2 and 3 stalked; white with fuscous markings; a basal costal dot; a costal spot at one-fourth, connected with preceding along costal edge, and usually in disc with anterior fascia; an oblique fascia from midcosta to one-third dorsum, dilated in margins; a second fascia from near base of first to tornus, often interrupted, broadly dilated before tornus; a third narrower, strongly sinuate fascia from costa before apex to tornus; a narrow marginal fascia on termen; cilia fuscous, apices white, on tornus white. Hindwings and cilia whitish-grey.

Queensland: Bunya Mts. in October and February; National Park (3,500 feet) and Springbrook (3,000 feet), in December. Seven specimens.

324. *BAREA COELIOTA*, n. sp.

κοιλιοτος, hollowed.

♂. 14 mm. Head with a circular hollow on vertex between antennae; pale brownish, posterior margin of crown and face grey. Palpi with second joint exceeding base of antennae, terminal joint three-fifths; pale fuscous, second joint with subapical and apical whitish rings. Antennae grey-whitish; ciliations in ♂ 1. Thorax whitish-grey. Abdomen whitish-ochreous-grey. Legs fuscous with whitish rings; posterior pair whitish. Forewings oval, costa moderately arched, apex rounded, termen very obliquely rounded; 2 and 3 separate; whitish; suffused fuscous costal spots at one-third, two-fifths, and before apex; a short basal subcostal line; stigmata dark fuscous, closely approximated, first discal at one-third, plical beneath it, second discal in middle, an additional dot below and before second; some fuscous suffusion above tornus; an ill-defined subterminal series of dots; cilia whitish. Hindwings and cilia pale grey.

The curious cephalic excavation is probably analogous to that found in some species of *Thudaca*.

North Queensland: Dunk Island in May; one specimen.

325. *BAREA OPHIOSTICHA*, n. sp.

ὄφιοστιχος, with serpentine line.

♂. 16-18 mm. Head whitish-ochreous. Palpi with second joint reaching base of antennae, terminal joint three-fifths; ochreous-whitish, basal half of second joint and a median ring on terminal joint fuscous. Antennae fuscous; ciliations in male 1. Thorax whitish; anterior edge dark fuscous. Abdomen brownish; apices of segments and tuft ochreous-whitish. Legs dark fuscous with whitish-ochreous rings; posterior pair whitish-ochreous. Forewings narrow, slightly dilated, costa slightly arched, apex pointed, termen oblique, slightly

rounded; 2 and 3 separate; whitish; markings dark fuscous; a thick streak from base of costa along fold to one-fourth, then curved sharply upwards and again downwards to beneath middle of disc, ending abruptly, or confluent with posterior line; the latter arises from a short bar on costa beyond middle and runs very obliquely and straight to termen above tornus; a large irregularly oval costal spot before apex; a few dark fuscous scales on termen; cilia whitish-ochreous. Hindwings pale grey, becoming whitish towards base; cilia pale grey, on tornus and dorsum whitish.

Nearest *B. basigramma*.

Queensland: National Park (3,000 feet), in October and November; two specimens.

326. *BAREA DICRANOTYPA*, n. sp.

*δικρανотυπος*, fork-marked.

♀. 16 mm. Head white. Palpi with terminal joint nearly 1; whitish. Antennae grey-whitish; basal joint fuscous. Thorax fuscous with a posterior white spot. Abdomen ochreous-whitish. Legs ochreous-whitish. Forewings narrow, costa slightly arched, apex pointed, termen very oblique; 2 and 3 separate; white; markings blackish; a streak from base of costa joining another from base of dorsum on fold, on which it is prolonged to two-fifths, there turned upwards and ending abruptly; a suffused interrupted fascia from three-fifths costa to tornus; a small subapical blotch extending from costa to termen; cilia white, on mid-termen and tornus fuscous. Hindwings and cilia whitish-grey.

Near *B. ophiosticha*.

New South Wales: Ben Lomond (4,500 feet), near Guyra, in February; one specimen.

331. *BAREA CHLOROBAPHES*, n. sp.

*χλωροβαφης*, suffused with green.

♂. 21-23 mm. Head white; lower half of face fuscous. Palpi with second joint exceeding base of antennae, terminal joint three-fifths; fuscous, second joint with subapical and apical rings and most of inner surface whitish. Antennae fuscous, basal joint white; ciliations in male  $3\frac{1}{2}$ . Thorax pale green; apices of patagia and a posterior spot white. Abdomen ochreous-whitish; apices of segments grey-whitish; tuft ochreous-grey-whitish. Legs fuscous with whitish rings; posterior pair ochreous-whitish. Forewings not dilated, costa moderately arched, apex round-pointed, termen slightly oblique; 2 and 3 stalked; whitish with suffused green fasciae often becoming fuscous on margins; first narrow, sub-basal; second from one-fourth costa to two-fifths dorsum; third broad, median, somewhat deficient in middle; fourth inwardly curved, from five-sixths costa to before tornus, confluent with preceding on dorsum, not always distinct; from fourth fascia beneath costa rises at a sharp angle an outwardly curved line to tornus; stigmata fuscous, first discal before one-third, plical beneath it, second discal slightly beyond middle; cilia grey, apices paler. Hindwings whitish with pale suffusion towards apex; cilia whitish.

The description of *B. chlorozona* Low. is partly based on a confusion with this species, but an example labelled by him, and presumably the type, is *B. subviridella* Turn.

Queensland: Mt. Tambourine, in November; National Park (3,000 feet), in November. New South Wales: Dorrigo. Six specimens.

334. *BAREA BRYOPIS*, n. sp.

*βρωπις*, mossy green.

♂, ♀. 22-23 mm. Head whitish; side-tufts wholly or partly fuscous. Palpi with second joint exceeding base of antennae, terminal joint three-fifths; fuscous with some whitish irroration, apex and inner surface of second joint whitish. Antennae grey; ciliations in male 1. Thorax whitish-green, tuft fuscous. Abdomen whitish; bases of segments brown; tuft ochreous-whitish. Legs fuscous with whitish rings; posterior pair mostly ochreous-whitish. Forewings not dilated, costa gently arched, apex rounded, termen obliquely rounded; 2 and 3 separate; green; markings dark fuscous, partly narrowly edged with white; a basal costal spot, which sometimes gives rise to a curved line to one-fifth dorsum; stigmata distinct, first discal at one-third, plical well beyond it, large, second discal before one-third, large, a dot between and in a line with discals; a pretornal spot; suffused costal spots before and after middle; a broad suffused fascia from costa before apex, not reaching tornus; cilia whitish with some fuscous irroration, bases more or less green. Hindwings pale grey; cilia whitish with a sub-basal pale grey line.

North Queensland: Eungella (2,000 feet), in September and October. Queensland: National Park (3,000 feet), in January. New South Wales: Lismore, in October. Seven specimens.

335. *BAREA POLIOBRYA*, n. sp.

*πολιοβρυος*, grey mossy.

♂. 18-21 mm. Head whitish; lower half of face fuscous or grey. Palpi with second joint reaching base of antennae, terminal joint three-fifths; fuscous, second joint with internal surface, apical ring, and sometimes a subapical ring, whitish. Antennae grey; ciliations in male 3. Thorax whitish-grey, sometimes greenish-tinged. Abdomen whitish-grey; bases of segments ochreous-brown. Legs fuscous with whitish rings; posterior pair ochreous-whitish. Forewings not dilated, costa gently arched, apex round-pointed, termen oblique; 2 and 3 approximated; whitish irrorated with grey-green; markings dark fuscous; basal costal and dorsal dots; small costal dots at two-fifths and four-fifths and sometimes a third before apex; stigmata small, first discal at one-third, plical before it, second discal rather larger, before two-thirds; sometimes a fine line from subapical spot, acutely angled inwards, then curved to tornus, not always traceable; cilia whitish-grey sometimes barred with fuscous. Hindwings and cilia grey-whitish.

North Queensland: Millaa-millaa and Ravenshoe near Herberton, in September; Malanda near Atherton, in September; Babinda near Innisfail, in September; Eungella, in October; ten specimens.

336. *BAREA PHAULOBRYA*, n. sp.

*φauλοβρυος*, shabbily mossy.

♂, ♀. 14-16 mm. Head pale fuscous. Palpi with second joint reaching base of antennae, terminal joint three-fourths; fuscous, second joint with apical and subapical rings and inner surface whitish. Antennae fuscous; ciliations in male 1. Thorax fuscous. Abdomen grey; tuft ochreous-whitish. Legs fuscous with ochreous-whitish rings; posterior pair mostly whitish-ochreous. Forewings narrow, costa gently arched, apex rounded, termen obliquely rounded; 2 and 3 connate or separate; green-whitish with fuscous irroration and markings; a darker suffused basal area; stigmata obscure, first discal at one-third, plical beneath it, second discal before two-thirds; an elongate costal spot beyond middle;

an inwardly oblique streak from costa before apex, sharply angled in disc and continued as a fine curved line to tornus; cilia fuscous, apices grey, on tornus grey. Hindwings and cilia pale grey.

Queensland: Coolangatta, in September. New South Wales: Lismore, in October. Six specimens, but all except type in poor condition.

337. *BAREA PHAEOBRYA*, n. sp.

*φαιοβρυος*, dark mossy.

♂, ♀. 18–22 mm. Head fuscous; in male face whitish. Palpi with second joint exceeding base of antennae, terminal joint three-fourths; fuscous; apex of second joint, median area of internal surface, and sometimes also of external surface, whitish. Antennae ochreous-whitish, towards base fuscous; ciliations in male 2½. Thorax fuscous; apices of tegulae and a posterior spot whitish. Abdomen ochreous-fuscous; apices of segments and tuft whitish. Forewings rather narrow, slightly dilated, costa moderately arched, apex pointed, termen oblique; 2 and 3 connate; pale green with much patchy fuscous suffusion; markings dark fuscous; a basal costal dot; a narrow, sometimes interrupted, oblique line from base of dorsum towards one-sixth costa; a costal spot at one-third, another larger beyond middle; a broad streak from five-sixths costa, inwardly oblique, acutely angled above middle, and often continued by a curved line to tornus; first discal at one-third, plical below or slightly before it, second discal slightly beyond middle; a terminal line; cilia grey with a fuscous sub-basal line. Hindwings and cilia grey.

Near *B. subviridella*, but that species lacks the basal line from dorsum and the subterminal line, while the antennal ciliations are shorter (1½).

North Queensland: Malanda near Atherton; Ravenshoe and Millaa-millaa near Herberton, in September; fourteen specimens.

342. *BAREA XANTHOPTERA*, n. sp.

*ξανθοπτερος*, yellow-winged.

♂, ♀. 18–20 mm. Head yellow. Palpi pale yellowish; basal two-thirds of second joint fuscous on external surface. Antennae grey, paler towards apex; in male thickened, ciliations 1. Thorax yellow; base of patagia fuscous. Abdomen pale ochreous. Legs pale ochreous; anterior pair, and to a less extent middle pair, fuscous on dorsum. Forewings moderate, posteriorly dilated, costa gently arched, apex rounded, termen obliquely rounded; 2 and 3 separate; yellow; markings fuscous; a rather broad costal streak to one-fourth; first discal at one-third, plical slightly before it, second discal before two-thirds connected with midcosta and tornus so as to form a suffused oblique fascia; a suffusion on dorsum before middle, sometimes connected by a suffused fascia with costal streak; a sub-terminal line strongly indented inwards beneath costa, sometimes broadly suffused; cilia yellow. Hindwings and cilia pale ochreous-grey.

Queensland: Coolangatta, in September; National Park (2,000–3,500 feet), in December and January; twelve specimens.

344. *BAREA ALEUROPASTA*, n. sp.

*ἀλευροπαστος*, sprinkled with flour.

♀. 16 mm. Head white. Palpi with second joint exceeding base of antennae, terminal joint three-fourths; whitish, base and a subapical ring on second joint, and terminal joint except base, fuscous. Antennae pale fuscous; basal joint white. Thorax white; bases of tegulae and some irroration fuscous. Abdomen grey; apices of segments whitish. Legs fuscous with whitish rings (posterior pair

missing). Forewings oval, costa gently arched, apex rounded, termen very obliquely rounded; 2 and 3 stalked; white with patchy suffusion and markings; a basal costal spot giving rise to an incomplete sub-basal fascia; a fuscous suffusion, including first discal and plical, confluent with a median dorsal spot; second discal at two-thirds; a suffused subapical costal spot and some suffusion before termen; cilia whitish. Hindwings and cilia grey-whitish.

North Queensland: Kuranda, in November; one specimen received from Mr. F. P. Dodd.

349. *BAREA ANGUSTA*, n. sp.

*angustus*, narrow.

♂, ♀. 15–20 mm. Head dark fuscous. Palpi with second joint reaching base of antennae, terminal joint four-fifths; fuscous with some grey-whitish irroration, especially on inner surface, apex of second joint whitish. Antennae fuscous; ciliations in male one-half. Thorax dark fuscous. Abdomen grey. Legs fuscous with whitish rings; posterior pair mostly whitish. Forewings narrow, not dilated, costa gently arched, apex rounded, termen obliquely rounded; 2 and 3 separate; grey-whitish irrorated with dark fuscous; markings dark fuscous; rather indefinite costal spots at one-third, two-thirds, and apex, the last enlarged, more clearly defined and with a sharp projection inwards in disc; first discal at one-third, plical before it, often approximated or fused with it, second discal before two-thirds; cilia grey with grey-whitish points, bases fuscous. Hindwings and cilia grey.

Queensland: Brisbane, in August; Toowoomba, in September. New South Wales: Sydney, in October.

350. *BAREA ECLECTA*, n. sp.

*ἐκλεκτος*, picked out.

♂. 25 mm. Head white. Palpi with second joint exceeding base of antennae, terminal joint three-fourths; white, base of second joint and terminal joint, except base, fuscous. Antennae white, finely annulated with fuscous; ciliations in male 1. Thorax fuscous mixed with white. Abdomen grey; apex of basal segment white; tuft whitish-ochreous. Legs fuscous with whitish rings; posterior pair mostly whitish. Forewings rather narrow, not dilated, costa moderately and evenly arched, apex rounded, termen obliquely rounded; 2 and 3 separate; white with a few scattered fuscous scales; a blackish spot on base of costa with some surrounding irroration; a fuscous spot on one-third costa, continued as a blackish curved fascia to one-fourth dorsum; second discal at three-fifths, rather large, blackish; two blackish dots before this, above and below middle; a suffused fuscous fascia from two-thirds costa to tornus, including second discal; a large fuscous apical spot with a few subterminal dots beneath it; cilia white with a few pale fuscous sub-basal points. Hindwings and cilia whitish.

Easily recognized by the white forewings with strong blackish antemedian fascia.

New South Wales: Mt. Kosciusko in December; one specimen received from Mr. G. M. Goldfinch, who has the type.

351. *BAREA GRAPHICA*, n. sp.

*γραφικος*, distinctly marked.

♂. 22–24 mm. Head grey. Palpi with second joint exceeding base of antennae, terminal joint one-half; fuscous, internal surface of second joint except

a subapical ring and apices of both joints whitish. Antennae grey; ciliations in male 2½. Thorax fuscous. Abdomen brown. Legs fuscous with whitish rings. Forewings dilated, costa moderately arched, apex rounded, termen obliquely rounded; 2 and 3 separate; whitish, much sprinkled with fuscous; markings dark fuscous; a moderate suffused basal patch; first discal connected with plical, which lies beneath, to form an irregular spot, sometimes connected with a costal spot at one-fourth and with one-third dorsum; second discal just beyond middle, connected with a median costal spot and with tornus; a subterminal line enlarged into a subapical costal spot, which is directed inwards, thence sharply angled and outwardly curved to tornus; cilia whitish; bases partly fuscous. Hindwings and cilia grey-whitish.

Near *B. zygophora*, but larger, more distinctly marked, and with long antennal ciliations.

New South Wales: Mt. Kosciusko (5,000 feet) in December and January; two specimens received from Mr. G. M. Goldfinch, who has the type.

354. *BAREA GLAPHYRA*, n. sp.

γλαφυρος, smooth.

♂. 19–20 mm. Head and thorax pale fuscous. Palpi with second joint exceeding base of antennae, thickened and slightly rough anteriorly, terminal joint three-fifths; whitish, external surface fuscous except apices of second and terminal joints. Antennae grey; ciliations in male 1. Abdomen pale grey; apices of segments whitish. Legs fuscous with whitish rings; posterior pair whitish. Forewings oval, rather narrow, costa rather strongly arched, apex rounded, termen obliquely rounded; 2 and 3 stalked; grey sparsely sprinkled with fuscous; markings dark fuscous; a small suffused basal fascia; first discal at one-fourth, second discal about middle, a dot midway between discals, separated from them by pale dots, plical linear, well before first discal; an indistinct curved series of dots from two-thirds costa to tornus; cilia grey-whitish with fuscous points. Hindwings and cilia grey-whitish.

Queensland: Bunya Mts., in November, December, and February; three specimens.

356. *BAREA OCHROSPORA*, n. sp.

ὤχροσπορος, pale-spotted.

♂. 18–24 mm. ♀. 21–30 mm. Head and thorax fuscous-brown. Palpi with second joint exceeding base of antennae, thickened and slightly rough anteriorly, terminal joint three-fifths; dark fuscous mixed with whitish, apices of second and terminal joints whitish. Antennae fuscous-brown; ciliations in male 1. Abdomen pale grey. Legs dark fuscous with whitish-ochreous rings; posterior tibiae mostly whitish-ochreous. Forewings suboval, costa moderately arched, apex rounded, termen obliquely rounded; 2 and 3 stalked; fuscous-brown; fine blackish interneural streaks in terminal area; stigmata blackish, first discal at one-fourth, plical beneath it, often elongated into a fine streak, second discal beyond middle, an additional dot between first and second; two pale dots between the three discals; cilia fuscous-brown, apices grey. Hindwings grey, becoming grey-whitish towards base; cilia grey-whitish, on apex grey.

North Queensland: Kuranda, in August; Malanda, in September. Queensland: National Park (3,000 feet), in October, November, and December; Mt. Tambourine, in November; Bunya Mts., in October and January. New South Wales: Lismore, in October; Mt. Wilson (3,000 feet), in November.



## 358. BAREA TANYPTILA, n. sp.

*τανυπτιλος*, long-winged.

♂. 27 mm. Head white. Palpi with second joint much exceeding base of antennae, terminal joint four-fifths; white, base of second joint fuscous. Antennae fuscous; ciliations in male 1. Thorax dark fuscous with a white posterior spot. Abdomen and legs fuscous. Forewings elongate, not dilated, costa slightly arched, apex rounded, termen obliquely rounded; 2 and 3 separate; white; markings dark fuscous; a small basal patch, a streak along fold to plical dot; first discal beyond one-third, plical beneath it, second discal at two-thirds, a dot midway between discals; an irregular fascia from three-fifths costa to tornus including second discal; a small apical blotch; cilia fuscous; on tornus white. Hindwings and cilia pale grey.

New South Wales: Mt. Kosciusko, in January; one specimen received from Mr. G. M. Goldfinch, who has the type.

## 359. BAREA ECTADIA, n. sp.

*εκταδιος*, stretched out.

♂. 34 mm. Head white. Palpi with second joint reaching base of antennae, terminal joint two-thirds, stout; base and a subapical band on second joint, and a subapical ring on terminal joint, fuscous. Antennae fuscous; ciliations in male 4. Thorax white; bases of tegulae blackish. Abdomen whitish-grey. Legs dark fuscous with whitish rings; posterior tibiae whitish. Forewings elongate, not dilated, costa gently arched, apex rounded, termen obliquely rounded; 2 and 3 separate; whitish with patchy fuscous suffusion; markings dark fuscous; a short streak from base of costa; a short transverse line from one-fourth dorsum; suffused fuscous bands before and beyond middle and before termen; stigmata large, first discal at one-third, obliquely oval, plical slightly before it, longitudinally oval, second discal before two-thirds, transversely elongate; a terminal series of whitish dots; cilia fuscous, on tornus grey. Hindwings and cilia grey.

New South Wales: Acacia Plateau (3,000 feet), near Killarney (Queensland), in January; one specimen received from Mr. E. J. Dumigan.

## 365. BAREA PISSINA, n. sp.

*πισσιγος*, black as pitch.

♂. 20 mm. Head black; face grey-whitish. Palpi with second joint exceeding base of antennae, terminal joint two-thirds, fairly slender; black, apices of second and terminal joints narrowly white. Antennae blackish; ciliations in male one-half. Thorax black, apex of tegulae white. Abdomen pale grey; tuft whitish. Legs blackish with white rings; posterior pair grey. Forewings rather narrow, suboblong, costa slightly arched, apex rounded, termen obliquely rounded; 2 and 3 separate; black with patchy white irroration and markings; a small basal spot and another on dorsum; a dorsal spot or suffusion at three-fifths; some discal suffusion, in which are black discal spots before and after middle; a spot on three-fifths costa connected by a wavy line with tornus; cilia grey-whitish with black points. Hindwings and cilia grey.

Queensland: Maryland (N.S.W.) near Stanthorpe, in December; one specimen received from Mr. W. B. Barnard.

## 366. BAREA EBENOPA, n. sp.

*εβενωπος*, black as ebony.

♂. 24 mm. Head and thorax blackish. Palpi with second joint exceeding base of antennae, terminal joint two-thirds, fairly slender; blackish, inner surface

and anterior edge of second joint grey. Antennae blackish; ciliations in male two-thirds. Abdomen grey. Legs blackish with whitish rings; posterior pair mostly whitish. Forewings suboblong, slightly dilated, costa moderately arched, apex rounded, termen straight, not oblique, rounded beneath; 2 and 3 stalked; blackish with thinly scattered whitish points; stigmata black, obscure, first discal at one-third, plical beneath it, second discal before two-thirds; cilia blackish. Hindwings and cilia grey.

Not such an intense black as *B. pissina*, forewings without white markings, their shape and neuriation different.

Queensland: Maryland (N.S.W.) near Stanthorpe, in October and November; two specimens received from Mr. W. B. Barnard, who has the type.

367. *BAREA SIDERITIS*, n. sp.

*sideritis*, made of steel.

♂. 20-23 mm. Head brown. Palpi with second joint exceeding base of antennae, thickened and rough anteriorly, terminal joint three-fourths; whitish with fuscous irroration, external surface of second joint except apex fuscous. Antennae fuscous; ciliations in male 1. Thorax fuscous mixed with grey-whitish. Abdomen fuscous; bases of last four segments ochreous-brown; apices of segments and tuft whitish-grey. Legs dark fuscous; with whitish rings. Forewings scarcely dilated, costa gently arched, apex rounded, termen obliquely rounded; 2 and 3 separate; grey-whitish with fuscous irroration without any brownish tinge; markings dark fuscous; an ill-defined narrow basal fascia; first discal at one-third, plical just before it, second discal just beyond middle, a dot between and in a line with discals, separated from them by white dots; suffused ill-defined spots on costa at two-thirds and tornus; a broad streak from costa before apex, inwardly oblique, angled in disc, and thence curved to tornus; cilia grey-whitish with fuscous points. Hindwings and cilia grey.

Without any brown tinge except on head. In all other species of *Barea* I have found the absence of a pecten absolute; in this only have I observed one or two pectinal scales in some examples.

Western Australia: Albany and Denmark in March; ten specimens received from Mr. W. B. Barnard, who has the type.

370. *BAREA LIMPIDA*, n. sp.

*limpidus*, clear.

♂, ♀. 16-18 mm. Head and thorax whitish. Palpi with second joint reaching base of antennae, terminal joint three-fifths; whitish, outer surface of second joint except apex fuscous. Antennae whitish, sometimes with fuscous annulations; ciliations in male 2. Abdomen whitish-ochreous. Legs fuscous with ochreous-whitish rings; posterior pair ochreous-whitish. Forewings moderate, somewhat dilated, costa moderately arched, apex pointed, termen very obliquely rounded; 2 and 3 connate; whitish with some grey irroration; blackish dots at base of costa and dorsum; a very short slender subcostal streak from base; small fuscous costal spots at one-third, before two-thirds, and before apex; the first connected with a short blackish subcostal streak, the last giving rise to a slender line, indented beneath costa, to tornus; stigmata blackish, first discal at one-third, plical beneath it, second discal at two-thirds, double; cilia whitish. Hindwings whitish with some grey suffusion towards apex; cilia whitish.

Queensland: National Park (3,000 feet), in October and November; four specimens.

377. *BAREA CERAMODES*, n. sp.

*κεραμωδης*, clay-coloured.

♂, ♀. 22 mm. Head pale brown. Palpi with second joint exceeding base of antennae, terminal joint three-fourths, stout; fuscous. Antennae grey; ciliations in male two-thirds. Thorax brown, partly mixed with fuscous. Abdomen pale ochreous-grey. Legs fuscous with whitish-ochreous rings; posterior pair mostly whitish-ochreous. Forewings rather narrow, suboblong, costa moderately arched, apex rounded, termen obliquely rounded; 2 and 3 separate; pale brown unevenly sprinkled with fuscous; markings dark fuscous; a dot on base of costa and another more elongate on base of dorsum; triangular costal spots at two-fifths and three-fifths; suffused dorsal spots at one-third and tornus; stigmata rather obscure, plical lost in dorsal spot, first discal at one-third, second before two-thirds, a dot above and between them; an apical blotch confluent with tornal spot, sometimes narrowly separate from termen, leaving a terminal series of dots; cilia grey, bases barred with fuscous and pale brown. Hindwings and cilia whitish-grey.

Queensland: Springbrook, in October; two specimens received from Mr. W. B. Barnard, who has the type.

378. *BAREA ZEUGMATOPHORA*, n. sp.

*ζευγματοφορος*, with conjoint spots.

♂, ♀. 22–26 mm. Head ochreous-whitish. Palpi with second joint much exceeding base of antennae, terminal joint three-fifths; base and a subapical ring on second joint, and a broad median ring on terminal joint fuscous. Antennae ochreous-whitish, near base fuscous; ciliations in male three-fourths. Thorax ochreous-whitish, bases of tegulae and of tuft fuscous. Abdomen whitish-grey. Legs fuscous with ochreous-whitish rings; posterior pair mostly ochreous-whitish. Forewings slightly dilated, costa slightly arched, apex rounded-rectangular, termen nearly straight, slightly oblique; 2 and 3 connate or separate; ochreous-whitish with slight fuscous irroration; markings dark fuscous; suffused basal spots on costa and dorsum; first discal at one-third, plical before it, often enlarged and closely approximated, second discal before two-thirds, pale-centred; costal spots beyond middle and before apex, from the latter a fine line of dots to tornus, acutely angled inwards beneath costa, but sometimes this portion is obsolete; cilia pale grey, sometimes with obscure basal fuscous bars. Hindwings and cilia grey-whitish.

Western Australia: Denmark, in March and April; seven specimens received from Mr. W. B. Barnard, who has the type.

379. *BAREA PLESIOSTICTA*, n. sp.

*πλησιοστικτος*, with approximated spots.

♂, ♀. 24–26 mm. Head brownish. Palpi with second joint exceeding base of antennae, terminal joint three-fourths; whitish, basal half and a subapical bar on second joint, and basal half of terminal joint, dark fuscous. Antennae brownish, towards base annulated with fuscous; ciliations in male 2. Thorax fuscous-brown; apices of tegulae whitish. Abdomen pale grey. Legs fuscous with whitish rings; posterior pair ochreous-whitish. Forewings slightly dilated, costa gently arched, apex rounded, termen slightly rounded, slightly oblique; 2 and 3 separate; brown-whitish with some fuscous irroration; faint suffused costal spots at one-fourth, beyond middle, and before apex, not always present, from the last a curved line

of spots to tornus, often indistinct; stigmata dark fuscous, elongate longitudinally, first discal beyond one-third, plical well before it, second discal before two-thirds, nearly approximated to first; cilia whitish-grey. Hindwings and cilia whitish-grey.

North Queensland: Eungella in October; three specimens.

380. *BAREA BATHROCHORDA*, n. sp.

*βαθροχόρδος*, with basal cord.

♂. 23 mm. Head brownish. Palpi with second joint exceeding base of antennae, rather stout and rough anteriorly, terminal joint three-fifths; whitish with dark fuscous irroration, terminal joint and a subapical ring on second dark fuscous. Antennae brownish with blackish annulations; ciliations in male 2. Thorax brown. Abdomen pale ochreous. Legs fuscous with ochreous-whitish rings; posterior pair ochreous-whitish. Forewings dilated, costa gently arched, apex rounded, termen obliquely rounded; 2 and 3 stalked; brown; a broad dark fuscous streak from base of costa along fold to one-fourth, ending abruptly before first discal, its apex formed by the plical stigma; discals dark fuscous, rather large, rounded, first at one-third, second before two-thirds, an additional spot between and in a line with them; indications of a subterminal line from costa, acutely angled inwards beneath costa, thence fine and indistinct to tornus; cilia brownish with some fuscous points, apices ochreous-whitish. Hindwings and cilia grey-whitish.

Very distinct by the broad basal streak and large discal spots.

New South Wales: Sydney (Galston), in August; one specimen received from Mr. G. M. Goldfinch, who has the type.

385. *BAREA CRASSIPALPIS*, n. sp.

*crassipalpis*, with thick palpi.

♂. 20-25 mm. Head fuscous-brown. Palpi with terminal joint stout, acute, brown-whitish with blackish irroration; terminal joint except base and apex blackish. Antennae fuscous; ciliations in male nearly 1. Thorax fuscous, paler posteriorly. Abdomen fuscous; apices of segments and tuft grey-whitish. Legs fuscous with whitish rings, which are broader in posterior pair. Forewings elongate, not dilated, costa rather strongly arched, apex rounded, termen obliquely rounded; 2 and 3 stalked; fuscous or fuscous-brown mottled with suffused paler areas; a blackish longitudinal line above middle from one-third to two-thirds, containing a brown-whitish dot near anterior end, another more distinct in middle of disc ending in a similar dot; a short blackish line on fold slightly before median line; ill-defined fuscous spots on costa at one-fourth and middle; a series of fuscous streaks of some length on veins before termen, preceded by pale streaks; cilia brown-whitish, bases mixed with fuscous. Hindwings grey, paler towards base; cilia grey-whitish, bases mixed with grey.

Near *B. periodica* Meyr., but forewings not dilated and without subterminal series of pale dots. Also near *B. ochrospora* Turn., but darker, line from base of costa not defined, and with much better defined markings in terminal area.

Queensland: Bunya Mts. (3,500 feet), in February and March; two specimens.

387. *BAREA PLATYOCHRA*, n. sp.

*πλατυώχρος*, broadly pale.

♂, ♀. 15-20 mm. Head fuscous; face paler. Palpi ochreous-whitish irrorated with dark fuscous. Antennae grey; ciliations in male 1. Thorax and abdomen fuscous. Legs fuscous with ochreous-whitish rings; posterior pair ochreous-whitish.

Forewings somewhat dilated, costa moderately arched, apex pointed, termen very obliquely rounded; 2 and 3 separate; ochreous-whitish, rather densely but unevenly irrorated with fuscous; a dark fuscous discal dot at one-third, a second beneath it on fold, a third in middle, a fourth at two-thirds; darker suffusions on costa at three-fifths and apex; between these is a pale broad fascia bent inwards below middle, and enveloping a fuscous spot on dorsum before tornus; the lower part of this fascia may be partly or wholly suffused with fuscous, leaving a clear margin round dorsal spot; cilia ochreous-whitish sprinkled with fuscous. Hindwings and cilia pale grey.

In the forewings vein 7 ends beneath apex, yet I cannot regard the species as other than a *Barea*; it is, in fact, nearly allied to *B. helica*.

Queensland: National Park (3,000 feet) and Bunya Mts. (3,500 feet), in October and November; eight specimens.

#### 43. Gen. EUCRYPHAEA, n.g.

εὐκρυφαίος, well hidden.

Tongue present. Palpi with second joint exceeding base of antennae, much thickened with appressed scales, slightly rough anteriorly, but not more so towards apex; terminal joint shorter than second, rather stout, acute. Antennae with basal pecten; in male moderately ciliated. Thorax with strong posterior crest. Forewings with 2 from angle, 7 to apex. Hindwings ovate; 5 from below middle.

The only known species in form, pattern, and coloration suggests a close connection with *Barea*, from which it differs only in the antennal pecten.

388, *phoenochyta* Turn., *P.R.S.Tas.*, 1926, p. 141 (Tasmania).

(In one of my examples of this species, 7 and 8 of forewing are coincident on one side only.)

#### 44. Gen. IOPTERA Meyr.

PROC. LINN. SOC. N.S.W., 1883, p. 344. Type, *I. aristogona* Meyr.

Tongue present. Palpi with second joint reaching or exceeding base of antennae, more or less thickened, especially in ♂, with loosely appressed hairs, dilated, and sometimes with a small tuft at apex; terminal joint shorter than second, slender, acute. Antennae with basal pecten; ciliations in male moderate or long. Forewings with 7 to apex. Hindwings elongate-ovate; neuration normal. The sexual variation in the scaling of the palpi is an unusual character.

Four species: 389, *distincta*, n. sp. (Birchip).—390, *aristogona* Meyr., Proc. LINN. SOC. N.S.W., 1883, p. 345 (Newcastle to Tasmania).—391, *demica* Meyr., *ibid.*, 1888, p. 1589 (Victoria, Tasmania, Adelaide).—†392, *xenica* Meyr., *Exot. Micro.*, i, p. 157 (Hoyleton, S.A.).

#### 389. IOPTERA DISTINCTA, n. sp.

*distinctus*, easily separable.

♂. 24 mm. Head ochreous-whitish. Palpi with a moderately long tuft of hairs on apex of second joint beneath; fuscous, apex of second joint ochreous-whitish. Antennae fuscous; ciliations in male 1. Thorax dark fuscous. Abdomen fuscous. Legs fuscous; rings on tibiae and tarsi and dorsum of posterior tibiae ochreous-whitish. Forewings narrow, posteriorly dilated, costa straight, apex rounded, termen obliquely rounded; ochreous-whitish with dark fuscous markings, a moderately broad costal streak from base to five-sixths; first discal before one-third, plical before it, second discal before two-thirds, both discals touching

costal streak, an interrupted line around apex and termen; cilia ochreous-whitish. Hindwings and cilia whitish.

The well-marked tuft on palpi differs from the slight projection present in other species, but does not justify generic separation.

Victoria: Birchip, in November; one specimen in Coll. Lyell.

45. Gen. PHRICONYMA Meyr.

PROC. LINN. SOC. N.S.W., 1883, p. 340. Type, *P. lucifuga* Meyr.

Palpi with second joint reaching base of antennae, thickened with dense scales roughly expanded beneath towards apex; terminal joint shorter than second, moderately stout, acute. Forewings with 7 to apex. Hindwings elongate-ovate; neuration normal.

Restricted to one species, which I have not seen. The others referred here in the *Genera Insectorum* will be found under *Pachybela* Turn.

†390, *lucifuga* Meyr., PROC. LINN. SOC. N.S.W., 1883, p. 340 (Katoomba).

46. Gen. BATHYDOXA, n.g.

*βαθυδοξος*, far-famed.

Tongue strong. Palpi very long; second joint three times length of face, thickened with appressed scales, slightly rough anteriorly; terminal joint shorter, slender, acute. Antennae without basal pecten; in male moderately ciliated. Thorax smooth. Forewings with 7 to apex. Hindwings normal.

Distinguished by the very long palpi together with the absence of antennal pecten. Type, *B. euxesta*.

391. BATHYDOXA EUXESTA, n. sp.

*εὐξέστος*, smooth.

♂, ♀. 24-30 mm. Head grey. Palpi grey, rather densely sprinkled with whitish. Antennae grey; ciliations in male  $1\frac{1}{2}$ . Thorax grey; tegulae fuscous. Abdomen pale ochreous-grey. Legs pale grey. Forewings elongate, costa rather strongly arched, apex pointed, termen straight, oblique; grey; costal edge grey-whitish; a blackish subcostal streak from base of costa to one-fourth; a broader subdorsal streak from base to three-fourths; discal stigmata represented by a fine longitudinal streak, sometimes interrupted, edged beneath with whitish; cilia grey. Hindwings grey, towards base paler; cilia grey.

Queensland: Brisbane; Toowoomba, in December and February. New South Wales: Mittagong, in December. Five specimens.

392. BATHYDOXA TENUISTRIA, n. sp.

*tenuistrius*, finely streaked.

♂. 30 mm. Head and face fuscous with fine lateral white lines. Palpi rather densely sprinkled with whitish. Antennae fuscous; ciliations in male  $1\frac{1}{2}$ . Thorax fuscous with fine central and lateral white lines. Abdomen ochreous-fuscous, apices of segments grey-whitish. Legs fuscous; inner surface whitish; posterior pair whitish. Forewings elongate, narrow, costa moderately arched, apex pointed, termen very oblique; fuscous, with numerous fine white longitudinal streaks; these are closely applied so as to form costal median and dorsal bundles; from end of cell these are replaced by two broad bundles, first to apex end of costa, second to lower two-thirds of termen; cilia grey traversed by extremities of the white streaks. Hindwings and cilia grey.

Queensland: Toowoomba, in November; one specimen received from Mr. W. B. Barnard, who has the type.

## 48. Gen. LOCHEUTIS Meyr.

PROC. LINN. SOC. N.S.W., 1883, p. 341. Type, *L. philodora*.

Tongue present. Palpi slender; second joint reaching or exceeding base of antennae, with appressed scales, slightly rough anteriorly; terminal joint shorter than second, slender, acute. Antennae without basal pecten; in male with tufts of long cilia. Thorax without crest. Forewings with 7 to apex. Hindwings elongate-ovate; 5 sometimes approximated to 6 at or after origin.

The neuration of the hindwings is variable. Meyrick records also one species from New Zealand and one from Ceylon.

Six species: 393, *philochora* Meyr., Proc. LINN. SOC. N.S.W., 1883, p. 342 (Deloraine, Tas.).—394, *myrophenges*, n. sp. (Burnie, Tas.).—395, *desmophora* Meyr., *ibid.*, 1883, p. 343 (Mt. Wellington).—396, *periscia* Meyr., *ibid.*, 1888, p. 1589 (Launceston, Campbelltown).—397, *dolichotricha* Turn., *P.R.S.Tas.*, 1926, p. 140 (Mt. Wellington).—398, *inconcinna* Turn., *ibid.*, 1926, p. 141 (Mt. Wellington).

## 394. LOCHEUTIS MYROPHENGES, n. sp.

μυροφειγγης, shining with oil.

♂. 16 mm. Head whitish. Palpi with second joint reaching base of antennae, terminal joint three-fifths; whitish, base of second joint and anterior edge of terminal joint fuscous. Antennae fuscous; ciliations in male 2. Thorax fuscous; tegulae whitish. Abdomen grey. Legs fuscous with whitish rings; posterior tibiae grey-whitish. Forewings narrow, dilated, costa gently arched, apex round-pointed, termen obliquely rounded; shining grey-whitish; markings and some scattered scales blackish; a subcostal streak from base of costa to costa at one-third; a dot on base of dorsum; first discal at one-third, plical before it, second discal at three-fifths; a spot on two-thirds costa connected by a fine line with first discal, plical, and dorsum at one-third; a subterminal series of dots; a fine terminal line not reaching tornus; cilia grey-whitish barred with fuscous except towards tornus. Hindwings and cilia grey.

Tasmania: Burnie in January; one specimen.

## 49. Gen. UTIDANA, n.g.

ούτιδανος, insignificant.

Tongue present. Palpi moderately long, recurved, ascending; second joint not reaching base of antennae; terminal joint as long as second, stout, moderately acute. Antennae without basal pecten; in male with very long ciliations. Posterior tibiae very shortly rough-haired on dorsum. Forewings with 2 from well before angle, 7 to apex. Hindwings lanceolate; 3 and 4 connate, 5 from middle of cell.

Type, *U. pleurostigma*. The palpi are distinctive.

## 399. UTIDANA PLEUROSTIGMA, n. sp.

πλευροστιγμος, with costal spots.

♂, ♀. 10 mm. Head pale ochreous. Palpi pale ochreous; outer surface of second joint, except apex and an antemedian ring, and apex of terminal joint fuscous. Antennae pale ochreous annulated with fuscous; ciliations in male 8. Thorax fuscous. Abdomen grey. Legs fuscous with ochreous rings; posterior pair ochreous-whitish. Forewings narrow, costa gently arched, apex pointed, termen only slightly rounded, oblique; pale ochreous slightly sprinkled with fuscous; markings fuscous; first discal at one-third, plical beneath it, second

discal before two-thirds; a somewhat elongate rather suffused costal spot at two-thirds; cilia pale ochreous. Hindwings and cilia pale grey.

Queensland: Brisbane in March; two specimens.

400. *UTIDANA CALAMAEA*, n. sp.

*καλαμαίος*, straw-coloured.

♂. 12-14 mm. Head and thorax whitish-brown. Palpi whitish-brown, second joint except apex fuscous. Antennae pale grey; ciliations in male 8. Abdomen whitish-grey; tuft whitish-ochreous. Legs fuscous-brown. Forewings narrow, costa slightly arched, apex rounded, termen obliquely rounded; whitish-brown; discals blackish, first at one-fourth, plical beyond it, second beyond middle; some fuscous-brown scales on veins in terminal area; cilia whitish-brown. Hindwings whitish-grey; cilia whitish.

Queensland: Bunya Mts. (3,000 feet), in January; Killarney, in November; four specimens.

50. Gen. *ALLODAPICA*, n.g.

*ἀλλοδαπικός*, strange, foreign.

Tongue present. Palpi moderately long; second joint reaching base of antennae, thickened with smoothly appressed scales; terminal joint shorter than second, slender, acute. Antennae without basal pecten; ciliations in male moderate or rather long. Thorax smooth. Posterior tibiae with long hairs on dorsum. Forewings with 2 from near angle, 7 to apex. Hindwings elongate-ovate; 3 and 4 connate, 5 approximated to 6 at origin, 7 and 8 separate, at first parallel, then diverging.

Type, *A. lechriosema*. Exceptional in the family by the origin of 5 in the hindwings. In this it is similar to *Scotodryas*, and there may be real relationship.

Two species: 401, *steriphota* Meyr., *Exot. Micro.*, i, p. 163 (1914) (Brisbane; Barrington Tops) = *eutheta* Turn., *Proc. Linn. Soc. N.S.W.*, 1916, p. 357 (Bull).—402, *lechriosema* Turn., *P.R.S.Q.*, 1919, p. 147 (Mt. Tambourine, Macpherson Range, Beaconsfield, Vic.).

51. Gen. *HELIOSTERES*, n.g.

*ἠλιοστέρης*, shading from the sun.

Tongue present. Palpi long, recurved, ascending; second joint reaching base of antennae, thickened with appressed scales, slightly rough anteriorly; terminal joint shorter than second, slender, acute. Antennae with basal pecten; ciliations in male long. Thorax smooth. Forewings with 2 and 3 stalked, 7 and 8 coincident, running to costa. Hindwings elongate-ovate; neuration normal.

Apparently a development of *Elaeonoma*.

403. *HELIOSTERES PLEUROSPILA*, n. sp.

*πλευροσπίλος*, with costal spots.

♂. 17 mm. Head and thorax brown. Palpi with terminal joint three-fifths; brown, outer surface of second joint except apex fuscous. Antennae brown; ciliations in male 2½. Abdomen grey; tuft brownish. Legs fuscous with whitish-ochreous rings; posterior pair mostly whitish-ochreous. Forewings dilated, costa moderately arched, apex rounded, termen oblique; rather pale brown; markings and some irroration fuscous; first discal at one-third, plical beyond it, second discal before two-thirds; a moderately large spot on two-thirds costa; some fuscous suffusion between this and tornus, and on dorsum before tornus; a second costal



spot before apex; cilia pale brown with a fuscous median line. Hindwings and cilia pale grey.

North Queensland: Malanda near Atherton, in September; one specimen.

52. Gen. ACTENOTIS, n.g.

*ἀκτενωτίς*, uncombed.

Tongue present. Palpi long, slender, recurved; second joint reaching base of antennae; terminal joint shorter than second. Antennae without basal pecten; in male shortly ciliated. Forewings with 2 and 3 stalked, 7 and 8 stalked, 7 to apex. Hindwings with 5 from below middle of cell.

Differs from *Elaeonoma* only in the absence of an antennal pecten.

404. ACTENOTIS DIASEMA, n. sp.

*διασημος*, very distinct.

♂. 20–22 mm. Head and thorax brown. Palpi with terminal joint two-thirds; pale brownish. Antennae whitish-brown; ciliations in male two-thirds. Abdomen whitish-grey. Legs pale brown; posterior pair whitish. Forewings oval, costa rather strongly arched, apex pointed, termen very obliquely rounded; pale brown; markings fuscous-brown; a fine streak along fold to one-third; commencing above its posterior end a longitudinal streak through disc to apex, slightly angled and thickened at two-thirds; a slender marginal line from one-fourth dorsum to beyond tornus; a series of dots on apical fourth of costa and upper part of termen; cilia pale brown. Hindwings and cilia grey-whitish.

Queensland: National Park (3,500–4,000 feet), in December and January; four specimens.

53. Gen. ELAEONOMA MEYR.

*Exot. Micro.*, i, p. 238 (1914). Type, *E. deltacostamela* Low.

Tongue well developed. Palpi ascending, recurved; second joint reaching or exceeding, or rarely not reaching, base of antennae, more or less thickened with appressed scales, sometimes rough anteriorly, rarely slightly expanded at apex; terminal joint shorter than second, slender. Antennae with basal pecten; in male with moderate or long ciliations. Forewings with 2 and 3 stalked, 7 and 8 stalked, 7 to apex. Hindwings with 5 from middle or below middle of cell.

Differs from *Eulechria* in the stalking of 2 and 3 of forewings. In *Eulechria* these veins may be nearly approximated or even connate. Besides the species enumerated below one has been recorded from Lord Howe Island, two from New Guinea, and two from Ceylon. In Australia the great majority of the species occur on or near the north-east coast and are found among rain-forest. A few occur in the south, and three have been recorded from Western Australia. This suggests that the genus has a Papuan origin; and if a direct development of *Eulechria*, as appears probable, that genus must have reached the Papuan region early. As with other genera of the family, there is always a permissible doubt whether it is monophyletic.

Twenty-eight species: 405, *dolicha*, n. sp. (Birchip).—406, *icmaea* Meyr., *Exot. Micro.*, i, p. 299 (Mackay, Toowoomba, Sydney).—407, *fumea*, n. sp. (Adelaide).—408, *chromatica*, n. sp. (Cape York).—409, *anisochroa*, n. sp. (Bunya Mts., Allyn R.).—410, *hemiochra*, n. sp. (Cape York).—411, *polytypa*, n. sp. (Cape York).—412, *tetraspila*, n. sp. (Milmerran).—413, *citritis*, n. sp. (W.A.: Perth).—414, *ochrocrana*, n. sp. (Macpherson Range).—415, *eucryphaea*, n. sp. (Macpherson Range, Killarney).—416, *acrophaea* Turn., Proc. Linn. Soc. N.S.W., 1916, p. 349

(Nambour to Lismore, Bunya Mts.).—417, *adocima*, n. sp. (Cairns to Macpherson Range).—418, *cirrhosis* Turn., *P.R.S.Tas.*, 1926, p. 145 (Tasmania).—419, *hyperopta* Meyr., *PROC. LINN. Soc. N.S.W.*, 1888, p. 1586 (Beaconsfield, Vic.; Albany, W.A.).—420, *fuliginosa*, n. sp. (Atherton).—421, *silvicola* Turn., *Tr.R.S.S.Aust.*, 1898, p. 206 (Tweed Heads, Mt. Tambourine, Macpherson Range).—422, *conia*, n. sp. (Cape York).—423, *phaulostola*, n. sp. (W.A.: Perth).—424, *deltacostamela* Low., *ibid.*, 1896, p. 165 (Duaringa) = *pidodes* Meyr., *ibid.*, 1902, p. 148.—425, *eucrypta* Turn., *PROC. LINN. Soc. N.S.W.*, 1916, p. 363 (Adavale, Q.).—426, *psammophanes*, n. sp. (Cairns).—427, *eburnea*, n. sp. (Cairns).—428, *homoconia* Turn., *P.R.S.Tas.*, 1926, p. 142 (Tasmanian Mts.).—429, *galactina* Turn., *ibid.*, 1916, p. 362 (Cairns, Atherton, Mackay, Yeppoon).—430, *aleuritidis*, n. sp. (Yeppoon, Toowoomba).—431, *silvestris* Turn., *Tr.R.S.S.Aust.*, 1917, p. 81 (Nambour to Lismore) = *lenita* Meyr., *Exot. Micro.*, ii, p. 308.—432, *lathraea* Turn., *PROC. LINN. Soc. N.S.W.*, 1916, p. 349 (Brisbane, Toowoomba, Macpherson Range).

405. ELAEONOMA DOLICHA, n. sp.

δολιχος, long.

♂. 30 mm. Head and thorax white. Palpi with second joint exceeding base of antennae, somewhat expanded at apex, terminal joint one-half; white. Antennae grey, towards base white; ciliations in male 3. Abdomen grey, towards apex whitish. Legs whitish-grey. Forewings elongate, narrow, costa straight except near base and apex, apex round-pointed, termen very oblique; white, tinged with grey towards margins; a few fuscous scales in basal and dorsal areas; cilia white. Hindwings and cilia whitish.

Victoria: Birchip, in April; one specimen received from Mr. D. Goudie.

407. ELAEONOMA FUMEA, n. sp.

fumeus, smoky.

♀. 26 mm. Head and thorax fuscous. Palpi with second joint slightly exceeding base of antennae, terminal joint three-fourths; fuscous, post-median and apical rings on second joint and apex of terminal joint whitish. Antennae grey. (Abdomen missing.) Legs fuscous; posterior tibiae ochreous-whitish. Forewings elongate, slightly dilated, costa nearly straight, apex pointed, termen nearly straight, oblique; fuscous with some grey-whitish irroration; cilia fuscous. Hindwings pale grey; cilia pale grey, becoming ochreous-whitish on tornus and dorsum.

South Australia: Adelaide in October; one specimen received from Mr. J. D. O. Wilson.

408. ELAEONOMA CHROMATICA, n. sp.

χρωματικός, coloured.

♂. 18–22 mm.; ♀. 24–26 mm. Head brown-whitish. Palpi with second joint exceeding base of antennae, terminal joint three-fifths; brown-whitish sprinkled with fuscous, base of second joint fuscous. Antennae grey, towards base fuscous; ciliations in male 2½. Thorax fuscous-brown. Abdomen ochreous, apices of segments dark fuscous. Legs dark fuscous with ochreous rings. Forewings rather narrow, costa gently arched, apex rounded, termen oblique; whitish sprinkled with fuscous-brown, densely in male, more sparsely in female; markings dark fuscous; elongate fuscous spots at base, two-fifths, and three-fifths; stigmata approximated, in male partly outlined with whitish, first discal at two-fifths, plical beyond it, second discal at three-fifths; a very slender subterminal line

from four-fifths costa; cilia grey, in male ochreous on tornus. Hindwings orange-ochreous; a dark fuscous terminal band broadest at apex, narrow towards tornus; cilia fuscous.

North Queensland: Cape York in October and November; seven specimens received from Mr. W. B. Barnard, who has the type.

409. *ELAEONOMA ANISOCHROA*, n. sp.

*ἀνισοχρῶος*, unequally coloured.

♂, ♀. 17-19 mm. Head dark fuscous; face pale ochreous. Palpi with second joint exceeding base of antennae; terminal joint three-fifths; pale ochreous, base of second and all terminal joint dark fuscous. Antennae fuscous; ciliations in male slightly over 1. Thorax dark fuscous, tegulae except bases and a large posterior spot pale ochreous. Abdomen dark fuscous. Legs dark fuscous with pale ochreous rings; posterior pair mostly pale ochreous. Forewings narrow, costa slightly arched, apex rounded, termen obliquely rounded; dark fuscous with pale ochreous markings; a basal spot; a narrow spot beneath costa near base; a narrow fascia from costa before middle to mid-dorsum, indented posteriorly beneath costa; a large spot on three-fourths costa produced to mid-disc, in female nearly obsolete; cilia dark fuscous. Hindwings and cilia dark fuscous.

Queensland: Bunya Mts., in October (female in Coll. Barnard). New South Wales: Allyn River, in December (male type in Coll. Goldfinch).

410. *ELAEONOMA HEMIOCHRA*, n. sp.

*ἡμιωχρῶος*, half pale.

♂. 18 mm. Head whitish-ochreous. Palpi with second joint exceeding base of antennae, terminal joint four-fifths; whitish, basal half and a subapical ring of second joint, and a basal ring and apical half of terminal joint, dark fuscous. Antennae dark fuscous; ciliations in male 1. Thorax fuscous; anterior edge whitish-ochreous. Abdomen fuscous; tuft and underside whitish. Legs fuscous with ochreous-whitish rings; posterior pair mostly ochreous-whitish. Forewings with costa rather strongly arched, apex rounded, termen rounded, slightly oblique; whitish ochreous with fuscous markings; a costal streak from base to two-fifths; a costal blotch beyond middle prolonged between discal stigmata; a triangular spot on dorsum before middle, its apex reaching plical; stigmata blackish, distinct, first discal at one-third, plical slightly beyond it, second discal scarcely beyond middle; a very large terminal and apical blotch reaching beyond second discal, containing a whitish apical dot; cilia fuscous, bases pale ochreous, on apex wholly pale ochreous. Hindwings and cilia grey.

North Queensland: Cape York, in April; one specimen received from Mr. W. B. Barnard.

411. *ELAEONOMA POLYTYPA*, n. sp.

*πολυτυπος*, with many markings.

♂. 18-21 mm. Head ochreous-whitish. Palpi with second joint reaching base of antennae, terminal joint three-fifths; ochreous-whitish with some fuscous irroration of terminal joint and outer surface of second joint towards base. Antennae ochreous-whitish, sometimes with some slender fuscous rings towards base; ciliations in male 2. Thorax fuscous; anterior edge, apices of tegulae, and sometimes posterior edge ochreous-whitish. Abdomen pale fuscous; apices of segments and tuft ochreous-whitish. Legs fuscous with ochreous-whitish rings; posterior pair ochreous-whitish. Forewings oval, costa rather strongly arched,

apex rounded, termen obliquely rounded; ochreous-whitish with fuscous markings; a narrow curved fascia from base of costa to one-third dorsum; a basal dorsal spot; first discal at one-third, more or less connected with costa at one-fifth, plical beyond it, suffusedly connected with mid-dorsum, second discal before two-thirds; a moderately broad rather suffused fascia from three-fifths costa to tornus, immediately following second discal; a subapical costal spot connected by a slender line or series of dots with tornus; a terminal series of dots; cilia ochreous-whitish with some median fuscous irroration. Hindwings and cilia grey.

North Queensland: Cape York in April and May; four specimens received from Mr. W. B. Barnard, who has the type.

412. *ELAEONOMA TETRASPILA*, n. sp.

*τετρασπιλος*, four-spotted.

♂. 18–20 mm. Head white. Palpi with second joint just reaching base of antennae, terminal joint three-fifths; fuscous, apex and part of inner surface of second joint, and all terminal joint white. Antennae grey; ciliations in male 2. Thorax fuscous; posterior edge whitish. Abdomen ochreous-grey. Legs fuscous; posterior pair paler. Forewings narrow, oval, costa moderately arched, apex round-pointed, termen very oblique; whitish; markings and slight patchy irroration blackish; a suffused basal costal spot; first discal at one-fourth, plical beneath it, second discal just beyond middle, a fourth dot on tornus; a suffused costal spot at two-thirds, and another larger at apex; cilia whitish with some blackish irroration. Hindwings whitish-grey; cilia whitish.

Queensland: Milmerran, in December; two specimens received from Mr. J. Macqueen.

413. *ELAEONOMA CITRITIS*, n. sp.

*κιτριτις*, lemon-tinged.

♂. 24 mm. Head and thorax pale ochreous. Palpi with second joint exceeding base of antennae, slightly rough anteriorly, terminal joint three-fifths. Antennae grey, towards base pale ochreous; ciliations in male slightly over 1. Abdomen grey. Legs fuscous; posterior pair grey-whitish. Forewings moderately broad, costa rather strongly arched, apex rounded, termen slightly rounded, slightly oblique; whitish-grey, ochreous-tinged, especially towards base; costal edge near base dark fuscous; stigmata fuscous, minute, first discal at one-third, plical beneath it, second discal before two-thirds; cilia concolorous. Hindwings pale grey; cilia grey-whitish.

Western Australia: Mundaring, near Perth, in October; one specimen received from Mr. G. M. Goldfinch, who has the type.

414. *ELAEONOMA OCHROCRANA*, n. sp.

*ωχροκρανος*, with pale head.

♂. 15 mm. Head whitish. Palpi with second joint just reaching base of antennae, terminal joint three-fourths; fuscous. Antennae fuscous; ciliations in male 1½. Thorax fuscous. Abdomen grey. Legs: anterior pair fuscous; middle pair grey with whitish rings; posterior pair mostly whitish. Forewings rather narrow, somewhat dilated, costa nearly straight (apices imperfect); fuscous; stigmata dark fuscous, obscure, first discal at one-fourth, plical beneath it, second discal about middle; cilia fuscous, apices ochreous-whitish. Hindwings and cilia whitish.

Recognizable by the whitish head and hindwings contrasting with the fuscous thorax and forewings.

Queensland: National Park (3,000 feet), in January; one specimen.

415. *ELAEONOMA EUCRYPHAEA*, n. sp.

*εὐκρυφαιος*, well concealed.

♂, ♀. 12–14 mm. Head and thorax fuscous-brown. Palpi with second joint just reaching base of antennae, terminal joint three-fifths; fuscous-brown. Antennae fuscous; in male with long ciliations (5) in tufts. Abdomen blackish; beneath ochreous-whitish. Legs grey; posterior pair mostly ochreous-whitish. Forewings suboblong, rather narrow, costa slightly arched, apex obtusely pointed, termen obliquely rounded; fuscous-brown; cilia fuscous-brown. Hindwings elongate-ovate; as forewings.

This small and obscure species is fortunately recognizable by its structural characters.

Queensland: National Park (2,500 feet), in open forest; Killarney; six specimens in October.

417. *ELAEONOMA ADOCIMA*, n. sp.

*ἀδοκιμος*, mean, shabby.

♂, ♀. 11–18 mm. Head pale ochreous-brown. Palpi with second joint reaching base of antennae, terminal joint two-thirds; pale brown, second joint fuscous externally. Antennae fuscous; ciliations in male  $3\frac{1}{2}$ . Thorax and abdomen fuscous. Legs fuscous with obscure whitish-ochreous rings. Forewings suboval, costa rather strongly arched, apex round-pointed, termen very obliquely rounded; pale ochreous-brown; markings and a variable amount of suffusion fuscous; a suffused basal fuscous spot sometimes prolonged into a costal streak; first discal at one-fourth, plical beneath it, second discal near middle; small costal suffusions at two-thirds and before apex, the latter giving rise to a submarginal line to tornus; sometimes there is a general fuscous suffusion; cilia pale ochreous-brown, sometimes with an indication of a darker median line. Hindwings and cilia pale grey.

Very like *Coesyra syneches* Turn. from Ebor, but the similarity must be due to external conditions. Mountain examples are larger and more infuscated than those from the lowlands.

North Queensland: Babinda in September. Queensland: Yeppoon in October; Nambour in August and October; Brisbane in September; Stradbroke Island in August and September; Tweed Heads in August; National Park and Springbrook (3,000–4,000 feet), in December, January and March; abundant in the last-named locality.

420. *ELAEONOMA FULIGINOSA*, n. sp.

*fuliginosus*, sooty.

♂. 13 mm. Head, thorax, and abdomen fuscous. Palpi with second joint not reaching base of antennae, terminal joint four-fifths; pale ochreous. Antennae fuscous, basal joint pale ochreous; ciliations in male  $2\frac{1}{2}$ . Legs pale ochreous; tibiae and tarsi partly fuscous. Forewings with costa slightly arched, apex rounded, termen nearly straight, oblique; brownish-fuscous; stigmata obscurely darker, first discal at one-third, plical beyond it, second discal at two-thirds; cilia fuscous. Hindwings and cilia dark fuscous.

Obscure, but not like any other species. The palpi are distinctive.

North Queensland: Millaa-millaa (Atherton Tableland), in September; one specimen.

## 422. ELAEONOMA CONIA, n. sp.

*κοινος*, dusty.

♀. 18 mm. Head and thorax brownish-grey. Palpi with second joint exceeding base of antennae, terminal joint three-fifths; ochreous-whitish sprinkled with fuscous. Antennae grey. Abdomen grey. Legs brown-fuscous with ochreous-whitish rings; posterior pair mostly ochreous-whitish. Forewings suboval, costa rather strongly arched, apex pointed, termen very oblique; grey-whitish, densely sprinkled with brownish-fuscous, which in basal area tends to form close parallel transverse lines; stigmata small, dark fuscous, first discal at one-fourth, plical beyond it, second discal about middle, double; some dark fuscous terminal dots; cilia ochreous-whitish with fuscous basal, median, and terminal lines. Hindwings pale grey; cilia whitish, with antemedian and terminal grey lines.

North Queensland: Cape York in November; one specimen received from Mr. W. B. Barnard.

## 423. ELAEONOMA PHAULOSTOLA, n. sp.

*φαιλοστολος*, shabbily clothed.

♂. 20 mm. Head and thorax ochreous-brown. Palpi with second joint reaching base of antennae, terminal joint three-fifths; ochreous-brown. Antennae grey, towards base ochreous-brown; ciliations in male 1. Abdomen grey; basal segments brownish; tuft whitish-ochreous. Legs fuscous; posterior pair ochreous-whitish. Forewings narrow, somewhat dilated, costa slightly arched, apex round-pointed, termen strongly oblique; ochreous-brown; costal edge fuscous towards base; stigmata minute, obscure, first discal at one-third, plical slightly before it, second discal before two-thirds; cilia ochreous-brown. Hindwings and cilia grey.

Western Australia: Kalamunda, near Perth, in November; one specimen received from Mr. W. B. Barnard.

## 426. ELAEONOMA PSAMMOPHANES, n. sp.

*ψαμμοφανης*, sand-coloured.

♂. 16 mm. Head and thorax pale ochreous-brown. Palpi with second joint reaching base of antennae, terminal joint three-fourths; pale ochreous-brown. Antennae grey; ciliations in male  $2\frac{1}{2}$ . Abdomen ochreous-brown; apices of segments and tuft whitish. Legs ochreous-whitish; anterior tibiae and tarsi pale fuscous. Forewings suboblong, costa moderately arched, apex rounded, termen obliquely rounded; pale ochreous-brown; dots and slight irroration fuscous; first discal at one-third, plical beyond it, second discal before two-thirds; a costal dot at three-fourths, from it an indistinct curved subterminal line of dots; cilia ochreous-whitish. Hindwings and cilia ochreous-whitish.

North Queensland: Kuranda, in September; one specimen received from Mr. F. P. Dodd.

## 427. ELAEONOMA EBURNEA, n. sp.

*eburneus*, ivory-white.

♀. 21 mm. Head and thorax white. Palpi slender, second joint exceeding base of antennae, terminal joint three-fifths; ochreous-brown, terminal joint whitish. Antennae grey, towards base white. Abdomen pale grey. Legs ochreous-grey-whitish. Forewings suboblong, costa moderately arched, apex rounded, termen obliquely rounded; white; markings and a few scattered scales fuscous; discals approximated, first discal beyond one-third, plical beneath or slightly before it, second discal well before two-thirds; an irregular spot on three-fifths

costa; an indistinct subterminal line; cilia grey-whitish. Hindwings and cilia grey-whitish.

North Queensland: Kuranda, in October; one specimen received from Mr. F. P. Dodd.

430. ELAEONOMA ALEURITIS, n. sp.

*ἀλευριτις*, floury.

♂. 16–24 mm.; ♀. 25–30 mm. Head and thorax grey-whitish. Palpi with second joint exceeding base of antennae, terminal joint three-fifths; ochreous-whitish, outer surface of second joint except apex fuscous. Antennae pale grey; ciliations in male  $1\frac{1}{2}$ . Abdomen brownish; apices of segments and tuft ochreous-whitish. Legs ochreous-whitish; anterior tibiae and tarsi fuscous. Forewings suboval, costa rather strongly arched, apex rounded, termen obliquely rounded; ochreous-grey-whitish; cilia concolorous. Hindwings pale grey; cilia whitish, bases pale grey.

Queensland: Yeppoon, in October, locally common; Toowoomba, in December.

53. Gen. EPITHYMEMA TURN.

PROC. LINN. SOC. N.S.W., 1914, p. 562. Type, *E. disparile* Turn.

Tongue present. Palpi extremely long, ascending, recurved; second joint 5 or 6 times length of face, slender, smooth, in female slightly rough towards apex anteriorly; terminal joint long, but less than half second, very slender, acute. Antennae with a weak basal pecten; ciliations in male moderate or rather long. Thorax smooth. Forewings with 2 from shortly before angle, 7 to apex. Hindwings elongate-ovate; neuration normal.

Remarkable for its unusually long palpi.

Two species: 433, *disparile* Turn., PROC. LINN. SOC. N.S.W., 1914, p. 562 (Ebor).—434, *parile*, n. sp. (Macpherson Range).

434. EPITHYMEMA PARILE, n. sp.

*parilis*, similar.

♂, ♀. 18–20 mm. Head fuscous. Palpi very long, slender, second joint five times length of face, terminal joint one-half; fuscous. Antennae fuscous; ciliations in male  $2\frac{1}{2}$ . Thorax brownish-red with slight fuscous suffusion anteriorly. Abdomen and legs fuscous. Forewings elongate-oval, costa slightly arched, apex rounded, termen very obliquely rounded; brownish-red; in female with a broad subdorsal suffusion and interneural streaks fuscous; cilia reddish-orange, on termen apices blackish, on tornus and dorsum wholly blackish. Hindwings elongate-oval; orange; an ill-defined fuscous patch occupying apical third; cilia fuscous.

By its coloration this species can be referred to the same synaposematic association as species of *Snellenia* in the Heliodinidae. It is very closely allied to *E. disparile* from Ebor, but apart from the colour differences the antennal ciliations in the latter do not exceed  $1\frac{1}{2}$ .

Queensland: Macpherson Range (2,500–3,500 feet), in December, January, and February; five specimens.

THE LEAF ANATOMY AND VEGETATIVE CHARACTERS OF THE  
INDIGENOUS GRASSES OF NEW SOUTH WALES. I.

ANDROPOGONEAE, ZOYSIEAE, TRISTEGINEAE.

By JOYCE W. VICKERY, M.Sc.

(Forty-three Text-figures.)

[Read 25th September, 1935.]

*Introduction.*

Increasing interest in present-day pasture problems, and the number of workers experimenting with pastures, have made it a matter of some importance that there should be a means of identifying species of grasses at times when the flowering shoots are not present. Most of the other constituent species of pastures may usually be recognized fairly readily at all stages of development by their habit and macroscopic leaf-characters. However, in many cases, and wherever the turf is closely grazed, the general vegetative features of a number of grass species growing together may be so similar as to make their diagnosis on macroscopic characters very uncertain or almost impossible.

A few workers have therefore directed their attention to the anatomy of the grass leaf, as shown in transverse section, as an aid in the determination of species when their vegetative parts only are available.

The general morphology of the grass leaf has been discussed by Duval-Jouve (1870), Schwendener (1889, 1890), and Pée-Laby (1898). MacAlpine (1890) and Ward (1901) used characters of the leaves as seen in transverse section as aids in identification. In 1904, Lewton-Brain described the anatomy of the leaves of British grasses, with a key for their determination.

Bews (1918) figured a number of transverse sections of leaves of South African grasses, and discussed the relationship between such features of the leaf of a species as its degree of lignification, and its palatability to stock and use as a pasture grass. In a recent publication, Burr and Turner (1933) described and figured transverse sections of the leaves and young shoots of the British economic grasses, and gave two keys for their identification based respectively on the vegetative, and on the anatomical characters. In Australia, Breakwell (1914, 1915) has described and figured the transverse sections of some of the native grasses.

The writer proposes to publish a series of papers describing the vegetative features and the anatomical characters of the leaves of the indigenous grasses of New South Wales, and to construct an artificial key which will aid in their identification.

While this should be of material assistance to ecologists and pasture workers, it should be remembered that such identification is only provisional until complete flowering material is available. In cases where there is a known assemblage of grasses in an area, it can be used without hesitation to separate the plants when



in their vegetative state alone, but where the assemblage is quite unknown, it must be used more cautiously.

Many characters seen in transverse sections of leaves are found to be quite constant and can be used with confidence in identification, but other characters may vary with the habitat of the plant, the size of the leaf, and the position in the leaf at which the section is made.

In this study it has been found, as by previous workers, that closely allied species may have an almost identical anatomical structure, particularly when they exist in similar habitats, and that even widely separated species may strongly resemble each other in transverse section. To attempt to separate such species on minute differences would almost certainly lead to confusion, so the writer has considered it better to group the species with similar anatomy, than to attempt to distinguish them completely on characters which may prove unreliable and variable.

In Australia the great variation in the habitat factors, edaphic, climatic, and seasonal, makes it a matter of very considerable difficulty to arrive at a conclusion as to what is the typical form of a species, and to include in its description all the possible variations met with. For instance, such species as *Themeda avenacea*, *Cymbopogon bombycinus*, and *Cymbopogon exaltatus* may have flat leaves of about 5-7 mm. width, and, under different conditions, filiform leaves which consist essentially of an enlarged midrib region without the expanded lateral portion of the blade. Such a reduction in the width of the leaf usually involves a reduction in the number of vascular bundles; therefore little reliance can be placed on the number of large and small bundles present. Throughout the descriptions which follow, dimensions of the leaf and numbers of the bundles are given merely to indicate the order of magnitude, and to give some standard to the less exact descriptive terms, but they cannot be taken as showing the absolute limits of variation.

Similarly the size and degree of development of the midrib vary tremendously in different leaves of the same species and at different points along the leaf, so that its appearance in transverse section can only be of importance when taken in conjunction with its macroscopic appearance in a number of leaves.

#### *Material and Methods.*

The writer is indebted to Mr. E. Cheel, Curator of the National Herbarium, Sydney, for permission to inspect the collection of grasses at the National Herbarium, to Mr. Cheel and Mr. D. Cross for assistance in the determination of the systematic position of a number of species, and to Mr. S. Blake for material sent from Queensland.

The greater part of the material used for anatomical investigation has been collected by the writer from plants growing under field conditions in various parts of New South Wales. In a number of instances, sections for purposes of confirmation have also been made from herbarium material from different localities. In the case of a very few species where fresh or fixed material was not available, use was made of dried herbarium material boiled out before sectioning. Such sections were seldom completely satisfactory, as it is difficult to obtain good recovery in tissues showing such differential thickening as do those of a grass leaf, but usually the general type of anatomy could be made out. Wherever possible, a fairly wide range of material from a number of different localities was examined.

Fresh leaves were usually fixed in 70-95% alcohol. Hand-sections of all material have been cut in pith, microtome sections proving unsatisfactory. It is essential to maintain an extremely keen edge on the razor, and stropping or grinding is necessary after every few sections. Very thin sections are desirable, but it is even more important that the sections should be absolutely transverse. For reference purposes, sections have been double stained and mounted in Canada balsam, or mounted direct into glycerine jelly coloured with various stains. For identification purposes only this is unnecessary; fresh leaves may be cut, the sections placed in alcohol for a few moments to expel air, and mounted in water or glycerine. The various anatomical features can be readily recognized without staining.

Well-developed leaves from the lower vegetative part of the plant should always be taken, never those from the culm. In the case of annual plants on which the leaves occur only on the culms, a leaf from as near the base as possible should be selected. As the anatomy of the leaf varies in some details from the base to the apex, sections should always be made at a point one-third of the length of the leaf blade from its base.

#### *Systematic.*

During the last 20-30 years, considerable changes in the nomenclature of Australian grasses have occurred, owing to recent critical systematic work. As these changes are for the most part scattered through the literature and difficult for anyone but the experienced systematist to obtain without considerable labour, it has been thought desirable wherever possible to include after the name at present adopted, those synonyms which have appeared in Australian literature. It is hoped that this summary will reduce the inevitable confusion due to the use of different names by the various Australian authorities from time to time. No attempt has been made to include synonyms used in other parts of the world, or to undertake a critical revision of the nomenclature. It is to be expected that further changes will take place during the next few years. The species are arranged according to the tribes of Hackel (1896).

#### *Vegetative Characters and Growth Forms.*

As the vegetative organs and growth forms of the Gramineae are well known (see Hackel, 1896; Bews, 1929; Hutchinson, 1934), reference will only be made to those features of particular importance in the present study. With the exception of the Bambuseae, the grasses are all annual or perennial herbs, usually branching at the base. In the annuals all the shoots are flowering shoots (culms). In perennials, sterile shoots (innovations) are also formed, which are responsible for the formation of the 'flag' or basal tuft of leaves. The shoots may be erect or prostrate. Where the latter predominate, and have comparatively long internodes, the plants develop a creeping or straggling habit. These horizontal portions may be above or below the surface of the ground, forming stolons or rhizomes respectively. More often the prostrate shoots have extremely short internodes, and bear numerous erect or ascending shoots, giving the plant the characteristic tufted habit of most pasture species.

The culm may be circular in outline in cross-section, or sometimes angular or flattened. The nodes are glabrous or ciliate.

The leaf sheaths are typically split along one side (open) and rolled around the culm, or may ultimately slip from it, but in some species the sheath is closed

and tubular (entire) for at least part of its length. The sheath may be rounded at the back, or definitely flattened.

At the upper end of the sheath, at its junction with the blade, is the ligule, which may be membranous or ciliate. In the former case it may be acute, or truncate, long or short, sometimes almost absent. Lateral auricles may also occur.

The character of the ligule is often regarded as an important diagnostic feature. It is best developed by the culm leaves, however, and is not so useful a character when the leaves of innovations only are available.

The blade is usually linear, but in some species may be narrow lanceolate or ovate. In some species the leaves are filiform, due either to a permanent inrolling of the margins, as in some forms of *Poa caespitosa*, or to a reduction of the blade to an enlarged midrib region, as in *Cymbopogon exaltatus* (Text-fig. 7). Linear and filiform leaves may occur in the same species.

The leaves typically have parallel venation. The presence or absence of a well-defined midrib may be of importance. Where this causes a prominent ridge on the lower surface, the leaf is said to be keeled. In some species, e.g. *Neurachne Mitchelliana* and *Zoysia Brownii* (Text-figs. 34 and 40), the midrib cannot be distinguished, but in other cases it varies, being large and conspicuous near the base of the leaf, but scarcely distinguishable towards the apex. The number of lateral veins visible macroscopically may vary with the width of the leaf, but the approximate number and their wide or close spacing may be of importance in some of the broader-leaved forms.

Different species vary in the behaviour of the leaves on drying. In a few the leaves remain fairly flat, e.g. *Oplismenus* spp., *Brachiaria* spp. In many the margins become inrolled, and in others the two halves of the leaf fold together at the midrib. In some types, e.g. *Cymbopogon refractus*, *Dichanthium sericeum* and allied species, the leaves fold inwards a little at the midrib, but the margins become rather reflexed. A few species have permanently folded or rolled leaves, e.g. some forms of *Poa caespitosa* and *Danthonia pauciflora*.

Some species may produce numerous hairs on the leaves and sheaths, but this is often an unreliable character, although fairly constant in a few types. The presence of microscopic pointed hairs may give the leaves and sheaths a rough or scabrous feel, according to their abundance, but, although this may at times be a useful feature, most species are rather variable in this respect.

#### *Leaf Anatomy.*

Reference has already been made to the work of previous investigators, and workers are advised to consult Lewton-Brain (1904) for a more detailed description of the grass leaf-anatomy.

In an examination of the grass leaf in transverse section the following features should be noted:

The upper surface of the leaf may be flat, undulating, or ribbed. If ribbed, the ridges may be high or low, acutely pointed, rounded or flattened at the apex. Low ribs may also occur on the lower surface in a few species (e.g. Text-figs. 4, 5, 34). The width and thickness of the leaf should also be noted.

The epidermis consists of two types of cells: (a) small, often thick-walled cells which make up the lower epidermis and part of the upper epidermis, and (b) larger, usually thinner-walled 'motor cells' or 'bulliform cells' (e.g. Text-figs. 3, 6, 39). These motor cells are arranged in longitudinal bands throughout the length of the leaf. In transverse section, they are usually seen in groups

situated at the base of the grooves in the case of leaves which have a ribbed upper surface; where the leaves have a flat surface they occur between the larger bundles, sometimes between every bundle. In some leaves they occur only above or at each side of the midrib (e.g. Text-figs. 9, 12, 18). In shape the groups may be rather elongated, composed of cells of a rather similar size, becoming gradually larger towards the centre of the group, or short, often with a very conspicuously larger central cell, giving the group a triangular outline. The individual motor cells may be rounded and only distinguishable from the other epidermal cells by their size (Text-figs. 21, 28), but more often they are narrow at their outer side, and rather broad at the base where they are in contact with the chlorophyll tissue (Text-figs. 37, 39). The typical motor cells grade into the ordinary epidermal cells on either side of the group.

These motor cells allow the leaf to roll or fold on drying, according to their position, as they are large and comparatively readily compressed. Whether these cells actually cause the rolling movement by collapse due to water loss, or whether their size and plasticity merely permit them to be compressed and so allow rolling to take place, has been the subject of some controversy. It has been postulated by some writers that rolling is of considerable biological importance, in that it occurs at times of water shortage, and results in the leaf becoming tubular. Thus the stomates on the upper surface, often on the sides of the grooves, are protected from excessive transpiration. This teleological viewpoint is not supported by the fact that in many Australian grasses, including drought-resistant forms, which exhibit the rolling movement, the stomates are more numerous on the exposed lower surface, where they would rather tend to be held open by the rolling.

The ordinary epidermal cells vary in size and in the thickness of the wall in different species. They are often square or rectangular in section, or the outer wall may be more or less arched or papillate. The papillate appearance may be due to the very strong arching of the whole outer wall, or more often to the presence of a number of separate papillae arranged in a longitudinal row, as seen in surface view. Where these are in a single row, and as wide as the epidermal cell, the outer wall appears to be very strongly arched in transverse section (L, in Text-figs. 3 and 16). Where the papillae are narrower than the epidermal cell, they appear in transverse section as small distinct papillae on the outer wall. If there is more than one row on each epidermal cell, then the outer wall shows bifurcate or multiple papillae (L, in Text-fig. 32).

In a few species with a strongly papillate epidermis, the cell beside a stomate in the same longitudinal row has a large papilla nearest the stomate. In transverse section, therefore, the cell which is placed immediately below a stomate appears more swollen than the neighbouring epidermal cells. This is seen in *Dichanthium sericeum* and *Bothriochloa decipiens*.

A few species (e.g. *Tragus racemosus* and *Neurachne Mitchelliana*) bear long tubercle-based hairs, but these are more easily observed macroscopically than in section. Long silky hairs are seldom developed by Australian species, but short stiff hairs are quite common. Where these are very short, they form stiff emergences or asperities (A, Text-fig. 3). These reduced hairs are the cause of the rough or scabrous feel of the leaf. They may be reflexed so that the leaf is scabrous when the hand is rubbed along it in one direction, but not in the other.

The cells of the chlorophyll tissue (chlorenchyma) may be arranged in two distinct ways: (a) when the vascular bundles are fairly widely spaced, the

chlorenchyma may be more or less irregularly arranged between them (Text-fig. 35); (b) when the vascular bundles are relatively close together, the chlorenchyma forms a fairly regular row around them, with just a few cells between. In this second type, the chlorenchyma cells usually appear narrow in transverse section, with their long axes at right angles to the bundles, giving the section a distinctive appearance (e.g. Text-figs. 3, 37). A variation of this type is found in which the chlorenchyma cells are rather shorter and rounder, approaching the arrangement of the irregular type. Where additional cells occur between the rows around the bundles, they usually contain distinctly less chlorophyll.

In general, however, the two main types of arrangement are very sharply defined, with comparatively few intermediate forms, and this feature constitutes a very valuable diagnostic character. Both types are well represented amongst Australian grasses.

Intercellular spaces occur between the cells of the chlorenchyma, but in the accompanying diagrams these have been neglected, since it has been considered that the general structure of the leaf as it appears in transverse section can better be emphasized if they are omitted. They may, however, be very conspicuous, especially in hygrophilous species. In others, e.g. *Vertiveria elongata* (Text-fig. 12), large air-cavities are present.

The conducting tissue of the vascular bundles is surrounded by a sheath consisting of one or two layers, with which the metaxylem vessels are in contact. Where two layers are present, the inner one consists of small cells with sclerized walls, the inner and lateral walls often more strongly thickened than the outer, resembling the typical monocotyledon endodermis. Often this layer cannot be distinguished in the small bundles, although present in the large bundles of the same leaf. The outer layer consists usually of larger, thinner-walled cells. Around the smaller bundles these are as conspicuous as around the larger, or more so. In *Aristida*, however, the inner sheath consists of larger cells than the outer and is conspicuous around all the bundles.

In other species, including most of the Andropogoneae, the bundle sheath consists of a single layer of rather large cells, which become fairly strongly sclerized around the large bundles, but are only slightly thickened around the smaller (e.g. Text-figs. 3, 30). These cells are sometimes almost clear (*Neurachne Mitchelliana*). In other cases they contain a certain amount of chlorophyll, though usually not as much as the chlorenchyma cells, and occasionally they appear to have unusually dense contents (*Tragus racemosus*). These cells form a layer which may completely encircle the bundle or may be interrupted by the intrusion of groups of fibres above and below the bundle. According to the arrangement of the sheath cells, the bundles, especially the smaller, may be circular (Text-fig. 1), oval or triangular (Text-fig. 40) in outline. In the lower magnification diagrams, these cells are included in the bundles.

The largest vascular bundles of the leaf have the typical monocotyledonous structure, with two large metaxylem vessels, a protoxylem vessel, or the space in which it occurred, and a number of smaller lignified elements forming the xylem, and a small group of phloem consisting of sieve tubes and companion cells. The smaller bundles have considerably reduced tissues.

Pée-Laby divided the vascular bundles into five orders. The first order comprises those with distinct protoxylem and metaxylem vessels, and group of phloem; the second order is similar, except that the protoxylem is absent; the third order has neither metaxylem nor protoxylem, but a number of lignified

elements; the fourth order resembles the third, but has fewer lignified cells; and the fifth has no lignified tissue. In practice, it has been found that bundles of the fifth order are seldom seen, and those of the fourth cannot usually be distinguished from the third order bundles. Second order bundles are also very erratic in occurrence, and often appear to take the place of a first order bundle in the leaf. In some species, however, it may be convenient to distinguish between the first and second orders. In the following descriptions, only the first, second, and third order bundles are referred to.

The tissue of the bundles in the various species is so uniform that it is seldom useful as a means of identification, but the number of bundles of the different orders and their relation to the ribbing of the leaf and position of the motor cells is of importance.

The stereome or mechanical tissue consists of groups of fibres. These are usually placed above and below the bundles, and when connected with the bundles are said to form girders. At other times, hypodermal groups occur which are not connected with the bundles, or which may be placed between the bundles. In a few species a continuous hypodermal band may be formed, usually on the lower side. A group of fibres also occupies the margins of the leaf. Although it is subject to a certain degree of variation in any species, the distribution and quantity of stereome is of considerable importance in diagnoses.

The general distribution of each species in New South Wales is given after the description of the vegetative characters, and the localities from which material has been examined anatomically are stated after the description of the anatomical characters in each case.

#### *Description of Species.*

##### ANDROPOGONEAE.

##### ANDROPOGON.

Most of the species of *Andropogon* of Bentham's "*Flora Australiensis*" are now referred to the genera *Amphilophis*, *Bothriochloa*, *Cymbopogon*, *Dichanthium*, *Schizachyrium*. The species at present included under *Amphilophis* may, on further study, be found to be referred more correctly to *Bothriochloa*. Other writers have also included the genera *Capillipedium*, *Chrysopogon*, *Heteropogon*, *Sorghum*, and *Vertiveria* in the genus *Andropogon*.

##### DICHANTHIUM.

##### DICHANTHIUM SERICEUM A. Camus. (Syn. *Andropogon sericeus* R.Br.)

Erect, tufted perennial, usually not very large, 15-75 cm. high, but producing a considerable amount of flag, typically glaucous, but a green form also common; base of the stem very slightly aromatic; nodes prominently ciliate; leaves linear, narrow, 5-25 cm.  $\times$  2-4 mm., glabrous, smooth to rough but hardly scabrous, folding inwards slightly and the margins recurving on drying; midrib present, at least in the lower part, though scarcely prominent; ligule membranous truncate, jagged, or ciliate. *Distribution*: All over the State, especially in the northern districts west of the Divide. Pasture species.

Anatomical characters: (Text-fig. 1. Cf. also Text-fig. 3.) Leaf rather thin; both surfaces flat; upper epidermis consisting of elongated groups of about 3-8 motor cells, interrupted over every fourth, sometimes every second bundle by smaller, thick-walled, rather papillate epidermal cells; motor cells of each group of similar size, the central few rather larger, occupying about half the leaf thick-

ness. A few colourless cells may occur beneath the motor cells, especially near the midrib region. Cells of the lower epidermis distinctly, usually very strongly papillate, the cells under a stomate usually more prominently swollen than the other epidermal cells; stomates mostly on the lower surface, few on the upper surface; chlorenchyma regular; bundle sheath single, forming a circular layer. About 7 bundles of the first order occur, with 3-8 bundles of the third order between each; midrib usually moderately conspicuous in section, with a group of colourless cells above the midvein and associated bundles; stereome very weakly developed as a small group of fibres above and below bundles of the first order, forming girders with them, and as an extremely small group below, and sometimes above every second and especially every fourth bundle of the third order, but not usually connected to them. *Localities*: Warialda, Dungog, Narrabri, Gobarralong.

DICHANTHIUM ANNULATUM Stapf. (Syn. *Andropogon annulatus* Forsk.)

Tufted erect perennial, not large, 20-60 cm. high, producing a little flag; nodes ciliate or glabrous; sheaths almost glabrous, smooth, very slightly flattened upwards; leaves linear, 7-15 cm.  $\times$  2-5 mm., glabrous or with a few hairs, smooth or slightly rough, folding inwards slightly and the margins recurving on drying; midrib present but hardly prominent; ligule of long cilia. *Distribution*: Northern coast and tablelands. Pasture species.

Anatomical characters: (Resembles *D. sericeus*. See Text-fig. 1.) Leaf fairly thin; both surfaces flat or almost so; upper epidermis consisting of elongated groups of about 4-10 motor cells, interrupted over about every second, occasionally only over every fourth bundle; motor cells of similar size, the central ones rather larger, occupying nearly half the leaf thickness. Occasionally a few colourless cells occur below the motor cell groups; lower epidermal cells with moderately thick, very conspicuously papillate outer walls; stomates more numerous on the lower surface, few on the upper surface; chlorenchyma regular; bundle sheath single forming a circular layer. About 7-9 bundles of the first or second order occur, with about 3-7 bundles of the third order between each; midrib present with a group of colourless cells above the midvein and associated bundles; stereome very weakly developed as a small group of fibres above and below the bundles of the first order with which short girders are formed, and as extremely small groups of about 1-5 fibres below every bundle, and above about every second, of the third order, but not forming girders. *Localities*: Glen Innes, Botanic Gardens, Rockhampton (Q.).

BOTHRIOCHLOA.

BOTHRIOCHLOA DECIPIENS C. E. Hubbard.

(Syn. *Amphilophis decipiens* Domin, *Andropogon decipiens* Domin, *Andropogon pertusus* Benth., *Fl. Aust.* non Willd., *Andropogon pertusus* var. *decipiens* Hack.)

Rather slender, tufted, erect or ascending perennial, 30-90 cm. high, producing a comparatively small amount of flag; culms often pinkish; nodes glabrous; sheaths glabrous, smooth, rather flattened, lightly striate; leaves narrow, linear, 2-15 cm.  $\times$  2-5 mm., glabrous, smooth to rough, folding inwards slightly and the margins recurving on drying; midrib present, especially towards the base; ligule membranaceous, truncate, 1-2 mm. long. *Distribution*: Throughout the State. Pasture species.

Anatomical characters: (Text-figs. 2 and 3.) Resembles *Dichanthium sericeum*. Leaf rather thin; both surfaces flat; upper epidermis consisting of

elongated groups of about 4-8 large motor cells, interrupted by smaller epidermal cells over about every second bundle; all motor cells of the group of rather similar size, the central ones of each group only slightly larger, and occupying about one-third to one-half the thickness of the leaf; cells of the lower epidermis fairly thin-walled, prominently papillate, moderately large, unequal in size, the cell seen immediately below a stomate usually distinctly more swollen than the others; stomates present on both surfaces, occurring between the groups of motor cells on the upper surface, more numerous on the lower surface; chlorenchyma regular; bundle sheath single, forming a circular layer. About 7-9 bundles of the first order occur, with 3-7 bundles of the third order between each; midrib usually moderately conspicuous in section with a group of colourless cells above the midvein and associated bundles; stereome very weakly developed as a rather small group of fibres above and below bundles of the first order, forming small girders, and sometimes also as a very small group above and below every second or fourth bundle of the third order but not connected to them to form girders. *Localities*: Sydney, Homebush, Cobbitty.

*BOTHRIOCHLOA ERIANTHOIDES* C. E. Hubbard.

(Syn. *Andropogon erianthoides* F. Muell.)

Tall, erect, tufted perennial, 60-120 cm. high, often glaucous; nodes glabrous; stems and base of sheaths shining; leaves linear, 10-60 cm.  $\times$  2-8 mm., flat, smooth or with rather scabrous margins, folding slightly and the margins recurving on drying; midrib whitish and prominent in the lower part of the leaf; ligule membranous, jagged. *Distribution*: Western parts of the State, chiefly in the north. Pasture species.

*Anatomical characters*: (Resembles *Dichanthium sericeum* and *Bothriochloa decipiens* in structure, cf. Text-figs. 1-3, but the leaf is much wider.) Leaf very thin; both surfaces very flat; upper epidermis composed of elongated groups of 4-12 motor cells interrupted by smaller epidermal cells over bundles of the first order, and over every second, third, or fourth bundle of the third order; motor cells of similar size, the central ones slightly larger, occupying one-third to one-half the thickness of the leaf. A few colourless cells may occur below the motor cells, especially near the midrib; lower epidermal cells with moderately thick, arched to slightly papillate outer walls; chlorenchyma regular; bundle sheath single, forming a circular layer. About 11-13 bundles of the first and second order occur, with 3-7 bundles of the third order between each; midrib fairly conspicuous in section, with a mass of colourless cells above the midvein and associated bundles; stereome very weakly developed as a rather broad but thin mass above and below bundles of the first order forming short girders with them, and as a very small group below, and occasionally above some bundles of the third order, but not connected with them to form girders. *Localities*: Warialda, Moree. Dried specimens only examined.

AMPHILOPHIS.

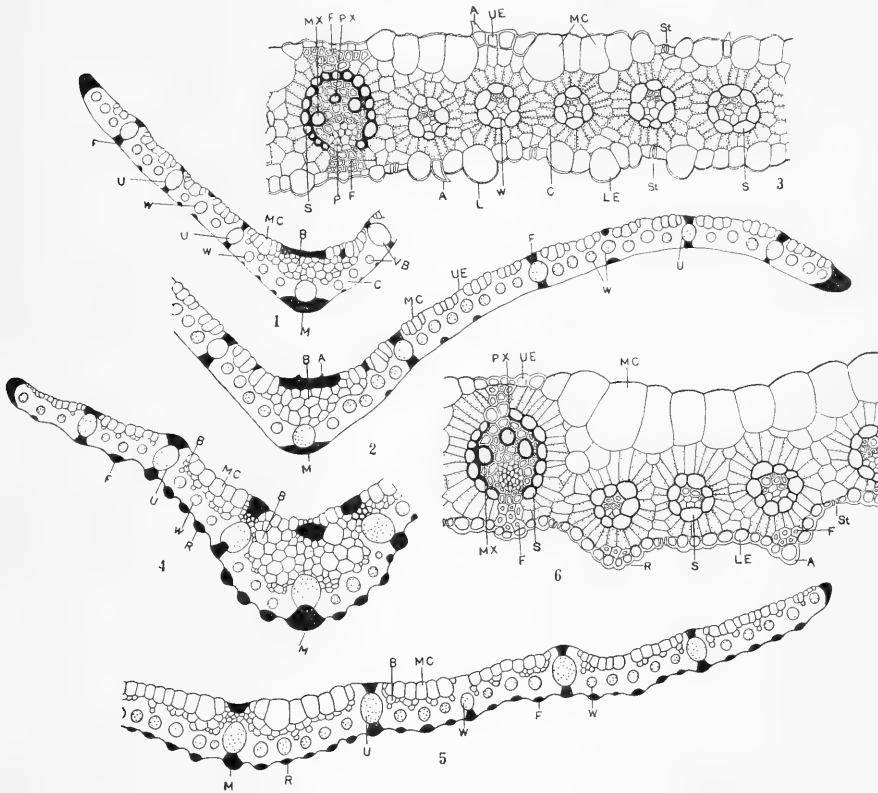
*AMPHILOPHIS AFFINIS* A. Camus. (Syn. *Andropogon affinis* R.Br.)

Tufted, erect or ascending, rather slender glabrous perennial, 25-60 cm. high, not forming a very great quantity of flag; nodes glabrous or pubescent; sheaths and leaves glabrous, smooth or slightly rough; leaves linear, 2-12 cm.  $\times$  1-5 mm., folding inwards slightly and the margins recurving on drying; midrib present, especially towards the base, but scarcely conspicuous; ligule membranous,



truncate, 1 mm. long. *Distribution*: Coast district and dividing range. Pasture species.

*Anatomical characters*: (Very similar to *Bothriochloa decipiens* and *Dichanthium sericeum* in structure, cf. Text-figs. 1-3.) Leaf fairly thin; both surfaces flat; motor cell groups of the upper epidermis interrupted over every second, third, or fourth bundle; lower epidermis papillate; stomates on both surfaces, more numerous on the lower surface, but also occurring at the edges of the motor cell groups on the upper surface; chlorenchyma, vascular bundles, and stereome as in the above types. *Locality*: Liverpool.



Text-figs. 1-6.\*

- 1.—*Dichanthium sericeum*. × 38. 2.—*Bothriochloa decipiens*. × 38. 3.—*Bothriochloa decipiens*. × 150. 4.—*Cymbopogon refractus*. × 38. 5.—*Cymbopogon bombycinus*. × 38. 6.—*Cymbopogon bombycinus*. × 150.

\* In the lower magnification drawings, vascular bundles are stippled, stereome shown as black, chlorenchyma unshaded, motor cells and colourless parenchyma cells shown in detail, and air cavities indicated by horizontal lines. The following explanation of the lettering applies to all the Text-figures: A, asperity; B, colourless tissue; VB, vascular bundle; C, chlorenchyma; MC, motor cells; D, air cavity; UE, upper epidermis; LE, lower epidermis; F, stereome; G, groove; L, papilla; M, midrib; P, phloem; R, ridge; S, bundle sheath; IS, inner bundle sheath; OS, outer bundle sheath; St, stomate; U, first order bundle; W, third order bundle; MX, metaxylem vessels; PX, protoxylem vessels.

## AMPHILOPHIS INTERMEDIA Stapf.

(Syn. *Andropogon intermedius* R.Br., *Andropogon punctatus* Roxb., according to Maiden and Betche's Census of N.S.W. Plants.)

Erect, tufted perennial, 60–100 cm. high, producing a rather small amount of flag; nodes mostly ciliate, to almost glabrous; sheaths rather striate, smooth, glabrous, slightly flattened upwards; leaves linear, narrow, 12–25 cm. × 2–5 mm., glabrous, smooth or with somewhat rough margins, sometimes slightly glaucous, the leaf folding somewhat and the margins recurving on drying; midrib fairly prominent; ligule membranous, short, truncate, jagged or ciliate. *Distribution*: Tableland to the interior. Pasture species.

Anatomical characters: (Resembles *Bothriochloa decipiens* in type, cf. Text-figs. 2 and 3.) Leaf fairly thin; both surfaces flat; upper epidermis consisting of elongated groups of motor cells, interrupted over about every fourth bundle; motor cells of similar size, the central ones of the group slightly larger, occupying nearly half the thickness of the leaf. A few colourless cells may occur below the motor cells; lower epidermal cells with only moderately thick outer walls, arched or prominently papillate, the cell below a stomate often rather more swollen than the others; stomates present on both surfaces, more numerous on the lower surface; chlorenchyma regular; bundle sheath single, forming a circular layer around the bundles. About 9–13 bundles of the first order occur, with 3–10 bundles of the third order between each, the central one of which may be a little larger than the others; midrib conspicuous with a group of colourless cells above the midvein and associated bundles; stereome very weakly developed as a small group of fibres above and below bundles of the first order forming girders, and as extremely small groups of about 1–5 fibres below, and occasionally above about every fourth bundle of the third order. *Localities*: Richmond, Sydney Botanic Gardens, Blair Athol (Q.).

## CYMBOPOGON.

CYMBOPOGON REFRACTUS A. Camus. (Syn. *Andropogon refractus* R.Br.)

Erect, tufted perennial, 45–120 cm. high, producing a fair amount of flag; stem bases slightly aromatic when dry; nodes glabrous; sheaths glabrous, smooth to scabrous; leaves narrow, linear, tapering to filiform points, 7–30 cm. × 1–4 mm., glabrous, scabrous downwards, and with scabrous margins, folding somewhat and the margins recurving on drying; ligule membranous, truncate, often jagged, 1 mm. long. *Distribution*: Coast districts to west of the Divide. Pasture and forest species.

Anatomical characters: (Text-fig. 4.) Leaf moderately thin; upper surface flat; lower surface undulating with low ridges below the bundles which are occupied by small groups of fibres; upper epidermis consisting of elongated groups of about 4–8 motor cells, the groups interrupted by a few smaller epidermal cells over bundles of the first and second order; motor cells all of similar size, the central one of the group slightly larger, occupying one-third to one-half the thickness of the leaf. A few colourless cells may occur below the motor cells; lower epidermal cells with moderately thick, arched outer walls, with occasional short pointed emergences especially on the sides of the ribs; stomates almost entirely on the lower surface; chlorenchyma regular; bundle sheath single, forming a circular layer. About 7 bundles of the first order occur, with 3–7 bundles of the third order between each; midrib conspicuous in section, with a group of colourless cells placed above the midvein and associated bundles;

stereome developed as a group of fibres above and below bundles of the first order forming girders with them, and as a small group below, but not attached to each bundle of the third order, causing ribbing of the lower surface. *Localities*: Warialda, Rookwood, Homebush.

CYMOPOGON BOMBYCINUS Domin. (Syn. *Andropogon bombycinus* R.Br.)

Erect, rigid, tufted perennial, producing a fair amount of flag, 45–120 cm. high; bases of the stems slightly aromatic when dry; nodes ciliate or glabrous; sheaths glabrous, or pubescent in the lower part, smooth to slightly rough; leaves narrow, linear, 7–30 cm.  $\times$  2–6 mm., rather rigid, glabrous, rough, flat, folding and the margins recurving on drying; midrib noticeable at the base only or not at all; ligule membranous, rather prominent, entire, 1–5 mm. long. *Distribution*: Interior, extending to the tablelands. Pasture species.

Anatomical characters: (Text-figs. 5 and 6; resembles *Cymbopogon refractus* in type.) Leaf moderately thin; upper surface practically flat; lower surface with low ribs occupied by small groups of fibres below almost every bundle; upper epidermis consisting of elongated groups of about 4–10 motor cells, the groups interrupted by smaller epidermal cells over bundles of the first order; motor cells of similar size, the central ones slightly larger, occupying nearly half the leaf thickness. A few colourless cells may occur below the motor cells; lower epidermal cells with moderately thick, arched outer walls, bearing a few pointed emergences (asperities) on the ridges; chlorenchyma regular; stomates almost entirely on the lower surface, few on the upper surface; bundle sheath single, forming a circular layer. About 7 bundles of the first order occur, with about 3–7 bundles of the third order between each; midrib small or conspicuous, often with a group of colourless cells above the midrib and associated bundles; stereome developed as a small group of fibres above and below bundles of the first order, forming short girders with them, and also as small groups below bundles of the third order, occupying the ridges, but not forming girders. *Localities*: Warialda, Laverton (W.A.), Bourke, McDonnell Ranges.

This species may also produce filiform leaves, in which the blades are reduced to an enlarged midrib structure, with a large mass of colourless tissue above the bundles, and barely any expanded lateral regions. The bundles are placed around the lower edges of this structure, and are surrounded by chlorenchyma as in the flat leaves. About 7 first order bundles occur, with 3–4 bundles of the third order between each. The lower surface is ribbed. A few large epidermal cells (resembling motor cells) occur along the upper surface, between patches of fibrous tissue. (Cf. Text-fig. 7.) *Locality*: Broken Hill.

CYMOPOGON EXALTATUS Domin. (Syn. *Andropogon exaltatus* R.Br.)

Erect, stiff, tufted, glabrous, perennial, 30–200 cm. high, forming flag; stem bases scented when dry; nodes glabrous; shoots often rather flattened with the leaf sheaths also flattened towards the base; leaves long, narrow linear to filiform, 15–45 cm.  $\times$  2–5 mm., the flat leaves rolling on drying, scabrous downwards or smooth with scabrous margins; midrib noticeable in the flat leaves, the leaves reduced to an enlarged midrib region in the filiform types; ligule membranous, acute, 3–6 mm. long. *Distribution*: Western districts. Pasture species; rare.

Anatomical characters: (Similar in type to *Cymbopogon refractus*, cf. Text-figs. 4, 5, 6.) Upper surface practically flat; lower surface with distinct low ribs containing groups of fibres below almost every bundle; upper epidermis

consisting of elongated groups of about 4-10 motor cells, interrupted by small epidermal cells over each bundle of the first order, and occasionally, where the larger bundles are widely spaced, over bundles of the third order also; motor cells all of a similar size, the central ones of each group slightly larger, occupying about half the thickness of the leaf. A few colourless cells may occur below the motor cells; lower epidermis of small cells with rather thick, slightly arched outer walls, bearing some asperities, especially on the ribs; stomates mostly in the grooves on the lower surface, a few on the upper surface; chlorenchyma regular; bundle sheath single, forming a circular layer. About 7-11 bundles of the first order occur, with 3-7 bundles of the third order between each; midrib conspicuous with a mass of colourless tissue above the midvein and associated bundles; stereome developed as a mass of fibres above and below bundles of the first order, forming girders with them, and also as groups of fibres occupying the ribs below each bundle of the third order, but not usually connected with them. *Localities*: Castle Hill near Townsville (Q.); Western Australia.

This species also produces filiform leaves which are reduced to an enlarged midrib region with a mass of colourless cells above all the bundles, the lateral expanded parts of the blade almost or entirely reduced (Text-fig. 7). *Locality*: Broken Hill (2 collections).

All gradations may occur between these two forms. Stomates may be entirely absent from the upper surface of the filiform and intermediate forms. Groups of enlarged cells resembling motor cells may still be present in the reduced types. *Localities of intermediate forms*: Broken Hill, Torrawangee.

#### HYPARRHENA.

##### HYPARRHENA FILIPENDULA Stapf.

(Syn. *Andropogon filipendulus* Hochst. according to Maiden and Betche's Census of N.S.W. Plants, *Andropogon filipendulus* var. *lachnantherus* Hack., *Andropogon lachnantherus* Benth.)

Erect, tufted perennial, 60-120 cm. high, producing a considerable amount of flag; stem bases scented when dry; nodes glabrous; sheaths smooth, mostly glabrous; leaves linear, narrow, 10-25 cm. × 1-4 mm., rather flat, folding somewhat and the margins recurving on drying, glabrous or with a few scattered hairs, slightly rough to scabrous downwards; midrib usually noticeable, often light coloured; ligule membranous, 1-2 mm. long, or ciliate. *Distribution*: Northern coast, tablelands, and western slopes. Pasture species.

Anatomical Characters: (Text-fig. 8.) Resembles *Dichanthium sericeum* in type; leaf fairly thin; both surfaces flat; upper epidermis consisting of elongated groups of 3-10 motor cells interrupted by small epidermal cells over about every second or fourth bundle; motor cells of somewhat similar size, the central ones progressively larger, and occupying nearly half the thickness of the leaf; lower epidermis of fairly small cells with moderately thick, arched or papillate outer walls, bearing occasional asperities, the cells below a stomate often more prominently papillate; stomates mostly on the lower surface; chlorenchyma regular; bundle sheath single, forming a circular layer. About 7-9 bundles of the first order occur, with 3-7 bundles of the third order between each; midrib fairly conspicuous; stereome very weakly developed as small groups of fibres forming girders with bundles of the first order, and as extremely small groups below, and sometimes above about every second bundle of the third order, rarely connected to them. *Localities*: Warialda, Copmanhurst.

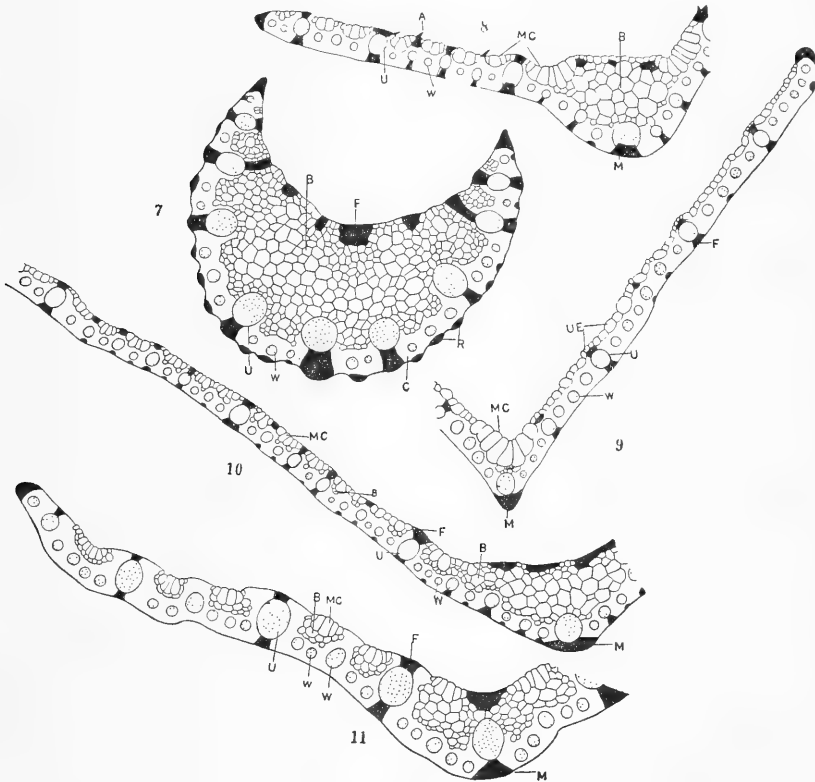
## SCHIZACHYRIUM.

## SCHIZACHYRIUM OBLIQUIBERBE A. CAMUS.

(Recorded from N.S.W. as *Andropogon brevifolius* Swartz, and *A. fragilis* R.Br.)

Rather small tufted plant, 15-45 cm. high, producing little flag; nodes glabrous or shortly pubescent; sheaths fairly smooth, glabrous, flattened especially towards the upper end; leaves rather short, 2-15 cm.  $\times$  2-4 mm., glabrous, smooth to rough, folding on drying, the margins rarely recurving; ligule membranous, truncate, 0.2-1 mm. long. *Distribution*: Northern coast and tablelands; rare in N.S.W.

Anatomical characters: (Text-fig. 9.) Leaf fairly thin; both surfaces flat; upper epidermis of fairly large and moderately thin-walled cells, alternating with a very few smaller cells over the larger bundles, the larger cells occupying one-quarter to one-third of the thickness of the leaf, but hardly organized as groups of motor cells. A group of large motor cells occurs above the midrib, the leaf



Text-figs. 7-11.

7.—*Cymbopogon exaltatus*. T.S. filiform leaf, which is reduced to an enlarged midrib region.  $\times$  38. 8.—*Hyparrhena filipendula*.  $\times$  38. 9.—*Schizachyrium obliquiberbe*.  $\times$  38. 10.—*Capillipedium parviflorum*.  $\times$  28. About one-third of the transverse section. 11.—*Chrysopogon Gryllus*.  $\times$  38.

being prominently keeled and folding on drying; lower epidermal cells with moderately thin, arched to papillate outer walls, the cells about half to two-thirds the size of the larger cells of the upper epidermis; stomates on both surfaces, rather more numerous on the lower surface; chlorenchyma regular; bundle sheath single, forming a circular layer. About 7-9 bundles of the first order occur, with 4-7 bundles of the third order between each; midrib conspicuous though not large; stereome very weakly developed as a small group of fibres above and below bundles of the first order forming girders, and above and below, or only below, about every third or fourth bundle of the third order, but not forming girders. *Localities*: Copmanhurst, Narrabri West, Tambourine Mt. (Q.), near Cape River east of Pentland (Q.).

#### CAPILLIPEDIUM.

##### CAPILLIPEDIUM PARVIFLORUM Stapf.

(Syn. *Chrysopogon parviflorus* Benth., *C. parviflorus* var. *spicigera* Benth., *C. violascens* Trin., *Andropogon micranthus* Kunth.)

Large, tufted perennial, 60-120 cm. high, producing a considerable amount of flag; nodes conspicuously bearded to glabrous; sheaths glabrous or with rather long, scattered hairs, somewhat keeled in the upper part, open, but closely wrapped around the stem, or finally slipping from the stem; leaves linear, narrow, 12-30 cm.  $\times$  2-6 mm., glabrous, smooth to scabrous, especially on the upper surface, margins, and midrib region, inrolling on drying, or sometimes folding slightly and the margins recurving; midrib present, conspicuous at least at the base; ligule ciliate, the cilia often long. *Distribution*: Coast to tablelands and western slopes. Pasture species.

Anatomical characters: (Text-fig. 10.) Leaf wide, thin; both surfaces flat or almost so; upper epidermis of groups of 3-6 motor cells, interrupted by small epidermal cells over about every second bundle; motor cells of similar size, the central few of the group slightly larger, occupying one-third to one-half the thickness of the leaf. A few colourless cells may occur below the motor cells, especially between the bundles; lower epidermal cells with only moderately thick, arched to papillate outer walls, sometimes with scattered asperities, the cell below a stomate usually more prominently papillate; pointed hairs sometimes present on both surfaces; stomates mostly on the lower surface, few on the upper surface; chlorenchyma regular; bundle sheath single, forming a circular layer. About 9-13 bundles of the first order occur, with about 5-11 bundles of the third order between each; midrib conspicuous with a mass of colourless tissue above the midvein and associated bundles; stereome very weakly developed as a small mass of fibres above and below first order bundles, forming girders, and as extremely small hypodermal groups of about 1-6 fibres above and below about every second bundle of the third order, and occasionally below a few others, but usually not forming girders with the third order bundles. *Localities*: Warialda (3 collections), Glenbrook.

#### CHRYSOPOGON.

##### CHRYSOPOGON GRYLLUS Trin. (Syn. *Andropogon Gryllus* L.)

Erect, tufted perennial, 45-120 cm. high, producing some flag; nodes glabrous; base of the stem swollen and woolly-hairy in western specimens, but not in the coastal and highland specimens; sheaths sometimes flattened, the upper culm sheaths glabrous and smooth, the lower ones often woolly hairy around the

swollen stem bases; leaves linear, 7-25 cm.  $\times$  1-4 mm., sometimes almost filiform, glabrous or with few scattered hairs, slightly rough or smooth, inrolling on drying, occasionally also the margins recurving; midrib present; ligule composed of a few cilia, or truncate membranous, jagged, very short. *Distribution*: Tableland to the interior. Pasture species.

Anatomical characters: (Text-fig. 11.) Leaf of moderate thickness; both surfaces flat, or the upper surface very slightly undulating over the larger bundles; upper epidermis consisting of small, flat, moderately thick-walled cells over the larger bundles, with isolated groups of 3-6 motor cells between, the groups sometimes slightly arched at the surface. A row of colourless cells may occur beneath the motor cells which, together with the motor cells, occupy about half the thickness of the leaf; motor cells progressively larger towards the centre of the group; lower epidermal cells small, with fairly thick, flat or slightly arched outer walls, similar in size to the smaller cells of the upper epidermis, and forming a fairly compact layer; stomates frequent on both surfaces; chlorenchyma regular; bundle sheath single, forming a circular layer. About 7-9 bundles of the first order occur, with about 2-6, usually 5 bundles of the third order between each; midrib often conspicuously developed with a mass of colourless cells above the midvein and associated bundles; stereome extremely weakly developed as a rather small mass above and below bundles of the first order forming girders. There is usually no fibre associated with even the larger third order bundles. Localities: Warialda (2 collections), Coolabah.

#### VERTIVERIA.

##### VERTIVERIA ELONGATA C. E. Hubbard.

(Syn. *Chrysopogon elongatus* Benth., *Chrysopogon Gryllus* var. *spicigera* Maiden and Betche.)

Rather large, tufted perennial, 60-120 cm. high; base of the shoots and the sheaths very prominently flattened; nodes glabrous, depressed; sheaths glabrous, almost smooth; leaves linear, 10-30 cm.  $\times$  2-8 mm., slightly folded, rather striate, almost glabrous; midrib prominent; ligule very short, membranous, truncate. *Distribution*: North coast to west of the divide. Probably a hygrophilous species, often on river sands.

Anatomical characters: (Text-fig. 12.) Leaf rather thick; both surfaces flat, or occasionally the lower surface very slightly undulating; leaf folded on drying, with large air cavities between the larger bundles; upper and lower epidermis of small cells with rather thick, flat or very slightly arched outer walls. A group of large motor cells occurs over the midrib, subtended by a number of colourless cells; occasionally a few motor cell-like groups also occur towards the margins of the leaf. Colourless cells form a more or less continuous band under the upper epidermis, over the air spaces and between the larger bundles and the upper epidermis, the cells above the bundles more or less lignified, grading into fibrous tissue. The air cavities and parenchyma together occupy half to three-quarters of the leaf thickness; stomates numerous on both surfaces; chlorenchyma of rather short rounded cells arranged rather regularly in a row around the somewhat closely spaced bundles, but with other similar cells between, sometimes grading into the colourless cells of the upper side of the leaf; bundle sheath single, forming a circular layer; bundles of three types: first order, large third order, and small third order bundles. About 11 bundles of the first order occur, with a similar number of large third order bundles alternating with them, and one,

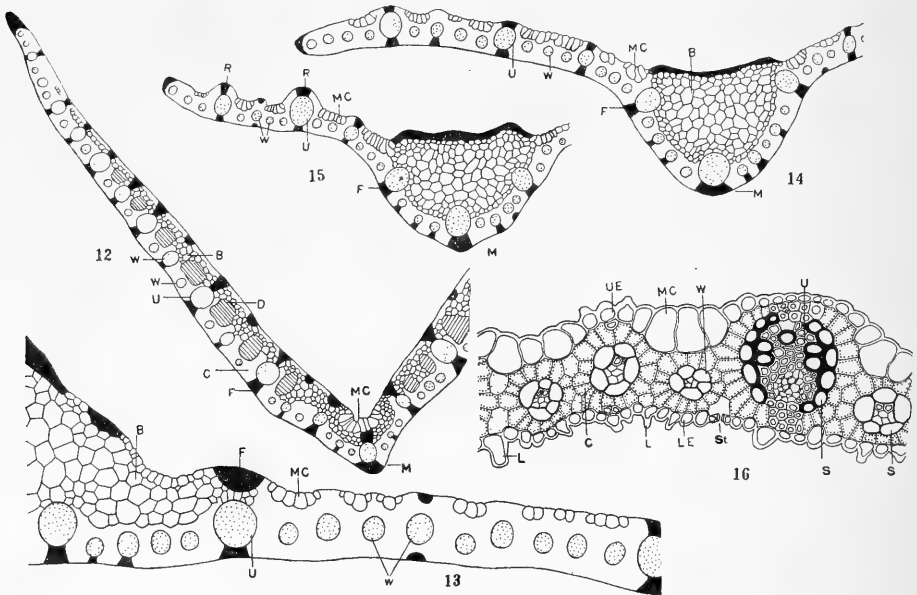
rarely two, small third order bundles between each of the above; midrib small but conspicuous owing to the folding of the leaf and position of the motor cells; stereome rather weakly developed as small groups below the larger bundles (of first and third order), and also above them, where it may grade into the parenchyma cells, thus forming girders. *Localities*: Orara River at Bawden Bridge in river sands, Tabulam, Greenridge, Narrabri.

#### SORGHUM.

*SORGHUM HALEPENSE* Pers. (Syn. *Andropogon halepensis* Sibth. and Smith.)

Tall, erect perennial, 75–180 cm. high, tufted and also producing rhizomes; nodes glabrous or very shortly ciliate; sheaths finely striate, long, smooth; leaves linear, wide, 12–45 cm.  $\times$  5–15 mm., flat or irregularly folding on drying, striate, with 3–6 conspicuous veins on either side of the midrib, fairly smooth but with scabrous margins; midrib conspicuous, pale coloured; ligule jagged or ciliate. *Distribution*: Coast and tablelands. Often a weed of cultivation.

Anatomical characters: (Text-fig. 13.) Leaf very wide, rather thick, but appearing thin compared with width of leaf; both surfaces flat; upper epidermis consisting of about 2–6 rounded motor cells alternating with groups of smaller epidermal cells; motor cells small, all of similar size, occupying only about one-quarter the thickness of the leaf, becoming less and less clearly distinguished from the other epidermal cells towards the margins of the leaf, not forming a very conspicuous feature of the epidermis; lower epidermal cells of moderate size, rather irregular, with flat or very slightly arched, moderately thick, outer walls; stomates frequent on both surfaces; chlorenchyma regular; bundle sheath single,



Text-figs. 12-16.

12.—*Vertiveria elongata*.  $\times$  28. 13.—*Sorghum halepense*. About one-tenth of the transverse section.  $\times$  38. 14 and 15.—*Sorghum* sp. (*Andropogon australis* var. *leiocladum*), showing variations in the contour of the upper surface.  $\times$  38. 16.—*Sorghum* sp.  $\times$  150.



strongly sclerized around the larger bundles, of slightly larger cells with thinner walls around the small bundles, forming a circular layer. About 19 bundles of the first order occur, with 3-15 bundles of the third order between each; midrib conspicuous, with a large mass of colourless tissue above the midvein and associated bundles; stereome very weakly developed except in the midrib region; a small mass of fibres occurs above and below the first order bundles forming girders, and occasional extremely small groups below, rarely above some of the third order bundles. At the midrib nearly every bundle has a few hypodermal fibres below it, every second one with a large group below and connected with it. A narrow band of fibres also occurs below the upper epidermis at the midrib. *Localities*: Richmond, Homebush.

## SORGHUM sp.

(Syn. *Andropogon australis* Spreng. var. *leiocladum* Hackel, *Sorghum plumosum* of Maiden and Betche's Census of N.S.W. Plants, non Beauv. In a list of determinations sent to me from Kew in 1931, this species was identified as *Sorghum leiocladum* C. E. Hubbard MS, sp. nov., non *S. plumosum*.)

Robust, erect, tufted perennial, 30-100 cm. high, forming abundant flag; nodes conspicuously bearded; sheaths rather flattened in the upper part, pubescent, especially in the upper part, to glabrous, rough; leaves long, linear, narrow, 7-30 cm.  $\times$  2-5 mm., glabrous or somewhat pubescent, scabrous, folding slightly and the margins recurving on drying; midrib present, usually fairly conspicuous; ligule short, membranous, truncate and jagged, or ciliate. *Distribution*: Coast and tablelands. Pasture species.

Anatomical characters: (Text-figs. 14, 15, 16.) Leaf moderately thin; both surfaces flat or nearly so, the upper surface sometimes irregularly undulating on account of low ridges over the bundles; upper epidermis consisting mainly of elongated groups of about 5-10 motor cells interrupted by a few smaller epidermal cells with flat or arched outer walls over every second or fourth bundle; motor cells all of similar size, the central ones of the group rather larger, occupying slightly less than half the thickness of the leaf; lower epidermal cells with only moderately thick outer walls, strongly papillate, and bearing distinct papillae; stomates on both surfaces, more numerous on the lower surface; chlorenchyma regular; bundle sheath single, forming a circular layer. About 5-7 bundles of the first order occur, with 3-7 bundles of the third order between each; midrib usually conspicuous with a large mass of colourless tissue above the midvein and associated bundles; stereome very weakly developed as a small mass of fibres above and below bundles of the first order forming insignificant girders, and as extremely small groups of about 1-5 fibres above and below about every second or fourth bundle of the third order but usually not connected to it. Sometimes a small mass occurs below almost every bundle in the midrib region. *Localities*: Prospect, Camden, Barrington Tops, Warialda.

## ARTHRAXON.

## ARTHRAXON CILIARIS Beauv. var. AUSTRALE Benth.

Creeping, stoloniferous perennial, ascending 30-45 cm.; leaves all on the culms, no flag produced; sheaths with scattered long hairs; leaves lanceolate, or cordate at the base, acute or acuminate, 10-30 cm.  $\times$  5-10 mm., smooth, glabrous or ciliate at the margins, flat, not rolling or folding freely on drying; midrib distinct, veins widely spaced; ligule membranous, not long. *Distribution*: New England, in swamps; rare.

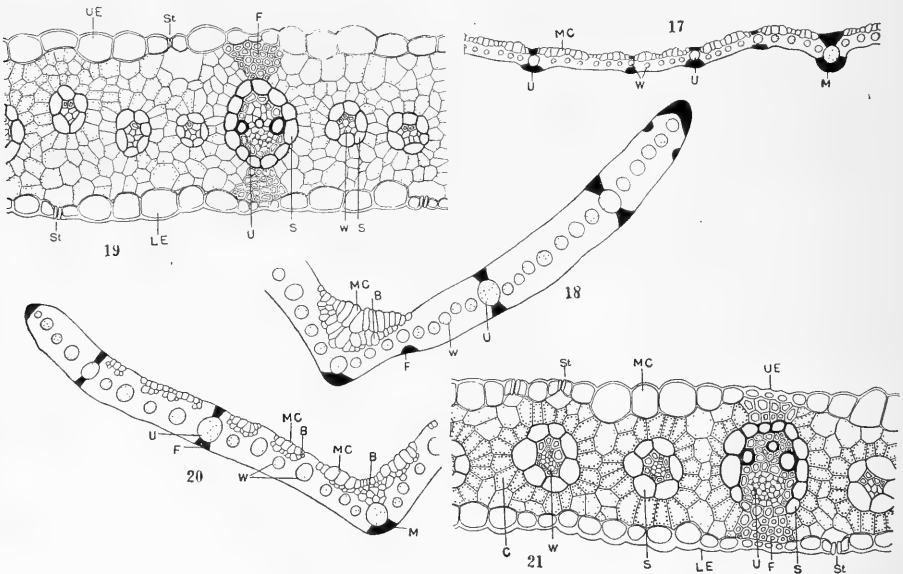
Anatomical characters: (Text-fig. 17.) Leaf very thin, wide; both surfaces flat, upper epidermis almost entirely composed of very elongated groups of large motor cells occupying half the thickness of the leaf, interrupted by a very few smaller cells over the larger bundles and occasionally over a third order bundle; motor cells of similar size; lower epidermal cells with only moderately thick to rather thin outer walls, flat to slightly arched or even somewhat papillate, occasionally bearing rather long pointed hairs, the cells much smaller than those of the upper epidermis; stomates mostly on the lower surface; chlorenchyma fairly regular, but the bundles slightly more widely spaced than in such types as *Bothriochloa decipiens*; bundle sheath single. About 13 bundles of the first order occur, with 5-20, often 17, bundles of the third order between each, a few of which are rather larger and associated with fibre groups; midrib rather small, not conspicuous, consisting of a rather large bundle with a small group of fibres above it, and a large group below it projecting on to the lower surface, so that the leaf is keeled; stereome developed as a rather broad mass below the first order bundles, and as a narrower mass above them forming girders; a smaller mass occurs below about every fourth or sixth bundle of the third order, but is not connected to it. *Localities*: New England, Stradbroke Is. (Q.). Dried material only examined.

EREMOCHLOA.

EREMOCHLOA MURICATA Hack.

(Syn. *Ischaemum pectinatum* Trin., *Rottboellia muricata* Retz.)

Small, tufted perennial, ascending 15-45 cm.; leaves mostly at the base; culms angular; shoots prominently flattened; sheaths strongly flattened, glabrous, smooth, striate; nodes shortly ciliate to almost glabrous; leaves linear, usually



Text-figs. 17-21.

17.—*Arthraxon ciliaris*. About one-eighth of the transverse section. × 27. 18.—*Eremochloa muricata*. × 38. 19.—*Eremochloa muricata*. × 150. 20.—*Hemarthria uncinata*. × 38. 21.—*Hemarthria uncinata*. × 150.

short, 2-8 cm.  $\times$  1-3 mm., occasionally up to 15-20 cm. long, folded on drying, covered with short, scattered hairs, smooth to slightly rough; ligule membranous, truncate, short, 1 mm. long, often also with a few cilia at the orifice. *Distribution*: North Coast to tablelands. Pasture species, often in slight depressions where drainage collects.

*Anatomical characters*: (Text-figs. 18 and 19.) Leaf of moderate thickness, folded on drying; both surfaces flat; upper epidermis of moderately thin to rather thick-walled, arched or sometimes papillate cells all of similar size, with a group of large motor cells above the midrib, which are subtended by a few other colourless cells; lower epidermal cells only slightly smaller than those of the upper epidermis, the outer walls not strongly arched; stomates on both surfaces; chlorenchyma semi-regular in type, the bundles being fairly closely spaced, but more than one layer of chlorenchyma present between the bundles and the epidermis; bundle sheath single; midrib small, but conspicuous on account of the folding of the leaf and the position of the motor cells above it; stereome very weakly developed as a small group of fibres above and below the first order bundles forming small girders, and rarely as an extremely small group below a very few of the third order bundles. *Localities*: Warialda, Tenterfield, Wallangra, Wallangarra, Byron Bay. In the specimen from Byron Bay, a hypodermal row of colourless cells occurs under the upper and lower epidermis, interrupted only at the first order bundles.

#### HEMARTHRIA.

##### HEMARTHRIA UNCINATA R.Br.

(Syn. *Hemarthria compressa* Benth., *Fl. Aust.*, non R.Br., *Rottboellia compressa* Beauv.)

Perennial, creeping, or decumbent at the base, ascending 30-60 cm.; nodes glabrous; sheaths glabrous or ciliate along the margins; leaves linear, narrow, 2-20 cm.  $\times$  2-5 mm., glabrous or with few cilia, smooth, folding, and sometimes the margins recurving when dry; midrib not prominent, but visible near the base; ligule minute, truncate, or almost absent. *Distribution*: Coast district and tablelands. Usually in moist situations.

*Anatomical characters*: (Text-figs. 20 and 21.) Leaf moderately thin; both surfaces flat; upper epidermis composed of fairly small cells with moderately thick, slightly arched outer walls, interrupted towards the centre half of the leaf by groups of motor cells, which are absent or scarcely distinguishable from epidermal cells towards the margins of the leaf; motor cells usually in groups of 4 or 5, all of similar size, the central ones only a little larger than the lateral ones, not very big, occupying only about one-quarter to one-third of the leaf thickness; a more conspicuous group of motor cells often occurs on either side of the midrib. Colourless cells may occur beneath the motor cells, at times forming an almost complete hypodermal band; lower epidermis of medium-sized cells with moderately thick, flat or slightly arched outer walls; stomates numerous on both surfaces, especially on the lower surface; chlorenchyma regular; bundle sheath single, forming a circular layer. About 5 bundles of the first order occur, with 5-7 bundles of the third order between each; midrib usually not large, but noticeable on account of the leaf folding at this point; stereome very weakly developed as a small group of fibres above and below bundles of the first order forming weak girders, usually none associated with the third order bundles. *Localities*: Homebush (3 collections), Taronga Park, Dapto, Guyra, Mt. Lofty (S.A.).

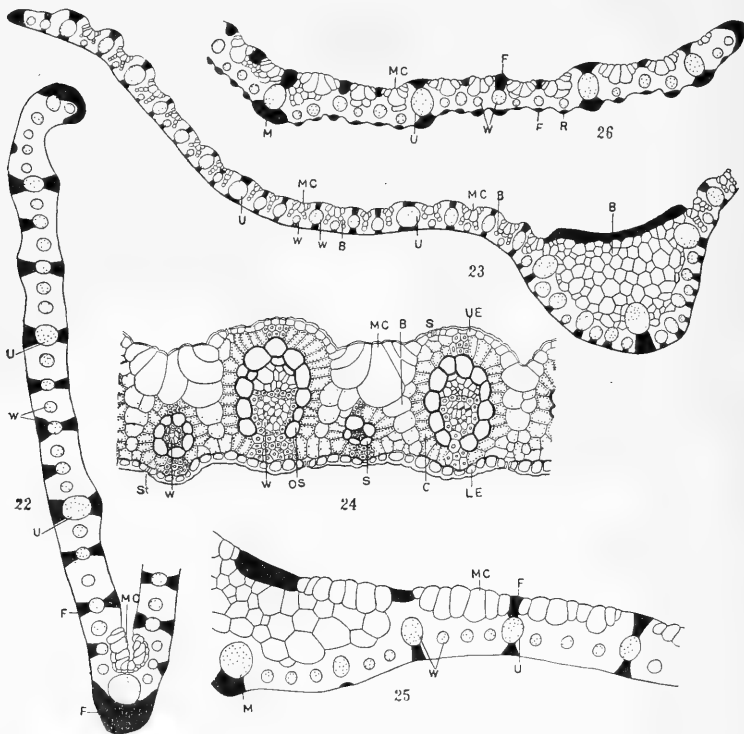
## HETEROPOGON.

## HETEROPOGON HIRTUS Pers.

(Syn. *Heteropogon contortus* Roem. and Schult., *Andropogon contortus* L.)

Erect or ascending, tufted perennial, 60–100 cm. high, producing a fair amount of flag; nodes glabrous; culms angular, shoots flattened; sheaths distinctly flattened, sometimes striate, glabrous; leaves linear, 5–25 cm.  $\times$  2–10 mm., folded on drying, glabrous, smooth to scabrous, often slightly glaucous; midrib mostly fairly conspicuous, at least in the lower part, but not large; ligule short, membranaceous, truncate. *Distribution*: North Coast and tablelands. Pasture and forest species.

Anatomical characters: (Text-fig. 22.) Leaf rather thin, folding on drying; both surfaces flat, or with slight protuberances over the larger bundles; upper epidermis of cells very irregular in size, with moderately thick, flat or arched outer walls, a few cells papillate; a few asperities sometimes present on both surfaces; stomates frequent on both surfaces, especially on the lower surface; chlorenchyma regular around the very closely spaced bundles; bundle sheath single, forming a circular layer. About 9 bundles of the first order occur, with 3–7 bundles of the third order between each; midrib conspicuous on account of



Text-figs. 22-26.

22.—*Heteropogon hirtus*.  $\times$  38. 23.—*Imperata cylindrica* var. *Koenigii*.  $\times$  28.  
24.—*Imperata cylindrica* var. *Koenigii*.  $\times$  150. 25.—*Ischaemum australe*. About  
one-eighth of the transverse section.  $\times$  38. 26.—*Ischaemum laxum*.  $\times$  38.

the motor cells situated above it, and a mass of fibres below, giving the leaf a prominent, acutely pointed keel. The midrib may be small with a few colourless cells above it, or larger with a big group of colourless tissue and more than one group of motor cells (usually 2-3) above it; stereome moderately developed as masses of fibres forming girders with bundles of the first order, and usually every second, occasionally every fourth bundle of the third order, and as a large mass below the midrib. *Localities*: Warialda, Copmanhurst, Brisbane (Q.).

#### IMPERATA.

IMPERATA CYLINDRICA var. KOENIGII Durand and Schinz.

(Syn. *Imperata arundinacea* Cyr., not the typical form.)

Stiff, erect perennial, 30-90 cm. high, propagating by means of rhizomes with long internodes, so that each shoot arises singly or in small tufts, not forming large tufts; nodes ciliate; sheaths glabrous, except for a few hairs often present near the ligule; leaves mostly from the base, stiff, ascending, very long, up to 90 cm.  $\times$  3-10 mm., linear or very narrow lanceolate, tapering at both ends, glabrous, slightly scabrous on the upper surface and margins, folding and the margins inrolling on drying; midrib conspicuous, often slightly excentric, prominent and thick towards the base where it constitutes almost the whole blade; ligule ciliate, with long hairs at the sides. *Distribution*: Throughout the State, especially in coastal districts, where it is often found on poor sandy soils.

Anatomical characters: (Text-figs. 23 and 24.) Leaf wide, thin; both surfaces usually flat, or the upper surface slightly and irregularly undulating over the larger bundles; upper epidermis consisting of small cells with rather thick, flat or arched outer walls over the bundles, alternating with rather short groups of 3-6 motor cells, the central one of which is usually much larger than the lateral ones, and occupies one-third to barely one-half the thickness of the leaf. Colourless cells or cells with few chloroplasts usually occur below the motor cells, tending to form a row downwards towards the lower surface, or, where the motor cell groups occur over a small bundle, two rows of these colourless cells may be produced from the motor cell group, one row on either side of the bundle; lower epidermis of small thick-walled cells, the outer walls flat or only slightly arched; stomates on both surfaces, rather more numerous on the lower surface; chlorenchyma of rather short, rounded cells arranged in a somewhat irregular row around the bundles which are only moderately closely spaced, often with a number of additional cells between the rows; bundle sheath of two layers, at least around the largest bundles, the inner layer very strongly sclerized, the outer thinner-walled, especially around bundles of the third order, forming a circular or oval layer; bundles of three distinct sizes, large first order bundles, medium-sized bundles of the third order, and small third order bundles. About 11-13 bundles of the first order occur, with about 3-9 (often 7) bundles of the third order between each, of which every second is a large third order bundle. Midrib always conspicuous, with a large mass of colourless tissue above the midvein and associated bundles, the lower narrowed part of the leaf consisting almost entirely of an enlarged midrib region; stereome moderately well developed, forming narrow girders with the first order and most of the third order bundles, often with the smaller bundles. Even if no girder is formed, the small third order bundles at least have small groups of fibres below them. The stereome is particularly strongly developed in the narrow, lower part of the leaf. *Localities*: Pennant Hills, Pittwater, Rookwood, National Park.

## ISCHAEMUM.

## ISCHAEMUM AUSTRALE R.Br.

Creeping, stoloniferous or slightly tufted perennial, the shoots ascending 30-75 cm., rather slender; nodes slightly swollen, prominently ciliate, but the hairs tend to rub off in older specimens; sheaths glabrous, smooth, somewhat flattened, especially towards the upper end; leaves linear to linear-lanceolate, 5-15 cm.  $\times$  5 mm., smooth but slightly scabrous along the margins; midrib present; ligule membranous, truncate or acute, sometimes splitting into two acute lateral lobes, 2-4 mm. long. *Distribution*: Northern coast district.

Anatomical characters: (Text-fig. 25.) The anatomy as seen in transverse section conforms to the general *Dichanthium* and *Bothriochloa* type, but the leaf is wider. Leaf moderately thick, or appearing thin on account of width of leaf; both surfaces flat or almost so; upper epidermis of rather elongated groups of 4-7 motor cells interrupted or partly so over about every third or fourth bundle; motor cells of similar size, the central ones of the group rather larger and occupying nearly half the thickness of the leaf; lower epidermis of strongly papillate cells whose outer walls also have simple, or sometimes multiple lobed papillae on them; stomates mostly on the lower surface; chlorenchyma regular; bundle sheath single, forming a circular layer. About 11-13 bundles of the first order occur, with 3-13 bundles of the third order between each; midrib conspicuous, with a mass of colourless tissue above the midvein and associated bundles; stereome weakly developed as small masses forming girders with the larger bundles, and very small groups above and below occasional third order bundles. *Localities*: Trial Bay; Manning River. Dried specimens only examined.

## ISCHAEMUM TRITICEUM R.Br.

Creeping, stoloniferous perennial, the shoots ascending 30-60 cm.; nodes somewhat swollen, usually ciliate; sheaths usually hairy, especially on the margins, or glabrous, fairly smooth, rather flattened in their upper part; leaves linear to narrow lanceolate-ovate, sometimes slightly cordate at the base, 5-20 cm.  $\times$  4-5 mm., slightly hairy, smooth but with scabrous margins, especially towards the apex; midrib present; ligule membranous, truncate, 1-2 mm. long, often forming auricles at the top of the sheath. *Distribution*: Northern coast district.

Anatomical characters: The anatomy as seen in transverse section appears almost identical with that of *I. australe*. Leaf wide, flat; upper epidermis of elongated groups of 4-9 motor cells which occupy most of the upper surface; lower epidermis, stomates, chlorenchyma, bundle sheath and stereome as in *I. australe*. About 11-17 bundles of the first order occur, with about 5-17 bundles of the third order between each. *Localities*: Burringbar, Port Macquarie. Dried specimens only examined.

## ISCHAEMUM LAXUM R.Br.

(Syn. *Andropogon nervosus* Rottb., *Setima nervosum* Stapf.)

Erect, tufted, rather slender perennial, about 45 cm. high; nodes glabrous or ciliate; sheaths very slightly flattened, with scattered hairs, finely striate; leaves 10-25 cm.  $\times$  2-4 mm., tapering to filiform points, glabrous, rough; midrib distinct, whitish; ligule ciliate with rather long hairs. *Distribution*: Northern coast district and tablelands.

Anatomical characters: (Text-fig. 26.) Leaf fairly thin; upper surface flat, or very slightly undulating; lower surface slightly and closely undulating with a small group of fibres occupying the ridges below each bundle; upper epidermis

composed of groups of about 5 motor cells, interrupted over every second bundle by small thick-walled epidermal cells which often bear short pointed emergences; the central one or two motor cells conspicuously larger than the lateral ones, the group thus broadly triangular, and occupying rather more than half the leaf thickness; lower epidermis of small, very thick-walled cells, usually with flat outer walls, and bearing a number of emergences, especially on the sides and tops of the ridges; chlorenchyma regular; bundle sheath single, forming a circular layer. About 7 bundles of the first order occur, with 3-7 bundles of the third order between each, of which every second is slightly larger; stereome weakly developed as a rather wide but thin mass above and below bundles of the first order forming girders, and as a small mass below each third order bundle, occupying the ridges on the lower surface, and as a few hypodermal fibres above every second bundle of the third order. *Locality*: Castle Hill near Townsville (Q.).

## ISEILEMA.

## ISEILEMA MEMBRANACEA Domin.

(Syn. *Iseilema Mitchellii* Anderss., *Anthistiria membranacea* Lindl.)

Small, tufted, ascending, usually annual grass, 7-45 cm. high, glabrous; nodes glabrous; culms angular; sheaths prominently flattened, striate, smooth or slightly rough; leaves flat or folded, 1-10 cm.  $\times$  2-6 mm., rather rough downwards; midrib only conspicuous on account of the folding of the leaf; ligule short, membraneous, truncate. *Distribution*: Interior. Pasture species.

Anatomical characters: (Text-figs. 27 and 28.) Leaf thin, folding on drying; both surfaces flat. The main group of thin-walled motor cells occurs over the midrib, with a small mass of colourless tissue below it, but the upper epidermis also has groups of 2-3, rarely 4, large, almost circular, motor-cell-like cells whose walls are only moderately thick, and slightly arched or slightly papillate, interrupted over every second bundle, and occupying slightly more than one-third of the thickness of the leaf; lower epidermis of rather irregular sized cells, only moderately thick-walled and slightly arched to slightly papillate; stomates on both surfaces, more numerous on the lower surface; chlorenchyma regular; bundle sheath single, forming a circular layer. About 7 bundles of the first order occur, with about 3-9, usually 7 bundles of the third order between each; stereome very weakly developed as small groups of fibres above and below bundles of the first order forming girders, sometimes also forming minute girders with about every fourth bundle, and as extremely small groups of about 1-5 fibres below almost every bundle, and occasionally also above every second bundle. *Localities*: Walgett-Brewarrina Road (2 collections), Borambil, Murray Downs.

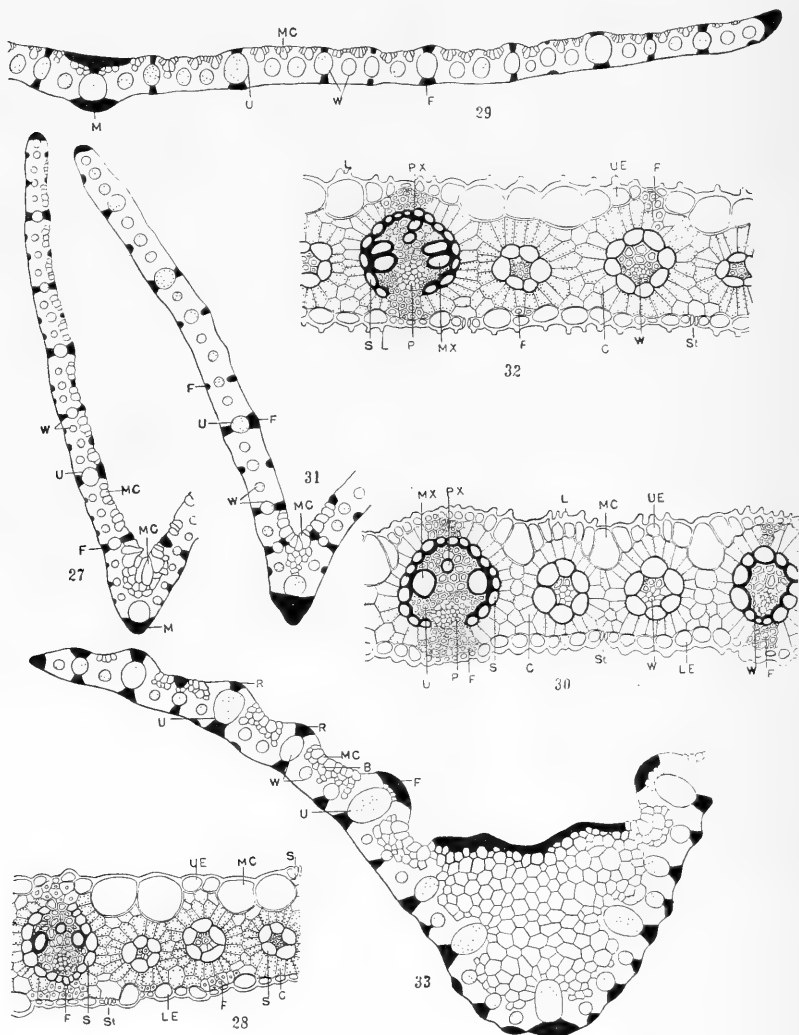
## POLLINIA.

POLLINIA FULVA Benth. (Syn. *Erianthus fulvus* Kunth.)

Erect, tufted perennial, rather slender, 60-90 cm. high, leafy at the base forming flag, and the culms also leafy; nodes glabrous or occasionally shortly bearded; sheaths smooth, glabrous or with a few scattered hairs; leaves flat, linear, 5-25 cm.  $\times$  3-4 mm., glabrous or with a few scattered hairs especially near the orifice of the sheath, mostly smooth on the lower surface, smooth to rather rough on the upper surface, inrolling, or sometimes the margins recurving on drying; ligule membraneous, truncate, rather jagged; midrib usually present, but not conspicuous. *Distribution*: Tablelands to the interior. Pasture species.

Anatomical characters: (Text-figs. 29 and 30.) Leaf moderately thin; both

surfaces flat, or sometimes with very shallow grooves over the motor cells; upper epidermis consisting of groups of motor cells, one group occurring between each bundle, separated by a few smaller epidermal cells over the bundles; each motor cell group more or less flattened triangular in outline, as the central cell is distinctly larger than the more flattened lateral cells, the central motor cell occupying rather less than half the thickness of the leaf at that point; all the upper epidermal cells with moderately thick, strongly arched to papillate outer walls, many bearing papillae; lower epidermal cells of medium size, with



Text-figs. 27-33.

27.—*Iseilema membranacea*.  $\times 28$ . 28.—*Iseilema membranacea*.  $\times 150$ . 29.—*Pollinia fulva*.  $\times 38$ . 30.—*Pollinia fulva*.  $\times 150$ . 31.—*Themeda australis*.  $\times 28$ . 32.—*Themeda australis*.  $\times 150$ . 33.—*Themeda avenacea*.  $\times 28$ .



moderately thick walls, very strongly arched to papillate, often also with papillae on the outer walls; stomates on both surfaces, more numerous on the lower surface; chlorenchyma regular; bundle sheath single, forming a circular layer. About 7-11 bundles of the first order occur, with 3-7 of the third order between each; midrib quite inconspicuous in section to conspicuous; stereome weakly developed as a small group of fibres above and below the larger bundles forming girders, and as an extremely small group above and below, or only below, nearly every second bundle of the third order, often completing very slender girders with these. *Localities*: Coonabarabran, Warialda, Botanic Gardens Sydney.

## THEMEDA.

## THEMEDA AUSTRALIS Stapf.

(Syn. *Themeda Forskallii* Hack., *Themeda triandra* Forsk., *Anthistiria ciliata* Benth. non Linn., *Anthistiria imberbis* Retz.)

Erect, tufted perennial, 30-200 cm. high, often rather brownish or reddish coloured; nodes glabrous; sheaths somewhat flattened, smooth, glabrous or in some forms with scattered tubercle-based hairs; leaves long, linear, narrow, often tapering to filiform points, 10-30 cm.  $\times$  2-4 mm., almost glabrous, smooth to rough; midrib present; ligule membranaceous truncate, or ciliate. One form of this species is rather glaucous. *Distribution*: Throughout the State. Pasture and open forest species.

Anatomical characters: (Text-figs. 31 and 32.) Leaf fairly thin; both surfaces flat or almost so; leaf distinctly keeled, folding, the margins recurving on drying; upper epidermis consisting of small cells above the larger bundles, alternating with groups of rather large cells with flat or arched walls, sometimes bearing papillae, and resembling motor cells, over the smaller bundles. These larger cells occupy one-quarter to one-third of the thickness of the leaf. A distinct group of larger, thin-walled motor cells sometimes occurs over the midrib; lower epidermis consisting of small cells whose outer walls are strongly arched, and bear small but prominent, sometimes bifurcate papillae; both surfaces bearing occasional asperities; stomates most numerous on the lower surface, very few on the upper surface; chlorenchyma regular around the bundles, with few cells between; bundle sheath single, strongly sclerized around bundles of the first order, thinner walled around the smaller bundles, forming a circular layer. About 7-9 bundles of the first order occur, with 3-7 bundles of the third order between each; midrib distinct owing to the keeling of the leaf, but usually not large, composed essentially of just the midvein, with a mass of fibre below it projecting on to the lower surface, and sometimes with a few colourless cells above it. In a specimen from Glenbrook, however, a large midrib is present, consisting of a large mass of colourless tissue above the midvein and associated bundles, and the motor cell group immediately above the midrib is absent; stereome very weakly developed as a very small mass above and below the first order bundles forming girders, and as extremely small groups above and below about every second bundle of the third order, often joined to them to form small girders. *Localities*: Warialda, Collarenebri-Walgett Road, Bourke, Megalong, Homebush, Glenbrook.

THEMEDA AVENACEA Hack. (Syn. *Anthistiria avenacea* F.v.M.)

Tall, erect, tufted perennial, 90-200 cm. high, rather glaucous, producing abundant flag; nodes glabrous; bases of the stem usually swollen and the sheaths surrounding them woolly hairy; culm sheaths smooth, glabrous; leaves narrow, becoming filiform, rather glaucous and scabrous, 12-40 cm.  $\times$  1-5 mm., folding

inwards on drying, the margins rarely recurving; midrib rather conspicuous in the wider flat leaves, or the leaf reduced to a midrib region in filiform leaves; ligule membranaceous, jagged or ciliate. *Distribution*: Tableland to interior. Pasture species.

Anatomical characters: (Text-fig. 33.) Leaf moderately thick; lower surface flat; upper surface with low ribs and shallow grooves, sometimes so low as to be merely undulating, the ribs usually over alternate bundles; upper epidermis consisting of small epidermal cells over the ribs, and groups of 3-8 fairly small motor cells in the grooves, sometimes with a few colourless cells below them, especially in the western specimens; motor cells of similar size, occupying about one-quarter to one-third of the thickness of the leaf at the grooves; epidermal cells all bearing prominent papillae, the walls of moderate thickness; lower epidermis of cells with moderately thick outer walls, bearing prominent, sometimes bifurcate papillae; stomates on both surfaces, rather more numerous on the lower surface, those on the upper surface mostly on the sides of the grooves; chlorenchyma in a fairly regular row around the closely spaced bundles, or sometimes with a number of additional cells between the rows, making the arrangement somewhat intermediate in type; bundle sheath single, forming a circular or oval layer. About 7-11 bundles of the first order occur, with 3-7 bundles of the third order between each. About every second or third bundle (i.e. bundles of the first order, and larger third order bundles) occupies a rib, with small bundles of the third order below the grooves; midrib conspicuous, with a mass of colourless tissue above the midvein and associated bundles; stereome developed as moderately small groups above and below every second bundle forming girders with them, and sometimes below and usually connected to the others. *Localities*: Scone, Warialda (2 collections).

In a specimen from Bourke, the leaf is larger and thicker than in the above, with about 2 small bundles of the third order under the grooves (between the larger bundles). Colourless cells below the motor cells well developed; some asperities present on the surface. Filiform leaves may also occur in which the leaf consists mainly of an enlarged midrib region with barely any expanded lateral portions; stereome rather more strongly developed with a group of fibres below and attached to every bundle; a large mass of colourless tissue occurring above the bundles. *Locality*: Rockhampton.

#### ZOYSIEAE.

#### NEURACHNE.

#### NEURACHNE MITCHELLIANA Nees.

Erect, tufted perennial, 15-45 cm. high, the base of the stems and basal shoots swollen and covered with woolly hairs; culms covered with woolly hairs which rub off where not protected by the sheaths; stem leafy, no flag produced; nodes ciliate; sheaths and nodes short, about 2-4 cm. long; sheaths and leaves irregularly ciliate with long tubercle-based hairs, especially the margins of the leaves; leaves narrow ovate-lanceolate, or linear, narrowing rather abruptly to a point at the top, 1-5 cm.  $\times$  3-5 mm., smooth, and very slightly scabrous on the margins, to slightly rough but not scabrous on the surface, sometimes slightly glaucous, rather inrolled on drying; midrib not noticeable; ligule ciliate. *Distribution*: Interior. Pasture and open forest species.

Anatomical characters: (Text-figs. 34 and 35.) Leaf fairly thick; upper surface flat or very slightly undulating; lower surface regularly undulating with

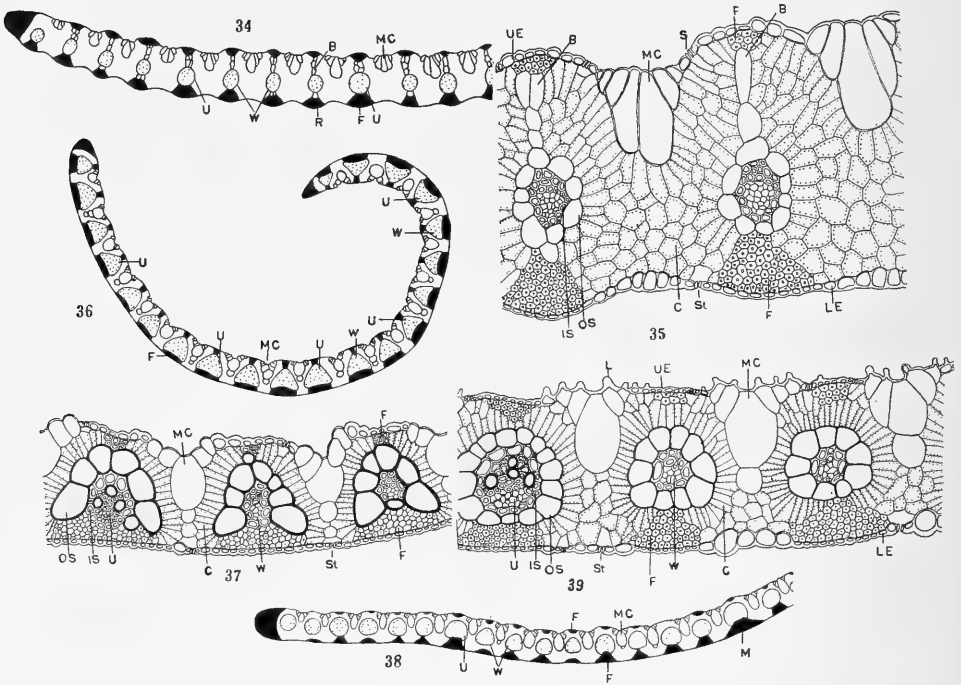
low flat ribs below the bundles; upper epidermis consisting of groups of small cells with moderately thick, flat or arched outer walls, alternating with deep, but narrow groups of 5-6 motor cells, of which the central cell is conspicuously the largest, occupying one-third to one-half the leaf thickness, the lateral ones increasingly smaller towards the side, so that the group is deeply triangular in outline; lower epidermis of small cells with thick, flat or arched outer walls, those between the bundles (under the motor cell groups) usually decidedly larger than the rest, but thick-walled; stomates numerous on both surfaces; chlorenchyma irregularly arranged, about two rows occurring around the bundles, and numerous others between the widely spaced bundles; bundle sheath double, the inner one always strongly sclerized, the outer one thin-walled, and usually consisting of slightly larger cells around the third order bundles than around the first order bundles, forming a circular or oval layer; outer sheath usually connected with the hypodermal fibre groups below the upper epidermis by 1 or 2 rows of colourless, rather elongated cells; midrib indistinguishable except for its position. About 5-7 bundles of the first order occur, with 3-4 bundles of the third order between each; all the bundles rather similar in size, widely spaced; stereome developed as a moderately large mass below each bundle, usually connected to the outer sheath, and as a very small hypodermal group above the bundles, with which it is connected by the colourless cells. Sometimes the colourless cells are absent, and the fibre group is larger, and connected with the bundles forming girders (as in the specimen from Cobar). *Localities*: Collarenebri-Walgett Road, Cobar, Broken Hill, Uriseno-Thurlow Downs.

#### NEURACHNE ALOPECUROIDES R.Br.

Erect, tufted grass, 15-45 cm. high, leaves chiefly at the base, forming a small amount of flag; the lower portion of the stem rather thick but not conspicuously swollen and corm-like as in *N. Mitchelliana*; a few woolly hairs present at the base but not conspicuously developed; stems slightly angular; nodes shortly ciliate; sheaths open but remaining wrapped around the stem, striate; sheaths and leaves hairy, with rather rigid hairs, slightly rough, or sometimes only ciliate with occasional hairs; leaves narrow, short, 5-8 cm.  $\times$  1-2 mm., often inrolled. *Distribution*: Interior.

Anatomical characters: (Similar to *N. Mitchelliana*, cf. Text-figs. 34 and 35.) Leaf thick; upper surface probably flat; lower surface undulating or almost ribbed with low ridges under the bundles; upper epidermis of small cells with rather thick, flat or arched outer walls, alternating with groups of 5-8, usually 7, motor cells, all rather flattened, the central one much the largest, the lateral ones progressively smaller, so that a deep triangular group is formed, occupying about half the leaf thickness; upper epidermis bearing a few long hairs; lower epidermis of small cells with thick, flat outer walls, but those in the grooves rather larger though still thick-walled; stomates on both surfaces; chlorenchyma irregular; bundle sheath double, the inner strongly sclerized, the outer thin-walled, forming a circular or oval layer; bundles alternately large (of first or second orders) and small (of third order), about 17-19 in all. In all bundles of the first and second orders, the phloem is divided down the centre by a zone of fibres into two groups (this feature is not shown by the third order bundles). Midrib not distinguishable; stereome rather weakly developed as a broad but thin hypodermal mass in the ridges below all the bundles, but only joined to a few of the largest bundles, and as a very small hypodermal mass above the bundles, but widely separated from

them. The colourless tissue which connects the bundles and the upper group of fibres in *N. Mitchelliana* could not be detected in this material, but may be present. *Locality*: Tammin. Dried material only examined.



Text-figs. 34-39.

- 34.—*Neurachne Mitchelliana*. Slightly more than half the transverse section.  $\times 28$ .  
 35.—*Neurachne Mitchelliana*.  $\times 150$ . 36.—*Perotis rara*.  $\times 38$ . 37.—*Perotis rara*.  $\times 150$ .  
 38.—*Tragus racemosus*.  $\times 28$ . 39.—*Tragus racemosus*.  $\times 150$ .

#### NEURACHNE MUNROI F.V.M.

Small tufted grass, 15-40 cm. high, the lower part of the stem rather thickened but not conspicuously swollen, woolly hairy at the nodes; culm nodes also ciliate; leaves mainly towards the base; stem slightly angular; sheaths glabrous, open but closely rolled around the stem, smooth or slightly scabrous; leaves very narrow lanceolate (tapering somewhat towards the base), 1-8 cm.  $\times$  1-3 mm., nearly glabrous, or with a few tubercle-based hairs, fairly smooth, or slightly scabrous on the lower surface, inrolled on drying; midrib absent; ligule ciliate. *Distribution*: Interior.

Anatomical characters: Leaf moderately thick; upper surface with low, rounded ribs over every bundle, those over the larger bundles broader, but very slightly higher than those over the small bundles; lower surface also undulating, or with low ribs below each bundle; upper epidermal cells over the ridges with moderately thick, strongly arched to rather papillate outer walls; epidermis in the grooves consisting of groups of 5-8 motor cells, which are increasingly large towards the centre of the group; numerous pointed hairs present on the upper

surface; lower epidermis of thick-walled cells with flat, or only slightly arched outer walls, little more than half as large as the upper epidermal cells, and bearing a few scattered hairs and asperities; stomates on both surfaces, chiefly on the sides of the grooves; chlorenchyma apparently rather irregular, but the bundles much more closely spaced than in *N. Mitchelliana*; bundle sheath apparently of one layer only, forming a circular layer. About 23 bundles occur, of which about every second is either a first or second order bundle, the remainder third order bundles; midrib indistinguishable; stereome moderately developed as a group of fibres below each bundle, occupying the ribs, and above every second bundle, a larger group over every fourth bundle; stereome usually not connected to the bundles. *Localities*: Cobar, Upper Arckaringa Valley (S.A.). Dried material only examined.

## PEROTIS.

## PEROTIS RARA R.Br.

Small, tufted grass, ascending, 15-30 cm. high, mainly leafy near the base, but not forming much flag; nodes glabrous; sheaths glabrous, smooth; leaves thin, linear to very narrow lanceolate, 1-5 cm.  $\times$  1-4 mm., fairly flat, or inrolled on drying, glabrous, very slightly rough, or a very few hairs may be present; ligule extremely short, truncate. *Distribution*: Western slopes to interior. Pasture species.

Anatomical characters: (Text-figs. 36 and 37.) Leaf very thin; both surfaces flat, or the upper surface with very short narrow grooves over the motor cells; upper epidermis of groups of small papillate cells, with very occasional asperities over the bundles, alternating with deeply triangular groups of 5-7 motor cells between the bundles; central motor cell of each group very conspicuously larger than the more flattened lateral ones, occupying nearly two-thirds the leaf thickness, often with 1 or 2 small colourless cells below it; lower epidermis of small cells with rather thick, arched or slightly papillate outer walls; stomates on both surfaces, more numerous on the lower surface; chlorenchyma regular, consisting of very narrow cells arranged in a narrow row around the sides of the rather closely spaced bundles, interrupted at the base and often at the top of the bundle by the stereome; bundle sheath of two layers, at least around the larger bundles, the inner sheath of small, thick-walled cells, the outer of very large cells which form a distinctly triangular layer around all the bundles, except that they are interrupted at the base of the bundles by the stereome; the triangular outline formed is about as wide as high; the conducting elements forming only very small groups even in the larger bundles. About 21 bundles occur, of which about 7 are small first order bundles; midrib quite undistinguished; stereome fairly well developed for such a thin leaf, forming a wide but rather thin mass of small fibres below each bundle, which extends laterally as far as do the outer bundle sheath cells, and is usually connected with the inner sheath, and a small mass above the bundles, so that a girder is formed with each bundle which is broad at the lower surface, very narrow at the upper surface. *Localities*: Warialda, Pilliga.

## TRAGUS.

TRAGUS RACEMOSUS All. (Syn. *Lappago racemosus* Willd.)

Small, tufted annual, erect or ascending, 10-45 cm. high, leafy mainly at the base; nodes glabrous; stems angular; sheaths sometimes rather flattened, glabrous except for a few cilia on the margins, smooth; leaves short, narrow-

lanceolate to linear, 1-5 cm.  $\times$  2-6 mm., the margins ciliate with long, tubercle-based hairs, otherwise mostly glabrous, the surface fairly smooth, rolling on drying; midrib usually absent, occasionally showing very faintly; ligule ciliate. *Distribution*: All over the State, chiefly west of the Divide. Pasture species.

*Anatomical characters*: (Text-figs. 38, 39.) Leaf moderately thin; both surfaces flat; upper epidermis consisting of very small cells with arched or papillate walls over the bundles, alternating with groups of usually 5 motor cells, of which the central cell is rather narrow but deep, and very conspicuously larger than the lateral somewhat flattened ones, and occupies half or more of the leaf thickness; outer wall of the motor cells also bearing papillae; lower epidermis of rather small cells with fairly thick, flat or very slightly arched outer walls; stomates on both surfaces, very small; chlorenchyma regular, consisting of unusually narrow cells; bundle sheath double around the larger bundles, the inner consisting of small sclerized cells, the outer of broad, but rather short cells with fairly thin walls and very dense contents; inner sheath absent from the smaller bundles; outer sheath forming a layer which is sometimes slightly flattened below the bundle, giving the bundle a very slightly triangular outline, or at other times almost completely circular. About 7-8 bundles of the first order occur, with 2-4 bundles of the third order between each; midrib quite undistinguished; stereome developed as a rather broad but thin group of small fibres below each bundle, often connected to it, and as very small hypodermal groups above the bundle, sometimes connected to the outer bundle sheaths of the first order bundles, rarely to the third order bundles. *Localities*: Warialda (2 collections), Bourke, Homebush.

#### ZOYSIA.

ZOYSIA BROWNII\* C. Muell. (Material identified at Kew, 1931.)

(Syn. *Zoysia pungens* Benth., *Fl. Aust.*, non Willd.)

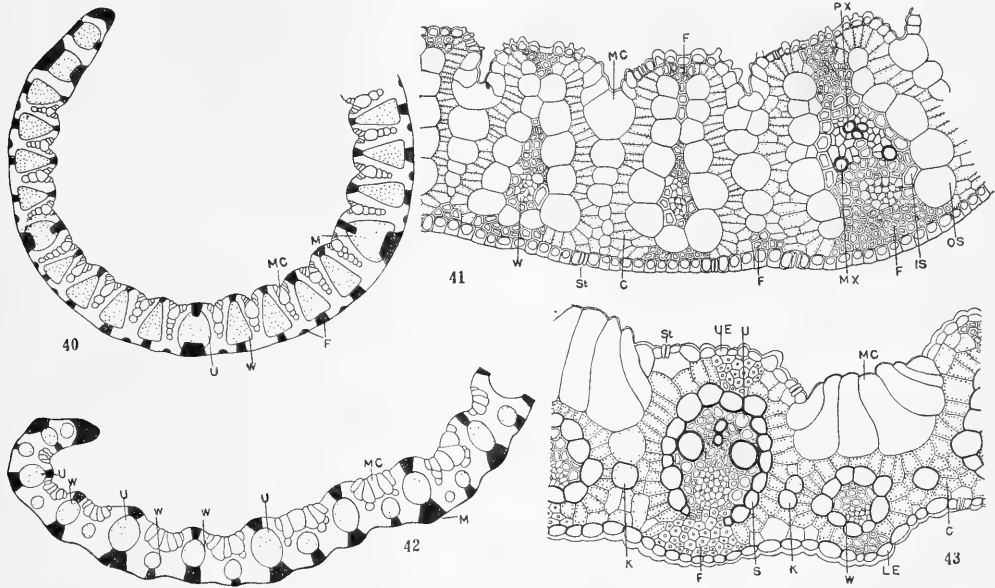
Perennial, creeping by rhizomes, ascending 7-30 cm., rather like 'couch grass' in habit; leaves all on the culms, crowded, the sheaths short; internodes sometimes, but not always, unequal in length, alternately long and short, so that the leaves approximate in pairs; nodes glabrous, often enclosed by the sheaths; leaves and sheaths glabrous, smooth; leaves linear, 1-10 cm.  $\times$  1-3 mm., narrow, pointed, inrolled on drying; midrib not or scarcely distinguishable; ligule consisting of a few cilia, sometimes almost absent. *Distribution*: Coast, on sand dunes and salt swamps.

*Anatomical characters*: (Text-figs. 40 and 41.) Leaf moderately thin; both surfaces flat or almost so, sometimes slightly undulating; upper epidermis consisting of small cells with rather thick, arched or papillate outer walls, and bearing numerous, small, often bifurcate papillae, over the bundles, alternating with groups of 5-7 motor cells between the bundles; lateral motor cells of each group flattened, the central one very conspicuously larger, and more rounded, occupying nearly one-third of the leaf thickness, but with a row of colourless, or almost colourless cells below it, which extend three-quarters or the whole way to the lower epidermis; outer walls of the motor cells fairly thin and papillose; lower epidermis of small cells with very thick, flat or very slightly arched outer

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\* Since this paper went to press, a contribution by C. E. Hubbard in *Icones Plantarum* (Vol. 3, No. 3, Tabular 3264, Aug., 1935) has come to hand in which he shows that the name *Zoysia macrantha* (Tribe Zoisieae) should supersede *Zoysia* (*Zoysia*) *pungens* R.Br. and *Z. Brownii* C. Muell.

walls, forming a compact layer; stomates on both surfaces, fairly small; chlorenchyma regular, consisting of small, narrow cells forming a very narrow row around the bundles, usually interrupted above and below the bundles by the stereome; bundle sheath double; inner sheath of small thick-walled cells, only shown by the larger bundles; outer sheath of large, fairly clear cells, forming a layer which extends upwards towards the upper surface, and is flattened at the lower surface, so that the bundle has a strongly triangular outline, the triangle



Text-figs. 40-43.

40.—*Zoysia Brownii*. × 60. 41.—*Zoysia Brownii*. × 210. 42.—*Arundinella nepalensis*. × 28. 43.—*Arundinella nepalensis*. K, thick-walled cells resembling isolated bundle sheath cells. × 150.

much taller than wide, with its apex towards the upper surface; midrib undistinguished. About 7 bundles of the first order occur, with 3-5, usually 4, bundles of the third order between each; stereome weakly developed as rather small masses above and below the first order bundles forming girders, and as extremely small groups above and below the third order bundles and usually connected with them. A very small hypodermal group of about 3-5 fibres may also occur on the lower side, between the bundles (below the motor cell groups). The first order bundle nearest the leaf margins has a much larger group of fibres above and below it forming a very strong girder, than any other bundle. *Localities*: Harbord, Homebush Bay.

TRISTEGINEAE.

ARUNDINELLA.

ARUNDINELLA NEPALENSIS Trin.

Tall, cane-like perennial, 90-240 cm. high, creeping by means of short rhizomes with slightly swollen nodes, and sending up stiff, erect culms, producing little leaf and no flag; nodes glabrous; sheaths glabrous, mostly smooth, or some-

times rough downwards, rather striate; leaves linear, 5–25 cm. × 3–8 mm., slightly glaucous green, the margins and upper surface scabrous, the lower surface sometimes smooth, inrolling on drying; midrib inconspicuous, or very slightly shown towards the base; ligule minute, truncate. *Distribution*: Coast to interior, chiefly in the north.

Anatomical characters: (Text-figs. 42 and 43.) Leaf of moderate thickness; both surfaces somewhat undulating, scarcely ribbed; upper epidermis consisting of alternating groups of small, arched to papillate cells above the bundles, and groups of about 3–7 large motor cells, which are progressively larger towards the centre of each group, and occupy nearly half the thickness of the leaf at the point where they occur; all cells of the upper epidermis moderately thin-walled. A few colourless cells may occur below the motor cell groups; lower epidermal cells with rather thick, flat or slightly arched outer walls; stomates on both surfaces, rather more numerous on the lower surface; chlorenchyma arranged fairly regularly in a row around the bundles, with a few additional cells between the bundles, sometimes somewhat intermediate in type between the regular and irregular arrangements; bundle sheath single, the cells only a trifle more sclerized around the larger bundles, forming a circular layer; bundles of three types, first order, large bundles of the third order (with no vessels, but a considerable amount of lignified tissue and a distinct phloem group), and smaller third order bundles with less lignified tissue. The larger bundles are alternately first and large third order bundles, with 1 or 2 small third order bundles between each; midrib almost or completely indistinguishable; stereome developed as moderate-sized masses above and below all the larger bundles, usually forming girders. Between almost every bundle, one or two rounded, rather thick-walled cells resembling isolated bundle sheath cells occur (K, Text-fig. 43). *Localities*: Warialda, Barraba, Gulgong.

#### SUMMARY.

The leaf anatomy and vegetative characters of the indigenous grasses of New South Wales belonging to the tribes Andropogoneae, Zoysieae and Tristegineae are described and illustrated.

In conclusion, I desire to thank Professor T. G. B. Osborn, of the Department of Botany, Sydney University, who first suggested this work to me, for his helpful interest during the course of the investigation.

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UPPER PERMIAN INSECTS OF NEW SOUTH WALES. IV.

THE ORDER ODONATA.

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(Plate xii, figs. 1-3; four Text-figures.)

[Read 30th October, 1935.]

The association of insects and plants in the freshwater beds of Upper Permian age of Belmont and Warner's Bay, near the shores of Lake Macquarie, is such that it has all along been evident that dragonflies of some kind or other must have been present there. Yet the mode of fossilization appears to have been distinctly against the complete preservation of wings of large size, and most of the specimens found have proved to be exceptionally small for Palaeozoic types. This may be partly accounted for by the admitted coldness of the climate in Upper Permian times in Australia. But dragonflies of considerable size can exist in an Arctic climate, and there has never been any reason to suppose that they did not exist in the Australian Upper Permian, since a number of fine types have been found in the Upper Carboniferous of Europe and Lower Permian of Kansas.

The first discovery of a fragment of a dragonfly wing was made by Mr. T. H. Pincombe in 1931, in a piece of rock from Warner's Bay. It is a small piece of a rather large wing, showing the nodus and portions of the costa, subcosta, radius and radial sector around it, as far as the beginning of the pterostigma. A further discovery of portion of the posterior margin and cellules just above it, of a much crumpled Odonate wing, was also made by Mr. Pincombe in 1931.

The above-mentioned material was considered by me to be too fragmentary for description by itself. The search for a more complete wing has now at last been rewarded, twenty years or so after the original discovery of the Belmont Beds by Mr. John Mitchell, by the finding of a nearly complete forewing by Mr. M. S. Stanley on 2nd April of this year, in a piece of pale grey shale brought by him from Warner's Bay. Mr. Stanley is to be heartily congratulated on this fine discovery, which is commemorated in the naming of the species in his honour in this paper. The other fragmentary remains are also dealt with in this paper.

It seems best to deal with the descriptions of the new families, genera and species first, and then to discuss their affinities. The known Odonate fauna of the New South Wales Upper Permian can now be classified under the following tentative key:

- Nodal fork with long anterior branch (Sc) and the subnodus (Sn) continuing the line of the short lower branch ..... Genus *Polytaxineura*, n.g.
- Nodal fork with both branches short, and the subnodus descending practically at right angles to  $R_1$  ..... Genus *Antitaxineura*, n.g.

## Family POLYTAXINEURIDAE, n. fam.

Dragonflies of moderate size, belonging to the Suborder Protanisoptera. Hindwing slightly broader than fore. A coriaceous precostal area present at base of costa. Costal margin serrated. Numerous antenodals of both series present; apparently only one postnodal present. A complete nodus and subnodus present at a point well beyond half-way along costa, with a marked bend or break at the junction of Sc with C. Radius and media (MA) are distinct though contiguous veins from base to arculus; Rs + MA leaves  $R_1$  at arculus in a very gentle slope.  $Cu_2$  and 1A both strongly curved in an upward hump in the region of the arculus. Discoidal cell of forewing open basally; an elongated subquadrangular cell present below it.

This family is formed to receive the new genus *Polytaxineura*, defined below. It also includes the less well preserved genus *Pholidoptilon* M.D. Zalesky, from the Upper Permian (Kazanian) of Russia, for which its author did not propose a family name, and possibly also the imperfectly preserved genus *Permaeschna* Martynov, also from the Upper Permian of Russia (Iva-Gora). The basal portion of this latter genus is not known and therefore its actual classification must remain uncertain. Should it, however, prove later on to belong to the same family as *Polytaxineura* then the name of the family must be changed to Permaeschnidae Martynov, since Martynov actually defined this family in 1931.

## Genus POLYTAXINEURA, n.g.

(Plate xii, figs. 1-3, and Text-figs. 1-3.)

Antenodals of the first and second series for the most part not corresponding, the exceptions being the first, fifth and sixth (cf. recent Aeschnidae). Costal and subcostal spaces narrow, especially towards nodus. Beyond nodus, the costal and radial spaces, as far as they are preserved, are almost entirely devoid of cross-veins, there being only a single postnodal, slightly obliquely placed, at a level just beyond the third cellule below  $R_{2+3}$ . Below this, in the radial space, there is a similar cross-vein, followed shortly after, above the fourth descending cross-vein from  $R_{2+3}$ , by a second cross-vein placed very obliquely in the opposite direction, i.e., nearly parallel to the subnodus (cf. *Ditaxineura*). In the region of the arculus, about two-fifths of the way from base to nodus,  $Cu_2$  arches strongly upwards in a hump-like fashion and then begins to diverge slightly from the descending free portion of MA above it. There is no posterior arculus, the discoidal cell (*dc*) remaining open basally, and being closed distally by the discoidal vein (*dv*), which descends transversely from MA on to  $Cu_2$  at a point about three-fifths of the way along the elongated subquadrangle (*sq*). Basilar or median space entirely without cross-veins. Cubital space with four oblique cross-veins before the basal side of the subquadrangle; of these, the fourth forms, with the hump of  $Cu_2$  above it, a smaller portion of the hump of 1A below it, and the basal side of *sq*, a small trapezoidal cell which I propose to designate as the *prequadrangle* (*pq*).

About half-way between arculus and nodus, MA gives off a posterior branch, the median supplement, Mspl, concave and separated from MA itself by a single series of cellules. (This must not be confused with the true, original posterior median, MP, which is known to have been suppressed entirely in Lower Permian ancestral forms, and which, in any case, arose quite close to the base of the wing.) 1A also gives off, just distad from the prequadrangle, a similar posterior branch, the anal supplement, Aspl, also slightly concave. The spaces between Mspl,

basal portion of 1A, Aspl and the posterior border are all filled with a polygonal network of cellules for the most part fairly regularly arranged; this formation has suggested the name of the genus.

Nodus complete, the upper fork (end of Sc) being very oblique and about four times as long as the lower fork or nodal cross-vein (*nc*). Subnodus (*Sn*) is continuous with the nodal cross-vein above it and also with  $R_{4+5}$  below it; this vein runs parallel to and close above MA.

Where the vein 1A terminates, the posterior margin has a slight bend; probably the same is true where MA terminates, though this portion is not preserved. The pterostigmatic region and apex of the wing are not preserved, but there are some signs of the immediate presence of the pterostigma itself just beyond the break at the end of  $R_1$ . Also a comparison of this region of the wing with that of *Ditaxineura* indicates that the backwardly oblique cross-vein, *k*, should be about in the same relationship to the pterostigma itself as in that genus.

The above definition applies chiefly to the forewing, which is almost completely preserved except for its apical one-fifth. The fragment of the hindwing preserved shows, fortunately, the arculus region, with Rs and MA diverging slightly more from  $R_1$  than in the forewing. From this we may deduce quite legitimately that the hindwing was somewhat broader than the fore. There being no sign of 1A in the broken space below  $Cu_2$ , it is clear also that the subquadrangle was at least somewhat wider than in the forewing, possibly considerably so. The discoidal cell must have been very similar to that of the forewing, but apparently with MA and  $Cu_2$  less diverging owing to the greater obliquity of the former; the distal side of this cell is not preserved.

Genotype, *Polytaxineura stanleyi*, n. sp.

Horizon: Upper Permian of Warner's Bay, New South Wales.

POLYNTAXINEURA STANLEYI, n. sp.

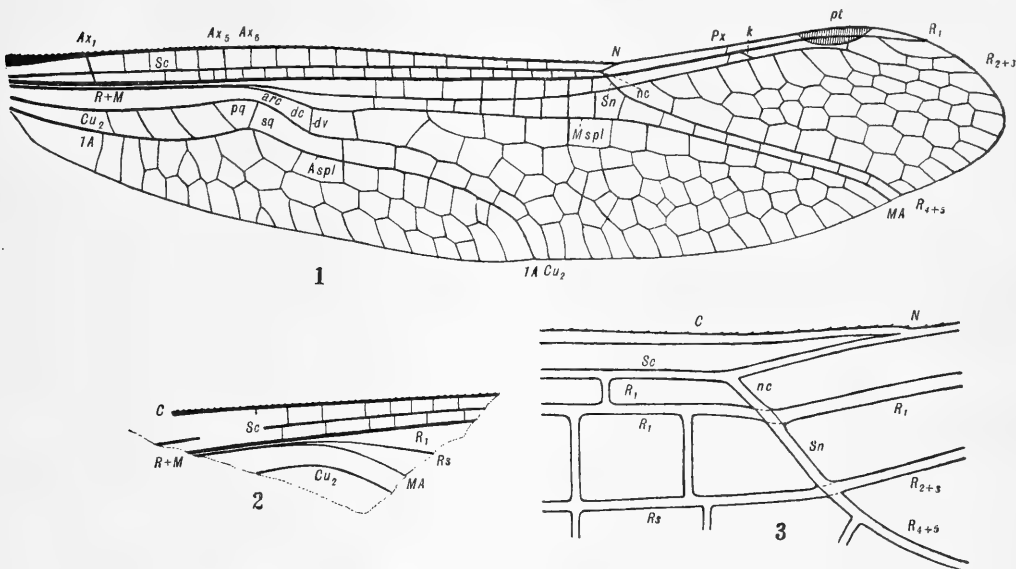
(Plate xii, figs. 1-3; Text-figs. 1-3.)

The preserved portions of this species are as follows:

- A. (1) A nearly complete forewing (Plate xii, fig. 1), obverse impression, with apex to the left; the apical one-fifth missing and also slight breaks on costa just before nodus and on posterior margin about half-way along preserved portion. Rest of the wing very well preserved, except that there is slight damage to the chitinous ridges of  $Cu_2$  and 1A just beyond their humps. The rock is cracked transversely to the wing, and the wing itself very slightly displaced, just distad from these humps; 5 to 6 mm. further distad there is another transverse crack, but without any displacement of the wing. Just distad from nodus there is a third transverse crack, also without displacement of the wing to any extent. The completely restored forewing, with the apex turned to the right, for comparison with other wings, is shown in Text-figure 1.
- (2) (Plate xii, fig. 1). On same piece of rock as above, and lying in its correct position just below the forewing, there is a small portion of the corresponding hindwing (Text-fig. 2), 10 mm. long and triangular in shape, showing C, Sc and R, with the arculus formation and the hump of  $Cu_2$  below it.
- B. (Plate xii, fig. 2.) The counterpart (reverse impression, with apex to right and  $R_1$  concave) of the basal half of the wing mentioned under A (1),

with the humps of  $Cu_2$  and  $1A$  somewhat better preserved than in the obverse impression. A small portion of the hindwing is also preserved, corresponding with  $A$  (2).

- C. (Plate xii, fig. 3.) A separate distal piece of the counterpart of  $A$  (1), about 12 mm. long, showing the nodus, very well preserved, and the portion of the costal area of the wing basad from it. This piece fits exactly into the distal edge of B.



Text-fig. 1.—*Polytaxineura stanleyi*, n.g. et sp. Order Odonata, Suborder Protanisoptera, fam. Polytaxineuridae, n. fam. Restoration of complete forewing, based on the actual specimens as shown in Plate xii. Comstock-Needham Notation except MA, anterior median (convex) of Lameere; *arc*, arculus; *Aspl*, anal supplement;  $Ax_1$ ,  $Ax_5$ ,  $Ax_6$ , first, fifth and sixth antennodals (corresponding in the first and second series); *dc*, discoidal cell; *dv*, discoidal cross-vein; *k*, oblique radial cross-vein placed after *Px*; *Mspl*, median supplement; *N*, nodus; *nc*, nodal cross-vein; *Pc*, precostal area; *pq*, prequadrangle; *pt*, pterostigma; *Px*, postnodal; *Sn*, subnodus; *sq*, subquadrangle. ( $\times 2.6$ .) Apex to right.

Text-fig. 2.—*Polytaxineura stanleyi*, n.g. et sp. Fragment of hindwing, with apex placed to right, showing region of arculus. Lettering as in Text-fig. 1. ( $\times 4$ .)

Text-fig. 3.—*Polytaxineura stanleyi*, n.g. et sp. Forewing, region of nodus. ( $\times 11.3$ .) Lettering as in Text-fig. 1.

The following description is drawn from all the above specimens:

Forewing.—Length of obverse impression in the actual fossil, 40 mm., representing a complete wing of about 50 mm. in length (Text-fig. 1). Greatest breadth 10 mm. at end of *Aspl*; the breadth only varies between 9 and 10 mm. for most of the length of the wing. The pale grey surface of the rock is mottled irregularly with rust-coloured staining due to oxide of iron. This, however, does not represent any colour-pattern on the wing, as it runs irregularly beyond the wing-impression on to the rock outside.



*Precostal area* present at base of costa, narrowly wedge-shaped, opaque, coriaceous, its free anterior margin meeting the true costal vein at an angle of about  $10^\circ$ .

*Costa* (Text-fig. 3, *C*) strongly serrated along its anterior margin. Basally, along the precosta and the first few antenodal cellules, the teeth of the serrations are close together; further distad, they tend to space out and appear as small black denticles wider and wider apart and directed very slightly forwards. Beyond the nodus, they are much fainter, and still more widely spaced.

*Antenodals* (Text-fig. 1, *Ax*), 17 in the first series (costal) and 20 in the second series (subcostal); only the first, fifth and sixth of the first series corresponding with the second; the costal space is distally free of antenodals for a distance covering the last three of the second series. (Two antenodals of the first series lost in a slight break along the costa in the obverse impression are present in the reverse and are counted in the total.)

*Nodus* (Text-figs. 1, 3, *N*). At the nodus, *Sc* approaches *C* very gradually, at an angle of about  $12^\circ$ , but the angle which the nodal cross-vein below *Sc* makes with *R* is about  $45^\circ$ . Hence the upper arm of the nodal fork is about four times as long as the lower. The subnodus (*Sn*) continues the slant of the nodal cross-vein (*nc*) above it, and joins *Rs* at its point of bifurcation into  $R_{2+3}$  and  $R_{4+5}$ , the latter branch continuing the line of *Sn* downwards with a gentle curve towards the apex. The nodus is therefore complete and specialized except for the long approach of *Sc* to the costal margin. As far as can be judged in an incomplete wing, the nodus lies at three-fifths of the total wing-length from the base. This is a primitive character in so far as it indicates a small degree of recession of *Sc* from its ancestral position far along the costal margin.

It should be noted (Text-fig. 3) that both *Sc* and  $R_1$  are somewhat bent at the nodus. The upwardly bent end of *Sc* at the nodus is slightly narrower than the rest of that vein, but the portion of  $R_1$  beyond the nodus is distinctly broader and flatter. The costa itself also becomes narrowed as it approaches its junction with *Sc*, but broadens slightly again immediately afterwards. The marginal serrations become very weak and indistinct distad from the nodus.

*Postnodals* (Text-fig. 1, *Px*). In the preserved distal portion of the wing, only a single postnodal (*Px*) can be seen between *C* and *R*, with a similar cross-vein just below it. Both of these are situated at a level slightly distad from the third descending vein from  $R_{2+3}$  after *Sn*. Slightly distad from the lower of these two cross-veins, and just above the fourth descending vein below  $R_{2+3}$ , there is a very oblique, backwardly directed cross-vein (*k*) in the radial space, resembling that found in *Ditaxineura*.

*The Pterostigma* (Text-fig. 1, *pt*). This is missing in the actual fossil, but its probable structure can be deduced by reference to *Ditaxineura* Till. and *Permaeschna* Mart. (1931a), coupled with the observed fact that *C*,  $R_1$  and  $R_{2+3}$  all converge as they approach the pterostigmatic region. In Text-fig. 1, I have restored the pterostigma as elongate but somewhat of the swollen form found in *Ditaxineura* and *Permaeschna*. I have also shown  $R_{2+3}$  curving away from  $R_1$  beneath the pterostigma, as it does in these other two genera.

*The Arculus* (Text-figs. 1, 2, *arc*). From base to beginning of arculus, the two veins  $R_1$  and  $Rs+MA$  are quite distinct but contiguous. At the level of the sixth antenodal,  $Rs+MA$  begins to diverge very gently from  $R_1$ ; at the level of the seventh antenodal, *MA* separates itself from *Rs* and makes a more markedly downward curve as far as the level of the ninth antenodal, where the discoidal

cross-vein (*dv*) descends from MA on to  $Cu_2$  almost at right angles to the former vein. The arculus is therefore only an *anterior arculus*, the posterior portion (i.e., basal side of discoidal cell) being absent.

*The Discoidal Cell* (Text-figs. 1, 2, *dc*). This is entirely open basally, but is closed distally by the discoidal cross-vein (*dv*). The discoidal cell in the forewing is widest distally owing to the greater curvature of its posterior side,  $Cu_2$ , compared with its anterior side, MA. In the hindwing (Text-fig. 2), although the discoidal cell is not completely preserved, it can be seen that it must be more rectangular distally owing to the greater obliquity of MA.

*Cells in the cubital space*. It will be seen (Text-fig. 1) that the basilar or median space is devoid of cross-veins from base right up to the discoidal cross-vein (*dv*). The cubital space, however, possesses four basal cross-veins descending obliquely from  $Cu_2$  to 1A between the base and the humps of these veins. A little distad from the fourth of these veins there is a strong cross-vein arising from the top of the hump of 1A and slanting upwards and outwards to end on  $Cu_2$  just beyond the top of its hump. This cross-vein forms with its two connected main veins and the fourth of the oblique cubital cross-veins already mentioned a trapezoidal figure, the prequadrate (*pq*). Next to this comes the elongated and much curved subquadrate (*sq*), a cell of great importance in the further evolution of this portion of the Odonate wing.

The number of cellules in the part of the forewing preserved is approximately two hundred, indicating that the wing had altogether about two hundred and fifty cellules in it. This is apparently somewhat in advance of the wing of *Pholidoptilon*, and very greatly in advance of the wing of *Ditaxineura*, which had less than sixty.

Type.—*Holotype*, Specimen S 343, A, B and C: A, obverse impression of forewing and small portion of hindwing, with apex to left; B, basal half of reverse impression of same; C, anterior portion of distal half of reverse impression of same.

*Locality*: Warner's Bay, Lake Macquarie, N.S.W. Found by Mr. Malcolm Stanley, 2nd April, 1935, in a rather large lump of hard pale grey shale having somewhat conchoidal fracture. In the same piece of rock were found part of a leaf of *Glossopteris* and a leaf-scale of same.

#### AFFINITIES OF THE GENUS POLYTAGINEURA.

The only genus with which the new fossil shows any close affinity is *Pholidoptilon* Zalesky (1932) from the Upper Permian (Kazanian) of Russia. *Pholidoptilon* differs from *Polytagineura* in having much fewer antenodals, those of the first series numbering only thirteen, while those of the second (possibly incomplete) are shown as only seven in Zalesky's figure (l.c., p. 717). The precostal coriaceous area is present in *Pholidoptilon*, but is strongly humped. The first antenodal, complete as in *Polytagineura*, is more oblique, suggesting the brace-vein of recent Plectoptera. *Pholidoptilon* agrees with *Ditaxineura* in possessing no postnodals at all and with *Polytagineura* in having the costal and radial spaces very narrow. The nodus resembles that of *Polytagineura*, but with the upper arm of the nodal fork much shorter. The pterostigma is preserved as a very narrow, elongated, chitinized cell only about two cellules' distance from the nodus. As in *Polytagineura*,  $R_{4+5}$  arises from below *Sn*.

*Pholidoptilon* has the basilar space and arculus very much as in *Polytagineura*, but the humps of  $Cu_2$  and 1A are less marked, and  $Cu_2$  runs parallel with MA as far as the discoidal cross-vein, so that the discoidal cell is an elongated rectangle with the basal side open. The cubital space has a single cross-vein,

slightly oblique, followed by a much more oblique one forming a triangle in the place of the prequadrangle of *Polytaxineura*. Zalesky has jumped to the conclusion that this triangle is homologous with the triangle of Anisoptera, and has explained the line of evolution of this cell from *Pholidoptilon* to Anisoptera along one developmental series, and to Zygoptera along another. The result is that he makes the supratriangle of Anisoptera homologous with the quadrilateral or discoidal cell of Zygoptera, moving the *Pholidoptilon*-triangle (i.e., the prequadrangle of *Polytaxineura*) gradually forward until it comes beneath the discoidal cell.

No student of Odonata could possibly accept this explanation, which controverts the basic work of Needham (1903) on this important phase of venational evolution in Odonata.

We have only to turn to the hindwing of such a genus as *Liassophlebia* Till. (1925, p. 15, fig. 4) to see the falsity of Zalesky's argument. In this wing, the discoidal cell is already practically a pentagon and only requires the development of a longitudinal cross-vein strut to divide it into triangle-plus-supratriangle, exactly along the lines predicted by Needham (1903) in his classical memoir, written long before this genus was discovered. Further, Zalesky has to suppress his triangle entirely in order to bring the Zygoptera into his scheme of evolution. But one could not suppose that a cellule that, on his own argument, was to prove so important in the scheme of evolution of the Anisoptera, would be entirely eliminated in the other recent Suborder.

Zalesky placed *Pholidoptilon* in a new Order, Permodonata, which he claims to be the real ancestor of all recent Odonata. However, when we come to discuss *Ditaxineura* Till., it will readily be seen that the "Order" Permodonata is nothing more than the Suborder Protanisoptera, erected previously (1931) by F. M. Carpenter to contain this latter genus.

*Polytaxineura* shows distinct affinities (though more distant than with *Pholidoptilon*) with *Ditaxineura* in a number of points of very great importance, viz., the presence of the precostal coriaceous area, the completeness of the oblique first antenodal, the absence or paucity of postnodals, with narrowing of costal and radial spaces beyond the nodus, the origin of  $R_{2+3}$  at the subnodus, the very gentle divergence of  $Rs+MA$  at the arculus, the form of the discoidal cell, the humped curvature of  $Cu_2$  and  $1A$  below the arculus and the presence of a long, curved subquadrangle.

*Ditaxineura* is more primitive than *Polytaxineura* in the smaller number of antenodals, in the complete absence of postnodals, in the less perfectly formed nodus and subnodus, in the presence of a short basal remnant of  $Cu_1$  and in the very weak formation of the prequadrangle; also, most probably, in the weaker development of the supplement below  $1A$ . *Ditaxineura* may be somewhat in advance of *Polytaxineura* in the highly specialized form of the pterostigma, and is certainly so in the very regular arrangement of the cross-veins in two gradate series in the distal half of the wing. This latter character, recalling the similar arrangement in the Planipennian family Chrysopidae, is, as far as I know, unique in the Order Odonata.

#### THE SUBORDER PROTANISOPTERA.

It is now evident that Carpenter's Suborder Protanisoptera must stand, and that it should include the three Permian genera *Ditaxineura* Till., *Polytaxineura*, n.g., and *Pholidoptilon* Zalesky, and possibly *Permaeschna* Martynov also.



The Suborder should be defined as follows:

Odonata with non-petiolate wings, the forewing being slightly longer and narrower than the hind. Precostal coriaceous area present. A true nodus formed at a point beyond half-way along the costa, with a distinct break or bend of the costa at the nodus. Antenodals of both series present; postnodals absent or very few. Arculus formation very weak, no posterior arculus present. Discoidal cell open basally, closed distally by the discoidal vein (*dv*). A long, curved subquadrange present.  $Cu_2$  and 1A both curved upwards in a humped manner below arculus.

Two families can now be defined within the Suborder, as follows:

Family 1. DITAXINEURIDAE.—Basal remnant of  $Cu_1$  present. Nodus and subnodus incompletely formed. Few antenodals present; postnodals entirely absent. Pterostigma much swollen, projecting across radial space almost as far as  $R_2$ . Prequadrangle merely an unspecialized space between two cross-veins. Cross-veins in distal part of wing arranged in two gradate series.

Genus *Ditaxineura* Till. Lower Permian of Kansas.

Family 2. POLYTAXINEURIDAE.—Basal remnant of  $Cu_1$  absent. Nodus and subnodus completely formed and in line. Numerous antenodals present; postnodals absent or very few. Pterostigma probably swollen. Prequadrangle a specialized cell, either trapezoidal or triangular in shape. Cellules and cross-veins much more numerous than in the previous family, but without the specialized arrangement of cross-veins into two gradate series in the distal part of the wing.

Genera, *Polytaxineura*, n.g., *Pholidoptilon* M.D. Zalesky, and possibly also the imperfectly known *Permaeschna* Martynov (1931).

Zalesky did not define a family for his genus *Pholidoptilon*. As the new genus *Polytaxineura* appears to be much better preserved, it seems advisable to name the new family after it rather than after the older but less perfectly known genus. If *Permaeschna* Mart. belongs to this family, the name must be changed to Permaeschnidae Mart.

It will be seen that the Ditaxineuridae foreshadow the Libelluloidea amongst the true Anisoptera, while the Polytaxineuridae foreshadow the Aeschnoidea. It is quite possible that the Ditaxineuridae may prove eventually to be the actual ancestors of the Libelluloidea, giving origin directly to primitive types of Corduliidae, such as *Cordulephya*. But it appears more likely, on present evidence, that the Libelluloidea are a side-branch from the older Aeschnoid complex, and therefore not earlier than Jurassic in geological age. The Polytaxineuridae appear to me to lie in the direct ancestral line of the Anisozygoptera, from which the Aeschnoidea, and therefore most probably the whole of the Anisoptera, were derived in Upper Triassic times, the evolutionary connection being with the Liassogomphidae in the Anisozygoptera and the Petaluridae (more especially Tachopteryginae) in the Aeschnoidea.

Looking backwards geologically, it now appears possible that the Meganeuridae may have been the group with which the Protanisoptera have the closest affinity. Martynov's separation of this family (1932) into a distinct Suborder Meganisoptera would appear to be justified on the single but very important character of the complete absence of a nodus. In other characters the Meganisoptera stand much closer to the Protanisoptera than would appear evident on a cursory inspection; notably in the weak arculus-formation and the humped

curvature of  $Cu_2$  and 1A below the arculus. The more specialized types found in the Protanisoptera have evidently been evolved from a small ancestor with very weak cellule-formation and without any true nodus. Such an ancestor would have to be classified within the Meganisoptera, but not within the Meganeuridae.

The Meganeuridae themselves, though existing in the Upper Carboniferous and Lower Permian, stand far in advance of the true Protodonata (*Protagrion*, *Calvertiella*, *Cockerelliella*, etc.), in which the general scheme of venation is much more complete and more closely approaches that of the Palaeodictyoptera. In the Meganeuridae, as I have previously shown (Tillyard, 1925a), the original main veins MP and  $Cu_1$  are in process of suppression, and only short basal remnants of these veins at the most are still preserved; whereas in the true Protodonata both of these veins remain complete.

I am still unable to satisfy myself that any ancient type lying within the Odonatoid Complex ever possessed more than one true anal vein, viz., 1A. This character is shared with the Order Megasecoptera, as is also another of great importance, viz., the serrated costa. Therefore I must still maintain that we should look for the original ancestor of the whole Odonatoid Complex within the Order Megasecoptera, and not within the Order Palaeodictyoptera, where the anal venation was complete. As the oldest types within the Odonatoid Complex all possess a precostal coriaceous area, we should search for an ancestral form in which this character also appears. Such a form is *Brodica*, which stands at the very base of the Order Megasecoptera, and in which also, as we are fortunate to be able to know, the wing-sheaths of the larva stood upright above the body, thus giving a possible starting-point for the peculiar arrangement in the larvae of Odonata, where the sheath of the hindwing comes to overlie that of the fore.

The discovery of the complete wing of *Ditaxineura* made it necessary, as Carpenter rightly pointed out (1931, p. 136) to abandon my original claim that the Anisozygoptera arose from a Zygopterous or Protozygopterous ancestor, and to accept instead the hypothesis offered by Carpenter that the Anisozygoptera were directly descended from the Protanisoptera. I think that the discovery of the new genus *Polytaxineura* further strengthens this position. We now see that the Protanisoptera stand to recent Anisoptera much as the Marsupials do to Placental Mammals; they are not direct ancestors, but they foreshadow the main types which were destined to be developed, much later, out of the Anisozygoptera. The Ditaxineuridae are definitely "Corduloid" in venational structure, the Polytaxineuridae "Aeschnoid". The true origin of the great Libelluloid Complex still remains to be worked out.

#### ODONATA INCERTAE SEDIS.

##### Genus ANTITAXINEURA, n.g. Text-fig. 4.

Wing of fairly large size, with nodus perfectly formed, the upper arm of the nodal fork (Sc) short and quite strongly upturned at an angle of about  $30^\circ$  to costal margin; the lower arm arching strongly downwards to meet  $R_1$  nearly at right-angles and continuing across it as the subnodus (Sn) at right-angles to  $R_1$ . A complete series of antenodals present between C and Sc, but none in the subcostal space as far as it is preserved. One postnodal before pterostigma; the latter rather close to nodus, strongly chitinized, with its basal side oblique; in shape it is swollen, apparently much as in *Ditaxineura*, and projects downwards nearly to  $R_2$ , to which it is connected by a cross-vein. Radial space completely free of cross-veins as far as it is preserved, except for this hypostigmatic vein

(*hsv*). At subnodus,  $R_s$  appears to bend downwards at a slight angle, but this may be due to fracture of the vein. Just before the level of  $Sn$ ,  $R_s$  is supported by a long strut below it, slanting obliquely downwards and backwards, and there is another similar strut, slightly curved, one cellule's length distad from this; where this second strut drops from  $R_s$  two longitudinal veins can be seen, almost lying on top of one another, while a third, much broken, passes obliquely downwards and forwards. The two contiguous longitudinal veins, one of which must certainly be either  $R_s$  or  $R_{2+3}$ , run together to a point just below the level of the beginning of the pterostigma, where the uppermost of them forks. Assuming the two branches to be  $R_2$  and  $R_3$ , the upper,  $R_2$ , now converges strongly towards the pterostigma as far as the cross-vein *hsv*, where it bends to run parallel to and just below  $R_1$ . The lower branch,  $R_3$ , turns obliquely downwards until it meets a cross-vein, when it also runs parallel to  $R_2$  and very soon gives off a posterior branch.

Genotype, *Antitaxineura anomala*, n. sp.

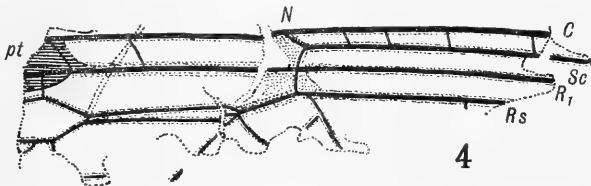
Horizon: Upper Permian of Warner's Bay, New South Wales.

As the above combination of characters should suffice to enable this genus to be recognized when more complete fragments of the wings may happen to be found, I have decided to define it on the very marked characters of the nodal and pterostigmatic regions. The genus is evidently allied to *Ditaxineura* and *Polytaxineura*, but cannot be placed in the same family with either of them. In the highly specialized form of the nodus, it stands well in advance of any Palaeozoic type yet discovered. The pterostigma, as far as it is preserved, is of the Ditaxineurid form, but is preceded by a single postnodal. Evidently the origin of  $R_{4+5}$  lies distad from the subnodus, but the fracturing of the main veins in this region forbids us to draw any very definite conclusions as to the course of the branches of  $R_s$ . The curious oblique struts below  $R_s$  on either side of the subnodus are very peculiar, but it should be noted that the Liassic genus *Liassophlebia* Till. (1925*b*), belonging to the Suborder Anisozygoptera, possesses two similarly directed struts much further apart in the same region. One would not be surprised to find that *Antitaxineura* was a true member of this Suborder.

ANTITAXINEURA ANOMALA, n. sp. Text-fig. 4.

Length of wing-fragment, 14 mm. Length from base of fragment to nodus, approximately 7 mm.; from nodus to distal fracture of pterostigma, also approximately 7 mm.

The specimen represents portion of the obverse impression of a left wing. Four antenodals are clearly preserved, the two most distal ones being closer together than the others. The single postnodal is oblique, as is also the basal side of the pterostigma. All the veins and cross-veins appear to be surrounded



Text-fig. 4.—*Antitaxineura anomala*, n.g. et sp. Order Odonata, *incertae sedis*. Fragment showing portion of anterior part of wing with nodus. Lettering as in Text-fig. 1. Apex to left. ( $\times 5.7$ .)

with a band of dark pigment; but this is most noticeable along  $R_1$  and  $R_s$  beyond the nodus, where the pigment spreads out considerably on either side of the actual vein. The postnodal cross-vein is also strongly pigmented, and the nodal area and pterostigma are widely pigmented, especially the region of the subnodus.

The reverse impression is also preserved, but is only 8 mm. long, most of this belonging to the portion beyond the nodus. The postnodal and pterostigmatic region are better preserved in this than in the obverse, as is also the distal oblique strut below  $R_s$ .

Type.—*Holotype*, Specimen P 127, A and B: A, obverse impression; B, reverse impression.

Locality.—Found by Mr. T. H. Pincombe in a piece of hard, medium grey shale from Warner's Bay in 1931.

Possibly belonging to this species is another specimen (P 128) of the basal portion of the posterior margin of a large Odonate wing with the series of cellules just above it. This wing evidently became partly disintegrated and longitudinally folded during the process of fossilization, for most of the main veins can be seen lying upon or slightly across one another. The only clear impression that one can get is of the single series of postcubital cellules of typical Odonate form which evidently intervened between 1A and the posterior margin.

In conclusion, I desire to thank Mr. Walter James, Division of Economic Entomology, C.S.I.R., Canberra, for the excellent photographs shown in Plate xii.

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#### EXPLANATION OF PLATE XII.

Figs. 1-3.—*Polytaxineura stanleyi*, n.g. et sp. Order Odonata, Suborder Protanisoptera, family Polytaxineuridae, n. fam.

1.—Obverse impression of forewing and small portion of hindwing lying just below it. 2.—Reverse impression of basal portion of same. 3.—Reverse impression of an apical fragment of same, showing nodal region. This fragment fits on to the broken distal portion of fig. 2. (All figures  $\times 2\frac{1}{2}$ .) (Photos by W. James, Canberra.)

## UPPER PERMIAN INSECTS OF NEW SOUTH WALES. V.

### THE ORDER PERLARIA OR STONE-FLIES.

By R. J. TILLYARD, M.A., Sc.D., D.Sc., F.R.S., etc.

(Plate xii, figs. 4-5; six Text-figures.)

[Read 30th October, 1935.]

Until recently, the Stone-flies (Order Perlaria) were not known from any geological strata older than the Jurassic. But a more primitive, ancestral Order, the Protoperlaria, was the dominant type of insect in the Lower Permian beds of Kansas and also in beds of the same age in Russia. Therefore it is evident that, somewhere between the Lower Permian and the Jurassic, true Perlaria must have been evolved. In view of the fact that the Australian fauna contains only archaic remnants of this Order, there was a reasonable chance that such forms might be discovered in the Upper Permian beds of New South Wales. This has now proved to be the case. Last year, Mr. T. H. Pincombe made the first discovery, in the form of the greater part of the abdomen of a Perlarian larva, with the two long cerci attached. More recently, in going through some material found by Rev. A. J. Barrett in 1931, I came across portion of a rather large wing which I had classified provisionally as "Neuropteroid". It was possible to uncover this specimen further, with the result that the two series of cross-veins, the medio-cubitals and intercubitals, characteristic of the Order Perlaria, were disclosed in their entirety, and the wing was seen to be definitely that of a true Perlarian.

It is interesting to note that the larval remains, though incomplete, can be definitely correlated with the fossil wing, and most probably belong to the same species. This conclusion is made possible because both the wing and the larval abdomen come very close to an existing Australian genus, *Stenoperla*, belonging to the archaic family Eustheniidae. Yet, in view of the wide differences between the Protoperlaria of the Lower Permian and the descendant Order Perlaria, he would have been a bold man who would have dared to prophesy that the family Eustheniidae extended back as early as the Upper Permian.

The Australian stone-fly fauna consists of only four families, of which three are definitely ancient types, while the fourth consists of a generalized remnant of a more specialized family, the Nemouridae. The three archaic families are the Austroperlidae, confined to Eastern Australia, Tasmania and New Zealand, the Eustheniidae, found in these same regions together with Southern Chile and Patagonia, and the Leptoperlidae, with a similar distribution, but extending more widely in South America and also reaching to Western Australia. A study of their distribution indicates with reasonable certainty that all three families arose in or near Australia, or, more correctly, Euronotia, inclusive of Antarctica, to which it was joined in Permian times. They are all cold-climate groups, but can be graded in a descending series, the larvae of Austroperlidae occurring only in very cold waters, those of the Eustheniidae favouring from very cold to cold waters, and thus extending as far as some mountain streams in Queensland, while those of the Leptoperlidae have a wider range of tolerance, and can stand streams from very cold to only moderate coldness; these also require, for certain species,

less movement of the water than the others. Comparative morphology indicates that the Austroperlidae (Text-fig. 3) are the oldest group of the three. This is best seen in the larvae, in which no special external gills are developed. But the cerci are greatly shortened, and the adult stone-fly has, besides, certain specializations in the wing-venation, notably the perpendicular series of costal veinlets in the forewing, and the thickening of the second interanal cross-vein in the same wing.

The Eustheniidae (Text-figs. 2, 6) are a very ancient group, but have a specialized, predatory larva, extremely active, and provided with five or six paired, filiform gills at the sides of the first five or six abdominal segments respectively. The cerci are not reduced. The general venational scheme is greatly enriched by extra branches of the main veins and by numerous cross-veins. The most striking specialization is the closure of the re-entrant angle between the anal fan and the rest of the hindwing, so that this exceptionally broad wing forms a single wide curve or sweep from apex to base posteriorly. It is not possible to derive the Eustheniidae from the Austroperlidae, but only from some older ancestor resembling them generally, but without the shortened cerci or the venational specializations mentioned.

The Leptoperlidae (Text-fig. 4) are, on the whole, smaller forms, but some genera are of large size and approach the Eustheniidae in appearance. They have sluggish larvae furnished with a rosette of gills around the anus. The adults have the cerci unshortened and the venational scheme very generalized, except for the narrowing of the basal portion of the forewing. Costal veinlets are generally not developed, and there is some fusion of the anal veins in the forewing.

In the present paper, the new fossil form will be compared with selected archaic genera from all three families, and the fossil larva will be shown to agree very closely with that of the genus *Stenoperla*. As the fossil wing also comes very close to that genus, I have no hesitation in classifying the new forms in the existing family Eustheniidae.

It may here be noted that we have now recorded ancient forms of both Odonata and Perlaria from the Upper Permian beds of New South Wales. In view of the fact that the Australian Mayfly fauna contains a complex of genera as ancient as any in the world, one may hazard the prophecy that it should not be long before the third archaic aquatic Order of Insects, the Mayflies, will be found to have existed also in these beds, and I would be inclined to think that whatever Upper Permian genus may be found will almost certainly be closely related to *Tasmanophlebia*, of the archaic family Siphonuridae.

In describing this fossil wing, the notation CuA and CuP will be used for the anterior (convex) cubitus and the posterior (concave) cubitus respectively. The anterior (convex) media will be termed MA; the posterior (concave) media, MP, is absent in all Perlaria, but appears in the Protoperlaria as a partially atrophied vein.

#### Family EUSTHENIIDAE.

Genus STENOPERLIDIUM, n.g. Pl. xii, figs. 4, 5; Text-figs. 1, 5.

Closely allied to the existing genus *Stenoperla* McL.

*Forewing* very narrow, being about four times as long as wide, but not particularly narrowed basally. Sc rather short, ending a little beyond half-way in a short fork connecting with both C and R<sub>1</sub>. Costal veinlets only moderately

well developed. Radius strongly built, close to Sc, very slightly curved, branched distally in the pterostigmatic area, which is well developed. Rs arising at about one-fourth, leaving R at a very gentle angle, and having a descending series of four pectinate branches distally. MA two-branched, forking just before half-way, the anterior branch curving somewhat upwards towards Rs and then diverging from it again; the posterior branch continues the line of the main stem almost straight. CuA a strong vein, divided into three distally; of these, the first two branches, CuA<sub>1</sub>, CuA<sub>2</sub>, are anterior and arise by a common stem, while the most posterior branch (CuA<sub>3</sub>) continues the line of the main vein directly to the wing-margin. CuP fairly strong, curving concavely to CuA, unbranched. Base of wing, anal area and apex missing; these have been restored by dotted lines in Text-figure 1. In the cross-vein system, the radial cell has only one cross-vein near middle of wing and two or three distally; the radio-median cell is devoid of cross-veins from base to just beyond middle of wing. The distal half of the wing is only moderately supplied with cross-veins, mostly very weakly chitinized. The medio-cubital series is weakly formed, and apparently consists of only three cross-veins. The inter-cubital series is well formed, consisting of six cross-veins.

Genotype, *Stenoperlidium permianum*, n. sp.

Horizon: Upper Permian of Warner's Bay, N.S.W.

STENOPERLIDIUM PERMIANUM, n. sp. Pl. xii, fig. 4; Text-figs. 1, 5.

*Forewing*: Length of fragment 22.5 mm., indicating a total length for the complete wing of about 27.7 mm. Breadth 6.3 mm.

The obverse impression lies with its apex to the left; it is preserved from the pterostigmatic region (extreme apex missing) back to within a fifth or less of the base. The preserved part includes all the main venational structures except the primary fork of Cu (which is just missing) and the whole of the anal area and veins. The costal and pterostigmatic veinlets are strongly chitinized; the basal portions of Sc and MA, the extreme base of Rs, its distal portion and branches, and the whole of R<sub>1</sub> are strongly formed, and so is the main stem of CuA. Cross-veins in the spaces between Rs and CuA are mostly weakly formed, except the medio-cubital series, which is fairly strong; in this particular fossil, there are two forked cross-veins, viz., rm (partly displaced by a local break in the rock) and the third medio-cubital, mcu<sub>3</sub>; the former is Y-shaped and the latter in the form of an inverted Y; these, however, are to be regarded as only individual peculiarities and not as specific.

There is a definite colour-pattern visible on the fossil wing, consisting of alternating, irregular areas of light and dark pigmentation, together with shading along the main veins, suggestive of the colour-scheme in many recent forms, e.g., some of the New Zealand Leptoperlidae. Deep pigmentation occurs around the end of Sc and the interradiial cross-vein ir, just below it; along R<sub>1</sub>, especially distally, and around the pterostigmatic veinlets, spreading out triangularly; also around the distal branches of Rs, less noticeably, and a large, somewhat squarish patch between CuA<sub>1</sub> and CuA<sub>2</sub>. The basal portions of Sc and R are also strongly pigmented, and an area of medium shading occurs across the wing in the region of the first and second medio-cubitals, extending right down to CuP. A similar but larger area of medium shading passes in an indistinct band right across the middle of the wing and encloses the two darker areas around ir and between CuA<sub>1</sub> and CuA<sub>2</sub>.

Type.—*Holotype forewing*, obverse, Specimen No. B.77a, and reverse, Specimen B.77b (the latter very incomplete, showing only about one-half of Sc and R<sub>1</sub>, with the basal portion of Rs and MA).

Discovered by Rev. A. J. Barrett at Warner's Bay in 1931.

Larva of *STENOPERLIDIUM* sp. Text-fig. 5.

Specimen A.73, discovered by Mr. T. H. Pincombe in December, 1933, at Warner's Bay, shows the last seven segments of the abdomen of a Eustheniid larva, together with the two cerci almost complete. Total length of preserved part of abdomen 3.8 mm., of cerci 4.0 mm., representing a length for the complete specimen of about 13 mm., including cerci. Breadth of abdomen at fifth segment, 2.0 mm.

The abdomen is rather broad and somewhat flattened, as is usual in Eustheniid larvae. The most anterior segment visible is the fourth, which is incomplete along its anterior border. The fifth and sixth segments are about equally wide, and thereafter the abdomen tapers posteriorly to the tenth segment. All the segments except the tenth have the postero-lateral margins angulated. The specimen appears to be resting not quite horizontally on the rock and is curved towards the left; on the left side, it is possible to distinguish a finely denticulate lateral margin on segments 4 to 9. The last five segments are evidently without gills; but definite signs of the presence of paired lateral gills on segment 5 are to be seen, that on the right being a short, stumpy process with distinct moniliform annulations, that on the left apparently a small portion of a similar gill, broken off. On the fourth segment, the slight prolongation of the postero-lateral margins also suggests the presence of gills, but all except their basal parts are either broken off or turned in under the abdomen.

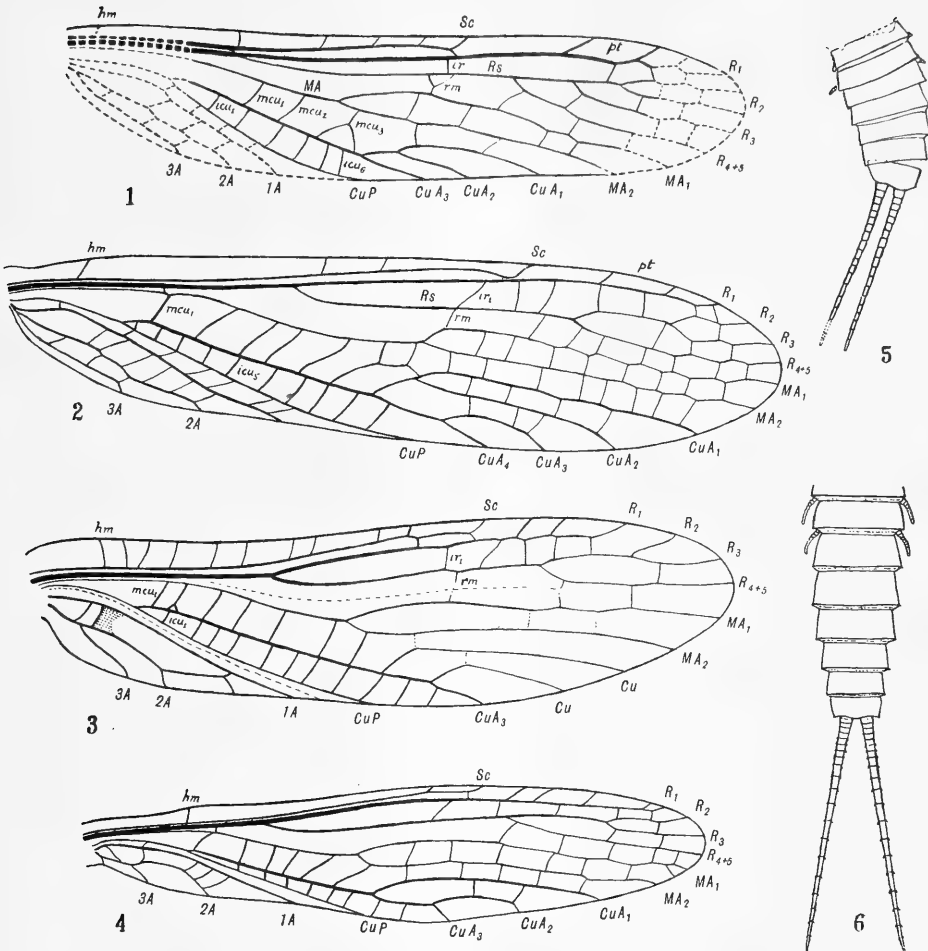
The cerci are about as long as the preserved portion of the abdomen; they are separated at bases by a space about equal to their width. The right cercus appears to be complete as to length, but is broken away in two places along its edges; the left cercus is quite complete except for a short portion missing apically. Nineteen segments can be counted on the right cercus, but the segmentation is very indistinct basally. Each cercus is widest basally and tapers gradually to its apex; the basal segments are the shortest, and the segments lengthen gradually to the apex. Some of the divisions are more marked than others (see Plate xii, fig. 5), suggesting that there were rings of pigmentation at these points.

Type.—*Holotype*, Specimen No. A.73. Dated "10.12.33" by T. H. Pincombe, on back.

This larval abdomen may with fair certainty be referred to the genus *Stenoperlidium*, since it differs little from the abdomen of a larva of the existing genus *Stenoperla* McL. If it belongs to the species *S. permianum*, n. sp., as is reasonably probable, then it cannot be a fully grown larva, since its size is too small. In the absence of the thorax and wing-sheaths, this point cannot be determined.

In order that the close resemblance between the larvae of *Stenoperlidium* and *Stenoperla* may be noted, a preparation in 10% KOH was made of the last seven abdominal segments and cerci of a larva of *Stenoperla prasina* (Newm.) from New Zealand (Text-fig. 6). Allowing for the extension of the segments after maceration, so that the soft sutural areas are fully shown (only partly visible in the fossil), the resemblance is remarkably close. It should also be borne in





Text-fig. 1.—*Stenoperlidium permianum*, n.g. et sp. Order Perlaria, Family Eustheniidae. Upper Permian of Warner's Bay, N.S.W. Forewing, restored and with apex to right. The parts missing in the actual fossil (Plate xii, fig. 4) are indicated by dotted lines. Colour-pattern omitted. Total length, about 27.7 mm.

Text-fig. 2.—*Stenoperla prasina* (Newm.). Family Eustheniidae. Forewing. Length 24 mm. Recent, New Zealand.

Text-fig. 3.—*Austroperla cyrene* (Newm.). Family Austroperlidae. Forewing. Length 12 mm. Recent, New Zealand.

Text-fig. 4.—*Trinotoperla australis* Till. Family Leptoperlidae. Forewing. Length 16 mm. Recent, Eastern Australia.

Text-fig. 5.—*Stenoperlidium* sp. Order Perlaria, Family Eustheniidae. Abdomen and cerci of larva. Actual length, including cerci, 7.8 mm.

Text-fig. 6.—*Stenoperla prasina* (Newm.). Family Eustheniidae. Last seven segments of abdomen, with cerci. 10% KOH preparation. Recent, New Zealand. Actual length, including cerci, 23 mm.

mind that it is only in the subfamily Stenoperlinae of the family Eustheniidae (including only two genera, *Stenoperla* McL. from Australia and New Zealand, and *Diamphipnoa* Gerst. from South America) that the larva possesses five pairs of gills on the first five segments, respectively, of the abdomen. In all other genera of this family there are six pairs of gills, on the first six segments of the abdomen respectively.

*Affinities of the Fossils.*

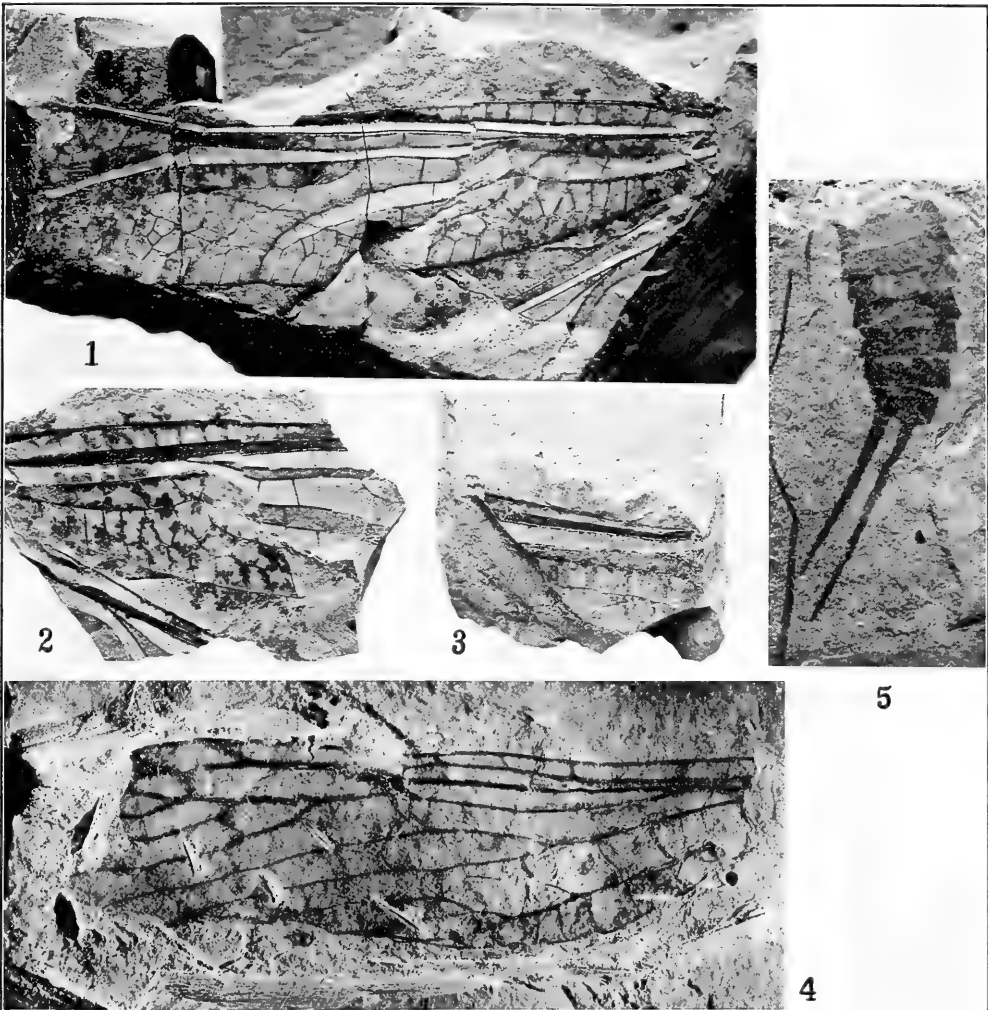
While it seems quite clear that both the forewing and the larval abdomen above described may be placed as directly ancestral to the existing genus *Stenoperla*, and therefore to the family Eustheniidae as a whole (since the genus *Stenoperla* is admittedly the most archaic existing type within the family), it appears advisable to compare the new fossil wing with an archaic type within each of the three families Eustheniidae, Austroperlidae and Leptoperlidae. I have therefore figured the forewing venations of *Stenoperla prasina* (Newm.) (Text-fig. 2), *Austroperla cyrene* (Newm.) (Text-fig. 3), and *Trinotoperla australis* Till. (Text-fig. 4) for comparison.

The principal differences between *Stenoperlidium*, n.g., and *Stenoperla* McL. would appear to be in the shape of the wing, which is broadest before half-way in the fossil genus, but definitely after half-way in *Stenoperla*, and in the greater development of the cross-vein system in the recent genus. We should note, in particular, the closer and more regular arrangement of the distal cross-veins in *Stenoperla*, and the much larger number of cross-veins in both medio-cubital and intercubital series.

Some specimens of *S. prasina* have a more complete series of costal veinlets than that shown in Text-figure 2, thus approaching quite close to *Stenoperlidium* in this respect. The ending of Sc by a sharp bend towards  $R_1$  and then a sudden upward curve to C is a specific character of *S. prasina* only. In the Australian species *S. australis* Till., Sc ends as in the fossil. But this species is usually very heavily veined and does not, in some ways, afford as good a comparison with the fossil as does *S. prasina*. *S. australis* agrees with the fossil more closely than *S. prasina* in the mode of origin of Rs, which is less abrupt and also somewhat nearer the base than in *S. prasina*. Both species of *Stenoperla* differ from the fossil in having Sc and R closer together and less strongly formed, and also in having the pterostigmatic area narrower than in the fossil. In *S. australis*, there are usually cross-veins developed in the radio-median space before the primary fork of MA, while CuP is straighter, nearer to CuA and lies more definitely in a straight furrow. Both species of *Stenoperla* agree with the fossil in the upward arching of the anterior branch of MA and in the continuity of the posterior branch with the main stem. They also agree in the type of branching of CuA, though there are usually four branches instead of three, the extra one being formed by forking of CuA<sub>2</sub>. This, however, is not a constant character. As the humeral veinlet is present in all Eustheniidae, it has been restored in the fossil in Text-figure 1.

It comes as a great surprise, in view of our knowledge of the Lower Permian Order Protoperlaria, that this Upper Permian fossil should stand so definitely within the family Eustheniidae and so extremely close to the existing genus *Stenoperla*.

There is no other Order known in which the resemblance between Upper Permian and recent forms is so close, except, indeed, it be so in the Cockroaches,



1-3.—*Polytaxineura stanleyi*, n.g. et sp. 4.—*Stenoperlidium permianum*, n.g. et sp.  
5.—*Stenoperlidium* sp.



which were absent from Australia at that period, probably owing to the extremely cold climate. In the Odonata, not even the existing Suborders Anisoptera and Zygoptera had been formed. In the Neuroptera, it is true, forms closely allied to the Ithonidae, Psychopsidae and other archaic families have been found; but not one of them comes as close to its descendant form as does *Stenoperlidium* to *Stenoperla*. The same is true for the Orders Mecoptera, Copeognatha and Hemiptera. Thus we must conclude that the Perlaria are a very ancient Order which, apparently, reached their dominant position as Protoperlaria in the Lower Permian, and thereafter degraded into a small, specialized remnant of cold-water forms—our present Order Perlaria.

It does not appear necessary to go so deeply into details in comparing the venation of the new fossil with either that of *Austroperla* (Text-fig. 3) or *Trinotoperla* (Text-fig. 4), since the differences are of family rank and therefore, presumably, well known to most students of the Order. The series of four figures of venations of forewings on p. 389, is instructive in showing the actual relationship of the new fossil to the three most ancient types now existing within this Order, in the Australian region.

We may, in conclusion, mention that *Stenoperla* McL. is the only existing Australian genus of Eustheniidae which has a distribution along the eastern coast-line of Australia and also in New Zealand. Wherever there are fast running streams, and the water is cold enough, even right up into North Queensland, the genus has established itself. Other Eustheniid genera are confined to Tasmania or to the alpine or sub-alpine streams of Victoria and southern New South Wales. Consequently, although we cannot be certain that other genera of Eustheniidae did not exist in Australia in the Upper Permian, they are not likely to be found in the lacustrine deposits around Newcastle, which were evidently not at a high elevation and not very far from the actual coast-line.

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#### EXPLANATION OF PLATE XII, FIGS. 4, 5.

Fig. 4.—*Stenoperlidium permianum*. n.g. et sp. Order Perlaria, Family Eustheniidae. Upper Permian of Warner's Bay. Forewing, obverse impression. (Actual length, 22.5 mm.)

Fig. 5.—*Stenoperlidium* sp. Order Perlaria, Family Eustheniidae. Abdomen and cerci of larva. (Actual length, including cerci, 7.8 mm.). Upper Permian of Warner's Bay.

ON THE CLIMATE AND VEGETATION OF THE KOONAMORE VEGETATION  
RESERVE TO 1931.

By T. G. B. OSBORN, University of Sydney; J. G. WOOD, University of Adelaide;  
and T. B. PALTRIDGE, Field Officer, Council for Scientific and Industrial Research.

(Plates xiii-xvii; ten Text-figures.)

[Read 30th October, 1935.]

1. INTRODUCTION.

The present paper gives an account of the climate and flora of a restricted area in an arid district during a six-year period, 1925-1931. The area is the Koonamore Vegetation Reserve, the Arid Flora Research Station of the University of Adelaide, which is situated about  $4\frac{1}{2}$  miles S.W. of Koonamore Head Station. It lies about 40 miles N. of Yunta, a small township on the Peterborough-Broken Hill Railway, in the North-East District of South Australia, at an altitude of about 650 feet.

The primary object of the Reserve is to study the growth and regeneration of the arid flora in an area protected from grazing by stock and, as far as possible, from rabbits. Since the exploitation for pastoral purposes of the arid districts of Australia a far reaching change has occurred in the biota. The effect upon the indigenous flora has been particularly great in areas of heavy sheep concentration, leading, at times, to complete extinction of the shrub-steppe community. The area chosen for the Reserve at Koonamore was deliberately picked as being "the worst eaten-out portion of the paddock". At the same time it was selected to show a variety of plant communities, including the scrub vegetation as well as the steppe flora.

On this site a long-dated experiment was planned.

The Reserve (Osborn, 1925), which comprises an area of some 1,260 acres, was enclosed by rabbit- and sheep-proof fencing in July, 1925. The lease was generously transferred to the University of Adelaide by the then owners of Koonamore, Messrs. Hamilton, Wilcox Ltd., towards the end of that year. In order to accommodate research workers, a three-roomed hut was built by the donors at the entrance to the Reserve. This hut was not ready for occupation until May, 1926, when the first quadrats were set out upon the area.

The original plan of operations involved quarterly visits to the Reserve by members of the Botanical Department, University of Adelaide. The visits were arranged for May and August, i.e. during the two short vacations, and December and March at the beginning and end of the long vacation. It was considered that a party of three or four observers could be relied upon at these times. When the first-named author transferred to Sydney at the end of 1927 the future of the Reserve seemed uncertain. However, the Council for Scientific and Industrial

Research made available a grant\* until June, 1931, enabling a field officer to be placed at the Reserve (from which base other research projects in the district were also conducted; Osborn, Wood and Paltridge, 1932). The original programme of work on the Reserve has been followed, and the results of five years' regular observations are now presented. Although the experiment is by no means completed, it is felt that the results already obtained are of sufficient interest to justify their publication at this stage. The results fall under the headings, climatic data during a drought cycle, methods of study employed, general biological observations, relation of the flora to climatic conditions, and the initial stages in regeneration of the perennial flora.

The control of the Reserve has now reverted to the University of Adelaide, and regular, though less frequent, observations are being continued.

## 2. DESCRIPTION OF RESERVE.

The Reserve is situated on an elevated peneplain surrounded by low hills. These hills are composed of Lower Pre-Cambrian gneisses and schists overlain by Upper Pre-Cambrian deposits consisting chiefly of quartzites and mudstones, penetrated in places by pegmatite dykes.

The soils of the plains are derived from these rocks during an arid cycle of erosion. The chief agencies are water, during flood times, leading to a deposit of silt, and wind, leading to the formation of more or less consolidated sand dunes. As a result of the interaction of these two agencies considerable variation in the soil may occur even in a small area, for such factors as the activity of watercourses and change in their beds have influenced the soil type considerably.

Reference to the sketch map (Text-fig. 1) will show that the Reserve has an undulating surface. It consists of a complex system of low sandhills alternating with harder soil on the intervening flats. These flats are a silty loam and subject to flooding in the centre and about the middle of the western side. Elsewhere they are of hard but coarser loam mingled with a good deal of nodular travertine limestone. On this latter soil type is developed the dwarf Chenopodiaceous shrub-steppe.

At the time of its enclosure practically all the original perennial flora other than the trees and tall shrubs had been destroyed. During a preliminary visit by one of us in August, 1925, possible sites for quadrats were located from the nature of the terrain and from the vestiges of the salt and blue bushes whose regeneration it was desired to study. These were the ten quadrats which have been charted regularly throughout the five years' work covered by this paper. Their location and relation to vegetation types is seen from Text-figure 1.

## 3. SOILS.

Four main soil types, or, more accurately, soil groups, have been recognized. These are the soils of the sandhills, the sand-plains, the silty flats, and the shrub-steppes.

These soils belong to Glinka's ectodynamorphic division and to his fourth group, viz., soils formed under insufficient moisture conditions. Soil analyses were given in our paper on *Stipa* (1931) and are not repeated here.

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\* My thanks are due to the Council for Scientific and Industrial Research for the generous grant which enabled the Koonamore investigations to be carried on upon an extended scale after my departure from Adelaide. I am also much indebted to the Council of the University of Adelaide for allowing me facilities for continued work at Koonamore after my appointment to Sydney.—T.G.B.O.

### A. *The Sandhill Soils.*

The sandhills cannot be regarded as forming a soil in the true sense of the word. Glinka states, "In deserts an energetic mechanical disintegration of rocks takes place producing a fine grained mass of earthy material which does not constitute a soil. The strong winds which predominate in desert regions blow the greater portion of this fine grained material out of the desert into its borderland, leaving only coarser material behind. This consists of sand, gravel and stone fragments, and in places rocky ledges."

The sandhills in the north-east of South Australia are derived from two sources: from the denudation of the Pre-Cambrian hills in the south and from the denudation of the Cretaceous peneplain in the north. The sands, whether river-borne or wind-borne, drift here and there by the action of the winds, frequently forming ridges, usually with an east-west trend and generally separated from each other by clay pans. In other cases ridge formation occurs more rarely and a sand plain is formed in which the sand covers silty or travertine limestone soils.

In the sandhills the profile shows no change to a depth of 6 feet, and consists of a uniform buff-coloured coarse sand. These sandhills carry typically Mulga (*Acacia aneura*), Wattle (*Acacia Burkittii*), and Turpentine (*Eremophila Sturtii*), with *Stipa nitida* and other shorter-lived annuals as a ground cover.

On the sand-plains these species also occur, but other species are commonly present, depending on the depths of sand and the nature of the underlying soil.

The remaining soil groups show the characteristic features of dry steppe soils in that the humus horizon of these soils (when one is recognizable at all) has no definite level. When present it is seen only in a thin layer on the surface. The carbonates of the alkaline earths, chiefly calcium carbonate and gypsum, are universal constituents of the profile of the loamy varieties, but the horizons in which they accumulate lie nearer to the surface as a rule than in soils of the Tschernosem group. Chlorides and sulphates have usually disappeared from the upper horizons.

Of these soil types, two have immature profiles—the silty soils and sand-plain soils—whilst the other, the saltbush soil, shows a mature profile.

### B. *Sand-plain Soil Group.*

The sand-plain soils vary in profile according to the (presumed) age of the soil and the nature of the material underlying the surface sand.

Characteristic features of the country adjacent to and inside the Reserve are monospecific communities of black oak (*Casuarina lepidophloia*), with *Bassia uniflora* as the accompanying undershrub. The soil profile in this society shows coarse sand to a depth of 5 feet, with layers of gypsum appearing first at a depth of about 3 feet. Frequently, owing to changes in the course of creeks or water-courses, finer soil material may be deposited on the sand and in this layer travertine limestone nodules and ironstone nodules may occur. When this is the case, other shrubs, and particularly *Kochia sedifolia*, may be present. A typical profile in Black Oak Creek, about half a mile south of the Reserve, illustrates this.

0-2 feet silty loam with little nodular travertine limestone, chocolate coloured.

2-8 feet sandy loam with river gravels.

8-11 feet hard red clay with ironstone nodules.

The country around this carries *Casuarina lepidophloia*, *Bassia uniflora* and *Kochia sedifolia*. In this soil the roots of *Casuarina lepidophloia* extend horizontally for some distance in the sandy loam and then run vertically into the clay.



Further south in the same river a more mature profile is seen, but showing a more varied history, which illustrates changes in river course and silt deposition. The profile is as follows:

- 0"-6" silty loam, no limestone.
- 6"-2' 6" solid limestone crust.
- 2' 6"-3' sand-silt matrix with clay pockets and little lateritic ironstone.
- 8'-10' red clay with ironstone.
- 10'-11' sand with river gravels.
- 11'-15' red clay.

Throughout this profile gypsum bands are developed at intervals from 4-15 feet.

This soil carries *Casuarina lepidophloia*, and in addition shrubs such as *Heterodendron oleaefolium*, *Pholidia scoparia*, *Cassia Sturtii*, *Cassia eremophila* and *Kochia sedifolia*.

Frequently over these soils sand of aeolian origin is found to various depths. On such areas mulga (*Acacia aneura*) is found.

The occurrence of bluebush (*Kochia sedifolia*) is bound up with the presence of limestone in the upper horizon and is probably correlated with the high lime content found in its ash (Wood, 1925).

#### C. Silty Soil Type.

The silty soils are found chiefly in the flood plains of water courses and in local depressions in which water accumulates and lies for some time. The silty layer is often of considerable depth (more than 5 ft.) and shows some signs of maturity in the accumulation of clay in lenticular pockets throughout the matrix in the B horizon. The matrix itself is buff-coloured and the pockets chocolate-brown.

These flats, after rain, carry a wealth of ephemeral plants. Permanent plants are few, the chief being the trees *Heterodendron oleaefolium* and *Eremophila longifolia*, *Myoporum platycarpum*. The shrubs *Pholidia scoparia* and *Cassia Sturtii* occur in the drier portions. Soils such as the above have a considerable amount of sand and do not crack on drying as do some of the silty-clay soils around freshwater lakes in the district.

#### D. Shrub-Steppe Group.

The soils belonging to the shrub-steppe group are typical of the more elevated plains and contain large quantities of limestone in the B horizon and are closely allied to the mallee soils of the wetter areas. These soils carry a shrubland of saltbush (*Atriplex vesicarium*) or bluebushes (*Kochia* spp.). The considerable amount of silt that is always associated with the sand seems to indicate that the soils were deposited on the flood plains of more ancient and extensive river systems of arid Australia. The plains are now above the level of the present watercourses and in their soils the travertine limestone has developed later. A typical profile and analysis of this soil type was given by us (1931, p. 308).

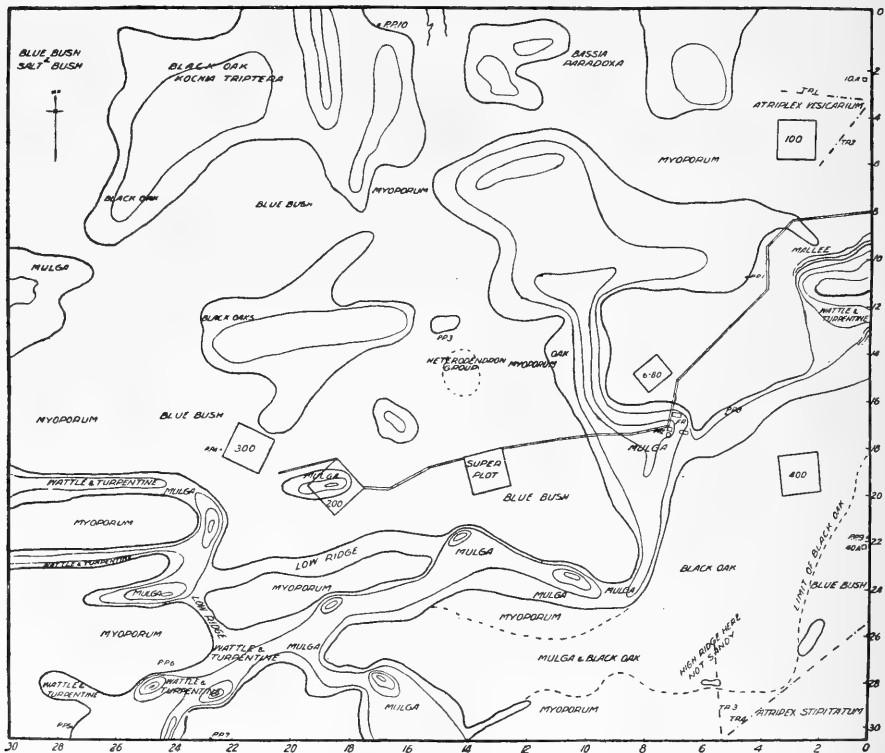
In these shrub-steppe soils the solid limestone crust is not a constant feature, the fraction with large limestone nodules giving place at greater depths to the smaller densely-packed nodules.

The vegetation on this soil type within the 10-inch isohyet is characteristically a Chenopodiaceous shrubland, but it may be modified in two ways. First, by the deposition of silt over the surface, such as occurs in times of flood and near hills and in such cases *Myoporum platycarpum*, *Cassia Sturtii*, *Pholidia scoparia* and *Heterodendron oleaefolium* are found occasionally scattered throughout the shrub-

land. And secondly, when a layer of sand is formed by drift over the surface, trees such as the Mulga and shrubs may be present along with the saltbushes and bluebushes.

Chemical analyses of the upper horizon of these soils have already been published (Osborn and Wood, 1923, and Wood, 1925). The percentage of soluble salts is low, usually about 0.10%, the pH averages 7.70 and the water at saturation about 38%.

It must be emphasized that although certain species are restricted to definite soil types, as for example *Kochia sedifolia*, the major factor determining distribution is the water relations of the soil rather than soil profile. The mulga (*Acacia aneura*) tends to dominance on both the rocky soils of the hills, also in the sandhills—both situations in which water tends to be conserved. Sandal-wood (*Myoporum platycarpum*), *Eremophila scoparia*, and *Heterodendron oleaefolium*, plants of the mallee districts, extend into the arid regions on soils of similar type in which moisture has been conserved by a sandy-silt mulch deeper than that found in the more typical shrub-steppe or mallee area itself.



Text-fig. 1.—Sketch map of the Koonamore Vegetation Reserve based on a prismatic compass survey. The form lines represent approximately 10-foot intervals. The heavier first form line is also a boundary between the sandy and loamy soil types. The position of the quadrat systems and transect lines within the Reserve is shown, also the various permanent photograph points (P.P.). The main vegetation types are indicated on the map. Scale, 1 inch = 500 metres.

J.G.W. fecit.

*Kochia sedifolia* and *Atriplex vesicarium* are the character plants on a soil which is incapable of supporting any but an extremely drought-resistant vegetation. *Kochia sedifolia* has a deep root system and apparently a need for limestone in the soil. *Atriplex vesicarium*, on the other hand, has a shallow root system; it is able to absorb water through its leaves from an atmosphere of 85% saturation and shows great resistance to drought, when it becomes defoliated (Osborn, Wood and Paltridge, 1932). *Atriplex vesicarium*, however, because of its drought resistance, is not confined to one soil type but occurs also on the Red Earth soils towards Lake Frome, around claypans in the sandhill regions north of Koonamore and in some cases on more gentle hill slopes.

At the two extremes stand the shrub-steppe communities on the arid mature soil and the desert scrub on hills and sandhills with better water relations, but transitions between the two are common and overlapping of the two communities occurs. It will be seen from the map (Text-fig. 1) that the area selected for the Koonamore Vegetation Reserve is such a junction region.

#### 4. METEOROLOGICAL DATA.

Complete meteorological records have been kept at the laboratory at Koonamore from July, 1928, to June, 1931, and these records have been utilized in the main for this section. The rainfall records of Koonamore Head Station are available for a longer period and have been obtained from the Commonwealth Bureau of Meteorology. The 1928-1931 records are given in detail, not only because the integration of all these factors is expressed in the growth of the plants, but also because certain of these records, and particularly temperature and humidity, have not hitherto been available for the north-east of South Australia.

The temperature and humidity instruments were housed in a standard Stevenson screen. All thermometers were tested by the National Physical Laboratory, Kew. Humidity records were obtained by means of an Edney thermohygrograph, and this was checked each morning at 9 o'clock by standard wet and dry bulb thermometers. Terrestrial radiation data were obtained by means of a standard thermometer placed in the open 2 inches above ground-level.

##### A. Rainfall.

The mean annual rainfall at Koonamore Head Stations,  $4\frac{1}{2}$  miles distant from the Vegetation Reserve, for a period of 27 years, is 8.12 inches, and in its distribution is fairly even throughout the year, 53% falling in the cold period from April to September, and 47% in the hot period from October to March. There is a tendency towards a winter maximum in May to September when the greatest number of rainy days are experienced. This is a reflection of the South Western Antarctic control experienced in Southern Australia.

It has been pointed out previously by Cannon (1921), Osborn and Wood (1923), and Osborn (1925) that the total rainfall in arid Australia does not give a true index of the amount of water available to plants, since light falls do not penetrate the ground to an extent sufficient to reach the roots of plants. Such rain is termed "ineffective", and Cannon (1921) considered 15 points of rain to be the minimum effective rainfall falling at one time during a dry period. Our observations, extending through one of the worst droughts in the history of South Australia, have shown that his figure is too low, and we consider 25 points to be the minimum amount of rain that is effective during a dry period. Lighter falls than this barely penetrate the surface mulch, although it must be realized that smaller falls are effective following rainy periods. In Table 1 are given

the mean monthly rainfall figures in inches over a period of 27 years, and also the mean number of rainy days in each month and the mean number of days in which falls greater than 25 points were recorded. The two last are derived from 15 years' records.

TABLE 1.

Table showing mean rainfall figures based on records for 27 years, also mean number of rainy days and falls over 25 points.

Rainfall figures in points (100 points=1 inch.)

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Mean rainfall .. ..	70	45	61	64	93	108	46	63	58	81	64	59	812
Rainy days .. ..	2.0	2.2	1.1	1.4	3.6	3.6	3.9	3.8	3.4	2.4	2.5	2.7	32.5
Falls > 25 points ..	0.9	0.8	0.5	0.7	1.0	1.3	0.8	0.7	1.2	0.7	0.7	0.9	10.2

It is evident from these figures that the amount of rainfall is low, and approximately only one-third of it is of the effective type, and further, that this ratio holds also for each month in the year.

The region is characterized by much sunshine. In 1929, a drought year, records taken on 180 days recorded only 21 completely cloudy days, i.e., 12% of the total. In 1930, a rainy year, records taken on 187 days recorded 34 completely cloudy days or 19% of the total.

Droughts covering more or less extended periods are of frequent occurrence in arid Australia, and the rainfall data during the five years in which observations have been made on the Reserve and including the previous year are shown in Table 2. This table includes one of the worst drought periods experienced in this portion of South Australia.

In all these years the rainfall has been below the average, as has also the "effective rainfall". Over the 15 months from August, 1928, to October, 1929, only 1.76 inches of rain were recorded, and over this period only three days recorded amounts greater than 25 points (note the droughty appearance in Pl. xiv, fig. 2, Pl. xv, fig. 6, and Pl. xvi, fig. 5).

Falls of rain of more than 2 inches in one day occur fairly frequently in the complete rainfall records, usually as the result of local thunder-storms. Three such heavy falls are given in Table 1, viz., February, 1928, 365 points; December, 1929, 311 points; April, 1931, 336 points in one day. Little of these heavy falls is absorbed, and there is a high run off, and in bare or overstocked areas a considerable amount of soil erosion occurs; only the vegetation of the flooded areas or sandy soils benefits considerably by such downpours. The harder soil may be so scoured that there is little immediate response of the vegetation (cf. Pl. xvi, fig. 3).

The rate of erosion varies in a geometrical ratio with the slope, and also in a geometrical ratio with the size and swiftness of streams, so that by far its greater effect takes place during storms. As long as the soil of a region is mantled with vegetation, the mechanical action of the water is to a large extent impeded. The efficiency of different plant forms in checking erosion varies widely, and an open community, such as the saltbushes and bluebushes form, barely holds ground against stream erosion. In denuded country deep gullies of a canyon type with

isolated buttes are formed, resulting in a considerable lowering of the water table.

TABLE 2.  
Rainfall at Koonamore Head Station during the period 1925-June, 1931, also numbers of rainy days and falls over 25 points.

Year.		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Tot.
1925	Rainfall .. ..	159	10	0	36	218	1	115	20	35	14	28	5	637
	Rainy days ..	3	1	0	2	9	1	6	2	1	1	2	1	29
	Falls > 25 points	2	0	0	1	3	0	2	0	1	0	0	0	9
1926	Rainfall .. ..	0	2	36	64	166	61	24	104	224	0	7	62	750
	Rainy days ..	0	1	2	3	6	3	6	8	6	0	1	4	40
	Falls > 25 points	0	0	1	1	2	1	0	2	3	0	0	1	11
1927	Rainfall .. ..	62	33	7	0	1	76	26	17	90	8	50	39	409
	Rainy days ..	4	2	1	0	2	5	5	1	5	4	4	3	36
	Falls > 25 points	1	1	0	0	0	2	0	0	2	0	0	0	6
1928	Rainfall .. ..	1	390	40	0	27	108	103	6	28	0	0	0	703
	Rainy days ..	1	4	3	0	2	6	5	1	2	0	0	0	24
	Falls > 25 points	0	1 <sup>1</sup>	1	0	0	3	2	0	1	0	0	0	8
1929	Rainfall .. ..	0	0	15	18	0	9	12	26	62	0	35	327	504
	Rainy days ..	0	0	1	1	0	1	1	1	2	0	3	3	13
	Falls > 25 points	0	0	0	0	0	0	0	1	1	0	0	2 <sup>2</sup>	4
1930	Rainfall .. ..	7	93	0	80	33	0	80	47	90	112	38	108	688
	Rainy days ..	1	4	0	2	3	0	6	4	3	6	2	3	34
	Falls > 25 points	0	1	0	2	0	0	1	0	2	2	1	3	12
1931	Rainfall .. ..	16	0	76	437	84	148							
	Rainy days ..	1	0	3	3	11	9							
	Falls > 25 points	0	0	2	2 <sup>3</sup>	0	0							

<sup>1</sup> 365 points in 24 hours.

<sup>2</sup> 311 points in 24 hours.

<sup>3</sup> 336 points in 24 hours.

B. Temperature.

Temperature data are available for three complete years, and show little variation from month to month in the different years. Table 3 gives the mean monthly records for the three years, and Table 4 the mean values derived from these figures.

TABLE 3.

Year.		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1927	Terrestrial radiation ..	—	—	46·6	32·3	24·1	28·8	27·0	30·3	35·5	43·7	50·1	56·1
1928	Daily maximum ..	—	—	—	—	—	—	58·5	69·6	68·8	75·9	94·0	91·7
	Daily minimum ..	—	—	—	—	—	—	36·3	38·7	40·5	47·4	62·0	61·3
1929	Terrestrial radiation ..	—	—	—	—	—	—	29·5	36·0	41·0	41·0	60·3	58·3
	Daily maximum ..	92·4	—	82·4	87·8	64·7	63·0	57·9	62·5	66·0	80·6	81·0	84·0
	Daily minimum ..	57·8	—	54·4	49·6	37·6	34·5	30·1	34·5	32·0	40·0	54·4	51·6
1930	Terrestrial radiation ..	57·5	—	51·0	40·2	37·2	32·0	26·5	32·5	27·1	45·6	51·7	45·0
	Daily maximum ..	—	90·0	87·6	87·0	59·0	60·8	61·0	69·2	69·3	79·7	87·7	89·3
	Daily minimum ..	—	67·6	56·6	43·9	34·5	37·0	39·0	37·2	41·6	50·9	53·3	59·3
1931	Terrestrial radiation ..	—	64·4	52·8	44·0	32·0	31·8	34·9	35·0	37·2	43·7	50·2	55·6
	Daily maximum ..	—	91·9	82·8	71·6	66·5							
	Daily minimum ..	—	55·3	54·3	46·3	41·4							
	Terrestrial radiation ..	—	47·0	48·8	42·9	41·5							

TABLE 4.  
Mean Temperature Data.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Anl.
Mean maximum ..	92.4	91.0	83.3	82.1	63.4	61.9	59.4	65.8	67.6	80.1	84.3	86.7	74.9
Mean minimum ..	57.8	61.4	55.1	46.6	38.7	35.7	34.6	35.8	36.8	45.4	53.8	55.4	46.4
Mean .. .. .	75.1	76.2	69.2	64.3	51.0	48.8	47.0	50.8	52.2	62.7	69.8	71.4	61.5
Terrestrial radiation ..	57.5	55.7	50.8	40.0	33.7	30.9	29.5	33.4	34.7	43.5	53.1	53.8	43.1
Mean diurnal range ..	34.6	29.6	28.2	35.5	24.7	26.2	24.8	30.0	30.8	34.7	30.5	31.3	30.1
Number of frosty days ..	0	0	0.1	1.5	4.2	15.4	15.7	11.4	5.1	0.1	0	0	53.5

The temperature shows the characters common to arid climates. The mean temperature tends towards a minimum in July, and there are two well-marked seasons—a hot season from October to March and a cold season from April to September. During the hot season the mean monthly maximum temperature ranges from 80° to 90°, and in the cold from 60° to 70°, the transition between the two seasons being well defined. During the hot seasons, temperatures exceeding 90° are very common, as can be gauged from the mean monthly figures, but accurate data cannot be given owing to gaps in the records in January due to the observer's absence.

The average number of frosty days per annum over a period of 8 years is 53.5 days, and these are confined to the cold season, the greatest number occurring in June and July, as reference to Table 4 will show. Records kept at Head Station show that during July, 1924, which was a dry winter, there were 27 frosts, of which 13 were severe, i.e., all outside pipes at the homestead remained frozen till 10 a.m.

A characteristic and important feature is the high diurnal range. The mean annual diurnal range (non-periodic amplitude) is 30.1° F., and it will be seen from Table 4 that the mean monthly range during both the hot and cold seasons closely approximates this figure. This high diurnal range has an important bearing on the humidity. Soil temperatures are not available, but they are high in the surface layer during summer, and the ground is often uncomfortably hot to the touch during the early afternoons.

### C. Humidity.

The humidity data are of special interest owing to the fact that high relative humidities are frequently recorded, and high humidities are of importance to many of the plants of arid Australia, which can absorb water through their leaves from nearly saturated atmospheres (Wood, 1925).

The mean monthly relative humidity data are available for four years, and these are given in Table 5.

The mean relative humidity over the four years is high for an arid climate and is higher on the average than the monthly means for Adelaide. The mean, however, does not give a true picture of the degree of saturation of the air, since wide daily fluctuations occur. The mean maximum and mean minimum humidities are therefore of importance, and reference to Table 5 will show that in practically every month the mean maximum exceeds 80% humidity, and that, excluding the winter months, the mean minimum falls below 40%. We are therefore dealing

TABLE 5.  
*Relative Humidity.*

Year.		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Anl.
1927	Mean maximum	—	—	74	88	90	95	97	89	92	81	79	86	87
	Mean minimum	—	—	34	39	44	56	50	43	42	41	34	39	42
1928	Mean maximum	95	—	—	81	77	86	87	85	80	82	73	87	83
	Mean minimum	42	—	—	47	48	56	41	36	35	31	33	37	40
1929	Mean maximum	94	82	88	88	84	90	91	88	88	77	83	81	86
	Mean minimum	41	39	42	36	38	42	41	39	36	32	32	31	37
1930	Mean maximum	—	83	87	85	91	94	90	86	89	86	83	81	86
	Mean minimum	—	42	35	39	40	49	46	50	37	36	27	23	39
1931	Mean maximum	90	80	85	93	95								
	Mean minimum	28	23	27	34	45								
1927 to	Mean maximum	93	82	83	87	87	91	91	87	87	81	80	84	85
	Mean minimum	37	35	34	39	43	51	47	42	37	35	31	35	39
1931	Mean .. ..	65	58	59	63	65	71	68	64	62	58	55	59	62
	Saturation deficit	0·31	0·40	0·30	0·22	0·13	0·10	0·10	0·14	0·15	0·24	0·35	0·35	

with a climate of extremes as regards humidity. The same day may be both moist and dry.

This variation in the humidity is a consequence of the high diurnal range of temperature, and since the relative humidity varies with the temperature, a more accurate picture of the degree of saturation of air is given by the *saturation deficit* which measures the difference in vapour pressure from saturated air in inches of mercury, and is independent of temperature. The highest relative humidity is recorded at the time of minimum temperature and the lowest relative humidity at the time of maximum temperature. The mean saturation deficits for each month are calculated therefore from the mean maximum temperature and mean minimum humidity, and from the mean minimum temperature and mean maximum humidity. The saturation deficits are shown in Table 6.

TABLE 6.  
*Saturation deficits in inches of mercury.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Mean maximum temperature ..	92·4	91·0	83·3	82·1	63·4	61·9	59·4	65·8	67·6	80·1	84·3	86·7
Mean minimum humidity ..	37	35	34	39	43	51	47	42	37	35	31	35
Saturation deficit	0·95	0·95	0·75	0·68	0·33	0·27	0·27	0·36	0·41	0·65	0·81	0·85
Mean minimum temperature ..	57·8	61·4	55·1	46·6	38·7	35·7	34·6	35·8	36·8	45·4	53·8	55·4
Mean maximum humidity ..	93	82	83	87	87	91	91	87	87	81	80	84
Saturation deficit	0·04	0·05	0·07	0·04	0·03	0·02	0·02	0·02	0·03	0·05	0·08	0·06

The figures for the saturation deficits bring out clearly that through every month, including the hot summer months, the air becomes almost saturated with water vapour for a part of the day. This fact, we believe, accounts for the success and ubiquity of the saltbush throughout the district. On the other hand

the aridity of the environment is indicated by the high value for the deficit during the daytime.

In view of the importance of the high humidity to the vegetation, the length of time during which such high humidities prevail becomes important. Table 7 gives the mean number of hours per day per month during which the relative humidity is greater than 80%, also, as an indication of the rigorous arid conditions, the mean number of hours per day each month in which the relative humidity is less than 40%. These figures are derived from the thermohygrograph charts for a period of three years.

TABLE 7.

Showing mean number of hours per diem which the relative humidity exceeds 80% and during which it is less than 40%.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Number of hours exceeding 80%	n.r.	3·9	4·5	7·2	9·6	8·7	8·1	6·2	4·7	3·8	3·8	3·1
Number of hours less than 40%	5·5	6·9	5·9	3·1	2·4	1·0	1·8	4·1	6·0	6·9	8·9	7·6

The time during which the relative humidity is highest lies between midnight and 7 a.m., reaching a maximum usually just before sunrise. The time of lowest relative humidity is between 2 and 4 p.m.

Koonamore resembles the Kimberley District of South Africa, which has a mean annual range of temperature of 31·3° F., and a mean relative humidity of 46% in November and 65% in April to June.

The humidities recorded by Cannon (1921) for the Algerian Sahara are lower, ranging from 43% to 55% for the mean humidity. Hann (1903) records an average of 35% for the mean humidity for May in the Punjab and north-western provinces of India, and in the south-western United States records a mean annual humidity of about 45%.

Fogs are relatively infrequent, but 7 fogs have been recorded since May, 1928, all in the cold months, and during these considerable amounts of water are condensed by trees and shrubs which drip as with rain. Pendant foliage such as that of *Myoporum platycarpum* causes a shower on the ground beneath. On one occasion the ground was appreciably moist beneath the canopy to a depth of 2·5 cm. Outside the canopy area the soil was quite dry.

No data are available for evaporation, but at Broken Hill, in a similar environment, the mean annual evaporation is 85·22 inches.

#### D. Winds.

Winds play an important part in the complex of environmental factors in arid regions.

The mean summer pressure at Koonamore is 29·957 inches, and the mean winter pressure 30·133 inches.

The winds from October to March (the hot season) have a south-westerly component, but in the cold season from April to September are variable. The winds have an effect in the first instance upon grazing, since sheep feed up wind in the summer and consequently the southern sides of paddocks tend to be more heavily grazed than the northern. The denuded state of the Reserve



was due in part to its location at the southern boundary of the paddock, and also to the shelter that the scrub afforded the sheep.

The more direct effect of the wind is seen in the dust-storms which are frequent in summer in the North-East District. The storms originate in overstocked areas around dams or watering-places, around townships, or from land that has been ploughed for agricultural purposes in essentially pastoral country. Noble (1904) records the removal by wind of 1 foot of soil from an area of more than 100,000 acres in New South Wales, and Free (1911) mentions the dust-storms of the spring of 1894 in Southern Russia as having removed soil to the depth of 6 inches over an area of 200 square miles. Free (loc. cit.) has made mechanical analyses of soils most liable to drift and removal by wind. These analyses approximate closely to the sands and sandy loams of the Koonamore area. It must be remembered, however, that these soils do not drift to any extent as long as they have a cover of vegetation.

As opposed to dust-storms, sand drift is of importance, i.e., the movement of the heavier sand particles along the ground. It also arises in overstocked areas, around watering places and from agricultural lands on the fringe of the pastoral country, especially from soils which have some depth of sand on the surface. The effect becomes accumulative since all vegetation in the path of the drift is destroyed.

## 5. METHODS OF INVESTIGATION.

### A. *Permanent Quadrats.*

The principal method chosen for the study of regeneration and sequence of vegetation has been the permanent quadrat, charted and photographed from two fixed points at regular intervals. The location of these is shown on the sketch map (Text-fig. 1).

Three sizes of quadrats were employed. They were as follows:

(a) The Hundred series.—Quadrats with sides 100 metres long, giving an area of 1 hectare, approx.  $2\frac{1}{2}$  acres. Four such quadrats were originally set out in April, 1926, and a fifth added in December, 1927 (Plates xiii–xv).

(b) The Ten series.—Quadrats with sides 10 metres long giving an area of 100 sq. metres. Four were set out in April, 1926, and a fifth added in December, 1927 (Plate xvi).

(c) The Unit series.—Quadrats with 1 metre sides. Two only were set out in April, 1926 (Plate xvii).

The 'hundred' quadrats were primarily intended to study the changes in the tree and tall shrub vegetation, the position of the trunk and extent of canopy of each tree being shown on the chart. As it was not anticipated that any rapid changes would occur, these quadrats were surveyed every 15 months, thus shifting the season of observation throughout the work. They were photographed, however, quarterly. On charts of these quadrats the position of individual salt and blue bushes was also recorded.

The 'ten' quadrats were primarily intended to study the changes in the salt and blue bushes. On the scale used it has been possible to show the canopy area of each plant. The more important smaller plants, e.g., *Stipa*, *Bassia* and so on, have been indicated by symbols. These quadrats were charted quarterly, and photographed at the same time.

The 'unit' series recorded every plant, however small, growing on the area. These, too, were charted and photographed quarterly.

The corners of the quadrats were marked by  $2 \times 2$ " jarrah stakes 6 ft. high, painted white for the top 2 ft., on which the number was recorded. In the case of the 'hundred' series, intermediate pegs, 2 ft. high, were placed at 20 metre intervals along the sides and throughout the area of the quadrat, thus dividing the whole into 25 squares, with  $20 \times 20$  metre sides. When the quadrat was to be charted, lines were stretched across the whole length and breadth of the area from these intermediate pegs. Usually a party of three observers was engaged on the mapping, one recording the data on the chart and the other two carrying a metre tape to measure the distance of the particular plant from the sides of the square.

In the case of the 'ten' series, short intermediate pegs were placed every metre along the four sides. For charting a line was stretched across the square from opposite pegs so that the whole area was divided into one metre squares (vide Pl. xvi, figs. 4 and 6). With the aid of a metre rule, where necessary, the position of any plant could be rapidly plotted.

The charting of the unit series calls for no special comment.

It was decided at the outset that, as more than a hundred photographs and charts of the quadrats would be made each year, a card system of filing the records was most suitable. The  $5 \times 8$  inch filing card was adopted. This is of sufficient size to allow of a quarter-plate photograph being pasted upon it, leaving room for essential data. For charting, a special card was prepared having one square decimetre divided into square millimetres printed upon it. This again left sufficient space at the side for the symbols and their explanation to be entered. The  $5 \times 8$  inch cards have been found a very convenient size to handle, they are stiff enough to write upon in the field. The charting in the field was done with pencil and the card inked in the same day, using Indian ink.

We have found this uniform system of recording and filing our maps and photographs very convenient for the compilation, handling and consultation of the records.

At the commencement of the work there was no guide as to the size of quadrat likely to prove most useful. The 'ten' series has yielded less information about the regeneration of the perennial undershrubs than was hoped. The regenerating community is necessarily an open one, and more valuable information as to the actual rate of spread of saltbush has been obtained from the 'hundred' series than the 'ten'. At the same time, on the scale upon which the hundred series is recorded, it is impossible to note more than the presence or absence of a plant the size of *Atriplex*. The 'ten' series, on the other hand, allowed the canopy of each bush to be recorded. This series has also proved of much value in studying the growth of *Stipa* and the relation of the annual flora to litter and the accumulation of sandy soil around the perennial undershrubs. The unit series has afforded much detailed information as to the growth of the ephemeral flora which could not have been obtained by other means.

It will be seen from the map (Text-fig. 1) that the location of the quadrats was arranged to include the principal types of vegetation and soil, paying particular attention to the plants of the shrub steppe type. One may wish now that at least one other 'hundred' quadrat had been set out, but, having regard to the original plan of work, and the short time available for the working parties on their quarterly observations, this was impracticable.

### B. *Permanent Photograph Points.*

In addition to the regular photographs of the quadrats, a number of other photograph points have been established and photographs taken from these at irregular intervals. The location of these is shown on the map (P.P.1, etc.). As the change in the perennial flora will necessarily be slow, it was felt that such photographs would be of value in years to come. Evidence will be given below to show that the rate of regeneration of the chenopodiaceous shrubs is in direct relation to the propinquity of a source of seed. Thus the photograph at the point known as P.P.6 (near S.W. corner of Reserve) was first taken in March, 1925, and used in the original note on the Reserve (Osborn, 1925, Pl. xxiv, fig. 3). The photograph repeated exactly 6 years later shows no change at all, the same scanty cover of *Bassia* being present, the same dead *Cassia* bushes, even the same fallen branch in the foreground. This area was once a saltbush flat with scattered *Cassia* bushes. It is shielded on the south by scrub-covered sandhills from a possible source of seed from the adjacent paddock. On the other hand, areas elsewhere on the Reserve, adjacent to sources of seed (e.g., in the south-east and north-east corners) show a good regeneration, sufficient to justify the setting out of transect system in August, 1930, though in 1925 hardly a saltbush was present on these areas.

### C. *Sampling Methods.*

The method of sampling the vegetation by means of a metre frame dropped on predetermined spots was used largely by us in a study of the grass flora (Osborn, Wood and Paltridge, 1931). It is unnecessary to refer further to it here. A method of point sampling was tried. Ten 2-inch nails were driven through a metre rod at 1 decimetre intervals and the rod mounted on a stick. This implement was dropped points downward at frequent intervals, the object being to record the plants actually speared. So open was the flora, even during a favourable season, that the record was 0 plants speared after 100 tries, i.e., 1,000 individual points. The method was discontinued as being quite unsuited to the open vegetation of an arid area.

### D. *Experimental Fires or Burns.*

Since scorching is known to have an important influence in accelerating the germination of the seeds of many species of *Acacia*, a number of bonfires of fallen trees and litter were lit in August, 1927. The results of these were so promising after the rains of February, 1928, that the experiment was repeated in June, 1929, on a more formal scale. As it was found that kangaroos selected the burnt areas to roll and lie upon, the experiments of 1929 were enclosed by fences and wire-netting from the outset. Some only of the 1927 series were netted. The results of these experiments are discussed below, in relation to the regeneration of *Acacia aneura* and the damage caused by rabbits (p. 425).

### E. *Rabbit-proof Enclosures.*

During the 1929 drought it became obvious that rabbit damage was a most serious adverse factor. A series of netted enclosures, approx. 5 × 5 ft., were set up, four along each fence, two in the Reserve and two outside. The two enclosures of each pair are approximately 50 yards away from each other, on similar soil types. From these enclosures, which are large enough to furnish a square metre inside, free from any fence effect, it is hoped to obtain information as to absolute protection from rabbits, also from stock in the surrounding paddocks.

## 6. BIOLOGICAL OBSERVATIONS.

In our previous papers we have dealt in some measure with the effects of sheep and rabbits upon the vegetation. The influence of sheep or grazing by other domestic animals is not considered in the present communication. Since the Reserve fence was erected in 1925 none have been within the enclosure. The effects of sheep are still to be seen, not only in the profound change that their grazing had effected in the flora as a whole, recovery from which is one of the major problems of study, but on the soil itself. The trampling of thousands of hooves has the effect of compacting the soil, causing the lighter surface layer over the silt soils of the shrub-steppe to blow away or to remain in mounds around the perennial plants, especially the low divaricate perennials of the saltbush type. It is well known that sheep tend to move in lines following a leader; in this way definite 'pads' are still left on the Reserve trodden hard and sunken a centimetre or two below the general level of the ground even after six years enclosure. These 'pads' are quite destitute of vegetation, even after favourable rains.

It was hoped to exclude all alien fauna from the field of observation, but it has been found impossible to eliminate rabbits. And this in spite of the fact that the fence is netted against them and that there is no permanent water on the area. Towards the end of the five-year period rabbits began to breed up rapidly throughout the district, and a marked increase in their numbers was noticed on the Reserve. In 1932 at the conclusion of the period covered by this paper, the desperate remedy of ploughing in all burrows was undertaken, and as a result 7,000 rabbits were killed inside the Reserve. This drastic action was not taken during the period of quarterly observations because of the inevitable damage to much of the area. Probably at no time has the area been free from rabbits but, until the last year of the observations here recorded, it was a rare thing to see an animal or find an "active" burrow. When seen, all such burrows were immediately blocked, often after treating with cyanide dust. We shall refer later to specific instances of rabbit damage and discuss their action in inhibiting all regeneration of trees and shrubs. As an instance of the incalculable harm that they must do to annual plants it may be recorded here that in August, 1929, during the height of the drought there was no green herbaceous plant to be seen on the whole Reserve, except within a small rabbit-proof enclosure. Inside this, in spite of the fact that there had been only 88 points of rain in the preceding twelve months, there were a few green plants of *Stipa nitida*, *Erodium cymnoidium* and *Tetragonia eremea*.

In 'good seasons', when there is an abundance of herbage, plagues of caterpillars take heavy toll of succulent-leaved annuals such as *Tetragonia eremea*. In June, 1928, there was such a plague. The insect concerned was *Heliothis leucatura*, one of the Noctuidae.

The prevalence of gall-forming insects of all kinds is noticeable, especially on mulgas (*Acacia aneura*), *Acacia Burkittii* and *Heterodendron*. These must reduce the seed output considerably. Even more noticeable are the galls formed by the rust, *Uromyctadium Tepperianum* on *Acacia aneura*. So severe are the attacks of this fungus that trees are not infrequently killed by it.

Phanerogamic parasites are a common feature of the flora in arid Australia. Species of *Loranthus* heavily infest certain of the trees and shrubs, which sometimes succumb to the attack, notably *Heterodendron* from a heavy attack of *Loranthus Exocarpi*. This is the most polyphagous of the local loranthus, occurring also on *Eremophila Sturtii* in the Koonamore district, while *L. Maidenii*

appears restricted to the mulga. Root parasites belonging to the Santalaceae are *Exocarpus aphylla*, *Eucarya acuminata*, the quondong, which is common, and the much less frequent *Eucarya spicata*, a commercial species of sandalwood. Haustoria of this latter were traced to the roots of the mulga.

Two adverse factors directly affecting seed production should be mentioned. Firstly, the very heavy toll that must be taken by bird life, particularly such gregarious birds as the galah (*Kakatoe roseicapilla*). Flocks of these birds ranging from a dozen or so to several hundred settle on any patch of vegetation at the seeding stage. Not only do they pick up fallen seed but they attack ripening fruits. A flock was put up from a patch of fruiting saltbush (*Atriplex vesicarium*) and the ground examined. It was littered with hundreds of fallen fruits, each neatly cut open with a semicircular incision and the seed removed. Moreover, there were many shoots of the shrub lying around, cut off by the powerful beaks of the birds.

Secondly, the sudden onset of hot weather before the seed has matured may cause the abortion of great numbers of seed. Thus all the awned mericarps of *Erodium cygnorum* collected in October, 1928, from a dense society of this plant that had germinated after the rains of February–July were found to have empty carpels. The 1928–29 drought set in with a burst of hot dry weather before the seed had matured.

In spite of the severe natural loss of seed from various causes, the amazing number of seedlings that appear after suitable rain, provided that there is a seed bed, is a feature of this, as of other arid districts. The fate of these therophytes is considered later.

Bird distribution of seed or fruit is not obvious, but a few cases have come under our observation. Emus spread the quondong (*E. acuminata*), the stones being common in their droppings when quondongs are in fruit. They also eat largely of the succulent berries of loranth (L. *Preissii* especially being noted), but in this case they can be of no service in dissemination. Succulent fruits are rare in Australia generally, but it is noteworthy that the succulent-fruited Chenopodiaceous genera, *Rhagodia* and *Enchylaena*, appear to be bird distributed. It is very noticeable that the young plants of *Rhagodia Gaudichaudiana*, which have appeared on quadrat No. 400 and other parts of the Reserve, have done so under trees that had served as perching places for birds.

Flood waters distribute many fruits. The remarkable woody capitula of *Erodiohyllum Elderi* appear particularly suited to such dispersal. The plant is essentially one of flooded flats. *Bassia paradoxa*, with its remarkable compound caltrop-like burrs, fully 1 cm. in diameter and consisting of about 10 concrescent woody perianths with their projecting stout spines, is essentially a plant of washes and flooded areas, though not altogether confined to this habitat in wet seasons.

The common occurrence of spines or awns on fruits is notable. The function of the awns of *Stipa* and *Erodium* in burying the seed is well known. After heavy fruiting of *Stipa nitida* at the end of 1928, masses a foot in diameter of entangled awns were common amongst the plants. Most of these appeared to have buried their caryopses, the loose awns lying on the ground. The biological significance of the spines upon the many fruits which bear them is less obvious. Spines of greater or less size characterize the fruits of all the *Bassia* species, of *Tribulus*, *Calotis*, *Aristida*, while *Lappula*, *Daucus*, and *Tragus racemosus* have shorter spines or hooked appendages, i.e., are burrs. We hesitate to suggest any significance for animal distribution. We do note, however, that spines become

entangled in litter. At times the litter of fruits and small branches of *Bassia patenticuspis* (containing other fruits) has covered many square metres of our quadrats.

Many fruits have wind dispersal mechanisms; such are the bladdery perianths of *Atriplex vesicarium*, *A. spongiosum*, *A. halimoides*, the papery perianths of several other *Atriplex* species (*A. limbatum*, *A. campanulatum*, *A. stipitatum*, *A. velutinellum*). Most of the *Kochia* species have more or less winged fruits, many of the Compositae have a plumose or scarious pappus, in *Eremophila Sturtii* the calyx persists and enlarges as it does in some other species of the genus, and the nutlet of *Casuarina lepidophloia* is winged.

Dehiscence mechanisms leading to a scattering of the seed are not common. Seed of *Acacia* is usually found immediately below the plant; so is the seed of *Templetonia egena*, though both have dry dehiscent pods. The capsules of *Zygophyllum* split with some violence when dry, ejecting the seed.

We offer no suggestion as to the significance of the aril, a feature of *Acacia* seeds and very noticeable also in *Heterodendron* where it is strikingly coloured red and half invests a black seed. Ants, which are not so much a feature of the insect life of the arid parts of Australia as they are of better rainfall areas, were abundant on and around fruiting *Heterodendron* trees.

Reference to the importance of a seed-bed was made in our paper on *Stipa* (1931, pp. 310-312). The effect of overstocking and subsequent wind erosion has been to destroy seed beds. The two very heavy falls of rain (February, 1928, and December, 1929) provided very little response in the germination of seedlings, except in areas that became flooded. The run-off from hard soil surfaces is too rapid, the erosion effect is intensified. The seeds of some of the plants characteristic of flooded ground contain a considerable quantity of mucilage, e.g., *Zygophyllum* spp. and *Clianthus*. The biological significance of the peculiar mucilaginous investment of the fruits of *Boerhaavia* is less obvious. When the fruits are ripe it swells rapidly after only a few points of rain. Fallen fruits with a glairy gelatinous investment were abundant round the dying plants in May, 1928, after a light shower. The plant did not reappear on the quadrats till March, 1930.

Time of flowering appears to be determined more by the rainfall than the season of the year. On the whole most perennials flower between July and October, but flowering is by no means of regular annual occurrence. It is rare in the case of *Acacia aneura*, *Heterodendron*, *Casuarina* and *Eucarya*. Of the Chenopodiaceous shrubs *Kochia sedifolia* rarely is found with flowers or fruits; this is very noticeable in comparison with *K. planifolia* or *K. Georgei*, which appear to flower freely in good seasons. Three plants are rarely without some flowers, *Pholidia scoparia* (with pale mauve corolla), *Kochia pyramidata* and *Bassia patenticuspis*.

## 7. RESULTS FROM STUDY OF QUADRATS.

### A. Trees.

#### (i) *Acacia aneura* (the mulga).

Quadrat 200 (Text-fig. 2) includes a portion of a typical mulga grove (Plates xiii-xiv). The trees occur in pure community, growing so densely that their crowns may interlace. The extent of the crown may be as much as 10 metres in diameter, but the narrow phyllodes, which usually stand more or less erect, do not cast a dense shade. The ground beneath the tree usually has a fairly extensive litter of fallen phyllodes. In height, the trees range up to 10

metres. They are very graceful with their light tracery of obliquely ascending branches and silvery-green foliage.

The trees of a mulga grove are usually of only one or two ages. Flowering is irregular following rain, and never as heavy as in most other acacias. Seed is apparently rarely set; we have found much difficulty in collecting even an ounce. The trees are often severely damaged or even killed by the gall-forming fungus, *Uromycladium Tepperianum* (Osborn and Samuel). They are also parasitized by *Loranthus*.

The distribution of the mulgas on quadrat 200 is not continuous over the whole quadrat (Text-fig. 2). This is because there is a change in soil type along the southern sides in the north-east corner. The mulga is limited to the sandy soil. Text-figure 3, which shows the distribution of saltbush and of seedlings of *C. eremophila* on this quadrat, shows clearly that other perennials do not readily establish themselves under growing mulgas.

Seedlings of mulga are rarely seen unless germination is stimulated by fire. Apparently they only occur after heavy summer rains. Five only were observed in February, 1930, on quadrats 200, 300 and 6-80 (an area of 2.48 hectares in the aggregate), following the rain of December, 1929, though at this date all quadrats were searched carefully for seedlings of trees and shrubs. Only one had been recorded after the rain of February, 1928.

On the other hand, after fire, germination is not infrequent. As mentioned previously, in August, 1927, a number of experimental bonfires were lit near mulga trees, the ground immediately around the burnt area serving as a control. In June, 1928, 10 months after the fire and four months after heavy rain, there were 23 mulga seedlings on these burnt areas, 12 being on one patch of about 4 square metres. Three more seedlings appeared by December, 1928; thereafter no more have germinated.

A second series of burns shows a somewhat similar history. The fires were lit in June, 1929, during the drought. Rain fell at the end of December, 1929, and in the March following 4 mulgas were noted at the edge of one of the two burnt patches. A fifth seedling appeared about 7 months later, since when there have been no more. The other burnt patch has shown no seedlings.

It is clear from these two experiments that germination of mulga can be induced around the edges of local burns, that the majority of the seeds that will germinate do so shortly after a heavy summer rain, but that there are a few laggard seeds which do not germinate till 9 or 10 months later. The young mulgas are much sought after by rabbits. No seedling in the Reserve has survived more than a few months except on areas specially protected. Further reference is made to this below (page 426) when discussing rabbit damage.

Though the adult tree is erect with usually only a single stem, the seedling stem is always oblique, sometimes inclined at an angle of 35°-45° to the vertical. More than one stem is commonly present. The plant is slow growing, but as the severe drought affected the 1928 germination, useful information cannot be given. In January, 1931, these plants, at approximately three years, were 20-25 cm. high. They were no larger than those of the 1930 germination which had only made 15 months' growth.

(ii) *Other tree species.*

The mulga is the only tree upon which detailed observations on the regeneration have been made, but the following notes on the three other important tree species are given.

. Quadrat No. 400 was set out to include portion of a woodland of *Casuarina lepidophloia* (belah or black oak). This species is the tallest growing tree in the district, specimens 10–14 metres high being known to us. The trees are more or less gregarious, with a single trunk that breaks up into several obliquely ascending limbs at 2–3 metres. The diameter at breast height of the biggest tree on the Reserve is 0.5 metre. Trees much larger than this must have existed. The decorticated stump of one occurring in a water-course close to the south of the Reserve is 1.1 m. in diameter. The foliage shoots persist for some years; when they fall they form a more or less continuous litter around the trees and help to suppress other vegetation.

The species is monoecious, and in the Reserve staminate inflorescences have only been noted on a few trees on two occasions. Seeding is apparently rare, no seedlings having been recorded.

The main root system is superficial and there is clear evidence that root budding occurs, giving rise to new upright stems of considerable size. In other cases, on quadrat No. 400, trees have blown over and rooted again with 2 or 3 upright stems from the prostrate trunk.

*Heterodendron oleaefolium* occurs scattered over the rises on the Reserve as low trees, 3–4 metres. This plant only attains large size where it can receive occasional flooding. There it forms a low spreading tree of 6 metres high with a dense rounded canopy of foliage. A clump of such trees occurs about the centre of the Reserve. The shade cast by such well-grown *Heterodendrons* is remarkably dense for a plant of an arid climate. Flowering is irregular, but occasional trees have been seen with heavy crop of seed. These are very strikingly coloured, black with a red aril. Reproduction from root buds occurs. Suckers have been observed several times, but none have been noted as persisting.

The most important tree on the Reserve, after the mulga, is *Myoporum platycarpum*, the "sandal" wood of the district. This occurs scattered over large areas, giving a park-like effect. It grows principally on hard loamy soil with more or less travertine limestone. Quadrat 100 was laid out to observe this tree (Text-figs. 4 and 5).

Most specimens grow 6–8 metres high and are about 20–30 cm. in diameter at breast height. At about 2–3 metres the trunk breaks up into a few obliquely ascending branches. The foliage forms an irregularly rounded crown, usually with a fair amount of dead wood. The main trunk and branches have a dark deeply-furrowed bark, showing an appreciably greater development on the northern side. The ultimate branches are smooth, greyish and with slender semiflexuose twigs. The simple leaves are rather thick, glabrous, with characteristic oil glands. When young they are protected by a resinous secretion or lacquer. They persist for two or three years, the older ones falling in late summer. During the 1928–1929 drought the trees became almost defoliated, and many of the branches died back. Such defoliation is seen in the trees shown on Plate xvi (cf. figs. 1 and 4, also 5 and 6). In March, 1931, many trees were noted as developing strong new branches from the level of the main forking, the older limbs dying out.

The root system is largely superficial and the several trees on the Reserve have been noted as blown over during strong winds. When this is so, a quantity of soil is torn up with the superficial roots. Such trees show an indication of a tap root, but at 30–50 cm. depth this tapers to a few centimetres in diameter.

Flowering occurs freely from a series of buds borne in the axil of each leaf on the ultimate branches. Seed has not been observed to be set in more than



very small amounts. Occasional seedlings have been noted from time to time, but none have survived for long, except in the rabbit-proof enclosures.

#### B. Shrubs.

There are five important shrub species on the Reserve. These are *Acacia Burkittii* on the sand hills, *Eremophila Sturtii* and *Pholidia scoparia* principally on loamy soil, and *Cassia Sturtii* and *C. eremophila*.

No special study was made of *Acacia Burkittii*. Seedlings were rarely found. It will be seen from Table 11 that a few appeared in connection with the experimental fire areas. Germination cannot be common without such stimulus. No seedlings were recorded on the quadrats in February, 1930, when a special search for all seedling shrubs was made.

*Eremophila Sturtii* is widespread over the Reserve, except on open hard loam plains, either as isolated bushes or as thickets. Of all the plants it appears to suffer least from grazing and rabbits. The bushes are dense, upright in habit, with large numbers of characteristic linear leaves, recurved at the tips and showing an appreciable amount of lacquer even in the old stages. Flowering is infrequent and seed rarely set. Only occasional seedlings have been noticed.

*Pholidia scoparia*, as the local name, the broom-bush, implies, has a strict erect habit. The leaves and young branches are silver-grey owing to the covering scales. Though plants usually show some flowers, seeding is not common and no seedling was recorded.

It is quite otherwise with the two species of *Cassia*. Both after fires and after the heavy summer rain of December, 1929, seedlings of the two species were abundant. The frequent occurrence of seedlings of *C. eremophila* is interesting, for the species is extinct on the Reserve, all the bushes having been killed before the enclosure was made. *C. Sturtii* is only represented by occasional old bushes. These have a straggling upright stem, 1-1.5 m. high, and a small crown of foliage shoots. They show obvious signs of having been heavily grazed. Both these species appeared with numbers of seedlings after the experimental burns and were first recorded in June, 1928 (Table 11). The heavy rainfall of December, 1929, caused them to germinate freely over the whole Reserve. They were specially searched for when the hundred quadrat series was mapped in February, 1930. The results are as follows:

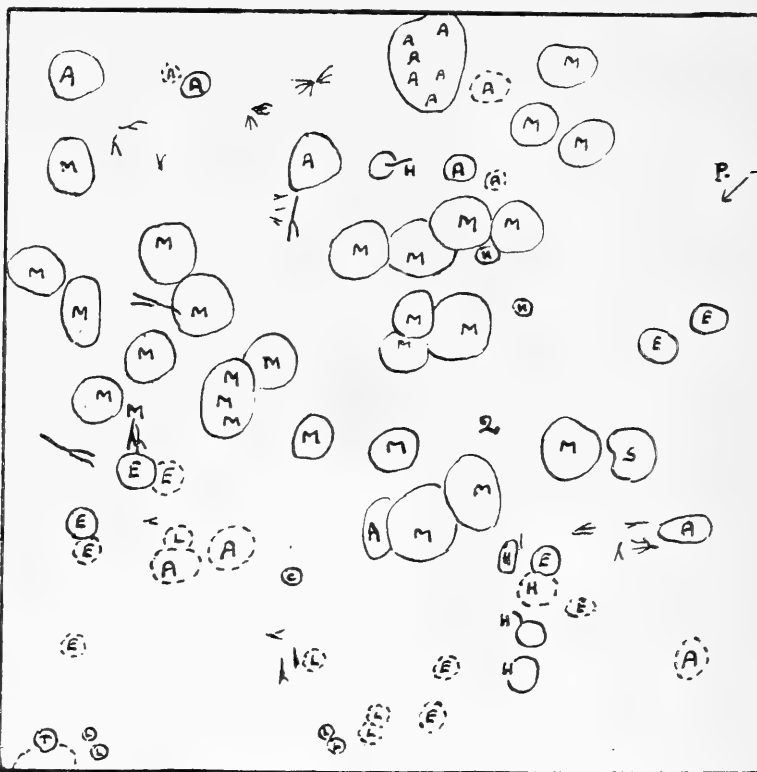
Quadrat.	<i>C. eremophila</i> .	<i>C. Sturtii</i> .
100	—	65
200	48	1
300	5	25
400	1	5
6-800	28	14

Text-figure 3 shows the distribution of the seedlings on quadrat No. 200. *C. eremophila* is evidently a plant of the sandhills and areas of light soil liable to flooding. *C. Sturtii*, on the other hand, occurs more on the harder loam soils where it grows with *Atriplex vesicarium* and *Myoporum platycarpum* (cf. quadrat No. 100, Text-fig. 5).

#### C. Dominants of the Shrub-Steppe.

(i) *Atriplex*.—In a previous communication we have considered the growth of *Atriplex vesicarium* at some length. We shall confine ourselves here to an account of its regeneration under protection. Originally, a considerable part of the Reserve, except the sandhills, must have been shrub-steppe covered with either *A. vesicarium* or *A. stipitatum*, or both in association. Quadrat 200 shows well that the mulga-

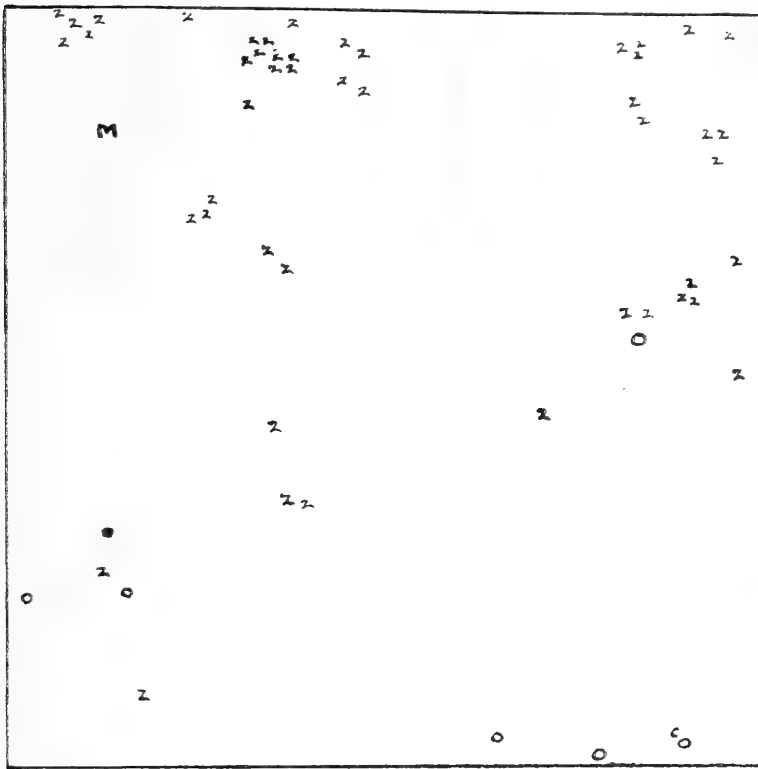
covered sandhills and the loamy plain with *A. vesicarium* are distinct communities. In Text-figure 2 the distribution of the mulgas on this quadrat is shown. They do not extend along the southern or eastern sides where the soil is loamy. Text-figure 3, based on the chart of February, 1930, shows that it is along these areas *Atriplex* began to appear. In June, 1931, five of these seven bushes were still growing and six more were present, all on the loamy soil.



Text-fig. 2.—Quadrat chart of 200, 27/2/30 (scale 1/1,000), showing the distribution of the tree and shrub vegetation. A full line indicates the canopy of a living tree, a broken line the extent of a dead standing tree. The chief fallen trees indicated by forking lines. M = *Acacia aneura*, A = *Ac. Burkittii*, H = *Heterodendron oleaeifolium*, E = *Eremophila Sturtii*, L = *Lycium australe*, T = *Templetonia egena*. 2 marks position of quadrat 2, P with an arrow the position of camera and direction of the photographs, Plates xiii and xiv.

Quadrat 100 has been particularly useful for studying the spread of *Atriplex*. In May, 1926, there were four saltbushes only on the hectare. One of these was alive and growing vigorously in 1931, a large sprawling bush 160 cm. in diameter, but the remainder died before or just after the 1927 mapping. Text-figure 6 shows the distribution of the saltbush in June, 1931, 72 plants (53 *A. vesicarium* and 19 *A. stipitatum*) being present.

Below is given in tabular form (Table 8) the results of our quadrats of 100-metre scale, showing the increase of *Atriplex* during the five-year period.



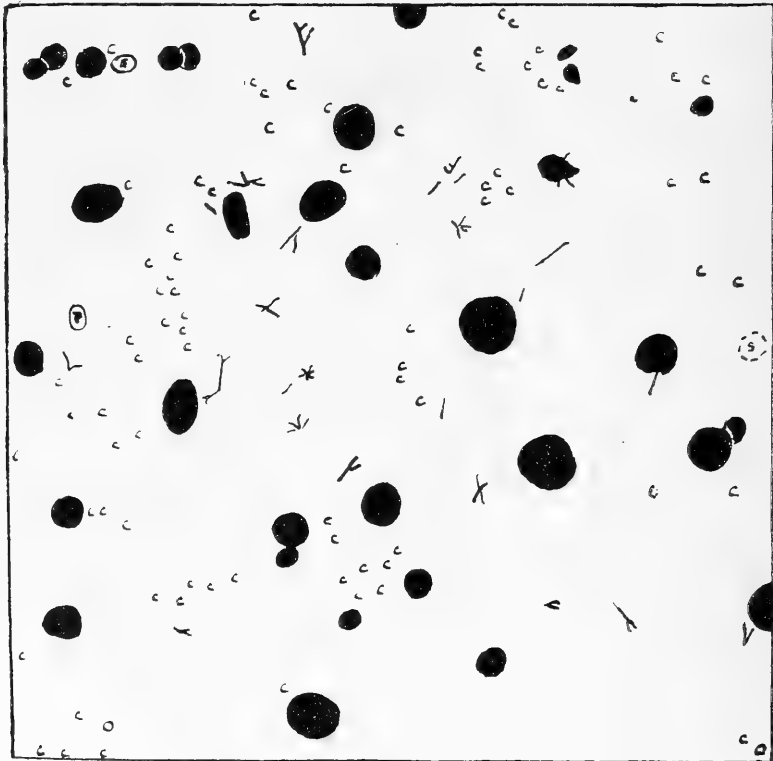
Text-fig. 3.—Quadrat chart of 200, 27/2/35 (scale 1/1,000), showing distribution of seedlings and saltbushes. M = *Acacia aneura*, Z = *Cassia eremophila*, C = *C. Sturtii*, o = *Atriplex vesicarium*, and a full dot = *A. stipitatum*. *C. eremophila* occurs on the sandy soil which also supports mulga and *A. Burkittii*, also on the NE. side of the quadrat where flooding occurs. *Atriplex* occurs on the southern side where the soil is hard loam, with *Lycium*, *Eremophila* and *Heterodendron*, but no mulgas.

TABLE 8.  
Spread of *Atriplex vesicarium* and *A. stipitatum* in hectare quadrats.  
Number of quadrat.

Charted.	100.			200.			300.			400.		
	No. Map-ped.	Gross In-crease.	Sur-vived.	No. Map-ped.	Gross In-crease.	Sur-vived.	No. Map-ped.	Gross In-crease.	Sur-vived.	No. Map-ped.	Gross In-crease.	Sur-vived.
May, 1926 ..	4	—	2	—	—	—	—	—	—	1	—	1
Sept., 1927 ..	28	26	25	—	—	—	4	4	3	17	17	13
Dec., 1928 ..	55	30	48	4	4	3	13	10	12	18	5	18
March, 1930 ..	62	14	60	7	4	5	27	15	26	30	12	26
May, 1931 ..	72	12	—	11	6	—	30	4	—	30	4	—

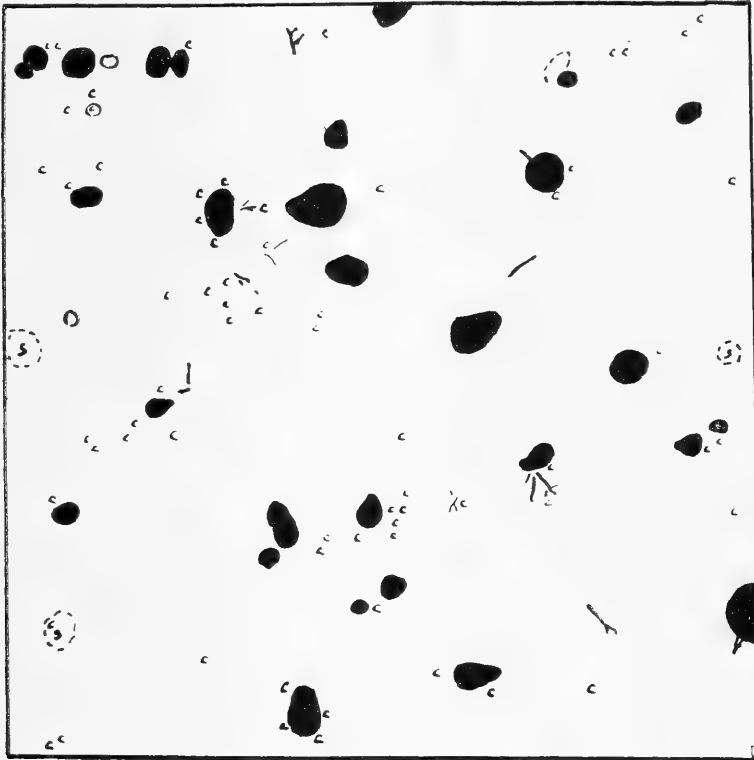
The figures show that the rate of return is slow, particularly when the area is removed from a possible source of wind-blown seed (cf. Nos. 100 and 300). The difficulty that plants have in establishing themselves without a proper seed-bed is clearly brought out by a detailed study of No. 100. The heavy rainfall of December, 1929, scoured the surface of this quadrat, and the increase in the number of saltbushes seen upon it between December, 1928, and February, 1930, is proportionately much less than in the other quadrats.

Quadrat 10 A (Plate xvi, figs. 1-4) was laid out in May, 1926, at the margin of a fairly vigorous saltbush colony. By comparing Text-figures 7 and 8, it is seen that in the five years most of the bushes then established have grown well and increased their cover, but that few new plants have appeared. The bare area along the north (top of Text-figs. 7 and 8) of this quadrat is very striking. There are several square metres of eroded surface here on which no plant of any description has been recorded in any of our quarterly observations throughout the whole five years (cf. foreground, Pl. xvi, figs. 1-4). Our observations on the Reserve show, if further evidence were needed, the fatal results of overstocking to such a degree that the surface soil is eroded.



Text-fig. 4.—Quadrat chart of 100, 24/5/26 (scale 1/1,000), showing the distribution of *Myoporum platycarpum*. Living trees shown in full black, dead trees with broken line and S. E = *Eremophila Sturtii*, P = *Pholidia scoparia*, C = dead but standing bushes of *Cassia Sturtii*, and o = plants of *Atriplex vesicarium*. Fallen timber indicated by lines.

*Atriplex stipitatum* differs somewhat from *A. vesicarium* in its habit and habitat requirements. It is generally a more erect growing plant with smaller, more glossy leaves. It is apparently less palatable to stock on account of its bitter taste.

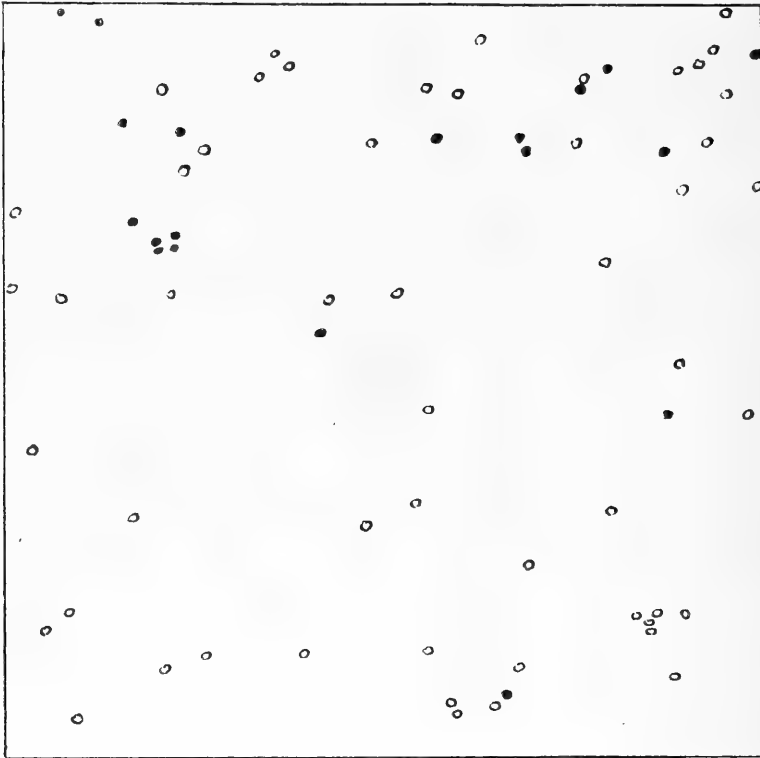


Text-fig. 5.—Quadrat chart of 100, 27/2/30 (scale 1/1,000), showing reduction in extent of canopy of *Myoporum platycarpum* after the 1928-1929 drought. Some trees have died (S and broken line). On the other hand, there has been a considerable germination of *Cassia Sturtii*; the symbol C here shows seedling plants.

Though the two species grow together on the Reserve, *A. stipitatum* is not a constituent of the big open plains, the typical *A. vesicarium* habitat dealt with by us in our previous paper. *A. stipitatum* on the Reserve occurs most abundantly in and around patches of scrub. Its main centre is in the south-east corner, where it is associated with a woodland of *Casuarina lepidophloia*. Its spread in this corner has been rapid, a source of seed being along the northern side of the adjacent paddock.

(ii) *Kochia sedifolia*.—*Kochia sedifolia*, the blue bush, is sometimes called "old man" blue bush because of its size, to distinguish it from the lower growing species, such as *K. planifolia*, which also forms an important element in certain shrub-steppes.

Plants of *K. sedifolia* may exceed 1 metre in height. They form dense rounded or columnar plants with several main stems and densely interlacing lateral branches. The ultimate tips of the finer lateral branches are often pendent. The stems are clothed with numerous short (averaging about 0.5 cm.), clavate, rather fleshy leaves which are covered by a dense tomentum, thus causing the blue-white appearance. The leaves apparently persist for several years, but are shed in times of severe drought when this plant becomes more or less aphyllous.

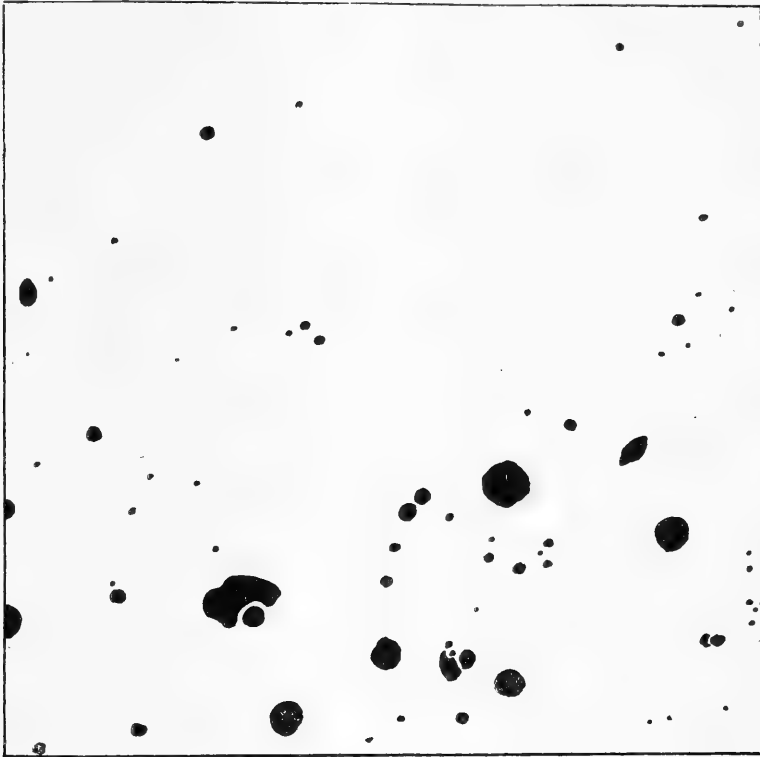


Text-fig. 6.—Quadrat chart of 100, 1/6/31 (scale 1/1,000), showing distribution of *Atriplex* over the area. o = *A. vesicarium*, and full dot = *A. stipitatum*. Only one of these plants, that in the SW. corner, was present on 24/5/26 when the quadrat was set out.

As will be seen from the sketch map (Text-fig. 1), blue bush occurs in patches over the Reserve, notably at the south-east side, near quadrat 40 A (Pl. xvi, figs. 5, 6), across the middle of the Reserve, and on the north-west corner. The soil in all these places is hard loam with much travertine limestone. The plant may be regarded as definitely calcicolous.

At the time of its enclosure, all the *Kochia* plants on the Reserve had been grazed and broken down to mere woody stumps. Clusters of these, holding more or less blown soil occurred in areas mentioned. Text-figure 9, A, shows a dissection of such a clump. It is seen to be a complex system of branches, ascending obliquely in the main, but bearing upright shoots. In 1925 and 1926 such stumps

looked dead, as in fact many of them were. Shortly after enclosure, however, some of them began to shoot and others, apparently dead, did so during the following year. Slowly, the area round 40 A and the plain by the *Heterodendron*



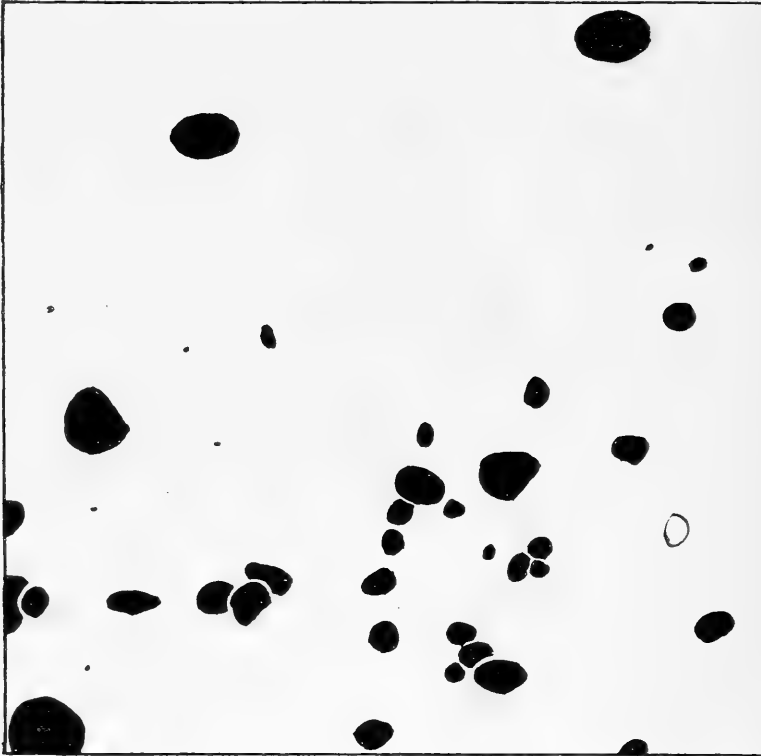
Text-fig. 7.—Quadrat chart of 10A, 24/5/26 (1/100), showing distribution and extent of cover of *Atriplex vesicarium*; cf. Pl. xvi, fig. 1.

clump in the middle of the Reserve became lightly covered with a re-growth of the *Kochia*. After the first season's active growth, further development of the individual plants proceeded slowly, so that at the end of five years few of the bushes exceeded 40 cm. high. They were largely defoliated during the 1929 drought but most of them had recovered by 1931 (Pl. xvi, fig. 6).

An excavation of the root-system of a plant of *Kochia sedifolia* is seen in Text-figure 9 (B, C). The roots are in the main spreading. They extend 5–6 metres from the plant at a depth of 20–30 cm. The individual roots follow a rather tortuous course and become much contorted before they branch. The ultimate branches (which may be of the 5th or 6th order) are slender and are evidently deciduous rootlets such as occur in the case of *A. vesicarium*. Though the root-system is in the main spreading, there is a marked development of secondary roots which descend vertically to a depth of more than 2 metres. These roots taper gradually from a diameter of 2 cm. to less than 1 mm. at their apices. All roots except the feeding groups are covered with an almost black bark.

Frequently a whole branch of the root-system dies back close to the main stock for no apparent reason.

*Kochia sedifolia* flowers and fruits very sparingly and at infrequent intervals. No plant on the Reserve is recorded as having flowered.\* The paucity of seed



Text-fig. 8.—Quadrat chart of 10A, 2/6/31 (scale 1/100), showing distribution and extent of cover of *Atriplex vesicarium*. One dead plant, outline only, is shown; cf. Pl. xvi, fig. 4.

production may account for the rare occurrence of seedlings in our quadrats. Two only have been recorded, both on quadrat No. 400, in August, 1927, and neither survived until the next mapping in December, 1928. We know that one, which fell within quadrat No. 40, was destroyed by caterpillars in August, 1928.

It is evident that when a *K. sedifolia* shrub-steppe has suffered from severe overstocking it can only regenerate from seed with great difficulty. On the other hand, observations that we have made elsewhere in the district show that when vigorous plants are severely grazed and knocked about by sheep for a limited time only they recover well and rapidly, but, so far as our observations go, they do so by shooting from the butts of old plants, and not from seedlings. It appears to us that this is largely due to lack of suitable seed-bed. The hard loam with travertine, in which *K. sedifolia* grows, rapidly loses its surface mulch of

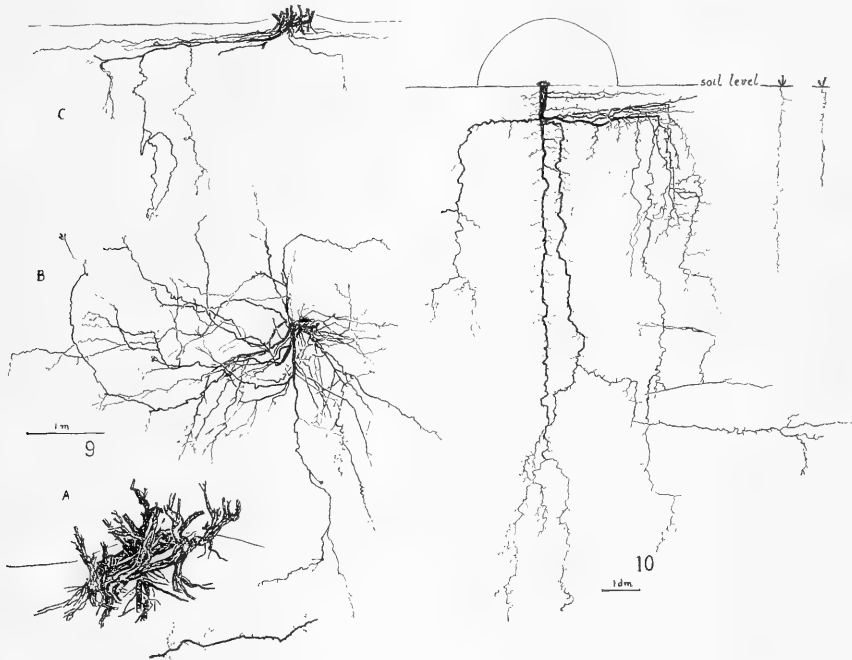
\* This was flowering fairly abundantly outside the eastern fence in August, 1932.



finer soil under the combined influence of trampling and wind. The only seedlings that we have observed were growing on quadrat No. 400 in places in which there had been a local accumulation of silt after rain.

#### D. Other Chenopodiaceous Species.

Four other Chenopodiaceous species which play a subsidiary part in the normal flora have appeared on the hectare quadrats. They are *Kochia Georgii*, *K. tomentosa*, *Rhagodia spinescens* and *R. Gaudichaudiana*. The first three are low-growing much-branched shrubs, the last a more straggling bush. Both species of *Kochia* flower and fruit freely; the fruits have the typical membranous wing. In *Rhagodia* the fruit is a very small red berry (approx. 3 mm. diam.). As noticed



Text-fig. 9.—*Kochia sedifolia*. A. Dissection of base of a large bush showing complex of obliquely ascending stems from which erect aerial branches arise as well as vertically descending roots. These "stumps" have great power of resistance, and all regrowth of *K. sedifolia* on the reserve has taken place from them (Pl. xvi, figs. 5, 6).  $\times 1/50$ . B. Plan of surface root system. C. Section of root system. T.B.P. *ad nat. del.*

Text-fig. 10.—Sectional view of root-system of *Bassia patenticuspis* showing the surface system and the deep descending portion. Root systems of two young plants shown to right. T.B.P. *ad nat. del.*

previously, it is interesting to observe that all the young plants of *R. Gaudichaudiana*, ten in number, have appeared beneath small trees which had served as perching places for birds.

Lastly reference must be made to some of the species of *Bassia*, notably *B. patenticuspis*. This is a low-growing short-lived perennial with weakly woody stems and very numerous cylindrical leaves, 0.5–1 cm. long, grey in colour

because of their dense tomentum. From a very early stage the plant begins to flower. Post-fertilization development of the perianth leads, in this species, to the development of two sharp slender spines near the apex of the indurated perianth tube. These spines, which are from 0.5 to 0.8 cm. in length, make the whole plant intensely prickly. Though the plant rarely grows more than 20 cm. in height, it has a root-system which has been found to penetrate to 140 cm. A drawing of an excavated root-system is given in Text-figure 10. The deep descending main root appears in the very young plant. Later, there is some development of a horizontal system near the surface, but this gives rise to several strong branches which descend vertically almost to the depth of the main root itself.

When the Reserve was enclosed in 1925, *B. patentiuspis* was the most abundant low-growing plant in the loamy soils over the whole area. Quadrat No. 100 was covered with it and the detailed study of a small part of this, quadrat No. 1, enables us to speak with certainty of the length of life and regeneration of this species. The plants recorded in the first charting, May, 1926, were then fully grown. They died back during 1927, shedding most of their branches which formed in places a continuous prickly mat. The heavy rain of February, 1928, caused a germination of seed, but the young plants did not survive the onset of the drought and died before the end of the year. Heavy rain fell in December, 1929, and seedlings were recorded in March, 1930. These plants were still at the seedling stage in June, but by August most of them covered an area that could be charted. By December, 1930, they were full grown and were still vigorous in June, 1931, when the observations recorded were concluded (Pl. xvi, fig. 6, foreground). At that time the loamy soil portions of the Reserve had a heavy covering of *Bassia patentiuspis*, similar to that observed in 1925-1926. Examination of the rainfall data, Table 1, shows that the sequence of rainfalls had been very similar. Germination began in each case after a heavy fall in early summer (381 points Nov., 1925, and 327 points Dec., 1929), and in each case the rainfall during the succeeding winter and spring was reasonably good.

*Bassia patentiuspis* is normally a pioneer plant in the succession leading to shrub-steppe. When the climax communities of *Atriplex vesicarium* or *Kochia sedifolia* are destroyed it can become the dominant ground cover over very large areas. In spite of its spines it is, when young, eaten readily by sheep.

Other important *Bassia* species on the Reserve are *B. obliquicuspis*, *B. uniflora*, *B. sclerolaenioides* (white plants in foreground, Pl. xvi, fig. 6), and *B. paradoxa*.

#### E. Herbaceous Plants.

A general impression of the abundance of the therophytic flora and the sequence in its composition can be obtained by comparing the series of photographs of quadrats 200 and 300 (Pl. xiii, xiv, xv). Detailed information as to the time of appearance and persistence of the various therophytes is best obtained from the two 1 sq. metre quadrats, No. 1 on hard loam and No. 2 on sandy soil (vide Tables 9 and 10). When these were set out, extreme conditions, such as eroded surfaces, areas liable to flooding or shelter of trees, were avoided, but, with these reservations, the areas were selected as the result of a random throw upon the hectare quadrats Nos. 100 and 200 respectively.

It has been our custom to record the annual plants on the quadrats of the tens series also, although on the scale of these quadrats it was impossible to map them accurately. The individual plant records so gained have been helpful,

TABLE 9. *Quadrat 1, 1 sq. metre.*

	1926.			1927.			1928.			1929.			1930.			1931.				
	May.	Sept.	Dec.	Mar.	May.	Aug.	Dec.	Apr.	May.	Aug.	Dec.	Feb.	June.	Sept.	Dec.	Mar.	June.	Aug.	Dec.	Mar.
	Rainfall during preceding three months, in points .. .. .	102	251	231	157	8	119	148	430	67	217	28	0	33	47	97	427	113	127	240
<i>Stipa nitida</i> .. .. .	1	12	13	13	12	12	12	12	10	20	6	1	—	—	—	—	—	—	—	—
<i>Atriplex cananulatum</i> .. .. .	1	1	1	1	1	1	—	—	—	1	1	1	—	—	—	—	—	1	1	1
<i>Bassia patenticuspis</i> .. .. .	25	39	42	22	17	9	7	33	24	8	1	—	—	—	—	25	27	29	26	24
<i>Salsola Kali</i> .. .. .	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1	1	1	1	1
<i>Tetragonia eremaea</i> .. .. .	—	40	12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	—
<i>Zygophyllum ovatum</i> .. .. .	1	6	1	—	—	—	—	13	8	—	—	—	—	—	—	6	1	1	—	—
<i>Erodium botrys</i> .. .. .	—	9	1	—	—	—	—	2	2	2	—	—	—	—	—	—	—	—	—	—
Total number of individuals .. .. .	49	131	69	36	30	22	19	60	44	31	8	2	0	0	0	32	29	41	27	25
Total number of species .. .. .	5	14	5	3	3	3	2	4	4	4	3	2	0	0	0	3	3	4	2	2

The following species, with numbers of individuals in brackets, were recorded in the Aug., 1926, charting only: *Trisetum pumilum* (1), *Schismus calycinus* (1), *Zygophyllum prismatocentrum* (3), *Stenopeltium lineare* (5), *Plagiobothrys plurisepala* (4), *Brachycome pachyptera* (3), *Rutidosis pumilo* (1).

TABLE 10. *Quadrat 2, 1 sq. metre.* (Cf. Plate xvii, references to particular figures in which are given in relevant columns.)

	1926.			1927.			1928.			1929.			1930.			1931.				
	May.	Sept.	Dec.	Mar.	May.	Aug.	Apr.	May.	Aug.	Feb.	June.	Sept.	Dec.	Mar.	June.	Aug.	Dec.	Mar.		
	Fig. 1	Fig. 2	Fig. 3	Fig. 4	Fig. 5	Fig. 6	Fig. 7	Fig. 8	Fig. 9	Fig. 10	Fig. 11	Fig. 12	Fig. 13	Fig. 14	Fig. 15	Fig. 16	Fig. 17	Fig. 18	Fig. 19	
Rainfall during preceding three months, in points	102	251	231	157	8	119	148	430	67	217	28	0	33	47	97	427	113	127	240	124
<i>Schismus calycinus</i> .. .. .	10	13	10	—	16	474	—	—	—	38	9	—	—	—	—	—	—	—	—	—
<i>Stipa nitida</i> .. .. .	—	10	9	9	9	9	9	51	47	69	50	—	—	—	—	—	94	115	18	—
<i>Chenopodium cristatum</i> .. .. .	—	28	8	—	—	—	111	82	98	—	—	—	—	—	—	129	28	43	—	—
<i>Bassia patenticuspis</i> .. .. .	3	8	7	5	4	13	3	3	2	5	2	—	—	—	—	3	3	6	4	3
<i>Salsola Kali</i> .. .. .	1	2	2	2	1	3	—	—	—	—	—	—	—	—	—	3	4	4	4	—
<i>Boerhaavia diffusa</i> .. .. .	—	—	—	—	—	—	14	9	—	—	—	—	—	—	—	13	—	—	—	—
<i>Tetragonia eremaea</i> .. .. .	310	193	—	—	—	—	3	7	4	—	—	—	—	—	—	—	513	532	—	—
<i>Geococcus pusillus</i> .. .. .	48	15	—	—	—	5	—	—	2	2	—	—	—	—	—	—	6	26	—	—
<i>Erodium cicutarium</i> .. .. .	21	13	—	—	—	12	3	2	2	—	—	—	—	—	—	—	8	7	—	—
<i>Erodium cicutarium</i> .. .. .	2	3	—	—	—	—	1	6	4	—	—	—	—	—	—	—	9	11	—	—
<i>Zugophyllum ammophilum</i> .. .. .	1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Euphorbia Drummondii</i> .. .. .	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	4	4	—
<i>Lappula concava</i> .. .. .	—	3	—	—	—	2	—	—	—	10	—	—	—	—	—	—	—	2	—	—
<i>Plagiobothrys plurisepala</i> .. .. .	—	34	—	—	—	74	—	—	—	28	—	—	—	—	—	—	5	14	—	—
<i>Colotis hispidula</i> .. .. .	—	16	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	15	—
<i>Helipterum moschatum</i> .. .. .	—	1	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	70	—
<i>Angianthus pusillus</i> .. .. .	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total number of individuals	396	369	36	16	31	592	12	188	157	265	61	0	0	0	0	147	688	852	26	3
Total number of species	8	21	5	3	5	8	2	9	9	13	3	0	0	0	0	4	11	16	3	1

The following species, with numbers of individuals in brackets, were recorded in Aug., 1926, charting only: *Trisetum pumilum* (1), *Calandrinia rotundifolia* (3), *Stenopetalum lineare* (1), *Crassula colorata* (2), *Isotopsis graminifolia* (5), *Rutidosis pumilo* (9), and *Tocanthus Muelleri* (1) in Aug., 1930.

especially from quadrat No. 30, which is on loamy ground, a part of it being liable to flooding.

The number of individual plants has been found to vary from 0 per sq. metre, during the drought of 1929, to as many as approximately 852, belonging to 16 different genera, on quadrat No. 2 in August, 1930. Of this number some 532 (approx.) were seedlings or young plants of *Tetragonia eremea*, not one of which survived until the following December. It was almost as abundant the following June (Pl. xvii, fig. 8).

Twenty-one species, belonging to 20 genera, was the greatest variety in the flora found growing at any one date upon one sq. metre (quadrat No. 2, August, 1926).

The richness of the ephemeral flora growing at any given time obviously depends upon the rainfall during the preceding few months. The results for quadrats Nos. 1 and 2 for the whole period are set out in Tables 9 and 10. It will be noticed that during the three-monthly periods immediately following the two heavy falls of rain (February, 1928, and late December, 1929) the therophyte response was poor (Pl. xvii, fig. 7). This is due to the rapid rate of run-off and consequent erosion of the surface and removal of the seeds.\* The peak numbers of individuals have always been found following a winter rainfall of 250 points and upwards, distributed over the months April to August.

There is a distinct change in the facies of the flora, depending upon the season at which the rain falls. The following plants are characteristically summer growing, but some of them evidently require a certain amount of flooding before they will germinate. They are marked F in the following list, these records being obtained from quadrat No. 30.

- Stipa nitida* (especially on sandy soil).
- Chenopodium cristatum* (especially on sandy soil).
- Bassia patenticuspis*.
- Salsola Kali* (especially on sandy soil), Pl. xiv, fig. 3; Pl. xv, fig. 7.
- Boerhaavia diffusa* (especially on sandy soil).
- Tribulus terrestris* (F).
- Zygophyllum iodocarpum* (F).
- Z. ovatum*.
- Z. prismatothecum* (F).
- Lotus australis* (F).
- Convolvulus erubescens* (F).
- Heliotropium europaeum* (F).

But, with the exceptions noted in the previous list, the majority of the ephemerals are plants of winter growth. The following plants have always appeared with a wealth of seedlings after winter rains:

- Plagiobothrys plurisepala*.
- Helipterum moschatum*.
- Bassia sclerolaenioides*.
- Tetragonia eremea*.
- Erodium cygnorum*.

*Cyanthus speciosus*, the brilliant scarlet and black flowered Sturt's desert pea, on the other hand, has been found blooming in spectacular profusion on flooded ground after both summer and winter rains.

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\* It seems significant that the chief herbaceous plants following these two heavy rains either had spinescent fruits (i.e., *Stipa*, *Bassia*, *Erodium*) or mucilaginous seeds (*Zygophyllum*), Pl. xvi, fig. 2, the low dark plant.

## 8. LICHENS.

Lichens play an important part in the ground flora of hard loam surfaces, i.e., the soil type upon which the shrub-steppe develops. They are crustaceous species which live at or just below the surface of the soil. The most obvious is an undetermined species of *Acarospora*\* which forms white patches 8 cm. or more in diameter. The thalli swell after rain and, becoming somewhat puffed up above the level of the soil, have a superficial resemblance to fragments of travertine limestone. Three other species are chiefly conspicuous because of their apothecia, the thalli being usually hidden in the dust of the ground. One of these, *Lecidia decipiens* Ach., has clusters of pinkish apothecia with white margins. It is widespread and very obvious after rain. The other two are *Dermatocarpon hepaticum* Th. Fr., and *Biatorina caeruleo-nigrum*; both are general, but not so conspicuous as the two preceding.

Most exposed surfaces of travertine limestone have the saxicolous species *Rinodina diffractella* Mull. Arg. growing upon them.

Two species of foliaceous lichen occur on the ground. They are *Parmelia australiensis* Cromb. and *P. adhaerens* Cromb. Neither develops rhizinae or is attached to the soil, but the thallus, when moist, lies flat upon the surface of the wet soil though quite free from it. When the wet period is over the thallus dries up and, curling inwards, forms a loose mat-like mass. The dried plants of *P. australiensis* may be 2 inches or more in diameter. They are rolled about on the ground by the wind or caught in projecting twigs. This lichen is widely distributed, but it became definitely more abundant inside the Reserve under protection than it was in the adjacent paddocks. The second species forms much smaller plants and is less frequent.

Corticolous lichens are generally rare on Australian trees but lignicolous lichens are not uncommon. We have four species of the latter from Koonamore, all growing on the dead decorticated stems of shrubs, generally *Cassia* bushes.

*Parmelia caperata* Arch. is the most common, covering the stems over lengths of 2 inches or more. Less abundant, but forming even larger patches when it does occur, is the golden-yellow *Candelaria concolor* Wain. *Theloschistes chrysophthalmus* Th. Fr. and an undetermined species of *Calopacea*, the latter with a partially submerged thallus, are the two other species.

## 9. FACTORS AFFECTING REGENERATION.

After regular observations upon the regeneration of the flora of the Reserve extending over five years it is possible to arrive at certain conclusions as to the factors which affect the regeneration rate.

The change in the soil condition which has followed erosion due to the removal of the perennial vegetation has destroyed the seed-bed over a large part of the area. The hard loamy soil, having lost its surface mulch, offers particularly great difficulties to the establishment of any seedlings. Anything favouring the accumulation of litter or blown soil helps to develop a seed-bed. The abundance of seedlings and their much more thrifty growth in and amongst fallen bushes or even the mounds of soil held by stumps and dead plants are very marked. We have drawn attention to this in our work on *Stipa* (1931), and reference may be made to some of the quadrats figured there (e.g., Text-figs. 3 and 5).

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\* We are indebted to the Royal Botanic Gardens, Kew, for naming the lichens which were forwarded at the suggestion of the Director, after his visit to Koonamore in December, 1927.

Obviously high temperatures, strong winds and low rainfall are climatic factors that have harmful effect upon the growth of plants, especially on herbaceous plants or seedlings of perennials. What is less to be expected in arid Australia is the effect of low temperatures and heavy rainfall, yet both are experienced, as is shown by the climatic data that we have given. The effect of frosts in checking the growth, especially of the herbage during the winter months, has frequently been noted by us.

On three occasions during the progress of our work has there been a rainfall of 3 inches or more within 24 hours. In 1928 and 1929 these falls were more than half of the total precipitation for the whole year. Such heavy falls cause destruction of the seed-bed. The surface soil is removed over large areas and deposited as sand or silt upon others. The heavy rainfall of December, 1929, was definitely harmful to the regeneration of *Atriplex* on quadrat No. 100, for the hard loam was scoured severely by the violence of the rain. On the other hand, areas receiving a considerable deposit of silt are also unsuitable for the growth of plants. There are extensive areas in the south-west corner of the Reserve, which have been flooded regularly after heavy rainfalls, but upon which no germination has occurred.

The most aggressively harmful factor to the regeneration of woody plants has certainly been the rabbit. Of the 42 seedlings of both species of *Cassia* recorded in February, 1930, on quadrat No. 6-80, only two, both *Cassia eremophila*, survived until June, 1931. Quadrat No. 200 suffered severely from rabbit damage, for a burrow was established in the sand-hill near its north-western corner. Only 10 of the 48 *Cassia eremophila* seedlings recorded upon it in February, 1930, survived till June, 1931. These had all been eaten back and were still showing their juvenile foliage on short secondary shoots growing from the crown of the roots. *Cassia* seedlings of similar age on quadrat No. 300 were at that time bushes from 60 to 70 cm. high and some were coming into flower. The majority

TABLE 11.  
*Fire Regeneration Experiments.*

Burns made 28/8/27. Areas first charted after rains of Feb., 1928.

N.B.—All seedlings occurred at margins of burns or, occasionally, on burnt areas. None recorded within enclosures away from the fire influence.

No. of Experiment.	Fenced.		22/6/28.	14/12/28.	9/6/29.	20/3/31.
F.R.2	Yes.	<i>Ac. aneura</i> .. .. .	3	4	4	4
		<i>Ac. Burkittii</i> .. .. .	1	2	4	3
		<i>C. eremophila</i> .. .. .	2	2	2	3
F.R.4	Yes.	<i>Ac. aneura</i> .. .. .	16	16	18 <sup>1</sup>	1
		<i>Ac. Burkittii</i> .. .. .	2	2	1	—
		<i>C. eremophila</i> .. .. .	10	12	13	10
		<i>C. Sturtii</i> .. .. .	2	3	2	3
F.R.6	Yes.	<i>Ac. Burkittii</i> .. .. .	1	1	1	1
		<i>C. eremophila</i> .. .. .	8	6	5	5
		<i>C. Sturtii</i> .. .. .	6	11	12	11
F.R.7	No.	<i>Ac. aneura</i> .. .. .	4	2	—	—
F.R.8	No.	<i>C. eremophila</i> .. .. .	4	2	1	—
		<i>C. Sturtii</i> .. .. .	11	13	1	—

<sup>1</sup> On the night 4-5 July, 1929, a rabbit burrowed under the netting and ate all the mulgas.

of the *C. Sturtii* seedlings on quadrat No. 100, recorded in February, 1930, were growing as sturdy young plants in June, 1931.

Table 11 gives the history of five of the experimental burns started to stimulate germination of mulga and other shrubs. It is seen that only when the area was protected by netting was there any survival of the young shrubs for one season. The amount of damage that a single rabbit can cause is seen from the records of quadrat No. F.R.4. There 18 one-year-old mulgas were destroyed in a single night. Until some means of controlling the rabbit is discovered, all hope of regeneration of woody perennials is vain.

#### SUMMARY.

1. The investigations described in this paper were conducted at the Koonamore Vegetation Reserve in the north-eastern district of South Australia during the period May, 1926, to June, 1931. The Reserve is the Arid Flora Research Station of the University of Adelaide. The work herein described was aided by a grant from the Commonwealth Council for Scientific and Industrial Research from March, 1928, to June, 1931.

2. The Reserve is shortly described and its soils discussed.

3. The following meteorological data are given for the area: mean rainfall; monthly rainfall, number of rainy days and falls exceeding 25 points, 1925-31; temperature records, and relative humidities March, 1927, to June, 1931, and saturation deficits.

4. The methods of investigation are described, particularly a series of permanent quadrats.

5. Some account of the biology of the plants is given.

6. Results as to the distribution and regeneration of the principal trees and shrubs, also the dominants of the Chenopodiaceous shrub-steppe, are described.

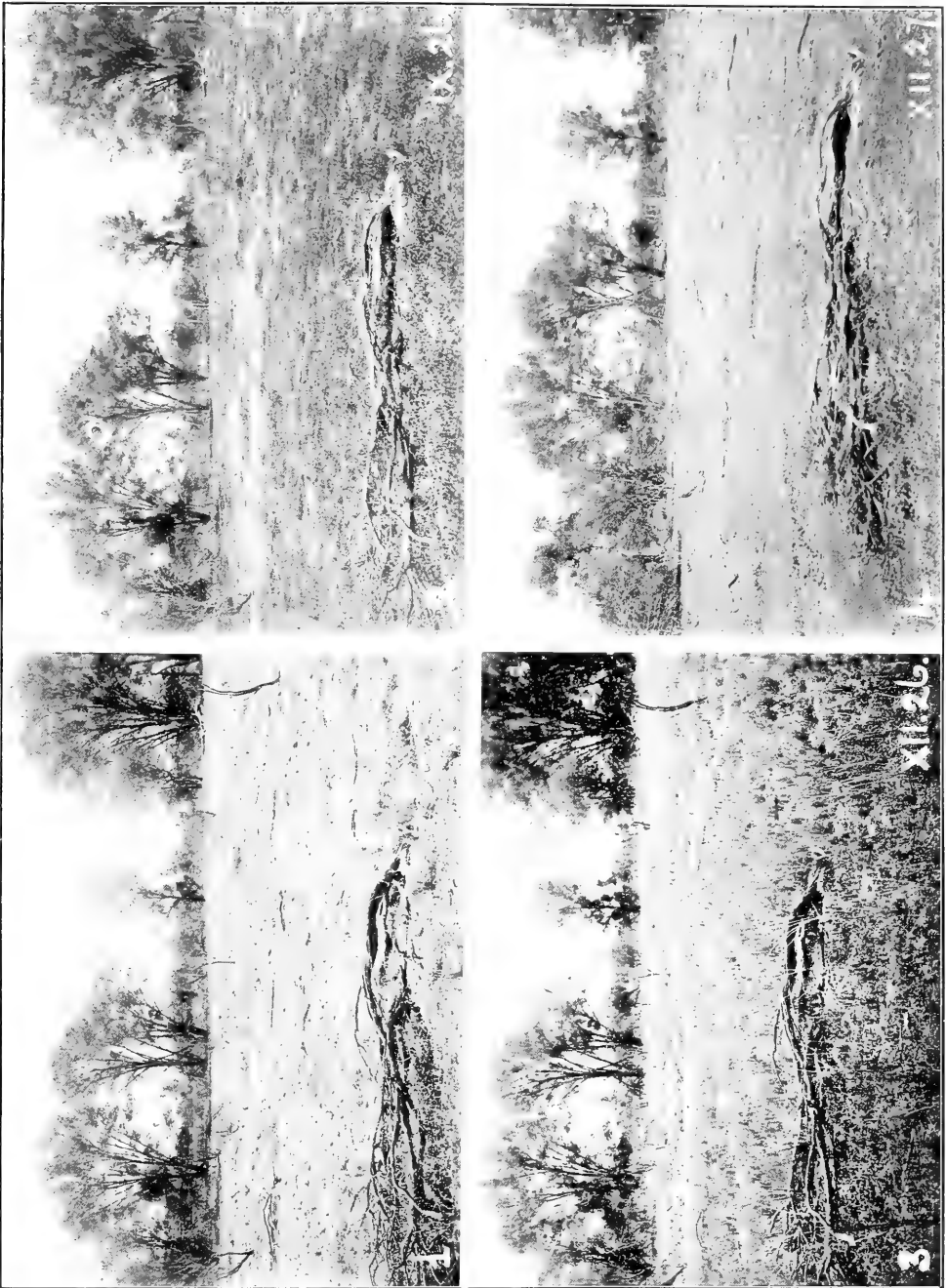
7. The sequence and abundance of the herbaceous plants is described, with special reference to two 1 sq. m. permanent quadrats.

8. Regeneration of the perennial flora is found to be a slow process, the rate of which is much influenced by the recurring droughts. Rabbits are found to prevent almost completely the regrowth of woody perennials.

#### References.

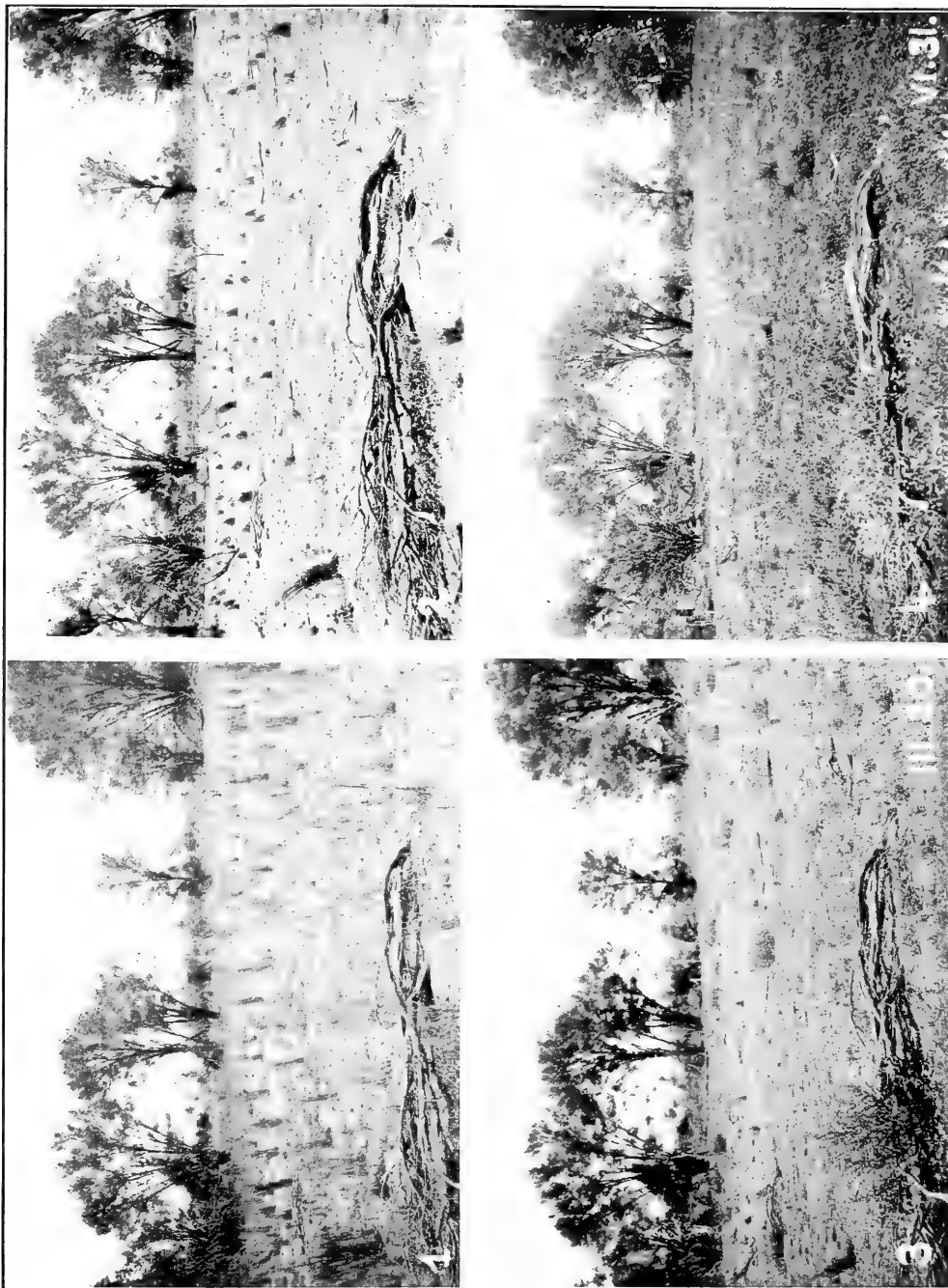
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Keonamore Vegetation Reserve. Quadrat 200.





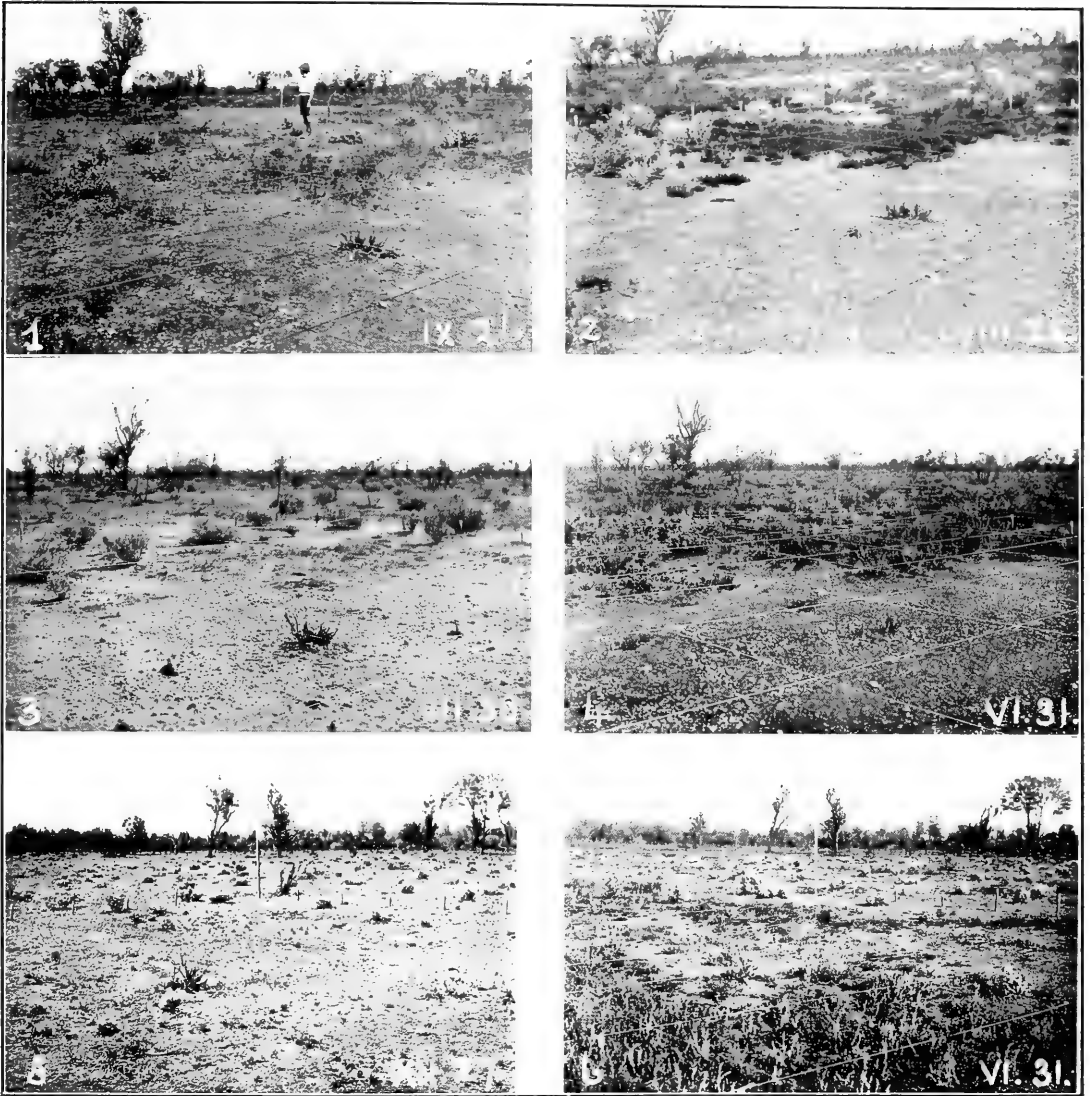
Koonamore Vegetation Reserve. Quadrat 200.





Koonamore Vegetation Reserve. Quadrat 300.

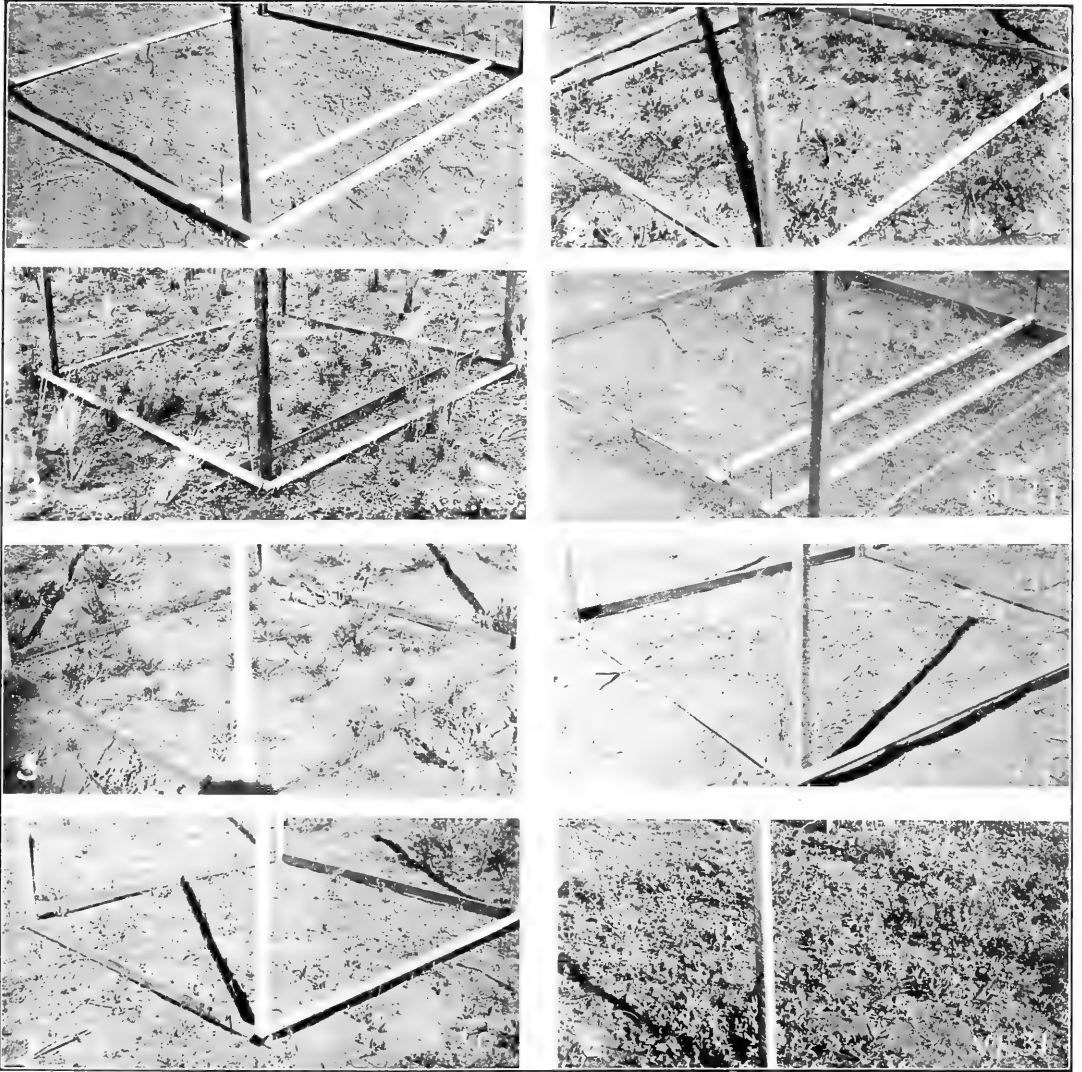




Koonamore Vegetation Reserve. Quadrats 10A (1-4) and 40A (5-6).







Koonamore Vegetation Reserve. Quadrat 2.



## DESCRIPTION OF PLATES XIII-XVII.

## Plate xiii.

Series of photographs, from fixed point, of quadrat 200. *Acacia aneura* (mulga) with light sandy soil in foreground. Corner posts of quadrat 2 seen in middle distance about the centre of the picture.

1.—May, 1926. Few plants of *Stipa nitida* in foreground. At this date the ephemerals only in seedling stage.

2.—Sept., 1926. Fair winter rains led to growth of ephemerals, *Helipterum moschatum* abundant.

3.—Dec., 1926. *Stipa nitida* just dying off, the winter annuals have disappeared.

4.—Dec., 1927. Drought conditions; only 409 points of rain in the previous twelve months.

## Plate xiv.

Series of photographs of quadrat 200, continued.

1.—March, 1929. The heavy rainfall of Feb., 1928 (390 points), followed by a wet winter, produced a heavy crop of *Stipa nitida*. This is shown dying off; only 15 points of rain in previous six months.

2.—Dec., 1929. At the end of fifteen months' drought. Note the evidence of wind erosion; cf. Pl. xv, fig. 6.

3.—March, 1930. Three months after a heavy rainfall (311 points in one day at end of previous December). *Salsola Kali* obvious.

4.—June, 1931. Heavy growth of winter annuals, cf. rainfall for previous 18 months, largely *Tetragonia*, *Helipterum*, and *Bassia* spp.

## Plate xv.

Series of photographs, from fixed point, of quadrat 300; quadrat 30 in middle distance to left. The large tree at centre back is *Myoporum platycarpum*.

1.—May, 1926. Shows general retrograde state of area soon after enclosure. The dead bushes are chiefly *Cassia Sturtii* and *Eremophila Sturtii*.

2.—Sept., 1926. General cover of winter annuals, *Zygophyllum ovatum* and *Z. prismatothecum* (dark plants) and *Atriplex campanulatum* (light plants) in foreground. *Bassia patenticuspis* and *Erodiophyllum Elderi* by figures in distance.

3.—Dec., 1926. Note disappearance of annuals except *Atriplex*, now dying off, and prominence of *Stipa nitida*.

4.—Dec., 1927. At end of a year's drought.

5.—Aug., 1928. *Stipa nitida* in foreground. Middle distance had been flooded by rains of previous February. Now dense growth of *Zygophyllum* spp., *Erodiophyllum Elderi*, *Erodium cymnorum*. Perennials of the shrub-steppe began to appear about this date.

6.—Dec., 1929. Drought conditions during previous fifteen months. Tussocks of dead *Stipa nitida*.

7.—Aug., 1930. Much *Salsola Kali* following rain of late Dec., 1929.

8.—June, 1931. Dense growth of winter annuals with a considerable admixture of *Bassia* spp. *B. paradoxa* in right foreground (white plant).

## Plate xvi.

Series of photographs of quadrats 10A (1-4) and 40A (5-6).

1.—Sept., 1926. Note persistence of bare area from which seed-bed has been eroded in foreground.

2.—Aug., 1928. Note increase in size of *Atriplex vesicarium* both on the quadrat and in distance. The dark plants are *Zygophyllum*.

3.—Mar., 1930. Note the persistence of the drought effect, although there had been heavy rain three months previously. Such heavy rain falling on hard dry soil does not penetrate. Note the *Atriplex* bushes which are still more or less aphyllous; they are just passing out of the anabiotic state.

4.—June, 1931. *Atriplex* in full foliage on quadrat and over plain beyond. Note increase in number of bushes by comparing this figure with fig. 1.

5.—Dec., 1927. Quadrat 40A at end of a drought period. Low bushes of *Kochia sedifolia* beyond.

6.—June, 1931. Shows regeneration of *Kochia sedifolia* bushes. *Bassia patenticuspis* and *B. sclerolaenioides* (white) in foreground.

## Plate xvii.

Series of photographs of quadrat 2, taken on dates shown on figures 1-3. References, with detail of flora, on Table 10.

STUDIES IN THE AUSTRALIAN ACACIAS. V.

THE PROBLEMS OF THE STATUS AND DISTRIBUTION OF ACACIA BAILEYANA F.V.M.

By I. V. NEWMAN, M.Sc., Ph.D., F.L.S., Linnean Macleay Fellow of the Society  
in Botany.

(From the Botanical Laboratories, University of Sydney.)

(Plate xviii; three Text-figures.)

(With a NOTE ON THE OCCURRENCE OF HYBRID ACACIAS, by E. CHEEL, Botanist and  
Curator of the National Herbarium, N.S.W.)

[Read 27th November, 1935.]

*Introduction.*

The "Cootamundra Wattle" (*Acacia Baileyana* F.v.M.) has always created interest on account of the smallness of the area from which its natural occurrence has been reported. Because it grows and propagates well in cultivation, and has been successfully distributed in this and other continents for ornamental use, the problem arises, why its natural distribution is so restricted. A search shows that there are no really precise records of its natural occurrence, and that there were no specimens from a natural habitat in the National Herbarium, Sydney. In the hope that a quick result would be obtained, two excursions were made to the district concerned (in the south-east quarter of New South Wales) to study the distribution of the species and its relation to the habitat. Precise records of its occurrence for certain localities are set forth in this paper for the first time. The problems raised by the restricted nature of its distribution have been found to be so complex that they can only be stated, at present, without attempting to offer a final solution.

Three facts have caused doubt of the status of the species and have called forth the suggestion that it is a hybrid which arose in cultivation and then escaped. These facts are: (1). The first specimens received for description were from a tree in cultivation at Brisbane, Queensland (Mueller, 1888*a*, 169); (2). It is not unusual for seedlings from trees in cultivation to show some marked variations from the normal;\* (3). There were no clearly marked early specimens from the natural habitat.

These problems of the distribution and status (including mode of origin) of the species are closely linked. Their solution would be an important contribution to our knowledge of what constitutes a species and of the factors

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\* In no case, however, have such seedlings been derived from seed set under conditions that excluded foreign pollen. Therefore it is possible that they are the  $F_1$  generation of crosses between *Baileyana* and some other species of *Acacia*. Mr. E. Cheel, Botanist and Curator of the National Herbarium, N.S.W., has kindly added a note on "The Occurrence of Hybrid Acacias". From this note it will be seen how easily *A. Baileyana* appears to hybridize.

determining the establishment and limitation of species. From the investigations so far made about this species, it appears that a long and wide inquiry would be needed before finality could be reached. The spread of settlement in the country has made these inquiries difficult, and is rapidly making them more difficult. For this reason, and to provide a basis for further work, this paper will present the available knowledge germane to these problems of *Acacia Baileyana*, a clear statement of the problems and an indication of the lines along which they may be solved.

#### PREVIOUS RECORDS.

##### *The Original Description.*

In his paper, von Mueller (1888a) gives a very detailed and accurate description (in English) separating the new species from *A. polybotrya*. The description is apparently based on three lots of material received in Melbourne. By the courtesy of the Government Botanist of Victoria and the Government Botanist of New South Wales, I was able to inspect seven specimens of *Acacia Baileyana* sent on loan from the National Herbarium, Melbourne, to the National Herbarium, Sydney. These and three others are all the specimens of this species in the National Herbarium, Melbourne. Presumably, they would include the type specimens, as von Mueller was the Government Botanist of Victoria. In comparing the statements in the paper with the labels on the specimens, difficulty arises, as there are no reference numbers in the paper or on the specimens. All the sheets examined, except one, have the label of the "Phytologic Museum of Melbourne", which bears at the foot, "Baron Ferd. von Mueller, P.H. & M.D."

Of the first lot of material von Mueller says: "The species is named in honour of Mr. F. M. Bailey, from whom flowering branchlets were received, taken at Brisbane from a tree in Bowen's Park, the origin of which could not with certainty be traced." Of the two specimens from Bailey, the label of the first, in von Mueller's handwriting, is: "Acacia Baileyana, F.v.M. Cultiv. in Bowen's Park. F. M. Bailey." There is no date, and the specimen is a flowering one. The label of the second specimen, in von Mueller's handwriting, is: "Acacia Baileyana F.v.M. Cultiv. in Bowen's Park, Brisbane. F. M. Bailey." There is no date, and the specimen is a very poor and broken one with some loose pieces of leaf and inflorescence preserved in an attached folder. Accompanying the specimen is a note in red pencil in Bailey's handwriting on a sheet of rough paper, as follows: "This is a form (?) of *A. polybotrya* which came up amongst seeds collected by me many years ago on or near Seaview Range back 60 miles from Cardwell the tree never seeded at Bowen Park and is since dead. F.M.B." Cardwell is a small town near Townsville, Queensland. Mr. C. T. White, Government Botanist of Queensland, in a letter dated 29th July, 1935, informs me that the seeds referred to were "mostly without names, and were supposed [italics mine] to have come from the neighbourhood of Cardwell"; and that "evidently a mistake had been made as the species [i.e., *A. Baileyana*] was quite unsuitable for growing in the tropics", and there is no such specimen from North Queensland. Cardwell, therefore, does not concern us.

Of the second lot of material von Mueller says: "Somewhat later, fruiting specimens were sent by the Rev. Dr. Woolls, who got them from Mr. H. D. Coker of Brookfield, through Mr. John Dawson of Humberstone; he found this rare species only near Cootamundra on one of the sources of the Murrumbidgee and near To-morrow on a Tributary of the Lachlan River on stony ridges up to an elevation of about 1,600 feet." "To-morrow" is doubtless Temora. *The Sydney*

*Mail* (1888) gives "Humberstone" as the name of Mr. Dawson's property in a suburb of Sydney. An old resident of the locality tells me that the property was at the corner of Parramatta Road and Lang Street, in what is now North Croydon. There are three specimens in the Herbarium that are possibly referred to in the above quotation. The first is a small specimen in bud, labelled: "Acacia Baileyi, F.v.M. Murrumbidgee. Mr. Coker. Dec., 1887." The second is a fruiting specimen and there is no official label; but a small slip of paper has at the top, in Dr. Woolls's handwriting: "A. polybotrya.", and below, in von Mueller's handwriting: "Dec. 1887. Revd. Dr. Woolls. Acacia Baileyana F.v.M." The third specimen is "Seed from J. Dawson per Rev. W. Woolls—1887" (letter from the Government Botanist of Victoria, 3rd July, 1935). These specimens are not easily correlated with von Mueller's statement; but they are not inconsistent with it, for in December the trees would show both ripe fruits and young buds.

Of the third lot of material, von Mueller says: "Quite recently *A. Baileyana* has been found also near Wagga Wagga by Messrs. Garland and Deane." There is one specimen in the Herbarium referable to this statement, labelled: "Acacia Baileyi, F.v.M. Bet. Murrumbidgee and Lachlan R. J. R. Garland. 1887." It is a very small broken specimen of foliage only.

The only other important specimen in the Herbarium is an unnamed, broken flowering one labelled: "Near the Parramatta River. Dr. Woolls. 1887."

The other specimens in the Herbarium are four from cultivation: at Sydney, N.S.W., and East Kew, Vic. (1899), and Oakleigh, Vic.—two—(1891).

Von Mueller's paper, read on 12th December, 1887, was based partly on material derived from seed of doubtful origin sown at Brisbane, Queensland, about 500 miles from the supposed natural home. About that time he had a specimen from near the Parramatta River,\* N.S.W., 260 miles from the supposed natural home; and four years later the species was cultivated some 300 miles in the opposite direction from the supposed natural home. Until June of the present year, the only specimens of the species in the National Herbarium, Sydney, were from cultivation. These facts have caused doubt of the species being a naturally occurring one. This question will be discussed after reference to later records and the statement of my own observations.

#### *Later Records*

There are three contemporary records which regard the species as occurring naturally in the Cootamundra District. Woolls (1888) says, "This is a species from the Murrumbidgee, which has hitherto gone under the name of *A. Polybotrya*. . . . Mr. Dawson, of Humberstone, has cultivated this shrub with much success." In the *Sydney Mail* (1888) it is recorded that the species was called the "Cootamundra Wattle" from the fact that "Mr. Dawson, of Humberstone, Burwood, distributed very liberally seeds of this beautiful species, which had been procured for him in the neighbourhood of Cootamundra". It is also stated that the figure in von Mueller's "Iconography" (Mueller, 1888*b*) was drawn from specimens from Mr. Dawson's garden. Maiden (1911, p. 9), after quoting extensively from von Mueller's paper, quotes a newspaper article written by himself "shortly" after it, in which he says that Mr. John Dawson

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\* Mr. Dawson's property was only about 300 yards from some mud-flats of the Parramatta River.

"brought seeds from Cootamundra and distributed them among his friends", and that *Acacia Baileyana* is "naturally found only . . . about Cootamundra, Bethungra, Big Mimosa Run, in the Wagga District and thereabout".

Later records of localities are, in general, repetitions of those given in von Mueller's paper, with variations. Such are Moore and Betche (1893, p. 171), Maiden (1906, p. 66, and 1911, pp. 9-10) and Anderson (1932, p. 37). The localities are: Cootamundra, Bethungra, Temora, Barmedman, Wagga District, "Big Mimosa Run, Wagga District", and "Parish of Inglebah, County Bourke (Temora)". Judging from the history of the locality recorded by Cramp (1923, p. 342), "Big Mimosa Run, Wagga district" would be in the angle (and its extension westward) between Pucawan, Temora and Mimosa (see Text-fig. 1), and would include the Parish of Inglebah (Ingalba). Today, it would not be described as "Wagga district". I can find no signs or report of the species occurring naturally at present in what would commonly be understood as "Wagga district".

Summerhayes (1933) lists many references to the species in botanical and horticultural literature. Those available to me do not add to our knowledge of the species, but some of them contain errors whose origin will be apparent on reading the present paper. The species is not about Wagga Wagga, and neither Wagga Wagga nor Cootamundra is at a source of the Murrumbidgee (Summerhayes, 1933); and it is not native of Queensland (Luxford—and the Editors—, 1916, and Comber, 1929).

There are two records of personal observation. Cambage (1902) made a journey through the district, and specifically mentioned the *Acacias* observed. Though passing through Barmedman and Temora, he only notes *Acacia Baileyana* between Stockinbingal and Cootamundra and on the main Temora-Cootamundra road a few miles to the west (p. 198), also between Cootamundra and Junee (observed from the train, p. 202). From the inquiries, he concluded that a circle of radius about 30 miles centred between Cootamundra and Temora "would have included every tree of Cootamundra Wattle in the known world" before its cultivation (p. 198).

Bishop Dwyer (1921, p. 218) records *A. Baileyana* near Temora on "Ironbark Ridges". He describes these ridges as frequently having "ironstone and quartzite pebbles" mixed in the clayey or shaley soils, with the red Ironbark tree (*Eucalyptus sideroxylon*) "usually very predominant" (p. 212).

Absence of specimens in the National Herbarium at Sydney or at the School of Botany, University of Sydney, makes verification of the records difficult.\* Both Cambage and Dwyer, who record visits to the locality, do not mention Barmedman as a location for the species. And I regard references to the "Wagga district" as referring to localities which to-day would not be so described.

#### *Summary of the Previous Records.*

We expect, therefore, to find *Acacia Baileyana* in the neighbourhood of Cootamundra (particularly north-west), Bethungra and Temora (particularly south-west) and possibly Barmedman, growing on stony (ironstone and quartzite) ridges associated with the red Ironbark (*Eucalyptus sideroxylon*). In a previous

\* The Keeper of Botany, British Museum (Natural History) and the Deputy Keeper of the Herbarium, Royal Botanic Gardens, Kew, inform me by letters (dated 19th and 17th July, 1935) that there are no wild specimens represented in the Herbaria at South Kensington and Kew respectively.

paper (Newman, 1933, pp. 147-148), I showed that these localities lie in an area of coincidence of Silurian sedimentary rocks (associated with patches of granites and porphyries), an altitude of between 500 and 1,500 ft., and an average annual rainfall of between about 18 and 23 inches. The only other such coincidence in New South Wales is a much smaller area just to the north.

#### RECENT OBSERVATIONS.

##### *Locations.*

During October, 1934, and May, 1935, I made a search, the extent of which is shown in Text-figure 1. No sign of the species growing naturally was seen in the possible parts of the routes outside the area shown in the map, i.e., from Bathurst through Blayney to Cowra, and through Tuena to Crookwell and Goulburn; from Goulburn through Gunning to Rugby (by back roads) and Boorowa; and from Bookham to Gunning. No sign of it was observed on the route from Cowra through Marsden, Corringale and Barmedman to Temora, nor from Boorowa through Murringo and Monteagle to the Bribaree Hills and back into Wallendbeen. Residents in the localities said the species does not grow naturally in the Murringo district nor along a cross-country route travelled weekly between Thuddungra and Temora. I could not confirm a report of it for two miles south of the road on Black Range between Boorowa and Murringo. In the south of the area, the species could not be located by observation or inquiry south of a line joining Mimosa and Mitta Mitta and east of a line joining Wallendbeen and Adelong Crossing. In the central part of the area, the species was found in various situations among the localities marked A, B, C, D, E, and HJK, on Text-figure 1.

The area within which *Acacia Baileyana* was found, enclosed in a rectangle in Text-figure 1, is shown in greater detail in Text-figure 2. In the short accounts of each locality, the numbers refer to the specimen numbers in my *Acacia* Herbarium. Duplicates of Nos. 301, 304, 305, 306 and 321 are in the National Herbarium, Sydney, and the Herbarium of the School of Botany, University of Sydney.

*Locality A.*—The species was seen for about two and one-half miles of route, in very hilly country on the eastern side of the divide, rising from a little over 400 metres to nearly 600 metres. The trees were mostly in the depressions, and extended into the cleared land. Specimen No. 305 was taken at the northern end of this locality from the "Fairfield" Station of Mr. Lindsay Thompson. Specimen No. 306 was taken from the tree shown at the left of Plate xviii, fig. 1, on the property of Mr. Bush, at the southern end of the locality. According to Mr. Bush, these magnificent trees extend for only about a quarter of a mile down the creek, whose course is not steep. The bed rock is porphyroid. These trees are growing in virgin timber, about 50 yards from the edge of the clearing in which were many seedlings, saplings and dead trees.

*Locality B.*—This is shown in Plate xviii, figs. 3 and 4, and is on the property of Mr. Cecil Ward of Moatefield. The altitude is about 600 metres and the bed rock is granitic. This place is a shallow valley running northerly from the divide to the top of the steep descent to the lowlands. In the partly cleared area shown in Plate xviii, fig. 4, there were a very few small seedlings of the species that had been nibbled by stock, and many trees of which all were dead. None of these trees showed signs of having been cut or ring-barked. Figure 3 on the same plate shows what must have been an exceedingly fine tree, surrounded by







Ward said the species grows in such situations for at least two miles south along the range.

*Locality C.*—The species was seen for nearly two miles as the route ran gently down from the divide, passing through the 350 metres altitude level. Some was in uncleared land. Specimen No. 304 was taken from a large tree, 30 feet high, one of a number left in a belt of trees between the road and the fields, near the junction of the Silurian and Cainozoic sedimentary rocks.

*Locality D.*—The species was seen for two stretches of about 0.6 and 0.4 miles of route just to the north-east of the crests of Warrim Hill and the divide, at and below 400 metres altitude. The soil was Silurian slate accompanied by quartzite gravel. The red Ironbark tree (*Eucalyptus sideroxylon*) was plentiful. Specimen 301 was taken from the tree shown well to the front in the left half of Plate xviii, fig. 2 (on Warrim Hill). On the Puawan-Coolamon road, about three or four miles north-west from this place, a resident said that the district was "the home of these wattles", for they are always coming up in the fields after ploughing, and profusely in the forests after the big timber is cut down. There were numerous trees of the species growing along that part of the road, which ran north-south between the divide and a low ridge to the west.

*Locality E.*—The species was seen for about three-quarters of a mile of route at about 400 metres altitude along the western side of a shallow valley running northerly. On the property of Mr. Sleeman, at the southern end of the locality, there were a number of trees growing in the cleared valley, which Mr. Sleeman said were not escapes from cultivation. He also said that the species grows in similar depressions for several miles in either direction along the range. According to Pittman (1914), this locality is on Silurian sedimentary rocks.

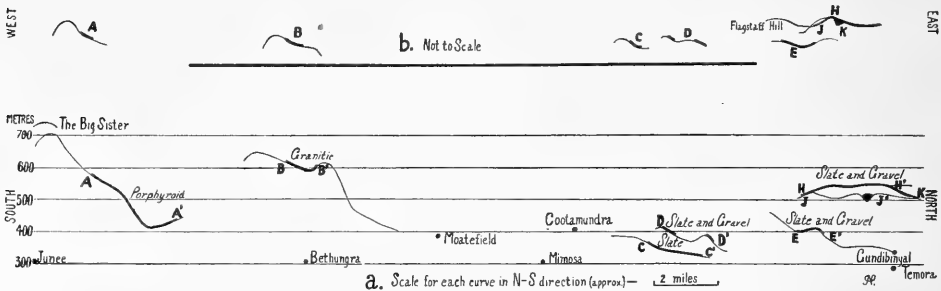
*Locality HJK.*—This is the locality where the species appeared to be most plentiful. Parts of it are known as "Wattle Valley" to the people of Cootamundra, who use it as one of the sights to show visitors in the season. The profusion of trees here is probably due to the area being in a proclaimed reserve for some years past. It is in the district of Berthong and is from 500 to 550 metres in altitude, the geological formation being Silurian slate with quartzite gravel. The red Ironbark trees are plentiful. The species was seen along the route HH', a distance of nearly three miles, either in a south facing shallow valley or on the eastern slopes of the divide. At J, in a shallow valley facing south-east, ten specimens, No. 207, were taken from the trees shown in Plate xviii, fig. 5 (looking west). At J', several steep-sided, shallow, gently sloping gullies facing west were full of the species. Plate xviii, figs. 6 and 7 are from photographs taken in one of these gullies. Figure 6 shows the trees in profusion among the Ironbarks. Figure 7 shows a fallen one of the many dead trees among the living ones, without sign of having been cut or ring-barked. These gullies, though facing west, are sheltered by Flagstaff Hill, and have protection by the good stand of big timber. Specimen No. 321 was taken from this situation. At K, which was not visited, the field-glasses showed a splendid growth of the trees.

Reports were received of the existence, a few years ago, of the species near the Cootamundra-Temora and Cootamundra-Dirnaseer roads on or about the divide west of Cootamundra. An examination failed to reveal any at this time. A report I could not confirm was for the divide west of Temora where the Temora-Puawan road crosses it. These localities are marked F? and G?, respectively, in the maps (Text-figs. 1 and 2).

Of the localities recorded here (see Text-fig. 2), J and HH' or F? would probably correspond with von Mueller's (1888*a*, p. 170) "near Cootamundra on one of the sources of the Murrumbidgee" (J' and K are on a tributary of the Lachlan); CC' and DD' would probably correspond with his "near To-morrow on a tributary of the Lachlan River" and also with Maiden's (1906, p. 66) "Found also on Big Mimosa run, Wagga district, also Parish of Inglebah"; I was directed to CC' by Bishop Dwyer (cf. Dwyer, 1921, p. 218); F? would correspond with Cambage's (1902, p. 198) "parts of the main coach road from Cootamundra to Temora". The localities AA', BB' and EE' are probably additional to the previous records. It is interesting to note that, apart from the large towns and the more settled area between Sydney, Bathurst and Goulburn, it is only within 20 or 30 miles of the line joining Cootamundra and Temora that the species is found frequently in cultivation or with signs of former habitation; as though, being common in the area, it was cleared out except around the dwelling when settlement took place.

*Habitat Factors.*

*Physiographical.*—Text-figure 3 (with which cf. Text-fig. 2) contains two diagrams to show the relative altitudes and aspects of the localities where the species was found. It will have been noticed already that the localities are all in proximity to some part of the system of more or less pronounced ranges which are a feature of the district. Text-figure 3 will emphasize the fact that these localities are not only near the crest of the divide, or (in the case of AA') of a prominent spur of it, but are in general in an aspect sheltered from the west and south by the high ground of the range. In some of the localities, AA', BB', EE', JJ', and K there is a tendency to keep to the depressions. These facts point to some factor tending to restrict the occurrence of the species to certain physiographic conditions, for the specifying of which there is not yet enough evidence. If the species were escaped from cultivation, I would not expect to find this local restriction of occurrence.



Text-figure 3.—Diagram to show the relative altitudes of the localities of *Acacia Baileyana* and nearby towns, etc. This should be studied in close comparison with Text-fig. 2.

a. Looking west.—Only the parts of the route immediately adjacent to the localities are shown. The north-south spacing of the localities, etc., is approximate only. The curves are rough projections on the north-south line of the parts of routes along which the species was observed, the heavy lines showing the actual part where it was seen.

b. Looking north.—Diagram not to scale, complementary to a, to complete the demonstration of the aspects of the various localities. The curves are not, of course, in the correct east-west sequence.

Another interesting feature is that the species occurs towards the high ground of the regions concerned. This is not mere repetition, but emphasizes the fact that at the eastern side of the area shown in Text-figure 2 there is plenty of country at the same altitude as localities CC' and DD', and possessing similar aspects; and that, in spite of this, the species was not observed by me or reported to me in situations other than those already described. The species may therefore be tending to keep to the high ground, subject to certain conditions of aspect, etc., the high ground in the west being of a lower altitude than the high ground in the east. The two localities of greatest altitude are on igneous rocks, namely, AA' and BB'. If the sedimentary rocks have been denuded from these localities it is possible that the species is fighting a rearguard action in the silty depressions containing conditions as nearly similar as possible to those of the sedimentary formation before the physiographic changes took place. It seems possible, therefore, that *Acacia Baileyana* is a relict of a species which may have flourished widely before physiographic changes initiated a losing battle between it and the environment. The possibility of it being a relict species was suggested by Cambage (1902, p. 198). The existence of such relicts following on physiographic or climatic change is not unknown elsewhere, as, for example, the basalt flora of Mt. Wilson (Brough, McLuckie and Petrie, 1924), and plants referred to in a recent discussion on the origin of the British Flora (Royal Society, 1935, p. 570).

*Edaphic.*—The study of the soil conditions associated with a species in the field would be very lengthy, if done in detail. A few rough observations were made in case they should indicate some factor operating. As the samples were taken at a depth of about three inches, they would provide information only concerning conditions governing the establishment of seedlings. Ten samples were taken from among the different situations (except EE', HH' and K). The range of pH was from 5.4 to 5.7, except for the porphyroid locality AA' (6.6 and 5.8). This range is in general more acid than for the soils of four other localities in or towards the region concerned. The water capacity of the soil as it occurred without sorting, showed no extremes in the measurements made on the samples from where the species occurred; but the other four samples gave extremes in one or other of the measurements made. There is the suggestion of the restriction of the species to a band of soil conditions governing seedling growth, the determination of which would entail extensive soil analyses.

*Biotic.*—The continuation of the species in its natural home, if this region is its natural home, is in danger from the biotic factors of its environment. Sheep and cattle (and probably rabbits) eat the seedlings, and property owners seem to have an objection to it, for so many spoke of cutting it out. In addition, the trees seem to be short lived, due either to a normally short life-period or to some natural enemy such as borer. These factors, combined with bush-fires and fluctuations in stocking, would provide ample explanation of its disappearance and reappearance from time to time in various situations.

In considering the influence of the rest of the vegetation on the local distribution of the species, it must be remembered that the present day forests of that region are not necessarily of the same composition or profile as the forests were before settlement occurred. For instance, in the area westerly from Temora, much of the uncleared land to-day is covered with forests of red Ironbarks (*Eucalyptus sideroxylon*) and "pines" (*Callitris* spp.), etc., so dense that long vistas cannot be obtained. Plate xviii, fig. 2 shows a not very dense forest of

that area. According to Cramp (1923, pp. 345-6), this forest covered much of the country when the late Mr. William Fisher "selected" at Mimosa West in 1883. Steele (1931, p. 3) records that Mimosa run (later divided into Mimosa East and Mimosa West) was originally leased to McCansh and Windeyer in 1857. Gow (1925, pp. 5-6) says that before the coming of settlement to the district near Ardlethan (bordering the map in Text-fig. 2 on the west) there was a tall forest of Eucalyptus and "pines" in which long views could be obtained; and that with the clearing of the tall forest a dense growth of seedlings took place. It is probable that the specimens sent to von Mueller from this district were from regeneration forests. In support of this is his statement that the height of the species is not more than 15 feet, whereas many trees up to 30 feet high can be seen.

#### Variations.

Doubt of the specific status of the species has been due not only to absence of clearly located specimens from the reputed natural home, but also to the experience of apparent variability of some of the characters. Seedlings markedly different in leaf-form and colour from the more typical *Baileyana* seedlings frequently appear in cultivation. The impossibility of the hybrid origin of these marked variations has not yet been demonstrated. Illustrating less marked variations, Cheel has exhibited (1930, p. xv) leaves from 24 trees of *Acacia Baileyana* which show a variation in the number of pairs of pinnae, and in the presence or absence of hairs on the young branches. By the courtesy of Mr. Cheel, I was able to make a slight statistical examination of the numbers of pairs of pinnae in some of the trees he mentioned, growing on his property at Hill Top.

Two series of samples were taken from each tree: Series A, from the end of a branch to one foot or the first junction, if near one foot; Series B, from the first junction to the second junction or for one foot. The samples were taken low, shoulder level and high. The scores from the three samples were added together and are shown in the following table:

Tree Number.	Number of leaves in Samples A having						Number of leaves in Samples B having					
	2	3	4	5	6	6+	2	3	4	5	6	6+
	pairs of pinnae.						pairs of pinnae.					
22 .. ..		6	60					7	33	1		
23 .. ..	2	13	25	12			6	29	17			
24 .. ..	5	27	42				4	40	19			
25 .. ..		8	36	24				29	56			
27 .. ..	1	55	32	2			4	50	21	1		
28 .. ..			17	11	22	6			5	24	10	4

On trees Nos. 23, 24 and 28, in passing from the end of the branch, the maximum score changes to a smaller number of pairs of pinnae. On trees Nos. 22, 25 and 27, where the maximum remains on the same number of pairs of pinnae, the score for the smaller number of pairs becomes proportionately greater on passing down the branch. These figures suggest that variations in the number of pairs of pinnae may be due not to genetical factors so much as to variations in vigour at different periods of growth.

In the places where the species was found growing in what I interpret as the natural habitat, except for being with or without hairs on the young branches and varying in the number of pairs of pinnae within the above limits, the species presented a reasonably uniform appearance. There was never a suggestion of a hybrid swarm with or without close association of two possible parent species.

#### DISCUSSION.

The first problem that presents itself is whether what is known as *Acacia Baileyana* is a naturally occurring species, or whether it arose suddenly in cultivation, as either a hybrid or a mutant, and then escaped from cultivation. The second alternative raises the problem of why the escape from cultivation in the early days should have taken place with vigour in one small district only, and in the parts of that district remote from the denser settlement, and why it should have retreated to a relatively specialized habitat.

The argument for the origin in cultivation is largely based on the presence of specimens from cultivation at Brisbane in the material on which the original description was based. But by 1880 there was a tree of the "Cootamundra Wattle" in cultivation in the garden of Mr. Joseph Hadfield, "Stanmore", Stanmore Road, Christchurch, New Zealand. Maiden, in the newspaper article contemporary with von Mueller's paper, said (Maiden, 1911, p. 9): "it has been largely cultivated (chiefly in Burwood gardens) for years". If the species could be in cultivation in New Zealand by 1880, there is no reason why it should not have been taken to Brisbane by "many years ago" before 1887. The dates of the first settlement of the Cootamundra and Temora districts and the country to the south of them give ample time for these wide dispersals in cultivation. There was settlement at Wagga Wagga in 1832 (Gormly, 1909, p. 7), Cootamundra in 1843 (Gormly, ?, pp. 147-8), "Warri" run, near Ardlethan in 1849 or 1850 (Gow, 1925, p. 8), Junee about 1845 (Gormly, 1915, p. 77), "Temora" run in 1851 (Steele, 1931, p. 3), and "Mimosa" run (west of Temora) in 1857 (loc. cit.). Settlement had so increased that Post Offices were established at Albury and Gundagai in 1843 and Wagga Wagga and Tumut in 1849 (Dalgarno, 1908, pp. 158-9). In view of the evidence of very early settlement and communication, it is quite probable that such a striking tree as the "Cootamundra Wattle" should be spread rapidly as an ornamental tree; so that the great distances of its reported early cultivation from the reputed natural home are no real bar to it being a naturally occurring species.

The question of the natural or cultivated origin of the species could be answered with a full knowledge of its earliest distribution in nature and cultivation. It may be noted, however, that three records (quoted above) published in Sydney soon after the description of the species, regard it as being brought into cultivation from its natural habitat in the region concerned. In any case there would still be the problems of the mode of origin of the species and the reasons for its present restricted distribution in the field. If it arose in cultivation, it is either a hybrid or a mutant. If it be of natural origin, whatever be the mode of origin, it is either an old species living in a restricted habitat or it is a new species that did not spread far before the coming of settlement restricted its powers of spreading.

Whether the species arose in cultivation or in nature, the practical approach to the solution of the problems will be the same. The question of it being a hybrid would require analytical breeding and synthetical crossing experiments, supported

by cytological examination of the species and the possible parents. Cytological examination would also be necessary in the study of the possibility of the origin by mutation, and might be combined with experimental manipulation of possible originating species with a view to inducing similar mutations. Whether it be a relict species or a new species in nature, the geology and physiography of the district are fundamental for solving the problem of its origin, and, with the study of the edaphic, climatic and biotic factors are fundamental for solving the problem of its restricted distribution.

These complex problems require specialist knowledge and methods in several branches of study. With increasing settlement of the area concerned, investigation will be still more difficult than it is to-day. In view of these considerations, the foregoing account of past and present information on the subject, and the statement of the problems have been made to serve as a foundation on which any may build who becomes possessed of relevant information.

From the evidence before me, historical, ecological, etc., I believe *Acacia Baileyana* to be a species occurring naturally in a restricted habitat at localities within about twenty miles of Cootamundra and Temora. The chief contribution of this paper to the solution of the problems is the presentation of detailed records of the species in its natural habitat.

#### SUMMARY.

A record is required now of our present knowledge of, and a statement is needed of the associated problems of, the restricted distribution, specific status and mode of origin of *Acacia Baileyana*; for increasing settlement will make field investigations more and more difficult.

The probable type specimens in the National Herbarium, Melbourne, are correlated with von Mueller's paper describing the species, and are found to be unsatisfying as evidence for the natural occurrence of the species.

One set of later records seems merely to repeat the vague statements of locality given by von Mueller. Another set of records speaks more definitely (from personal observation) of two of the localities mentioned by von Mueller. Absence of Herbarium specimens makes verification difficult.

An account is given of a search, and its results, made by the writer in the region concerned. This account gives detailed references to the localities where the species appeared to be growing naturally, and refers to Herbarium specimens presented by him to the National Herbarium, Sydney, and the School of Botany, University of Sydney. A brief reference is made to certain kinds of environmental factor. A general similarity of aspect (sheltered from the south-west) and altitude relationship (towards the highest ground) is shown in the physiography. The species is possibly a relict. Estimation of pH and of water capacity suggest a band of edaphic conditions governing seedling establishment. Biotic factors are at present against the species; it appears short lived, and there may be considerable fluctuations in its occurrence. The vegetation's composition and profile have changed since the coming of settlement.

It is shown that some of the variations in number of pairs of pinnae observed in the species may be due to fluctuations of vigour. No field observations suggested hybridity.

The various alternatives to *Acacia Baileyana* being a naturally occurring species are put forward and their implications referred to. Historical search shows that there was ample time and opportunity for the species to have been taken



into cultivation and carried far afield before von Mueller described it in 1887. The mode of origin of the species and its features of restricted natural distribution are closely linked. The methods of attack upon these problems are indicated.

The evidence supports the validity of *Acacia Baileyana* as a species occurring naturally in a very restricted area.

#### Acknowledgements.

I have pleasure in expressing my thanks to many who have helped me by giving information and advice and providing facilities for the work. Mr. Colin Armstrong and Rev. W. C. Francis of Cootamundra guided, and Bishop J. W. Dwyer of Wagga Wagga directed, me to localities where the species was found. The Government Botanist of Victoria forwarded, for me to inspect, the specimens in the National Herbarium, Melbourne. Mr. E. Cheel, Botanist and Curator of the National Herbarium of New South Wales, has generously helped me with discussion on several occasions, and with permission to examine trees on his private property. Dr. G. D. Osborne, of the Geology Department, University of Sydney, has advised me on the geological references in this paper. Dr. P. Brough, of the Botany Department, has given helpful criticism. To Professor T. G. B. Osborn I am indebted for his advice and the provision of the facilities of this Department. Many residents of the district concerned courteously answered my inquiries and gave me directions.

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\* These are in the Mitchell Library, Sydney; and I would express my thanks to the Public Librarian for permission to inspect them.

† In the table of contents of Part ii of Vol. 24, the title of Article xvii, which is this paper, is "Description of some Papuan Plants". The title given here is at the head of Article xvii, but appears nowhere in the table of contents.

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## EXPLANATION OF PLATE XVIII.

Photographs illustrating the Habitat of *Acacia Baileyana* (cf. Text-fig. 2).

Fig. 1.—Locality A'. Trees in virgin forest, along the course of a slow creek, at the foot of the Big Sister Mt. Looking southerly.

Fig. 2.—On Warrim Hill, Locality D. In a regenerating forest of red Ironbark and "Pine" (*Callitris*). Note the white quartzite gravel. Looking northerly. The nearest tree is 25 yards from the camera.

Figs. 3, 4.—Near Moatefield, locality B, looking southerly. 3 shows a large dead tree of *Acacia Baileyana* which had split. The figure is standing on the fallen half. There are about eight younger dead trees encircling it, probably seedlings of it. 4 shows the locality as a shallow valley just below the top of the divide. The small dead bushy tree in the centre of the picture is an *Acacia Baileyana*. There are many dead trees of the species in the area, not showing in the picture (cf. Fig. 4).

Fig. 5.—Near Berthong, Locality J. The bushy trees in the middle distance are *Acacia Baileyana* in a shallow valley running south-east. Looking west. This land is partly cleared.

Figs. 6, 7.—Near Berthong, Locality J'. In a gully running west, showing *Acacia Baileyana* among red Ironbarks, in a regeneration forest. Note the fallen dead one at the left of Fig. 7. Looking south-easterly.

These photographs were taken in May, 1935, the trees being in bud. The whiteness of their appearance is due to the extremely glaucous foliage.



Habitat of *Acacia Baileyana*.



## THE OCCURRENCE OF HYBRID ACACIAS.

(By EDWIN CHEEL, Botanist and Curator of the National Herbarium,  
New South Wales.)

It has been suggested by several writers that *Acacia Baileyana* F.v.M., commonly known as "Cootamundra Wattle", produces various forms of seedlings in the seed-pan from seed gathered from a single tree. Some of the most noteworthy of these are as follows:

Dr. Cuthbert Hall (1910) "exhibited a hybrid seedling from seed gathered from a cultivated specimen of *Acacia Baileyana*. It had been found that this *Acacia* when growing near *Acacia decurrens* gave about 20% of hybrids, which differed materially from either parent . . .".

Mr. A. F. Brown (1919), of Dalton Nursery, Dubbo, "succeeded in growing a wattle which is a cross between *Acacia decurrens* and *Acacia Baileyana*, or between what is commonly known as the black wattle and the Cootamundra wattle. The tree has bloomed since July 15th, and the bloom is likely to remain on the tree for some time yet. One particular virtue of this crossbred variety is its frost-resisting quality. The brilliance of the flower has been much admired."

J. H. Maiden (1919), commenting on the "Crossbreeding in Wattles", "In regard to the crossbreeding in wattles, an instance of which was reported yesterday from Dubbo, inclined to the opinion that the Dubbo cross between the black and Cootamundra wattles was performed by nature, and not by the hand of man." Maiden also stated, "The natural crossing of these two species has been observed for very many years, and pointed out that nearly 30 years previously the late Rev. Dr. Woolls, who first collected *Acacia Baileyana* in the garden of the late Mr. John Dalton, Solicitor, of Burwood, and who persistently told the late Baron von Mueller that it was undescribed, informed him (Maiden) that the Baron had hesitated to describe it because of the known intermediate forms of natural crosses, and this has been the experience of most people who have studied the subject."

Maiden also referred to the supposed cross between *Acacia Baileyana* and *Acacia decurrens* series brought under notice by Mr. H. L. White, of Belltrees, Scone, which were submitted to me for report in December, 1912. In furnishing my report to the late Mr. Maiden, I gave details of the structural characters of the supposed parents (*Acacia dealbata* and *Acacia Baileyana*), together with a description of the supposed hybrid. My original report on these three forms is in the official files of the National Herbarium of New South Wales (vide 7934/12), and copies are also deposited with the original suite of specimens contained in the herbarium. A description of the supposed hybrid was also forwarded to Mr. H. H. B. Bradley, Secretary of the Horticultural Society of New South Wales, and specimens were exhibited at the Monthly Meeting held on 13th May, 1913, which were labelled "Acacia H. L. White". An account of this new hybrid was also published in *Gardeners' Chronicle*, 4th October, 1913, p. 236, and further elaborated in the same journal, 1914, p. 262, with photographic illustrations of

the hybrid and supposed parents. At the July (1923) meeting of the Linnean Society of New South Wales, I exhibited a series of specimens of different stages of development of the  $F_1$ ,  $F_2$  and  $F_3$  races of the supposed hybrid, which I had cultivated at Hill Top, on the Southern Line, 79 miles from Sydney. Specimens were also exhibited at the same meeting of a supposed hybrid collected by Mr. L. O. Gallard, at Carlingford and Epping, which, it was suggested, were very similar to *Acacia Nabonnandi*, which was probably the same as *Acacia adenophora* Sprengel (1826) collected by Sieber in Port Jackson district in 1822.

It is of interest to note that Pescott (1914) has referred to the variability of the "Cootamundra Wattle", as will be seen from the following remarks: "Above all Acacias, *A. Baileyana* is noted for the variability of its seedlings, and it may be that this peculiar 'hybrid' is merely the result of the usual seed variation known among horticulturists as 'sporting'. It is hardly possible to plant a 'batch' of seed of *A. Baileyana* and find every resultant plant true to type. I have seen growing in Victoria a tree named by the grower *A. decurrens* var. *normalis*, who explained that this plant came up among some *A. Baileyana* seed. The tree was not *A. decurrens* var. *normalis* at all, but merely one of the 'rogues' that frequently come from *A. Baileyana* seed, and to call these 'hybrids' would be a great mistake. They are reversions, break aways, or sports." Pescott (1917) has also described a var. *aurea* of *Baileyana*, the young foliage of which is of a golden colour.

It has also been found by H. Ludwig Winter of Bordighera, Italy, that hybrids can be produced by pollinating two species of Acacias.

*Acacia Bon accueil* Richon (1927) is said to be a chance hybrid perhaps between *Acacia decurrens* and *A. dealbata*. It is reported that this is "one of the most beautiful acacias grown on the Riviera. The flower clusters have up to 40 heads, larger than the best varieties of *Acacia dealbata*. They are beautifully grouped at the ends of the branches. The leaves are bright green with long very fine leaflets. The tree is vigorous and about 20 feet high, but a little less hardy than *Acacia dealbata*."

*Acacia Hanburyana*, *Gardeners' Chronicle* (1927).—This is said to be a seedling discovered by Mr. Joseph Benbow when he was in charge of the La Mortola Gardens, Ventimiglia, Italy, growing in close proximity to bushes of *Acacia Baileyana* and *Acacia podalyriaefolia*, and there seems to be no doubt but that *Acacia Hanburyana* is the result of a natural cross between these two species. It makes a tree fully twenty feet high. The silvery phyllodes bear short leaflets similar to those of *Acacia Baileyana*, and the round clusters of bright canary-yellow flowers are borne on pendulous spikes.

*Acacia Neufvillei* and *Acacia Siebertiana* (1924) are supposed to be hybrids (probably chance hybrids) between *Acacia pycnantha* and *A. podalyriaefolia*.

The three distinctive forms of what is known as the *Acacia decurrens* series, collected by Mr. L. O. Gallard in the neighbourhood of North Rocks Road to Parramatta, Pennant Parade, Carlingford and Epping, together with the evidence furnished in connection with these forms growing in close proximity to *Acacia Baileyana* cultivated in gardens, seems to me to suggest that there is a possibility of *Acacia Baileyana* being pollinated with *Acacia decurrens*. Both species flower at the same time, and in the areas mentioned we find numerous plants of the form which agrees with the description given of *Acacia adenophora* Sprengel which was collected by Sieber, which, as I have already stated, agrees in every particular

with the illustration of the supposed hybrid *Acacia Nabonnandi* of Nash. We have also received seedlings raised from seed of *Acacia Baileyana* from the Campbelltown State Nursery, which agree in every particular with what I regard to be *Acacia adenophora* Sprengel.

*Acacia adenophora* Sprengel.—This species was originally described by Sprengel in 1826, from specimens collected in the Port Jackson district by Sieber, who made collections of Australian plants in the vicinity of Port Jackson to the Blue Mountains and Southern Tablelands during his visit in June, 1822, to January, 1823.

It is evident from Sprengel's Latin description, translated into English by Don (1832), that Sieber's specimens were regarded as being quite distinct from *Acacia decurrens* Willd. The latter is described as having leaves with 9–11 pairs of pinnae, each pinna bearing 30–40 pairs of narrow, linear, distant leaflets, with a gland on the rachis between each pair of pinnae, whereas the leaves of *Acacia adenophora* are described as having only 8 pairs of pinnae, each pinna bearing many pairs of linear, bluntish, glabrous leaflets. Sieber also collected specimens of *Acacia decurrens* and *Acacia irrorata* in the Port Jackson district, which he evidently regarded as being distinct, for we find that Sieber is quoted as the author of *A. irrorata* by Sprengel. Bentham (1864) regarded *Acacia adenophora* of Sprengel as a synonym of *Acacia decurrens* var. *normalis*, and *Acacia irrorata* of Sieber as a synonym of *Acacia dealbata* Link. There is a superficial resemblance between the two species *Acacia decurrens* of Willdenow and *Acacia adenophora* of Sieber, but, if a close examination is made, it will be found that the seedling stages of the two species present quite a different appearance, as the pinnae of the former are more widespread than the latter and the leaflets longer and narrower. It is interesting to note that Sieber described another species from the Port Jackson district, namely, *Acacia sulcipes*, which is included as a synonym under *Acacia angulata* Desv. by DeCandolle. Bentham lists all three species as synonyms under *Acacia decurrens* Willdenow var. *normalis*. When it is noted that Bentham also includes *Acacia irrorata* of Sieber as a synonym under *Acacia dealbata* and at the same time records the same plant as a variety of *Acacia decurrens* under the name var. *pauciglandulosa* F.v.M., it will be seen that there is room for doubt as to the classification of the various forms or so-called varieties of *Acacia decurrens*.

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# NOTE ON THE PERMIAN SEQUENCE IN THE WERRIE BASIN.

WITH DESCRIPTION OF NEW SPECIES OF FOSSIL PLANTS.

By S. WARREN CAREY, M.Sc.

(Four Text-figures.)

[Read 27th November, 1935.]

## *Introduction.\**

The following observations were made by the writer, chiefly in the year 1932, in the course of the structural mapping of the Werrie Basin. The main problems of the investigation were the geological structure and the Carboniferous stratigraphy. The infolded Permian rocks were examined incidentally to that work, but as they were not the prime subject of enquiry the present discussion of them is not so exhaustive as it might otherwise be.

Little work has hitherto been published concerning the Permian strata of the Werris Creek district. Carne (1913) recorded the occurrence of *Glossopteris*-bearing sandstones, which had been discovered by Mr. Hammond of Escott Park. Carne suggested that they might be correlated with the Greta horizon. These were later examined by Benson, who (1920, p. 306) tentatively referred them to the Upper Coal Measures. This suggestion has been proved to be correct by the present writer. Benson (l.c., p. 301) also described the Werrie Basalts, but regarded them as Carboniferous. He did not recognize the Lower Coal Measures, but grouped them with the tuffs and conglomerates of the Kuttung Series. Later, coal was discovered at Currabubula by Mr. Eugene McCarthy, and was briefly reported by Raggatt who, following Benson, regarded it as Carboniferous. In 1931 McCarthy discovered plant fossils which were identified as Permian by the present writer, thus also establishing the age of the Werrie Basalts.

The general distribution and structural relations of the Permian strata in the Werrie Basin have already been recorded (Carey, 1934). Reference will be made in this paper to the maps and sections accompanying that article.

The writer wishes to express his thanks to Professor W. R. Browne, for his constant advice and encouragement, and to Dr. Walkom, for helpful discussion of the plant fossils. He has also enjoyed the company and assistance of Mr. McCarthy of Currabubula on many of his fossil-collecting expeditions. The author is also grateful to Mr. H. Thomas for placing at his disposal records of the prospecting bores put down by him at Werris Creek. Many residents of the region, who have been referred to in the earlier paper, have assisted in the work by their liberal hospitality, and in connection with the Permian work one has particularly to thank Mr. and Mrs. McCarthy of Currabubula, Mr. and Mrs. Middleton of "Dunolly", Werris Creek, and Mr. and Mrs. W. R. Bridge and family of "Willawa", Quipolly Creek.

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\* The work on which this paper is based was done while the author was holding the Deas-Thomson Scholarship in Geology and a Science Research Scholarship of the University of Sydney.

*The Lower Coal Measures.*

The Lower Coal Measures overlie the Kuttung Series with apparent conformity, and underlie the Werrie Basalts. They are well developed along the eastern and southern side of the Werrie Basin, and around the Quipolly and Castle Mountain Domes. They wedge out rapidly in the north-west, and are overlapped by the Werrie Basalts. As the result of the overlap the series does not outcrop in the Pialloway sector. A line from the Gap to Currabubula roughly defines the limit of their extension to the north-west.

The rocks are very conglomeratic on the whole, but interbedded with the conglomerates are tuffs, sandstones, shales, and coal-seams. Nearly all the strata are somewhat tuffaceous. The facies becomes notably coarser eastwards. The thickness of the series may be up to 500 feet.

*Economic Importance.*—Evidence of the presence of coal in these beds is not lacking. Three shafts at Currabubula revealed a seam between ten and fifteen feet thick, heavily cindered by invading sills of keratophyre from the Warrigundi complex. A bore on portion 68, Parish of Werrie, a couple of chains north-west of the outcrop of the series, bottomed in coal at 80 feet; another water bore in portion 32 Werrie bottomed at a depth of 213 feet in a seam of coal alleged to be 20 feet thick. Still another bore 100 feet deep, near the boundary of the Lower Coal Measures at the northern end of the Jacob-and-Joseph Basin, also struck coal. Furthermore, in portion 20 in the Parish of Werrie, a weathered coal-seam at least  $2\frac{1}{2}$  feet thick outcrops in the cliff face; the unperished coal-seam is probably considerably thicker. This seam is intruded by a sill. In portions 136 and 205 in the Parish of Quirindi, in a tributary gully to Rocky Gully, weathered coal-seams and carbonaceous shales outcrop at the surface. Similar exposures are found in portion 185, Quirindi.

Thus there can be no doubt concerning the existence of coal-seams in the series. The quality of the coal can at present only be inferred from our knowledge of the same series elsewhere. The possible influence of the Warrigundi intrusives is, however, important. It is evident that in the northern part of the area what coal there is is destroyed by these intrusions. However, in the preliminary discussion of the Warrigundi rocks (Carey, 1934) it has been shown that the sills and dykes have a definite range beyond which they rarely, if ever, go. These ranges are seven and six miles respectively measured from the Warrigundi centre. The hybrid sheets extend southwards for much greater distances, but they are always confined to the Werrie Basalts, and so are quite innocuous. Thus beyond a zone of about seven miles from Warrigundi centre there need be little fear of trouble from this source. Occasional members of the older dyke series may be met, but these are never very abundant. The Jacob-and-Joseph Basin, the southern nose of Quipolly Dome, and the basin at the southern limit of the area mapped may be considered free from extensive igneous invasion. Parts of Quipolly Dome show much minor dislocation, and the Quirindi Dome is closely followed by the overthrusts, so the most promising area for commercial operations is the extensive Jacob-and-Joseph Basin, which shows no disadvantages in the way of volcanic intrusions or faults, and is easy of access.

*Fossil Flora.*—The discovery of the *Gangamopteris-Noeggerathopsis* flora in this district, by Mr. McCarthy, has resulted in a considerable extension of our known Lower Coal Measures, and has led to the dating of the Warrigundi vulcanism and the Werrie Basalt extrusions. The fossils have been found by the present writer at many localities along the outcrop of the series. The following types have been

collected: *Noeggerathiopsis Hislopi*, *Gangamopteris cyclopteroides*, *Gangamopteris* sp.  $\alpha$  (? n. sp.), *Gangamopteris* sp.  $\beta$ , *Glossopteris* cf. *Browniana*, *Palaeovittaria McCarthyi*, n. sp., *Neocalamites* (?), *Cornucarpus striatus*, n. sp., *Cordaicarpus emarginatus*, n. sp.

The seeds collected by the writer have been described by Walkom (1935). The description of the silicified wood given below is the work of Mr. R. N. Robertson, B.Sc., Science Research Scholar in Botany in the University of Sydney.

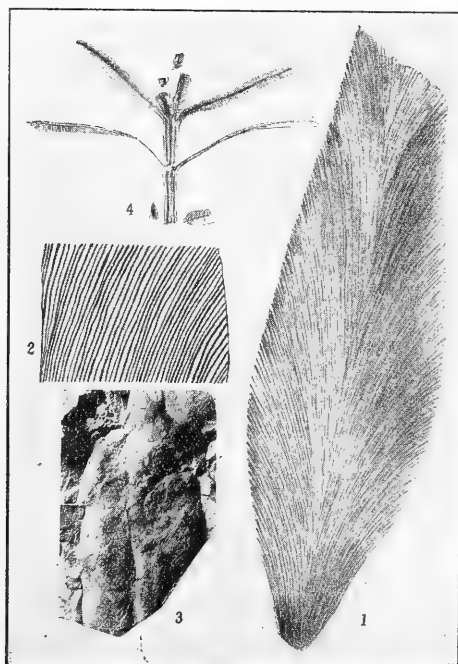
Genus PALAEOVITTARIA.

PALAEOVITTARIA MCCARTHYI, n. sp. Text-figs. 1-2.

Type, Specimen W263, Museum of Geology, University of Sydney.

Frond oval-lanceolate, length about 15 cm. when complete, breadth 3.8 cm. at widest part, which is almost one-third of the distance from the base to the apex; apex not preserved. Venation non-reticulate, erect, slightly arching and spreading at a narrow angle, occasionally dichotomizing. There are about twenty veins to the centimetre.

This leaf is very similar in size and shape and in the general character of the venation to *Palaeovittaria Kurzi* Feistmantel (1876, p. 368; 1880, p. 91), which occurs sparingly in the Raniganj group of the Damuda division in India and the Triassic beds of Tonquin. It differs from that species in the absence of the median fold, the more arched venation, and the very much closer spacing of



Text-figs. 1-4.

- 1, 2.—*Palaeovittaria McCarthyi*, n. sp. Fig. 1,  $\times \frac{2}{3}$ ; Fig. 2, venation,  $\times \frac{4}{3}$ .  
 3.—*Gangamopteris* sp.  $\alpha$ .  $\times \frac{2}{3}$ .  
 4.—*Neocalamites striatifolia*, n. sp.  $\times \frac{4}{3}$ .

the veins. In view of these differences, together with its rather lower horizon, it seems wise to refer it to a new species. I have much pleasure in dedicating it to Mr. McCarthy of Currabubula.

NOEGGERATHIOPSIS HISLOPI.

W158, W347b. This species is very abundant on some horizons as sub-linear leaves widening gradually from the base. The longest specimen is 18 cm., incomplete.

GANGAMOPTERIS SP. *a*. Text-fig. 3.

W261, W268. Frond oblong, symmetrical, 10 cm. in length, 4 cm. wide, apex obtusely rounded. No midrib, but a median fold is visible for two-thirds of the length of the leaf; venation apparently reticulate, arched so that it meets the margin at an angle of 70°. The anastomosis of the secondary veins appears to be very subordinate, but it is not well shown in any of the specimens. The leaf is particularly coriaceous, being very wrinkled in two specimens, and rolled up into a cylinder in the third. I suspect that this type is a new species.

GANGAMOPTERIS SP. *β*.

W262 (one nearly complete frond and four fragments), W156. Frond obovate, asymmetrical, 8 cm. long, 3.5 cm. wide at the widest part, apex rounded, slight median fold, but no midrib. Veins dichotomize frequently at fairly regular intervals, and anastomose occasionally. These fronds are similar to *Gangamopteris cyclopteroides*, but I am not certain that they are referable to that species.

GANGAMOPTERIS CYCLOPTEROIDES.

Several small fragments of large fronds, with the nervation well preserved.

CORDAITEAN WOOD.

This wood is represented by two specimens. Sections of one of the specimens were made. Neither pith nor protoxylem could be found, the specimen consisting of secondary xylem. Though the specimen seems to have been considerably crushed, resulting in convolutions in the wood, there is definite evidence of annual rings. This crushing has also destroyed the shape of the xylem elements in transverse section. The longitudinal section shows the xylem to consist of tracheids, which, though not well preserved, show pits on their radial walls. The pits are the characteristic bordered pits of the Cordaitales. Both transverse and longitudinal sections show numerous medullary rays. In transverse section they are one cell in width. Longitudinal section shows them to be several cells high. The rays are composed of parenchymatous cells which appear rectangular in section.

*Correlation.*—Some doubt arises as to whether the Lower Coal Measures of the Werrie Basin are on the Greta Horizon, or whether they correspond to a horizon in the Lower Marine Series, as do some of the coals of Queensland. This doubt is at first sight aggravated by the fact that the Werrie Basalts are similar to the well developed melaphyres of the Lower Marine Series. However, although alkali-basalts have been regarded as typical of the Lower Marine, evidence of their development in Upper Marine strata is not lacking. Browne (1929, p. xxix) points out: "Evidence has been found to the east of Raymond Terrace suggesting strongly that these basaltic eruptions were continued into Greta Coal Measure times, and at Jerry's Plains Mr. H. G. Raggatt has discovered, interbedded with the Upper Coal Measures, amygdaloidal basalts with analcite-lined

vesicles . . . at Temi, near Murrurundi, analcite-bearing basic lavas are interbedded with strata at least as young as Upper Marine."

Unfortunately no marine fossils have yet been found in the Werris Creek-Currabubula area which might settle this question of the age of the Werrie Basalts. In their absence the exact horizon will probably not be established until the area is linked with the Hunter Valley by continuous mapping.

Our knowledge of the time-distribution of the Permian floras is not sufficiently complete to give precise correlation based on them alone. The flora of the Lower Coal Measures of the Werrie Basin contains many elements which are different from the Greta flora of the Hunter Valley. *Glossopteris* is less abundant, and most of the *Gangamopteris* belongs to species with much less reticulate venation. This tendency is carried to the limit in *Palaeovittaria*. *Noeggerathiopsis* is more abundant, in this respect recalling the flora of the Ashford beds (Pittman, 1896, p. 21). Indeed the flora in the Werrie Basin is in many ways intermediate between those of Ashford and Greta. The assemblage is much more in keeping with the Greta than the Upper Coal Measures, but it is impossible to state from the flora alone whether it is of Greta or Lower Marine age.

Lithologically the Werrie Basin Coal Measures are undoubtedly very similar to the Greta Series elsewhere. The association of conglomerates, grits, and characteristic tuffs with thick coal-seams is very typical.

The areal distribution of the Lower Permian units provides another line of evidence. For, as the Permian strata are traced north-westwards from Scone to Wingen, the Lower Marine beds beneath the Greta Coal Measures gradually thin out, so to find that, some thirty miles further to the north-north-west, the coal measures rest directly on the Kuttung is not unexpected. Furthermore, at Temi, which occupies an intermediate position, there are some basalts both above and below the coal, the presumption being that the lower basalts represent the Lower Marine Series. Still further to the north-north-west the coal measures are also overlapped, and the basalts rest directly on the Carboniferous rocks, which have in turn also thinned.

But, although these units wedge out in the north-north-west, it does not follow that they also decline to the north and north-east. Indeed, at Nundle Permian marine fossils, which are quite absent at Werris Creek and Currabubula, have been recorded by Stonier (1891, p. 261) and Benson (1913, p. 586), and the extensive development of Permian marine beds further north is well known.

Thus, reviewing all the available data concerning flora, lithology, and areal distribution, I consider that there is strong evidence for regarding the Lower Coal Measures of the Werrie Basin as being strictly comparable with the Greta horizon, but until the correlation is established by the systematic mapping of the intervening region, the case cannot be regarded as proved.

#### *The Werrie Basalts.*

The Werrie Basalts are a series of alkalized basic lavas, about five thousand feet in thickness. The series is very extensive, covering more than 100 square miles within the trough of the Werrie Basin between Piallaway and Castle Mountain. They also occur immediately to the west of the range of Kuttung rocks which lies to the west of Werris Creek, and it seems probable that much of the black soil-covered lowlands of the Breeza Plains is due to the erosion *in situ* of this formation, and not to the presence of Burindi rocks under alluvial black soil cover as was suggested by Benson (1921, pp. 299-300). Indeed the



occurrence near Boggabri of basic amygdaloidal lavas similar in appearance to the Werrie Basalts would suggest a far greater extension of this formation than has hitherto been recognized. Southwards these rocks extend towards Temi, but beyond the range they have not been traced.

Stratigraphically the Werrie Basalts occupy the hiatus between the *Gangamopteris-Noeggerathiopsis* beds and the Upper Coal Measures with *Glossopteris*, so that their age is fixed between limits corresponding approximately to the Upper Marine Series of the Hunter Valley. The junction with the underlying beds is quite conformable; indeed, one often finds thin beds of fossiliferous sandstone and shale interstratified with the lower flows. Good exposures of the relationship between the two series may be seen in portions 133 and 134 in the Parish of Werrie. In portion 161 in the Parish of Quipolly, near Mr. Chapman's homestead, the interstratified shales contain a cindered and brecciated coal-seam. At the same locality the sediment appears to have been a soft mud, and the basalt settled into it in the form of blocks and chilled fragments, giving interesting contact-effects. The sandstone in contact with the lavas often shows well-developed prismaticization. Such interbedding of thin layers of sandstone between the lower flows is rather common in the Fairfield Basin, along the eastern side of the Jacob-and-Joseph Basin, and in the succeeding basin to the south, but never appears further west, thus suggesting that the sedimentation came from the east, a view supported by the increasing coarseness of the sediments in that direction. Since the interbedded sandstones often contain plant fossils such as *Gangamopteris*, *Noeggerathiopsis* and *Glossopteris*, it is evident that the extrusions commenced in Lower Coal Measure times.

The sequence at the top of the series is again conformable, but it is not certain how much time elapsed between the last extrusions and the initiation of the Upper Coal Measure sedimentation. The highest beds are clastic, but it is difficult to say whether they are tuffs, or material derived from the contemporaneous erosion of the lavas. They are of medium to fine grain size, without a marked stratification, and have a rich chocolate colour.

It would be unwise, therefore, to state that the Werrie Basalts were extruded throughout the time-interval of the Upper Marine Series. The most definite conclusion which can be made on the present evidence is that they occupy the stratigraphical interval of the Upper Marine Series, together with the Tomago Coal Measures and the Dempsey Series, and that they commenced in Lower Coal Measure time, but the last flow may have been extruded a considerable time before the beginning of the Upper Coal Measure sedimentation.

The intimate association of the lower flows with the freshwater sediments, and certain constant petrological and lithological characters, suggest that the whole series was poured out under sub-aqueous, probably freshwater conditions. This implies concurrent subsidence to the extent of five thousand feet.

Typically the Werrie basalts are highly amygdaloidal, with or without evidence of flow. The abundance and size of the amygdaloids may change suddenly; occasionally the flows have a suggestion of crude pillow-structure, and elsewhere become slaggy and ropy. A good exposure is to be seen beneath the bridge over Jacob-and-Joseph Creek, on the east side of the town of Quirindi. The vesicle-fillings are commonly stilbite, but calcite, chlorite, analcite and other zeolites, or one or more forms of silica, also occur. Fine-grained types are found with the amygdaloidal lavas.

The series is very susceptible to weathering and erosion, and invariably forms low-lying country with heavy black soil. Exposures are rare and fresh specimens are impossible to obtain. The evidence of water bores indicates that the same decomposed condition persists, even at depths of two and three hundred feet, and it probably continues throughout.

In view of the altered state of the rocks, petrographic work is attended with considerable difficulty. Although several specimens have been sectioned, only one is from an outcrop which was not intimately associated with the Warrigundi intrusives. This was collected on the side of an unusual knoll in the centre of the Fairfield Basin. The section described by Professor Browne (1920) was of a specimen collected from a well near the head of Anstey's Creek, and was in very close contact with the Warrigundi intrusives. There can be little doubt that the specimens examined under the microscope are far from typical of the series as a whole, for it is quite the exceptional lava which makes any outcrop at all.

However, from an examination of the slides, it is evident that the Werrie lavas are uniformly basaltic, usually without olivine, although that mineral may occur. They probably carry a very high proportion of iron. They show heavy deuteric modification with an abundance of analcite, chlorite, iddingsite and other kindred minerals. The important question arises as to whether we are to consider this alteration a magmatic birth-mark dating back to the Permian or purely an accomplishment of groundwater? That the basalts are saturated with circulating groundwater there can be no doubt, for the series forms the aquifer for a fruitful sub-artesian basin. On the other hand, it needs little extension of the observed evidence in even the freshest members of the series to account for the whole of the effects as deuteric phenomena. Yet it is unlikely that the copious meteoric waters, with which the Werrie Basalts are saturated, have not superimposed their stamp on the changes already wrought by the magmatic fluids. Indeed it is probable that it is the fact that the structure favours wholesale attack by groundwaters, coupled with the initial alteration of the lavas, that has been responsible for the complete physiographic failure of these rocks.

The Werrie basalts have a good deal in common with the spilites. The main distinction is perhaps one of degree rather than of any inherent difference. It is true that the development of albite is not universal among the specimens examined, but it must be remembered that most of the material comes from the zone of influence of the Warrigundi intrusives, which were injected at a high temperature and could have regenerated the basic feldspar. Such spilitic affinities could advantageously be approached with the aid of chemical analyses, but none of the Werrie Basalts has yet been analysed.

#### *The Upper Coal Measures.*

The most interesting outcrop of this series is a small basin-outlier to the west of the railway line, three miles south of Werris Creek, where one of the coal-seams has been worked for a number of years. The beds have the typical lithology of the Newcastle Coal Measures, and in view of their flora and stratigraphical position there is no doubt that they are to be correlated with that series. They consist of 400 feet of conglomerates, sandstones and shales, with four coal-seams. They lie conformably on the Werrie Basalts, with which they are folded, and the view taken by Benson that the outlier is an unfaulked block (1920, p. 306) has already been refuted (Carey, 1934). The folding is somewhat asymmetrical, the eastern limb being the steeper by a few degrees.

The series consists largely of sandstones, with some shales and coal-seams and some thick conglomerates at the top of the section. The conglomerates are well graded, the pebbles being almost exclusively derived from a fine white quartzite, and when screened are used for road gravel.

The thickness of the series which has been left by erosion is about 400 feet. A detailed section of the lower half of this has been provided by Mr. H. Thomas, who sank four prospecting bores on the site where the Werris Creek Colliery now stands. The details of the bores are:

Feet.	Inches.		
34	6	.. ..	Sandstone.
11	0	.. ..	White Shale.
5	11	.. ..	Conglomerate.
2	2	.. ..	Coal.
	5	.. ..	Dark Band. } No. 1 Seam (worked).
8	10	.. ..	Coal. }
54	11	.. ..	Hard Sandstone.
2	0	.. ..	Grey Shale.
3	0	.. ..	Coal. No. 2 Seam.
16	9	.. ..	Soft Yellow Sandstone.
40	0	.. ..	Brown Clay Shale.
5	0	.. ..	Coal. No. 3 Seam.
7	0	.. ..	Grey Shale with <i>Glossopteris</i> .
9	6	.. ..	Sandstone.
9	0	.. ..	Grey Shale.
4	8	.. ..	Coal. No. 4 Seam.
			Werrie Basalts.
<hr/>			
214	8		

Fragments of silicified Cordaitean wood are abundant in the conglomerates, and the sandstones frequently contain large impressions of plant stems, particularly in the gritty phase at the base of the series. These are sometimes quite large, one being nearly four feet long and nine inches across. An interesting flora is preserved in the shales. One horizon of pink and terra cotta shales, which outcrops on the north-east side of the outlier, gives very perfect preservation, and some new species are recorded from them. The following plants are present: *Glossopteris Browniana*, *Glossopteris indica*, *Glossopteris ampla*, *Noeggerathiopsis Hislopi*, *Phyllothea australis*, *Phyllothea* (cf.) *Etheridgei*, *Neocalamites striatifolia*, n. sp., ?*Pityolepis* sp., *Samaropsis moravica*, *Carpolithus circularis*, n. sp.

The specimens are lodged in the Museum of Geology, University of Sydney. In the following descriptions that of the Cordaitean wood is the work of Mr. R. N. Robertson, B.Sc. The fructifications collected by the writer have been described by Dr. A. B. Walkom (1935).

The *Glossopteris* fronds present a great deal of variation, but all the specimens can be referred to the three species listed, which are used in the wider sense, as defined by Arber (1905), and followed by Seward (1910), as distinct from the more restricted definitions of Feistmantel.

#### NEOCALAMITES STRIATIFOLIA, n. sp. Text-fig. 4.

Type in University of Sydney, Macleay Museum. Three specimens have been collected. The nodes are up to 1 cm. apart, and the leaves are about 2 cm. long, and the thickness of the stem is about 2 mm. The surface of the stem shows parallel ribs about 0.5 mm. apart, which are continuous at the node. The leaves



are quite separate from each other throughout their entire length, and do not form a sheath. Each whorl contains about eight leaves, which are 2 cm. long and 1 mm. wide, linear, and tapering to a point. They have a distinct midrib, which seems to be composed of a bundle of parallel fibres. At right angles to the midrib are closely-set transverse striae, which often bifurcate near the margin, much like the venation of *Taeniopteris*.

W785, portion of stem showing five nodes with leaves attached; W786 shows the leaves and stem very well; W787 shows the crown of the plant with a cluster of about eight leaves.

There seems to me no doubt that these specimens must be referred to Halle's genus *Neocalamites*. They are, however, the first to be recorded from the Palaeozoic. They bear considerable resemblance to *N. hoerensis* (Schimper), but differ from it in possessing much shorter leaves, whose width is not much less than that of the stem. Their horizon, too, is much lower.

#### PHYLLOTHECA cf. ETHERIDGEI (Arber).

About twelve specimens of unattached peltate leaves have been referred to this species. Each leaf opens out, trumpet-like, and curls slightly downward at the margin. They are usually elliptical in shape owing to the distortion, and their diameter is roughly one centimetre. The surface is finely striated with radial markings which diverge from the centre to form a finely crenulated margin. The veins are undivided and approximate to forty on each sheath. The stem is about two mm. in diameter.

These specimens differ from the *Phyllothea Etheridgei* type-specimen in the smaller size and the apparent absence of marginal free teeth. However, if the Werris Creek specimens are not specifically identical with Arber's species, they are very closely allied.

#### CORDAITEAN WOOD.

Two specimens were obtained. Longitudinal and transverse sections were made. In transverse section the pith and primary xylem were obvious. The pith is probably about 5 mm. in diameter, but it has been crushed and it is difficult to determine its original shape. The cells of the pith are parenchymatous, mostly containing a brown substance. Occasionally there are larger cells which are devoid of contents. The primary xylem occurs in a number of bundles round the pith. The protoxylem is not well preserved but is definitely centripetal. Unfortunately the protoxylem does not appear in longitudinal section. Most of the specimen consists of secondary xylem showing annual rings. The tracheids of the secondary xylem are arranged in quite regular radial rows with numerous medullary rays. In transverse section the medullary rays are only one cell wide, but the longitudinal section shows they may be many cells high. The pitting of the tracheids is poorly preserved, but some show multiseriate bordered pits, hexagonal in shape. In some an oval pore is visible. The cells of the medullary rays appear rectangular in both radial-longitudinal and transverse sections. The cortex is apparently not preserved.

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A PRELIMINARY NOTE ON THE ACACIA LEGUME AS A LATERAL ORGAN.

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(From the Botanical Laboratories, University of Sydney.)

(Six Text-figures.)

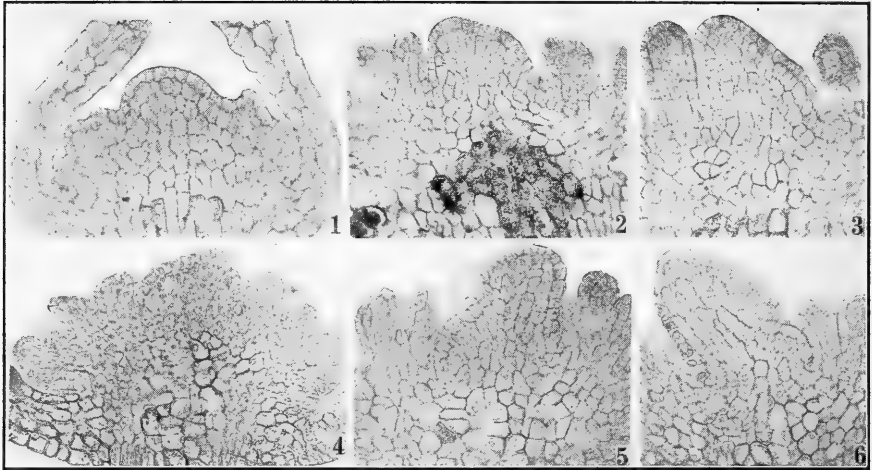
[Read 27th November, 1935.]

The classical interpretation of the carpel as a fertile modified leaf has been adversely criticized. Generally the criticisms contain the statement that the carpel (or one of the carpels) or the gynaeceium is terminal, the whole of the residual tissues of the floral apex giving rise to the primordium of the (or a) carpel, leaving no sign of a suppressed apex. It is significant that in the papers I will refer to shortly, propounding four different theories, there are no figures showing the cell-details of the primordial tissues of the floral apex in support of the contentions made. A study of these tissues in *Acacia suaveolens* and *A. longifolia* has convinced me that in these species the carpel (legume) is lateral in origin, the floral apex remaining suppressed. A full presentation and discussion of the evidence cannot be issued before May of next year, owing to the long vacation, so the essence of this important matter is presented in this preliminary note.

During the formation of sepal and petal primordia the floral axis is conical in shape. After this the upper part of the axis broadens into a disc-like structure leaving the apex as a central dome. The broadened region is the place of origin of the stamens (Fig. 1). The carpel begins as a lateral protuberance on the apical dome which is so small that the primordium occupies nearly half of the surface as seen in longitudinal section (Figs. 2, 3, 4). The carpel soon overtops and pushes aside the relatively minute residue of the apex whose regularly arranged cells on one side of the central structure in Figures 2-6 contrast with the large and differently arranged cells of the primordium or base of the young carpel on the other side. The large-celled pith comes to extend between the pro-cambium of the carpel and the suppressed apex (Fig. 6). The confined space between the stamens ultimately forces the carpel (legume) into an erect position which almost obliterates the minute, laterally displaced, suppressed apex. In all median sections examined (about 12 each of domed apex and lateral primordium in both species) the number of epidermal and hypodermal cells of the suppressed apex was just more than half that of those cells in the domed apex. The figures are explained in the legend.

Thompson (1931, pp. 43, etc., and cf. Fig. 63) describes the legume as terminal, and in the end interprets it as a phylloclade. (See also 1932.) Saunders (1929, pp. 225-7, cf. especially Figs. 1-3) regards the legume as terminal, "arising through the continued activity of cells which are actually apical", and refers to *A. suaveolens* and *longifolia*. Grégoire (1931), after discussing primordia (without giving cellular detail), concludes that, in general, the whole of the central part of

the floral axis becomes, or could become, a carpel. The evidence given here of the beginning of the carpel disproves these statements of terminality as far as these legumes are concerned. Thomas's (1934, p. 188) scheme for the evolution of the follicle (which he applies to the legume) does not agree with the ontogeny of the legume as given here, for the ovules are well known to be borne on the "margins" of the legume which is here shown as an organ lateral to the suppressed apex of the flower.



Text-figures 1-3.—L.S., young flowers of *Acacia suaveolens*,  $\times 200$  (approx.). 1, from insertion of petals upwards, showing domed apex and stamen primordia; 2 and 3, carpel beginning at the left of the apex by divisions and enlargements in the hypodermis there, suppressed apex to the right with just more than half the number of epidermal cells as in the domed apex.

Text-figures 4-6.—L.S., young flowers of *Acacia longifolia*,  $\times 200$  (approx.). 4, from insertion of the petals upwards, showing the carpel beginning at the right of the domed apex by divisions and enlargements in the hypodermis there; 5, section down the incipient groove of the carpel, one face is included just out of focus. Suppressed apex on the left; 6, section includes one face of the groove to which it is parallel. Carpel procambium to the left, suppressed apex to the right, extension of pith cells between them, hypodermis of apex and carpel now realigned, section slightly oblique to length of the groove.

Extended evidence and discussion will be given in the paper being prepared. This evidence is of a type necessary to such discussions, but is not presented by those mentioned above when making generalizations. It is hoped that botanists will give more attention to cellular details of tissues as a basis for morphological conclusions (or even speculations).

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SOME FOSSIL SEEDS FROM THE UPPER PALAEOZOIC ROCKS OF  
THE WERRIE BASIN, N.S.W.

By A. B. WALKOM, D.Sc.

(Plate xix.)

[Read 27th November, 1935.]

The seeds described in this paper were collected by Mr. S. W. Carey during the course of his geological investigation of the Werrie Basin (Carey, 1934). They include specimens from three distinct Series, viz.: (a) Kuttung Series, (b) Greta Coal Measures, (c) Newcastle Coal Measures.

The seeds from the Kuttung Series were collected from several horizons within the Glacial Stage of that Series and represent a variety of types. This variety of seed types is interesting in view of the limited number of species of which the vegetative organs are known in the Kuttung Series. From the upper part of this Series (part of Volcanic Stage, and the Glacial Stage) the following plants have been described:

*Archaeocalamites radiatus*, *Lepidodendron* sp., *Rhacopteris ovata*, *R. intermedia*, *R. Roemeri*, *R. septentrionalis*, *R. Wilkinsoni*, ?*Noeggerathia* sp., *Cardiopteris* cf. *frondosa*, *Sphenopteris Clarkei*, ?*Sphenopteridium cuneatum*, *Adiantites* (?) *robustus* and *Rhacophyllum diversiforme*.

These plants have been recorded from the Upper Kuttung Series in areas south of the region investigated by Mr. Carey. I have no record of the extent of the collections of vegetative organs made by Mr. Carey from the Kuttung Series in the Werrie Basin.

Attention has been drawn in other parts of the world to the numerical excess of seeds over vegetative organs in Upper Palaeozoic rocks. It would appear that collectors in the past have paid little attention to the seeds which are almost certainly obtainable in the Kuttung Series in association with the vegetative remains. Mr. Carey has shown that seeds are quite abundant on a number of horizons in the Werrie Basin and future collecting in other areas may be expected to reveal the presence of a variety of seeds. The seeds are preserved as impressions, and little information is available regarding their structure. It is, however, worth while recording their occurrence as a guide to future collectors.

(a) *Seeds from the Upper Kuttung Series.*

TRIGONOCARPUS (?) OVOIDEUS, n. sp. Pl. xix, fig. 1.

Impressions of ovoid seeds, broadest near base, gradually narrowing towards apex where there is a short narrow projection. The impressions are 7-8.5 mm. long by 5 mm. broad, the apical projection 0.5-1.0 mm. long. There are some fine vertical striations, and indication of one or two vertical wrinkles. The edge (for a breadth of about one-third of a millimetre) appears solid.

. There is insufficient evidence for any accurate determination. It is suggested that the specimens may represent impressions of the sclerotesta of *Trigonocarpus*. If this interpretation be correct, no trace of the sarcotesta is to be seen in either of the specimens. They bear some resemblance to Arber's figure (1914, Text-fig. 1) of *Trigonocarpus clavatus* (Sternberg), and also to Halle's figures (1927, Pl. 54, figs. 23, 24) of *T. (?) Norinii* from the Lower Shihhotse Series (basal Permian) of Shansi, though our specimens are somewhat smaller than the latter.

The figured specimen is No. 2022 in the collection of the Geology Department, University of Sydney.

TRIGONOCARPUS (?) ELLIPTICUS, n. sp. Pl. xix, fig. 2.

Small, rounded, elongate seeds, 8-8.5 mm. by 4-4.5 mm. One specimen (No. 2024) shows two rather prominent ridges extending from the apex to about half-way down the seed; there are also faint indications of fine vertical striation. There is a thin outer carbonaceous layer, and, near the apex, some slight indication of the existence of a wing.

These seeds perhaps do not give sufficient information even for generic determination. They are obviously not platyspermic types and so they may not be referred to the *Samaropsis* type of seed. They show some resemblance to those described below as *Carpolithus striatus*.

The figured specimen is No. 2024 in the collection of the Geology Department, University of Sydney.

SAMAROPSIS (?) OVALIS, n. sp. Pl. xix, fig. 3.

Small, ovate to almost circular impressions, to 10 mm. long by 7 mm. broad, showing no structure beyond a division into three sections. The central portion, which is about 3 to 3.5 mm. wide, may represent the nucule, and the outer portions the wings, of a species of *Samaropsis*. The apex of the impression is shallowly emarginate.

These seeds are generally similar to some examples of *Samaropsis Seiwasi* (White) from Brazil (cf. Seward, 1917, p. 350, fig. 502F), and also to the specimen referred by Halle (1927, Pl. 54, fig. 21) to *Samaropsis?* sp. from the Upper Shihhotse Series (Lower Permian) of Shansi. Some general resemblance may also be noted to the specimens figured by Arber (1914, Pl. vii, fig. 41) as *Radiospermum ornatum*, which Seward (1917, p. 323) suggested should be transferred to *Polygonocarpus*.

The figured specimen is No. 2028 in the collection of the Geology Department, University of Sydney.

SAMAROPSIS cf. BARCELLOSA White. Pl. xix, fig. 4.

Nucule almost circular, about 4 mm. diameter, completely surrounded by comparatively broad wing, widening at apex. The dimensions, including wing, are about 8 mm. by 6 mm.

This seed is distinct from any of the others herein described; it may be compared with *Samaropsis barcellosa*, another species described by David White from the Permo-Carboniferous of Brazil (cf. Seward, 1917, p. 350, fig. 502G). It also shows some resemblance to specimens described as *Samaropsis (?)* sp. by Feistmantel from the Lower Gondwanas (Karharbari) of India.

The figured specimen is No. 2030 in the collection of the Geology Department, University of Sydney.

## SAMAROPSIS MILLERI (Feistmantel). Pl. xix, fig. 7.

A number of ovate specimens, about 20 mm. by 12 mm., appear to be identical with the nucule of *Samaropsis Milleri* as figured by Feistmantel and by Seward (1917, p. 353, fig. 504). In our specimens there is, however, no trace of the wing, but this may have been completely destroyed before fossilization.

The figured specimen is No. 2031 in the collection of the Geology Department, University of Sydney.

## CARPOLITHUS STRIATUS, n. sp. Pl. xix, fig. 5.

Rounded, ovate seed, 6-7 mm. by 4 mm., with numerous fine vertical striations, which appear to spread from a single strand entering the seed from a narrow basal projection. There is no indication of a wing, though there is a thin carbonaceous film on the outside at the base.

It is difficult to place these seeds. They bear some resemblance to the nucule in such forms as *Samaropsis barcellosa* White. They may be referred to *Carpolithus* in view of the small amount of information available.

The figured specimen is No. 2032 in the collection of the Geology Department, University of Sydney.

## CORDAICARPUS (?) OVATUS, n. sp. Pl. xix, fig. 8.

Flattened impressions, ovate to almost circular, 6.5 mm. by 5 mm., with distinctly pointed apex; sometimes with a more or less distinct ridge running from apex; in some examples there appears to be a flattened margin. It is possible that they may be impressions of the sclerotesta of a species of *Trigonocarpus*. Adopting Seward's use of the term *Cordaicarpus* for "platyspermic seeds, preserved as casts or impressions, having a comparatively narrow border enclosing an ovate or cordate-ovate nucule", these impressions may for the present be included in this genus.

The figured specimen is No. 2034 in the collection of the Geology Department, University of Sydney.

## CORDAICARPUS PROLATUS, n. sp. Pl. xix, fig. 6.

Nucule 9 mm. by 5 mm., with broad base, and narrowing to pointed apex. There is a short vertical ridge at the centre of the base which may be an indication of a vascular strand. There is some indication of a narrow sarcotesta or wing about 1 mm. wide.

Specimen 2035 gives some indication of the structure of the apex, suggesting a short micropyle leading to the pollen chamber.

The figured specimen is No. 2035 in the collection of the Geology Department, University of Sydney.

## (b) Seeds from the Greta Coal Measures.

## CORNUCARPUS STRIATUS, n. sp. Pl. xix, fig. 9.

Halle (1927) proposed to use the name *Cornucarpus* Arber as a general designation for platyspermic seeds with two horn-like projections at the apex. He defined the genus as "Platyspermic seeds, with or without wings, provided at the apex with two acute projecting horns, which are at least as long as they are broad, or more often longer".

With this general conception, a specimen from the Greta Coal Measures may well be referred to this genus. It is about 11 × 7 mm., ovate, without wings, apex acute divided by a narrow sinus about 2 mm. in length. The surface is

covered with a series of fine vertical striations. It seems to show closest resemblance to *Cornucarpus ? carinatus* Halle, except that it does not possess the marked keel and it is not emarginate at the base. In general appearance it is not unlike some specimens that have been described as scale-leaves of *Glossopteris*.

The figured specimen is No. 2038 in the collection of the Geology Department, University of Sydney.

CORDAICARPUS EMARGINATUS, n. sp. Pl. xix, fig. 11.

Seeds ovate, platyspermic, 6-8 mm.  $\times$  4-5 mm., with slight emargination at apex.

No structure is preserved, but most of the impressions show fine vertical striations. The shallow emargination at the apex suggests the existence of a narrow wing, which is supported by the fact that a narrow marginal portion of the impression in some cases appears flat, the central area being slightly raised. These seeds are associated with *Noeggerathiopsis Hislopi*.

The figured specimen is No. 2039 in the collection of the Geology Department, University of Sydney.

(c) *Specimens from the Newcastle Coal Measures.*

? PITYOLEPIS SP. Pl. xix, fig. 12.

The name *Pityolepis* is one of a series proposed by Nathorst for specimens suggesting alliance with Abietineous genera—*Pityolepis* being used for cone-scales. Two specimens from the Newcastle Coal Measures (Permian) show such a resemblance to a cone-scale of *Pinus monophylla* bearing a single seed (see Seward, 1919, p. 119, fig. 686B) as to suggest the possibility that we may have here in rocks of Permian age some suggestion of the occurrence of a cone with Abietineous relations.

The specimens are rounded-oval in shape, about 10 by 7 mm. The central depression is about 5 by 8.5 mm., the flattened outer portion being about 1 mm. wide and decreasing in width towards the base. There is a series of vertical striations over the whole. The outer zone is not sufficiently distinct from the central portion to be regarded as a wing such as is characteristic of *Samaropsis*.

The figured specimen is No. 2040 in the collection of the Geology Department, University of Sydney.

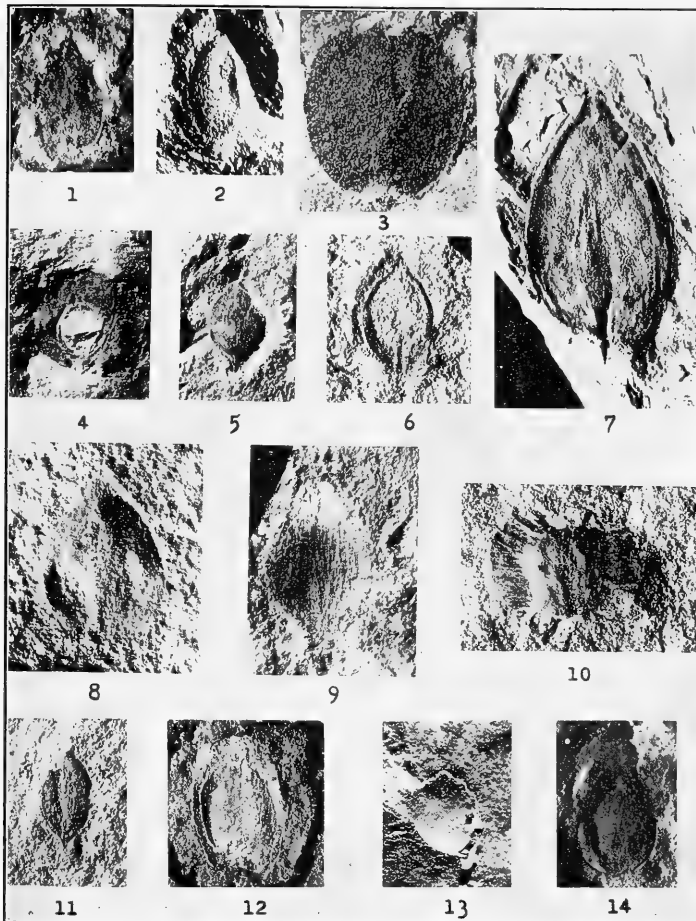
SAMAROPSIS MORAVICA (?) (Helmhacher).

A specimen in the collection shows a close resemblance to one previously figured from the Newcastle Series at Belmont (Walkom, 1928, p. 562, fig. 10). The nucular portion is about 4 by 2 mm., and the whole, including the wing, about 6-7 mm. by 4.5 mm.

CARPOLITHUS CIRCULARIS, n. sp. Pl. xix, figs. 13, 14.

A series of small rounded, almost circular, flattened specimens, 2.5 to 3.5 mm. in diameter, are shown, by a more complete specimen, to represent the nucules of a species in which the sarcotesta is produced to an elongated apex. This specimen has a total length of about 4.5 mm., its nucule being 2.5 mm. in diameter. There is no indication of any structure or of the nature of the vascular strands, and it is therefore considered advisable to include it as a species of *Carpolithus* for the present.





Seeds from Upper Palaeozoic Rocks of the Werrie Basin.



In its general shape and in the relation between the nucule and the sarcotesta there is a resemblance to the type of seed belonging to the genus *Rhynchogonium* (cf. Seward, 1917, p. 359, fig. 506G).

The figured specimens are Nos. 2042 and 2043 in the collection of the Geology Department, University of Sydney.

CONE (? Araucarian). Pl. xix, fig. 10.

A small fragment of what appears to be portion of a cone is figured (Pl. xix, fig. 10). This is about 12 mm. wide, consisting of a broad axis (about 6 mm.) to which are attached numerous scales about 3 mm. long and 0.75 mm. thick. On the central axis there are vertical markings which may represent the bases of attachment of scales.

From the Series immediately succeeding the Newcastle Series in the Sydney District, viz., the Narrabeen Stage of the Hawkesbury Sandstone Series, numerous small Araucarian cones have been collected and described under the name *Araucarites sydneyensis* (Walkom, 1925). The specimen here described differs in the fact that it has a much broader axis, but it seems quite possible that it may represent a similar type of cone. *A. sydneyensis* has cone-scales up to 1 cm. long and 5 mm. broad (see Burges, 1935, p. 262).

The figured specimen is No. 2044 in the collection of the Geology Department, University of Sydney.

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EXPLANATION OF PLATE XIX.

- Fig. 1.—*Trigonocarpus* (?) *ovoideus*, n. sp. × 2.
- Fig. 2.—*Trigonocarpus* (?) *ellipticus*, n. sp. × 2.
- Fig. 3.—*Samaropsis* (?) *ovalis*, n. sp. × 3½.
- Fig. 4.—*Samaropsis* cf. *barcellosa* White. × 2.
- Fig. 5.—*Carpolithus striatus*, n. sp. × 2.
- Fig. 6.—*Cordaicarpus prolatus*, n. sp. × 2.
- Fig. 7.—*Samaropsis Milleri* (Feistmantel). × 2.
- Fig. 8.—*Cordaicarpus* (?) *ovatus*, n. sp. × 3½.
- Fig. 9.—*Cornucarpus striatus*, n. sp. × 2.
- Fig. 10.—? Araucarian cone. × 2.
- Fig. 11.—*Cordaicarpus emarginatus*, n. sp. × 2.
- Fig. 12.—? *Pityolepis* sp. × 2.
- Figs. 13, 14.—*Carpolithus circularis*, n. sp. × 3½.

The figures are all from untouched photographs taken by Mr. H. G. Gooch, of the Geology Department, University of Sydney.



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- i.—Geological Sketch Map of the Hartley District, N.S.W.
- ii-iii.—Erosion in Upper Murray Catchment, N.S.W.
- iv.—Varieties of *Dendrobium teretifolium*.
- v-ix.—Mosses from Lord Howe Island.
- x.—Fossil plants from Narrabeen Stage of the Hawkesbury Series in New South Wales.
- xi.—Yacht "Thistle", and sounding apparatus.
- xii.—Fossil insects: *Polytaxineura* and *Stenoperlidium*.
- xiii-xvii.—Koonamore Vegetation Reserve, 1926-1931.
- xviii.—Habitat of *Acacia Baileyana*.
- xix.—Fossil seeds from the Werrie Basin, N.S.W.

# ABSTRACT OF PROCEEDINGS.

## ORDINARY MONTHLY MEETING.

27th MARCH, 1935.

Dr. W. L. Waterhouse, M.C., D.I.C. (Lond.), President, in the Chair.

The Donations and Exchanges received since the previous Monthly Meeting (28th November, 1934), amounting to 53 Volumes, 382 Parts or Numbers, 7 Bulletins, 12 Reports and 27 Pamphlets, received from 164 Societies and Institutions and 1 private donor, were laid upon the table.

### PAPERS READ.

1. The Diptera of the Territory of New Guinea. i. Families Muscidae and Tachinidae. By J. R. Malloch. (*Communicated by F. H. Taylor.*)
2. The Diptera of the Territory of New Guinea. ii. Family Tipulidae. By C. P. Alexander. (*Communicated by F. H. Taylor.*)
3. The Petrology of the Hartley District. iii. The Contact Metamorphism of the Upper Devonian (Lambian) System. By Germaine A. Joplin, B.Sc.
4. Revision of Australian Lepidoptera. Oecophoridae. iii. By A. J. Turner, M.D., F.R.E.S.
5. Australian Rust Studies. v. On the Occurrence of a New Physiologic Form of Wheat Stem Rust in New South Wales. By W. L. Waterhouse, D.Sc.Agr.

## ORDINARY MONTHLY MEETING.

24th APRIL, 1935.

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

Mr. M. D. Garretty, Bronte, Mr. N. S. Noble, M.S., B.Sc.Agr., D.I.C., Lindfield, and Dr. Kenneth K. Spence, Bondi Beach, were elected Ordinary Members of the Society.

The President announced that the Council had elected Professor T. G. B. Osborn, Dr. C. Anderson, Professor A. N. Burkitt and Professor W. J. Dakin to be Vice-Presidents for the Session 1935-36.

The President also announced that the Council had elected Dr. G. A. Waterhouse to be Honorary Treasurer for the Session 1935-36.

The President drew the attention of members to a prize of 1,000 francs offered by the Société de Physique et d'Histoire Naturelle de Genève for the best unpublished monograph on a genus or family of plants. Manuscripts offered must reach the Society at Geneva by 31st October, 1937.

The Donations and Exchanges received since the previous Monthly Meeting (27th March, 1935), amounting to 9 Volumes, 101 Parts or Numbers, 1 Bulletin, 3 Reports and 8 Pamphlets, received from 59 Societies and Institutions, were laid upon the table.

## PAPERS READ.

1. On some Australian and South African Species of Acarina of the Genus *Stereotydeus* (Fam. Penthalodidae). By H. Womersley, F.R.E.S.
2. Studies in the Genus *Uromycladium*. ii. Notes on the Dikaryon Stage of *U. Tepperianum*. By Alan Burges, M.Sc.
3. Notes on the Mosses of New South Wales. ii. By Alan Burges, M.Sc.
4. An Investigation of the Sooty Moulds of New South Wales. iii. The Life-histories and Systematic Positions of *Aithaloderma* and *Capnodium*. By Lilian Fraser, M.Sc., Linnean Macleay Fellow of the Society in Botany.
5. The Gasteromycetes of Australasia. xvii. New Species of Hymenogastraceae. By G. H. Cunningham, D.Sc., Ph.D., F.R.S.N.Z.

## NOTES AND EXHIBITS.

Mr. F. H. Taylor exhibited the larva of *Megarhinus speciosus* Skuse, Family Culicidae, which was taken at Goddard's Wharf, Palm Beach, on 31st March of this year, by Miss I. Bennett. This species was described by Skuse in these Proceedings (xiii, 1889, 1722) from Port Denison, Queensland. Skuse stated that "There is also a ♀ specimen in the Macleay Collection taken by Mr. Masters about twenty years ago near Sydney; it seems to me to belong to this species, but is too abraded to satisfactorily decide". No specimens of this species have been recorded from the Sydney district since Skuse published the above remarks.

Mr. G. Murray, of Rabaul, exhibited photographs showing coconut palms attacked by species of *Sexava* (Family Tettigoniidae).

## ORDINARY MONTHLY MEETING.

29th MAY, 1935.

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

The Chairman announced that the Management Committee of Science House has made Room No. 514 on the fifth floor available as a Common Room for the use of members of the Societies which are tenants of Science House. Members may obtain meals from the caretaker upon giving him notice and may also obtain light refreshments in this room.

The Donations and Exchanges received since the previous Monthly Meeting (24th April, 1935), amounting to 5 Volumes, 75 Parts or Numbers, 5 Bulletins, 1 Report and 6 Pamphlets, received from 61 Societies and Institutions, were laid upon the table.

## PAPERS READ.

1. An Investigation of the Sooty Moulds of New South Wales. iv. The Species of the Eucapnodieae. By Lilian Fraser, M.Sc., Linnean Macleay Fellow of the Society in Botany.
2. Notes on Australian Orchids: A Review of the Species *Dendrobium teretifolium*. By Rev. H. M. R. Rupp, B.A.
3. The Relationship between Erosion and Hydrographical Changes in the Upper Murray Catchment, N.S.W. By F. A. Craft, B.Sc., Linnean Macleay Fellow of the Society in Geography.

## NOTES AND EXHIBITS.

Mr. J. G. Churchward explained an exhibit prepared by Mr. G. Wright to demonstrate the use of *Aspergillus niger* as a biological indicator of the amount of available potassium in certain soils from different parts of New South Wales.



The thick mycelial growth without sporulation on a nutrient solution, to which has been added a sample of soil taken from the University of Sydney, indicated the presence of a sufficiency of available potassium. On the other hand, the poor mycelial growth and abundance of spores resulting when a soil sample from Glen Innes was used, indicated a deficiency of available potassium and the probability that such a soil would respond to a potassic fertilizer. Intermediate reactions were obtained with soil samples from Fairfield and Gunnedah.

Dr. W. L. Waterhouse exhibited material showing the occurrence of albino seedlings in wheat, oats, sea-barley (*Hordeum maritimum* With.), perennial rye grass, waratahs and pumpkins. The wheat concerned is a selection of the variety "Alberta Red", which produces variegated seedlings and albinos. Work is in progress dealing with the genetics of these occurrences. The results already obtained with the close-pollinated plants indicate that the mode of inheritance of this character is complex.

#### ORDINARY MONTHLY MEETING.

26th JUNE, 1935.

Professor T. G. B. Osborn, D.Sc., Vice-President, in the Chair.

Miss Elizabeth C. Pope, B.Sc., Northbridge, and Mr. J. L. Still, B.Sc., Drummoyne, were elected Ordinary Members of the Society.

The Chairman drew the attention of members to the first circular for the Seventeenth International Geological Congress to be held in Moscow in 1937.

The Chairman informed members that the Royal Society of New South Wales will make the third award of the Walter Burfitt Prize this year. The award will be for work published during the three years ended 31st December, 1934, and applications should be in the hands of the Royal Society not later than 31st August, 1935.

The Donations and Exchanges received since the previous Monthly Meeting (29th May, 1935), amounting to 18 Volumes, 216 Parts or Numbers, 17 Bulletins, 3 Reports and 26 Pamphlets, received from 91 Societies and Institutions and 2 private donors, were laid upon the table.

#### PAPERS READ.

1. The Marine Algae of Lord Howe Island. By A. H. S. Lucas, M.A., B.Sc.
2. Contributions to the Microbiology of Australian Soils. iii. The Rossi-Cholodny Method as a Quantitative Index of the Growth of Fungi in the Soil, with some Preliminary Observations on the Influence of Organic Matter on the Soil Microflora. By H. L. Jensen, Macleay Bacteriologist to the Society.
3. Australian Coleoptera. Notes and New Species. ix. H. J. Carter, B.A., F.R.E.S.

#### NOTES AND EXHIBITS.

Mr. J. G. Churchward explained an exhibit set up by Mr. Holman, demonstrating the use of the *Cunninghamella* plaque method of measuring the available phosphorus in several soil samples which were collected in different parts of New South Wales. Soil plaques were made by mixing a nutrient solution, which lacked phosphorus, with the soil samples. The diameter of the colony of *Cunninghamella*, which was measured two days after a spore suspension had been added to the centre of the plaque, was used as a criterion of phosphatic

deficiency; soils rich in available phosphorus gave colonies of greater diameter than those deficient in phosphorus.

Dr. I. V. Newman exhibited five herbarium specimens of the "Cootamundra Wattle", *Acacia Baileyana*, taken from trees growing in the natural habitat at Warrim Hill and Bagdad about seven miles southerly from Temora, near Burra Creek, and the northern foot of the Big Sister Mountain about fifteen miles south of Cootamundra, and at Berthong about six miles north of Cootamundra. These specimens are duplicates of five that were presented to the National Herbarium, Sydney. The specimens presented to the Herbarium are the first in its collection coming from trees of this species growing in the natural habitat.

Miss Lillian Fraser exhibited specimens of *Harpographium corynelioides* Cke. & Mass., a fungus belonging to the Stilbaceae, Fungi Imperfecti. It has not previously been recorded in New South Wales, though present in Victoria, Tasmania and South Australia. It has recently been found at Blackheath on *Leptospermum flavescens* Sm. and *L. lanigerum* Sm. (6, 1935), on *L. aciculare* Schau. (3, 1935), at Lowther on *L. myrtifolium* Sieb. (6, 1935), and at Huskisson on *L. juniperinum* Sm. (1, 1935, collected by G. Rodway). It does not appear to parasitize the *Leptospermum* spp. directly, but lives on the gall-forming coccid, *Sphaerococcus leptospermi* Mask.

Professor Osborn spoke about the organization and work of the Second Myall Lakes Expedition which was run by the Sydney University Rover Crew at the end of May. Mr. R. N. Robertson outlined briefly the work done by the botanists. The problems to which they paid particular attention on this trip were the problems of swamp succession and of the distribution of the eucalypt forest and subtropical rain-forest.

#### ORDINARY MONTHLY MEETING.

31st JULY, 1935.

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

The Chairman announced that in response to the Society's representations twelve species of orchids have been added to the protected list for one year from 1st July, 1935.

The Donations and Exchanges received since the previous Monthly Meeting (26th June, 1935), amounting to 30 Volumes, 93 Parts or Numbers, 1 Bulletin, 1 Report and 10 Pamphlets, received from 72 Societies and Institutions and 3 private donors, were laid upon the table.

#### PAPERS READ.

1. Miscellaneous Notes on Australian Diptera. iii. By G. H. Hardy.
2. An Investigation of the Sooty Moulds of New South Wales. v. The Species of the Chaetothyriaceae. By Lillian Fraser, M.Sc., Linnean Macleay Fellow of the Society in Botany.
3. The Relations between the Internal Fluid of Marine Invertebrates and the Water of the Environment, with Special Reference to Australian Crustacea. By Enid Edmonds, M.Sc.

#### NOTES AND EXHIBITS.

Mr. N. J. B. Plomley sent for exhibition the stomachs and contents of two specimens of the common brush-tailed opossum, *Trichosurus vulpecula*. Rabbits caught in traps (Epping, N.S.W., 16.vi.1935) had been partly eaten, apparently

after having been killed earlier by another animal (? a fox). Snares were set, baited with portion of a rabbit, and a dove. In each an opossum was caught, one of each sex. The stomach contents of the male comprised vegetable material, some rabbit's fur, and portions of flesh and feathers of a dove. The stomach of the female contained chiefly vegetable material, but also rabbit's fur, and what is apparently portion of the intestine of a rabbit, with the contents. Both stomachs also contained opossum fur. It is of interest that in 1846 Waterhouse stated that occasionally a dead bird was given to the specimens of *T. vulpecula* captive at the London Zoo, "for which they evinced great fondness, and more particularly for the brain, which was the first part consumed". Until the appearance of a note in the last issue of the *Australian Zoologist* (Vol. viii, p. 149) there have been no authentic records of these animals being carnivorous in a state of nature. In Queensland, Dr. E. A. Briggs has seen *T. vulpecula* feeding on beetles.

Mr. J. G. Churchward exhibited stock flowers, *Matthiola incana*, which showed variegation due to infection by a virus. The pathogen is spread by insects and the infection results in various petal patterns.

#### ORDINARY MONTHLY MEETING.

28th AUGUST, 1935.

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

Messrs. N. C. W. Beadle, Chatswood, and W. I. M. Holman, B.Sc.Agr., Waitara, were elected Ordinary Members of the Society.

The President welcomed Dr. Germaine Joplin on her return from Cambridge.

The Donations and Exchanges received since the previous Monthly Meeting (31st July, 1935), amounting to 20 Volumes, 144 Parts or Numbers, 8 Bulletins, 4 Reports and 10 Pamphlets, received from 71 Societies and Institutions and 1 private donor, were laid upon the table.

#### PAPERS READ.

1. Upper Permian Insects of New South Wales. iii. The Order Copeognatha. By R. J. Tillyard, M.A., Sc.D., F.R.S.

2. Additions to our knowledge of the Flora of the Narrabeen Stage of the Hawkesbury Series in New South Wales. By Alan Burges, M.Sc.

3. Notes on Australasian Anisopodidae (Diptera). By Mary E. Fuller, B.Sc.

#### NOTES AND EXHIBITS.

Mr. E. Cheel exhibited specimens of three very bad weeds which have become naturalized in this State, as follows: (1) *Salvia aethiopsis* L.—Commonly known as "Ethiopian Sage" or "Woolly Clary", collected in the Inverell district by Mr. C. Campbell, in June, 1935. The only other record for Australia is Hallett to Peterborough, Eyre Peninsula, J. M. Black, "Flora of South Australia", p. 489 (1922-1929), so that it would appear to be a comparatively recent introduction for South Australia, as it is not recorded in "The Naturalised Flora of South Australia" (1909). It is a native of the Mediterranean region and is likely to become a very serious weed pest if not eradicated. (2) *Arctium lappa* L.—Commonly known as "Burdock". Said to be widely spread in Victoria, but only recently found in this State at Coombing Park, Carcoar, forwarded by the Whitney Pastoral Company in January, 1931, and six miles west of Blayney, forwarded for

identification by the Lyndhurst Shire Council in February, 1935. The burrs of this weed are furnished with hooked points upon the bracts of the flower heads and are a serious menace when caught up in the fleece of sheep. (3) *Grindelia squarrosa* Dunal.—A native of North America, commonly known as "Pitch Weed" or "Gum Plant", naturalized in Victoria and recently found at Bathurst on a farm owned by Mrs. S. Bayliss.

Mr. Cheel also exhibited live plants of the common "Flax-leaved Fleabane" (*Erigeron linifolia*) to show the extreme variability of the foliage characters (see These PROCEEDINGS, 1918, 610, and 1920, 404, for notes on this species).

Mr. Cheel exhibited, on behalf of Professor J. B. Cleland, Part ii of "Toadstools and Mushrooms and other larger Fungi of South Australia", issued by the British Science Guild (South Australian Branch).

Rev. H. M. R. Rupp reported the following new locality records for orchids: *Dendrobium Schneiderae* Bail.—N.S.W.: Lynch's and Grady's Creeks, Kyogle, April, 1934, A. W. Dockrill; *Bulbophyllum Weinthalii* Rogers.—N.S.W.: same locality and collector as the last; *Sarcochilus Fitzgeraldii* F.v.M.—N.S.W.: Boolambayt Creek, near Bullahdelah, July, 1935, W. J. Enright; *Sarcochilus Hartmannii* F.v.M.—N.S.W.: Nimbin, Richmond River, June, 1933, H. E. Small; and later near Kyogle, A. W. Dockrill; *Cleisostoma brevilabre* F.v.M.—S. Queensland: Noosa, 80 miles from Brisbane, Jan., 1935, M. Gall (per C. T. White); *Calochilus grandiflorus* Rupp.—N.S.W.: Brunswick Heads, Oct., 1934, F. Fordham (see *Victorian Naturalist*, Feb., 1934); *Cryptostylis erecta* R. Br.—S. Queensland. Dr. R. S. Rogers received specimens from near Brisbane several years ago, but they were not placed on record. Specimen received from Dr. C. P. Ledward, Burleigh Heads, Nov., 1934; *Diuris palachila* Rogers.—N.S.W.: Molong, Sept., 1932, W. F. Blakely. One previous N.S.W. record (Paterson) is doubtful; *Prasophyllum Archeri* Hook.—S. Queensland: Burleigh Heads, Dec., 1933, Dr. C. P. Ledward. Also sent from neighbourhood of Brisbane by Mr. C. T. White (B. D. Grimes, coll.); *Prasophyllum viride* Fitzg.—S. Queensland: Burleigh Heads, Jan., 1935, Dr. C. P. Ledward; *Pterostylis grandiflora* R. Br.—N.S.W.: near Kurri Kurri, July, 1933, M. W. Nichols; *Chiloglottis Gunnii* Lindl.—N.S.W.: Round Mountain, 40 miles north-east of Armidale, Nov., 1934, Gordon McRae and R. Ferguson, per Rev. E. Norman McKie.

Miss J. M. Wilson exhibited a species of *Cyttaria*, apparently *C. septentrionalis*. *C. septentrionalis* was collected by Dr. D. A. Herbert from Mt. Hobwee on the border of New South Wales and Queensland on *Nothofagus Moorei* in 1929. These specimens were collected near the summit of Barrington Tops, also on *Nothofagus Moorei*, and, although the fruits are not yet mature, it seems almost certain that the species is the same as Dr. Herbert's. Several species of *Cyttaria* have been found growing parasitically on the branches of different species of *Nothofagus* from South America, New Zealand, and Australia, the only species recorded in Australia being *C. septentrionalis* and *C. Gunnii* which grows on *Nothofagus Cunninghamii* in Victoria and Tasmania. The mycelium is parasitic and causes the formation of galls on the twigs and branches. Little is known of the anatomy of the galls, but apparently the mycelium is perennial. It produces clusters of fruiting bodies every Spring. These fruiting bodies grow rapidly and produce apothecia over almost their entire surface, within a protective layer. At maturity the fructification gelatinizes and the covering layer is ruptured, thus allowing the spores to be freed. The fruits remain only for a few weeks. In this species the galls eventually become very large and extend for a considerable

distance. The mycelium appears to travel along the stem, causing large areas to become infected.

Dr. C. Anderson exhibited, on behalf of the Trustees of the Australian Museum, the wing of a fossil insect found at Beacon Hill, near Brookvale. The wing is more than five inches in length and beautifully preserved, the details of the venation being clearly shown. In the centre of the wing is a curious "grid" of large cells, probably a resonating area, but unlike anything hitherto found in fossil insect wings. This interesting specimen is possibly a member of the rare Order Protohemiptera, established by Handlirsch on the Lower Permian fossil *Eugereon boeckii*. Dr. Tillyard has established the Family Mesotitanidae for two species belonging to this Order, namely, *Mesotitan giganteus* from St. Peters and *Mesotitan scullyi* from Beacon Hill, and it is possible that this new find belongs to the same Family.

Dr. I. V. Newman exhibited leaves of *Acacia discolor* showing examples of crimson and of green pulvini, the inheritance of which he is investigating. He also described methods of examination of the distribution of sap and plastid pigments in the flowers of that species. The distribution in the flowers of any one tree appears to be uniform, but varies from tree to tree. The elimination of sap pigment by boiling and its change of colour by reduction of the sugar in the glucoside were demonstrated; where only plastid pigment was present there was no loss or change respectively. This was shown on filaments of two specimens. Such differences of coloration are also under genetical examination.

Mr. C. J. Magee exhibited photographs of Beetroot plants affected with Downy Mildew caused by the parasitic fungus *Peronospora schachtii* Fuckel. There is evidence that the disease was introduced into Australia in imported seed. Samples of seed taken from the consignment from which the diseased crop was grown were shown to contain oospores of the fungus. Besides beetroot the fungus attacks Sugar Beet, Mangelds, Swiss Chard and several other *Beta* spp.

Mr. J. G. Churchward exhibited specimens illustrating the isolation and cultivation of fungi from the roots of orchids. Seeds of orchids, which were sown on pure cultures of *Rhizoctonia repens* obtained from orchid roots, germinated on artificial media. By this means a high percentage of germination was obtained.

Dr. W. L. Waterhouse exhibited specimens of cultivated Cinerarias attacked by *Puccinia cinerariae* McAlp. collected at Lindfield, N.S.W. Only two plants in a large bed showed infection which so far has resulted in production of the aecidial stage only. This appears to be the second record of the occurrence of this rust. It was suggested that the possibility of a genetic relationship with *P. calendulae* McAlp. should be considered.

#### ORDINARY MONTHLY MEETING.

25th SEPTEMBER, 1935.

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

The Chairman announced that the Council is prepared to receive applications for four Linnean Macleay Fellowships tenable for one year from 1st March, 1936, from qualified candidates. Applications should be lodged with the Secretary, who will afford all necessary information to intending candidates, not later than Wednesday, 6th November, 1935.

The Donations and Exchanges received since the previous Monthly Meeting (28th August, 1935), amounting to 15 Volumes, 106 Parts or Numbers, 3 Bulletins,

3 Reports and 5 Pamphlets, received from 64 Societies and Institutions and 1 private donor, were laid upon the table.

## PAPERS READ.

1. Revision of Australian Lepidoptera. Oecophoridae. iv. By A. J. Turner, M.D., F.R.E.S.

2. The Leaf Anatomy and Vegetative Characters of the Indigenous Grasses of New South Wales. i. Andropogoneae, Zoysieae, Tristegineae. By Joyce W. Vickery, M.Sc.

3. Observations on the Seasonal Changes in Temperature, Salinity, Phosphates, and Nitrate Nitrogen and Oxygen of the Ocean Waters on the Continental Shelf off New South Wales and the Relationship to Plankton Production. By Professor W. J. Dakin, D.Sc., F.Z.S., and A. N. Colefax, B.Sc.

## NOTES AND EXHIBITS.

Mr. E. Cheel exhibited eight species and varieties of *Echinopogon* described as new by Mr. C. E. Hubbard (*Hooker's Icones Plantarum*, Vol. 3 (5th Series), Part iii, August, 1935): *Echinopogon intermedius* C. E. Hubbard (Walcha Road, J. L. Boorman, December, 1912, type; figured in *Agric. Gaz. N.S.W.*, Vol. 3, p. 388, 1892, as *E. ovatus*. See left, B, C and D); *E. Cheelii* C. E. Hubbard (Glen Innes, E. Cheel, type); *E. nutans* C. E. Hubbard (Brisbane River, C. T. White); *E. nutans* var. *major* C. E. Hubbard (Wandsworth, 15 miles NW. of Guyra, Rev. E. N. McKie, December, 1931); *E. caespitosus* C. E. Hubbard (Awaba, near Newcastle, J. L. Boorman, November, 1914; figured in *Agric. Gaz. N.S.W.*, Vol. 3, p. 388, 1892, as *E. ovatus*. Right A, B and C); *E. caespitosus* var. *Cunninghamii* C. E. Hubbard (recorded for Wellington Valley, but is not represented in the National Herbarium of N.S.W.); *E. ovatus* (G. Forst.) Beauv. (Bulba Island, Lake Macquarie, E. Cheel, November, 1929); *E. ovatus* var. *pubiglumis* C. E. Hubbard (Western Australia, Drummond 342. Not represented in National Herbarium of N.S.W.); *E. McKiei* C. E. Hubbard (Walcha, E. Beteche, December, 1898; Elderbury Creek, 7 miles SW. of Guyra, Rev. E. N. McKie); *E. phleoides* C. E. Hubbard (Tenterden, 23 miles NW. of Guyra, Rev. E. N. McKie, December, 1930; Wandsworth, McKie, December, 1931).

Mr. Cheel also exhibited seedlings of "Skeleton Weed" (*Chondrilla juncea*) to demonstrate the close resemblance to *Taraxacum*, *Leontodon* and *Hypochaeris*.

Mr. R. N. Robertson exhibited a special apparatus for extracting gas from the intercellular space system of leaves and for analysing the gas for its relative percentage of carbon dioxide and oxygen.

Dr. W. L. Waterhouse exhibited specimens of *Chamaelaucium uncinatum* showing the well-known variation in colour of the flowers. Observations on this character, on a mosaic pattern on the leaves and on the apparent spread to a second plant in a garden where a number of virus diseases of other plants were present, point to the possibility that the condition is due to a virus. Further investigation is desirable. A plant of the common "Lamb's Tongue", *Plantago lanceolata*, was shown, illustrating a sectorial chimera. From a normal green rosette, one shoot arose which was variegated.

## ORDINARY MONTHLY MEETING.

30th OCTOBER, 1935.

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

Dr. Geoffrey Bourne, Canberra; Mr. V. Lindsay, Mackay, Queensland; and Mr. M. S. Stanley, Sydney, were elected Ordinary Members of the Society.

The Chairman reminded candidates for Linnean Macleay Fellowships, 1936-37, that Wednesday, 6th November, is the last day for receiving applications.

The Donations and Exchanges received since the previous Monthly Meeting (25th September, 1935), amounting to 23 Volumes, 185 Parts or Numbers, 2 Bulletins, 3 Reports and 31 Pamphlets, received from 78 Societies and Institutions and 3 private donors, were laid upon the table.

## PAPERS READ.

1. Upper Permian Insects of New South Wales. iv. The Order Odonata. By R. J. Tillyard, M.A., Sc.D., D.Sc., F.R.S.
2. Upper Permian Insects of New South Wales. v. The Order Perlaria, or Stone-flies. By R. J. Tillyard, M.A., Sc.D., D.Sc., F.R.S.
3. On the Climate and Vegetation of the Koonamore Vegetation Reserve to 1931. By T. G. B. Osborn, J. G. Wood and T. B. Paltridge.

## NOTES AND EXHIBITS.

Mr. W. W. Froggatt exhibited some fruits of *Owenia acidula*, a handsome western scrub tree known to the bushmen as "Colone", "Grewi", and "Emu apple". The fruits consist of a thin covering of reddish-purple enveloping a solid woody nut from one-half to three-quarters of an inch in diameter, which is almost as hard as vegetable ivory. In the centre are one or more small cells containing a seed somewhat like an apple pip. Mr. Froggatt has been trying to raise seedlings from these nuts for two years without any results. The late Mr. J. H. Maiden stated that he had no record of anyone growing them, and Mr. C. T. White, Queensland Government Botanist, does not know of them being grown from seed. It is understood that the Director of the Royal Gardens at Kew has been obtaining seeds with the object of trying to germinate them.

Mr. Froggatt also exhibited specimens of the palm-seed beetle, *Coccotrypus dactyloperda*, breeding in composition buttons imported from Italy.

Mr. E. Cheel exhibited a fresh sporophore or spore-bearing pileus of the so-called "Blackfellow's Bread" fungus (*Polyporus mylittae*). Photographic and coloured illustrations of the same species were also exhibited to show the extreme variation of the method of development in the different sclerotia.

Dr. I. V. Newman exhibited: (a) a photograph of plasticene models built from serial sections of *Acacia longifolia* and *Acacia suaveolens*, (b) photomicrographs of longitudinal sections of young flowers of *Acacia longifolia*, *Acacia suaveolens* and *Acacia discolor*, (c) three of the slides of (b).

These exhibits demonstrate the lateral emergence of the primordial tissue of the legume from a domed apex which remains suppressed. The legume assumes a grooved form and on the margins of the groove the ovules are borne. This evidence is of great importance for the morphological interpretation of the angiospermic gynaecium. Recent theories of Miss E. R. Saunders and Professor McLean Thompson are based on the assumption that the classical monocarpellary gynaecium, as exemplified by the legume, is a terminal structure. The exhibits indicate that it is a lateral structure.

A theory of Dr. H. Hamshaw Thomas is based on the assumption that the ovules are terminal structures closed in by the carpel wall which is derived from a cupule-like structure. The exhibit shows the carpel wall as a lateral structure bearing ovules on its margins, the apex of the flower remaining suppressed.

## ORDINARY MONTHLY MEETING.

27th NOVEMBER, 1935.

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

Mr. A. G. Lowndes, M.Sc., Balmain, Sydney, was elected an Ordinary Member of the Society.

The Chairman announced that the Council had reappointed Miss Lilian Fraser, M.Sc., Dr. I. V. Newman, M.Sc., and Mr. R. N. Robertson, B.Sc., to Linnean Macleay Fellowships in Botany for one year from 1st March, 1936, and will consider the appointment to the fourth Fellowship at its next meeting in December.

The Chairman called the attention of members to the proposed memorial to the late Dr. Leonard Cockayne, subscriptions to which should be sent to the Secretary, Royal Society of New Zealand, Wellington, N.Z.

The Donations and Exchanges received since the previous Monthly Meeting (30th October, 1935), amounting to 13 Volumes, 109 Parts or Numbers, 4 Bulletins, 5 Reports and 62 Pamphlets, received from 67 Societies and Institutions and 1 private donor, were laid upon the table.

## PAPERS READ.

1. Studies in Australian Acacias. v. The Problems of the Status and Distribution of *Acacia Baileyana* F.v.M. By I. V. Newman, M.Sc., Ph.D., F.L.S., Linnean Macleay Fellow of the Society in Botany.

2. Note on the Permian Sequence in the Werrie Basin. By S. Warren Carey, M.Sc.

3. Some Fossil Seeds from the Upper Palaeozoic Rocks of the Werrie Basin, N.S.W. By A. B. Walkom, D.Sc.

4. A Preliminary Note on the *Acacia* Legume as a Lateral Organ. By I. V. Newman, M.Sc., Ph.D., F.L.S., Linnean Macleay Fellow of the Society in Botany.

## NOTES AND EXHIBITS.

Mr. E. Cheel exhibited live seedling plants of *Eucalyptus* raised by Mr. J. L. Drummond, in charge of Kuring-gai Council Nursery, Pymble, from seeds of *Eucalyptus Nicholi* Blakely. The seedlings show two forms of leaf characters—some with leaves 7–8 mm. wide, characteristic of *E. acaciaeformis* Deane and Maiden, and others 1–2 mm. wide, characteristic of *E. acaciaeformis* var. *linearis* Deane and Maiden. In view of this it would appear to be unwise to regard *E. Nicholi* as a distinct species.

Mr. Cheel also exhibited herbarium specimens of *Eucalyptus* collected by Banks and Solander during Captain Cook's voyage in "H.M.S. *Endeavour*" in 1768–71, described by Gaertner (de Fructibus et Seminibus Plantarum, Vol. i, p. 171, 1788, Tab. xxxiv, fig. 3, A & B) under the name *Metrosideros salicifolia*. This is mentioned as a probable synonym by Labillardière under his *Eucalyptus amygdalina* (Plantae Nov. Holl., Vol. i, p. 14, 1806). Bentham (Fl. Aust., iii, p. 222) quotes the B of Gaertner as a synonym under *E. crebra* F.v.M. Britten (Illust. Bot. Captain Cook's Voyage, 1901, part ii, p. 39) quotes *Metrosideros salicifolia* Gaertner as a synonym under *Eucalyptus terminalis* F.v.M., and illustrates the drawing made from Banks and Solander's specimen which is said to have been collected on Lizard Island, Thirsty Sound. Blakely (Key to the Eucalypts, p. 210) takes up the specific name *salicifolius* of Gaertner, and merges *E. amygdalina* of Labillardière as a synonym. The specimen collected by



Banks and Solander, together with the drawing published by Britten, in no way resembles either *E. amygdalina* Labill., or *E. terminalis* F.v.M., but seems to be a form of *E. crebra* as suggested by Bentham and Maiden. In view of this, the specific name *racemosa* of Cavanilles cannot be taken up for *E. crebra* F.v.M., as proposed by Blakely. The original specimens of Banks and Solander, together with the illustration published by Britten, and typical specimens of *E. terminalis* F.v.M., and *E. crebra* F.v.M., were exhibited for comparison. Live plants of "Flame Tree" (*Brachychiton acerifolia*), "Tweed River Pine" (*Callitris columnaris*) and "Skeleton Weed" (*Chondrilla juncea*) were exhibited to show the extreme variability of the habit and foliage characters as a result of soil and climatic conditions.

Mr. T. H. Pincombe exhibited a fossil limuloid crustacean from Beacon Hill Quarry.

Mr. C. J. Magee exhibited photographs of lettuce and potato plants attacked by spotted wilt.

Mr. W. H. Maze exhibited a photograph showing soil erosion developed to the gully stage on a slope of 20°, which had been cleared of its native vegetation.

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DONATIONS AND EXCHANGES.

Received during the period 29th November, 1934, to 30th October, 1935.

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

- ABERYSTWYTH.—*Welsh Plant Breeding Station, University College of Wales.* "The Welsh Journal of Agriculture", xi (1935).
- ACCRA.—*Geological Survey of the Gold Coast.* Report for the Financial Year 1933-34 (1934).
- ADELAIDE.—*Department of Mines: Geological Survey of South Australia.* Mining Review for the Half-years ended June 30th, 1934 (No. 60) (1935) and December 31st, 1934 (No. 61) (1935).—*Field Naturalists' Section of the Royal Society of South Australia and South Australian Aquarium Society.* "The South Australian Naturalist", xvi, 1-3 (1934-1935).—*Public Library, Museum and Art Gallery of South Australia.* 50th Annual Report of the Board of Governors, 1933-34 (1934); Records of the South Australian Museum, v, 3 (1935).—*Royal Society of South Australia.* Transactions and Proceedings, lviii (1934).—*South Australian Ornithological Association.* "The South Australian Ornithologist", xiii, 1-3 (1935).—*University of Adelaide.* "The Australian Journal of Experimental Biology and Medical Science", xii, 4 (T.p. & c.) (1934); xiii, 1-3 (1935).—*Woods and Forests Department.* Annual Report for the Year ended June 30th, 1934 (1934).
- ALBANY.—*New York State Library, University of the State of New York.* New York State Museum Bulletin, Nos. 292, 296, 297 (1934).
- ALGER.—*Société d'Histoire Naturelle de l'Afrique du Nord.* Bulletin, xxv, 6-9 (T.p. & c.) (1934); xxvi, 1-5 (1935); Memoires, Nos. 4-5 (1934).—*Station d'Aquiculture et de Pêche de Castiglione.* Bulletin, 1932, 2 (T.p. & c.) (1934).
- AMSTERDAM.—*Koninklijke Akademie van Wetenschappen.* Proceedings of the Section of Sciences, xxxv, 2 (T.p. & c.) (1932); xxxvi, 1-2 (T.p. & c.) (1933); xxxvii, 1-5 (1934); Verslag van de Gewone Vergaderingen der Afdeeling Natuurkunde, xlii-xliii (1932-1933) (Series concluded).—*Nederlandsche Entomologische Vereeniging.* Entomologische Berichten, ix, 198-203 (1934-1935); Tijdschrift voor Entomologie, lxxvii, 3-4 (T.p. & c.) (1934); lxxviii, 1-2 (1935).
- ANN ARBOR.—*University of Michigan.* Contributions from the Museum of Palaeontology, iv, 13-18 (1935); Miscellaneous Publications of the Museum of Zoology, No. 25 (1934); Occasional Papers of the Museum of Zoology, Nos. 279-295 (T.p. & c. for Nos. 266-295) (Vol. xii) (1933-34); Nos. 296-306 (1934-1935).
- AUCKLAND.—*Auckland Institute and Museum.* Annual Report, 1934-35 (1935); Records, i, 6 (T.p. & c.) (1935).
- BALTIMORE.—*Johns Hopkins University.* Bulletin of the Johns Hopkins Hospital, iv, 4-6 (T.p. & c.) (1934); lvi, 1-6 (T.p. & c.) (1935); lvii, 1-2 (1935); with Supplement to the Bulletin (Bulletin of the Institute of the History of Medicine, ii, 8-10) (T.p. & c.) (1934); University Circular, N.S. 1934, 8-10 (1934); 1935, 1-7 (1935).
- BANDOENG.—*Dienst van den Mijnbouw in Nederlandsch-Indie.* Bulletin of the Netherlands Indies Volcanological Survey, Nos. 68-71 (1934-1935); Wetenschappelijke Mededeelingen, Nos. 25-26 (1933, 1935).
- BARCELONA.—*Academie de Ciencies i Arts.* Butlleti, vi, 6 (1935); Memories, Tercera Epoca, xxiv (complete) (1935); xxv, 1-7 (1934-1935); Nomina del Personal Academic, 1934-35 (1934).
- BASEL.—*Naturforschende Gesellschaft.* Verhandlungen, xlv, 1933-34 (1934).—*Schweizerische Naturforschende Gesellschaft* (formerly at Bern). Verhandlungen, 115. Jahresversammlung, 1934 (1934).

- BATAVIA.—*Departement van Economische Zaken*. Bulletin du Jardin Botanique, Serie iii, Supplement, Vol. ii, 3-4 (T.p. & c.) (1934); Serie iii, xiii, 2 (1934); "Treubia", xiv, 4 (T.p. & c.) (1934); xv, 1 (1935).—*Koninklijke Natuurkundige Vereeniging in Nederlandsch-Indie*. Natuurkundig Tijdschrift voor Nederlandsch-Indie, xciv, 3 (T.p. & c.) (1934); xcvi, 1-3 (1935).
- BERGEN.—*Bergens Museum*. Arbok, 1934, 1-2 (T.p. & c.) (1934-1935); 1935, 1 (1935); Arsberetning, 1933-34 (1934).
- BERKELEY.—*University of California*. Bulletin of the Department of Geological Sciences, T.p. & c. for Vol. xxii, 1932 (1934); xxiii, 8-10, 12 (1934-1935); Publications, Botany, xvii, 13-15 (1934); xviii, 1 (1935); Physiology, viii, 7 (1934); Public Health, T.p. & c. for Vol. i, 1928-1934 (1934); Zoology, xxxix, 14-18 (1934-1935); xl, 7-10 (1934-1935); xli, 1-2 (1935); Publications of the University of California at Los Angeles in Biological Sciences, i, 1-5 (1933-1935).
- BERLIN.—*Deutsch-Ausländischer Buchtausch*. "Flora", Neue Folge, xxvii, 1-4 (T.p. & c.) (1933-1934); xxviii (complete) (1933); xxix, 1-3 (1934-1935); The Kaiser Wilhelm Society for the Furtherance of Sciences. Prospectus (no date); Harnack House (belonging to the Society). Prospectus (no date).—*Deutsche Entomologische Gesellschaft, E.V.* Deutsche Entomologische Zeitschrift, 1934, 3-4 (T.p. & c.) (1935); Mitteilungen, vi, 1-4 (1935).—*Zoologische Museum*. Mitteilungen, xx, 1-3 (T.p. & c.) (1934-1935).
- BERLIN-DAHLEM.—*Botanisch Garten und Museum*. Notizblatt, xii, 112-114 (1934-1935).—*Deutsches Entomologisches Institut*. Arbeiten über morphologische und taxonomische Entomologie aus Berlin-Dahlem, i, 4 (T.p. & c.) (1934); ii, 1-2 (1935); Arbeiten über physiologische und angewandte Entomologie aus Berlin-Dahlem, i, 3-4 (T.p. & c.) (1934); ii, 1-2 (1935).
- BERN.—*Naturforschende Gesellschaft*. Mitteilungen a.d. Jahre 1934 (1935).
- BIRMINGHAM.—*Birmingham Natural History and Philosophical Society*. Proceedings, xvi, 5 (1934).
- BLOEMFONTEIN.—*Nasionale Museum*. Argeologiese Navorsing, ii, 1 (1935).
- BOLOGNA.—*Laboratorio di Entomologia del R. Istituto Superiore Agrario di Bologna*. Bollettino, vi (1933-1934).
- BOMBAY.—*Bombay Natural History Society*. Journal, T.p. & c. for xxxvii, pts. 1-2 (1935); xxxvii, 3-4 (1934-1935); xxxviii, 1 (1935); "The Bombay Natural History Society, 1883-1933" (1934).
- BOSTON.—*American Academy of Arts and Sciences*. Proceedings, lxxix, 7-13 (T.p. & c.) (1934-1935); lxxx, 1-2 (1935).—*Boston Society of Natural History*. Proceedings, T.p. & c. for xxxix (1928-1931); xl, 1-2 (1934).
- BRISBANE.—*Department of Agriculture*. Queensland Agricultural Journal, xlii, 6 (T.p. & c.) (1934); xliii, 1-6 (T.p. & c.) (1935); xliv, 1-4 (1935).—*Department of Mines: Geological Survey of Queensland*. "Queensland Government Mining Journal", xxxv, Nov.-Dec., 1934 (T.p. & c.) (1934); xxxvi, Jan.-Oct., 1935 (1935).—*Queensland Naturalists' Club and Nature-Lovers' League*. "The Queensland Naturalist", ix, 4-5 (1935).—*Royal Society of Queensland*. Proceedings, xlvi, 1934 (1935).
- BRNO.—*Prirodovedecká Fakulta, Masarykovy University*. Spisy (Publications) (Botanical only), Cis. 192, 199 (1934, 1935); "Epilithicæ sinice Serpentinu mohelenskych. Part i. Chroococcales", by Dr. Fr. Novacek (1934).
- BROOKLYN.—*Botanical Society of America*. American Journal of Botany, xxi, 9-10 (T.p. & c.) (1934); xxii, 1-7 (1935).
- BRUSSELS.—*Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique*. 101re Annuaire, 1935 (1935); Bulletin de la Classe des Sciences, 5me Série, xx, 4-12 (T.p. & c.) (1934); xxi, 1-5 (1935).—*Musée Royal d'Histoire Naturelle de Belgique*. Bulletin, x, 1-47 (T.p. & c.) (1934); Mémoires, Nos. 59-66 (1933-1935); Mémoires, Hors Serie (Résultats Scientifiques du Voyage aux Indes Orientales Néerlandaises), ii, 14-16; iii, 15-16; iv, 10 (1934).—*Société Entomologique de Belgique*. Bulletin and Annales, lxxiv, 4-12 (T.p. & c.) (1934); lxxv, 1-6 (1935); Mémoires, xxiv, 1 (1934).—*Société Royale de Botanique de Belgique*. Bulletin, lxvi, 1-2 (T.p. & c.) (1933-1934); lxvii, 1-2 (T.p. & c.) (1934-1935).—*Société Royale Zoologique de Belgique*. Annales, lxiv, 1933 (1934).

- BUDAPEST.—*Hungarian National Museum*. *Annales Historico-naturales*, xxix (1935).—“*Index Horti Botanici Universitatis Budapestinensis*”, 1934 (1934).
- BUENOS AIRES.—*Ministerio de Agricultura de la Nacion*. *Comision Central de Investigaciones sobre la Langosta*, Informes de las Comisiones Exploradoras, Mayo a Agosto de 1933 (1934); *Comision Nacional de Defensa contra la Langosta*. *Lucha Nacional contra la Langosta*. *Contribucion Cientifica de la Sociedad Entomologica Argentina* (1934).—*Museo Argentino de Ciencias Naturales “Bernardino Rivadavia”* (formerly *Museo Nacional de Historia Natural*). *Anales*, xxxvii (1931-1933).—*Sociedad Argentina de Ciencias Naturales*. *Revista*, “*Physis*”, xi, 40 (T.p. & c.) (1935).—*Sociedad Entomologica Argentina*. *Revista*, T.p. & c. for Vol. v; vi, 2-4 (1934).
- CAEN.—*Société Linnéenne de Normandie*. *Bulletin*, 8e Série, v-vi, 1932-1933 (1933-1934).
- CAIRNS.—*North Queensland Naturalists' Club*. “*North Queensland Naturalist*”, iii, 3-12 (1934-1935); iv, 37 (1935).
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- O'DWYER, Dr. Margaret H., Forest Products Research Laboratory, Princes Risborough, England.—“The Hemicelluloses of the Wood of English Oak. ii” (From *Biochemical Journal*, xxviii, 6, 1934).
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## LIST OF MEMBERS, 1935.

### ORDINARY MEMBERS.

- 1927 \*Albert, Michel François, "Boomerang", Elizabeth Bay, Sydney.  
1929 Allan, Miss Catherine Mabel Joyce, Australian Museum, College Street, Sydney.  
1905 Allen, Edmund, c/o Mulgrave Mill, Gordonvale, Queensland.  
1906 Anderson, Charles, M.A., D.Sc., Australian Museum, College Street, Sydney.  
1922 Anderson, Robert Henry, B.Sc.Agr., Botanic Gardens, Sydney.  
1899 Andrews, Ernest Clayton, B.A., F.R.S.N.Z., 32 Benelong Crescent, Bellevue Hill.  
1932 Andrews, John, B.A., Department of Geography, Sydney University.  
1927 Armstrong, Jack Walter Trench, "Callubri", Nyngan, N.S.W.  
1912 Arousseau, Marcel, B.Sc.
- 1913 Badham, Charles, M.B., Ch.M., B.Sc., Bureau of Microbiology, 93 Macquarie Street, Sydney.  
1888 Baker, Richard Thomas, The Crescent, Cheltenham.  
1919 Barnett, Marcus Stanley, c/o Colonial Sugar Refining Co., Ltd., O'Connell Street, Sydney.  
1935 Beadle, Noel Charles William, 36 Anglo Street, Chatswood.  
1907 Benson, Professor William Noel, B.A., D.Sc., F.G.S., University of Otago, Dunedin, N.Z.  
1920 Blakely, William Faris, Botanic Gardens, Sydney.  
1929 Boardman, William, Australian Museum, College Street, Sydney.  
1935 Bourne, Geoffrey, D.Sc., Australian Institute of Anatomy, Canberra, F.C.T.  
1923 Brough, Patrick, M.A., D.Sc., B.Sc.Agr., Botany School, Sydney University.  
1921 Brown, Horace William, 871 Hay Street, Perth, W.A.  
1924 Brown, Miss Ida Alison, D.Sc., "Caversham", 166 Brook Street, Coogee.  
1911 Browne, William Rowan, D.Sc., Geology Department, The University, Sydney.  
1932 Bryce, Ernest John, 47 Nelson Road, Lindfield.  
1931 Burges, Norman Alan, M.Sc., 35 Wetherell Street, Croydon.  
1920 Burkitt, Professor Arthur Neville St. George Handcock, M.B., B.Sc., Medical School, The University, Sydney.  
1921 Burns, Alexander Noble, "Meringa", Fuchsia Street, Blackburn, Victoria.  
1926 Buzacott, James Hardie, Meringa (private bag), via Cairns, North Queensland.
- 1901 Campbell, John Honeyford, I.S.O., M.B.E., Royal Canadian Mint, Ottawa, Canada.  
1927 Campbell, Thomas Graham, Flat No. 8, The Washington, Musgrave Street, Mosman, Sydney.  
1930 Carey, Miss Gladys, B.Sc., 32 Rawson Street, Epping.  
1934 Carey, Samuel Warren, M.Sc., c/o District Officer, Aitape, Sepik District, Territory of New Guinea.  
1905 Carne, Walter Mervyn, University of Tasmania, Hobart, Tasmania.  
1903 Carter, Herbert James, B.A., F.R.E.S., "Garrawillah", Kintore Street, Wahroonga.  
1899 Cheel, Edwin, Botanic Gardens, Sydney.  
1924 Chisholm, Edwin Claud, M.B., Ch.M., Comboyne, N.S.W.  
1932 Churchward, John Gordon, B.Sc.Agr., Faculty of Agriculture, Sydney University.  
1901 Cleland, Professor John Burton, M.D., Ch.M., The University, Adelaide, S.A.  
1931 Colefax, Allen N., B.Sc., Department of Zoology, Sydney University.  
1933 Coleman, Mrs. Edith, "Walsham", Blackburn Road, Blackburn, Victoria.  
1908 Cotton, Professor Leo Arthur, M.A., D.Sc., Geology Department, The University, Sydney.  
1928 Craft, Frank Alfred, B.Sc., 11 Mulgray Avenue, Maroubra.  
1925 Cunningham, Gordon Herriot, Ph.D., Department of Agriculture, Fields Division, Plant Research Station, P.O. Box 442, Palmerston North, N.Z.

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- 1929 Dakin, Professor William John, D.Sc., Department of Zoology, The University, Sydney.
- 1934 Davidson, Harold James, 11 Melrose Street, Croydon Park.
- 1932 Davis, Harold Fosbery Consett, St. Paul's College, Newtown.
- 1934 Day, William Eric, 23 Galling Avenue, Strathfield.
- 1929 Deane, Cedric, A.M.I.E.Aust., "Cloyne", 6 State Street, Malvern, S.E.4, Victoria.
- 1925 de Beuzeville, Wilfred Alexander Watt, J.P., "Melamere," Welham Street, Beecroft.
- 1928 Dickson, Bertram Thomas, B.A., Ph.D., Council for Scientific and Industrial Research, Division of Plant Industry, Box 109, Canberra, F.C.T.
- 1927 \*Dixson, William, "Merridong", Gordon Road, Killara.
- 1921 Dodd, Alan Parkhurst, Prickly Pear Laboratory, Sherwood, Brisbane, Q.
- 1926 Dumigan, Edward Jarrett, State School, Toowoomba East, Queensland.
- 1920 Dwyer, Rt. Rev. Joseph Wilfrid, Bishop of Wagga, Wagga Wagga, N.S.W.
- 1932 \*Ellis, Ralph, 2420 Ridge Road, Berkeley, California, U.S.A.
- 1930 English, Miss Kathleen Mary Isabel, B.Sc., March Street, Yass, N.S.W.
- 1914 Enright, Walter John, B.A., West Maitland, N.S.W.
- 1908 Flynn, Professor Theodore Thomson, D.Sc., Queen's University, Belfast, Ireland.
- 1930 Fraser, Miss Lilian Ross, M.Sc., "Hopetoun", Bellamy Street, Pennant Hills.
- 1911 Froggatt, John Lewis, B.Sc., Department of Agriculture, Rabaul, New Guinea.
- 1886 Froggatt, Walter Wilson, F.L.S., Young Street, Croydon.
- 1930 Fuller, Miss Mary Ellen, B.Sc., Council for Scientific and Industrial Research, Box 109, Canberra, F.C.T.
- 1935 Garretty, Michael Duhan, B.Sc., c/o J. H. H. Miller, Esq., Suva, Fiji.
- 1932 Gay, Francis Joseph, B.Sc., Glebe House, Reid, Canberra, F.C.T.
- 1912 Goldfinch, Gilbert Macarthur, University Club, 70 Phillip Street, Sydney.
- 1911 Greenwood, William Frederick Neville, F.L.S., F.R.E.S., c/o Colonial Sugar Refining Co., Ltd., Lautoka, Fiji.
- 1910 Griffiths, Edward, B.Sc., Department of Agriculture, Raphael Street, Sydney.
- 1901 Gurney, William Butler, B.Sc., F.R.E.S., 18 Milson Road, Cremorne, Sydney.
- 1925 Hale, Herbert Matthew, South Australian Museum, Adelaide, S.A.
- 1919 Hall, Leslie Lionel, 24 Wellesley Road, Pymble.
- 1897 Halligan, Gerald Harnett, F.G.S., "Rivenhall", Hastings Road, Turramurra.
- 1885 Hamilton, Alexander Greenlaw, "Tanandra", Hercules Street, Chatswood.
- 1928 Hamilton, Edgar Alexander, 16 Hercules Street, Chatswood.
- 1922 Hardwick, Frederick George, B.D.S., D.D.Sc., "Wyoming", 175 Macquarie Street, Sydney.
- 1917 Hardy, G. H. Hurlstone, Station Road, Sunnybank, Brisbane, Queensland.
- 1932 Harris, Miss Thistle Yolette, B.Sc., 129 Hopetoun Avenue, Vaucluse, Sydney.
- 1911 Haviland, The Venerable Archdeacon F. E., Moore Street, Austimmer, South Coast, N.S.W.
- 1930 Heydon, George Aloysius Makinson, M.B., Ch.M., School of Public Health and Tropical Medicine, The University, Sydney.
- 1930 Holmes, Professor James Macdonald, B.Sc., F.R.G.S., Department of Geography, The University, Sydney.
- 1932 Hossfeld, Paul Samuel, M.Sc., c/o Deputy Administrator, Alice Springs, Central Australia.
- 1907 Hull, Arthur Francis Basset, Box 704, G.P.O., Sydney.
- 1892 Hynes, Miss Sarah, B.A., M.B.E., "Isis", Soudan Street, Randwick.
- 1917 Jacobs, Ernest Godfried, "Cambria", 106 Bland Street, Ashfield.
- 1930 Jensen, Hans Laurits, Department of Bacteriology, Sydney University.
- 1907 Johnston, Professor Thomas Harvey, M.A., D.Sc., F.L.S., The University, Adelaide, S.A.
- 1930 Joplin, Miss Germaine Anne, B.Sc., Ph.D., Geology Department, Sydney University.
- 1933 Judge, Leslie Arthur, 36 Romsey Street, Hornsby.
- 1930 Julius, Sir George Alfred, B.Sc., B.E., M.I.Mech.E., M.I.E.Aust., 67 Castlereagh Street, Sydney.

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 1924 Kinghorn, James Roy, Australian Museum, College Street, Sydney.
- 1932 Lawson, Albert Augustus, 9 Wilmot Street, Sydney.  
 1923 Lindergren, Gustaf Mauritz, Swedish Chamber of Commerce, 38 Carrington Street, Sydney.  
 1893 Lucas, Arthur Henry Shakespeare, M.A., B.Sc., "Girrahween", William Street, Roseville.
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 1932 Magee, Charles Joseph, B.Sc.Agr. (Syd.), M.Sc. (Wis.), Department of Agriculture, Raphael Street, Sydney.  
 1931 \*Mair, Herbert Knowles Charles, B.Sc., c/o Council for Scientific and Industrial Research, Box 109, Canberra, F.C.T.  
 1929 Mann, John, Commonwealth Prickly Pear Laboratory, Sherwood, Brisbane, Queensland.  
 1932 Martin, Donald, B.Sc. c/o University of Tasmania, Hobart, Tasmania.  
 1905 Mawson, Sir Douglas, D.Sc., B.E., F.R.S., The University, Adelaide, S.A.  
 1933 Maze, Wilson Harold, 39 Lucas Road, Burwood.  
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 1917 McKeown, Keith Collingwood, Australian Museum, College Street, Sydney.  
 1927 McKie, Rev. Ernest Norman, B.A., The Manse, Guyra, N.S.W.  
 1919 McLuckie, John, M.A., D.Sc., Botany Department, The University, Sydney.  
 1934 Melvaine, Miss Alma Theodora, 101 Cook Road, Centennial Park, Sydney.  
 1932 Messmer, Pearl Ray (Mrs. C. A.), Treatts Road, Lindfield.  
 1930 Munch-Petersen, Erik, Ph.B., M.Sc. (Hauensis), M.I.F., Veterinary Research Institute, Story Street, Parkville, Melbourne, N.2, Victoria.  
 1926 Mungomery, Reginald William, c/o Meringa Sugar Experiment Station, Box 146, Gordonvale, North Queensland.  
 1920 Musgrave, Anthony, F.R.E.S., Australian Museum, College Street, Sydney.
- 1934 Newman, Florence Rewa Wear (Mrs. I. V.) (née Burton), B.A., Dip.Ed., "Whitehaven", 5 Llandilo Avenue, Strathfield.  
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 1935 Noble, Norman Scott, M.S., B.Sc.Agr., D.I.C., Department of Agriculture, Raphael Street, Sydney.  
 1920 Noble, Robert Jackson, B.Sc.Agr., Ph.D., Department of Agriculture, Raphael Street, Sydney.  
 1912 North, David Sutherland, c/o Colonial Sugar Refining Co., Ltd., Broadwater Mill, Richmond River, N.S.W.
- 1920 O'Dwyer, Margaret Helena, B.Sc., Ph.D., Forest Products Research Laboratory, Princes Risborough, Bucks., England.  
 1927 Oke, Charles George, 56 Chaucer Street, St. Kilda, Victoria.  
 1910 Oliver, Walter Reginald Brook, F.L.S., F.Z.S., D.Sc., F.R.S.N.Z., Dominion Museum, Wellington, C.1, New Zealand.  
 1927 Osborn, Professor Theodore George Bentley, D.Sc., F.L.S., Department of Botany, The University, Sydney.  
 1921 Osborne, George Davenport, D.Sc., Geology Department, The University, Sydney.
- 1922 Perkins, Frederick Athol, B.Sc.Agr., Biology Department, University of Queensland, Brisbane, Q.

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- 1934 Plomley, Norman James Brian, c/o Bank of New South Wales, Threadneedle Street, London, E.C.2, England.
- 1935 Pope, Miss Elizabeth Carington, B.Sc., 36 Kameruka Road, Northbridge.
- 1931 Pratt, Enid Mary, (Mrs. W.), (née Edmonds), M.Sc., Congregational Manse, Broken Hill.
- 1918 Priestley, Professor Henry, M.D., Ch.M., B.Sc., Medical School, The University, Sydney.
- 1929 Raggatt, Harold George, B.Sc., Geological Survey, Department of Mines, Sydney.
- 1924 Roberts, Frederick Hugh Sherston, M.Sc., Department of Agriculture and Stock, Animal Health Station, Yeerongpilly, Brisbane, Q.
- 1932 Robertson, Rutherford Ness, B.Sc., 15 The Boulevard, Lewisham.
- 1925 Roughley, Theodore Cleveland, B.Sc., F.R.Z.S., Technological Museum, Harris Street, Sydney.
- 1927 Rupp, Rev. Herman Montagu Rucker, B.A., The Rectory, Woy Woy, N.S.W.
- 1932 Salter, Keith Eric Wellesley, B.Sc., "Hawthorn", 48 Abbotsford Road, Homebush.
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- 1930 Sherrard, Mrs. Kathleen Margaret, M.Sc., 43 Robertson Road, Centennial Park, Sydney.
- 1909 Smith, George Percy Darnell, D.Sc., F.I.C., F.C.S., c/o Lyon's Boat Shed, The Spit, Mosman, Sydney.
- 1928 Smith, Jacob Harold, M.Sc., N.D.A., Department of Agriculture and Stock, Atherton, N. Queensland.
- 1928 Smith, Thomas Hodge, Australian Museum, College Street, Sydney.
- 1916 Smith, Miss Vera Irwin, B.Sc., F.L.S., 13 Upper Cliff Road, Northwood.
- 1935 Spence, Kenneth Kinross, M.B., Ch.M., 51 Sophia Street, Bondi Beach.
- 1926 Stanley, George Arthur Vickers, B.Sc., "Clelands", 33A Battery Street, Clovelly.
- 1898 Stead, David G., "Boongarre", Pacific Street, Watson's Bay.
- 1935 Still, Jack Leslie, B.Sc., 61 Alexandra Street, Drummoyne.
- 1905 Stokes, Edward Sutherland, M.B., Ch.M., 15 Highfield Road, Lindfield.
- 1911 \*Sulman, Miss Florence, "Burrangong", McMahon's Point.
- 1904 Sussmilch, C. A., F.G.S., Sydney Technical College, Ultimo, Sydney.
- 1930 Taylor, Frank Henry, School of Public Health and Tropical Medicine, The University, Sydney.
- 1904 Tillyard, Robin John, M.A., D.Sc., F.R.S., F.L.S., F.R.E.S., C.M.Z.S., The Dial House, Red Hill, Canberra, F.C.T.
- 1921 \*Troughton, Ellis Le Geyt, Australian Museum, College Street, Sydney.
- 1902 Turner, A. Jefferis, M.D., F.R.E.S., Dauphin Terrace, Brisbane, Queensland.
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- 1888 Bale, W. M., F.R.M.S., 63 Walpole Street, Kew, Melbourne, Victoria.  
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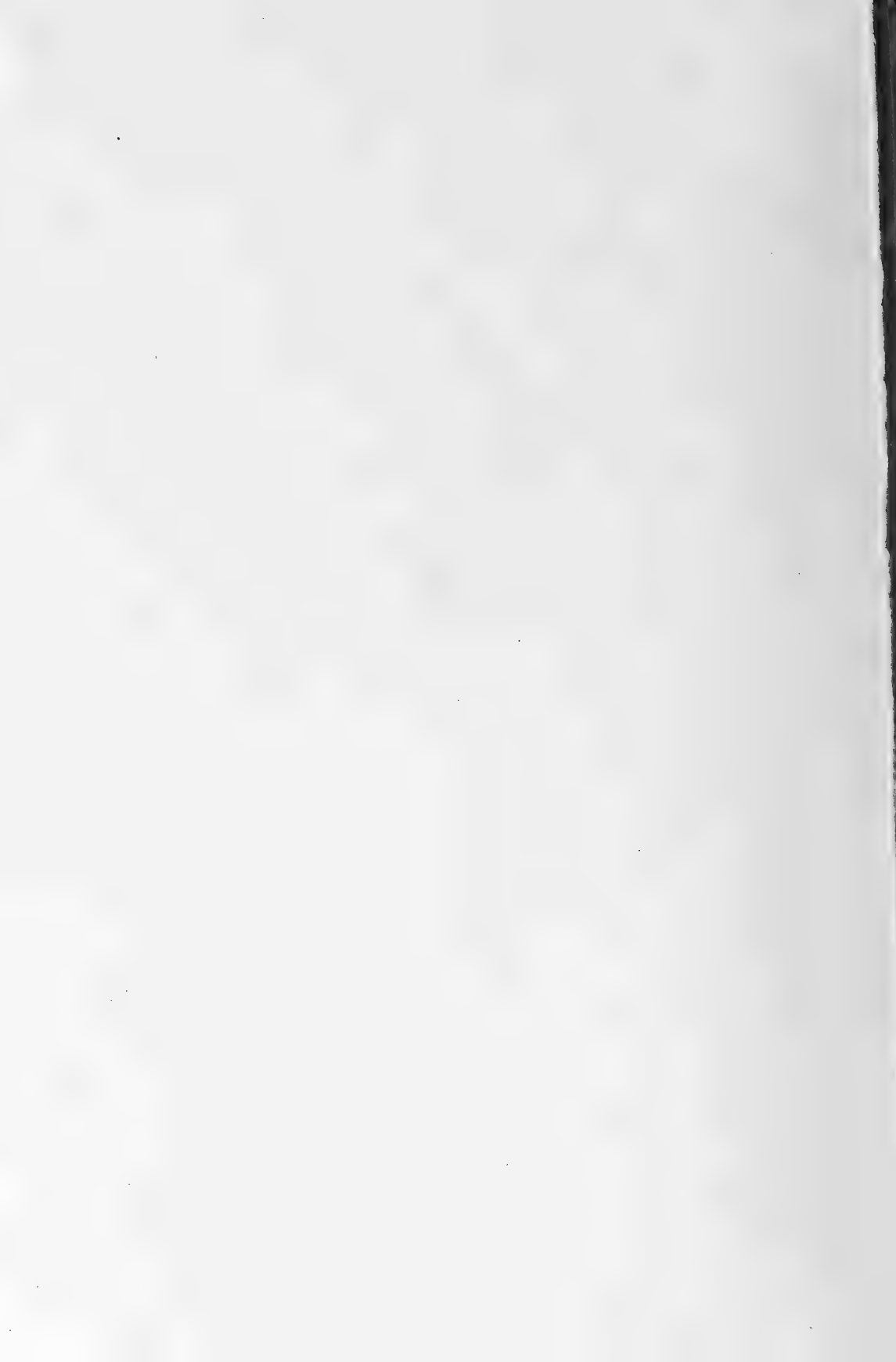
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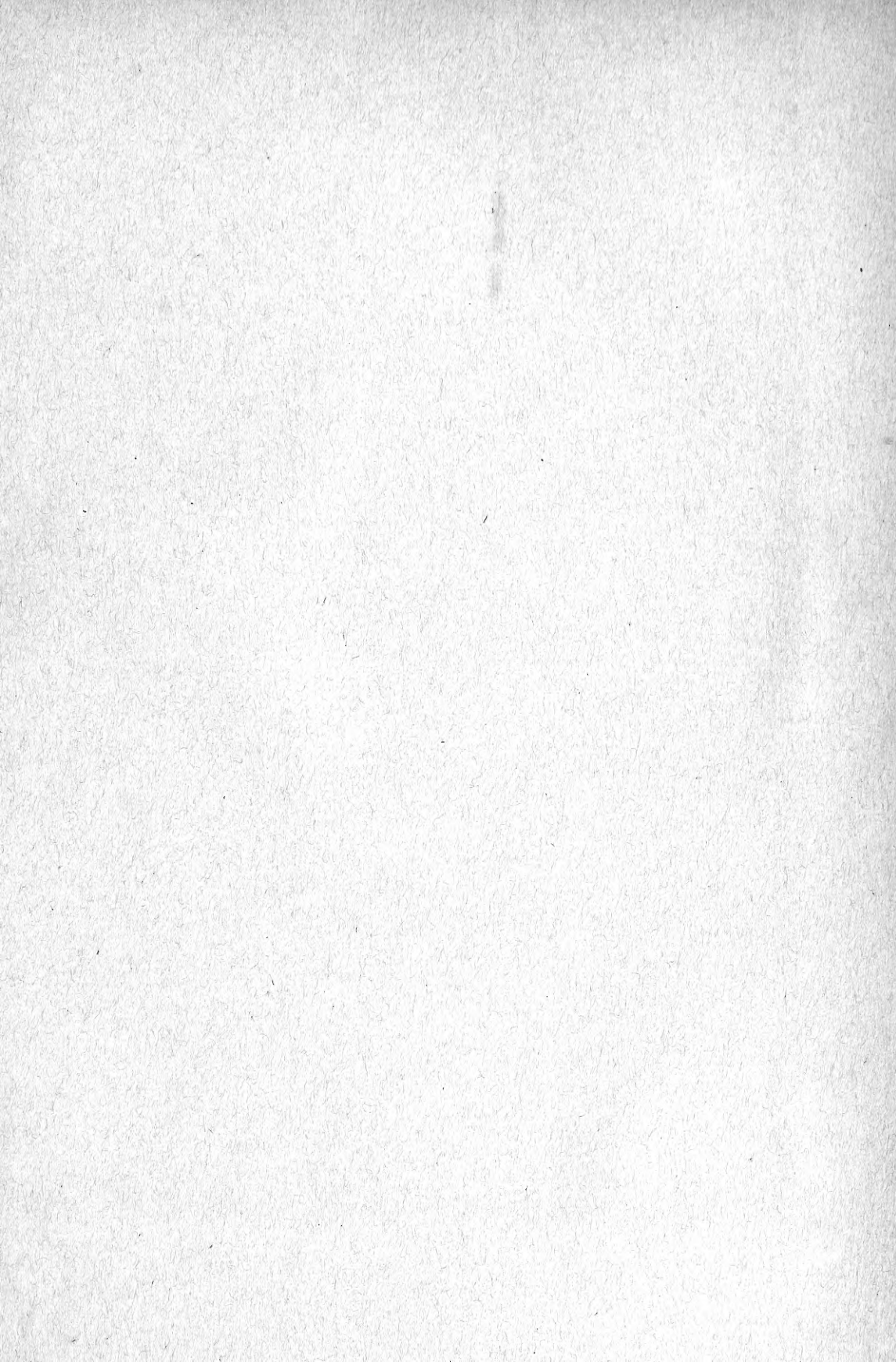
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